Identification of Maternal Deaths, Cause of Death and Contributing Factors in Mangochi District, Malawi: A RAMOS Study

Thesis submitted in accordance with the requirement of the University of Liverpool for the degree of Doctor of Philosophy

By

Florence Mvula Mgawadere

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Liverpool School of Tropical Medicine

Dedication

To my loving and supportive husband, Charo Mgawadere, thank you for your remarkable patience, unwavering love and support for me, throughout my course of study. You were a source of motivation and you strengthened me during moments of despair and discouragement. I am truly thankful for having you in my life.

To my daughter, Janet, you made me proud by gaining admission to the University despite my absence. To my triplets, Moffat, Mahara and Vanessa for being my best cheerleaders though you really missed my company, guidance and motherly care, but you persevered.

To my parents, Beshany and Milia, who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

To my late sisters Harriet and Rosemary, had you both lived, this would have made you proud.

To women who have suffered preventable deaths, may your souls rest in peace.

Abstract

Identification of maternal deaths, cause of death and contributing factors in Mangochi District Malawi

Introduction: The recent World Health Organization (WHO) report on trends in Maternal mortality (MM), from 1990 to 2013, ranks Malawi as one of the fifteen sub-Saharan countries with the highest Maternal Mortality Ratio (MM) of above 500 per 100,000live births (WHO 2014b). Malawi has no registration system for recording births and deaths. MM estimates are based on direct sisterhood methods, (used in Demographic and Health Surveys) and WHO modelled estimates, which are both highly susceptible to inaccuracies because they are both indirect methods which do not identify individual deaths within a defined population. The difficulties in obtaining accurate MMR estimates highlight the need to explore other methodologies that give more reliable data on levels as well as the cause of maternal deaths (MDs). A Reproductive Age Mortality Survey (RAMOS) is one such approach and can provide more direct and complete estimation of MMR in countries without reliable vital registration or other data sources. This is the first RAMOS used in Malawi. The aim of this study was to identify the magnitude, causes of, and factors associated with MDs in the Mangochi district in Malawi.

Methods: Deaths of women of reproductive age (WRA), (15 to 49 years) that occurred from December, 2011 to November, 2012 in the district were identified. Multiple data sources were used to identify deaths, including; health facilities, communities, mortuary records and police records. Classification the death as a MD or not was done according to the ICD-10 definition. Facility based audit were conducted for all facility based MDs and verbal autopsies for all MDs. Cause of death attribution was done in three ways, 1) by a panel of experts in maternal health using the WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium (ICD-MM) (WHO 2012c), 2) by health professionals working in health facilities and 3) by using an InterVA-4 computer model. Cause of death attributed by the three methods was then compared. The three delays model was used to identify delays associated with MDs. The number of MDs identified in this study was compared to the official register in the district. MMR was calculated based on three proxy denominators; 1) number of babies who received BCG vaccine, 2) live births from the census report and 3) live births calculated from general fertility estimates.

Results: A total of 424 deaths of WRA were identified and 151 of these (35.6%) were identified to be MDs. Based on the three denominators, the MMR for the Mangochi district was within the range of 341-363 per 100,000 live births (95% CI: 289-425 per 100,000 live births). Only 86 MDs had been reported via existing registers, giving an underreporting rate of 43%. The highest MMR was in age group 25-29 years (494/100,000 live births (95% CI: 349-683 per 100,000). Most MDs (62.3% (94/151)) occurred in health facilities. Based on ICD-MM cause classification, 74.8% were direct MDs, 17.3% were indirect and 7.9% were due to unknown causes. The leading cause of direct MDs (n=113) was obstetric haemorrhage (35.8%) followed by pregnancy related infections (14.4%) and hypertensive disorders (12.6%). The most frequent indirect cause of MD (n=26) was malaria (56.7%). There was low level of agreement over the cause of death between the panel of experts and health the professionals (κ= 0.37), while a substantial level of agreement was observed between the panel of experts and the InterVA-4 model (κ= 0.66). Based on ICD-MM, health professionals identified contributory factors (morbidity group) to 15.1% of MDs (n=86) as the underlying cause of death. Substandard care for obstetric emergencies, lack of blood, lack of transport, failures to recognize the severity of a problem at community level and delays in starting the decision-making process to seek health care were frequently factors associated with MDs.

Conclusion: The current MD reporting system in Malawi needs strengthening**.** The high numbers of health facility deaths, cause of MDs and their contributing factors in Mangochi reflect serious deficiencies in the quality of maternal care that need to be urgently rectified. Urgent orientation of health workers on ICD-MM is required to obtain accurate information on cause of MDs that can be used to design effective interventions. There is need to strengthen the referral system and educate women on obstetric danger signs.

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Thank God Almighty for the gift of life and wisdom, to Him always is Glory and Praise. This thesis is the beginning of my journey.

Declaration

This thesis is the result of my work. The material contained in the thesis has not been presented nor it is currently being presented, either wholly or as part of any other degree or other qualification.

Acronyms

ANC	Antenatal Care
BCG	Bacillus Calmette–Guérin
BEmOC	Basic Emergency Obstetric Care
CBDA	Community Based Distribution Agents
CCVA	Computer Coded Verbal Autopsies
CEmOC	Comprehensive Emergency Obstetric Care
CHAM	Christian Health Association of Malawi
COD	Cause of Death
DC	District Commissioner
DEHO	District Environmental Health Officer
DFID	Department for International Development
DHMT	District Health Management Team
DHO	District Health Officer
DHS	Demographic Health Survey
DIP	District Implementation Plan
DMO	District Medical Officer
DNO	District Nursing Officer
EHP	Essential Health Package
EmONC	Emergency Obstetric and Neonatal Care
GCSE	General School Certificate of Examination
GFR	General Fertility Rate
GHO	Global Health Observatory
GoM	Government of Malawi
HAART	Highly Active Antiretroviral Therapy
HIV	Human Immuno- Deficiency Virus
HMIS	Health Management Information System
HSA	Health Surveillance Assistant
HWCVA	Health Worker Coded Verbal Autopsy
ICD	International Classification of Disease
ICD-MM	International Classification of Disease on Maternal Mortality
ICPD	International Conference on Population and Development
IHME	Institute for Health Metrics and Evaluation

IPT	Intermittent Presumptive Treatment
ITN	Insecticide Treated Nets
MD	Maternal Death
MDA	Maternal Death Audit
MDS	Malawi Development Strategy
MDG	Millennium Development Goal
MDHS	Malawi Demographic and Health Survey
MDSR	Maternal Death Surveillance and Response
MiP	Malaria in Pregnancy
MMR	Maternal Mortality Ratio
MMIEG	Maternal Mortality Estimation Inter-Agency Group
MoH	Ministry of Health
MoLG	Ministry of Local Government
MSCE	Malawi School Certificate of Examination
NCD	Non-Communicable Diseases
NGO	Non-Governmental Organization
NSO	National Statistics Office
OPD	Out Patient Department
PCVA	Physician Coded Vernal Autopsy
PI	Principal Investigator
PLSC	Primary School Leaving Certificate
PM	Proportion of deaths among women of reproductive age due to maternal causes
PNC	Postnatal Care
RAMOS	Reproductive Age Mortality Study
RSA	Republic of South Africa
RHU	Reproductive Health Unit
RDT	Rapid Diagnostic Test
SBA	Skilled Birth Attendant
SLA	Service Level Agreement
TA	Traditional Authority
TB	Tuberculosis
TBA	Traditional Birth Attendant
TFR	Total Fertility Rate

UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
VA	Verbal Autopsy
WHO	World Health Organization
WRA	Women of Reproductive Age

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1 INTRODUCTION

1.1 Chapter overview

This chapter introduces the research topic under study and has 6 sections. The introductory section, (1.2) provides an overview on the burden of maternal mortality (MM) at a global, regional and national level. Section 1.3 provides the rationale for the study. The study aim and objectives, definitions of terms, thesis structure and map are presented in sections 1.4 to 1.6.

1.2 Introduction

Complications from pregnancy and childbirth remain the leading cause of disability and deaths among women of reproductive age (WRA). The International Statistical Classification of Diseases and Related Health Problems (ICD-10) define a maternal death (MD) as "the death of a woman while pregnant or within 42 days of termination of pregnancy irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes" (WHO 1992a). Globally, approximately 289,000 women die during pregnancy, childbirth and the puerperium (WHO 2014b). This is a decline of MM by 45% from 1990. The majority of these deaths (99%) occur in low-income countries, predominantly in sub-Saharan Africa and South Asia (WHO 2014b)

The maternal mortality ratio (MMR) has been identified as an indicator that shows the greatest disparity between high and low-income countries (Cross, Bell & Graham 2010). In high-income countries, the average MMR is currently 16 per 100,000 live births, whereas in low and middle-income countries, this is 230 per 100,000 live births (WHO 2014b). The recent Maternal Mortality Estimation Inter-Agency Group (MMEIG) reported fifteen countries in sub-Saharan Africa, including Malawi, (510) still have the highest MMR(WHO 2014b).

In addition to high MMR, 15-20 million women globally survive pregnancy and childbirth but suffer lifelong morbidity such as incontinence, severe anaemia, infertility and chronic pain (Koblinsky 2012). Lack of skilled attendance at birth, poor

quality of care, and inability to access health care facilities have been some of the causes of MDs in sub-Saharan Africa (Lewis 2008; WHO 2007d). Most of these deaths are, preventable if the complications are diagnosed and managed effectively and in time. (Kongnyuy & van den Broek 2008).

Since the 1980s, the global health community has focused on reducing MM through a sequence of initiatives beginning with 'Safe Motherhood' in 1987, the International Conference on Population and Development (ICPD in 1994) and the Fourth World Conference on Women in 1995 (Fortney et al. 1986; Ghabbour 1994; Mahler H 1987.; Population Council 1995). Reducing MM received heightened attention when MM became one of the eight goals for development in the Millennium Declaration (Millennium Development Goal [MDG]) adopted at the 2000 Millennium summit (United Nations 2000b). The fifth MDG (MDG5) includes two sub-goals: 1) reducing the MMR by three quarters from 1990 to 2015 and 2) achieving universal access to reproductive health by 2015 (Sachs & McArthur 2005). While most countries aspire to achieve the MDG5 target A by 2015, some countries such as Malawi are unlikely to attain this goal.

Malawi is one of the countries in sub-Saharan Africa with the highest MMR. The number of women who die each year as a result of being pregnant is not precisely known because the MM figures vary widely by source and are highly controversial. The review of maternal mortality for 181 countries from 1980 to 2008, published in the Lancet 2010, indicated MMR of 1,140 per 100,000 live-births (Hogan et al. 2010); the MMEIG, in the report on global trends in MM for 1990 to 2010 reported MMR of 460 per 100,000 live births (WHO 2012a); while the Malawi Demographic and Health Survey (MDHS) 2010, reported MMR of 675 per 100,000 live births (MDHS, 2011). However, the recent global report by MMEIG reported MMR of 510 per 100,000 live births (WHO 2014b). Despite the conflicting figures, this MMR is unacceptably high compared to 2013 global MMR at 210 per 100, 000 live birth and remains far from the MDG5 target of 155 per 100,000 in 2015 (Bowie & Geubbels 2013).

Comprehensive vital registration is widely regarded as the gold standard for measuring MM (Hill et al. 2007; Mahapatra et al. 2007). Less than two-fifths of countries globally had a complete civil registration system with good attribution of cause of death (WHO

2014b). Many countries, including Malawi with its high MM, suffer from incomplete death registration system and inaccuracy in the ascertainment of the causes of MDs (Khan et al. 2006; Lozano et al. 2011c). MM is considered to be difficult to measure due to failure to identify when a death of a woman of reproductive age (WRA) is a MD, underreporting, the rarity of the event and the expense incurred in conducting population-based studies (Graham & Campbell 1992; Westhoff et al. 2009; WHO 2010). Even in countries with a satisfactory vital registration, MDs tend to be underreported and/or misclassified (Qomariyah et al. 2009a; WHO 2004f 2010).

To address the absence of data on MDs, in settings with high MM, the MMEIG started developing internationally comparable global and country estimates of MM using statistical models every five years since 1990 (WHO 1996, 2007a, 2012a, 2014b). The method involves adjusting the MMR estimates to account for underreporting and misclassification where MM estimates already exist. Where no reliable estimates are available, a model based on fertility rates and the proportion of births that are assisted by skilled personnel generate an estimated figure (World Health Organisation 2010). The UN-modelled estimates of MM have become popular sources of data for policy making, planning, monitoring and evaluation of maternal health interventions in developing countries (Graham & Hussein 2006). Although these estimates are useful, they are made using statistical modelling and have wide margins of error and only provide orders of magnitude. Such estimates are often disputed by countries, and not acted upon at times (Font et al. 2000).

The issue is not limited only to dispute estimates, but there is also a challenge with available limited data, which hardly provides information on who has died, what they died of. The Commission on Information and Accountability for Women's and Children's Health (CIAWH) 2011 report, recommended on the need for adequate information on which to base strategies to reduce MDs that all countries by 2015. That necessitated all countries to have well developed systems to measure births, deaths and causes of deaths (WHO 2011c). Consequently, the commission's recommendation echoed the current shift in the global efforts away from simply measuring levels of MM but to look "Beyond the Numbers" to identify cause and contributing factors to these MDs (WHO 2004a). This was because not knowing who has died, and what they

have died of, makes it impossible to build an accurate picture of where there are gaps in access to, availability and quality of maternal health services. Country estimates are important to prioritize maternal health programmes, and to guide advocacy efforts and research activities at the national level (WHO 2007b).

Therefore, alternative measurement strategies and options for estimating MMR in countries, which lack reliable data, have been suggested, although each presents different challenge. These include population-based surveys (including the sisterhood method), community-based continuous surveillance systems and Reproductive Age Mortality Surveys (RAMOS) (Graham et al. 2008b; Walraven et al. 2000).

Population-based surveys require large samples (often > 50,000 births), which makes them costly or, when a large sample size is not feasible, they produce imprecise estimates. A way to overcome this problem is to use the sisterhood-method (direct and indirect) (Graham, Brass & Snow 1989). The sample size is reduced to less than 4,000 households in the indirect sisterhood method but, the uncertainty of the estimates derived using these methods tends to be very large. The data refers to the past 7-12 years making them unsuitable for proactive response, planning or resource allocation (Danel, Graham & Boerma 2011). On the other hand, community-based surveillance systems (i.e. longitudinal studies) are also costly, but have the ability to provide current estimates and insight into the determinants of MM.

A RAMOS approach, assesses the extent and causes of MM by identifying and investigating the causes of death of all WRA in a defined population, using a variety of sources of information, e.g. civil registers, health facility data, community leaders, religious authorities, undertakers, cemetery officials (Betrán et al. 2005). In the absence of vital registration data, RAMOS approach is considered the best (World Health Organisation, 2010). The RAMOS approach has been effectively and efficiently used on a small scale to determine MMR and cause of death in low and high-income-countries, including Surinam, Tanzania, Gambia and Mozambique (Amarin et al. 2010; Ghebrehiwet & Morrow 2010; Zakariah et al. 2009). In all these studies, use of the RAMOS, led to an increase in the number of MDs identified and highlighted underreporting via the existing mechanisms in place to report MD compared to hospital and national estimates. The relative success of RAMOS

prompted an interest in this method to identify the levels and causes MDs in Mangochi district rural Malawi.

The study was designed to answer the following research questions, what is the maternal mortality ratio in Mangochi district Malawi, why and where are women dying and what are the causes and associated factors of these maternal deaths?

1.3 Rationale for study

A significant reduction in MM was witnessed globally in the year 2010, yet; no reduction was recorded in Malawi. However, it has been a challenge to assess the extent of progress towards MDG5 due to lack of more reliable and accurate data on MM. The national estimates which are based on the direct sisterhood method in the MDHS and MMEIG are not reliable, due to the sampling methods and the use of aggregated national figures, which lack precision. (Hounton et al. 2013). These estimates are not timely, always referring to the past and cannot be used to monitor progress towards reduction of MM.

There are also controversies in MMR estimates for Malawi as different sources provide varied estimates (MOH 2011b). The absence of accurate data on the numbers, causes and associated factors influencing adverse maternal outcomes has been identified as a major obstacle hindering appropriate distribution of resources targeted towards improving maternal healthcare (WHO 2007a). More reliable MMR primary estimates are required to define the scale of the problem in Malawi, to help with planning and allocation of adequate resources and to monitor progress towards MDG5. The controversies in estimates and the current lack of progress in tackling maternal mortality, created the need to explore other better methods of establishing current data on MM to contribute to the reduction of MM.

The RAMOS approach has been reported to provide a more complete estimation of MMR in countries without reliable data sources (WHO 2012a). To the best of our knowledge, the RAMOS approach has not been used in Malawi. It is evident that due to the robustness of the approach more MDS than the usual were going to be captured.

This in turn would promote planning and implementation of effective maternal health interventions based on sound evidence in the Mangochi district.

Anecdotal evidence reveals that Mangochi district has high MMR compared to other districts in Malawi, yet there is paucity of data in the literature on recent studies addressing MM levels and causes in the district. A prospective assessment of mortality among a cohort of pregnant women was conducted from 1987 to 1989 revealed MMR of 398 per 100,000 (McDermott et al. 1996). The study only focused on pregnant women who received antenatal care in 4 out of 26 clinics, which were operational during the study period. The results of this study could not be generalised because the sample used was not a representative of the whole district. Ever since, the district has relied on the Health Management Information System (HMIS) and national data for implementation of maternal health interventions. The HMIS data only captures facility based data, leaving out women who die outside the facility. The national estimates which are used as a basis for some programmes and allocation resources are presented as averages that hide major disparities between the districts. This background justified the need for this study to specifically uncover where the greatest burden of mortality is located, identify who is concerned and what the causes are, both in the community and in health facilities and to improve the quality of care provided to women.

1.4 Aims and Objectives

1.4.1 Aim

The overall aim of the study was to identify and determine the cause of, and factors associated with MM in one district in Malawi.

The purpose was to come up with better intervention which will assist in improving MDs surveillance, reviews and notifications and maternal health care services in general for the achievement of the fifth millennium development goal by 2015 and plan for post 2015.

1.4.2 Objectives

Specifically, the objectives of the study were:

1. To identify all deaths among women of reproductive age (15-49 years) in Mangochi district over a one year.
2. To determine the proportion of maternal deaths among all deaths of women of reproductive age in Mangochi district.
3. To identify the degree of underreporting of maternal deaths in the district.
4. To classify the causes of MDs using the new WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium (ICD-MM).
5. To compare causes of MDs based on ICD-MM classification with the causes assigned by health professionals and computer coded software (InterVA-4).
6. To identify factors associated with maternal deaths using the 3 delays model.

1.5 Definition of terms used in this study

Developing country: Denote any low- and middle-income country as defined by the World bank based on the income group (gross national income (GNI) per capita) from less than 1,035 to 12, 615 or more (World Bank 2012).

Direct maternal deaths: "Deaths resulting from obstetric complications of the pregnant state (pregnancy, labour and puerperium) from interventions, omissions, incorrect treatment, or from a chain of events resulting from any of the above. For example, deaths due to haemorrhage, pre-eclampsia/eclampsia or those due to complications of anaesthesia or caesarean section" (WHO 1992b).

Community death: Any death outside a health facility.

Fortuitous or Incidental: "Deaths during pregnancy but unrelated to a pregnancy or the puerperium" (WHO 2007a).

High-income country: A country whose gross national income (GNI) per capita, (based on the International US dollar ($) was 12,6l6 and more in 2012 according to The World Bank definition (World Bank 2012).

Indirect maternal death: "Deaths resulting from previous existing disease, or disease that developed during pregnancy and, which was not due to direct obstetric causes, but, which were aggravated by the physiological effects of pregnancy. For example: epilepsy or aggravation of an existing cardiac disease" (WHO 1992b).

Late maternal deaths: Deaths occurring between 43 days to year after abortion, miscarriage or delivery. They can be due to direct or indirect causes (WHO 2004d).

Live birth: "The complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g. beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles - whether or not the umbilical cord has been cut or the placenta is attached. Each product of such a birth is considered live born" (WHO 2004d).

Lower Income Country

A country whose gross national income (GNI) per capita, (based on the international US dollar ($)) was within $1,0335 or less in 2012 according to a World Bank definition (World Bank 2012).

Lower -middle income country: A country whose gross national income (GNI) per capita, (based on the international US dollar ($)) was within $1,036 to 4,085 in 2012 according to a world bank definition (World Bank 2012).

Maternal death: "The 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 incidental causes" (WHO 1992b).

Facility based maternal death audit: "is a qualitative investigation of causes of and circumstances surrounding MDs occurring at health facilities. The lessons learned from such an audit are used in making recommendations to prevent similar future deaths" (WHO 2004a).

Maternal mortality ratio: Number of maternal deaths during a given time period per 100 000 live births during the same time period (WHO 2014b).

Misclassification of maternal deaths: When a maternal death is wrongly classified to causes not used for the purpose of identifying maternal deaths.

Non-pregnancy deaths or non-maternal deaths: Deaths of women not related to pregnancy causes.

Panel of Experts: A panel comprising of two experienced physicians and a midwife who reviewed the verbal autopsy data.

Pregnancy-related deaths: "Deaths occurring in women while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of the death "(WHO 2014b).

Skilled birth attendant (SBA): WHO defines an SBA as "someone trained to proficiency in the skills needed to manage normal (uncomplicated) pregnancies, childbirth and the immediate postnatal period, and in the identification, management and referral of complications in women and new-borns" (WHO 2004e).

Underreporting of maternal deaths: It may occur due to misclassification or if the death was never reported or recorded.

Upper-middle income country: A country whose gross national income (GNI) per capita, (based on the international US dollar ($)) was within $ 4,086 to 12,615 in 2012 according to a World Bank definition (World Bank 2012).

A woman of reproductive age: Any woman within ages 15-49 years of age.

Youth and young people: The State of the World's Population Report (2005) defines "youth" as "persons aged 15-24 and young people as persons aged 10-24 years" (UNFPA 2006).

1.6 Thesis structure

This thesis is presented in ten chapters: Chapter one gives an introduction to MM, rationale for the study, objectives, and outlines the main potential contributions of this study to the field of research on MM in Malawi. The chapter further outlines the structure of the whole thesis and provides conceptual map [Figure 1.1].

Chapter two describes the background of the study area. This includes: Location, population; political, social, economic and health status; health care delivery system; maternal, reproductive and health strategies; trends and causes of MDs; MM situation; MD auditing; and MM reporting system.

Chapter three presents the literature review, which is split into different sub-sections starting with an introduction, the search strategy used to identify studies, approaches which are used to estimate MMR, causes and associated factors of MD. The chapter also presents cause classification of MDs. The chapter finally gives a summary of the literature review.

Chapter four describes the study designs; the methods and materials used and include a detailed description of the fieldwork, and the questionnaires used during the research. The chapter explains details of the pilot study, the recruitment and training of data collectors, administration of the study, how each objective was achieved and how the analysis was conducted. The chapter further explains the statistical methods used to analyze data and ethical issues are described.

Chapters' five to eight present the key findings of the study in line with the stated research objectives. The results are presented in figures, tables and graphs.

Chapter nine contains the general discussion of the main findings of the study reflecting on the strengths, and a weakness of the design used and discusses the findings in relation to the current literature on MM.

Chapter ten draws conclusions and makes recommendations based on study findings; lessons learnt are shown and recommendations made for future policy and research.

The appendix is composed of study questionnaires, figures and tables.

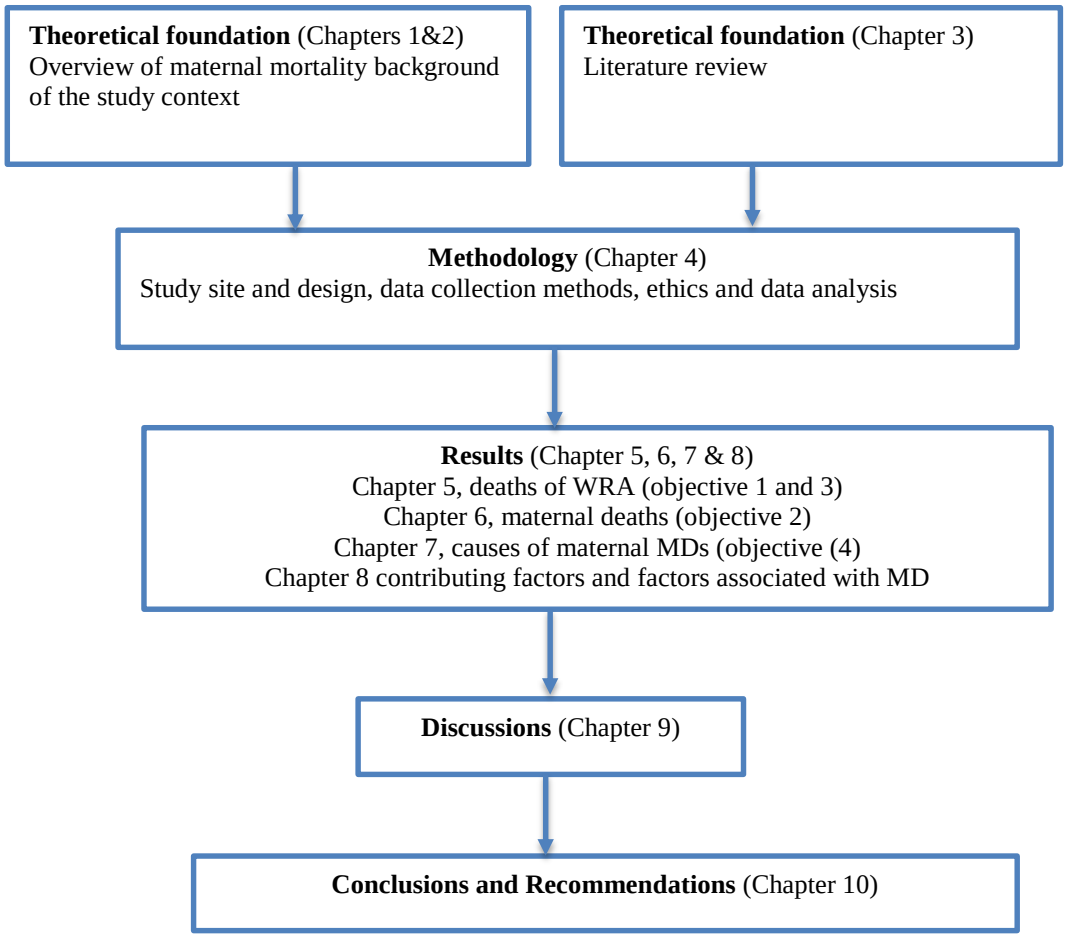


Figure 1.1: Conceptual map for the thesis

1.7 Chapter Summary

This chapter has provided a background which informed the study. The study is based on the high MM in Malawi with the lack of reliable data on levels and causes of MDs. The main aim of the study is to identify and determine the cause of, and factors associated with MM in one of the rural districts in Malawi. The purpose of the study was to formulate better interventions to be shared with stakeholders in reproductive health so as to improve maternal death surveillance, reviews and notifications and maternal health care services in the district. The chapter has specifically outlined the objectives used to achieve the aim of the study. To promote understanding of the thesis, definitions of terms have been provided and the chapter concludes with the thesis structure and a conceptual map.

2 BACKGROUND TO THE STUDY AREA

2.1 Chapter overview

This chapter presents a background of Malawi. There are 6 main sections. Section 2.2 locates the country and provides details about its population, education and social and economic status at the time of study. Section 2.3., provides information about its health care delivery system of Malawi. Details on the reproductive health strategies, levels, and causes of MDs are presented in sections 2.4 and 2.5. Specific details about the study site are presented in chapter 4.

2.2 Demographic and administrative characteristics

Malawi is a sub-Saharan land-locked country located south of the equator. Administratively, the country is divided into three regions: the northern, central and southern regions, which are further divided into 28 districts, six in the northern region, nine in the central region, and 13 in the southern region (GOM 2012), [Figure 2.1]. The districts are sub-divided into Traditional Authorities (TAs) which are presided over by Chiefs. Each TA is made up of villages, which are the smallest administrative units and are presided over by village headmen/women (Lowe Morna, Glenwright & Makaya Magarangoma 2010). Mangochi district, where this study took place, is in the southern region of Malawi [Figure 2.1].

Malawi had estimated population projection of 14,844,822 people in 2012 comprising of 49% males and 51% females (NSO 2008). Among the female population, 42.2% were women of reproductive age (WRA) aged 15-49 years. The Malawi's population is young, with 45% below the age of 15 years. Life expectancy at birth is 48.3 years for men and 51.3 for women. Unadjusted Total Fertility Rate (TFR) is 5.7 children per woman. The crude death rate is 10.4 per 1,000, 11.2 per 1,000 for males and 9.7 per 1,000 for females in the National Census 2008. About 83% of the population live in the rural areas (NSO, 2008).

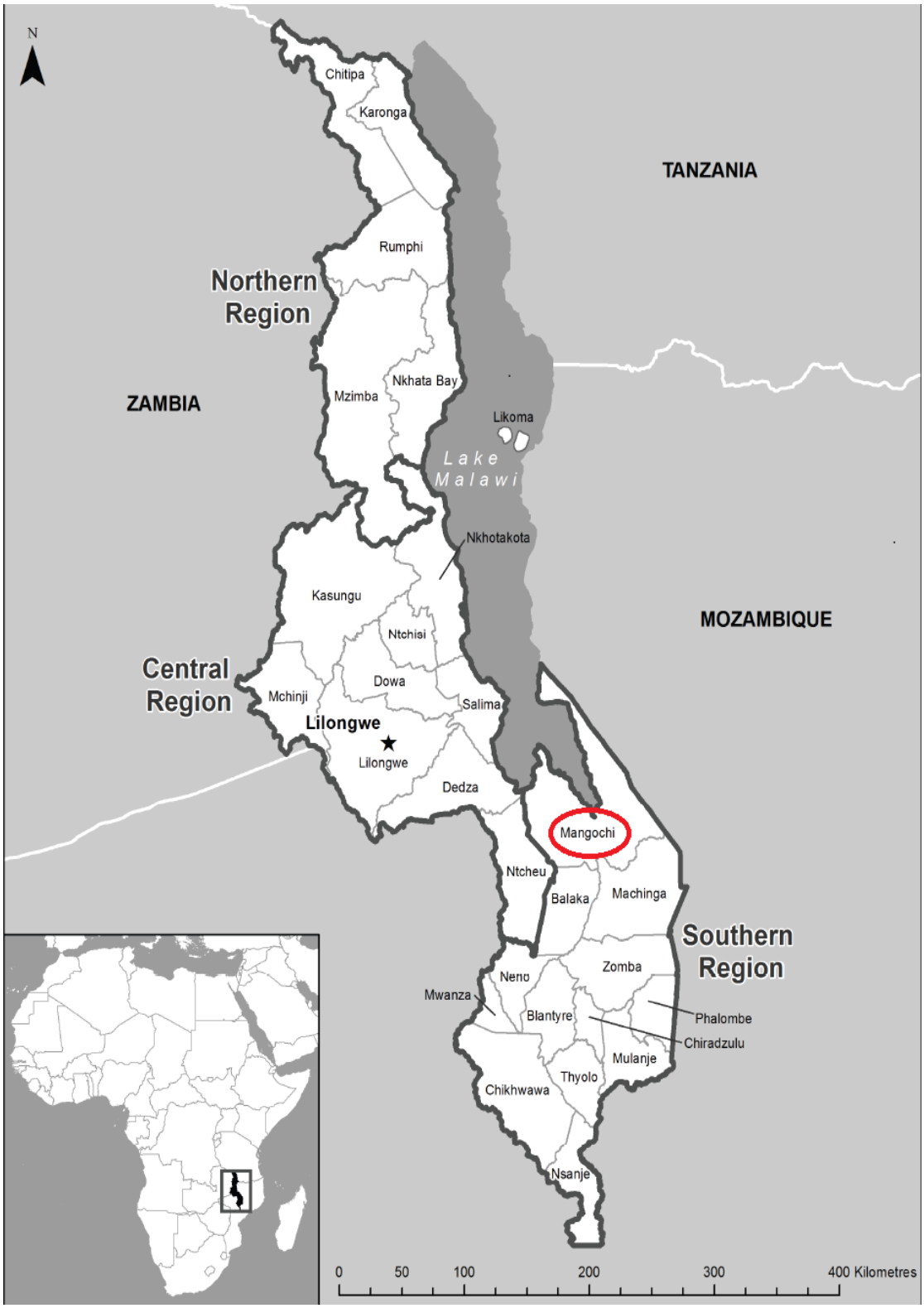


Figure 2.1: Map of Malawi showing districts and bordering

2.2.1 Educational Attainment

Educational attainment is higher for men than for women. MDHS (2011) reported that 20% of men had been to school, compared to 30% of women and literacy rate was at 64% (MDHS, 2011).

2.2.2 Age at first marriage and sex initiation

First marriage is an important social and demographic indicator and in most societies represents the point of woman's life when childbearing starts. The duration of exposure to the risk of pregnancy depends primarily on the age at which women first marry (MDHS 2011). The minimum age for marriage is 18, or 15 with parental consent (Government of Malawi 1995). Men marry considerably later than women, 25% of men aged 25-29 were married by age 20, compared to 76% of women in the same age group and by the age of 25, 66% of men aged 45-49 were married compared with 94% of women (MDHS, 2011).

The age of sexual debut is 13 in Malawi (Malawian Penal Code 1930b) and the average age of first sexual intercourse for both boys and girls, is 17 years. In 2012, the unmet need for family planning for girls was 45.4% (WHO 2012b).

Inadequate knowledge of sexual and reproductive health, reluctance to access health services, early marriage and sexual debut, and low rates of contraceptive use (17-20%) make Malawian teens particularly vulnerable to sexual and reproductive health problems, including complications of unsafe abortion (Biddlecom et al. 2007; Lema 2003; National Youth Council of Malawi 2009).

2.2.3 Socioeconomic profile

Malawi as one of the poorest countries in the world with a Human Development Index (HDI) of 0.418 (UNDP 2011). Its economy is predominantly agriculture-based and dependent on tea, tobacco, coffee and sugar. Sixty five per cent of the population is defined as poor and unable to meet their daily needs and over 50% of the population is defined as food-insecure (MGDHS 2004).

2.3 Health care system

Health care services in Malawi are provided by three main agencies. The Ministry of Health (MoH) which provides about 60% of services, the Christian Health Association of Malawi (CHAM) provides 37% and the Ministry of Local Government (MoLG) which provides 1%. There is a small private-for-profit health sector limited to urban areas as well as health services provided by private companies, commercial companies and the Army and the Police. Ninety percent (90%) of CHAM facilities are in rural and hard- to- reach areas and charge a fee for service. Malawi's health system is under-resourced, per capita expenditure per person is about $25, which is inadequate for the delivery of basic primary health care (World Bank 2012).

The delivery of health services follows the Essential Health Care Package (EHP). EHP refers to a prioritised but limited package of services that should be available to every individual in Malawi at all times (MOH, 2004). The Malawi MoH developed the EHP as an explicitly pro-poor strategy to deliver the minimum essential health services to rural communities. It focuses on those conditions and service gaps that disproportionately affect the health of the poor and disadvantaged population. Services provided by EHP include reproductive health, malaria prevention and treatment, prevention of diarrhoeal disease and prevention of acute respiratory diseases. Maternal health is one of the priority components in the EHP.

Provision of the EHP is seen as a way of enhancing achievement of the health-related Millennium Development Goals (MDGs), and as a departure from the 'balkanisation' of the health sector by donors which led to 'islands of excellence' operating within the public health structure (Pearson 2010). The introduction of the EHP necessitated the implementation of a service agreement between the government of Malawi and CHAM hospitals because health services are provided for free in all public health institutions while the private sector charges user fees for its services (GOM 2011). The service level agreement (SLAs) provides financial support towards service delivery between government and CHAM. Fees are set and paid separately by Malawi government, although this is not implemented in all CHAM health facilities. About 75 of 172 (36%) CHAM health facilities have SLAs with the government through district health offices (Kumwenda 2012). The SLAs are specifically for maternal and child

health programmes to promote the delivery of EHP and improve access to basic health care in rural areas. CHAM is critical in the delivery of the EHP considering their location in most rural areas where close to 85% of the Malawi population lives (Banda et al. 2006).

In addition, the Ministry of Health implemented a comprehensive and integrated routine Health Management Information System (HMIS) country-wide (GOM 2003). The HMIS supports the EHP and is seen an integral part of the national health system. It aims to provide reliable, relevant, current, and complete data for those managing health from community to central levels. The HMIS reports on the EHP components in a way that acts as indicators of delivery of service and utilisation in the public and formal health sector (Banda et al. 2006). Each district has an HMIS section which reports to the national level. The Ministry of Health and Population, in consultation with relevant stakeholders, has come up with standard indicators to be used in the HMIS to maintain comparability, coherence and consistency in the data collected. MD is one of the indicators in the HMIS along with other relevant maternal health indicators such as ANC attendance, number of deliveries, skilled attendance at delivery, number of stillbirths/live births, neonatal deaths, all immunisations including Bacillus Calmette–Guérin (BCG), neonatal deaths and postnatal attendance.

2.3.1 Levels of health care in Malawi

The health system in Malawi consists of three levels: primary, secondary and tertiary level [Table 2.1].

The primary level comprises community, rural/community hospitals, health centres, dispensaries and health posts. At community level, health services are provided by cadres such as Health Surveillance Assistants (HSAs), Community Nurses, Health Assistants, and other Community Volunteers (MOH 2011c). There are some Non-Governmental Organisations (NGOs) who work at community level. Each HSA is allocated a minimum a catchment population of 1,000 people (MOH 2009b). HSAs perform multiple overlapping promotional and preventive health services including HIV Testing and Counselling, family planning, provision of immunization services and death reporting which includes MD reporting (MOH 2009a). Village health

committees work in collaboration with HSAs to promote primary health care activities through community participation. The work of HSAs is supported by the health centre which is in turn supported by a community hospital. Each community hospital has an admission capacity of 200 to 250 beds.

The secondary level is made up of district hospitals, which usually have an admission capacity of between 200 and 300 beds. The district hospitals deliver both in-patient and out-patient services to the local town population. CHAM hospitals provide the same services as district hospitals.

The provision and management of health services at district level are the responsibility of the District Management Implementation Team (DHMT) which receives direct technical support for supervision from Zonal Health Support Offices. There are five Zonal Health Support Offices in Malawi and each one has district hospitals they support. The zonal offices report to the Ministry of Health.

The tertiary level consists of central hospitals that provide referral health services for their respective regions. There are four central hospitals in Malawi, two in southern region, one in central region and one in the northern region. Details of staff cadres and services are outlined in [Table 2.1].

Table 2.1: Levels of health care delivery in Malawi, services provided and staff cadres available

Level of health care	Type of facility	Services provided	Staff cadres
Primary Level	Health Post	• Family Planning • Case referrals to Health Centres (both OPD and Maternity	• HSAs, • CBDAs • Volunteers • Village Health Committees
	Dispensaries	• OPD Services • Immunisations • Family Planning	• Medical Assistant, • HSAs and volunteers
	Health Centres	• OPD Services • Immunisations • Family planning, antenatal care, Labour & Delivery, Basic Emergency Obstetric Care (BEmOC) services and HIV testing and counselling. • Attend to referrals from dispensaries and health posts	• Medical Assistant (SBA) • Nurses (SBA) • Health Assistant • Health Surveillance Assistants • Volunteers
	Community Hospitals	Provide primary and secondary care • Family planning, antenatal care, labour & delivery, postnatal care • Basic and comprehensive Emergency obstetric care (CEmOC) services • Attend to referrals from health centres • Immunisations • Outpatient department (OPD) services	• Clinical Officer (SBA) • Medical Assistants (SBA). • Nurses (Enrolled and Registered Nurses)(SBAs) • Anaesthetist (SBA) • Health Assistant (Cluster Supervisor), Health Surveillance Assistants.
Secondary Level	District and CHAM Hospitals	• All services at the health entre level. • CEmOC • Facilitating any training for the districts (Environmental, maternal etc.)	All the staff at the Health centre plus • DHO, DMO, DNO, Matron, Clinical officers (SBAs) • Anaesthetist • DEHO Health Assistants (Cluster Supervisors), Environmental Health Officers (Zone Coordinators)
Tertiary Level	Central Hospitals	• All the services at district level • Specialised services such as obstetrics and Gynaecology • Support the districts • Research • Professional training	All staff at the district level and Specialist staff such as Obstetricians and Gynaecologist (all SBAs)

KEY
DHO=District Health Officer, DMO=District Medical Officer, DNO= District Nursing Officer, EHO=District Environmental officer, OPD=Out Patient Department, SBA= Skilled Birth Attendant

Source: EHP, 2009

2.4 Reproductive health in Malawi

Table 2.2 shows, Malawi is performing poorly in the area of reproductive health. MMR, fertility rate, adolescent fertility rates are high and contraceptive prevalence rate is low (41.6%). About 73.2% of deliveries in Malawi take place in health facilities and 71% of women are attended by skilled birth attendant (SBA) at birth- doctors, nurses, clinical officers and medical assistants.

HIV prevalence among WRA is high (12%) and there few nurses and midwives to attend to obstetric emergencies in the facilities. These factors increase the lifetime risk of maternal deaths and contribute to high MM.

Table 2.2: Health and sexual reproductive health indicators for Malawi

Indicator	2009	2010	2011	2012	2013
% of pregnant attending antenatal care (at least one ANC attendance)	-	95	-	-	-
% of pregnant women who deliver under skilled care	-	73.2*	-	-	-
Proportion of births attended by skilled birth attendant	-	71	-	-	-
Maternal Mortality Ratio (MMR), (modelled estimate)	-	460	-	510	530
Number of maternal deaths	-	3000	-	-	3400
Lifetime risk of maternal death	-	1 in 36	-	-	1 in 34
% of women who received postpartum care after delivery by skilled health worker within seven days	-	10*	-	-	-
Fertility rate (births per woman)	5.7	5.6	5.6	5.5	-
Adolescent fertility rate (births per 1,000 women aged 15-19)	152	150	147	145	-
Contraceptive prevalence (of women ages 15-49)	-	41.6	-	-	-
Unmet contraceptive need (% of married women 15-49 years)	-	26	-	-	-
Birth rate crude (per 1,000 people)	41	41	40	40	-
Neonatal Mortality Rate (NMR)	-	-	31*	-	-
Infant Mortality Rate (per 1,000 live births)	55	53	49	46	-
Under Five Mortality Rate (per 1,000 live births)	89	83	77	71	-
%Prevalence of HIV among 15-24 year old pregnant women attending ANC	12%	12	-	-	-
Prevalence of HIV, total (% of population ages 15-49)	11.5	11.2	11.0	10.8	-
Life expectance at birth (total), (years)	53	53	54	55	-
Life expectancy at birth (female), (years)	53	54	54	55	-
Life expectancy at birth (male), (years)	53	53	54	55	-
Physician per 1,000 people		0.02			
Nurses and midwives per 1,000 people		0.283			

*Source: World Bank 2013, *MDHS, 2011*

2.4.1 Reproductive health improvement strategies in Malawi

Malawi government is committed to safeguard the sexual and reproductive health (SRH) of its people and to provide them with comprehensive care. MoH, Malawi manages SRH services through its Reproductive Health Directorate (RHD). The Reproductive Health Unit (RHU) in Malawi was established in 1997 to guide, coordinate and monitor reproductive health services at all levels.

Malawi is also a signatory to the MDGs and has made a renewed commitment to reducing MM in the country. The MOH through the RHU and with support from development partners has implemented several initiatives.

In 2002 a Reproductive Health Policy was created to guide the implementation SRH services (MOH 2009c). The policy was reviewed in 2009 to incorporate emerging issues like Anti-Retroviral Therapy and Prevention of Mother-to-child Transmission of HIV (PMCT). One of its goals is to accelerate the reduction of maternal and neonatal morbidity and mortality to achieve the MDG5 target. A key strategy for achieving this goal is improving quality of skilled maternal and neonatal care at all levels of healthcare.

Other policies include: the 2005 Road Map for accelerating the reduction of maternal and neonatal mortality and morbidity in Malawi and the 2007-2010 implementation plan for sexual and reproductive health. One objective of the road map is the provision of quality skilled obstetric are care during pregnancy, childbirth and postal period at all levels of the healthcare delivery system (MOH 2009d).

The National Sexual and Reproductive Health and Rights Strategy for 2011-2016, a revised version of the first strategy for 2006-2010 which identifies priority actions to reach the MDG targets and improve SRH outcomes of Malawians.

These guidelines are in line with the National Health Policy, the National Poverty Reduction Strategy, the recommendations by the 1987 Safe motherhood Initiative (SMI), International Conference on Population and Development (ICPD) held in Cairo, Egypt, 1994, the 2000 MDGs, and African Union Sexual and Reproductive

Health Rights (SRHR) policy guidelines (African Union 2005; ICPD 1994; MOH 2009c; Starrs 2006; United Nations 2000a).

Despite all these initiatives, there has been slow progress in reducing MDs over the past years. and it is unlikely that Malawi will reach its MDG projected target of reducing MMR to 155 per 100,000 live births in 2015 (Ministry of Development Planning and Cooperation 2009) [Figure 2.2]

Malawi uses the inter-sectoral approach in implementing the policies and receives technical and financial support from partners, including UNICEF, WHO, United Nationals Population Fund (UNFPA) and other international organisations in its strategies to reduce MM. The country, however, faces financial challenges and institutional challenges like inadequate numbers of adequately equipped facilities, uneven distribution of existing facilities, under-developed communication and transport systems, shortage of health workers and irregular supply of essential drugs and equipment (MOH 2011b).

2.4.2 Emergency obstetric care

Basic and Comprehensive Emergency Obstetric care (EmOC) have been defined as agreed minimum and essential care packages that need to be available to all pregnant women (WHO, UNFPA & UNICEF 2009).

There are six process indicators that can be used to measure the availability, utilisation and quality of EmOC (UNICEF 1997) [Table 2.3]. Two indicators measure availability, three, measure utilization and one measures of quality of care.

United Nation (UN) guidelines recommend that there at least 5 emergency obstetric care facilities (including at least 1comprehensive facility) for every 500,000 (UNICEF, WHO & UNFPA 1997b). The requirements for the other indicators are in [Table 2.3].

Table 2.3: Emergency obstetric care: UN process indicators and recommended levels

UN process indicator	Definition	Recommended level
Amount of EmOC services available	Number of facilities that provide EmOC	Minimum: 1 comprehensive EmOC facility and 4 basic facilities for every 500,000 people
Geographical distribution of EmOC facilities	Facilities providing EmOC well distributes at sub-national level	Minimum: 100% of subnational areas have the minimum acceptable numbers of basic and comprehensive EmOC facilities
Proportion of all births in EmOC facilities	Proportion of all births in the population that take place in EmOC facilities	Minimum: 15%
Met need for EmOC services	Proportion of women with obstetric complications treated in EmOC facilities	Minimum: 100% (estimated as 15% of expected births)
Caesarean sections as a percentage of all births	Caesarean deliveries as a proportion of all births in the proportion	Minimum: 5% Maximum: 15%
Case fatality rate	Proportion of women with obstetric complications admitted to a facility who die	Maximum: 1%

Source: *UN Process Indicators of Emergency Obstetric Services* (UNICEF, WHO & UNFPA 1997a)

On number of EmOC facilities, Malawi, with a total population of 13,077,160 should have 131 EmOC facilities of which at least 26 should be comprehensive. However an assessment on EmOC conducted in Malawi in 2010 reported that Malawi had only 52 EmOC facilities (weighted per district) which included 42 comprehensive hospitals (MOH 2011b). This means, Malawi only had 40% of the recommended EmOC facilities per 500,000 populations. On the other hand, the country has exceeded the recommended number of comprehensive facilities by 62% but has fallen short on the recommended number of basic EmOC facilities. Only 2 districts had the recommended number of EmOC facilities per 500,000 populations i.e. Mwanza and Phalombe. The met need (the percentage of expected complications that receive care in facilities) was only 22% in EmOC facilities and 50% in all facilities. The proportion of all deliveries by caesarean section and direct obstetric case fatality rate were also lower than the UN requirement at 3.6% and 2% respectively.

Availability of EmOC is measured by assessment of the availability of signal functions [Table 2.4], the number of facilities providing signal functions per 500,000 population as well as the geographical distribution of these facilities (Bailey et al. 2009). In surveys, a facility is generally designated as an EmOC facility (BEmOC or CEmOC) if it has provided all the relevant signal functions three months before the survey.

Table 2.4: Signal functions of essential (or emergency) obstetric care

Basic EmOC services	Comprehensive EmOC services
1.Parenteral antibiotics 2. Parenteral oxytocic drugs 3. Parenteral anticonvulsants 4. Manual removal of placenta 5. Removal of retained products (e.g. by manual vacuum aspiration) 6. Assisted vaginal delivery (usually ventouse delivery) 7. Resuscitation of the new-born using a bag and mask	All included in Basic EmOC (1–7) plus: 8. Caesarean Section 9. Blood Transfusion

Source: *WHO et al 2009*

The 2010 nationwide EmOC assessment showed that provision of assisted vaginal delivery, parenteral anticonvulsants, manual removal of placenta and removal of retained products were missing in most health facilities (MOH 2011b).

2.4.3 Human resources

The scarcity of skilled human resources is one of the critical challenges for effective delivery of health services in Malawi (MOH 2011c).To address this gap, in 2007, the government and CHAM commissioned a functional review and came up with concrete recommendations for staffing levels at health centre, community and hospital levels. Using these recommended staffing levels, huge shortfalls in staff of all cadres except medical assistants was revealed. At national level, there are only 40% of targeted enrolled nurses (or nurse/midwife technicians), 47% of the targeted registered nurses, 28% of the targeted clinical officers and 43% of the targeted medical officers. At district hospital level, there is severe shortfall of clinical officers (21%) and medical officers (27%). Most of the health centres surveyed did not have this minimum staffing complement (MOH 2011b).

2.5 Maternal mortality in Malawi

2.5.1 Levels of maternal mortality

There is no functioning vital registration system in Malawi. At national level, the direct sisterhood method has been used in Malawi with the Malawi Demographic and Health Surveys (MDHS) which are conducted every four years. So far four demographic health surveys have been conducted since 1992 (MDHS 1992, 2001, 2005; NSO 2010) [Table 2.5]. Both MDHS and MICS studies which provide national estimate use pregnancy–related deaths as case definitions of MDs to calculate MMR.

A further search from both peer reviewed and grey literature yielded thirteen (13) facility-based and twelve (8) population-based studies which have been conducted at sub-national level in Malawi. The results of these studies, sorted by setting and year of the study, are presented in [Table 2.5]. Most of the facility-based studies in Malawi were (11/13) were conducted at tertiary and secondary level hospitals (Bullough 1981; Driessen 1990; Government of Malawi & World Health Organization 1985; Keller ME 1985; Knowles 1988; Knowles 1989; Kongnyuy et al. 2009; Lema et al. 2005; Ratsma, Lungu & Hofman 2006; Sangala 1992; Van den Akker et al. 2011a; Wiebenga 1992). Most studies were conducted more than a decade. More recent studies from did not give MMR. Data were collected from maternity ward records. Records were reported missing in some studies (Keller ME 1985; Lema et al. 2005; Wiebenga 1992).Most (5/7) population-based studies were retrospective studies and reflected data for the past years (Beltman et al. 2011; Chiphangwi, Zamaere & Graham 1992; Colbourn et al. 2013; Hofman & Sibande 2005; van den Broek et al. 2003b).

Two studies estimated MMR from prospective population based surveillance systems in central region of Malawi (Colbourn et al. 2013; Lewycka et al. 2010). Only two population based studies presented 95% confidence intervals (Beltman et al. 2011; van den Broek et al. 2003b) which were wide, giving doubts to the precision of the figures. The 95% confidence intervals presented for the other studies were calculated in systematic review on MMR in Malawi by Lewycka et al., (2013) using the Newcombe-Wilson method.

Table 2.5: Maternal mortality studies in Malawi

Reference	Setting	Method	Year	Maternal deaths	MMR (CI)
Hospital based surveys					
Bullough 1981	All health facilities in Central Region	Retrospective hospital based survey (RHBS)	1977	118	263
Knowles 1988	Ekwendeni Hospital	Hospital survey	1976 - 1985	30	344
Government of Malawi & WHO 1985	Six district hospitals, countrywide	not indicated	1983	34	269
Keller 1989	Kamuzu Central Hospital, Lilongwe	RHBS	1985	77	945
Knowles 1989	Ekwendeni Hospital	RHBS	1986 - 1988	1	32
Driessen 1990	Two central, 5 district and 5 mission hospitals	RHBS	1989	214	113
Kempf 1990	Mulanje Mission Hospital	Hospital survey	1989	21	411
Wiebenga 1992	Queen Elizabeth Central Hospital	RHBS	1989 - 1990	151	529
Sangala 1992	Kamuzu Central Hospital	RHBS	1990	74	Not specified
Lema et al 2005	Queen Elizabeth Central Hospital	RHBS	1999	204	1027
Ratsma, 2006	9 hospitals and 5 health centres in southern region	RHBS	2001	312	Not specified
Kongnyuy, 2009	9 hospitals in three districts in central region	RHBS	2007	43	Not specified
Van den Akker, 2011	Thyolo district hospital, southern region	RHBS	Sept 2007-Sept 2009	46	Not specified
Population based-surveys					

Reference	Setting	Method	Year	Maternal deaths	MMR (CI)
Chiphangwi 1992	Community, Thyolo	Indirect sisterhood method	1989, but refers to Approximately 1976	150	409 (349-480)
McDermott 1996	Four ANC in Mangochi district	Prospective population based survey among ANC attendees	September 1987 - July 1989	15	398 (241-256)
Malawi DHS 1992	Random sample within 6 region / urban rural strata	Direct sisterhood method (DSM)	September 1987 - July 1989	71	620 (410-830)
Malawi DHS 2001	Random sample, but with oversampling for 11 districts	DSM	but refers to 1994 - 2000	344	1120 (950-1288)
Hofman, 2005	T/A Nankumba, Mangochi	Community based maternal death reviews	1999-2001	43	Not specified
Malawi DHS 2006	Random sample, but with oversampling for 10 districts	DSM	But -refers to 1998-2004	240	984 (804-1164)
(MICS) 2006	2 stage random sample (26 districts)	DSM	2006 - refers to 2001-2006	469	807 (896-918)
Beltman, 2011	Random sample Thyolo district	DSM	84	84	558 (260-820)
Malawi DHS 2011	2 stage random sample	DSM	2010 - refers to 2004-2010	331	675
Van den Broek 2003	Namitambo	Population based	2003	9	413 (144-682)
Lewycka et al Mwansambo C, Rosato M, et al. 2010	Mai Mwana factorial, cluster-randomised controlled trial. Mchinji.	Prospective surveillance	2006-2009	29	585 (407-838)
Colbourn et al.2013	MaiKhanda, a cluster randomised controlled effectiveness trial. Mchinji	Prospective surveillance	2007-2010	102	299 (247-363)

Source: Epidemiology of MM in Malawi (Bowie & Geubbels 2013)

2.5.1.1 ***Trend in national population-based estimates of MMR***

A literature review of 5 surveys representative of the whole of Malawi (four DHS surveys and the MICS survey) and the other surveys representative from three regions of Malawi from 1977 to 2010 using the best fit multi-term fractional polynomial transformation, [Figure 2.2] showed a rising trend of MMR throughout the 1980s and 1990s reaching a peak in the late 1990s from which it started to decline (Colbourn et al. 2013), [Figure 2.2].

The MMR decreased to 800 by 2003 and 675 in 2007 (MDHS, 2011). Although the trend observed must be interpreted with caution due to difficulties of measuring MMR accurately, some measure of change is necessary for monitoring progress towards achieving MDG target and understanding what contributed to the rise and fall of MMR is crucial.

Although Malawi's MMR has been showing a decline in the recent years, the figure remains far from the MDG5 target which aims to reduce maternal mortality by 75% between 1990 and 2015. To reach the target it means a reduction of MMR from 620 maternal deaths/100 000 live-births in 1990 to 155 by 2015. The decline could be as a result of improvements such as health education talks on safe-motherhood (Hussein et al. 2001) and increase in nurses and other staff providing emergency care from human resource plan (DFID 2010).

The provision of maternity care is still lacking especially the peripheral areas (Leigh et al. 2008a; MOH 2011b) and shortage of staff is still acute (Mueller et al. 2011). However, the declining of MMR signifies progress, however the progress towards MDG5 in reducing MDs has been uneven and unacceptably slow (Jackson et al. 2011) and efforts must be intensified to bring the MMR to the desired level in 2015.

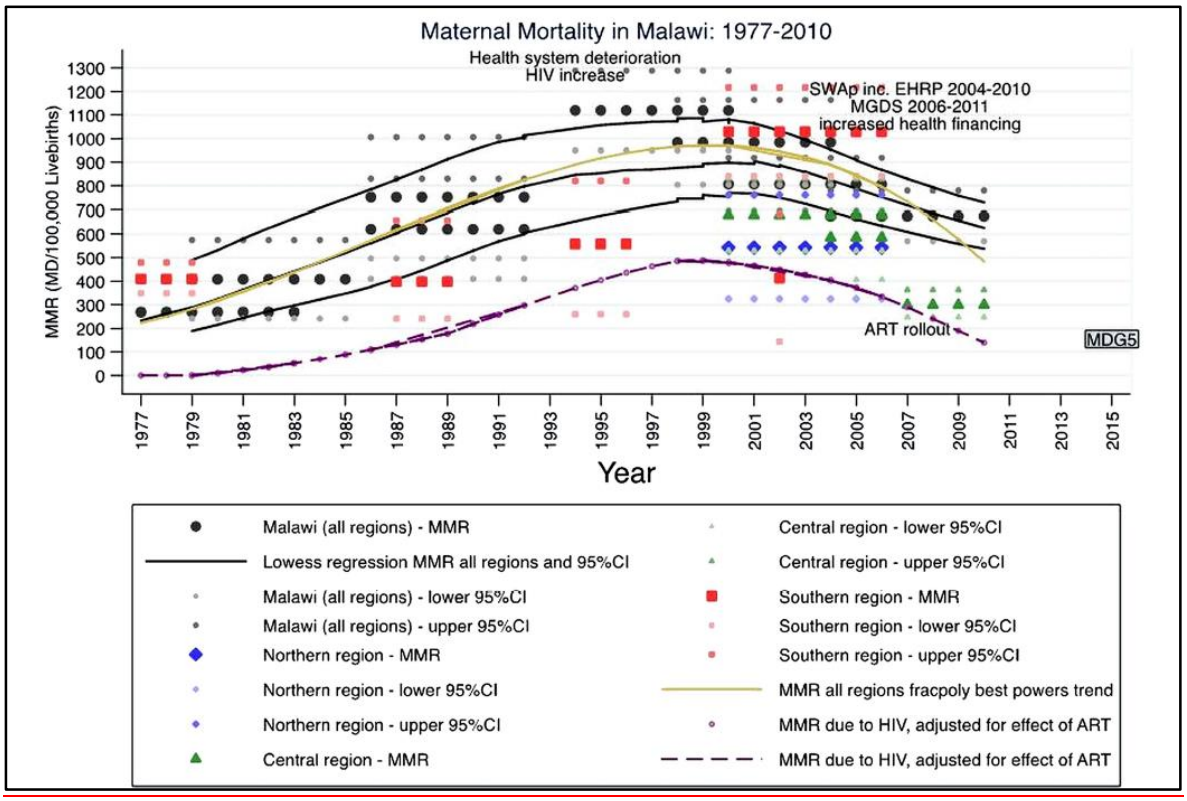


Figure 2.2: Trends of maternal mortality in Malawi and its southern, central and northern regions and estimated maternal mortality due to HIV

In Malawi studies have shown conflicting results on MMR [Table 2.6]. The Maternal Mortality Estimation Inter-Agency Group (MMEIG) and Health Metrics and Evaluation (IHME) estimates differ from this best-fitting estimate by Colbourn et al., (2013a), Hogan et al (2010), and the MDHS. The differences result from different methodologies used to come up with the estimates. The MMEIG uses gross domestic product per capita, general fertility rate and skilled birth attendance (SBA) (WHO 2014b). The IHME does not capture this rise and fall although they estimate a much higher peak around the year 2000 than the MDHS and the systematic review estimate (Lozano et al. 2011b). The IHME not only uses analogous measures and also uses antenatal care coverage, female education by age, ART-adjusted HIV prevalence, neonatal death rate and malnutrition. In addition, it is unclear whether the IHME estimates are based on exactly the same national-level MMR data sources as the MMEIG estimates (which use DHS and MICS), because the sources of the expanded set of sibling history data used by IHME are not disclosed in their paper or web appendix. Colbourn et al., (2013a) in the best-fitting estimate only used the national level MMR data by year without using any additional covariates. Hogan used models and MDHS, used the direct sisterhood method. This disparity

has been a source of considerable confusion for health workers, policy makers and development partners in the implementation of programs towards reducing MMR. Malawi needs valid and reliable figures for planning, interventions, resource allocation and monitoring and evaluation of maternal health interventions.

Table 2.6: Comparison of estimated trends in MMR in Malawi from 1990 to 2010

Source	1990	1995	2000	2005	2010
MMEIG	1,100	1,000	840	630	460
IHME	606	-	1,397	-	422
Colbourn et. al. 2013	748	916	970	846	484
Hogan et al, 2010	743	-	1,662	-	1,140
MDHS	620	-	1,120	984	675

2.5.2 Causes of maternal deaths in Malawi

The same causes of maternal deaths that are found globally are seen in Malawi. Over the years, causes of maternal deaths have remained the same. In the recent Malawi 2010 national wide Emergency Obstetric Care (EmOC) final report, direct causes of maternal deaths continue to accounted for more cases (61%) compared to indirect causes (MOH 2011b) [Figure 2.3].

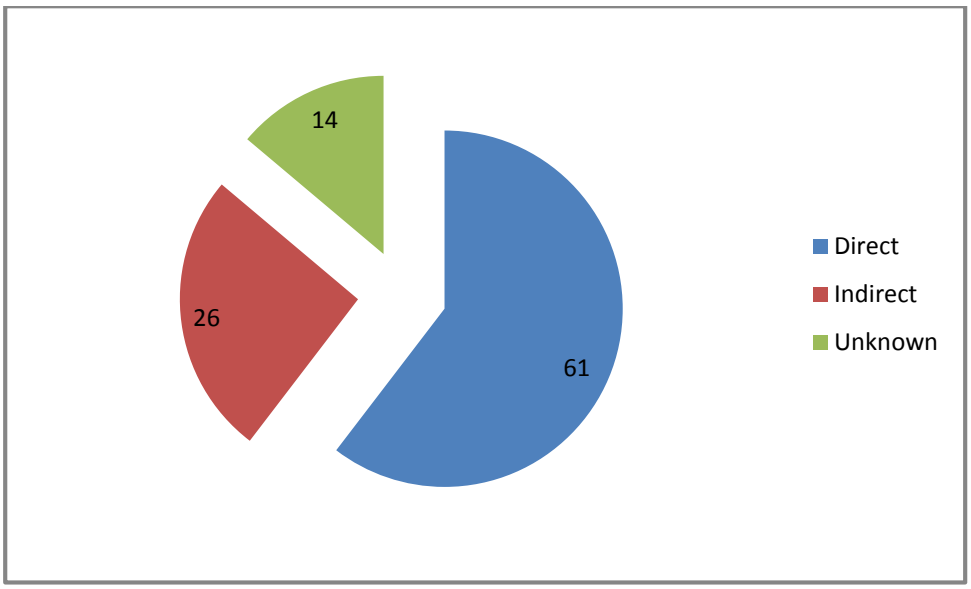


Figure 2.3: Percentage distribution of maternal deaths by direct, indirect or unknown causes.

The most common direct cause of maternal deaths was PPH/Retained placenta (34%) followed by postpartum sepsis (17.8%) and ruptured uterus (11%) (MOH 2011b) [Figure 2.4]. These causes do not include the community deaths as the assessment concentrated in health facilities.

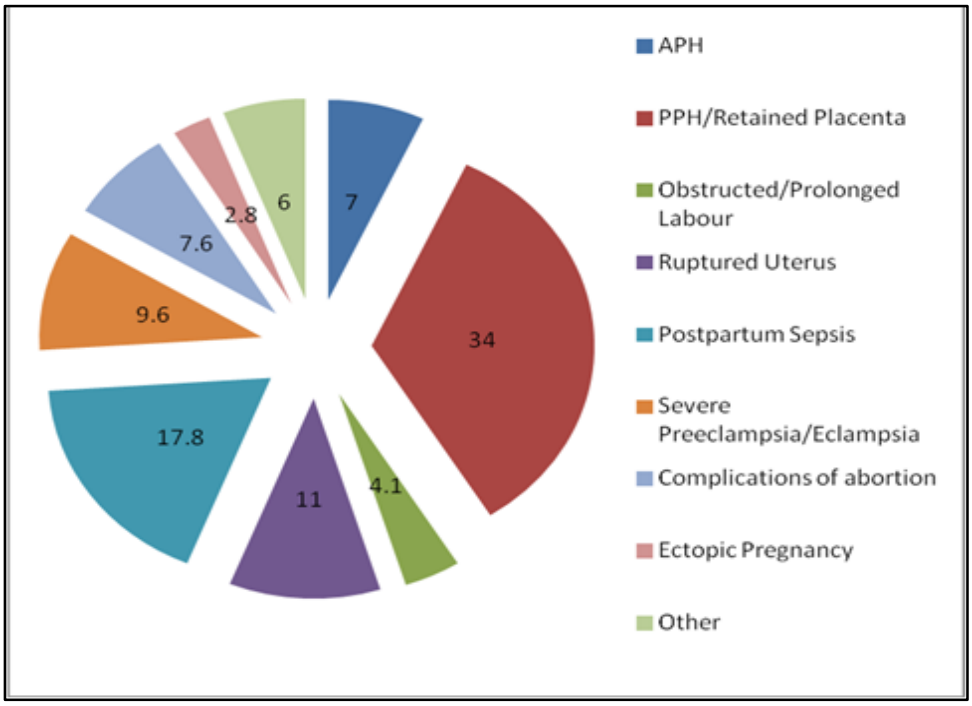


Figure 2.4: Percentage distribution of direct causes of maternal deaths in health facilities in Malawi

On the other hand the major indirect causes were infections (e.g. malaria, HIV, hepatitis), tuberculosis, cardiovascular diseases, psychiatric illnesses (e.g. suicide and violence), epilepsy, diabetes. HIV was attributed to 12 cases. Indirect causes of maternal deaths were likely to be underestimated owing to the fact that these deaths were not likely to be found in obstetric or gynaecology wards but rather in medical wards and therefore more difficult to identify.

Based on other previous studies conducted in Malawi, the three most important causes of death in the three earlier hospital studies were sepsis, complications of abortion and obstructed labour, sometimes resulting in ruptured uterus (Bowie & Geubbels 2013). In the later hospital study, the relative importance of deaths from abortion declined, possibly because of higher uptake of family planning methods and consequently fewer unwanted pregnancies (Lema et al. 2005).

In the community based study by Hofman, which tracked both deaths that occurred in the community and in-hospital, haemorrhage and ruptured uterus were a much more important cause of death (Hofman & Sibande 2005). This is a reflection of the acute nature of these complications. As for the indirect causes of death, no major changes seemed to have occurred within the last ten years, with the exception of AIDS that seemed to be diagnosed more often. However, the real contribution of AIDS to the incidence of maternal mortality could be estimated from most of the studies Already in 1990 Wiebenga commented that in more than half of all puerperal sepsis cases HIV was thought to have contributed to death. Also more than half of meningitis cases and all pulmonary TB and septicaemia cases were thought to be HIV-associated (Wiebenga 1992). Indeed, there is circumstantial evidence from the 1992 and 2000 demographic and health surveys (MDHS 1992, 2001) that the HIV epidemic has contributed substantially to the rise in maternal mortality in the 1990s. (MOH 2011b). Sepsis is becoming the leading cause of death where HIV is prevalent. The latest estimate for 2010 from the UN for Malawi is that 29% of maternal deaths are AIDS related indirect maternal deaths (MOH 2011b).

In Malawi, most MDs were due to obstetric complications, delays in seeking care, poor referral systems, and lack of appropriate drugs, equipment and staff capacity (Leigh et al. 2008b; Lema et al. 2005). Type 1 delay featured more in the contributing factors to MD due to cultural beliefs, socioeconomic factors, and fear of unnecessary referral in Malawi. Type II and III delays were also present in a study conducted in Mangochi (Hofman & Sibande 2005).

2.5.3 Maternal mortality reporting structure for Malawi

According to the National Sexual and Reproductive Health and Rights (NSRHS) policy maternal deaths are notifiable within 72 hours of occurrence (MOH 2009c). The reporting system for maternal deaths in Malawi is presented in [Figure 2.5]. The reporting system is the same across all the districts of Malawi.

HSAs, report MDs from the community to the health centre, then to the district by health centre staff who compile data on all deaths, report to the zone coordinators. The zone coordinators report to the Technical working group (TWG) at national level who are responsible for confidential enquiry into maternal deaths.

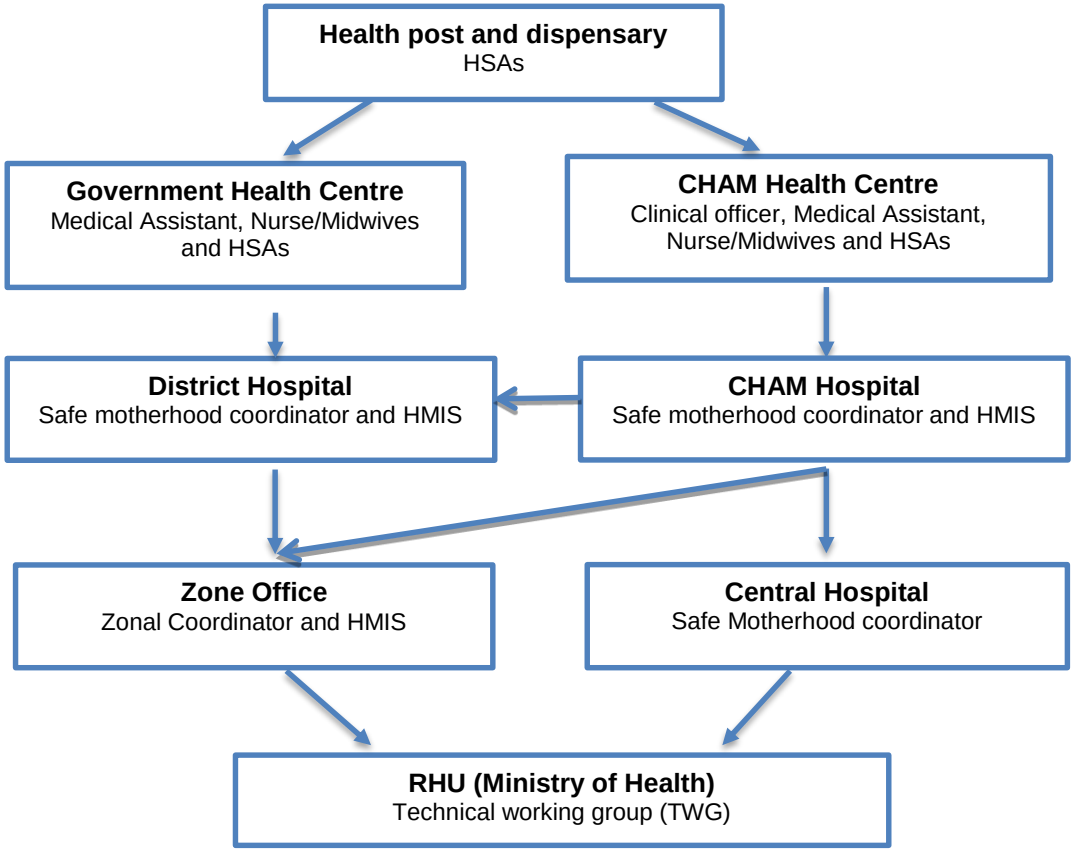


Figure 2.5: Maternal mortality structure and responsible reporting personnel at each level

2.5.4 Maternal Death Audit

Reducing maternal mortality requires information on the numbers of women dying and going "Beyond these Numbers" to identifying why women are dying (WHO 2004a). A maternal death audit (MDA) is an in-depth systematic review of maternal deaths to delineate the underlying health, social and other contributory factors to the death. Lessons learned from audits are used in making recommendations to prevent similar future deaths (WHO 2004a). MDA has shown evidence of improving quality of maternal care (Kongnyuy & Leigh 2008). Its disadvantages however, include inability to provide information on all deaths in a given population and dependence on information from the community to give complete picture of the circumstances around a death. MDA started as far back as the 1920s with the United Kingdom Confidential enquiries into MDs (CEIMD). They occur in different forms in different countries which include facility-based MDA, community-based MDA (verbal autopsies), CEIMD, clinical audit and surveys of near miss (severe morbidity) (WHO 2004a).

Malawi is one of the countries that has adopted the WHO recommendation of combining facility-based and community-based MDAs to improve professional practice and reduce MM

(Hofman & Sibande 2005; Kongnyuy, Mlava & Nynke 2009). Although the MDA focuses on deaths that occur in health facilities, it also identifies contributing factors from the community.

In Malawi, it is a requirement that after every occurrence of death, a maternal audit committee reviews the death within 7 days at each health care level and develops action points to mitigate the gaps that may have resulted to the death. The audit team is multidisciplinary team and may include: physicians, obstetricians, paediatricians, laboratory technicians, nurse-midwives, anaesthetists, medical assistants, clinical officers, public/community health professionals, and facility administrators, HMIS staff. Composition of the team depends on the level of health care. All are trained on the guidelines and the use of audit forms and the number of maternal deaths recorded determines the frequency (whether weekly, monthly, or quarterly) of the committee meetings.

The Malawi Ministry of Health developed three forms which are currently used for MDA namely:

1. Maternal death notification form (MDA1) contains the particulars of the deceased and its purpose is to notify the District Health Office within seven days of the maternal death.
2. Maternal death Audit form 2 (MDA2) which is filled during maternal death review meetings and contains details of the causes of maternal death, factors that contributed to the maternal death, and recommendations made during maternal death review [Appendix 1].
3. The death follow-up form (MDA3) is used to follow up the implementation of recommendations made during the MDAs.

There is a technical working group at national level which periodically meets to investigate systematically a representative sample of MDs to identify the causes and associated factors; the working group then gives written guidelines to health personnel and administrators on how to prevent similar deaths in future. The investigation is carried out in with "no blame, no shame" as a key prerequisite for audit success.

However some studies have identified challenges with maternal death audit such as 1) identification of cases: conflicting maternal death numbers, and missing medical charts, 2) data collection: poor record keeping, poor quality of documentation, difficulties in identifying and locating appropriate healthcare workers for interviews, the potential introduction of bias through the use of an interpreter, and difficulties with locating family and community members and recall bias; and 3) data analysis: determining the clinical diagnoses, causes of death, implementation, absence of senior staff during the audits and 4) use of findings, and non-implementation of recommendations (Kongnyuy & B 2008; Thorsen et al. 2014).

2.6 Chapter Summary

This chapter has provided an understanding the study area in relation to maternal health. The chapter has described the socio-economic status of the people in the country which has an impact on maternal health services. The chapter has described the poor maternal health indices the country still have poor reproductive indicators despite the strategies and initiatives the country is implementing towards achieving MDG5, such as the reproductive health policy and strategy, EmOC and quality assurance measures (e.g. MD audit) to improve maternal health. There is no functioning civil registration system in Malawi and MMR is still high with slow progress in reducing MM at national level. It is unlikely that the MDG5 target of reducing MMR from 620 to 155 per 100,000 live births will be realised in 2015. The chapter has also revealed that there are few recent population based studies conducted in the country and The most common direct cause of maternal deaths at health facility level are PPH/Retained placenta, postpartum sepsis, and ruptured uterus (11%) (MOH 2011b). Methods of data capture on MD at facility and community is presented.

3 LITERATURE REVIEW

3.1 Chapter overview

This chapter presents a structured literature review which was conducted to inform this research study. Peer reviewed and grey literature sources from low and middle-income countries (LMIC) were reviewed to identify gaps in research and assist in the development of data collection tools and methodology. The chapter is organised into six main sections, which include the following:

- Section 3.1, which gives the overview of the chapter
- Section 3.2 which describes methods for the literature review, and the search strategy used to identify the articles.
- Section 3.3 presents the results of the review based on the eight approaches used to measure MM, states the strengths and weaknesses of the approaches and maps out where the studies were conducted. The order of the approaches starts with the civil registration followed by the other alternative approaches for countries with no registration systems in place including; census, direct and indirect sisterhood method and Reproductive Age Mortality Studies (RAMOS). Places of death and cause of deaths are included in this section.
- Section 3.4 describes the conclusions of the literature review.
- Section 3.5 identifies gaps in literature and position of this study in the context of national and international research.
- Section 3.6 provides a summary of the chapter

The literature review was guided by the following research questions:

1. What approaches have been used to estimate MM in developing countries?
2. What are the strengths and limitations of these approaches and which are more appropriate for middle and low-income countries?
3. Where are the women dying?
4. What are the characteristics of MDs?
5. What are the causes of MDs in developing countries?

6. How do different cause classification methods for VA data compare (i.e. Physician Coded Verbal Autopsy (PCVA) methods, hospital (health professionals) diagnosis and Computer-coded verbal autopsy (CCVA)?

3.2 Methods

3.2.1 Search strategy

The search strategy was divided into three strings: 1) literature on approaches that have been used to estimate MM 2) literature on a place of death, causes and contributing factors to MDs and 3) studies comparing cause classification of maternal deaths using Verbal Autopsy (VA) data [Table 3.1].

Peer reviewed literature

A systematic search strategy with a narrative synthesis of published peer-reviewed literature was conducted using MEDLINE, CINAHLL Plus, Global health and LILACS. A further search was conducted using relevant websites such as the United Nations Population Fund (UNFPA), United Nations Children's Fund (UNICEF), World Bank, World Health Organisation (WHO) and Initiative for Maternal Mortality Programme Assessment (IMMPACT). Electronically unavailable articles were obtained from the holdings of the libraries of the University of Liverpool and Liverpool School of Tropical Medicine.

Grey literature

Internet searches, using Google search and a hand search of grey literature from ELDIS data base under 'Health and Malawi', 'maternal and new-born health' 'sexual reproductive health' and using the Malawi government website under 'Health' was also conducted. A hand search in the library and MoH offices were also done. The references of retrieved articles were also screened to identify relevant data.

Titles were scanned and abstracts which were considered relevant to the research questions above were reviewed and retrieved to obtain full text.

3.2.2 Search terms used

Search terms and strings in Table 3.1 were used either in combination or isolation using Boolean terms "AND" / "OR", based on the search questions. Synonyms were used to retrieve as much information as possible.

Table 3.1: Search terms used during literature search

String No.	Literature review section	Questions guiding the literature review	Search words
String 1	Identification of studies that have measured MMA	What are the current approaches for estimating MM in LIC?	Maternal deaths* OR maternal mortality OR *pregnancy death* AND *civil registration* AND *health facility data*AND census AND Reproductive Age Mortality Studies, AND sisterhood method AND surveys AND verbal autopsy AND developing countries.
String 2	Place of death	Where are women dying?	Maternal deaths*OR *maternal mortality* OR *Maternal death* OR *pregnancy death* OR '*motherhood death* OR *women deaths* AND place
String 3	Characteristics of maternal deaths	What are the characteristics of MDs?	Maternal deaths*OR *Maternal mortality* OR *Maternal death* OR *pregnancy death* OR '*motherhood death* OR *women deaths* AND age OR parity OR educational level AND developing countries
String 4	Causes, contributing and associated factors of maternal deaths	What are the causes of maternal death in developing countries?	Maternal deaths*OR *Maternal mortality* OR *Maternal death* OR *pregnancy death* OR '*motherhood death* OR *women deaths* AND Causes AND associated factors developing countries
String 5	Comparing cause classification Physician-coded verbal autopsy (PCVA) and other methods of assigning VA cause of death	How do PCVA ,hospital diagnosis and InterVA-4 compare as methods of cause classification for VA data	Maternal deaths*OR *Maternal mortality* OR *Maternal death* OR *pregnancy death* OR '*motherhood death* OR *women deaths* AND cause of death AND physician coded verbal autopsy OR computer coded verbal autopsy OR interVA-4 Or InterVA

3.2.3 Inclusion and exclusion criteria

Papers written between 2000 and June 2014 were selected from low and middle income countries as defined by the World Bank income categorization in 2012 (World Bank 2012).

The period of 2000 to 2014 was selected to cover the period when many developing countries became proactive in addressing the burden of maternal mortality through implementation of interventions to achieve MDG5 (United Nations 2000a).

3.2.3.1 ***Inclusion criteria***

- Studies that had precisely estimated MM regardless of method used.
- Studies identifying cause, contributing factors and factors associated to with MDs.
- Studies comparing methods of verbal autopsy cause classification.
- Written in English language.
- Conducted in low and middle income countries according to World Bank income categorisation for 2012 (World Bank 2012).
- Studies comparing different methods of assigning cause of death using verbal autopsy data.

3.2.3.2 ***Exclusion criteria***

- Studies assessing impact of interventions on MM.
- Studies from high income countries as defined by World Bank income categorisation 2012 (World Bank 2012).
- Demographic and health surveys and global estimates by WHO, UNICEF, UNFPA, The World Bank.
- Reviews, posters, editorials, and discussion papers.

3.2.4 Data extraction

Two reviewers independently screened all titles and abstracts. Full texts of included records were subsequently screened independently by the same reviewers for inclusion in the review. Any discrepancies in the selection were resolved through discussion between the reviewers and consultation with a third researcher (4 records). Duplicates were excluded. A summary table was developed and agreed by both reviewers before full-text review and all included studies were then summarized using the table in Appendix 3. Studies in the summary table were grouped into two outcome categories based on the search strings. Results for search strings 1 to 4 are grouped together while studies for search string 5 are separate [Appendix 3].

Quality of the included studies was assessed by using the grade system on study design, data source, and clarity of content and outcome included in the assessment (Grade Working Group 2004).

3.3 Results of literature search

3.3.1 Characteristics of studies included

A total of 114 were identified studies for inclusion, 107 for search strings 1-4 and 7 for search string 5, [Figure 3.1]. Studies included were conducted in 30 countries spread over four continents. The majority included studies carried out in Africa, 84/114 and 20/114 in Asia with the remaining studies from Central America (5/114), South America (1/114) and 5 studies were conducted in multiple countries and or on more than one continent. Most studies originated from upper middle-income countries (56/114) and lower-middle income countries (49/114) with a minority from low-income countries (9/114).

Most studies were descriptive and cross-sectional (104/114) and 6/114 were cohort studies, case control studies, 2/114, cluster randomized study, 1/114 and systematic review (1/114). Methods of data collection for the 107 studies within search strings 1-4 included, hospital studies (47/114), sisterhood method (direct and indirect) (18/114), civil registration (10/114), verbal autopsies (8/114), active surveillance (8/114), population surveys (7/114), RAMOS (5/114), census (3/114) and 1/114 systematic review. Eight (7%) of the studies were from Malawi of which 5 were population-based studies and 3 were hospital-based [Appendix 3].
Most (101/114) studies in search strings 1 to 4 (n=107) reported a MMR and only 11/114 presented the CI. Most studies (83/114) presented causes of MDs and associated factors (68/114).Few studies (23/104) presented place of death [Appendix 3].There were no specific studies which compared causes of MDs assigned by health workers, physician and a computer-based classification of VA data (CCVA). However, only studies which compared cause classification of all-cause mortality were identified. Among the studies which compared methods of assigning cause of death (n=7), five studies compared, cause classifications based PCVA with CCVA classification, and two studies compared PCVA with HWCVA, [Appendix 3].

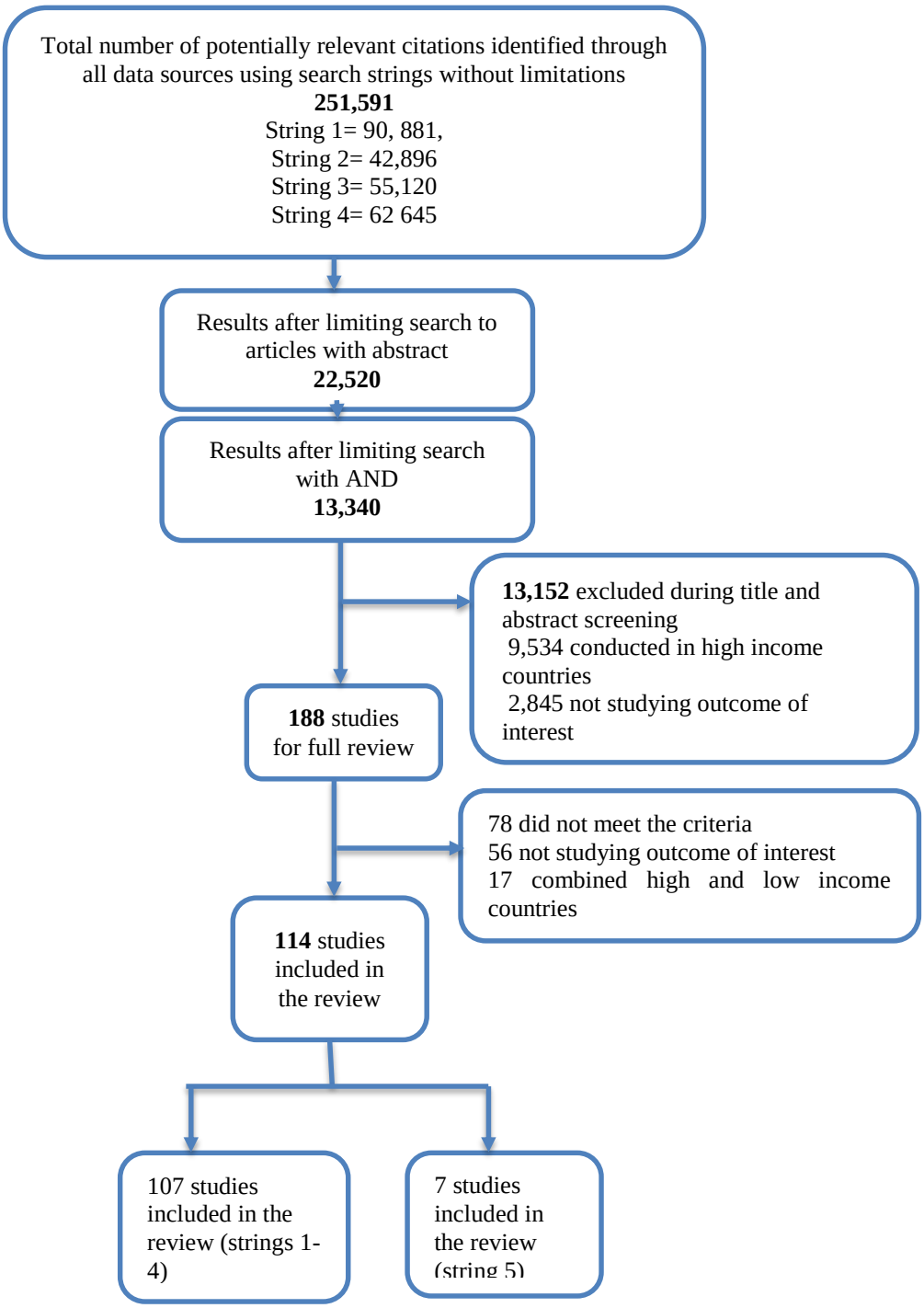


Figure 3.1: Prisma diagram of included studies

3.3.2 Data approaches for estimating MM in low and middle income countries

Graham et al (2008a) grouped the approaches used to estimate MM into two, the empirical (which are classified as routine and special opportunities) and the analytical approaches as shown in Figure 3.2 (Graham et al. 2008a). Empirical approaches include the major data-

gathering approaches for measuring MM such as the use of death registration, censuses, health facilities' statistics, surveys, surveillance and the composite approach. A RAMOS draws upon various combinations of these five sources to identify all WRA then ascertain which MDs are.

Analytical approaches include birth-death linkages and the use of United Nations models, which estimate MM using regression models to estimate MM levels for countries without reliable national-level data (WHO 2007a). The search which was limited to only LMIC showed that most studies used the empirical approaches to estimate MM. Studies identified in this review used 8 different approaches to estimate MMR, causes and associated factors with MDs. The approaches included: civil registration data, verbal autopsy, with civil registration, active surveillance, sisterhood methods, census and RAMOS, [Appendix 3].

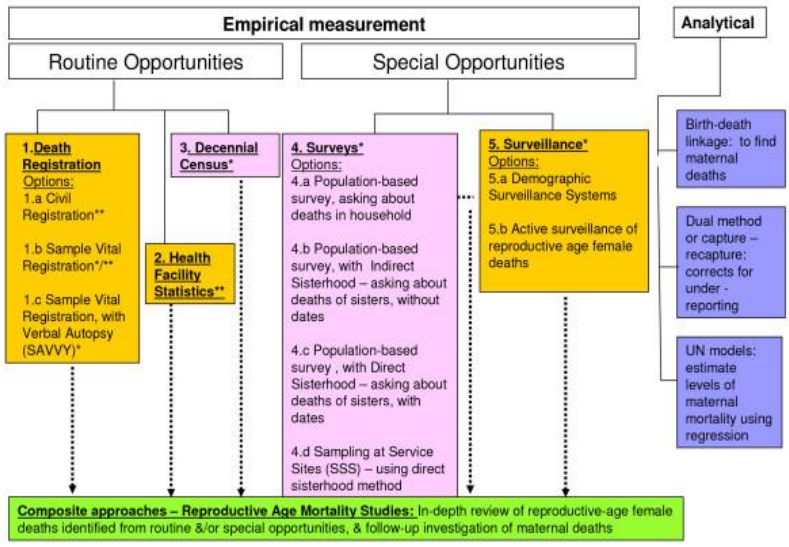


Figure 3.2: Summary of data sources and approaches for measuring maternal mortality

***Source**: Measuring maternal mortality: an overview of opportunities and options for developing countries Graham et al 2008*

3.3.2.1 ***Estimating maternal mortality using civil registration data***

This is an approach which involves registration of all births and deaths through medical certification. It is considered as the best source of data on MD that assures permanent, compulsory and universal recording of the occurrence and characteristics of vital events,

including births and deaths, and causes of death (AbouZahr 2011). Civil registration systems with high coverage and good cause attribution of death provide accurate data on the level of MM and the causes of MDs (WHO 2007a).The drawbacks, relate to primarily to the completeness, reliability, availability, and coverage of civil registration data. (Graham et al. 2008b).

Among the 107 studies which estimated MMR, six studies [Appendix 3] used birth and death registration data to estimate the MMR, and all these studies were conducted in upper-middle income countries (UMIC): China (x4) India and Nigeria (Adamu et al. 2003; Chawla, Kumar Saha & Akhtarkharvi 2014; Du et al. 2012; Fengzhi et al. 2012; Yang et al. 2014; Zhu et al. 2009). The search strategy used did not identify any study from a low middle income (LMIC) country and LIC, which used civil registration data to estimate MM. One of the studies complemented data obtained through civil registration with a Confidential Enquiry into MDs (CEMD) (Zhu et al. 2009).

However, there were some limitations with civil registration data reported in some studies. Information on pregnancy status was either incomplete or there was no check box on the death certificate to identify the pregnancy status of the woman (Zhu et al. 2009), and this might have resulted in misclassification and an underestimation of the number of MDs that had occurred. Also lack of data in the civil registration system from women living in villages accessible only by foot was noted in a study from the China (Du et al. 2012). Civil registration system can provide important information needed for estimating the MMR if correctly done. The availability of the numbers and list of deaths from civil registration data, make it easier to conduct a CEMD which in some cases then in turn revealed more cases of maternal death in the studies reviewed. Active surveillance measures, such as record matching and introducing a pregnancy checkbox on the death certificate has been reported to help in minimizing misreporting (Chang, Elman-Enas & Berg 2003; Hoyert 2007). In South Africa, a separate maternal death notification form that supplements the standard death certificate with more detailed information about the circumstances of a maternal death is used (Pattinson 1999).

However, an important challenge is that the majority of countries, especially low-resource countries such as Malawi still lack a complete civil registration system with good. The 2013 global MM estimates report that only 67 (36.6%) out of 183 countries had complete civil

registration data with good attribution of cause of death (WHO 2014b). Ninety six (52.5%) were countries lacking complete registration data and 20 (10.9%) had no data on MM at all.

In most countries, firstly, it is challenging to identify MDs precisely, as deaths might not be routinely recorded. Secondly, even if deaths were recorded, the pregnancy status or cause of death in WRA may not have been known (Cross et al., 2010, Westhoff et al., 2009. Deaths would not have therefore, been reported as MDs. Thus most developing countries where medical certification is not mandatory, cause of death does not exist and acurate attributon of a female death is difficult (Cross, Bell & Graham 2010).

3.3.2.2 ***Sample registration with verbal autopsy***

In the near future, a comprehensive system of civil registration and vital statistics may not be feasible in most developing countries (AbouZahr 2010). Some countries have introduced sample enumeration systems for vital statistics, which work fairly effectively although they do not include the issuance of legal documents certifying birth or death (Mari Bhat 2002; Yang et al 2005; Jha et al 2006). These systems use longitudinal tracking of demographic events in areas selected randomly, thus generating nationally representative results. Verbal autopsy techniques that involve interviews with family members of the deceased are used to determine the probable cause of death (WHO 2007).

Six studies which used sample registration to estimate MMR were identified. The studies were conducted in different countries as follows:

1) LIC: Malawi (Hofman & Sibande 2005)
2) LMIC: Kenya, Mozambique and Zambia and Pakistan (Desai et al. 2013b; Jafarey et al. 2009; Menéndez et al. 2008c; Ziraba et al. 2009)
3) UMIC: India (Nizamuddin & Pradhan 2013)

Four studies presented MMR with no CI (Appendix 3) and studies conducted in Malawi and Mozambique did not present MMR (Hofman & Sibande 2005; Menéndez et al. 2008c). Due to absence of data, a study in Kenya could not identify pregnancy status of some women (Desai

et al. 2013b). Some relatives refused verbal autopsies in India (Nizamuddin & Pradhan 2013). Similarly in another study in Kenya 14% of all female deaths did not have VA and medical records of 47% of the health care facilities were incomplete (Ziraba et al. 2009).

However, the accuracy on the cause of death tends to vary with this technique, as does the ability to detect trends in cause-specific mortality.

*3.3.2.3 **Active surveillance***

Active surveillance of MDs involves continuous tracing of MDs at facility and community level (Danel, Graham & Boerma 2011).

Six studies were identified and were conducted in both LIC and MIC [Appendix 3]. The studies were conducted in the following countries:

1) LIC: Malawi (Lewycka et al. 2010).
2) LMIC: Senegal (Kodio et al. 2002).
3) UMIC: Guatemala, Indonesia, China and India (Barnett et al. 2008; Kestler & Ramírez 2000; Liang et al. 2010; Qomariyah et al. 2010).

In Guatemala, a three year active surveillance was conducted with verbal autopsies (VA) for all the MDs identified at community level and autopsy reports were used for deaths that occurred at a health facility (Kestler & Ramírez 2000). The author reported the number of MDs detected during the surveillance was three times higher than the number of deaths identified by the national vital statistics registry in a few years before. A study in Malawi used surveillance system to trace MD among women groups in rural villages of 2500-4000 population in Mchinji district (Lewycka et al. 2010). In Senegal and India data from ongoing surveillance systems was used to estimate MMR (Kodio et al. 2002).

In general surveillance systems used in these studies managed to capture more maternal deaths due to active death identification. In Guatemala, India and China more MDs were identified compared to previous estimated using the civil registration data (Barnett et al. 2008; Kestler & Ramírez 2000; Liang et al. 2010). However, there were some limitations identified in the Senegalese study. There was incomplete information on the data collection tools which made

it difficult to classify maternal death or not (Kodio et al. 2002). In China, the pregnancy status of some women could not be identified. In addition, the surveillance missed a quarter of MDs compared to the national data. (Zhu et al. 2009). Wide CI were identified in Malawi (MMR 585 (95% CI: 407-838) and Senegal (MMR 436 per 100 000 live births (95% CI: 209-802) (Kodio et al. 2002; Lewycka et al. 2010).

Despite the limitations identified some studies, well established surveillance of MDs which requires a mandatory notification would serve as the basis for strengthening the civil registration and vital statistics system (Hounton et al. 2013). Active surveillance has the potential to frequently monitor of MM levels, trends, causes, and deliver real-time data. Investments are made to assess the completeness of reporting and data accuracy as part of the system (Danel, Graham & Boerma 2011). The approach is relatively cheap when it is well established.

To improve data capture on MDs in countries, which lack reliable data on MMR, WHO is currently advocating for Maternal Death Surveillance and Response (MDSR) (WHO 2013). A Technical Working Group (TWG) has been established chaired by the World Health Organization. Guidelines to be used by countries have been developed (WHO 2013). The overall objectives of MDSR are:

1. To provide information that guides effective actions to eliminate preventable MM at health facilities and in the community;
2. To permit an assessment of the true magnitude of MM by counting every MD, and the impact of actions taken to reduce it (WHO 2013).

3.3.2.4 ***Household Surveys***

Household surveys with direct death inquiry are used to generate data on MM in developing countries (AbouZahr 2010). Direct methods involve asking respondents about recent deaths in the household and asking extra questions about the timing of the death in relation to pregnancy.

Surveys provide the most accurate rates of MM in settings where routine information systems are weak or non-existent (AbouZahr 2010). These methods can generate estimates with a reference period of about 2–3 years before the survey, which is acceptable for monitoring purposes.

In this review, 10 studies were identified, [Appendix 3]. The studies were conducted LIC, LMIC and UMIC as follows:

1) The LIC (1): Malawi (van den Broek et al. 2003b).
2) LMIC (4): Afghanistan, Zambia, Ghana, Ethiopia (Asamoah et al. 2011; Bartlett et al. 2005; Gebreamlak, Alemayehu & Haftom 2013; Hynes et al. 2012).
3) UMIC (5): China, South Africa (x2), India and Egypt (Campbell et al. 2005; Garenne, McCaa & Nacro 2011; Jafarey et al. 2009; Liang et al. 2010; Qiu et al. 2010; Singh, Pandey & Aggarwal 2007; Udjo & Lalthapersad-Pillay 2014)),

All the 10 studies presented MMR estimates and only two studies conducted in Malawi and Afghanistan presented confidence intervals of the MMR which were wide (Malawi, n= 59,248, MMR 413 per 100,000, 95% CI: 144-682 and Afghanistan, MMR, 774 per 100,00 live births, 95% CI: 433-1115) (Barlett et al. 2005; van den Broek et al. 2003b).

It was difficult to tell the precision of the 8 studies which presented MMR as a point estimate. Other researchers have reported that it is much more accurate to give a confidence interval for an MMR estimate, to assess the degree of precision especially in countries without reliable sources of data (Graham & Hussein 2003a). Estimates of MM will have very wide confidence intervals, if the sample size in small, making it difficult to monitor changes over time (Hill et al. 2006). Although the method process better MM estimates when large sample sizes are used, may be difficult to manage large sample sizes in low resource countries.

Sample size requirements are significantly reduced when sisterhood or sibling survival methods are used to indirectly measure maternal mortality in household surveys (Stanton et al 1997, Hill et al 2006). The sisterhood method will be described later in this chapter.

3.3.2.5 ***Census***

Greater interest has been shown in using data from the population census to measure MM. This is a result of the endorsement of this method by the United Nations Principles and Recommendations for Population and Housing Censuses (WHO 2007a). To achieve greater accuracy in the 1980s, methods were developed for evaluating and adjusting population census data on household deaths in a defined reference period (Brass 1985; Preston & Hill 1980). The UN principles recommend two follow-up questions in cases where the household being interviewed reports a death during the past 12 months. After ascertaining the age, name, sex of the deceased and date of death, the interviewers ask the following questions:

1) Was the death due to violence, accident, homicide or suicide?
2) If the deceased was a woman aged 15 to 49, did she die while she was pregnant, during childbirth, or during the six weeks after the end of pregnancy?

Four studies were identified [Appendix 3]. These studies were conducted in the following countries:

1) UMIC, Latin America (Honduras, Nicaragua and Paraguay) and Republic of South Africa (Garenne, McCaa & Nacro 2008; Hill et al. 2009b).
2) LMIC Burkina Faso and one study was conducted in multiple countries, (Benin, Islamic Republic of Iran, Lao People' s Democratic Republic, Madagascar, and Zimbabwe) (Bell et al. 2008; Stanton et al. 2001).

A study by Hill et al. (2009a) in countries within Latin America, reported a greater number of pregnancy-related obtained via census data compared to the estimate obtained during a survey conducted at the same time in these countries (Hill et al. 2009a). It was concluded in this study that census data can be used to measure pregnancy-related mortality as a proxy for MM in countries with poor death registration systems. Similarly, the Republic of South Africa reported MMR of 4.3 times higher than the previous years of HIV (Garenne, McCaa & Nacro 2008). The high level of MM were not associated with lower education, lower income, or higher proportion of home delivery but correlated with the prevalence of HIV/AIDS. On the

other hand, a study conducted in Burkina Faso noted that the estimate of the MMR using census was similar to an earlier study which used the direct sisterhood method (441 deaths per 100,000 live births by census and 483 deaths per 100,000 using the direct sisterhood method) but lower than the WHO modelled estimate of 700 per 100,000 live births (95% CI: 390-1000) in the year 2005 (Bell et al. 2008).

In principle, a census allows the identification of deaths in a household in a relatively short reference period (1–2 years), and thereby provides estimates of recent MM (Stanton et al. 2001). Studies have shown that a census method has a potential for monitoring levels, trends and differentials in maternal mortality (Garenne, McCaa & Nacro 2010; Hill et al. 2009b). By definition, a census provides a complete picture of the whole population, and therefore, avoids issues of representativeness, which often hamper estimates based smaller samples. The census also offers small confidence intervals and large numbers in contrast to demographic surveys which use a small size. It also permits precise point estimates, which is not the case for estimates derived from the survival of sisters, an feature in situations where changes are rapid (WHO 2007a).

However, a common problem is that in most countries, a census is conducted at 10-year intervals, and this limits monitoring of MM and the number of deaths reported as pregnancy-related deaths is only an approximate for the number of true MDs (Zakariah et al. 2009). Therefore, it is recommended that a census is used an adjunct to other data sources, not as a stand-alone. However, data obtained from the census can be improved by conducting verbal autopsy as was the case in the study conducted in Burkina Faso (Beathe Andersgaard, Langhoff-Roos & Øian 2008).

3.3.2.6 ***The Sisterhood method***

The sisterhood method is an indirect technique for deriving population-based estimates of MM relevant to developing countries where other data sources and approaches to estimation are often inadequate and inappropriate (Graham, Brass & Snow 1989). Since its introduction in the early 1990s, the sisterhood method has been applied in low-resource settings to estimate MM. This technique was designed to overcoming the need for a large sample size and avoid high costs (Graham, Brass & Snow 1989).

The female respondents report numbers of surviving sisters and of sisters who have died. Aggregated data are used to calculate the proportion of sisters dying during pregnancy, childbirth, or up to 6 weeks after the end of pregnancy (puerperium), and standard adjustment factors are used to convert these proportions into estimates of MM (Danel et al. 1996).

Since its first trial in, Gambia in 1987, the sisterhood method has been applied in many settings and several evaluations of its reliability have been undertaken (Aa et al. 2011; Adegoke et al. 2013a; Font et al. 2000). The method provides a framework for both data collection and analysis. The sisterhood method has two variants (1) the original indirect variant by which maternal mortality is derived from respondents' answers to four basic questions (Graham, Brass & Snow 1989), and (2) the direct method which is more time-consuming and requires a larger sample size, by which respondents are asked to provide detailed answers to 11 questions pertaining to maternal mortality in their families (Rutenberg & Sullivan 1991).

The indirect sisterhood method which is more practical and less expensive has been developed to provide a method for calculating MM in countries or regions where vital events data are not routinely and reliably collected. It uses the proportions of adult sisters dying during pregnancy, childbirth or the puerperium reported by adults during survey or census to derive a variety of indicators of maternal mortality (Graham, Brass & Snow 1989). Questions for indirect sisterhood methods are:

1. How many sisters (born to the same mother) have one ever had who were ever-married (including those who are now dead)?
2. How many of these ever-married sisters are alive now?
3. How many of these ever-married sisters are dead?
4. How many of these dead sisters died while pregnant, or during childbirth, or during the six weeks after the end of pregnancy?

Graham et.al. (1989), suggest that to obtain reliable estimates, interviews with 3,000 to 6,000 adults will be required depending on MM and number of sisters per respondent that can be expected to have reached a reproductive age (Hanley, Hagen & Shiferaw 1996b). On the other,

hand Ibrahim suggested sample size of 2500-3000 is desirable to obtain reliable estimate (Ibrahim 1991).

The direct sisterhood method is an indirect approach, used in DHS (Rutenberg & Sullivan 1991). This method asks respondents to provide more detailed information about their sisters, the number that have died, the age at death, including the numbers reaching adulthood, the year in which the death occurred and the years since the death. The direct method entails more detailed questions on the survival status of not just sisters but all siblings. These questions can also be added to an on-going survey but require more time than the four questions of the original method. The direct sisterhood method relies on fewer assumptions than the indirect method and requires larger sample sizes, and the information is considerably more complex to gather and analyse (Hanley, Hagen & Shiferaw 1996a). The direct sisterhood method reports on a reference period for sister deaths 0-6 years prior to the survey compared to the indirect sisterhood method for which the reference period is 10-12 years prior to the data collection (Rutenberg & Sullivan 1991).

Collecting data from a single survey of those who are alive only at the end of a period of interest makes the method inexpensive and feasible, but it leads to a serious selection bias problem. Individuals from high-mortality families are usually less likely to appear in a survey as respondents (Gakidou & King 2006). Like the indirect method, the direct approach should not be used in low fertility settings (TFR less than 3) or where important migratory flows have occurred.

Fifteen studies included in this review used sisterhood method to estimate the MMR [Appendix 3], (Aa et al. 2011; Adegoke et al. 2013a; Beltman et al. 2011; Bhat 2002; Doctor et al. 2012; Font et al. 2000; Garimoi 2000; Idris et al. 2010; Lech & Zwane 2002; Mbaruku et al. 2003; Moseson et al. 2014; Olsen & Hinderaker 2000; Orach 2000; Oye-Adeniran et al. 2011; Smith et al. 2001; Wee et al. 2010) .

All the fifteen studies used indirect sisterhood method and were conducted in the following countries:

1) UMIC, five studies conducted in Nigeria (5) and India (x2).
2) LMIC, eight in (Tanzania (x3), Swaziland, Mali, Ghana and Uganda (x2)

3) LIC, two in (Malawi (x2))

All the studies identified, had the required sample size ranging from 2,500 to 4360 [Appendix 3]

A study in Uganda showed the MMR of 662/100,000 live births (CI 421-839) which was 1.3 times higher than the national estimate of 500 per 100,000 live births which based (Smith et al., 2001, Orach, 2000). Similarly, a study in Nigeria identified higher MMR, (6,525 per 100,000 live births (95% CI 6,144– 6,906) in the study setting, than previously identified in the same area (Adegoke et al. 2013a). The high MMR was possibly be due to the fact that the indirect sisterhood method identifies pregnancy related deaths rather than maternal death. However, the two studies did not document how the previous studies were conducted.

A study in Malawi also showed a MMR of 558 per 100 000 live births (95% CI 260 - 820) which was higher than the MMR from the 1989 sisterhood survey (409 per 100 000 live births) (Beltman et al. 2011). However, a study in Ghana which had a sample size of 2,679 revealed, MMR of 269 per 100 000 live births, which was lower than the national estimate obtained at the same time (Smith et al. 2001).

Sisterhood method has many practical advantages, such as speed and ease of its application (Graham, Brass & Snow 1989; Mbaruku et al. 2003). It also reduces the need for a large sample size relative to other estimation procedures, as there may be more than one respondent per household and more than one sister per respondent.

Although the method is relatively inexpensive to use and simple, a major disadvantage is that the overall results relate to a point around 10-12 years prior to the survey. This includes a reference period of 0–6 years for the direct sisterhood method and 10–12 years for the indirect sisterhood method (WHO 1991b). The method also leaves out deaths which occur in early pregnancy where this is not yet revealed to relatives. It can be argued that this cannot be used for monitoring and evaluating the effect of programmes (Font et al. 2000).

The other disadvantage is that, the indirect sisterhood method relies mostly on a number of assumptions about the relationships between age-specific and maternal mortality fertility, therefore, should not be used in settings where levels of fertility are low (Total Fertility Rate below 3), or where there have been recent and marked declines in fertility, or where major migration has occurred (Rutenberg & Sullivan 1991).

Given the nature of the questions asked about the deaths of adult sisters, both methods actually measure pregnancy-related deaths rather than MDs. All the studies identified estimated pregnancy-related deaths. For these reasons, sisterhood studies cannot be used to assess the impact of safe motherhood programmes in the short term and to monitor changes in maternal mortality (Hanley, Hagen & Shiferaw 1996a). The other important drawback is the difficulty in identifying the cause of death (as well as the decision as to whether the death was a maternal death or not) because sisters cannot always recall this.

3.3.2.7 ***Health facility data***

Health facility data remain the main routine source of data on MM for many developing countries. Currently, health facility data are not used in academics and by agencies for compiling global mortality estimates, but they are widely used in many countries as they are locally generated and continuously available. Many have captured maternal mortality from hospital-based studies. Fifty studies reviewed, used health facility data reporting to estimate the MMR. Appendix 3 shows the country distribution of the studies as follows:

1) UMIC had most of the studies (30/50) and the studies were conducted in Nigeria (x20), Egypt, India (x3), Pakistan (5), Jamaica and Jordan.
2) LMIC, 17/50 of the studies and were conducted in Kenya (4), Uganda (x5), Papua New Guinea (x2), Tanzania (x2), Sudan (x2), Cameroon (x2) and Gambia (x2)
3) LIC had 3 studies (Malawi x3)

The majority (44/50) of facility based studies conducted retrospective studies. Data were collected from facility records (registers, obstetric service delivery records, facility birth registry and separate manual tracing of all case records and reports). Maternal deaths were identified mostly from the labour ward, antenatal clinic and postnatal registers (Iftikhar 2009; Lema et al. 2005; Malatyalioglu et al. 2006). In some cases, MDs were identified in the female

ward and theatre registers (Onakewhor & Gharoro 2008). In a study conducted in Nigeria, case notes and midwifery and nurses' reports were also used (Onakewhor & Gharoro 2008).

A case control study was conducted in Nigeria, where case files of all maternal deaths that occurred in the hospital during the two-year study period were retrieved. Each maternal death was matched with three controls who delivered the same day and lived around the same area of Ibadan (Olopade & Lawoyin 2010).

It was noted that the majority of these studies were conducted in tertiary and teaching hospitals, which were admitting complicated cases (Agan, Archibong & Ekabua 2010; Ezegwui et al. 2013; Gumanga et al. 2011a; Lema et al. 2005; Nelissen et al. 2013a; Saleh, Ragab & Aboulgheit 2013; Tebeu et al. ; Yadav, Namdeo & Bhargava 2013; Yego et al. 2014).

In most studies, MMR was higher than existing estimates (Iftikhar 2009; Lema et al. 2005; Olopade & Lawoyin 2010; Omo-Aghoja et al. 2010a; Onakewhor & Gharoro 2008; Tebeu et al. 2007a). In a retrospective study conducted in Nigeria, the facility-based MMR was higher than the national estimate (Olopade & Lawoyin 2010). Other studies reported a lower MM and considerable under-reporting of deaths in the medical birth registry (Bergsjø et al. 2010; Gumanga et al. 2011a). For example, in Ghana the MMR at a health facility was reported to have dropped from 1,870 per 100,000 live births in 2006 to 493 per 100,000 live births in 2010 (Gumanga et al. 2011a) possibly due to missing case notes and lack of data on pregnancy status.

However, MMR from health care facilities have numerous biases and requires to be interpreted with caution (Nelissen et al. 2013b). The high MMR in some facilities could result of the fact that when hospitals function well, they attract most of the complicated obstetric cases (Gumanga et al. 2011a). This is likely to be the case for the studies reviewed where MMR was higher than the national estimate (Gumanga et al. 2011a; Lema et al. 2005; Olopade & Lawoyin 2010; Tebeu et al. 2007b) as these were mainly tertiary facilities, which were receiving most complicated cases.

On the other hand, MMR could be under-estimated by 50% when there is little access access to health care by the population (Garenne, McCaa & Nacro 2008; Qomariyah et al. 2009b; Sombie et al. 2007; Zakariah et al. 2009). This mostly occurs in areas where women deliver outside health and are not referred in case of complications.

Hospital records might be incomplete and maternal deaths occurring outside health facilities might not be recorded in the records (Graham et al. 2008a; Hill et al. 2006; Qomariyah et al. 2009b; WHO 2007a). As noted in most studies reviewed, case notes of women who died were quite often reported to be missing and considerable inaccuracies were noted in routine health facility registers (Bergsjø et al. 2010; Lema et al. 2005; Mbassi, Bouvier-Colle & Mbu 2011). The non-availability of audit reports, patients' folders and poor documentation by health workers will have contributed to underestimation in some studies (Ibeh & Okpala 2013; Lema et al. 2005).

Thus, although a vast number of facility-based statistics on maternal mortality exist for developing countries, these do not reflect the actual state of health of all women in a population. Population-based studies better capture the status of women's health where VR are very scarce (Gülmezoglu et al. 2004). In most developing countries/nations, only a small proportion of all births take place in health care facilities. Unless all women deliver in health care institutions, facility-based data (or data derived from systems for management of routine health information e.g. The HMIS) are rarely sufficient to calculate population-based estimates of maternal mortality (AbouZahr 2010).

Health service data may provide useful information on trends over time and, in particular, on geographic regions and the relative importance of various diseases and causes of death. At the facility level, identifying MDs is often the first step in conducting a detailed audit or a review of the causes and circumstances surrounding the deaths. Such audits often identify weaknesses in the health care system, which allows the development of strategies to resolve them.

3.3.2.8 ***Reproductive Age Mortality Studies (RAMOS)***

The RAMOS approach involves systematic efforts to combine data on MDs from multiple sources of data (AbouZahr 2010). Varied sources are used, depending on the context to identify all deaths of WRA and ascertain which of these are MDs (WHO, UNFPA & World Bank 2005).

RAMOS is generally seen as the gold standard for estimating MMR especially in most countries without reliable data on MMR (Hill et al. 2007).

RAMOS has the particular advantage of identifying 'maternal deaths' and not 'pregnancy-related deaths' if the deceased families interviewed to investigate the cause of deaths. RAMOS has previously been used as an economic and a successful way of measuring extent and causes of maternal mortality (Abou Zahr & Royston 1991). Also RAMOS has the potential to identify abortion deaths as investigation is done on all WRA (Zakariah et al. 2009).

According to WHO, this method has also been successfully used in some countries with good registration systems to calculate the degree of misclassification (WHO 2000). Triangulation of different sources of data increases the completeness of data used. Properly conducted, a RAMOS is considered to provide the most complete estimation of MM (WHO 2004b).

Most often, a RAMOS are conducted retrospectively, but may it also be done prospectively if a population of WRA is monitored over time, and all deaths are reviewed as they occur (Zahr et al. 2004). As maternal deaths are relatively rare events, RAMOS studies are conducted on a population level and in a defined setting (WHO 1991a).

RAMOS are conducted in two phases (Immpact 2007). The first phase, involves identification of all deaths among WRA in a population through multiple sources, such as existing records (civil registration, mortuary records, burial/cemetery records, health facility records, death certificates, newspapers, and census), interviews with social services providers, health care providers, and interviews of surviving family members and monitoring of burials in the community graveyards. These multiple sources of information are used to create a list of the deceased WRA (Turkyılmaz et al. 2009).

In the second phase, all deaths are investigated (using verbal autopsy, health facility reports or medical record reviews death certificates with medical cause and interview with household members and relatives) to ascertain if they are pregnancy related or MDs. The method has previously been used as a successful and economic way of measuring the extent and causes of

maternal mortality in countries such as Egypt, Honduras and Jamaica (Koblinsky 2003; WHO 2007a).

Ten studies which estimated the MMR using a RAMOS approach in LMIC and UMIC were identified. Details of the studies are in Appendix 3. The studies were conducted in both LIC and MIC as follows:

1) UMIC, 3 studies conducted in Jordan (2) (Amarin et al. 2010) and Philippine
2) LMIC, 7 studies conducted in in Pakistani, Tanzania, Eritrea, Mozambique and Ghana (Ghebrehiwet & Morrow 2006; Jafarey et al. 2009; Mohammed et al. 2011a; Olsen & Hinderaker 2000; Songane & Bergström 2002a; Walraven et al. 2000; Yakubu Zakariah et al. 2006; Zakariah et al. 2009).

In these studies, lists of WRA deaths were compiled using death certificates, health facility records (admission and discharge books, death certificate books, death registers, mortuary logbooks and individual case notes), and census data, primary data of the DHS, civil registration data, health surveys and the health management information system (HMIS). In some studies, deaths were identified using key informants such as imams of mosques, councillors, care takers of graveyards, school teachers and shop owners) and traditional birth attendants (TBAs) (Jafarey et al. 2009; Olsen & Hinderaker 2000).

In Jordan, civil registration data was used to identify all deaths among WRA (Amarin et al. 2010). Furthermore, in Jordan deaths of WRA were identified through visits to police units that had been in charge of "dead on arrival" cases and VA were conducted to ascertain cause of death for community-based deaths and to decide whether the death could be classified as a maternal death or not at the same time. In Pakistan primary informants (care takers of the grave yards) who were designated in all cemeteries in the selected provinces in the rural and urban areas to obtain basic information of all burials over a period of 12 months (Jafarey et al. 2009). In Philippines, compared vital registration and RAMOS (Garces et al. 2012) and gross under registration was revealed, as the health institutions failed by 86% in recording MDs, the same happened with other official sources, like the civil register in Mozambique (Songane & Bergström 2002a).

Several studies identified a problem of underreporting of MDs (Alves 2007; Olsen & Hinderaker 2000; Olsen et al. 2002a; Zakariah et al. 2009). Underreporting up to 44% compared to previous studies was identified in Ghana (Zakariah et al. 2009). In all the studies reviewed, the RAMOS approach improved identification of MDs due to the multiple sources used. There were missing records and unreported deaths in studies conducted in Pakistan (Jafarey et al. 2009). The study in Philippines showed that local civil registries missed three-quarters of all MDs (Garces et al. 2012).

RAMOS can be effectively and efficiently used to determine the levels and causes of MM although the approach has been reported to be expensive, unless conducted at a small scale (WHO 2010). However, a study in Eritrea reported cost reduction of two thirds when local people were used to report death of WRA (Ghebrehiwet & Morrow 2006).

As the identification of deaths of all WRA constitutes the major portion of the whole expense, use of local personnel available or community-based systems did not need additional costs, e.g. for transportation, while if external health workers from outside were used, they may have needed transport, translators and local guides to identify deaths.

Table 3.2: Summary of the approaches used to estimate Maternal Mortality

Method	Event measured	Precision and uncertainty	Reference period
Civil registration with medical certification of cause of death	Maternal mortality	Total count, MDs may be misclassified; evidence indicates ~ 50 per cent underreporting	Previous year
Sample registration with verbal autopsy	Maternal mortality	Representative count; maternal deaths may be misclassified; extent of misclassification in verbal autopsy not known so uncertainty cannot be calculated	Previous year
Household survey with direct estimation	Pregnancy related mortality	Depends on sample size; generally wide	Usually 1–2 years before survey, depending on recall period
Household survey with direct sisterhood method	Pregnancy related mortality	Uncertainty arises from sampling errors (20–30 %) and from misreporting of pregnancy status of deceased women	Around 5–7 years before survey
Household survey with indirect sisterhood method	Pregnancy related mortality	Uncertainty arises from sampling errors (~ 30 per cent) and from misreporting of age and pregnancy status of deceased siblings	Around 10–12 years before survey
Census	Pregnancy related mortality	Total count but estimates require adjustment using demographic techniques; also misreporting of age and pregnancy status of deceased women	Reference period for maternal deaths usually 1–2 years before census, depending on recall period. Demographic adjustments generate values at the midpoint between two censuses
Health facility reporting	Maternal mortality	HMIS generally covers only public health facilities; captures maternal deaths occurring in obstetric wards; maternal deaths in emergency and specialist wards often missed	Usually recent reference period
RAMOS	Combination of maternal and pregnancy-related mortality	Depends on the ability of investigators to identify all maternal/pregnancy-related deaths, and on the quality of the medical records and verbal autopsies	Usually covers multiple years

AbouZahr, C. (2010) Making sense of maternal mortality estimates)

3.3.3 Place of death and characteristics of maternal deaths

3.3.3.1 ***Place of death***

Only few studies (5/104) included in this review reported the place where MDs occurred. These studies were conducted in Nigeria, Pakistan, Malawi, China and India (Adegoke et al. 2013c; Hofman & Sibande 2005; Zhu et al. 2009). A population-based study conducted in Nigeria, which used the sisterhood method reported that most deaths identified in the study occurred in a hospital (38.6%) or private clinics (28.2%), with 16.0% dying at home and 6.5% on the way to hospital (Adegoke et al. 2013c).

A community-based study by Hofman and Sibande, (2005) in Mangochi district in Malawi reported 56% of MDs occurred in health facilities, 30% at home 7% at a TBA and 7% on the road. In Pakistan, 82 women (64%) died in health facilities, 33% died at home and 13% on the way to hospital (Bolnga et al. 2014). In China, 12% of maternal deaths occurred at home (Zhu et al. 2009). A study in India reported 70% deaths in tertiary hospitals than lower level facilities (Ratan, Soumya & Amitava 2014).

In Nigeria, a survey of MDs in health facilities revealed that MMR was highest in public health facilities (856.8 per 100,000 live births) compared to private (177 per 100,000 live births) (Ibeh & Okpala 2013).

3.3.3.2 ***Other characteristics***

Age

Another important aspect considered for designing programs, is to know who has highest risk of dying interns of age. Among the studies reviewed, 17/104 reported the age groups with the highest number of MDs. Most (13/17) studies were facility-based studies. Six (6/7) studies reported the highest number of MDs were among adolescents (15-19 years) or women of a young age (15-24 years) (Lema et al. 2005; Mairiga & Saleh 2009; Qureshi et al. 2001; Ratan, Soumya & Amitava 2014; Saleh, Ragab & Aboulgheit 2013; Surekha et al. 2012). The risk of death among young mothers was reported to be influenced by incomplete pelvic growth, leading to a greater probability of obstructed labour. Five studies, (5/17) reported the highest

number of deaths in the age group 25-29 (Gumanga et al. 2011a; Muchemi & Gichogo 2014; Shah et al. 2008; Westhoff et al. 2009) and the remaining 5 studies reported more deaths in women above 35 years old (Asamoah et al. 2011; Fouzia, Nosheen & Naeema 2012; Kestler & Ramírez 2000; Nwagha et al. 2010b; Olowonyo, Oshin & Obasanjo-Bello 2005). Literature reveals, yyounger and older women are less likely to receive antenatal care than women aged 20–34 years and older women are less likely to deliver with a skilled birth attendant (Stanton et al. 2007b). Another confounding factor is the correlation between having early and late births and low socioeconomic status of women in a population.

3.3.4 Associated factors

A number (48/104) of studies reported factors associated with MD [Appendix 3]. A total of 27/48 studies was conducted in UMIC, 18/48 in LMIC and 3/48 in LIC. The most frequently reported associated factors were; level of education, antenatal attendance, social-economic status and parity.

Education

Low level of education was reported in 32/48 of the studies. In some studies over 50% of were less educated (Mohammed et al. 2011a; Westhoff et al. 2009). In Malawi, lower numbers of deaths were observed with higher levels of education (van den Broek et al. 2003b). Poor women, living in rural areas were at high risk of dying (Bell et al. 2008; Ujah et al. 2005).

Antenatal care

The majority of MDs seen did not attend antenatal care visits (Guerrier et al. 2013; Oyieke, Obore & Kigondu 2006; Ratan, Soumya & Amitava 2014).

Parity

In Malawi, MDs were common among women with parity 1 or 2 (Lema et al. 2005). Conversely, other studies reported deaths were common in multiparous women (Saleh, Ragab & Aboulgheit 2013; Yego et al. 2014) and grand multiparas (above 5) (Begum, Aziz un & Begum 2003; Jafarey et al. 2009).

Time of death

Research has revealed that most deaths occur during or immediately after delivery from complications related to pregnancy, delivery and the postpartum period. (Ronsmans & Graham 2006).

In our review, 43/104 studies reported the pregnancy period in which women died [Appendix 3]. 28/43 studies reported women died after delivery, 17/43 during pregnancy and 8/43 during labour and delivery. Most studies (18/43) reported that most women died within 24 hours after delivery. A study in Ghana reported most women died following termination of pregnancy (abortion delivery) (Ganyaglo & Hill 2012).

3.3.5 Causes of maternal deaths in middle and lower income countries

A key requirement for further advances in reduction of maternal deaths is to understand the causes of maternal deaths (Say et al. 2014). Most MDs arise from the risks attributable to pregnancy and childbirth and from poor quality-health care (Mathers et al. 2005). MDs are classified according to medical causes, or by using the state of pregnancy as a proxy for cause in the absence of accurate information, (WHO 2007c). The ICD-10 definition of MM allows the identification of maternal deaths as either direct or indirect (WHO 1992b).

A total of 84/104 studies, presented causes of MDs and all the studies used the ICD-10 classification. Direct obstetric causes were the leading cause of MDs in most of these studies (81/84) [Table 3.3]. Most studies (43/81) were conducted in UMIC (including Nigeria, India, South Africa, Pakistan, Jamaica and China) and 3/81 in a LIC (Malawi) [Table 3.3]. Most studies were facility-based (52/81) and were conducted in Nigeria (22/52).

Only 3/84 studies, conducted in China, India and Malawi, reported indirect causes as the leading cause of MDs (Qiu et al. 2010; Surekha et al. 2012; Vink et al. 2013). Two of these studies were facility-based (Malawi and India) and one household survey (China).

Table 3.3: Leading cause of death by country level (n=84)

Country Level	Direct MDs	Indirect MDs	Total
Upper middle income	43	2	45
Low middle income	35	0	35
Low income	3	1	4
Total	**81**	**3**	**84**

The most important causes of MDs (most notably haemorrhage, hypertensive disorders, sepsis, obstructed labour and abortion) did not differ among the UMIC, LMIC and LIC. These were five direct common causes of MDs among 81 studies which reported direct causes. Obstetric haemorrhage was the leading cause in 42/81 studies, followed by pregnancy-related hypertension, (21/81), sepsis, (9/81) and obstructed labour (8/81). One study reported abortion as the leading direct cause of death (Ziraba et al. 2009) [Figure 3.3]. A study conducted in Mangochi district in 2005 reported that haemorrhage, ruptured uterus and complications of abortion accounted for 79% of direct causes of MDs (n=22), (Hofman & Sibande 2005).

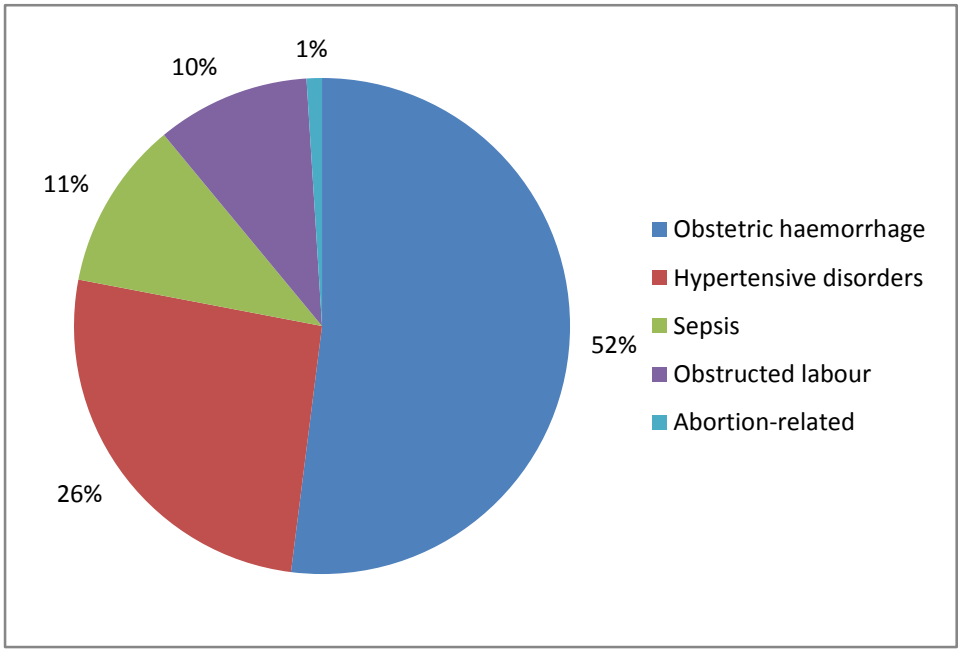


Figure 3.3: Leading cause of maternal deaths in 81 studies from UMIC, LMIC, and LIC

Indirect causes of deaths varied in different countries. Anaemia was reported as an indirect cause of death in seven studies in Nigeria (4 studies), Malawi, Gambia and India (Adamu et al.

2003; Chawla, Kumar Saha & Akhtarkharvi 2014; Gebreamlak, Alemayehu & Haftom 2013; Igwegbe et al. 2012; Mairiga & Saleh 2009; Nwagha et al. 2010a; Van den Broek et al. 2003a; Walraven et al. 2000). Studies from South Africa, Mozambique, Kenya, Nigeria and Malawi reported HIV as an indirect cause of death (Desai et al. 2013a; Garenne, McCaa & Nacro 2008; Menéndez et al. 2008b; Oladapo, Lamina & Fakoya 2006; Omo-Aghoja et al. 2010b; Oyieke, Obore & Kigondu 2006). HIV was reported mostly in hospital-based studies. Only a few studied reported malaria as an indirect cause of death (Desai et al. 2013b; Menéndez et al. 2008b).

3.3.6 Associated factors: The three delays model

Like most health problems, causes of maternal deaths can be viewed by using a narrow or broad approach in a population. A broad view would not merely look at the medical cause but take into account individual, community and health service factors that contribute to deaths.

The three delays model recognizes the different barriers of care women face in achieving the timely and effective medical care needed to prevent deaths occurring in pregnancy, childbirth and postpartum (Thaddeus & Maine 1994). Thaddeus and Maine have argued that delays in reaching adequate care are prominent factors that contribute up to 75% of MDs especially in resource-poor nations.

Thaddeus and Maine related lack of care to three factors, delay in deciding to seek care when a problem arises (delay 1), delay in reaching the health facility (transport) (delay 2) and delay in receiving quality care once at the health facility (delay 3) as illustrated in Figure 5. Their work offered a new approach to examining MM using a three-phase framework to understand reasons for delays in the management of obstetric emergencies (Pacagnella et al. 2012a). The delay model helps to identify community and health service factors which are associated with MDs and this is useful in devising interventions and strategies for preventive measures.

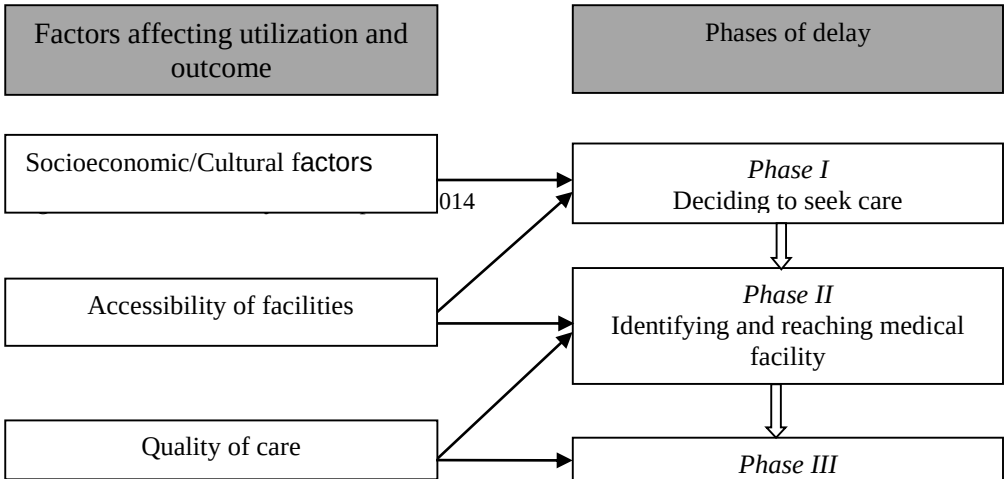


Figure 3.4: Three delays model

Source: Three delays model (Thaddeus & Maine, 1994)

Eight studies included in this review reported on delay in accessing emergency care. Delay 3 was leading in 4/8 studies (Hofman & Sibande 2005; Omo-Aghoja et al. 2010a; Onah et al. 2005; Walraven et al. 2000), delay 1 in 3/8 studies (Saleh, Ragab & Aboulgheit 2013; Sanga, De Costa & Mola 2010), and delay 2 in 1/8 cases (Shah et al. 2009).

Delay 1

In Malawi, a study conducted in Mangochi district, 77% of women were reported to have presented late at the health facility due to initial refusal to seek care (Hofman & Sibande 2005). Delay in decision to seek care was also reported in Egypt and Papua New Guinea (Saleh, Ragab & Aboulgheit 2013; Sanga, De Costa & Mola 2010). The delay was due to mainly failure to recognize obstetric complications.

Delay 2

In Pakistan, most women 74% experienced second delay due to long distance to the facility (Shah et al. 2009).

Delay 3

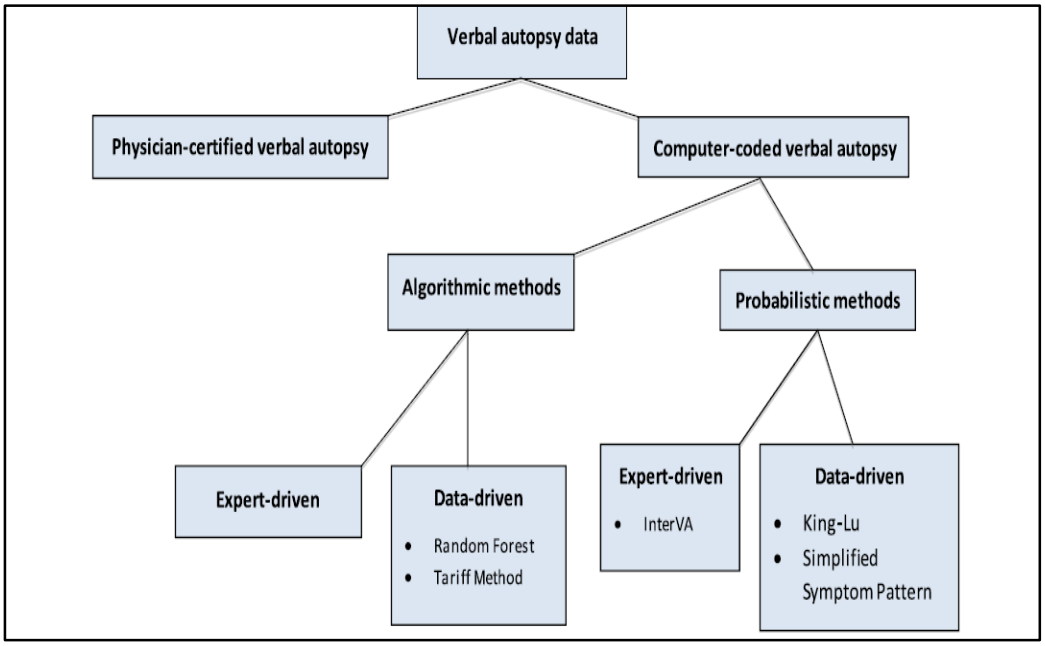
Two hospital-based studies in Sudan and Nigeria reported delay in referral among 73.4% and 61.9% of cases respectively (Mohammed et al. 2011a; Omo-Aghoja et al. 2010b). In addition, they identified lack of blood, midwifery staff, oxygen coupled with substandard care at the facility. Type 3 delays were also reported in hospital-based studies from Nigeria and Pakistan

(Onah et al. 2005; Shah et al. 2009). Mainly to delayed referral, lack of oxygen and inadequate midwifery staff.

3.3.7 Cause classification for verbal autopsy data on maternal deaths

Methods to assign causes of death (COD) using verbal autopsy data (VA) are categorized in two as; physician-certified verbal autopsy (PCVA) or Computer-coded verbal autopsy (CCVA). PCVA typically involves at least two physicians examining each record of a patient/client, with adjudication done by a consensus review or by a third physician (Fottrell & Byass 2010; Leitao et al. 2013). VA data has most commonly been analysed by medical/professional staff, but this has proven to be expensive, slow and non-reproducible process in many situations, and may provide VA cause of death information that cannot readily be compared between settings (Lozano et al. 2011a). In recent years, there has been interest in using CCVA to improve consistency, inter-observer agreement and comparability and to make the coding of VAs faster and cheaper (Byass et al. 2006; Murray et al. 2007) [Figure 3.5].

Figure 3.5: Analysis of Verbal autopsy data



Source Leitao et al 2014.http://www.biomedical.com/1741-7015/12/22

The development and details of other CCVA models have been described in detail in literature before (Fottrell & Byass 2010).This section will dwell on InterVA which was used to assign cause of death in this study.

The InterVA (Interpreting Verbal Autopsy) model is a probabilistic model that can be used to determine the cause of death for each case by processing successive indicators to generate up to three likely causes of death for each case in a computer. This model was initially used by a global network (most notably by INDEPTH), which conducted longitudinal health and demographic evaluation of populations in low and middle income countries (LMICs). The model was developed using an expert panel and was designed to be generic and not context dependent and to produce relatively broad cause of death categories. InterVA is freely available in the public domain.

A series of InterVA models have been developed over the past decade. The model was first tested on VA data from Vietnam for all deaths including maternal deaths, where over 70% of individual causes of death were identical with those determined by two physicians, (Byass, Huong & Minh 2003). These models progressed to InterVA-3, which has been used in a variety of settings across Asia, Africa, and the Latin America (Bauni et al. 2011b; Byass et al. 2011; Fantahun et al. 2006a; Ferri et al. 2012; Herbst, Mafojane & Newell 2011; Oti & Kyobutungi 2010; Ramroth et al. 2012; Tensou et al. 2010) and an associated model, InterVA-M, which analyses deaths among WRA separately (Bell et al. 2008; Fottrell et al. 2007b). The InterVA-M was not used in this study because it was under review when data were analysed.

The InterVA model generates up to three likely causes of death from 35 broad categories, with probabilities for each cause of death (WHO 2005). Fewer than three causes are displayed if the probability of the second or third cause is less than 50% of the probability of the preceding cause (Fottrell et al. 2010; Ramroth et.al 2012). Thus, the sums of the likelihood do not usually add up to 100. It also considers the levels malaria and HIV⁄AIDS prevalence in the region. The use of the InterVA model to interpret VA data has the advantage of achieving maximum consistency in interpreting VA data (Byass, Huong & Minh 2003; Fantahun et al. 2006b). It also requires relatively minimal time and labour resources, especially in comparison to the physician review method.

InterVA-4 was released in 2012 and is aligned to the 2012 WHO VA instrument. The new model has been designed to use the VA input indicators defined in the 2012 WHO VA instrument and to provide causes of death compatible with the International Classification of Diseases version 10 (ICD-10). The new model integrates experience accumulated from previous versions (interVA-3), latest data and research findings, and revisions by an expert panel. In addition, known shortcomings of previous InterVA models have been addressed in the current revision, as well as integrating other work on maternal and perinatal deaths (Byass et al. 2012). Further validation opportunities are still being explored now.InterVA-4 aims to provide a consistent and generally applicable means of interpreting VA data and is applicable in both prospective and retrospective data. The model is intended for use both within already-enumerated populations and as a stand-alone death registration tool, both in research and in civil registration system. The model is designed to interpret VA data for deaths from all causes and all ages in the community (Byass et al. 2012).

In this review we identified seven relevant studies which compared cause of death classification methods using VA data [Appendix 3]. One study in Pakistan compared hospital assigned causes of death **(**HCOD) and PCVA (Midhet 2008). There were 128 deaths and there was a complete agreement between the two groups of MDs. However, the agreement was weak for all other cause categories including indirect MDs (kappa test P-value of 0.055) (Midhet 2008). Another study in India which used HCOD as the gold standard for validating both PCVA and the InterVA model on causes of adult deaths reported that all the methods yielded the same top five underlying causes of adult deaths. However, the InterVA overestimated tuberculosis as a cause of death compared to the HCOD. On the other hand, PCVA overestimated diabetes. Overall, cause-specific mortality fractions (CSMF) for the five major cause groups by the InterVA, PCVA, and HCOD were 70%, 65%, and 60%, respectively. PCVA versus HCOD yielded a higher kappa value = 0.52, 95% confidence interval [CI]: 0.48, 0.54) than the InterVA versus HCOD kappa value of 0.32 (95% CI: 0.30, 0.38). Overall, agreement across the three methods was 0.41 (95% CI: 0.37, 0.48).

Both the InterVA and PCVA compared well with the HCOD at a population level (Bauni et al. 2011a). A study in Ethiopia showed the physicians' review and the probabilistic model in

determining causes of death, both approaches yielded very similar findings for the major CSMFs in this community, despite that the fact that the two approaches were applied independently to the same data, and that the model was built without direct reference to the data. In the study, patterns of mortality revealed were consistent with those anticipated for an underdeveloped population in sub-Saharan Africa (Mesganaw et al. 2006)

On the other hand, a systematic review of 19 comparison studies, most of which used hospital-based deaths as the reference standard, reported no single best-performing coding method for VA across various the studies and found little current justification for CCVA to replace PCVA (Leitao et al. 2014), Lozano et.al (2011) who compared interVA to PCVA and Simplified Symptom Pattern (SSP), across all age groups, reported that InterVA performed worse than PCVA and SPP, both on an individual and population level.

3.4 Conclusion of the literature review

From the literature reviewed, the most accurate estimates of the MMR can in principle, be obtained from civil registration data complemented by a national confidential enquiry into maternal deaths (CEMD). Where such systems are in place, the MMR can be calculated with minimal extra effort and cost (Andersen et al. 2009; Zhu et al. 2009). Even though estimates derived from complete vital registration systems, such as those in developed countries, suffer from misclassification and underreporting. Currently vital registration systems in most low and middle countries are weak, and thus, cannot provide an accurate assessment of maternal mortality. Most studies which attempted to use vital registration data to estimate MMR in this review were from UMIC.

Household surveys are one of the most important methods in settings where routine information systems are non-existent or weak. However, surveys require large sample sizes to obtain robust estimates (Hill et al. 2006).This is very costly and may still result in estimates with large confidence intervals if not properly conducted and or the sample size is too small.

To reduce sample size requirements, the sisterhood methods measure MM by asking respondents about the survivorship of sisters (Graham et al., 1989. However, neither the of the two, direct nor indirect sisterhood method provides a current estimate, i.e. for the year of the

survey (Graham, Brass & Snow 1989). For these reasons, sisterhood studies cannot be used to assess the impact of programmes in the medium to short term or monitor change in MMR.

Census data provide a complete picture of the whole population, and with a large sample size estimates for MMR will have narrow confidence intervals. However, censuses are conducted on average every ten years and are therefore less useful for more regular monitoring trends In addition; censuses usually identify pregnancy-related deaths and not true maternal deaths leading to an over-estimation of the MMR. Although valuable information on cause of and factors contributing to MD can be obtained from hospital-based studies, and this information can be used to improve health services, findings from hospital-based studies cannot be generalised to the population level, unless almost all births and or MDs take place in a hospital setting. In the absence of vital registration, a RAMOS has been reported to result in the most complete estimation of MMR because information regarding the number of maternal deaths comes from different sources of data (WHO 2014b). We identified only a few (8) studies conducted between 2000 and 2014 which have used RAMOS in a developing country setting. This must be because the RAMOS approach is considered difficult in the absence of a reasonably complete initial list of deaths. RAMOS are expensive and time consuming when conducted on a larger scale (Westhoff et al. 2009).

The ability to generate regional, country, and global estimates with higher precision and accuracy would be greatly facilitated if country civil registration systems were strengthened. This improvement would reduce the need to conduct special maternal mortality studies (which are time-consuming, expensive, and of limited use in monitoring trends). Obtaining increasingly more and better information about maternal deaths occur continues to be of critical importance to help identify what is needed to reduce the global burden of maternal mortality and morbidity. Review of the literature shows that in the absence of a vital registration system, two main methods can be used in LMIC to provide estimates of MMR; the sisterhood method and RAMOS. Both use relatively simple data collection tools and methods that can be used by healthcare providers and managers after minimal training. The review reveals most women die in a health facility (Adegoke et al. 2013c) at a younger and older age (Lema et al. 2005). Most studies report that the majority of deaths are direct MDs and haemorrhage is the leading cause

of death. There is still a controversy about the best method for cause of death attribution. Both PCVA and CCVA methods have been proposed. Some results have shown good agreement between the two and others not.

3.5 Gaps in literature and position of this study in research context

Existing evidence shows the importance of studying levels and causes of MM to reduce maternal deaths. Important outputs of MM studies include the numbers of MDs which could be used for advocating for resources and assessing the achievement towards MDG 5, and cause attribution and elucidated contributing /associated factors for MDs which constitutes important information used to structure and guide maternal mortality reduction programmes in poor resource countries. Nonetheless, an assessment of the magnitude of MM and assigning causes of death remains difficult in most countries (Hill 2006). Civil registration data is the gold standard for estimating the MMR, however, the approach this almost non-existent in Malawi. The direct sisterhood method which is currently in use at national level (as part of MDHS) has limitations. We did not find any recent study on MMR in Mangochi, and no previous RAMOS has been done in Malawi. Only a few have compared the PCVA, facility data and the CCVA to assign cause of death. And these studies were not specifically comparing cause of MDs.This study seeks to fill these gaps and sets to act to estimate MMR using RAMOS approach at sub-national level. It compares cause of death identified using the new classification ICD-MM and compares with InterVA-4 as an example of CCVA.

3.6 Chapter Summary

This chapter has provided the systematic search strategy with a narrative synthesis of the literature used to identify the gaps that informed the study. The chapter has further described data sources and methods precisely used for measuring MM in LMIC, which included: Civil registration system, health facility data, and population-based studies such as census, surveys, sisterhood method and RAMOS**.** Strengths and limitations of these approaches have been described. The chapter has also highlighted studies which have compared different VA data interpretation methods. Conclusions about the literature are made and the chapter ends the context of this study at national and international level.

4 METHODOLOGY

4.1 Chapter overview

This chapter details the research methodology used in this study. It lays out the study methods used to achieve the objectives outlined in Chapter 1. The chapter has 18 main sections, which begin with describing the study location and a rationale for the study location. The study population and the criteria used to select the population under study are described. The chapter further describes how the instruments were developed and outlines the study preparation procedures, data collection methods, data management, data analysis, study outcomes, and ethical considerations.

4.2 Study location

The study was conducted in Mangochi district in the southern rural Malawi [Figure 4.1].

4.2.1 Mangochi population and geography

Mangochi is the largest rural district in southern Malawi. According to the census report, NSO, (2008), the district had a total projected population of 916,274 people in the year, 2012 of whom 52% (475,602) were female and 48% (440,672) were male. The population density for the district was 127 people per square kilometre with an annual projected population inter-censual growth rate of 2.7%. The district covers an area of 6,273 square kilometres.

The census, further reported the projected, estimate of 207,868 of WRA in 2012 with an expected 42,496 number of deliveries (NSO 2008). The estimated number of WRA for the Mangochi district was calculated on the assumption that mortality and fertility were declining at the same pace as at national level. Data at a national level were used to project district population because of changes in boundaries in the districts and limited availability of district specific data. This number has been used to estimate the number of WRA in this study.

There are eight Traditional Authorities (TAs) in Mangochi district; [Figure 4.1] Mponda, Chimwala, Nankumba, Jalasi, Makanjira, Katuli, Chowe and Mbwananyambi. Population by TA is shown in Table 4.1 and TA Mponda has the largest population.

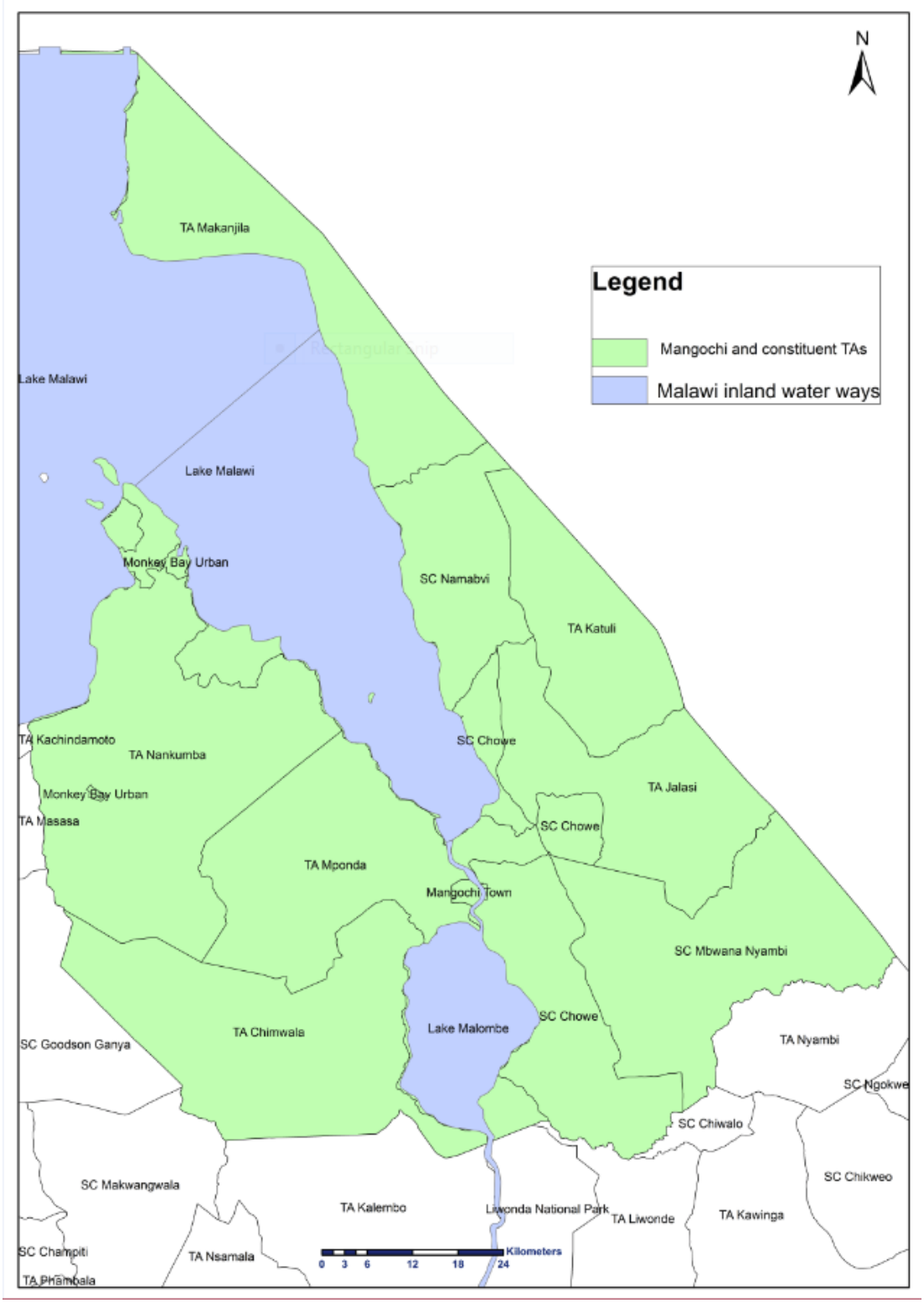


Figure 4.1: Map of Mangochi showing Traditional Authorities

*****_Senior Chief (SC) Namabvi and Chowe have been combined to TA Chowe by the government of Malawi._

Table 4.1: Population for Traditional Authorities in Mangochi District

Name of TA	Estimated Total Population
Mponda	178,657
Chowe	153,800
Chimwala	123,786
Jalasi	83,415
Bwananyambi	87,797
Makanjira	80,302
Katuli	68,153
Total	**916,274**

Source: Census report 2007(NSO 2008)

4.2.2 Demographic characteristics of Mangochi district

Mangochi is one of the two districts in Malawi with the lowest literacy rates (47%), the other being Dedza in Central Region, which has literacy rate of 49%. About 54% percent of men are literate and while 46% are women (NSO 2008).

The predominant ethnic group in the district is the Yao tribe which constitutes over 90% of the population. The prominent faith in this district is Islam. People depend on farming and fishing as their main source of income (MDHS 2005).

Compared to the national figures, women marry relatively young, 75% marry by the age of 20 compared with 30% of men who marry at the same age (Lema 1997; MDHS 2011; Munthali AC 2004). About 20% women marry at an age of less than 18 years (NSO 2008).

Women who marry earlier are more likely to have their first child earlier and give birth to more children overall, contributing to higher fertility rates.

4.2.3 Health System

4.2.3.1 ***Health care delivery system***

There are a total of 46 health facilities in the district of which four are hospitals (secondary level), 39 are health centres (primary level) and 3 are dispensaries (primary level). These health facilities are distributed in the eight TAs [Figure 4.2]. Thirty (30) facilities operated by the MOH in the district provide free services while 16 facilities, which are operated by the CHAM, charge a service fee. The district hospital acts as the main referral hospital for all the lower facilities in the district. The district hospital refers complicated cases to Zomba Central hospital, a tertiary hospital which is about 150 kilometres away (HMIS 2012a).

In order to facilitate effective and efficient health care delivery at facility and community level, the Mangochi district health office has divided the district into five zones and further into eight clusters. The zones and clusters do not match the TAs because some TAs have more catchment populations than the others. Each zone and cluster has a list of health facilities (Ministry of Health 2009) [Appendix 2].

The zones are headed by zone coordinators and clusters by cluster supervisors. There were five zone coordinators and eight cluster supervisors in 2011. Cluster supervisors work hand in hand with Health Surveillance Assistants (HSAs) who are community workers in these clusters. In 2012 **t**here were a total of 551 HSAs deployed in Mangochi district. Each HSA is assigned to a catchment population of 1,000 people (Ministry of Health 2009).

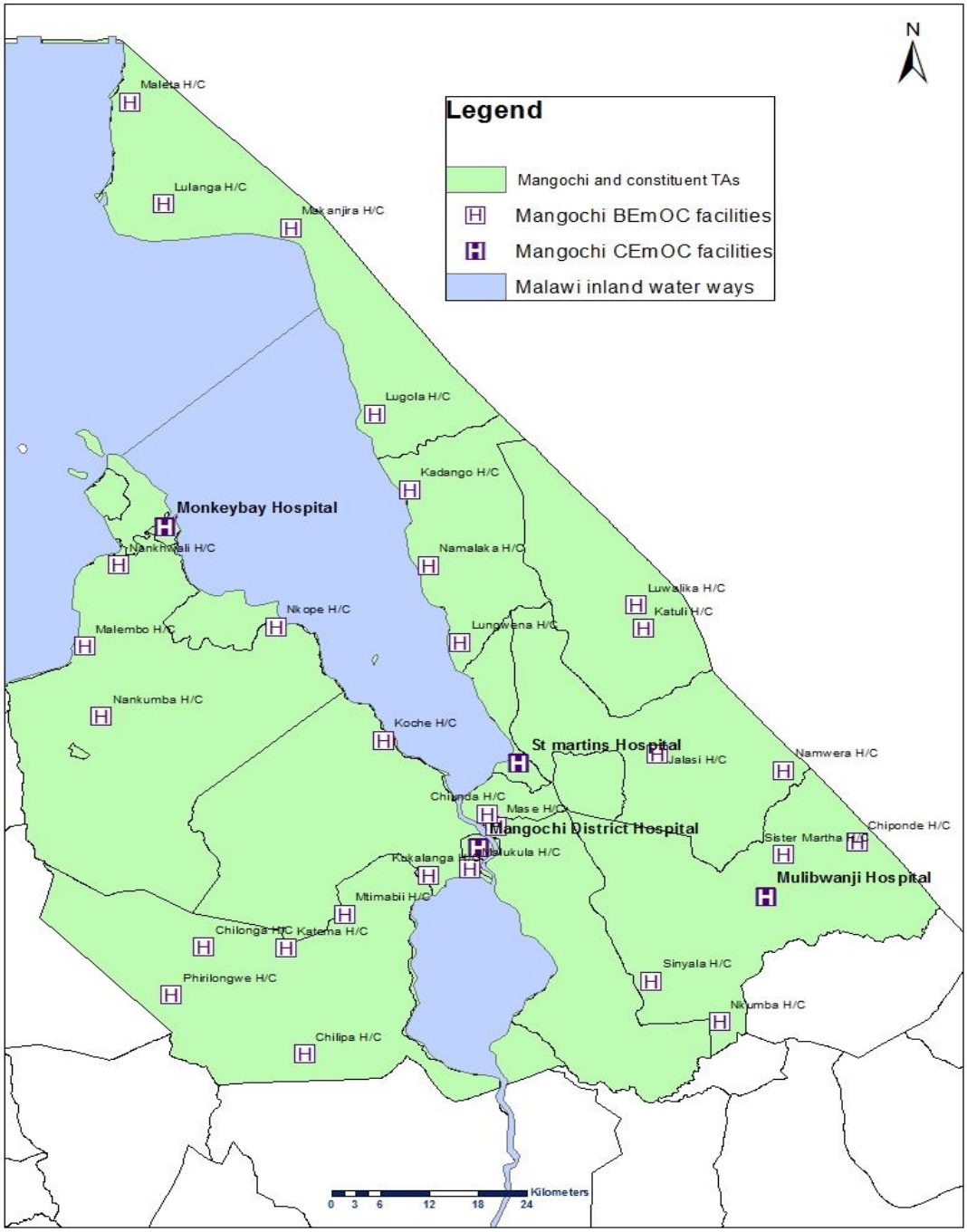


Figure 4.2: Map of Mangochi showing distribution of health facilities by traditional authorities of the Mangochi district

4.2.3.2 ***Emergency Obstetric Care (EmOC)***

There are 36 facilities in Mangochi district, which offer EmOC [Figure 4.2]. In 2010, a baseline study carried out by the Liverpool School of Tropical Medicine (LSTM) in conjunction with the MOH Malawi, to assess availability of EmOC in the district, revealed that the number of health facilities designated as EmOC facilities was less than what UN indicators recommend.

Six out of 36 designated BEmOC health facilities performed 4-6 out of the 7 signal functions; the rest (30) performed less than four signal functions. All four hospitals in Mangochi district performed all nine signal functions for CEmOC. Lack of complete signal function provision prevents treatment of life-threatening obstetric emergencies (MOH, UNICEF & LSTM 2010).

The study also found that the caesarean section rate was 3.6% (375 caesarean sections out of 10,417 deliveries in the district) which was lower than the 5% minimum recommended by UN process indicators. The calculated unmet need for caesarean section in this district was estimated at 28%. Skilled birth attendance at birth was estimated at 68% (MOH, UNICEF & LSTM 2010).

4.2.3.3 ***Reproductive health indices***

Compared to national-level indices, Mangochi is reported to have poor reproductive health indices. Table 4.2 shows more women (28.3%) begin child bearing at the age of 15-19 compared to the national average of (23.6%). Women in Mangochi have higher a fertility rate than the national level, (7.0 compared with 5.7). Both skilled birth attendances at birth and health facility delivery are lower than the national average. The crude death rate for women was also higher than the national average (13.2 per 1,000 versus 10.2 national averages).

Table 4.2: Comparison of Mangochi and National reproductive health indices

Indicator	Mangochi average (%)	National average (%)
% pregnant women attending at least 1 antenatal visit*	96.1	95.4
% of women aged 15-19 who have begun child bearing *	28.3	23.6
% of skilled attendance at birth*	68.5	71.4
% of Health facility delivery rate*	69.3	73.2
Total fertility rate*	7.0	5.7
% of unmet need for family planning*	29.7	26.1
% use of modern contraceptives among married women aged 15-49*	26.6	43.3
Crude death rate for women per 1,000*	13.2	10.4
Average age at first marriage (in years)**	18	20
% of caesarean section rate*	3.6	3.8

***Source:* Malawi Demographic and health survey, 2011, *****Adolescent sexual and reproductive health in Malawi: Results of the 2004 national survey of adolescents (Munthali, 2004)*

4.3 Choice of District

Purposive sampling was used to select the district under study. Purposive sampling is a form of non-probability sampling in which decisions concerning the individuals to be included is based on variety of criteria which may include specialist knowledge of the research issue or the segment of the population with the most information regarding the characteristic of interest (Devers & Frankel 2000). The method was considered appropriate for this study because of particular characteristics of Mangochi district that were considered to provide rich data on MM. The following were the factors that informed the selection of the district.

Firstly, Mangochi was selected out of 29 districts in Malawi due to its relatively poor reproductive health indices as indicated in Table 4.2. The skilled attendance at delivery in Mangochi was low compared with the national average (68.5% and 71.4% respectively). Facility delivery rate was at 69.3% against 73.2% at national level. The total fertility rate for the district was also higher at 7.0 compared with the national average 5.7 (MDHS 2011). The average unmet need for family planning was higher (29.7%) than the national average of 26.1%. In addition the average age at first, marriage is 18 compared to 20 at national level.

Little is known about MM in the district despite the poor maternal health indicators. We found one study which was conducted more than a decade in the district by McDermott et al., (1996). This was a trial on antimalarial chemoprophylaxis in pregnant women conducted by a malaria research project. The study was designed to examine the effect of malaria prevention during pregnancy on birth weight and infant outcomes. The project also provided an opportunity to examine prospectively mortality among 4,053 women who were consecutively enrolled at the first antenatal visit; followed through delivery and one year after delivery. This study reported a MMR of 398 per 100,000 live births (95% CI 242-656) (McDermott et al. 1996).

However, this MMR is likely to be an underestimate due to the sample of pregnant women used. The mean gestational age at first antenatal clinic visit (enrolment) for women was 24.5 weeks of pregnancy, which means all mortality of women associated with early pregnancy (first trimester) was not included. In addition, the study was conducted in 4 clinics out of 26 available in the district during the study period.

Furthermore, despite the national system of capturing MDs at facility and community level in place, the available data on MM for Mangochi district reflected the system was nor functional. Records for the period from July 2009 to June 2012, in the HMIS, reported only facility based MDs (43, 45 and 47 per year respectively) (HMIS 2012a). This implied that interventions towards reducing MM were established only on facility based deaths.

An additional, consideration was that, maternal death is a relatively rare event, there is need for a large population to obtain sufficiently accurate estimates on MM (Geubbels 2007). With the large population in Mangochi and the poor maternal health indicators, we expected to identify more than 300 MDs [Table 4.3] in the district which is considered high MMR by WHO (WHO 1994a, 2012a). Due to lack of reliable data on MMR for Mangochi district at the time of designing of the study, we calculated the estimated number of maternal deaths based on available MMR estimates from other different sources as outlined in [Table 4.3].

The district had 42,496 estimated live births as per census projection for 2011 (NSO 2008). We used the estimated live births from the census report instead of HMIS to cover live births, which occurred outside the health facility as the HMS only captured health facility live births.

Table 4.3: Expected number of maternal deaths in Mangochi district based on other MMR estimates for Malawi

Source	National MMR per 100,000	Calculation	Expected number of maternal deaths for Mangochi district
MDHS*, 2010	675	$\frac{675 \times 42{,}496}{100{,}000} = \mathbf{286.85}$	287
MICS** Report, 2006	807	$\frac{807 \times 42{,}496}{100.000} = \mathbf{342.94}$	343
WHO, 2010	510	$\frac{510 \times 42{,}496}{100{,}000} = \mathbf{216.73}$	217
Hogan et al, 2010	1140	$\frac{1140 \times 42{,}496}{100{,}000} = \mathbf{484.45}$	484
Average		$\frac{287+343+217+510+48}{4} = \mathbf{332.75}$	**333**

**MDHS-Malawi Demographic Health Survey, 2010, **MICS-Mixed Cluster Indicator Survey, 2006, World Health Organization, 2010*

4.4 Study design

This was a prospective descriptive study which used the RAMOS approach to collect data on deaths of WRA for a period of one year. Since the current system in Mangochi focuses only on facility based deaths, we expected the RAMOS which was planned for both facility and community deaths to provide a more comprehensive approach which was expected to identify deaths in the community too. The triangulation of different sources of data on deaths of WRA, coupled with record review and/or verbal autopsy to identify deaths in the RAMOS approach was expected to identify more MDs than the current system in the district. Information pertaining to cause and factors associated with maternal deaths were obtained via facility and community-based audit.

A prospective data collection method as opposed to a retrospective study was selected because prospective studies can provide more reliable and less biased data and are ranked higher in the hierarchy of evidence (Vandenbroucke 2008).

4.5 Study population and period

4.5.1 Target population

The target population comprised of WRA (15-49 years) who died between 1st December, 2011 and 30th November, 2012 in Mangochi district.

4.5.2 Selection criteria

4.5.2.1 ***Inclusion criteria***

- All WRA (15-49 years), who died while residing in Mangochi District between 1st December, 2011 and 30th November, 2012 inclusive, irrespective of the cause of death.

4.5.2.2 ***Exclusion criteria***

- Any woman below the age 15 or above 49 years.
- Any woman not from Mangochi District but who died in the district between 1st December, 2011 and 30th November, 2012.

4.6 The study protocol and preparatory procedures

The District Health Officer (DHO) for Mangochi District Hospital provided office space at the district hospital. This office acted as central point for coordinating all research activities during the study period. The office had a locked cupboard for data storage and a working telephone for communication.

4.6.1 Development of data collection tools

Five separate data collection tools were used to collect data about deaths of WRA and MDs from both facility and community levels. Details of all the tools on how they were developed, who used them and when they were used are listed in Table 4.4.

Table 4.4: Tools used to collect data

Name of the tool	Existing, adapted or adopted	Who used it	When	Appendix
Facility death identification form	adapted	PI, DCs, HSAs, Cluster Supervisors and health workers	Identification phase	4a
Community death identification form	adapted	PI, DCs, HSAs, Cluster Supervisors	Identification phase	4b
Facility record review form	adapted	PI, Panel of Experts	Assigning cause of death and factors associated to MDs	4c
Maternal death review form	existing	Health workers, DCs and PI	Assigning cause of death and factors associated to MDs	1
Verbal autopsy form	adopted	DCs, PI, Panel of Experts	Assigning cause of death and factors associated to MDs	5

4.6.2 Tools for identifying death of WRA

4.6.2.1 ***Health facility and community data extraction forms***

Two separate forms were used to identify deaths of WRA at health facility and community level, [Appendices 4a and 4b]. The health facility data extraction form was used to identify deaths of WRA which occurred at facility level while the community data extraction forms for the community. Both forms were adapted from the free online toolkit guide developed by the Initiative for Maternal Mortality Programme Assessment (IMMPACT) (IMMPACT/Population Reference Bureau 2007). IMMPACT is a global research initiative for the evaluation of safe motherhood intervention strategies based at the University of Aberdeen. IMMPACT has developed a range of tools for maternal health programme evaluation. These include ways to measure maternal and perinatal mortality and morbidity, quality of maternal health care, economic outcomes and health systems factors. The tools have been tested in countries such as Ghana and Burkina-Faso. Modifications were made to suit the Malawian context.

Both forms had detailed information on the socio demographic information of the deceased, details to identify the pregnancy status of the deceased woman and cause of death [see

appendices 4a and 4b]. The health facility data extraction form had additional information on the code level of facility where the woman died, date and time of admission and diagnosis.

4.6.3 Facility Record Review Form

This was a validated form adapted from the IMMPACT tool kit. The form was used to extract information from the individual case notes of women classified as MD. This form had information on the clinical management or procedures done on the deceased women. The information was collected to assist in identification cause of MD, [Appendix 4c]. This information was extracted by the PI who is a nurse/midwife with more than seven years of experience working in maternity and general wards within developing countries which facilitated collection of appropriate data. However to avoid observer bias which may have risen out of unconscious assumptions or preconceptions by the PI, patient case files and health passport books where information was gathered were photocopied and analysed by expert panel.

4.6.4 Maternal death review Form

The MDR2 is one of the existing tools in Malawi developed by MOH and is used during MD audit meetings. Details of the form are described in section 2.4.7 in Chapter 2 (See sample of MDA 2 in Appendix 1). The completed forms for the deceased were photocopied and used for cause classification. This form had the following details:

a) Social demographic data the deceased
b) Location where of death occurred (level of facility and ownership of facility e.g. public or private)
c) Admission date and time.
d) Reason for admission
e) Condition at admission
f) ANC, delivery and postpartum details
g) Cause of death
h) Associated factors that contributed to death (facility and community)
i) Action plan

4.6.5 Verbal Autopsy form

In order to achieve a high degree of consistency and ensure comparability with other data sets, a validated verbal autopsy (VA) questionnaire, developed by a WHO led expert group of researchers, data users, and other stakeholders, with sponsorship from the Health Metrics Network (HMN) in 2007, was used to collect data (WHO 2007d) [Appendix 5]. The tool was developed based on widely used validated VA questionnaires and procedures (Abou Zahr 2007). Standard VA questionnaires for three age groups were available: questionnaires for the under four weeks; four weeks to 14 years and 15 years and above. This study used the 15 years and above questionnaire for women. This study used the 2007, WHO standard VA tool, as it was the only validated tool available when this study commenced in 2010. However, the WHO revised the 2007 VA tool and published a new version in 2012 (World Health Organization 2012). In comparison with the 2007 version, the questions in the 2012 VA tool were the same but numbers of conditions and questions have been reduced. This implies the 2007 tool used in this study captured more data.

The VA questionnaire elicited information on signs, symptoms, medical history and circumstances preceding death. The tool comprised of six main sections as follows:

1) Background information on the deceased
2) Brief obstetric history of the deceased woman.
3) General information was collected about events preceding the death.
4) Information regarding general illness leading to death
5) Questions on symptoms and signs of the last illness
6) Information on MDs during pregnancy, delivery, abortion, and within six weeks after delivery or abortion.
7) Information regarding treatment and care-seeking behaviour of the deceased woman.

This questionnaire was translated in Yao language, the common language for the district, by an expert in Yao language. The Yao questionnaire was back-translated into English again to ensure accurate translation.

In this study, VAs were conducted by the Principal Investigator (PI) and the Data collectors (DCs) on all identified MDs, which occurred at both a health facility and at community level.

4.7 Recruitment and training of data collection staff

Two DCs) were recruited to assist the Principal Investigator (PI) throughout the data collection period. The DCs were recruited through interviews based on the following criteria: possession of a Malawi School Certificate of Examination (MSCE), at least three years research experience as a data collector and fluency in the Yao language which is the predominant language in Mangochi district. Both DCs were familiar with the district and were not employed by the health services.

A three day comprehensive training for the DCs was conducted before the study was commenced. During the training, the study protocol was reviewed with emphasis on the data collection tools. The DCs were also trained on good interviewing skills and ethics in research. To ensure a standard way of data collection, appropriate completion of all the data collection tools was discussed. The DCs went through the English and Yao verbal autopsy (VA) tool line by line and counter-checked the Yao tool if it was reflecting the English version since they were fluent Yao speakers. All errors in Yao language were corrected.

4.8 Pilot study

Following the training of the DCs, a pilot study was conducted in Machinga district. The purpose of conducting a pilot study is to test the methods and data collection tools prior to a larger study in order to improve the quality and efficiency of the method (De Vaus 2002). Machinga district was selected because it shares similar characteristics with the study district, Mangochi, in terms of culture, geographical location and ethnic group.

The pilot study lasted for four weeks from October to November 2011.The pilot study started with orientation of the district health authorities, senior HSAs and the TAS Results of the pilot study are not part of this thesis. However, challenges/problems identified during the pilot study guided the design of the main study. Problems identified during the pilot study were:

- Lack of awareness of the study by some village headmen because they were not included in the orientation.
- Difficulties in locating the relatives of the deceased for VA as we only oriented the senior HSAs during the pilot study and discovered that most senior HSAs were not very familiar with some villages as their main role was supervision.
- Some questions on the VA questionnaire were not in logical sequence.
- We only oriented the health facility in-charges prior to the pilot study and they did not communicate with other health workers about the study, and in their absence deaths of WRA were not reported.

Based on the findings of the pilot study, tools and procedures were adjusted and amended as follows:

- The main study orientation plan was revised and included all HSAs in the district (including the senior HSAs) and village headmen.
- Before the main data collection, all HSAs were requested to brief the village headmen about the study in their respective villages within their catchment areas.
- The health facility in-charges were oriented with all health care staff in all the health facilities.
- Questions in the VA tool were reorganised in a logical sequence.

4.9 District sensitization meetings and communication

After the pilot study, successive half day awareness meetings with District Health Officer (DHO), District Nursing Officer (DNO), District Environmental Health Officer (DEHO) and health facility in-charges, five zone coordinators, nine cluster supervisors and senior HSAs took place to create awareness about the study. The zone supervisors accompanied by the PI and the DCs conducted separate district-wide sensitization meetings of staff for all health facilities in Mangochi district. Separate meetings to brief all HSAs in the nine clusters in the district by the PI, DCs and the cluster supervisors followed. HSAs with assistance of the cluster

supervisors supplemented sensitization of village headmen to reach out to everyone in the district. Details of orientation are outlined in Table 4.5. The sensitization meetings were used to emphasize the roles and responsibilities of each party.

During the sensitization meetings, health facility in-charges, clinicians, nurses and HSAs were advised to continue reporting all deaths and send reports as per existing protocol. However, for the purpose of the present study deaths of all WRA including MDs were to be reported immediately as they occurred for a period of one year. This was done through a focal person designated in each health facility whose responsibility was to report deaths of WRA as they occurred to the PI and the DCs via a telephone call, by sending a text message (SMS) requesting call-back or by sending written reports to the PI. A call-back message is a free service offered by mobile providers in Malawi.

HSAs were requested to report all deaths from their catchment area regardless of whether the death occurred at the facility or community level via telephone or by to sending reports through the Cluster Supervisor who visited the HSAs every fortnight. This was to ensure capture of deaths which occurred at community level and had not been reported at health facility level as well as all deaths of WRA that had occurred in the HAS's target population and in a health facility.

Telephone numbers (mobile and landline telephones for all facilities, individual health workers at the facilities, zone coordinators, cluster supervisors and HSAs) were collected and used by the PI and DCs for communication during the entire study period. Similarly, phone numbers for the PI and the DCs were posted on the notice boards of the all the health facility and were provided to all HSAs.

In addition, the cluster supervisors were requested to include the study as one of the agenda items during their monthly meetings with HSAs to ensure capture of any deaths of WRA which may not have been reported. The PI accompanied the cluster supervisors every quarter to these meetings to give an update on the study and receive feedback from the HSAs.

Every fortnight the PI and the DCs made phone calls to each of the 46 health facilities and senior HSAs in the district to verify deaths and check if there had been any deaths which may not have been reported.

Table 4.5: Schedule for orientation meetings in Mangochi district

Staff cadre	Total number of attendees	Date of meeting
Zone coordinators and cluster supervisors	14	11th November 2011
Mangochi District Hospital staff (DHO, Matron, Administrator Clinicians and Nurses)	17	15th November 2011
Monkeybay hospital staff (Administrator, Clinicians and nurses)	9	15th November 2011
St Martins hospital staff (Administrator, Clinicians and Nurses)	4	16th November 2011
Mulibwanji hospital staff (Administrator, Clinicians and Nurses)	6	16th November 2011
Mangochi cluster and Malombe HSAs and H/C staff	140	17th November 2011
Malombe cluster	30	18th November 2011
Nankumba cluster	101	22nd November 2011
Chilipa cluster	74	23rd November 2011
Makanjira cluster	48	24th November 2011
Lungwena cluster	47	25th November 2011
Katuli cluster	48	28th November 2011
Namwera cluster	46	29th November 201l
Nkumba cluster	69	30th November 2011
Total Number of staff oriented	**639**	

4.10 Data Collection

4.10.1 Identification of deaths of WRA

All deaths of WRA were reported whether occurred at health facilities or community level from 1st December 2011 to 30 November 2012. Data on all MDs recorded by the Safe Motherhood

Coordinator and in HMIS for Mangochi district was also documented during the entire study period.

4.10.1.1 ***Identification of deaths of WRA and MD occurring at health facility level***

The PI and DCs collected data on all deaths of WRA in facilities with assistance from focal persons/ other health care providers from all the health facilities in the district. The focal person was designated at each health facility to take charge of reporting all deaths of WRA to the DCs and the PI and acted as a contact person for any relevant issues pertaining to the study. This person was chosen by the co-workers during the orientation workshop. The advantage of having this focal person was that he or she provided a unique opportunity to facilitate easy communication between the facility and the study team. The disadvantages were 1) the task added an additional workload and 2) in cases where he or she was not on duty, deaths may not have been reported. To deal with these two problems, all health workers were oriented to assist reporting deaths when the focal person was away. To reduce workload, the focal person was allowed to work over weekend and was remunerated for the extra hours.

The identification of deaths of WRA was not limited to obstetric wards only but included all the wards and departments where women received care, such as outpatient department, female wards, TB ward, antenatal, postnatal, labour ward, theatre, psychiatric ward and mortuary. Figure, 4.3 gives a summary of the identification process of all deaths of WRA at facility level which was as follows:

A. Identification of deaths of WRA

- Each health facility had a focal person who reported any deaths of WRA to either the PI or the DCs once a death occurs by a telephone call and documented the details of the death on the facility identification form [Appendix 4a] and send to either the PI or DCs.
- This focal person made sure no death was missed at a facility by checking all the registers where WRA received any service.
- In addition, the PI and DCs visited all 46 health care facilities every quarter and checked vital registers at the facility to identify any missed WRA death.
- The monthly reports from all the health facilities which were sent to the district hospital were reviewed on a monthly basis to check for any deaths of WRA. The PI

also checked with the HMIS office for any deaths of WRA recorded in their databases every month to avoid missing any.

- As deaths could be recorded in more than one register, the detail of the deceased was cross-checked and any duplication was corrected.
- A list of all facility deaths was created every month.

B. Decision regarding whether this is a MD or not

- The form (Appendix 4a) was reviewed to identify if they were MDs.
- In addition, the deceased's case notes (patient file) were reviewed by the PI to check for pregnancy status of the woman. Information on diagnosis, cause of death, treatments, procedures, obstetric history and demographics were extracted by the PI and documented on the form in Appendix 4c. The purpose of this extraction was not to review clinical management or procedures, but to collect details to assist to confirm a MD.
- When data collected from the facility were not clear, relatives of the deceased were contacted and asked questions through the HSA to determine pregnancy status at the time of death.
- Once all details were verified, the death was classified as a maternal death or not by the PI using the ICD-10 WHO definition of a maternal death: "the 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 incidental causes." (WHO 2004c).
- All deaths were reviewed by panel of experts who classified the deaths a maternal or not using the ICD-MM.

4.10.1.2 ***Identification of WRA deaths and MD occurring at community level***

At community level, all deaths of WRA were identified by HSAs. The procedure for identifying deaths of WRA at community level was as follows:

A. Identification of deaths of WRA

Deaths of WRA at community level were identified as follows: (Details are in Figure 4.3)

- HSAs cooperated with village leaders (who keep records of births and deaths in their villages), community members, Traditional Birth Attendants (TBA) and Traditional Healers to identify deaths of WRA in their catchment area.
- Once a death occurred, the HSAs reported this to the PI, DCs or cluster supervisors by phone.
- As soon as the death of WRA at community level was reported, the PI or the DCs called the HSAs to get the details of the deceased. This information was recorded on the community identification form [Appendix 4b].
- In addition, the PI or DCs contacted cluster supervisors fortnightly to check if any WRA deaths had been reported to them.
- Every month, the HSAs and village leaders agreed on the final number of WRA deaths in their villages to make sure no death was missed.

C. Decision regarding whether MD or not

- When details of the pregnancy status of the deceased were not clear from the HSA's information, families of the deceased were visited by the PI to get the additional information needed to classify the death as maternal or not.
- Once all details were available, the death was classified as a maternal death or not by the PI using the ICD-10 WHO definition of a maternal death.
- All deaths were reviewed by panel of experts who classified the deaths as maternal or not using the ICD-MM.

All the deaths which occurred at facility level were also reported at community level because HSAs reported facility deaths as well as deaths occurring in the community (not at facility). Duplicated deaths were removed from the list by looking at the deceased's demographic data and address. This was done by the PI and DCs in consultation with the HSAs who knew the deceased's addresses and names. A final list of WRA who had died for each community (population) was created every month by the PI, DCs and HSAs.

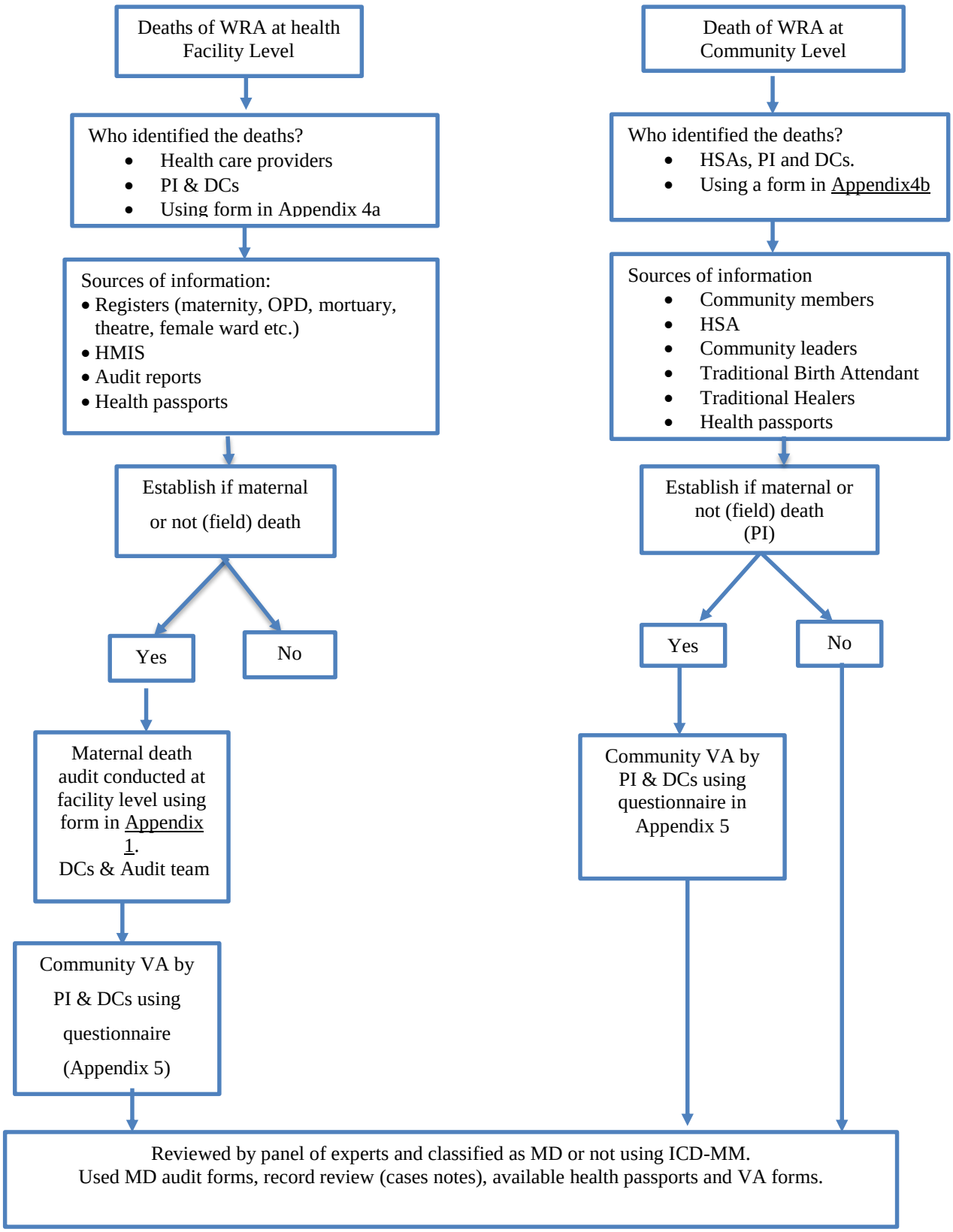


Figure 4.3: Identification of Deaths of WRA and Maternal Deaths (MD) in Mangochi District

4.10.2 Identification of cause of and factors contributing to maternal death

In this study, information was collected to assist in attributing cause and in identifying factors associated with MD. Information was obtained via facility-based MD audit forms, record review (cases notes), available health passports and verbal autopsy.

4.10.2.1 ***Facility-based maternal death audit and case-note review***

It is a requirement in Malawi that all MDs occurring at health facilities are audited as described in section 2.5.5 in chapter 2. During the study period, information of all the 86 audited MDs was documented on the MDA2. These were photocopied (because the original belonged to the facility) to be used for cause classification. To triangulate information from the MDA2s, case notes of all MDs that were identified from health facilities were reviewed by the PI and information was recorded on a record review form by the PI [see Appendix 4c]. The purpose of reviewing case notes was to obtain any additional information on cause and contributing factors including information with regard to history and treatment the woman had received in the health facility.

4.10.2.2 ***Conduct of Verbal Autopsies***

Prior to VA, the HSA responsible for the area where the woman had lived, had contacted the family members or people who knew the deceased woman and explained the purpose of the VA. Then an appointment was made after a two to three weeks delay in order not to intrude on the family's period of mourning.

We selected respondents who were present during the illness/condition that led to the death and were able to describe the signs and symptoms and any medical consultations (if any) prior to death. These included the spouses, sisters, mothers, fathers, mothers-in-law, grandmothers, neighbours and/or TBA. Sometimes it was useful to interview a number of respondents to obtain a more complete picture of the circumstances preceding the death. This was done when more than one person was in contact with the deceased woman during the illness that led to her death.

On the day of interview, permission was sought from the village headman to meet the family members. To gain trust of the gate keepers in the community, all the village leaders were oriented on the study with permission from the District Commissioner (DC) who is the in charge of all the villages [permission letter, Appendix 12]. The PI and the DCs carried the permission letter every time VA were conducted to which reminded the village leaders.

During the interview the family members or other people with knowledge about the death were also asked to describe the situation surrounding the death. The events leading to the death were recorded on the questionnaire [see Appendix 5]. To capture as much information from the deceased relatives, permission was sought to record the interviews. The purpose of recording was to capture as much information about the deaths. Sometimes there were more than one relative who were present at the time of deaths and tape recording assisted to capture information from each one of them. Almost half of the relatives (71/151) accepted tape recording. For the relatives who refused tape recording two DCs assisted each other in documentation of information.

Efforts were made to keep the interval between death and the interview as short as possible and appropriate. Most interviews were completed within one month of the death.

4.10.2.3 ***Health Passport***

A health passport is an individual booklet which was introduced by the MOH to improve the quality of individual health care (MOH, 2003). There are three booklets: specific for a child and a woman and general one. What the booklet contains depends on depends on them being used at each visit e.g. assessment of current problems and type of care given. The woman health booklet contains specific information on tetanus toxoids injection, family planning services, antenatal check-ups, obstetric history and postnatal services as well as her general history. A total of 74 women had health passports which assisted in assigning the cause of death. Health passports for the other women were either misplaced by the relatives or buried with the deceased.

4.11 Establishing cause of maternal death

Accurate identification and classification of the cause of a MD may prove difficult in the absence of clear criteria and guidance because of the relationships between different conditions that may be reported as cause(s) of death and/or contribute to that death (WHO 2009a). Methods of cause of death assignment include physician review of VA, ICD-10 certification coding and computerised algorithms (interVA). This study used three methods to assign the cause of death as follows:

1) MDA for MDs that occurred at health facility
2) Physician review (referred to as panel of experts in this thesis) using VA, case notes, health passports and MDA2 of VA forms from both health facility and community.
3) Interpretation of verbal autopsy data number 4, (interVA-4) (Byass et al. 2012).

4.11.1 Cause of death assigned at health facility using the MDA

All the MDs captured by the HMIS which occurred at facility level were audited by the MDA team and information on cause of death, contributing factors and associated factors to MD were documented on MDA2 [Appendix 1].

We applied the ICD-MM to the cause of death and contributing factors on the MDA2 form to assess any discrepancies in cause classification (WHO 2012c). The ICD-MM is a new recommended standard tool by WHO linked to ICD-10 developed to promote national and international comparability. Details of ICD-MM are described in section 4.11.2.1 below.

In addition we compared the causes assigned by the MDA team on all the health facility deaths audited with cause classification by panel of experts (described below) on the same cases using ICD-MM [Appendix 6].

4.11.2 Cause classification by the panel of experts

The panel of experts comprised of two obstetrician-gynaecologists and a midwife. Two obstetricians and the midwife had experience of working in low resource settings. The panel of experts were selected based on set criterion by the PI and research supervisors. The criteria were:

1. Senior obstetricians and gynaecologists and midwife with over five years of experience working in a developing country (countries). This was done to ensure that outcomes from panel of experts' deliberation could leverage their wealth of experience.
2. The reviewers should not been involved in the conceptualisation of the study, to reduce observer bias

All completed VA questionnaires, MDA forms and copies of case notes for facility maternal deaths were retrieved from the data storage and given to the panel of experts sequentially for review and assigning cause of death.

Each assessor independently reviewed all the VA questionnaires , MDA and case notes, health passports for other women and assigned a single cause of death (COD) based on the WHO tool which applies ICD-10 to assign causes of deaths during Pregnancy, Childbirth and the Puerperium (ICD-MM) (WHO 2012c).

If at least two of the assigned CODs for each death were identical, this was taken as the final COD for the deceased. However, if all the three assigned CODs were different the experts held a consensus meeting and reviewed the case. Agreement of three reviewers was necessary in this case to assign a final cause of death. In cases where these experts did not reach agreement a third independent Senior Obstetrician Gynaecologist with experience working in developing countries was consulted to assign a COD. The cause was assigned a "not determined/unknown" code if information was not clear. If there was no adequate information to assign a definite cause, the code "unknown" was assigned.

4.11.2.1 ***The WHO Application of ICD 10 to deaths during pregnancy, childbirth, and the puerperium (ICD-MM)***

The panel of experts used the ICD-MM to assign cause of death and contributing factors. The ICD-10 is the tenth revision of the international classification of diseases and related health problems and is a recognized international standard for classifying mortality and morbidity (MOH, 2012a).

Recent evidence has shown MD identification, attribution and classification are inconsistent or absent in most developing countries owing complicated the ICD-10 coding (Say & Chou 2011). The WHO, therefore led the development of the simplified application of ICD-10 to deaths during pregnancy, childbirth and the puerperium, the ICD Maternal Mortality (ICD-MM) in 2012 (Table 4.6). The ICD-10 is the tenth revision of the international classification

of diseases and related health problems and is a well-recognized international standard for classifying mortality and morbidity (WHO 2012a).

The ICD-MM is based on the ICD-10 coding and its coding rules (WHO 2012c). It is intended to facilitate the consistent collection, analysis and interpretation of information on MDs at both facility and community level. The WHO recommends that all countries incorporate the principles of ICD-MM into their maternal death data collection system. By using the same classification, reliable comparisons can be made within and between countries and regions (Pattinson et al. 2009). The ICD-MM classification is simpler and easy than using the full version of ICD-10 version.

Another added advantage is that there are different levels of classification depending information availability which makes this classification applicable at community or primary health care level. Also there are some clarifications on conditions that formerly led to confusion in cause assignment such as obstructed labour and HIV. The ICD-MM also helps to classify cause of MDs as either underlying cause or contributory condition.

4.11.2.2 ***Underlying cause of death***

Underlying cause of death is defined as "the disease or condition that initiated the morbid chain of events leading to death or the circumstances of the accident or violence that produced a fatal injury and is seen as the cause of death" (Word Health Organisation 1992). The single identified cause of death should be as specific as possible if a death certificate has been completed correctly; the underlying cause of death should normally be the single condition not two which the certifier has written.

Countries which collect vital registration data may be able to specify cause of death at both the category or subcategory level. An example of a subcategory in the case of abortion would be the category of abortion, e.g. abortion with infection or haemorrhage [Table 4.6]. In the circumstances where cause of death is documented by verbal historical data or autopsy gathering, researchers may only be able to analyse the data to the level of group or category but not usually to sub-category level.

Table 4.6: Cause of deaths during pregnancy, childbirth and puerperium

Type		No.	Group	Category
A	Maternal deaths Direct	1	Pregnancies with abortive outcome	Abortion, miscarriage, ectopic pregnancy and other conditions leading to maternal death with abortive outcome
		2	Hypertensive disorders of Pregnancy	Oedema, proteinuria and hypertensive disorders in pregnancy, childbirth or puerperium.
		3	Obstetric Haemorrhage	Obstetric diseases or conditions directly associated with haemorrhage e.g. placenta Previa, placenta abruption and postpartum haemorrhage.
		4	Pregnancy related infections	Pregnancy-related, infection-based diseases or conditions e.g. septicaemia during labour and puerperal sepsis
		5	Other obstetric complications	All other direct obstetric conditions not included in group 1- 4 e.g. excessive vomiting in pregnancy.
B	Maternal deaths	6	Unanticipated complications of management	Severe adverse effects and other anticipated complications of medical and surgical care during pregnancy, childbirth or postpartum e.g. complications of anaesthesia, surgery or management during pregnancy, labour and delivery
C	Maternal deaths Indirect	7	Non-obstetric complications	All indirect non-obstetric conditions not included in the group 7 e.g. chronic hypertension, diabetes mellitus, postpartum thyroiditis
D	Maternal deaths :unspecified	8	Unknown/undetermined	Pregnancy-related deaths where the underlying cause is unknown or was not determined
E	Deaths during childbirth and the puerperium	9	Coincidental causes	Pregnancy-related deaths due to external causes e.g. motor vehicle accident, assault and rape during pregnancy, childbirth or postpartum

Source: The WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium: ICD-MM, 2012

4.11.2.3 ***Contributory conditions***

Contributory conditions describe complications that may have contributed to, the risk factors or factors that may be associated with a death, but are not the underlying cause. Contributing conditions may predispose women to death either as pre-existing risk factor or because women develop associated complications in due course. It is possible that more than one contributing condition may exist and multiple coding of such conditions is permitted (WHO 2012d). For example, a woman who may die of postpartum haemorrhage (PPH) may have anaemia as a contributing factor and a woman with puerperal sepsis may have HIV as a contributing factor.

In this study the panel of experts assigned contributing conditions to maternal deaths based on ICD-MM. These contributing conditions were compared with contributing conditions assigned by the health professional to MDs on MDA2 which occurred in the health facilities.

4.11.3 The InterVA-4 Model

The required indicators from the VA data collected in this study were extracted and entered into the software to automatically generate CODs. Causes of maternal deaths generated by the InterVA-4 model were compared with causes assigned by the panel of experts to assess any differences.

4.12 Factors associated with maternal deaths

4.12.1 The three delay model

The three phases delay model was used to classify factors associated with maternal deaths in the present study (Thaddeus & Maine 1994).

The three delay model recognizes the different barriers women face to achieve the timely and effective medical care needed to prevent deaths occurring in pregnancy and childbirth (Thaddeus & Maine 1994). Thaddeus and Maine have argued that delays in reaching adequate care are prominent factors that contribute to MDs especially in resource-poor nations.

Thaddeus and Maine related lack of care to three factors, delay in deciding to seek care (delay 1), delay in reaching the health facility (delay 2) and delay in receiving quality care once at the health facility (delay 3). Their work offered a new approach to examining MM using a three-phase framework to understand reasons for delays in the management of obstetric emergencies

(Pacagnella et al. 2012a). The delay model helps to identify community and health service factors contributing to MDs.

In the present study delays were defined as follows:

- Delay 1- the delay to recognize illness and deciding to seek appropriate medical help for an obstetric emergency (demand side barriers). This may be due to failure to recognize complications, acceptance of maternal death as a normal or inevitable, low status of women and socio-cultural barriers to seeking care such as women's mobility, ability to command resources, decision-making abilities, beliefs and practices surrounding childbirth and delivery, nutrition and education (Pacagnella et al. 2012a). This delay applied to any woman who died at home or where it took more than 12 hours to seek outside care after the problem was identified.

- Delay 2 - The transport delay in reaching an appropriate obstetric facility (may be due to lack of poor roads, mountains, islands, rivers transport, or poor organization) (Thaddeus and Maine, 1994). In this study, this included maternal deaths where caregivers expressed problems with getting transport to receive care.

- Delay 3 (supply side barriers) - the delay in receiving quality care when a facility is reached (may be due to supplies, personnel, poor training inadequate facilities and demotivation of personnel or lack of finances (Thorsen et al., 2012)). This also included delay in receiving or failure to receive quality care (substandard care) as judged by the pre-existing care standards required to manage the case.

4.13 Data management during data collection

4.13.1 Ensuring complete data capture

4.13.1.1 ***Review meetings***

Review meetings with facility in-charges, focal facility persons, cluster supervisors, zone coordinators and HSAs were conducted every quarter to monitor data capture, identify

challenges and identify ways to improve methods where needed. There were a total of four review meetings during the study period. These meetings were facilitated by the PI, DCs and cluster supervisors. During the review meetings, the PI compared the compiled list of WRA deaths for the entire quarter with the facility and community deaths report lists in the area. Any strengths and problems were discussed. Problems identified during the review meetings included:

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- Part of the Phirilongwe health centre catchment area had a weak telephone network and sometimes it was difficult to report immediately when a death occurred. Therefore, it was agreed during one of the review meetings that once a death of a WRA occurred in the area, the HSAs or health worker should send a report containing details of the deceased through the cluster supervisors who were visiting the area fortnightly. Furthermore, the responsible HSAs and health workers were asked to send a call-back message to the PI and DCs once network was available to check if the information sent reached the research team. The PI and DCs counter-checked number of deaths during the quarterly review meetings in the area.

- A cluster supervisor for Lungwena area left for further studies but he was immediately replaced by a new cluster supervisor who was oriented on the study.

- Three HSAs from Chilipa, Makanjira and Namwera clusters were transferred to other districts and one HSA from the Mangochi cluster died during the study period. These four HSAs were not replaced during the study period. The senior HSAs responsible for the catchment areas took over their roles and responsibilities while awaiting new postings.

4.13.1.2 ***Triangulation***

Every month a list of deaths of WRA from the facility and community deaths were compared. The lists detailed each woman's birth date, place and date of death, address and admission number if the death had occurred at a health facility. Both lists were checked against each other by the PI and the DCs to assess for duplication. Duplication was identified by checking similar personal details of the deceased women. Almost all the facility deaths were duplicated on the community list because of the death identification system which was put in place at community level. HSAs were advised during the orientation period to report any death of a WRA regardless of place of death. This implied all the health facility deaths were to appear on the community

list. This step was taken to ensure that all deaths were captured. Once duplication was identified; the case was removed from the list by the PI in liaison with the HSAs who were aware of every woman's details in their catchment area.

At the end of the study, a comprehensive list of deaths WRA from all sources (all health facilities and communities) was created. The PI and the DCs checked the list again and no duplicated information was identified.

4.13.1.3 ***Study supervision***

The PI checked for completeness and accuracy of the forms throughout data collection period. All data collection forms were reviewed soon after field work for any mistakes which were corrected before processing data. If any information was not clear on the forms, the PI asked for clarification from the DCs. Post data collection meetings were held every day to evaluate everyday work and address any problems during the data collection process. Planned and ad-hoc meetings were held between the PI and the PhD supervisors on issues requiring urgent attention.

Both DCs were supervised by the PI twice a week during the fieldwork. The PI accompanied each DC separately and observed the interviews. Only minor problems were encountered during the study period. Discussions were held after each supervisory visit to rectify any shortfalls. Examples of problems identified were:

- Repetitions of questions during verbal autopsies as some questions were already answered before actually asking them.
- Illegible handwriting

The trained DCs were advised to be attentive during interviews to avoid repetition of questions already answered in the course of the interview. They were also advised to probe more when the response was not clear. The DCs were also advised to fill the forms clearly in English so that everyone would be able to read them.

4.13.2 Data protection

In order to maintain the confidentiality and integrity of data, the research team was fully trained about data protection procedures before data was gathered. To protect the data from physical damage as well as from tampering, loss or theft, a locked cabinet was placed in the office established at Mangochi District Hospital. Only the PI held the keys and DCs could only access the cabinet with consent from the PI. The PI and the DCs each had a secure bag which was used to carry all field work materials during field work. The PI collected all completed study forms and signed consent forms from the DCs on each day after data collection in the community. Consent forms were kept in a locked cupboard.

4.13.3 Data entry

Before entering the data, paper record sorting was done sequentially as the deaths occurred. Visual checks were made to remove obvious mistakes, and we were able to correct all the mistakes. All the completed forms and questionnaires were coded in succession in preparation for data entry. All completed forms were checked by PI to identify any missing information. Each tool was assigned a code number from the start of data collection. No names were used throughout the study. A database was created using the Statistical Package for the Social Sciences version 21. The file was protected with a password and saved with a relevant number. Back-ups were created on an external hard drive protected by a password every time new data was entered. Data entry was done by a data entry clerk who was well experienced with SPSS and was oriented on all the data collection instruments.

4.13.4 Data cleaning

After data entry, data was checked for correct coding, missing values, typing errors and variable naming were made. Missing values were corrected by verifying with the source documents (the original data collection tools). If the value was missing in the source document a follow-up of the case with the HSAs in the field was done to clarify the missing data. It was recorded as a missing value if the case could not be traced.

4.13.5 Data quality control

An important aspect of quality control in scientific investigations is monitoring data entry error rates to ensure that erroneous values do not contaminate the data and associated analysis (Reynolds-Haertle & McBride 1992). Data entry errors can have effects on the results and conclusions. The common practice for data entry has been a double data entry which is more

effective than single entry in reducing the data entry errors (Reynolds-Haertle & McBride 1992; University of Nevada 2011). Double data entry was done by two different people. Errors in data entry between the two data sets were checked sorting the data in A to Z Microsoft excel. We then compared cell-by-cell to find any inconsistencies between the two entries. Errors were corrected by verifying with the source documents.

4.14 Data storage

After field work was completed, all forms were sealed in cartons and sent by courier to Liverpool School of Tropical Medicine (LSTM) where forms were placed in a locked cupboard accessible only by the PI and supervisors. Data were only released to the reviewers to assign cause of death by consent from the PI. The reviewers signed for the forms collected for review and all the forms were put back in the locked cupboard when the exercise was completed. As per LSTM policy forms will be destroyed after 5 years. Electronic were protected by a password only accessible to the researchers

4.15 Data analysis

Data were analysed using SPSS version 21.0. Demographic data were analysed using descriptive and inferential statistics. Continuous data were summarised using means with standard deviations (SDs) and categorical data using proportions, 95% CI were used for both continuous and categorical data. The maternal age was stratified into 6 groups: 15–19 years; 20–24 years; 25-29; 30-34; 35–39 years; 40-45 and 45-49 years. This division was undertaken to explore age-related differences associated with maternal mortality. The demographic characteristics were sometimes collapsed depending on the type of analysis.

To compare differences in proportion and differences in frequencies of categorical variables .i.e. factors possibly associated with death of WRA and MDs, the Pearson's chi-squared test was used. Fisher's exact test was used for contingency tables where the expected value in any of the cells was <5. Statistical significance was determined at $p<0.05$. Analysis of Variance (ANOVA) was used to test differences of more than two means.

The chi-squared test for trend was used to assess the trend in the proportion of deaths over different ordered categories such as age group, level of education and parity we used. Ninety five (95%) CI was used to assess the effect of different demographic variables on the risk of maternal death and the level of significance was p = 0.05.

The level of agreement was measured using Cohen's kappa statistics (for two raters). Kappa statistics measures an agreement between different observers or raters of categorical or binary rating scale. The measure compares the level of agreement between two raters of a group of variables to the proportion that would be expected to occur by chance alone. In this study, it was used to compare the following pairs:

- Cause classification of MD by the panel of expert's pairs.
- Cause classification of MD by the panel of experts and health professionals.
- Cause classification of MD by the panel of experts and the InterVa-4 model.

Fleiss' kappa statistic was used to measure the level of agreement in more than two raters. Fleiss' kappa works for any number of raters giving categorical ratings to a fixed number of items (Fleiss, 1971). It can be interpreted as expressing the extent to which the observed amount of agreement among raters exceeds what would be expected if all raters made their ratings completely randomly.

It is important to note that whereas Cohen's kappa assumes the same two raters have rated a set of items the Fleiss Kappa. In this study Fleiss' kappa was used to assess the agreement of the three member panel in assigning cause of MDs.

In this study kappa interpretation was done according to Landis and Koch (1977), Table 4.7.

Table 4.7: Interpretation of kappa statistics

Kappa (*K*)	**Interpretation**
>0	No agreement
0.01-0.2.0	None to slight agreement
0.21- 0.40	Fair agreement
0.41- 0.60	Moderate agreement
0.61-0.80	Substantial agreement

0.81-1	Almost perfect agreement

Source: Landis and Koch (1977)

4.16 Indicators of maternal mortality

While the number of MDs occurring in a given locality is useful to measure the magnitude that can be used for planning, a number cannot be used as an indicator to measure change or make comparisons between locations (WHO 2006). Instead there are other distinct measures for estimating MM; the MMR, Maternal Mortality Rate (MMRate), the Life Time Risk (LTR) of maternal death and the proportion of adult female deaths due to maternal causes (PMFD) (Abou Zahr et al. 2004) [Table 4.8].

MMR is mostly used and depicts the risk of maternal death relative to the frequency of childbearing (Wilmoth 2009). Sometimes it can be difficult to obtain the total number of live births especially in countries with no civil registration system in place. Therefore MMR can be calculated by dividing the MMRate by the General Fertility Rate (GFR) as indicated in Table 4.8.

MMR is not age-standardised which makes it less comparable across countries. It ignores the fact that women will face this risk per birth several times in lifespan, and only captures the risk of death once pregnant (Graham & Hussein 2003b). MMR should not be displayed as a point estimate as it indicates a degree of unjustifiable precision rather much more accurate to give the estimate based on confidence interval (Graham & Hussein 2003a). It is important to display MMR with confidence limit to indicate the degree of precision especially in countries without reliable sources. MMR can sometimes inflate the risk by not including those pregnancies that ended in still-births in its denominator.

The related measure, the MMRate reflects not only the risk of maternal death per pregnancy or per birth, but also the level of fertility in a population, (WHO 2007a). The lifetime risk, or probability, of maternal death in a population is another measure. The lifetime risk of maternal mortality describes the cumulative loss of human life due to maternal death over the female

life course (WHO 2007a)**.** The proportion maternal of deaths among women of reproductive age (PM) reflects contribution of maternal deaths to overall mortality among women of reproductive age [Table 4.8]

Table 4.8: Indicators of maternal mortality

Indicator	Definition
MMR: expresses obstetric risk	Number of maternal deaths * 100000 Number of live births
Maternal mortality rate (MMRate): risk of maternal death among women of reproductive age	Number of maternal deaths * 1000 Number of women aged 15-49 years
The relationship between the MMRate and the MMR	MMR = MMRate General Fertility Rate
The lifetime risk of maternal death: chances of a woman dying from maternal causes over her 35-year reproductive life span.	LTR = 1-(1-MMRatio/100000)TFR
The proportion of maternal deaths among the number of deaths in women aged 15-49 years PM	Number of maternal deaths * 100,000 Total deaths in women aged 15-49years

(AbouZahr 2010)

In this study two indicators were calculated: the PM and the MMR. The denominator used to calculate PM was the number of all deaths of women aged 15-49 years identified during using the formulae in Table 4.8.

We calculated the estimated MMR using the formulae in Table 4.8. The best denominator for calculating the MMR is the total number of all pregnancies in the population during the study period (WHO 1991a). However, it is not possible to obtain an accurate number of all pregnancies that occurred. It is however, accepted practice to calculate MMR using the number of live births (WHO 1994a). However reliable source of data on live births such as civil registration for this study was unavailable, so other sources were used: 1) Immunization registers for BCG vaccinations 2) census report 3) using general fertility rate from MDHS. Multiple sources were used to compare the estimates and come up with a closer estimate.

1) **Estimating number of live births from immunisation registers**

Empirically, the number of BCG vaccinations has been found to be a reasonable proxy for live births (Songane & Bergström 2002b). New-borns receive the BCG vaccination before they leave the maternity ward and those born outside hospitals are vaccinated at the first visit to the health centre or outreach clinic. Even if delivery is at home, most mothers attend for immunisation visits of their babies. Immunisation coverage is almost universal in Malawi (97%).In Malawi, BCG vaccination is given within the first fourteen days after birth (MDHS 2011). The immunisation system targets new-born babies at both health facility and community level through static clinics (at health facilities) and outreach clinics (in the community). BCG coverage at the national level, is 97% and at 96% in Mangochi District (MDHS 2005). Figures for each district are compiled by the Expanded Programme of Immunization (EPI) coordinators every month. Each EPI coordinator submits the figures to the Ministry of Health every quarter.

In this study, the total number of BCG-vaccinated babies for Mangochi district was collected on a monthly basis from the EPI coordinator. We calculated the total monthly number of BCG vaccinations by adding all monthly reports from all 44 immunisation centres in the district. The total number of BCG-vaccinated babies documented during the study period was 39,958. We are sure that this study captured not only children born at a health facility but community live births as well because the immunisation reporting system in the district is 96% complete (HMIS 2012b). This figure was inflated by 1/0.96 to cover for the 4% of babies who did not receive BCG vaccine.

2) Estimating number of live births from national census data

Census data were also used to estimate the number of live births (NSO 2008). The projected estimated total live birth for Mangochi for 2012 was 43,000. This was calculated from raw Mangochi data from the national statistical office (NSO, 2012).

3) Estimated live births using General Fertility Rate (GFR)

GFR was selected because it is considered more accurate than the crude birth rate as it represents the population more likely to give birth. General fertility for rural Malawi was used to estimate the number of live births for Mangochi because Mangochi is a rural district in Malawi but no specific data for Mangochi were available. The GFR was estimated to be 213 per 1,000 population of WRA (National Statistics Office of Malawi 2008). The total number of WRA in Mangochi in 2012as per census projection was estimated at 207,868. Therefore using the GFR, the estimated number of births during 2012 in Mangochi was 44,276.

4.17 Study variables

The primary variables of the study were total number of deaths of WRA, MMR estimate, and underlying causes and contributing conditions using the ICD-MM and associated factors to MDs using the three delays [See Table 4.9].

Table 4.9: Study variables

Variable	Definition	Data source
Number of deaths of WRA	Women aged between 15-49 who died during the one year study period	Use of the facility and community death identification forms
(PM)	The proportion of maternal deaths among deaths in WRA	Use of the facility and community death identification forms
MMR estimate	The number of maternal deaths during a given time period per 100,000 live births during the same time-period	Number of MDs identified during the study period Live births from Immunisation register, census and using GFR
Underlying cause of MDs	The disease or condition that initiated the morbid chain of events leading to death or the circumstances of the accident or violence that produced a fatal injury	VA Case files Health passports MDA2 forms
Contributory conditions	The risk factors or complications that may have contributed to or may be associated with, but are not the underlying cause of death. Women develop associated complications.	VA Case files Health passport MDA2 forms
Associated factors	individual, community and health service factors that contribute to deaths	Vas, case files, health passport case files, MDD2 forms

4.18 Ethical considerations

4.18.1 Ethical Approvals

The study protocol was reviewed and approved by the Liverpool School of Tropical Medicine Ethics Committee (LSTMEC) and the Malawi National Health Research Ethics Committee

through the College of Medicine Research and Ethics Committee (COMREC) [Appendices 7 and 8].

Prior to the main study, letters of permission were sent to Machinga (the pilot district) and Mangochi (main study district) district hospitals and district authorities to seek permission to conduct the study. Permission to carry out the pilot and main study at the study site were granted by the Machinga and Mangochi District Health Officers (DHOs) representing the Ministry of Health and the District Commissioner (DC) representing the TAs and village headmen. Permission was granted by both districts [Appendices 9, 10 and 11].

Since most people in the study area speak Yao, translators were used (the two DCs) and a translator's agreement form was signed so that issues of confidentiality were maintained during the entire study period.

4.18.2 Ethical issues

4.18.2.1 ***Ethical issues for data collection***

Considering sensitivity of the topic, it was anticipated that the process of interviewing may cause anxiety and some respondents may break down since the interviews reminded them of the painful moments of losing their loved ones. In addition, the interviews could have effect on health care providers involved in the care of the deceased women who may have fear of being blamed or stressed as a result of the death.

To minimise the effects, all interviews were conducted in private and were kept strictly confidential. The interviews were carried out in a sensitive and non-judgemental (non-blame) manner to ensure that relatives of the deceased were made not to feel stigmatised. Relatives were informed to withdraw when uncomfortable. Then the interviews could be rescheduled. A contingent plan was made on the budget to cater for return visits if an interview has to be repeated.

Both the PI and the DCs who conducted the VA were counsellors who knew how to identify, handle distressed clients make appropriates referral when it was necessary. In case the relative of the deceased was distressed; the interview was stopped and postponed while basic counselling skills were in-order to assist the client. Special arrangement with the counselling services at nearest counselling centres were made in case of any referral. The PI and the DCs were aware of the arrangement.

No names (for both the deceased and all who were involved in the management of the deceased) were used during MDA meetings

4.18.3 Informed consent

Respondents were informed about the study through an information sheet which was read out to the deceased's relatives by the DCs. However, if a respondent wished to read the information sheet on their own, they were able to do so (Appendix 13).

Throughout the process the respondent was encouraged to ask questions on areas he/she did not understand. Respondents were also informed that data would not be shared with anyone apart from the research team and team of expert panel to ensure confidentiality and were informed that participation was solely voluntary and they could withdraw at any point or choose not to answer any particular question without any consequences.

Respondents were informed that code numbers were used to maintain anonymity and confidentiality. No names were used during the tape-recording and the relatives were informed not to mention their names. At the end the respondent was asked a few questions from the information sheet to check the level of comprehension.

When respondents understood and voluntarily agreed to participate in the study, they were asked to sign an informed consent (Appendix 14). For illiterate respondents the signing was done by thumb printing while a witness attested the consent procedure. The information on the consent forms was also translated from English into Yao.

4.18.3.1 ***Ethical issues for data management and storage***

Throughout the data collection period all notes and completed questionnaires were secured in a locked drawer and were only be accessible to the researcher and the DCs.
DCs were trained on data collection to ensure data quality and integrity of research ethics.
Relative's names were not requested, but were coded.

Data was stored securely for the 5-year period, after which they will be destroyed, following the guidelines of the university on data security. The laptop containing all data was password protected and only the PI knew the password.

4.19 Chapter summary

This chapter has described in detail the study site and methods used to achieve the objectives of the study. This was a prospective descriptive study which took place in Mangochi, a district in rural populated district in Malawi with poor maternal health indicators compared to national level. The study was approved by two ethics committees

The study which used the RAMOS approach to collect data on deaths of WRA for a period of one year using data collection instruments which were adopted and adapted based on literature review Deaths of WRA were identified at facility and community level and MDs were identified based on ICD-10 definition.

Cause classification of MDs was based on three methods: health professionals, panel of experts and InterVA-4 model using ICD-MM and ICD-10. MMR were calculated based on three denominators to come up with a closer estimate Data quality was ensured through trainings, pilot study, double data entry and strict storage measures. Data were analysed using SPSS.

5 RESULTS: DEATHS OF WOMEN OF REPRODUCTIVE AGE

5.1 Chapter overview

This chapter presents results regarding all deaths of women of reproductive age (WRA) identified during the study period. The chapter responds to objective one and two of the study. The main outcome of this study was maternal mortality (levels, causes and factors associated with maternal deaths (MD)). Results of this chapter are not the primary outcome of this research but the by-product of the data collection needed to identify MDs. However, the results are presented due to rarity of data on female deaths related to other causes than other than maternal. There are interesting results presented in this chapter that would inform future research as it was beyond the scope of this study into further detail with regard to non-MDs.

There are six main sections in this chapter which include: Sections 5.2 and 5.3, which describe deaths of WRA in terms of numbers and social demographic characteristics of all WRA in general. Place of death is presented in section 5.4. The chapter proceeds with the classification of deaths of WRA into maternal and non-maternal deaths and comparing characteristics of maternal and non-maternal deaths in section 5.5.

Section 5.6 describes cause of death of WRA who died of other non-pregnancy causes in health facility. Causes of non-maternal deaths that occurred outside health facilities were excluded because there were no formal medical attentions given or records available to identify the cause, and it was not possible to conduct a verbal autopsy (VA) as part of this study.

The COD presented in this section were derived from either case notes or health passports of the deceased and were assigned by skilled health workers (medical assistants, clinical officers, doctors and nurses) in the Mangochi district. Causes of all maternal deaths (MDs) are presented in chapters 7 and 8.

5.2 Deaths among Women of Reproductive Age (WRA)

Over a period of twelve months from 1st December 2011 to 30th November 2012, a total of 429 deaths of WRA (15 to 49 years) were identified in Mangochi district. Five deaths out of the 429 have been excluded from the analysis because they did not meet the study criteria which required exclusion of any death a WRA who was not residing in Mangochi district but died in

the district. The five women died in Mangochi health facilities but came from bordering districts of Mozambique to seek care. A total of 424 deaths were included in the final analysis.

5.3 Socio-demographic Characteristics of Deaths of WRA

5.3.1 Age

The ages at death used in this study are as reported by the relatives of the deceased WRA. All relatives reported the ages of their deceased. Relatives of 70.5% (299/424) gave the exact date of birth and age in years while 29.5% (125/424) reported only the age in years. Among the relatives who gave the exact date of birth, 4.3% (13/299) miscalculated the actual age at death and correct ages were calculated by the PI based on date of birth and were used in this study.

The 125 deaths whose relatives gave only age in years were assessed for any rounding by assessing if the ages were a multiple of 5. In mathematics rounding of figures is expected when more than 20% of the numbers given are a multiple of 5 (Wei Lee, Christopher Mulliss & Hung-Chih Chi 2000). Among the relatives who gave age without date of birth, only 14.4% (18/125) of the ages were multiples of 5, which may imply no rounding of the ages was done.

Among deaths of all WRA (n=424) the mean (SD) age was 30 (8.2) years, and the age range was 15 to 48 years. About 10.8% (46/424) of the deaths were among women aged 15-19 years and 32.5% (138/424) were 35 years and above.

5.3.1.1 ***Distribution of death of WRA according to Age groups***

Deaths of WRA were divided according to age groups to assess any differences in the proportion of deaths among different age groups. Table 5.1 shows the proportion of deaths according to population size per age group. An analysis of variance (ANOVA) was used compare the mean proportions of deaths among the age groups. The test revealed an overall significant difference among different age groups (p =0.041).

Table 5.1: Distribution of deaths of WRA by age groups

Age group	Number of deaths	Population per age group*	%
15-19	46	48,704	0.1
20-24	79	40,303	0.2
25-29	69	35021	0.2
30-34	92	29,646	0.3

35-39	62	22,262	0.3
40-44	54	19,373	0.2
45-49	22	12,559	0.2
15-49	**424**	207,868	**0.2**

**The population of WRA for each age group was estimated using the projected population 2012 from census for 2008 (NSO 2008)*

5.3.1.2 Comparing mortality rate among the age groups with the national data

The age- specific mortality rates of WRA from this study were compared to age specific deaths of WRA at a national level from MDHS (MDHS 2011). The national data was used as a reference because there was no specific data for the Mangochi district. Table 5.2 presents age-specific mortality rates for each age group.

Findings revealed, on average, Mangochi district had a higher mortality death rate of WRA compared to the national level, (2.0/1,000 and 1.4/1,000 respectively, p=<0.001), Table 5.2. The overall pattern of death rate is similar albeit on the lower level for Mangochi and the national data for age groups 15-19 to 34-39 where an increase in the deaths of WRA is observed and a decrease on group 45-49 [Figure 5.1].

Table 5.2: Mortality rate among the age groups compared to national level

Age group	Number of deaths of WRA	Population of (WRA**)	Mortality rate-per 1,000 Study	Mortality rate per 1,000, MDHS, 2011
15-19	46	48,704	0.9	0.6
20-24	79	40,303	2.0	0.8
25-29	69	35,021	2.0	1.4
30-34	92	29,646	3.4	2.1
35-39	62	22,262	2.7	2.2
40-44	54	19,373	2.8	2.6
45-49	22	12,559	1.8	2.4
15-49	**424**	**207,868**	**2.0**	**1.4**

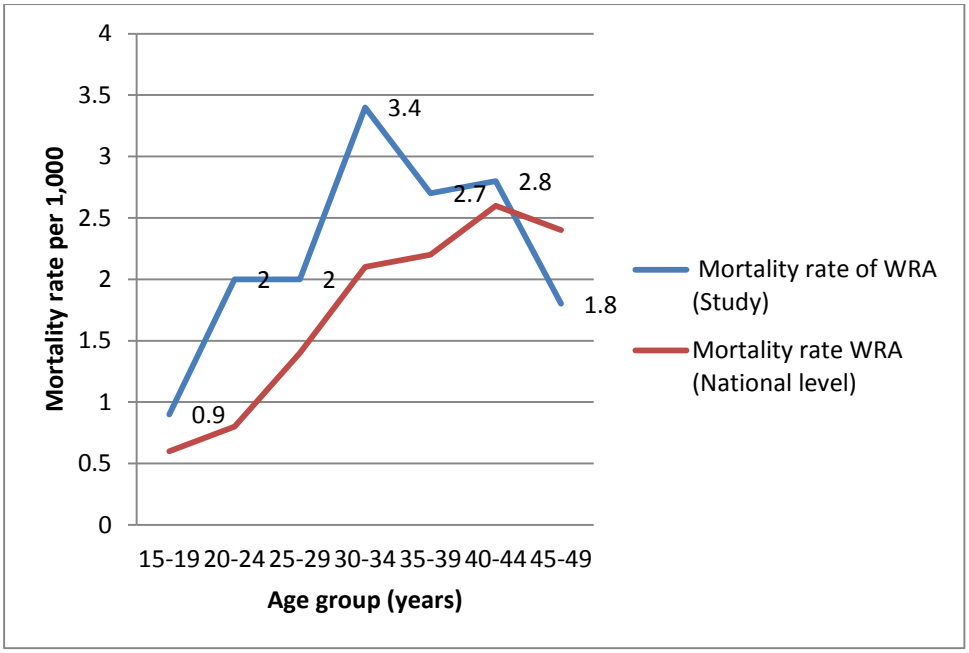

Figure 5.1: Age specific mortality rate for the study group compared to national data

5.3.2 Educational Attainment

A chi-squared test for trends was conducted to assess whether a death of a WRA is associated with increasing (or decreasing) educational attainment. Results revealed no evidence of linear relationship (p=0.256).

Compared to data from MDHS, 2010, a higher proportion of women in this study, 55.2%, did not go to school compared to 37% from previous data for Mangochi and 15.0% at national level (MDHS 2011). WRA who died in this study population were less likely to have gone to school compared to the average of the district (p=<0.001, CI: 50.4% - 59.57%) and national data (p=<0.001, CI: 50.4% - 59.8%) [Table 5.3].

5.3.3 Marital status

Over three quarters of WRA, 86.8% (368/424) were married and, 8% (34/424) were never married [Table 5. 3].

Compared to national data the trend for marital status was the same with more women married as compared to not married, divorced or separated [Table 5. 3].

5.3.4 Occupation and religion

Most deceased women were housewives, (43.6%; 185/424) and subsidence farmers (35.6% (151/424). A few women (16.7%; 71/424) had small businesses. This could be explained by the fact that most women did not go to school.

A higher proportion of women (90.1% (382.424) were Muslims. Previous Mangochi data confirmed the presence of more Islamic WRA in the district while the national data on WRA reports a higher proportion of Christian denomination across the country than the study population (MDHS 2011).

Table 5.3: Socio-demographic characteristics of WRA compared to Malawi Demographic and health survey data

Characteristic	WRA deaths, study(n=424)	WRA,Mangochi (n=1,442) MDHS, 2011	WRA, National (n= 23,837) MDHS, 2011
Education Attainment			
No education	234 (55.2%)	512 (35.3%)	3,623 (15.3%)
Some primary	144 (34.0%)	563 (45.3%)	13,230 (55.5%)
Completed primary	32 (7.5%)	108 (7.5%)	2,217 (9.3%)
Some secondary	7 (1.7%	108 (7.5%)	2,880 (12.5%)
Completed Secondary	4 (0.9%)	58 (4.0%)	1,335 (5.6%)
Above secondary	3 (0.7%)	6 (0.4%)	429 (1.8%)
Don't know	0 (0%)	0 (0%)	24 (0.1%)
Total	**424 (100%)**	**(1,442) 100%**	**23,738 (100%)**
Marital status			
Never married	34 (8.0%)	-	4.538 (19.7%)
Married	368 (86.8%)	-	15,528 (67.4%)
Divorced	15 (3.5%)	-	1,128 (4.9%)
Separated	6 (1.4%)	-	1,013 (4.4%)
Widowed	1 (0.2%	-	819 (3.6%)
Total	**424 (100%)**	-	**23020 (100%)**
Occupation			
Housewife	185 (43.6%)	-	-
Farming/agriculture	151 (35.6%	-	-
Small scale business	71 (16.7%	-	-
Student	13 (3.1%	-	-
Employed	4 (0.9%)	-	-
Total	**424 (100%)**	-	-
Religion			
Islam	382 (90.1%)	2,245 (73%)	2,993 (13.0%)
Christian	31 (7.4%	815 (26.5%)	18,961 (82.7%)
other	10 (2.4%)	12 (0.4%)	573 (2.5%)
None	1 (0.2%)	3 (0.1%)	344 (1.5%)
Missing	0 (0%)	3,075 (100%)	22,927 (100%)
Total	**424 (100%)**		

5.4 Place of death

Among the women who died at a facility level, a great number (76.9% (326/424) died in hospitals and 13% (55/424) died in the community level, [Table 5.4].

Table 5.4: Place of death

Place of death	Total deaths of WRA	Percentage (%)
Hospital*	326	76.9
En route from one facility to a referral facility	2	0.5
Health centre**	19	4.5
Community	55	13.0
On the way from home to health facility	19	4.5
Traditional healer	3	0.7
Total	**424**	**100**

*Includes four hospitals: Mangochi District Hospital, Monkeybay Community Hospital, Mulibwanji and St Martins Hospitals. **Including: Chilipa, Mase, Katuli, Lugola, Lungwena, Malembo, Jalasi, Makanjira, Namalaka, Namwera, Ngapani, Lulanga, Mtimabii, Luwalika and Nkumba health centres.

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5.4.1 Distribution of deaths of WRA by health facility

The mortality rate was calculated based on the total number of all in-patient admissions per facility during the one-year study period. Table 5.5 shows that the highest mortality rate for WRA was at Mangochi District Hospital (11.9/1,000), followed by Monkey-bay (8.4/1,000) and St Martin's Hospital, (5.8/1,000). Death of WRA at the health centres varied from 0 up to 4.8 /1,000. Two deaths which occurred during referral from Mulibwanji to Mangochi District Hospital are included in the Mulibwanji Hospital deaths. Typically, a hospital sees more referred and severe cases, which might explain the finding.

Table 5.5: Mortality rate of WRA by facilities

Name of the Facility	Total number of deaths of WRA	Admissions during the one year study period	Facility based death rate (per 1000)
Mangochi District Hospital	235	19,828	11.9
Monkeybay Community Hospital	53	6,240	8.4
St Martins Hospital	12	2,049	5.8
Mulibwanji Hospital	28	8,707	3.2
Lulanga health centre	2	414	4.8
Luwalika health centre	2	409	4.9
Mtimabii health centre	2	560	3.6
Other	13	6,061	2.1
Facilities with no deaths[b]	0	9,470	0
Total	**347**	**53,738**	**6.5**

[a] Included: Chilipa, Mase, Katuli, Lugola, Lungwena, Malembo, Jalasi, Makanjira, Namalaka, Namwera, Ngapani, Lungwena and Nkumba health centres.[b] Included: Chikole, Malombe, Chiunda, Chiponde, Chiumbangane, Sr Martha, Iba, Katema, Koche, Mpondasi, Asalaam, Nanmhwali, Nankumba, Nkope, Chilonga, Namalaka, Kadango, Chilonga, Kapire, Kukalanga, Phirilongwe, Mbalame and Chimwala

5.4.2 Geographical Distribution of deaths of WRA by Traditional Authority

Mortality rates of WRA for each of the eight TAs in Mangochi district were calculated based on the estimated population of WRA in each TA. Population estimates for each TA were obtained from the census projection report for 2007 (NSO 2008).

Table 5.6 shows that TA Makanjira had the highest mortality rate (343/100,000 and TA Mbwananyambi had the lowest mortality rate of WRA, (106/100,000).

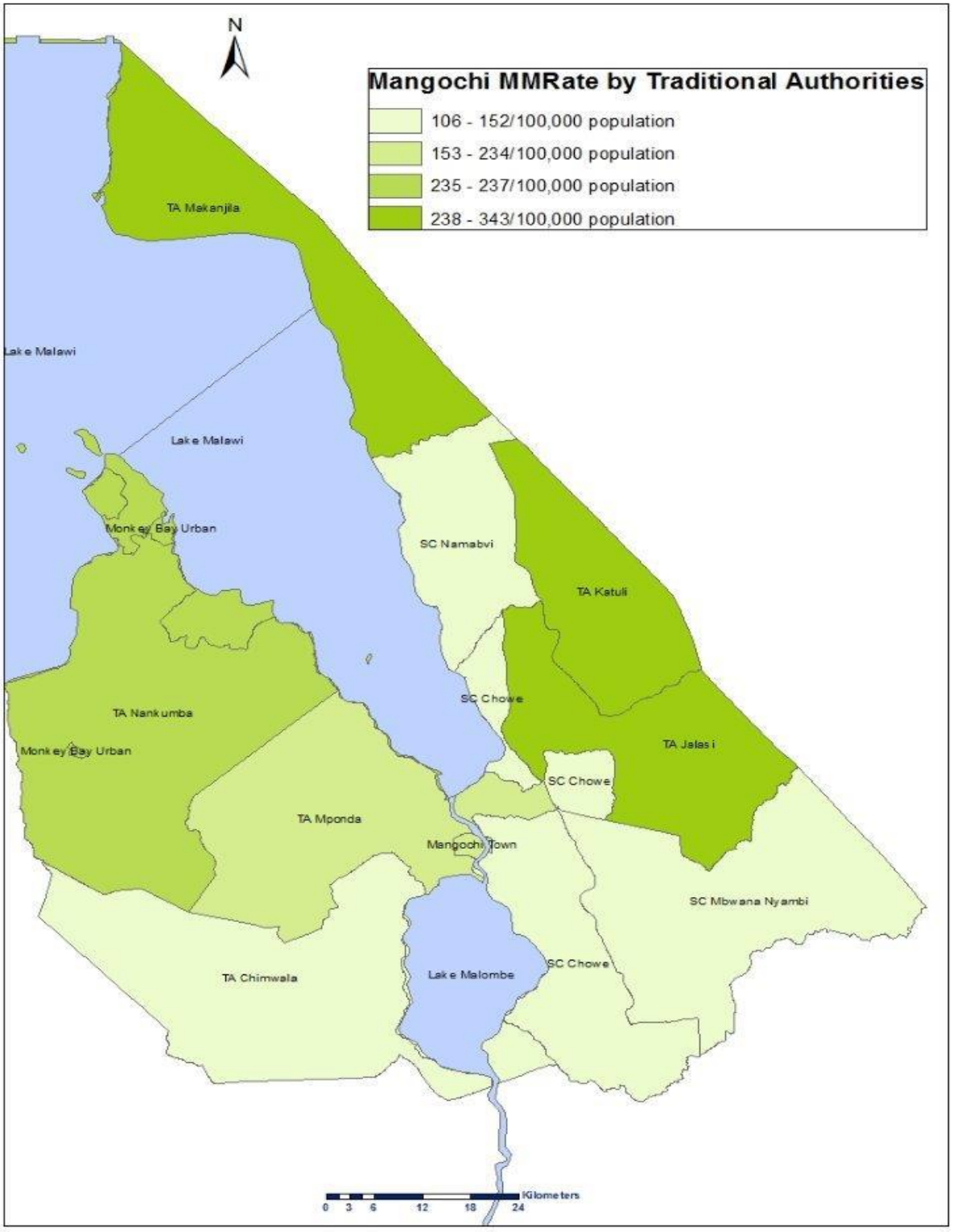
TAs Makanjira and Katuli are the two remote TAs, with poor dusty road network and furthest from the district hospital (about 110 and 105 respectively), [Figure 5.4].

Table 5.6: Proportion of deaths of WRA by traditional authorities

TA*	Estimated population** of WRA per TA	Total number of deaths of WRA per TA	Mortality rate per 100,000 population of WRA
Makanjira	17,187	59	343
Katuli	13,368	34	254
Jalasi	18, 929	46	243
Nankumba	31,213	74	237
Mponda	41,521	97	234
Chowe	36,066	55	152
Chimwala	28,831	37	128
Mbwananyambi	20,753	22	106
Total	**207,868**	**424**	**203**

*TA=Traditional Authority,**Population of WRA per TA was calculated based on the proportion of the population of WRA for Mangochi for 2008. The proportion was used to estimate WRA per TA for 2012 assuming the population was constant.

Figure 5.2: Map of Mangochi showing Mortality rate of women of reproductive age by TA



5.5 Classification of Maternal deaths

5.5.1 Classification of MD from death of WRA during field work

During the data collection period, each death of a WRA was classified as maternal or non-maternal by the PI, based on the definition of a MD by the 10th revision of the International Statistical Classification of Diseases and related health problems (ICD-10) (WHO, 1992b). Among the deaths identified, 36.8% (156/424) were classified as MDs and 63.2% (268/424) were non-MDs [Figure 5.3]. Following the field classification, all the 424 deaths identified were reviewed by panel of three experts (two obstetrician-gynaecologists and a midwife) to re-classify deaths, into maternal or non-maternal death.

5.5.2 Classification of maternal deaths by expert panel

The panel of three experts reviewed all the 424 deaths of WRA and assigned cause of death using the ICD-MM (WHO, 2012c). Table 5.7 shows documents used by panel of experts to review deaths of WRA. For deaths that occurred at facility level; all (347/424) had health facility data identification form (Appendix 4a], 94/347 deaths had case notes and 86/347 had MDA2 forms [Appendix 1]. All 86 deaths who had MDA2 forms were the MDs reported in the HMIS during the study period

For deaths which occurred at community; all (77/424) had information recorded on the community death identification form [Appendix 4b], 7/77 deaths had additional verbal autopsy (VA) information [Appendix 5) and 45/77 women had some information copied from their health passport [Table 5.7]

Table 5.7: Sources of data used for cause attribution by panel of experts by place of death

Document	Place where the woman died		Total
	Health facility level	Community	
Case notes	94	0	94
MDA 2 forms	86	0	86
Case review form	86	0	86
Facility data extraction form	347	0	347
Community data extraction form	0	77	77
Copies health passports or information from health passport	98	45	143
VA	94	57	151

A panel of experts (Two physicians and a midwife), reviewed each death independently to assign causes of death, by applying ICD-MM and subsequently met to reach consensus for cases where there were differences in opinion. The panel agreed on causes of 390/424 deaths and causes of 8% (34/424) of the deaths were reached after consensus. Consensus was reached

for all the 34 cases by the three-member panel with no further external inputs required by the fourth expert.

Following the panel review, (268/424) deaths were classified as non-maternal deaths, 35.6% (151/424) were confirmed as maternal deaths. Five (5) deaths were reclassified as deaths of women during pregnancy, childbirth and puerperium (incidental /not maternal deaths) [Table 5.8]. The five deaths were all reclassified as "HIV-related deaths during pregnancy, delivery or puerperium" (not MDs) and were assigned codes in block B20-B24 of ICD-10. For these 5 cases, pregnancy was incidental and HIV or AIDS was the underlying cause of death. HIV-related death was defined as death of a woman in pregnancy, childbirth and puerperium due to fatal complications of HIV or AIDS (World Health Organisation, 2012). Among deaths of WRA, the five deaths have been added to the group of non-MDs thereby increasing the proportion of non-MDs from 63.2% (268/424) to 64.4% (273/424) [Figure 5.3). Details of the five deaths are provided in [Table 5.9].

Table 5.8: Classifications of deaths of women of reproductive age by panel of experts

Type	Number	Percentage (%)
Non-maternal deaths	268	63.2
Maternal deaths -direct	113	26.7
Maternal death - indirect	26	6.1
Maternal Deaths unspecified	12	2.8
Deaths during pregnancy child birth and the puerperium (Coincidental causes)	5	1.2
Total	**424**	**100**

5.5.2.1 Intra-panel agreement on causes of deaths

We calculated level of agreement among the three experts using kappa statistic. Kappa statistics revealed a substantial agreement between the raters were as follows:

a) Experts 1 and 2 agreed on 82 .12% of the cases (κ= 0.8053)

b). Experts 1 and 3 agreed on 84.11% of the cases (κ= 0.8276)

c). Experts 2 and 3 agreed on 87.42% of cases (κ-0.925)

The overall of level agreement among the three using Fleiss's kappa statistic was also high (κ= 0.8321).

Table 5.9: Summary of cases reclassified as non-maternal deaths by panel of experts

No.	Summary of case	Assigned cause of death
1	A 40 years gravida 7, para 6 who reported at a facility at 28 weeks gestation. She was HIV positive, stage 4 according to WHO-staging. The woman became pregnant six months after she was started on HAART. She was also on anti-tuberculosis treatment on last admission in hospital (6 months ago). She reported at the facility while breathless, no fever, oral thrush, bilateral crepitation, wasted and had pneumonia. Foetus was viable.	**HIV disease resulting in multiple infections** (B20.7)
2	A 34 years para 4, reported at a facility 32 days after delivery with history of generalised lymphadenopathy, weight loss, fever, convulsions and body lesions. She was on HAART; urine protein was negative, no fever, lochia dry and no history of epilepsy. Blood pressure was 110/70. She was classified as HIV stage 4 according to WHO- classification of HIV. She lost weight, and was wasted. The baby was alive	AIDS-related complex (B24)
3	A 30 years para 4 reported to a health facility 39 days after delivery of a live full term infant at a facility. Uterus was well contracted, normal lochia, no fever and malaria negative. She came to facility aggressive, confused, refusing to eat, history of headache, seizures, weight loss and was on HAART due to stage 3-4 of HIV. She was admitted three months prior to this admission due to meningitis; she was unconscious for three weeks and was brought to hospital in a critical condition.	HIV encephalitis (HIV disease resulting in encephalopathy) (B22.0)
4	18 years para 2 admitted with history of oral thrush, confusion and heart palpitation 25 days after delivery at a health centre. She had black dots all over the body and history of frequent diarrhoeas. She was on HAART for 2 years. Had normal vital signs, was not speaking. Normal lochia and uterus well contracted.	HIV disease resulting in Kaposi , HIV Stage 3-4 (B21.0)
5	A 29 years para 4, on HAART since 2008. History of coughing for three months, fever, weakness, vomiting after food, difficulties in breathing, chest tightness and oral thrush. She was on andante- TB treatment at the time of death. She died at home.	HIV related (*Pneumocystis jiroveci)* **pneumonia**, HIV end stage B20.6.,

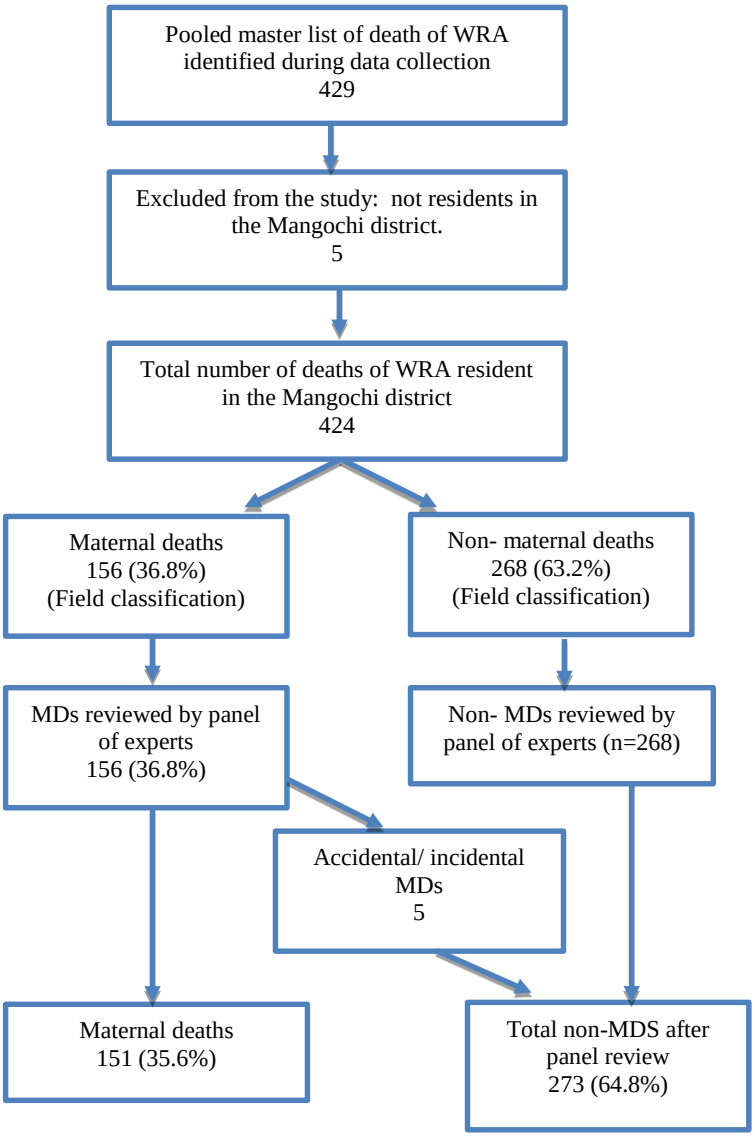


Figure 5.3: Classification of deaths of women of reproductive age in Mangochi district

5.6 Comparing maternal and non-maternal deaths demographic characteristics

5.6.1 Age distribution

Deaths of WRA were divided into two groups, maternal and non-maternal deaths. There were total 273 and 151 non-maternal maternal deaths respectively. Table 5.7 shows the age group distributions of deaths of WRA according to these two groups.

The mean (SD) age of the deaths that were classified as non-maternal deaths (n=273) was 31.9 (8.4) years, median 31, minimum 15 and maximum 48 years. In this group, the proportion of women aged 15-19 years was 8% (22/273) [Table 5.10]. The very young adolescents (15-16 years) among the deaths of WRA were 2.5% (7/273). On the other hand among the MDs (n=151), the mean (SD) age at the time of death was 27 (6.8) years and the age range was 15-45years. The proportion of adolescent MDs (15-19 years) was 15.2% (23/151) and the number MDs above 35 years were 17.3% (26/151), (Table 5.4). The very young adolescents (15-16 years) among the deaths of WRA were 3.9% (6/151).

Overall, there was a significant difference in the number of deaths across the groups between maternal and non-maternal deaths (p=<0.001). Table 5.10, shows, significant difference between non-maternal and maternal deaths in age groups 15-19, 25-29, 40-44 and 45-49 (p = 0.03, 0.001, 0.001 and 0.02, respectively).

Table 5.10: Numbers of maternal deaths by type of death by age group

Age group	Non-maternal deaths (% of the total)	maternal deaths (% of the total)	P-value for MDs versus Non-MDs
15-19	23 (8.4%)	23 (15.2%)	0.03
20-24	41 (15.8%)	38 (25.2%)	0.10
25-29	32 (11.7%)	37 (24.5%)	< 0.001
30-34	65 (23.8)	27 (17.9%)	0.156
35-39	45 (16.5)	17 (11.3%)	0.145
40-44	46 (16.8)	8 (5.3%)	0.001
45-49	21 (7.7%)	1 (0.7%)	0.02
15-49	**273**	**151**	**< 0.001**

5.6.2 Other socio-demographic characteristics

In both non-maternal deaths and maternal deaths, the majority of women did not go to school for and there was no significant difference between the two groups (p=0.066) [Table 5.11].The distribution of marital status, occupation, and religion were similar for both maternal and non-maternal deaths.

Table 5.11: Socio-demographic characteristics of WRA comparing maternal and non-maternal deaths

Characteristic	WRA deaths, study(n=424)	Non-maternal study, deaths (n=273)	Maternal deaths study (n=151)
Education Attainment			
No education	234 (55.2%)	160 (58.6%)	74 (49.0%)
Some primary	144 (34.0%)	89 (32.6%)	55 (36.4%)
Completed primary	32 (7.5%)	16 (5.9%)	16 (10.6%)
Some secondary	7 (1.7%	3 (1.1%)	4 (2.6%)
Completed Secondary	4 (0.9%)	3 (1.1%)	1 (0.7%)
Above secondary	3 (0.7%)	2 (0.7%)	1 (0.7%)
Don't know	0 (0%)	0 (0%)	0 (0%)
Total	**424 (100%)**		**151 (100%)**
Marital status			
Never married	34 (8.0%)	22 (8.8%	12 (7.9%)
Married	368 (86.8%)	239 (87.5%)	129 (85.4%)
Divorced	15 (3.5%)	8 (2.9%)	7 (4.6%)
Separated	6 (1.4%)	4 (1.5)	2 (1.3%)
Widowed	1 (0.2%	0 (0%)	1 (0.7%)
Total	**424 (100%)**	**273 (100%)**	**151 (100%)**
Occupation			
Housewife	185 (43.6%)	85 (31.1%)	100 (66.2%)
Farming/agriculture	151 (35.6%	135 (49.5)	16 (10.6%)
Small scale business	71 (16.7%	43 (15.7%)	28 (18.5%)
Student	13 (3.1%	8 (2.9%)	5 (3.3%)
Employed	4 (0.9%)	2 (0.7%)	2 (1.3%)
Total	**424 (100%)**	**273 (100%)**	**151 (100%)**
Religion			
Islam	382 (90.1%)	241 (88.2%)	141 (93.4%)
Christian	31 (7.4%	22 (8.1%)	9 (6.0%)
other	10 (2.4%)	10 (3.7%)	0 (0%)
None	1 (0.2%)	0 (0%)	1 (0.7%)
Missing	0 (0%)	0 (0%)	0 (0%)
Total	**424 (100%)**	**273 (100%)**	**151 (100%)**

5.7 Cause of death

The causes of deaths for the non-pregnant women, presented in this section were assigned by the clinicians who confirmed the deaths based on patient history, physical examination, clinical experience and laboratory tests. The causes are classified into four major categories according to ICD-10 classification of diseases (WHO 1992b). The categories were as follows:

A. Infectious disease

B. Non-Communicable Diseases (NCD) (including circulatory diseases, cancer, gastrointestinal diseases, diabetes, renal disorders, and asthma, epilepsy and rheumatic disorders)
C. Injury
D. Pregnancy- related

In this chapter cause of deaths of women in the first three categories and for only women who died in a health facility will be presented. Causes of non-maternal deaths of WRA, who died outside a health facility, have been excluded because verbal autopsy was not done. Causes of all maternal deaths are presented in the chapter 7 and 8.

5.7.1 Cause on non-maternal death

Of the deaths due to non-maternal causes, 90.1% (246/273) died in health facilities and 9.9% (27/273) died outside the health facilities.

Infectious diseases were the leading cause deaths among deaths that occurred in health facilities (with 73.6% (181/246)). Confirmed malaria cases accounted for the largest proportion (37% (67/181)) in this category. There were few (7.7% (14/181)) HIV-related cases (HIV wasting syndrome, lactic acidosis, chronic diarrhoea, HIV encephalitis [Table 5.12].

Among the NCD deaths, anaemia 61.3% (38/62) was the top cause of death. Cancer accounted for 25.8% (16/62), of the NCD, with cancer of the cervix as the top cause, causing 50% (8/16) of cancer deaths. Three deaths, 1.2% (3/246), were classified as unintentional injuries caused by road traffic accident and food poisoning [Table 5.12].

Table 5.12: Non-pregnancy related causes of death of WRA who died in health facilities (n=246)

Cause of death	Number of deaths of WRA	Percentage % of sub-category	Percentage (%) of the total category (n=246)
Infectious diseases			
Malaria	67	37.0	27.2
Pneumonia	51	28.2	20.7
Septicaemia	19	10.5	7.7
HIV related complications*	14	7.7	5.7
Meningitis	11	6.0	4.5
Tuberculosis	10	5.5	4.1
Dysentery	5	2.7	2.0
Hepatitis	4	2.2	1.6
Total infectious	**181**	**100%**	**73.6**
Non-communicable			
Anaemia	38	61.3	15.4
Hypertensive disorders	8	12.9	3.3
– Hypertension	4	50	
– Stroke	4	50	
Cancer	16	25.8	6.5
– Cervix	8	50	
– Oesophagus	4	25	
– Liver	3	18.8	
– Stomach	1	6.3	
Total non-communicable	**62**	**100%**	**25.2**
Injury			
Road traffic accident	2	66.7	0.8
Food poisoning	1	33.3	0.4
Total injury	**3**	**100%**	**1.2**
Grand Total	**246**		**100%**

5.8 Chapter Summary

This chapter has presented detailed information about the deaths among WRA identified in Mangochi district from December 2011 to November 2012. There were 424 deaths of WRA identified of which 35.6% were maternal deaths. The mean age of among the deaths of WRA was 30 (8.2) years and the age range were 15 to 48 years. More than half (55.2%) of the women who died did not go to school at all. There were 76.9% of deaths which occurred at facility level. More MDS in age groups 15-19 and 25-29 and less MDs in age groups 40-44 and 45-49. Malaria was the leading cause of death among women who died of non-pregnancy related causes.

6 RESULTS: MATERNAL DEATHS

6.1 Chapter overview

This chapter presents results on maternal deaths (MDs), identified during the study period. The MDs presented in this chapter are those confirmed after the panel of experts' review. There are four main sections which include: Section 6.2 which presents the total number of MDs and where these women died. The maternal mortality ratio (MMR) is presented in section 6.3 followed by section 6.4 which gives details on reproductive health characteristics of the deceased women i.e. parity, gravidity antenatal care (ANC), delivery and postnatal care received.

6.2 Maternal deaths and place of death

Among all deaths of WRA (n=424) identified during the study period, a total of 151/424 (35.6%) women were MDs. The number of MDs identified in this study was compared with the number reported via Health Management Information System (HMIS) for the same period. The HMIS documented 86 MDs [Figure 6.1]. Compared to the number of MDs identified in this study (151), the HMIS missed 43.0% (65/151) of the MDs. It was further noted that the HMIS only captured MDs which occurred in a health facility.

All 86 MDs reported via HMIS were captured by this study. Matches were identified by comparing details of the deceased which included: address, date of death, age at death and place of death. In addition, this study identified an additional 8 MDs which had occurred at facility level and were missing in the HMIS. Of these eight MDs, three occurred in the female ward at Mangochi District Hospital, two, in a female ward at St Martin's Hospital and three occurred at health centres (Lulanga (2) and Chiunda (1)). MDs which occurred in the female ward were missed by staff, despite an indication in their case files that they were pregnant or had an abortion. The three MDs which occurred at the health centres were not reported for official documentation as they were reported to have occurred on admission (death on arrival) before any treatment at the health centre and the staff had not presented these cases for MD audit.

Most MDs, 62.3% (94/151) occurred in health facilities. Other MDs occurred at home, on the way from home to a health facility, and at a traditional healer [Figure 6.1].

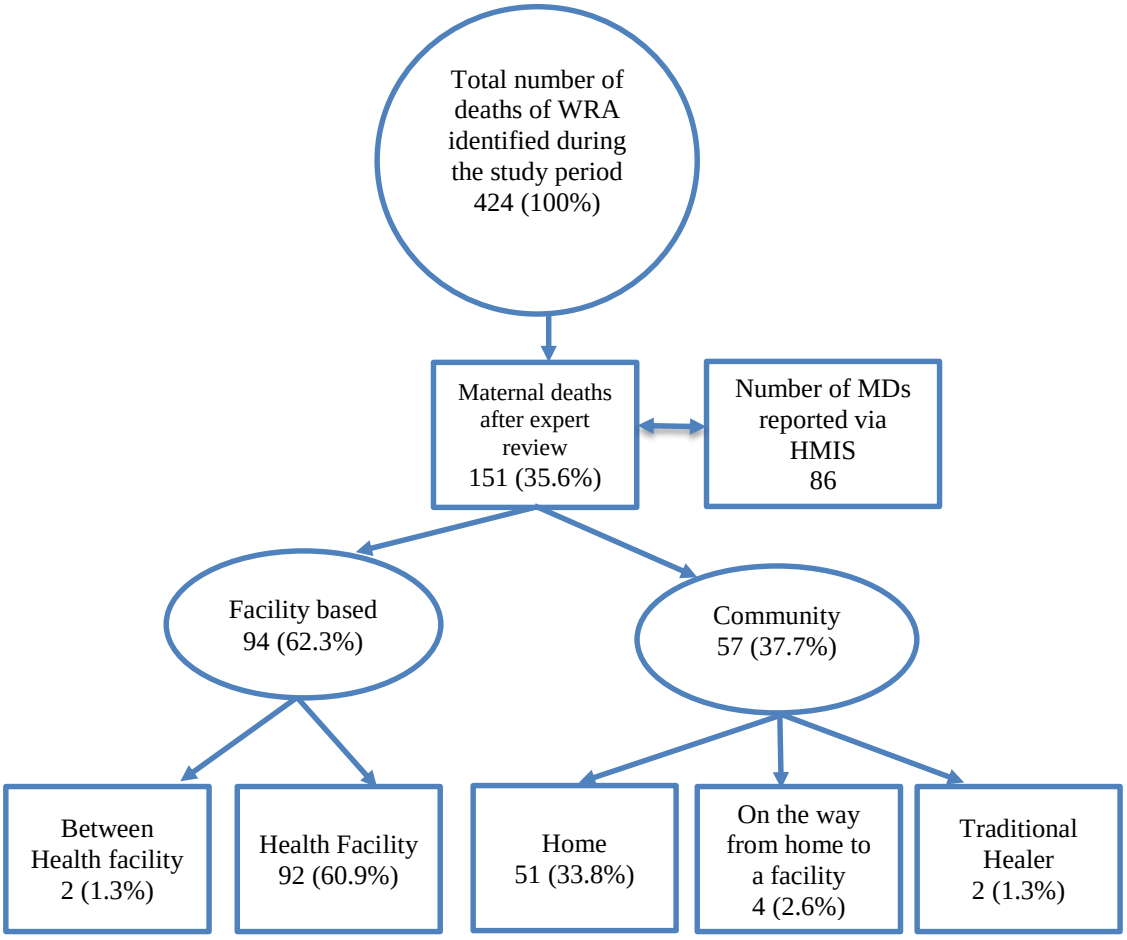


Figure 6.1: Maternal deaths identified during the study period

6.3 Maternal mortality

6.3.1 Maternal Mortality Ratio

There are three maternal mortality ratio (MMR) estimates presented in this section based on three different denominators (live births) estimated from: BCG-vaccinated babies in Mangochi district during the study period, census report 2008 and live births calculated from the General Fertility Rate (GFR) for rural Malawi (NSO 2008) as described in chapter 4. [Table 6.1] shows the three MMRs.

Based on the three confidence intervals for the three MMR estimates, the MMR for the Mangochi district lies within the range of 341-363 deaths per 100,000 live births and 95% CI range of 289-425 deaths per 100,000 live births [Table 6.1].

Table 6.1: Maternal mortality ratio estimates for Mangochi district

Source	Maternal deaths	Estimated live births	MMR /100,000	95% confidence interval
Number of BCG vaccinated babies (HMIS, 2012, Mangochi)	151	41,623	363	307-425
Live births from census report, 2008 (Census, 2008)	151	43,000	351	297-412
Live births calculated from GFR* (MDHS, 2011)	151	44,276	341	289-400

*GFR for 213 for rural Malawi (MDHS, 2011)

6.3.2 Facility based Maternal Mortality Ratio

The MMRs for specific health facilities were calculated to assess the distribution of MDs among different health facilities. The denominator (number of live births) used to calculate MMR for each health facility was based on total number of live births recorded in the maternity register per facility. A total of 94 MDs occurred in health facilities.

There was a significant difference in MMR among different health facilities (p=<0.001). Mangochi District Hospital (second level facility, a CEmOC facility) had the highest facility based MMR, 2,511 per 100,000 live births (95% CI: 1,936 -3,203) live births, followed by St Martin's hospital 624 per 100,000 live births (95% CI: 170 - 1,589). Lulanga health centre had the highest MMR of 517 per 100,000 live births, (95% CI: 63 - 1,185) among the 14 health centres which reported MDs during the study period [Table 6.2]. The overall facility-based MMR was 620 per 100,000 live births, (95% CI: 502-759).

It was observed that majority of MDs occurred in the government BEmOC and CEmOC health facilities (90.7%) with 9.3% in health facilities which were semi-private under the Christian Health Association of Malawi (CHAM), (9.3%) [Table 6.2].

Table 6.2: Maternal mortality ratio by health facility

Name of the health facility	Type of facility	Number of MDs per facility (% of the total)	*Number of live births during the study period	MMR*	95% CI
Mangochi District Hospital	GVMT***	63 (67.0%)	2,508	2,512	1,936-3,203
Monkey-bay Community Hospital	GVMT	6 (6.3%)	1,518	395	145- 858
St Martin's Hospital	CHAM****	4 (4.2%)	641	624	170-1,589
Mulibwanji Hospital	CHAM	6 (6.3%)	1,275	471	191-1,021
Lulanga health centre	CHAM	2 (2.1%)	387	517	63-1,185
Mtimabii health centre	GVMT	2 (2.1%)	807	248	30- 893
Malembo health centre	CHAM	2 (2.1%)	687	291	35-1,048
Chilipa health centre	GVMT	1 (1.1%)	780	128	3 -712
Chilonga health centre	GVMT	1 (1.1%)	576	174	4 - 963
Lungwena health centre	GVMT	1 (1.1%)	930	108	3 - 598
Luwalika health centre	GVMT	1 (1.1%)	549	182	4 -1,011
Katuli health centre	GVMT	1(1.1%)	830	120	3 - 669
Jalasi health centre	GVMT	1 (1.1%)	754	133	3 - 737
Makanjira health centre	GVMT	1 (1.1%)	789	127	3 -704
Namwera health centre	GVMT	1 (1.1%)	850	118	3 -654
Nkumba health centre	GVMT	1 (1.1%)	789	127	3 -704
Total		**94 (100%)**	**15,149**	**620**	**502 -759**

**Number of live births obtained from specific facility registers, **MMR=Maternal mortality ratio*
****GVMT=Government health facilities, **** CHAM=Christian Health Association of Malawi facilities*

6.3.3 Case fatality

Out of 1,680 women with direct obstetric complications, 73 deaths before discharge, and this gave a case fatality rate of 4%. The Malawi 2010 EmOC needs assessment recorded direct case fatality of 3% for Mangochi district and 2% at national level (MOH 2011b).

6.3.4 Duration of hospital stay and referral status and of the maternal deaths

Among all MDs which occurred in health facilities, (n=94), length of stay at a health facility ranged from 0 days (dead on arrival) to 36 days with a mean of 6.54 days (SD 5.62 days). Almost three quarters 73.4% (69/94) spent 1-7 days at the facility before they died. About one third 27.7% (22/94) reached the health facility in a critical condition and of these 31.8% (7/22)

were reported dead on arrival. Of the 94 deaths that occurred in a health facility, 56.4% (53/94) were direct admissions and 43.6% (41/94) were referred from health centres. In terms of how many times the women were referred, Table 6.3 shows the majority (78.0% (32/41) of women were referred once.

Duration of stay at a referral hospital before death, ranged from 0 (dead on arrival) days to 35 days with a mean stay of 3.92 days (SD 5.57days). Over half of the cases, 53.7% (22/41) spent 1-2 days at the referral facility before they died.

Table 6.3: Number of women referred from another heath care facility (n=45)

Referred MDs	Number of women	Percentage (%)
Once	32	78.0
Twice	7	17.1
Three times	2	4.9
Total	**41**	**100**

6.3.4.1 ***Referred the cases by health facilities***

Makanjira health centre referred over half of the MDs 65.9% (27/41), followed by Katuli health centre 19.5% (8/41), and the remaining 14.6% (6/41) were referred from other health centres. Fifty six percent (23/41) had post-partum haemorrhage.

6.3.5 Distribution of maternal deaths occurring in the community

A total of 57 MDs occurred outside the health facility, 89.5% (51/57) occurred at home, 7.1 % (4/57) died on the way to a health facility and 3.5% (2/57), died at a traditional healer [Figure 6.2].

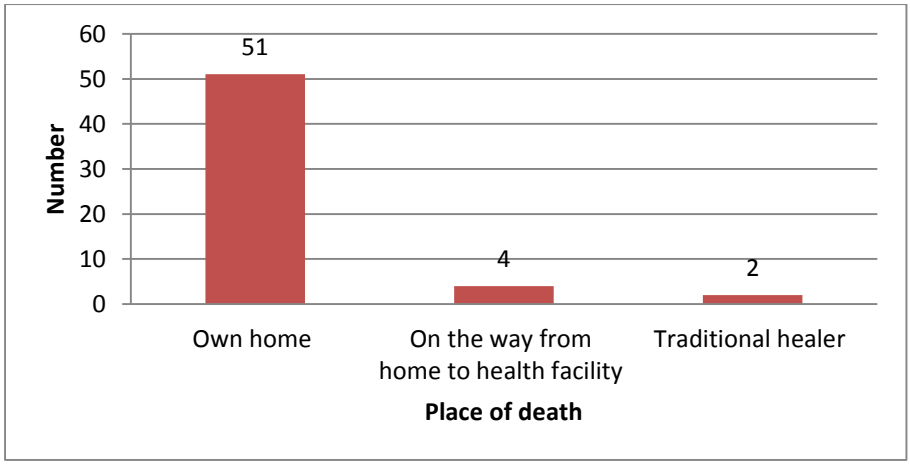


Figure 6.2: Maternal deaths that occurred outside a health facility

6.3.6 Maternal mortality ratios by Traditional Authorities

Maternal mortality ratios for all eight TAs in Mangochi district were calculated to identify the geographical distribution of MDs. The three sets of MMR were calculated using the denominators as described in section 6.3.

Overall, a significant difference in the MMR among all three sets of denominators used was observed (p= >0.001, range 144 -809 deaths per 100,000 live births). Based on the MMR calculated from estimated live births from census data and GFR, TAS Makanjira and Katuli had the highest MMR than the district average [Table 6.4]. TA Makanjira is the furthest TA from the district referral hospital with a dusty road (about 120km).

6.3.6.1 ***Age-specific maternal mortality ratio***

Table 6.5 shows on overall, the highest MMR was in age group 25-29, (496 per 100,000, 95% CI: 349-683). MMR in the age groups 20-24 through to 30-34 were significantly higher than age group 15-19 years (p= 0.010, 0.002 and 0.02 respectively) while MMR for age group 45-49 was significantly lower than the MMR in age group 15-19 years (p= 0.05), [Table 6.5].

Figure 6.3 shows that the MMR increased with age from age group 15-19 to age group 25-29 and starts decreasing from age group 30-34 through to 45-49.

Table 6.4: Maternal mortality ratio for each traditional authority in Mangochi district

TA	MDs per year	Live births (BCG)	MMR/100,000 (BCG)	CI	Live births census	MMR/100,000 (Census)	CI	Live births (GFR)	MMR/100,000 (GFR)	CI	MMR range
Mponda	23	8,231	279	177-414	7,955	289	183-434	8,844	260	164-390	260-289
Chimwala	16	5,473	292	167-474	5,623	285	163-462	6,141	261	149-423	261-292
Nankumba	15	5,340	282	157-463	5,541	271	152-446	6,648	226	126-372	226-282
Jalasi	18	4,053	**444**	263-701	4,343	**414**	246-654	4,032	**446**	265-705	414-446
Mbwananyambi	7	4,429	158	64-325	4,876	144	58-296	4,420	158	63-326	144-158
Chowe	29	7,590	**382**	256-548	7,917	**366**	245-526	7,682	**378**	253-542	366-382
Katuli	19	2,540	**748**	451-1,166	2,851	**666**	402-1,039	2,847	**667**	402-1040	666-382
Makanjira	24	2,967	**809**	519-1,201	3,894	**616**	395, 916	3,661	**792**	420-974	616-809
Total	**151**	**41,623**	**362**	**307.425**	**43,000**	**351**	**297,412**	**44,276**	**341**	**289-400**	**362-351**

Table 6.5: Age specific Maternal Mortality Ratio

Age group	Number of WRA	Maternal deaths	Live births	MMR/100,000	95% CI	P-value*
15-19	48,704	23	10,374	222	140 -332	
20-24	40,303	38	8,585	443	313-607	**.010**
25-29	35,021	37	7,459	496	349-683	**0.002**
30-34	29,646	27	6,315	428	282- 621	**0.02**
35-39	22,262	17	4,742	359	209-573	0.13
40-44	19,373	8	4,126	194	84-382	0.74
45-49	12,559	1	2,675	37	0.946 -208	**0.05**
15-49 (All)	**207,868**	**151**	**44,274**	**341**	**289-400**	**0.001**

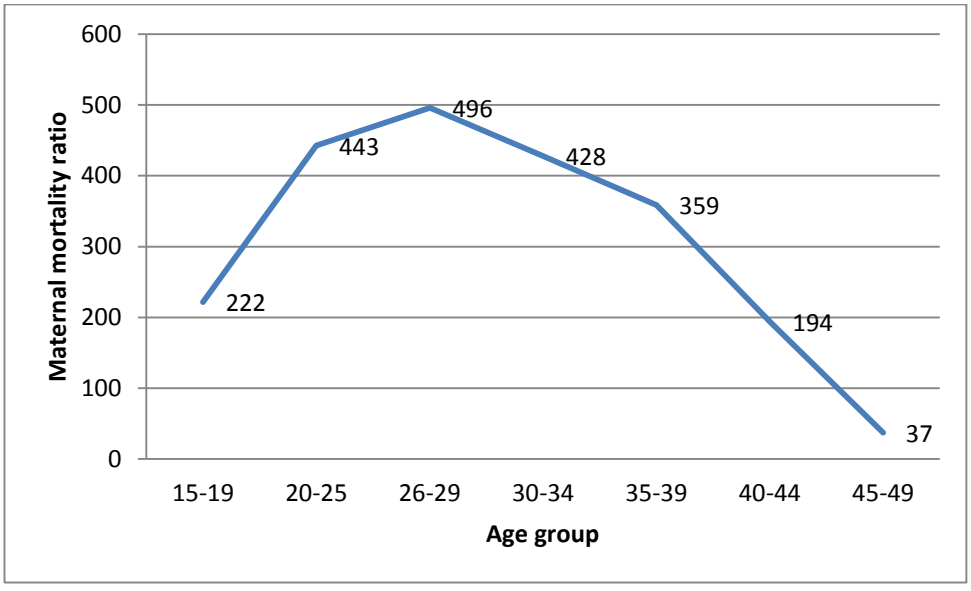


Figure 6.3: Maternal Mortality Ratio by age group

6.3.7 Number of MDs deaths audited at facility level

Of the 94 MDs that occurred at a health facility, 86 had been audited. The remaining 8 deaths had not audited because the deaths were not reported to the audit team. No

maternal death audits were conducted for any of the MDs which occurred in the community.

6.4 Reproductive characteristics of the maternal deaths

6.4.1 Gravidity

Gravidity is defined as the number of times that a woman has been pregnant (Creinin & Simhan 2009). In this study the median number of pregnancies the deceased was 3 with a minimum of 1 pregnancy and a maximum of 10 pregnancies. Gravida 1 and 2 comprised of 37.1% of the MDs, and 22.5% of MDs were gravida 5 and above [Table 6.6].

Table 6.6: Distribution of gravidity of women who died (MD)

Gravidity	Number	%
1	30	19.9
2	26	17.2
3	41	27.2
4	20	13.2
5 and above	34	22.5
Total	**151**	**100.0**

6.4.1.1 Gravidity and place of death

A Chi square test revealed no significant association between number of pregnancies and place of death (p=0.14). No significant differences observed between the number of MDs which occurred at a health facility or outside the facility except for MDs with three pregnancies where a significant difference was observed (p=0.014) and more women died outside facilities [Table 6.7]. Furthermore, a test for linear trend was conducted to assess whether there is an increasing or decreasing trend in proportion of women dying at a health facility with an increase in the number of pregnancies. The test found no evidence of a linear relationship (p= 0.56).

Table 6.7: Number of pregnancies by place of death

Gravida	Health Facility	Outside health facility	Total	P-value*
1	21 (70.0%)	9 (30.0%)	30 (100%)	0.327
2	16 (61.5%)	10 (38.5%)	26 (100%)	0.936
3	19 (46.3%)	22 (53.7%)	41 (100%)	0.014
4	15 (75.0%)	5 (25.0%)	20 (100%)	0.208
5 or more	23 (67.6%)	11 (32.4%)	34 (100%)	0.459
Total	**94**	**57**	**151 (100%)**	**0.001**

**Comparing % deaths at health facility vs outside health facility*

6.4.2 Parity

Parity is defined as the number of deliveries after 28 weeks gestation regardless of the outcome of pregnancy, during a woman's lifetime (Opara 2007).The number of children ever born to the deceased women ranged from 1 to 9 with a median of 2. The mean parity among the deceased women was 2.

Table 6.8 shows the highest proportion, 55.6% (84/151), died after 2-4 deliveries followed by those in parity 0-1. The women who were in parity 0 in this study included all women who died within their first pregnancy and women who had been pregnant more than once with pregnancies ending before 28 weeks gestation.

Table 6.8: Maternal deaths by parity

Parity	Total number	Percentage
0-1	49	32.4
2-4	84	55.6
5 and above	18	11.9
Total	**151**	**100**

6.4.3 Trimester stage at the time of death

The highest proportion, 65.6% (99/151) of the women died during the third trimester (29-40 weeks) and a few 3.3% (5/151) in the first trimester (1-12 weeks).
[Figure 6.4].

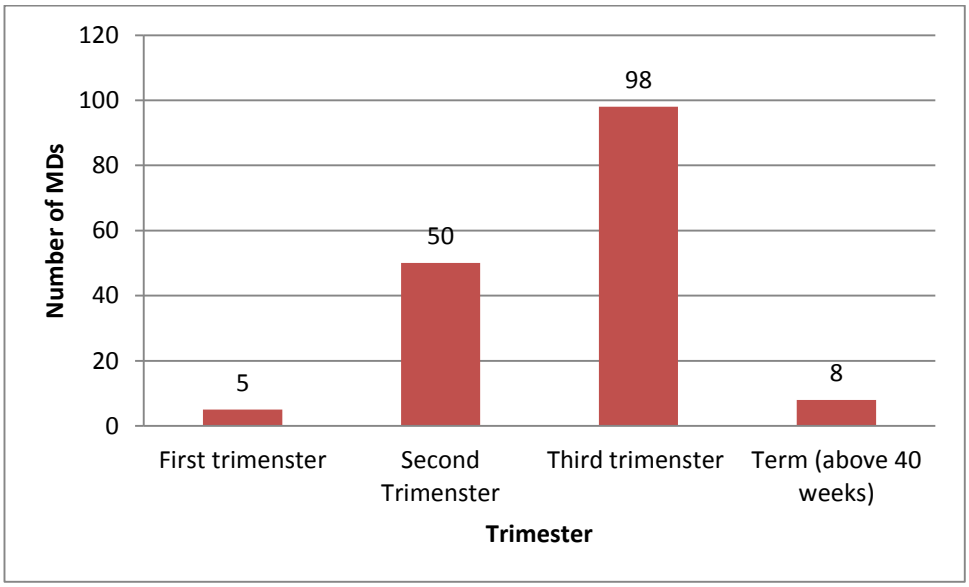


Figure 6.4: Trimester at the time of death

6.4.4 Pregnancy stage at the time of death

The highest proportion, 65.6% (99/151) of MDs occurred after delivery (72.2%: 72/99 and an important proportion, 33.1% (50/151), occurred during pregnancy [Figure 6.5]. The majority, 62.6% (62/99) of MDs which occurred after delivery took place at a health facility. Similarly more than half, 60% (30/50), of the women who died while pregnant died at a health facility.

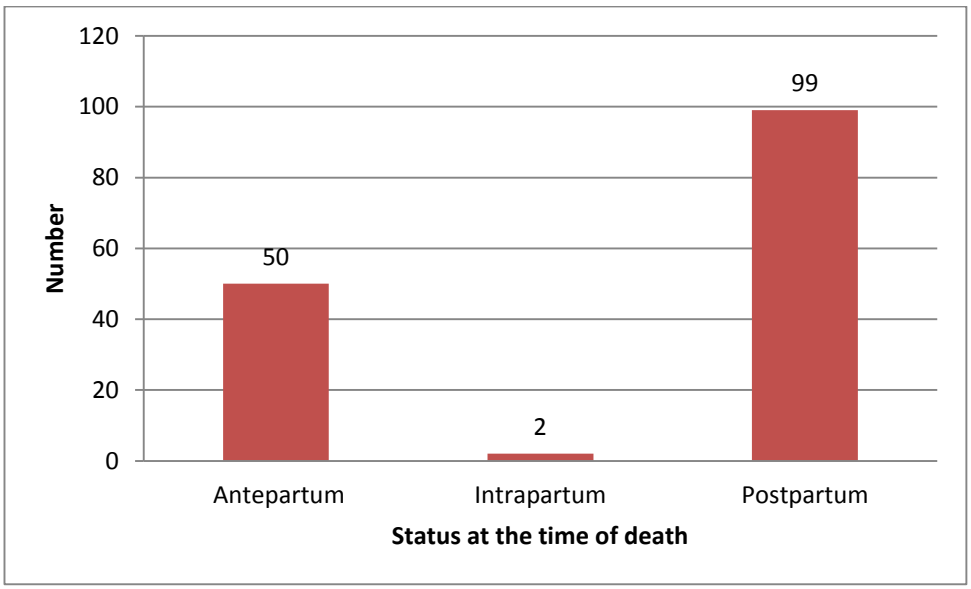


Figure 6.5: Maternal death by time of death

Among the women who died after delivery (n=99), the majority 47% (47/99) died within 24 hours after delivery and 30/99 within 1week after delivery [Figure 6.6].

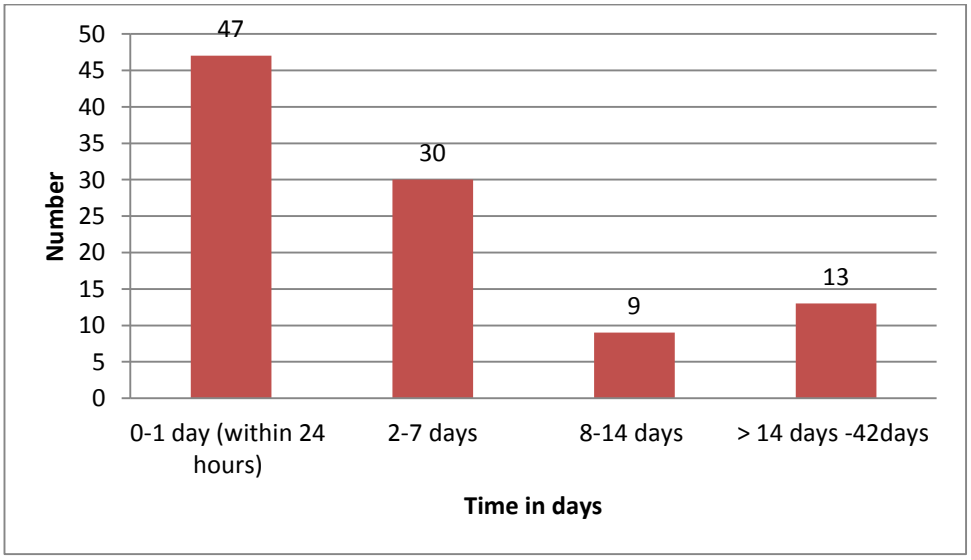


Figure 6.6: Time of death in days after delivery

6.4.5 Attendance for Antenatal care

Information on whether the women received antenatal care (ANC) during their pregnancy was collected. Among the women who attended ANC, information on gestational age of pregnancy at start of ANC and the number of ANC visits was obtained. Findings revealed the highest proportion, 76.2% (115/151), received antenatal care (ANC) and the majority, (72.2% (83/115), received ANC at a health centre [Table 6.9].

The proportion of women who attended ANC in this study (76.2%) was compared to the proportion of women who attended ANC (95%) at national level from the MDHS for 2010 .There were no data available on ANC coverage for Mangochi district per se so the national data was used. The proportion of antenatal attendance among women in this study (76.2%) was significantly lower than at national level (95%) (p= < 0.001, 95% CI 0.68 - 0.83).

Table 6.9: Place of antenatal care (n=115)

Place of ANC	Number	Percentage
Mangochi hospital	17	11.3
Monkeybay hospital	7	4.6
Mulibwanji hospital	7	4.6
St Martins hospital	1	0.7
Health Centres	83	72.2
Total	**115**	**100**

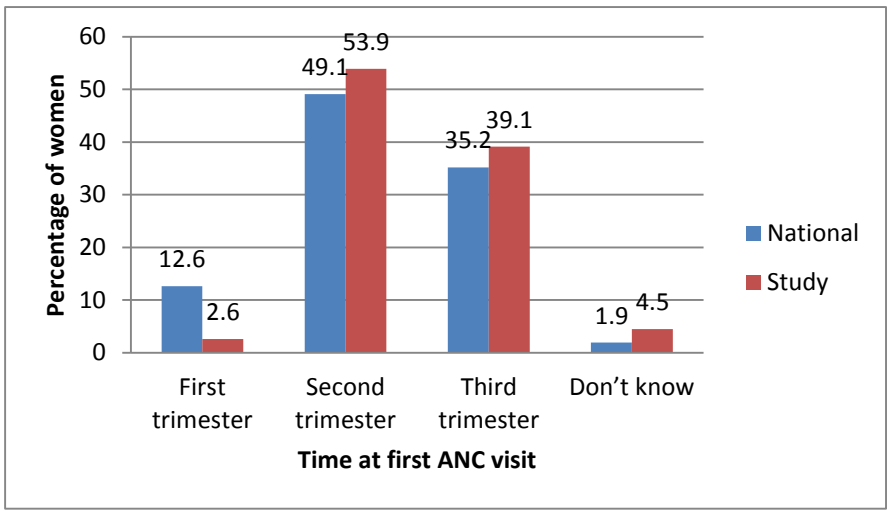
6.4.5.1 Gestational age at first antenatal visit

Most deceased women who attended ANC (n=115), had their first ANC visit in the second or third trimesters. Over half, 53.9 % (62/115) started ANC in the second trimester and only a few women, 2.6% (3/115) started ANC in the first trimester [Figure 6.7]. It was noted that the three women who started ANC in the first trimester had problems such as threatening abortion and malaria. Information on gestational age

at first visit was not available for 4.3% (5/115) of women who died, as there was no antenatal card and relatives of the deceased could not remember the dates.

Compared to the national data from the MDHS, (2010), the proportion of women who attended ANC in the first trimester were significantly lower in this study (2.6%) than the national level (12.6%), (p = >0.001, 95% CI 0.01- 0.07) and more women in this study accessed ANC in the second trimester than the national average (p = 0.003, 95% CI 0.002,- 0.006). However, there was no significant difference in women who started attending ANC in third trimester between the women and the national data (p= 0.38, 95% CI 0.31- 0.48).

Figure 6.7: Time of first ANC visit, comparing the study findings and the national data



6.4.5.2 Number of antenatal visits at full term gestation

Data for 61.6% (93/151) of women whose pregnancies reached term gestation (37-40 weeks) and who had attended ANC are presented in this section. Women who died before 37 weeks gestation have been omitted because they either died early in pregnancy or did not reach term gestation and would not have been able to complete the scheduled antenatal visits. A minimum of 4 or more visits is recommended in Malawi. In the study population 32.3% (30/93) women had 4 or more visits. In the national survey, there were 44.9%. The proportion of women with targeted visits were significantly lower in our study than the national proportion in the MDHS 2010 (p=0.01, 95% CI o.24 -0.42) [Figure 6.8].

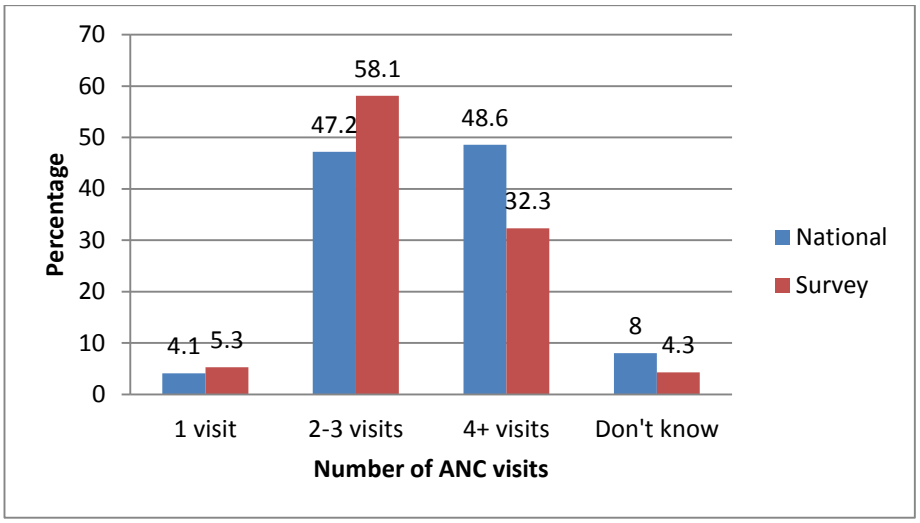


Figure 6.8: Number of antenatal visits for maternal deaths in the study compared to national data

6.4.6 Delivery

6.4.6.1 Mode of delivery

Of the women who died after delivery, (78.8% (78/99)), delivered by spontaneous vertex delivery, and 20.2% (20/99) delivered by caesarean section, (Table 6.10). There were 1,338 caesarean sections in the entire district during the study period and 41,623 estimated live births in the EmOC facilities. The proportion of caesarean section deliveries out of all live births was 3.2%.

Table 6.10: Mode of delivery for women who died after delivery (n=99)

Mode of delivery	Number	Percentage
Spontaneous vertex delivery	78	78.8
Caesarean section	20	20.2
Vaginal breech delivery	1	1.0
Total	**99**	**100**

6.4.6.2 Place of Delivery

Increasing the percentage of births delivered in health facilities is believed is an essential factor in reducing maternal deaths due to obstetric complications. In this study more than half, (62.6%, 62/99) of the women delivered in a health facility. Of these, 62.9% (39/62) delivered in a hospital and 40.3% (25/62) delivered at a health

centre. A significant proportion, 34.3% (34/99), was delivered by a Traditional Birth Attendant (TBA) [Table 6.11].

At national level, the MDHS 2010 reported 73.2% of deliveries occurred in health facilities and 14.4% at a TBA. Comparing the national estimates to this study's findings, a significantly lower proportion of women delivered in a facility in our study than at national level (p= 0.017, 95% CI 0.53 - 0.72).

However, the proportion of women who delivered with a TBA was significantly higher in our study than the proportion in the MDHS 2010, (p=<0.001, 95% CI 0.25 - 0.43).

Table 6.11: Place of delivery for women who died after delivery (n=99)

Place of Birth	Total number	Percentage
Hospital	38	38.4
Health Centre	24	24.2
TBA	34	34.3
Own Homes	3	3.0
Total	**99**	**100%**

6.4.6.3 Association between place of delivery and other background characteristics

Antenatal attendance and place of delivery

Out of 99 women who died after delivery, 93.9% (93/99) received antenatal care. Among the women who received ANC (n=93), 67.7% (63/93), delivered at a health facility and this result was significant (p=0.02). Among the women who did not attend antenatal care, 83.3% (5/6), delivered outside health facility [Table 6.12].

Age

There was no significant association between age and place of delivery (p= 0.89). A linear test of trend was conducted to assess if an increase or decrease in age had influence on place of delivery. There was no linear association between age and place of delivery (p = 0.64). The age of the deceased women did not influence place of delivery.

Education

There was a significant relationship between woman's education status and place of delivery (p=0.02). More women (64.5% %) who had gone to school delivered at a health facility than those who did not attend school at all (35.5%)

Other background characteristics

There were no significant differences between various background characteristics and place of delivery.

Table 6.12: Place of delivery and other background characteristics

Background Characteristic	Place of Delivery		
	Health facility	Outside health facility	Total
Age-group			
15-19	10 (71.4%)	4 (28.6%)	14 (100%)
20-24	12 (57.1%)	9 (42.9%)	21 (100%)
25-29	14 (60.9%)	9 (39.1%)	23 (100%)
30-34	14 (66.7%	7(33.3%)	21 (100%)
35-39	10 (66.7%)	5 (33.3%)	15 (100%)
40-44	2 (40.0%)	3 (60.0%)	5 (100%)
Total	**62 (62.6%)**	**37 (37.4%)**	**99 (100%)**
Level of education			
None	22 (42.3%)	30 (57.6%)	52 (100%)
Primary	37 (84.1%)	7 (15.9%)	44 (100%)
Secondary	3 (100%)	0 (%)	3 (100%)
Tertiary	0 (0%)	0 (0%)	0 (0%)
Total	62 (62.6%)	37 (37.4%)	99 (100%)
Occupation			
Employed	0 (0%)	1 (100%)	1 (100%)
Business	12 (63.2%)	7 (36.8%)	19 (100%)
Farmer	7 (53.8%)	6 (46.2%)	13 (100%)
Housewife	42 (64.6%)	23 (35.4%)	65 (100%)
Student	1 (100%)	0 (0%)	1 (100%)
	62 (62.6%)6	37 (37.4%)	99 (100%)
Antenatal Attendance			
Yes	61 (65.6%)	32 (34.4%)	93 (100%)
No	1 (16.7%)	5 (83.3%)	6 (100%)
Tota1	**62 (62.6%)**	**37 (37.4%)**	**99 (100%)**
Gravidity			
1-2	21 (63.6%)	12 (36.4%)	33 (100%)
3-4	22 (55.0%)	18 (45.0%)	40 (100%)
5 and above	19 (73.1%)	7 (26.9%)	26 (100%)
Total	**62 (62.6%)**	**37 (37.4%)**	**99 (100%)**
Parity			
1-2	30 (62.2%)	19 (38.8%)	49 (100%)
3-4	21 (61.7%)	13 (38.2%)	34 (100%)
5 and above	11 (68.8%)	5 (31.2)	16 (100%)
Total	**62 (62.6%)**	**37 (37.4%)**	**99 (100%)**

*6.4.6.4 **Assistance during delivery***

A total of 99 women died after delivery. Skilled attendance at delivery was reported for 64.6% (64/99) of the MDs. More than half, 67.2% (43/64) were assisted by nurse/

midwives. The rest were either assisted by clinical officers or a doctor [Table 6.13]. The majority, 97.1% (34/35) of women who died outside a facility were assisted by a TBA.

Compared to the national results of MDHS 2011, the proportion of women who had skilled care in at delivery was not statistically different in this study (p= 0.14 CI: 0:54-0.73). Similarly most women (60.6%) studied in the MDHS were also attended by nurse/midwives at the time of delivery (p=0.07). However, in the study population, more women were attended to by doctor or clinical officers than women in the MDHS (p=0.003). Women delivered by TBAs were significantly higher in this study than those studied in the MDHS, 2011 (p=<.001) [Table 6.13].

Table 6.13: Attendance at delivery

Attendant	Number of women in the study (%)	MDHS 2011 (%)	p-value*
Doctor/Clinical officer	21 (21.2)	2,108 (10.7)	**0.003**
Nurse /Midwife	43 (43.4)	11,936 (60.6)	0.07
Patient attendant	-	3151.6)	
Traditional Birth Attendant	34 (34.3)	2836(14.4)	>**0.001**
Relative	1 (1.0)	1,714 (8.7)	**0.01**
No one	-	512 (2.6)	-
Don't know	-	256 (1.3)	-
Total	**99 (100)**	**19,697**	

**Comparison is % in the study compared to national % from MDHS 2011*

6.4.7 Foetal outcome

Eighty seven (82.9%) of the women delivered live born baby and 11.4% (12/105) were still births, Table 6.14.

Table 6.14: Foetal Outcome

Foetal outcome	N (%)
Live births	87 (82.9)
Still births	12 (11.4)
Neonatal deaths (4 – 1st week ENND* and 2-1st month LNND**	6 (6.7)
Total	**105**

**ENND=Early Neonatal Death and **LNND= Late Neonatal Death*; (*6 twin deliveries).*

6.5 Postnatal care

According to the Road Map for Accelerating the Reduction of Maternal and Neonatal Mortality and Morbidity in Malawi, it is recommended that all women who deliver in a health facility receive a postnatal health check-up within the first 24 hours after delivery and also that women giving birth outside of a health facility should be referred to a health facility for a postnatal check-up within 12 hours of giving birth (MOH, 2005). To assess the extent of postnatal care, we checked in the case files for women who delivered at the facility and asked the relatives of the deceased women about postnatal care.

Among women all women who died after delivery (n=99), only 17.2% (17/99) received postnatal care. Most of these women, 15.2% (15/99) delivered at a facility translating into 24.1% (15/62) women received postnatal care from a skilled birth attendant within 24 hours after delivery and only 2.0% (2/99) of the women who delivered outside the facility came for the postnatal care within 24 hours after delivery. No woman came for postnatal check-up after 2 days to 42 days.

6.6 Chapter Summary

This chapter has presented detailed findings on maternal deaths identified during the study period. The MMR for Mangochi lies between lies within the range of 341-363 deaths per 100,000 live births and 95% Cis, ranged from 289-425 deaths per 100,000 live births. Most maternal deaths occurred at a facility level and Mangochi district hospital had the highest MMR. TA Makanjira and Katuli registered more MDs.

Most women, received ANC at a health facility, however there was late registration for ANC services mainly most women came for ANC services in the second and third trimester. Skilled birth attendant among the deceased was lower than the national level at 64.6% and 71.4% respectively. Only a few women (17.2% (17/99)) received postnatal care.

7 RESULTS: UNDERLYING CAUSES OF MATERNAL DEATHS

7.1 Chapter overview

The chapter has 7 main sections. The first 3 sections 7.2 to 7.4 presents underlying cause of death by three methods used to assign cause of death in the sequence outlined below:

1) Health care professionals in Mangochi, based on MD review for maternal deaths which occurred at a health facility.
2) A panel of experts in maternal health using the new WHO classification of maternal deaths (ICD-MM) published in 2012 (WHO 2012c).
3) WHO InterVA-4 software, a model designed to interpret verbal autopsy data.

ICD-MM classification is applied to each method. Causes of maternal death assigned by the panel of experts are compared with those assigned by the health professionals and InterVA-4 in section 7.5. Section 7.4 compares the cause classification by the health professionals and InterVa-4 model to the classification by the panel of experts using ICD-MM. Section 7.6 and 7.7 compares the underlying cause of death with place of delivery and socio-demographic characteristics and the final section summarises the chapter.

7.2 Underlying cause of MDs assigned by health care professionals in Mangochi

In this section underlying causes for 86 maternal deaths assigned by health professionals on the maternal death review form two (MDA2) are presented in Table 7.1.

Direct underlying causes were attributed to 44.1% (38/86) of MDs and 54.7% (47/86) were attributed indirect causes. The cause of one (1.2%) of the 86 MDs was unspecified. The leading underlying cause of death extracted from the MDA2 forms was anaemia, 19.8% (17/86), followed by malaria 10.5% (9/86), hypovolemic shock 9.3% (8/86), puerperal sepsis, and ruptured uterus, both 8.1% (7/86), [Table 7. 1].

Table 7.1: Underlying cause of death for women who died at a facility assigned by health professionals after maternal death review

Cause of death	Number	Percentage (%)

Anaemia	17	19.8
Malaria	9	10.5
Hypovolemic shock	8	9.3
Ruptured uterus	7	8.1
Puerperal sepsis	7	8.1
Abortion related	6	7.0
Eclampsia	4	4.7
PPH	4	4.7
Septic shock	4	4.7
Pre-eclampsia	3	3.5
Pneumonia	3	3.5
Retained placenta	3	3.5
APH	2	3.5
CCF	2	3.5
Unknown	2	3.5
Cardiac failure	1	1.2
Bowel obstruction	1	1.2
Amniotic embolism	1	1.2
Septic shock	1	1.2
Complications of anaesthesia	1	1.2
Total	**86**	**100**

7.2.1 Underlying causes of maternal death assigned by health professionals classified according to ICD-MM

The underlying causes of death on MDA2 were classified by the PI according to ICD-MM groupings. Results in Table 7.2, show the majority, (36.0%, (31/86)), were assigned group 7 (non-obstetric complications), followed by group 3, (obstetric haemorrhage), (18.6%, 16/86) and morbidity group (contributory conditions), 15.1% (13/86). (Figure 7.1 shows a pie chart for the classification). Other details of underlying cause of death as recorded by health professionals and classified using ICD-MM codes are in Appendix 6.

Table 7.2: Classification of underlying cause of MDs on MDA2 by PI using ICD-MM

ICD-MM group number	ICD-MM group name	Number	Percent (%)
1	Pregnancy with abortive outcome	6	7.0
2	Hypertensive disorders	7	8.1
3	Obstetric haemorrhage	16	18.6
4	Pregnancy related infections	7	8.1
5	Other obstetric complications	2	2.3
6	Unanticipated complications of management	1	1.2
7	**Non-obstetric complications**	**31**	**36**
8	Unknown/ undetermined	2	2.3
Morbidity	Contributory conditions	13	15.1
NC	No code	1	1.2
	Total	**86**	**100**

NC= means no code available for the condition in ICD-MM

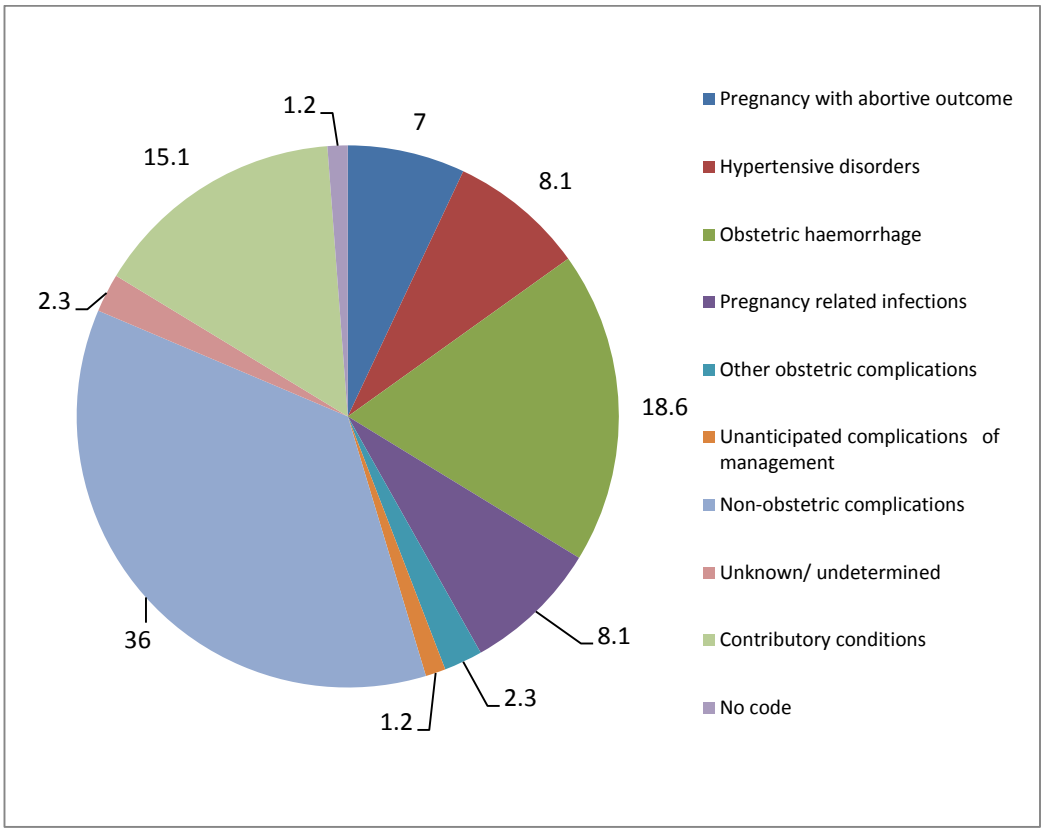


Figure 7.1: Pie chart showing classification of underlying cause of MD on MDA forms using ICD-MM

7.3 Underlying cause classification of Maternal Deaths by the expert panel

This section presents the underlying cause of death assigned by the panel of experts using the ICD-MM. The ICD-MM has divided the underlying causes of deaths during pregnancy, childbirth and the puerperium into four types and nine categories as described in Chapter 4 and outlined in Table 4.4. However the fourth type and ninth group has been excluded in this section because this is a group of non-maternal deaths according to ICD-MM. Details of this group are presented in Chapter 5. Seventy five percent, (74.8% (113/151) of the MD were assigned direct causes and 17.2% (26/151) indirect and 7.9% were MDs with unknown/undetermined (unclassifiable) cause of death [Table 7.3].

7.3.1 Direct Maternal Deaths

Among direct MDs, obstetric haemorrhage was the leading cause of death accounting for 47.8% (54/113), followed by pregnancy-related infections with 19.4%

(22/113), hypertensive disorders in pregnancy, childbirth and the puerperium, 16.8% (19/113) and pregnancy with abortive outcome, 13.2% (15/113), [Figure 7.2 and Table 7. 3].

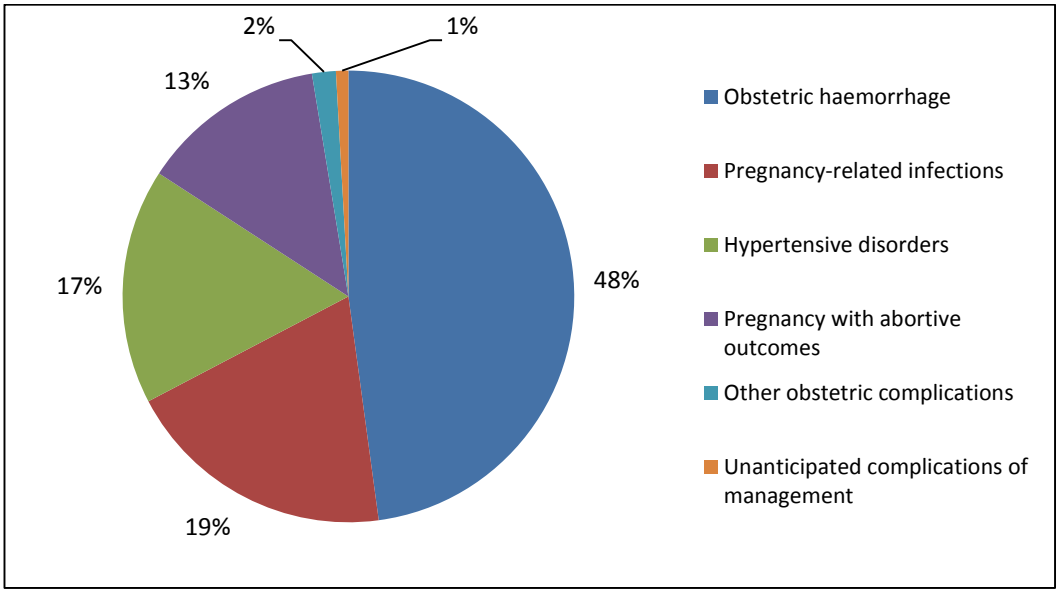


Figure 7.2: Direct underlying cause of maternal deaths

7.3.1.1 ***Obstetric haemorrhage***

Among the women who died of obstetric haemorrhage (n=54), bleeding following retained placenta was the leading cause of death in 31.5%, (17/54), followed by postpartum haemorrhage after delivery of the placenta with 25.9% (14/54), and ruptured uterus, (25.9%, 14/54). Nine, (16.7%), of the women died due to other causes such as placenta previa, placenta abruptio and trauma during delivery [Table 7.3].

7.3.1.2 ***Ruptured uterus***

Of the 14 women who died of ruptured uterus, [Table 7.3], 11 died at a referral hospital and 3 died at a health centre because of reported lack of fuel to transfer the women to a higher level facility.

Among the 11 deaths that occurred at a referral hospital, 6 ruptured in the waiting room of the maternity ward, 3 experienced delay to go to theatre because the hospital had no blood and 2 did not go to theatre in time because there was another case in theatre.

Other details of the 14 MDs with ruptured uterus were: 5 women were diagnosed with cephalo-pelvic disproportion and 3 with prolonged labour, 2 women were multigravidas with a previous history of caesarean section and had ruptured previous caesarean section scar during labour, 2 had mal-presentation (transverse lie in both) and 2/14 reportedly took traditional herbal medicine to accelerate labour.

7.3.1.3 ***Pregnancy-related infection***

There were 22 (19.4%) maternal deaths assigned to the group of pregnancy-related infections. Puerperal sepsis accounted for 17/22 (77.3%) of the MDs and 5/22 (22.7%) of these women developed infection 3-7 days post caesarean section (CS) [Table 7.3]. Among the 22 women who died of pregnancy related infections 9/22 (40.9%) were tested HIV positive. Three (3/9) who were HIV positive were among women who had post CS infection.

7.3.1.4 ***Abortion-related deaths***

Relatively few abortion-related cases were identified, 9.9% (15/151). Thirteen women (13/15, 86.7%) died at a facility and 2/15 (13.3%), of the women died at home. Spontaneous incomplete abortion with haemorrhage was the leading cause of death in 8/15 (53.3%) of the women. Only 2/15(13.3%), of the abortion related deaths were due to septic induced abortion [Table 7.3]. However these findings may be biased as abortion is illegal in Malawi, some women may not have disclosed abortion-related information when seeking care and relatives may not have been aware of the circumstances or not ready to volunteer this information for community deaths.

7.3.1.5 ***Hypertensive disorders***

There were 19 MDs associated with hypertensive disorders of pregnancy, childbirth and the puerperium. Eclampsia in the puerperium was a leading cause of maternal death, and accounted for 8/19 (42.1%) of the hypertensive deaths. The other cases of maternal death due to hypertensive disorders in pregnancy occurred in pregnancy and during labour [Table 7.3].

7.3.2 Indirect MD

MDs caused by indirect causes accounted for 26/151 (17.2%) of MDs. Maternal infections and parasitic diseases, complicating pregnancy, childbirth and the puerperium were the leading indirect cause in 18 (69.2%) of the MDs. Malaria was the leading cause of MD, in this group [Table 7.3]. AIDS-related indirect maternal deaths were the second most common category, (6/26, (23.1%). The other causes of indirect MDs were tuberculosis, meningitis and unspecified infections [Figure 7.3 and Table 7. 3].

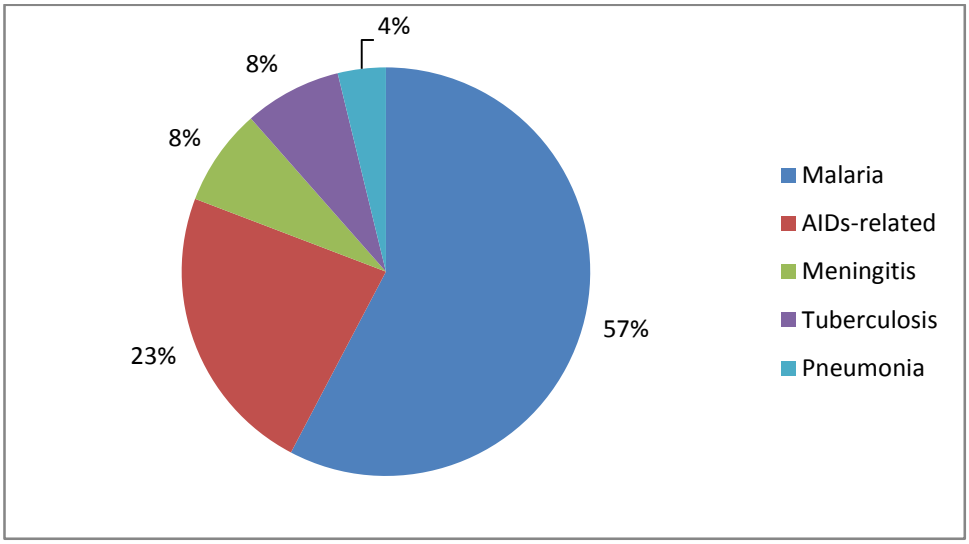


Figure 7.3: Indirect underlying cause of death

7.3.3 Unspecified/unknown cause of MD

There were 7.9% (12/151) MDs for whom underlying cause of death could not be determined by the panel of experts, [Table 7.3]. Among these 12 deaths, 9 occurred outside the health facilities. They were 5 antenatal and 7 postnatal deaths. The majority of the deaths (7/12) which occurred in community were postnatal deaths. The available details of MDs with unspecified cause of death are provided in Table 7.4.

Table 7.3: Underlying cause of maternal deaths by panel of experts using ICD-MM

Type and group name	Total number of MDs in sub-category (%)	Total number of MDs (n=151) (%)
A. Maternal death: Direct		**113 (74.8%)**
1. Pregnancies with abortive outcome		**15 (9.9%)**
– Spontaneous abortion, incomplete, complicated with genital tract and pelvic infection - 003.0	5 (33.3%)	

– Spontaneous abortion, incomplete complicated by excessive haemorrhage - 003.1	8 (53.3%)	
– Induced abortion - 006	2 (13.3%)	
2. Hypertensive disorders in pregnancy, childbirth and the pueperium		**19 (12.6%)**
- Eclampsia in pregnancy - 015.0	4 (21.1%)	
- Eclampsia in labour - 015.1	4 (21.1%)	
- Eclampsia in the puerperium - 015.2	8 (42.1%)	
- Severe Pre-Eclampsia - 014.1	3 (15.7%)	
3. Obstetric Haemorrhage		**54 (35.8%)**
– Placenta praevia with haemorrhage - 044.1	2 (3.7%)	
– Placenta abruption - 045	2 (3.7%)	
– Antepartum haemorrhage not specified - 046	1 (1.9%)	
– Retained placenta - 072.0	17 (31.5%)	
– PPH following placenta delivery (atonic PPH) - 072.1	14 (25.9%)	
– Postpartum haemorrhage - 072	3 (5.6%)	
– Ruptured uterus during labour - 071.1	14 (25.9%)	
– Obstetric laceration of cervix - 071.3	1 (1.9%)	
4. Pregnancy-related Infections		**22 (14.6%)**
– Puerperal sepsis - 085	17 (77.3%)	
– Puerperal sepsis after caesarean section - 086.0	5 (22.7%)	
5. Other obstetric Complications		**2 (1.3%)**
Amniotic fluid Embolism - 088.1	1 (50%)	
Pulmonary embolism - 088.2	1 (50%)	
6. Unanticipated complications of management		**1 (0.7%)**
– Complications of anaesthesia during labour and delivery -074	1 (100%)	
B. Maternal death indirect		**26 (17.3%)**
7. Non-obstetric complications		
– **AIDS related 0.98.7**	**6 (23.1%)**	
– Tuberculosis complicating pregnancy, childbirth and the puerperium - 098.0	2 (7.6%)	
– Other maternal infections and parasitic diseases, complicating pregnancy, childbirth and the puerperium - 098.8 o Malaria o Pneumonia o Meningitis	18 (69.2%) 15 (83.3%) 1 (5.6 %) 2 (11.1%)	
C. Maternal death: unspecified		**12 (7.9%)**
8. Unknown/Undetermined		
– Maternal deaths from unspecified cause occurring during pregnancy, childbirth or the puerperium - 095	12 (100%)	
Total		**151 (100%)**

Table 7.4: Details of maternal deaths with unknown/undetermined cause of death (n=12)

Id	Pregnancy state at time of death	Place of death	Summary of the case
12	antenatal	Health facility	Gravida 3 para 2 was 32 weeks gestation, complained of heart palpitations and died on arrival at the health centre. No history of vaginal bleeding, fever, anaemia or high blood pressure prior to death. She did not receive antenatal care.
24	antenatal	Health facility	Gravida 3 para 2 at 20 weeks gestation. Had negative test for malaria, convulsions, no fever and was bleeding vaginally. Blood pressure was 120/84. No history of high blood pressure, eclampsia or pre-eclampsia during the previous pregnancies. Her HIV status was unknown.

372	antenatal	Health facility	Gravida 2 para 1, 34 weeks gestation, had severe anaemia in pregnancy, coughing, malaria test (RDT) negative, reported to facility in a critical condition. Relatives said she convulsed three times at home before coming to the hospital. B.P: 110/75. HIV status was not known. She died within 30 minutes of admission.
26	postnatal	Outside health facility	Para 4, was HIV positive on HAART for one year, she had fever, was coughing and complained of abdominal pains and leg pains. Relatives reported she looked pale before she died. She died 24 days at home after caesarean section (C/S). Her C/S wound healed well. She died suddenly in her sleep.
34	postnatal	Outside health facility	Para 3, died at home 26 days after delivery with history of general body pains and heart palpitations and backache. She lost consciousness and was groaning on the day of death and relatives thought she was bewitched.
265	antenatal	Outside health facility	Gravida 1 para 0, divorced, at 24 weeks' gestation, with severe cough for more than three weeks, puffy face, breathlessness swelling of hands and legs and was pale. General body pains and no fever. Relatives reported she had distended abdomen. Crying sometimes. HIV status not known
291	postnatal	Outside health facility	Para 6 delivered a full term baby with history of shingles, weight loss, pale, chills, paralysis of legs and arms, not speaking. She was on HAART. Died at home 5 days after delivery.
150	Post abortion	Outside health facility	Gravida 3 para 2^{+1}, 20 weeks gestation, ?induced abortion at home and died 18 days after abortion, complained of headache and general body pains, chills , no fever and sleeplessness, she was also talking to herself (confused).
179	postnatal	Outside health facility	Para 3, who delivered at 38 weeks gestation, complained of general body pains, fever, and headache 30 days after delivery. Was HIV positive on HAART, was not eating and showed signs of wasting.
10	antenatal	Outside health facility	Gravida 2 para 1. Died at home at 24 weeks gestation had puffy face, blurred vision and oedematous limbs. She was confused at times She had no food in her house because her husband divorced her while pregnant, relatives thought she was bewitched. Was crying at times.
131	postnatal	Outside health facility	Para 5, delivered at home and had fever on and off after delivery, coughing, general body pains and pale. One side of the arm was not functioning. Had history of shingles. Went to traditional healer for treatment. She died 3 weeks after delivery.
293	postnatal	Outside health facility	Para 3 delivered a macerated still birth at 38 weeks at home. She had a puffy face, fever, headache, pale and one arm not functioning. HIV status was not known. Went to a traditional healer

7.4 Underlying causes of MDs generated by InterVA-4 model

7.4.1 Underlying causes of death by the InteVA-4 model

Information from VA form for all 151 MDs classified by the panel of experts was entered into the InterVA-4 software model to automatically generate COD. The interVA-4 model generated 16 different COD as outlined in Table 7.5.

The model classified most direct causes of MDs at group level and indirect causes as specific. For example direct causes of MDs such as antepartum haemorrhage, postpartum haemorrhage and retained placenta were grouped as obstetric haemorrhage. Indirect causes of death such as malaria, tuberculosis and anaemia were specific [Table 7.5].

Table 7.5: Cause of MDs by InterVA-4 model

No	Cause name
1	Obstetric haemorrhage
2	Pregnancy-induced hypertension
3	Pregnancy-related sepsis
4	Abortion-related death
5	Anaemia of pregnancy
6	HIV/AID-related death
7	Malaria
8	Obstructed labour
9	Acute respiratory infection (including pneumonia)
10	Tuberculosis
11	Meningitis
12	Ruptured uterus
13	Complications of anaesthesia
14	Other and unspecified maternal COD
15	Other unspecified cardiac disease
16	Chronic obstructive pulmonary disease

For 28 cases the model displayed more than one probable COD and the corresponding likelihood percentage [Table 7.6]. Twenty seven deaths (96.4%) were assigned two likely causes. For the analysis of this study the first most likely cause of death was used.

Table 7.6: List of cases with multiple causes of deaths by InterVA-4 model

Case ID	Cause of Death & Likelihood (%)		
15	Obstructed labour (41%)	Obstetric haemorrhage (25%)	Pregnancy-related sepsis (25%)
17	Malaria (49%)	Obstetric haemorrhage (30%)	-
18	Ruptured uterus (80%)	Obstetric haemorrhage (20%)	-
21	Obstetric haemorrhage (66%)	Anaemia in pregnancy (34%)	-
23	Obstetric haemorrhage (56%)	Anaemia in pregnancy (44%)	-
30	HIV/AIDS-related death (72%)	Acute respiratory infection including pneumonia (33%)	Unspecified cardiac disease (28%)
35	Obstetric haemorrhage (61%)	Anaemia in pregnancy (38%)	-
39	Obstetric haemorrhage (60%)	Pregnancy-related sepsis (30%)	-
45	Pregnancy induced hypertension (78%)	Obstetric haemorrhage (22%)	-
48	HIV/AIDS related death (80%)	Chronic obstructive pulmonary disease (20%)	-
65	Pregnancy-related sepsis (52%)	Obstetric haemorrhage (34%)	-
70	Obstetric haemorrhage (61%)	Anaemia in pregnancy (39%)	-
73	Pregnancy-related sepsis (62 %)	Obstetric haemorrhage (38%)	-
78	Malaria (59%)	Pregnancy-related sepsis (41%)	-
79	Pregnancy related sepsis (50%)	Anaemia (50%)	-
80	Malaria (53%)	Pregnancy-related sepsis (47%)	-
93	Obstetric haemorrhage (59%)	Obstructed labour (37%)	-
96	HIV/AIDS-related death (61%)	Pulmonary tuberculosis (39%)	-
98	HIV/AIDS-related death (83%)	Anaemia in pregnancy (17%)	-
99	Obstetric haemorrhage (61%)	Pregnancy-induced hypertension (39%)	-
100	Obstetric haemorrhage (56%)	Anaemia in pregnancy (44%)	-
101	Pregnancy-induced hypertension (60%)	Obstetric haemorrhage (37%)	-
102	Obstetric haemorrhage (55%)	Anaemia in pregnancy (44%)	-
113	Obstetric haemorrhage (60%)	Anaemia in pregnancy (40%)	-
114	Malaria (69%)	Acute respiratory infection including pneumonia 28%	-
118	Obstetric haemorrhage (61%)	Anaemia of pregnancy (38 %)	-
131	Pregnancy-related sepsis (62%)	Anaemia of pregnancy (26%)	-
153	Pregnancy-related sepsis 62%	Obstetric haemorrhage (34%)	-

Out of the 151 maternal deaths, direct causes were attributed in 74.1% (112/151), 23.8% (36/151) had indirect causes and 2.0% (3/151) were MDs where causes could not be specified (undetermined). The leading direct underlying cause of MD was obstetric haemorrhage with 37.5% (42/112), [Figure 7.4].

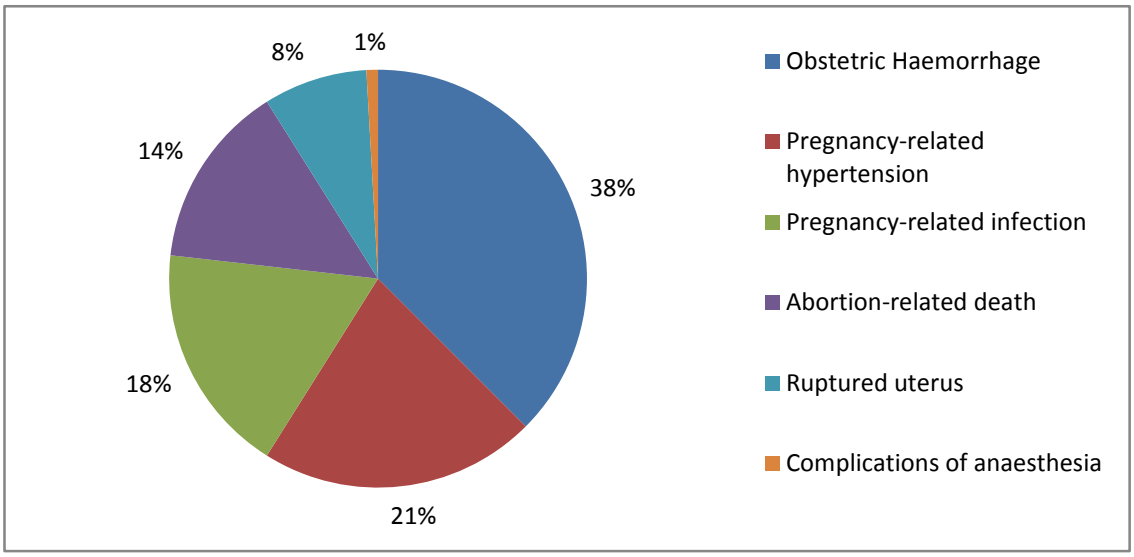


Figure 7.4: Direct causes of maternal deaths according to InterVA-4 model (n=112)

7.5.2 Indirect underlying causes of maternal death according InterVA-4 model

Indirect causes of MDs were assigned to 23.8% (36/151) of MDs. Anaemia in pregnancy was the leading indirect cause of maternal deaths, 36.1% (13/36), followed by malaria, 25.0% (9/36), HIV, 13.9% (5/36) and tuberculosis 8.3% (3/36). Figure 7.5 gives details on the indirect causes of maternal deaths according to model.

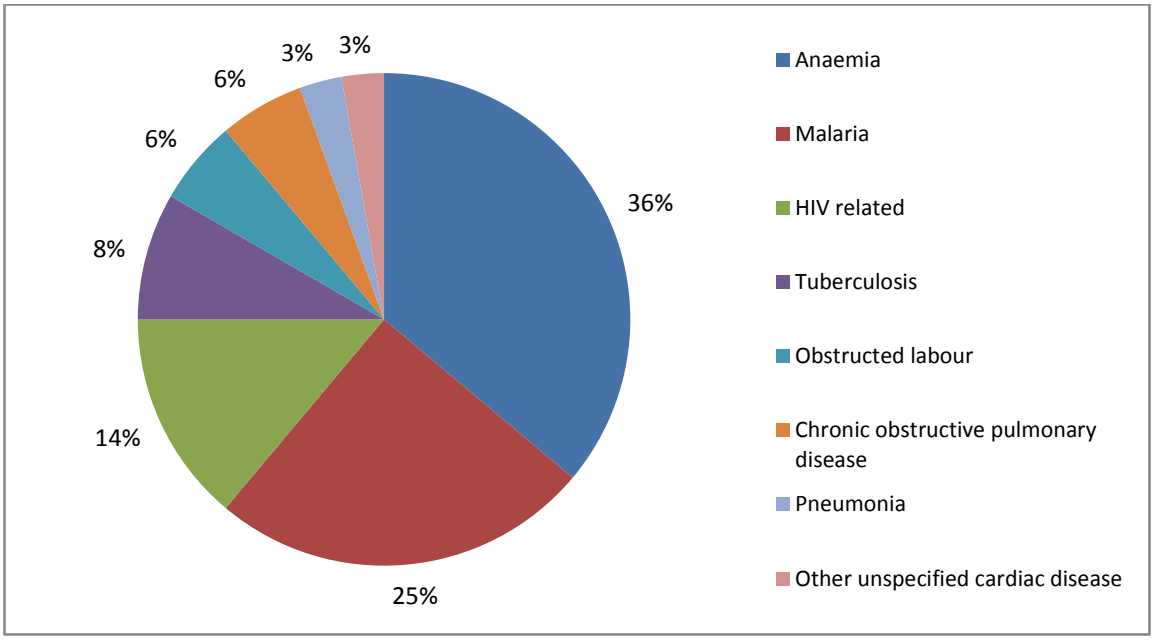


Figure 7.5: Indirect causes of maternal deaths according to interVA-4 model

7.4.2 Classification of underlying causes of death generated by InterVA-4 model according to ICD-MM

The underlying causes of deaths assigned by interVA-4 were classified using the ICD-MM groupings by the PI. Table 7.7 shows the ICD-MM groups to which the underlying causes of death belong. Most underlying causes belonged to group 3 (obstetric haemorrhage), 33.7% (51/151) followed by group 7 (non-obstetric complications) 22.5% (34/151), then group 2 (hypertensive disorders during pregnancy, childbirth and puerperium), 15.9% (24/151) and group 4 (pregnancy-related infection), 13.3% (20/151).

Table 7.7: Classification of underlying causes of maternal deaths generated by InterVA-4 model according to ICD-MM

ICD-MM group number	ICD-MM group name	Number	Percent (%)
1	Pregnancy with abortive outcome	16	10.6
2	Hypertensive disorders	24	15.9
3	Obstetric haemorrhage	51	33.7
4	Pregnancy related infections	20	13.2
5	Other obstetric complications	0	0
6	Unanticipated complications of management	1	0.7
7	Non-obstetric complications	34	22.5
8	Unknown/ undetermined	3	2.3
Morbidity	Contributory conditions	2	1.3
		151	100

7.5 Cause classification of MDs by the health professionals on the MDA2, InterVA-4 model with panel of experts using ICD-MM

This section compares cause-classification by the health professionals for MDs which occurred at facility level with the panel of experts classification using ICD-MM. Cause of MDs generated by the InterVA-4 model is also compared with the panel of expert's classification

7.5.1 Underlying cause of death by health professionals on the MDA2 and the panel of experts using to ICD-MM

In this section causes of 86 facility-based MDs assigned by the health professionals are compared with the panel of expert's classification and the level of agreement is presented. For comparison, underlying cause of death applied by the PI on the causes on the MDA2 (Table7.2) using ICD-MM are compared with same cases as classified by the panel in section 7.3. Details of this classification can be found in Appendix 6

Table 7.8, shows, most underlying cause of death assigned by health professionals, (36.0%, 31/86) belonged to group 7 (non-obstetric complications). There were more MDs (33.7%, (29/86) caused by obstetric haemorrhage as assigned by panel of experts compared to the health professionals, (18.6%, 16/86). Similarly the panel attributed more abortion related causes than the health professionals. Health professionals assigned causes in the morbidity group (contributory factors,) to 15.1% of the women as underlying cause of MDs [Table 7.8].

Table 7.8: Underlying cause of death of 86 facility based MDs by health professionals and panel of experts according to ICD-MM

ICD-MM group number	ICD-MM group name	Underlying cause of death by health professionals (%)	Underlying cause of death by panel of experts (%)
1	Pregnancy with abortive outcome	6 (7.0)	12 (14.0)
2	Hypertensive disorders	7 (8.1)	10 (11.6)
3	Obstetric haemorrhage	16 (18.6)	29 (33.7)
4	Pregnancy related infections	7 (8.1)	12 (14.0)
5	Other obstetric complications	2 (2.3)	2 (2.3)
6	Unanticipated complications of management	1 (1.2)	1 (1.2)
7	Non-obstetric complications	31 (36.0)	15 (17.4)
8	Unknown/ undetermined	2 (2.3)	5 (5.8)
Morbidity	Contributory conditions	13 (15.1)	**0**
NC	No code	1 (1.2)	0
	Total	**86 (100)**	**86 (100)**

NC means no code available for the condition in ICD-MM

7.5.1.1 *Measures of agreement between underlying cause of death from MDA2 and those attributed with ICD-MM by panel of experts*

Table 7.9 shows the comparison between the underlying cause of death extracted from MD2 and those attributed using ICD-MM by panel of experts. Cohen's kappa was further calculated to determine the agreement level on the causes of deaths assigned by the panel of experts and by the health professionals. They agreed in 40/86=46.5% of cases. The kappa coefficient revealed slight agreement (κ= 0.37), between causes assigned by health professionals and the panel of experts.

Table 7.9 Categorisation of cause of death and measures of agreement between health professionals and the panel of experts

Category assigned by health professionals	**Category by expert panel**										
	1	2	3	4	5	6	7	8	Morbidity	NC	**Total**
1	**3**	1	0	0	0	0	1	1	0	0	6
2	0	**7**	0	0	0	0	0	0	0	0	7
3	1	0	**11**	0	0	0	0	0	0	0	12
4	0	0	0	**6**	0	0	1	0	0	0	7
5	0	1	1	0	0	0	0	0	0	0	2
6	0	0	0	0	0	**1**	0	0	0	0	1
7	6	1	7	3	1	0	**12**	3	0	0	33
8	1	0	0	0	0	0	0	0	0	0	1
Morbidity	1	0	10	3	1	0	1	0	0	0	16
NC	0	0	0	0	0	0	0	1	0	0	1
Total	**12**	**10**	**29**	**12**	**2**	**1**	**15**	**5**	**0**	**0**	**86**

NC= means no code available for the condition in ICD-MM

Key

1. Pregnancy with abortive outcome
2. Hypertensive disorders in pregnancy, childbirth and the puerperium
3. Obstetric haemorrhage
4. Pregnancy related infection
5. Other obstetric complications
6. Unanticipated complications of management
7. None-obstetric complications
8. Unknown/Undetermined

7.5.2 Cause of death assigned by expert panel and generated by InterVA-4 model

In this section, underlying causes and areas of agreement of all 151 maternal deaths assigned by the InterVA-4 model and panel of experts using the ICD-MM are compared and level of agreement between the two methods is presented.

Causes of MDs by the InterVA-4 model were compared to causes assigned by the panel of experts. To allow meaningful comparison of causes assigned by the panel of experts [Table 7.3] and the underlying causes of deaths assigned by InterVA-4 which were classified according to the ICD-MM groupings [Table 7.4], were compared, [Table 7.10].

There was a slight difference between most causes assigned by interV-4 and expert panel (Table 7.10), except for the unknown causes where more 7.9% (12/151) by the panel than the interVA-4, (1.3%, 2/151).

The panel of experts assigned more MDs to unspecified causes (7.9% (12/151) than the model, (Table 7.10).

Table 7.10: Underlying cause of MDs assigned by InterVA-4 and experts panel using ICD-MM

ICD-MM group number	ICD-MM group name	Cause of death by InterVA-4 (%)	Cause of death by panel of experts (%)
1	Pregnancy with abortive outcome	16 (10.6)	15 (9.9%)
2	Hypertensive disorders	24 (15.9)	19 (12.6)
3	Obstetric haemorrhage	51 (33.7)	54 (35.8)
4	Pregnancy related infections	20 (13.2)	22 (14.6)
5	Other obstetric complications	0 (0.0)	2 2(1.3)
6	Unanticipated complications of management	1 (0.7)	1 (0.7)
7	Non-obstetric complications	34 (22.5)	26 (17.3)
8	Unknown/ undetermined	3 (2.0)	12 (7.9)
Morbidity	Contributory conditions	2 (1.3)	0 (0.0)

7.5.2.1 Level of agreement between experts panel and the InterVA-4 model

Further analysis was conducted to compare the level of agreement between the two groups using kappa statistics. Table 7.11 shows the comparison between the two ICD-MM groups for underlying causes of deaths by the model and by the expert panel.

Among the 151 cases, there was substantial agreement on the causes of deaths between the panel of experts and the InterVA-4 model, with 111/151= 73.5%, (κ=0.66).

Table 7.11: Measures of agreement between causes of maternal deaths by the panel of experts and the InterVA-4 model

	Category by expert panel									
Category assigned by InterVA-4 model	1	2	3	4	5	6	7	8	Morbidity	**Total**
1	**13**	0	0	1	0	0	1	1	0	16
2	0	**18**	1	2	0	0	1	2	0	24
3	0	1	**46**	0	1	0	2	1	0	51
4	1	0	0	**14**	0	0	3	2	0	20
6	0	0	0	0	**0**	**1**	0	0	0	1
7	0	0	5	3	1	**0**	**19**	6	0	34
8	1	0	2	0	0	0	**0**	0	0	3
Morbidity	0	0	0	2	0	0	0	**0**	0	2
Total	**15**	**19**	**54**	**22**	**2**	**1**	**26**	**12**	0	**151**

Key

1. Pregnancy with abortive outcome
2. Hypertensive disorders in pregnancy, childbirth and the puerperium
3. Obstetric haemorrhage
4. Pregnancy related infection
5. Other obstetric complications
6. Unanticipated complications of management
7. None-obstetric complications
8. Unknown/Undetermined

7.6 Underlying cause and type of maternal death according to place of delivery

Out of the total of 151 MDs classified by the panel of experts, 65.6% (99/151), died after delivery. Sixty two (62.6%) delivered at a facility and 37.4% (37/99) in the community. Direct cause of death had the highest proportion for both women who delivered at facility and community level, (80.6% (50/62) and 70.6% (26/37 respectively), [Figure 7.6].

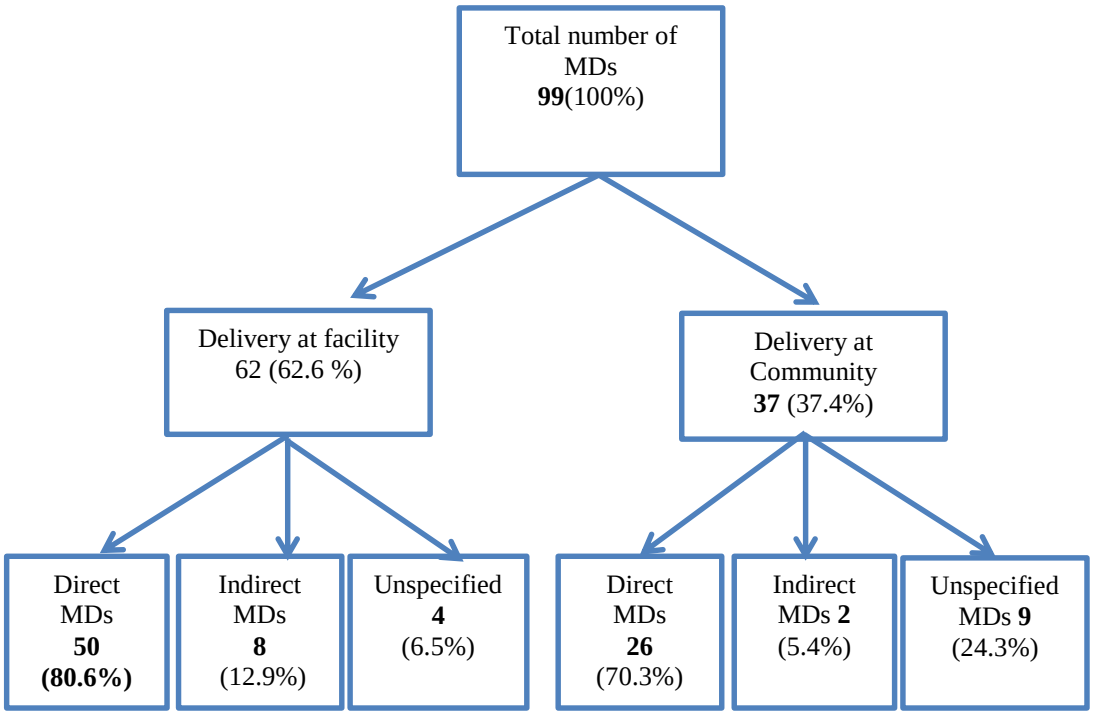


Figure 7.6: Cause distribution of MDs by place of delivery

7.6.1 Direct causes of maternal deaths and place of death

A comparison of underlying cause of direct MDs at facility and community level was done. There was no significant difference in the proportion of women who died of obstetric haemorrhage for both women who delivered at facility and community level (p= 1.0) [Table 7.12]. On the other hand pregnancy related infections were significantly higher among women who delivered at community level than at facility level (p=0.01). [Table 7.12].

Table 7.12: Direct causes of MDs and place of delivery

Cause of death	Health Facility (%)8	Community (%)	Total	p-value*
Obstetric Haemorrhage	20 (40)	13 (40.6)	33	1.0
Abortion-related causes	13 (26)	2 (6.3.)	15	**0.08**
Hypertensive disorders in pregnancy	11 (22)	5 (15.6)	16	0.89
Pregnancy-related infections	4 (8)	12 (37.50)	16	**0.01**
Embolism	1 (2)	0 (0)	1	-
Complications of anaesthesia	1 (2)	0 (0)	1	-
Total	**50 (100)**	**32 (100)**	**82**	

7.6.2 Indirect MDs and place of delivery

Direct causes of MDs who delivered at facility and community could not be compared because of the small numbers and different cause of death which were not comparable.

7.7 Underlying cause according to socio-demographic characteristics

Table 7.13 shows how the underlying causes of MDs were distributed according to age groups, level of education, residence and marital status. A significant difference was observed in the cases of obstetric haemorrhage among the age groups (p=0.01).

Age group 25-29 had the highest proportion of MDs with obstetric haemorrhage followed by 20-24 and 30-34 [Table 7.3] MDs with unspecified cause of death were significantly higher (p=0.05) in age groups 25-29 compared to age groups 15-19 through to 30-34. No significant differences were observed in the other underlying causes of MDs and age [Table 7. 13].

Abortion-related deaths were significantly higher among MDs who attended school than among their counterparts (p=0.05) (Table 7.4). No significant difference was observed between level of education and other underlying causes of death. Percentages of married women outweighed single women in almost all causes of maternal deaths except for HIV, other obstetric complications and other infections (p=0.57, respectively), (Table 7.13). All the maternal deaths identified in this study came from rural area.

Table 7.13: Underlying cause of maternal deaths by socio-demographic characteristics (n=151)

	Obstetric haemorrhage (n=54)	Pregnancy related infection (n=22)	Hypertensive disorders (n=19)	Pregnancy with abortive outcome (n=15)	Other*[a] (n=3)	Malaria (n=15)	HIV (n=6)	Other Infections (n=5)	Indeterminate /unspecified (n=12)
Age group									
15-19	5	4	5	4	0	3	0	1	2
20-24	11	4	5	6	0	7	1	1	2
25-29	16	4	2	4	1	1	2	2	7
30-34	11	4	3	0	1	3	1	0	1
35-39	9	4	2	1	1	1	1	1	0
40-44	2	1	1	0	0	0	1	23	0
45-49	0	1	1	0	0	0	0	0	0
p-value	**0.01**	**0.57**	**0.28**	**0.21**					
Educational level									
Never	26	11	11	4	2	6	3	25	7
Primary	28	10	8	8	1	8	3	23	5
Secondary	0	1	0	2	1	1	0	13	0
Tertiary	0	0	0	1	0	0	0	0	0
p-value	**0.85**	**1.0**	**0.52**	**0.03**	**1.00**	**0.49**	**1.00**	**1.00**	**0.60**
Single	**5**	**6**	**4**	**3**	**1**	**4**	**2**	**2**	**2**
Married	**49**	**16**	**15**	**12**	**2**	**11**	**4**	**3**	**10**
p-value	**0.001**	**0.006**	**0.01**	**0.003**	**1.0**	**0.03**	**0.57**	**1.0**	**0.003**

*Includes other obstetric complications and unanticipated complications of management. ** All figures in brackets are percentages)

7.8 Chapter Summary

In this chapter, underlying causes of maternal death according to three methods used to classify cause of death have been presented and compared i.e. panel of three experts, Health professionals and InterVA-4 so model. Obstetric haemorrhage is the leading underlying cause of MDs according to the panel of experts and InterVA-4 model while the health professional's assigned non-obstetric complications as the leading underlying cause of MDs. Few abortion-related deaths were identified both at facility and community level and there was a significantly high number of women who died of pregnancy related infection at facility and community level.

There was high level of agreement between causes by expert panel and InterVA-4 and little agreement with the health professionals. The InterVA-4 model assigned more general cause of MDs than the panel of experts. Health professionals assigned contributing factors as underlying cause of death to some MDs based on ICD-MM classification.

8 RESULTS: CONTRIBUTING CAUSES AND FACTORS ASSOCIATED WITH MATERNAL DEATHS

8.1 Chapter overview

The chapter presents contributory conditions and factors that were associated with MDs. There are four main sections: Section 8.2 outlines contributory conditions to MDs according to ICD-MM, Section 8.3 presents contributory conditions assigned by a panel of experts using the ICD-MM, and Section 8.4 compares contributing conditions assigned by health professionals on MDA2 forms and the panel of experts. In section 8.5, factors that were associated with MDs are presented using the three delays model.

8.2 Contributing conditions to maternal deaths according to ICD-MM

The ICD-MM defines contributing conditions as other conditions which are unlikely to cause MDs on their own but may have contributed to events leading to death and these contributing conditions may predispose women to death as either persisting conditions or a risk factor (World Health Organisation, 2012). Table 8.1 lists some of the common contributing factors to MDs with codes based in ICD-MM.

Table 8.1: Common contributory/associated conditions to maternal deaths according to ICD-MM

Common contributory factor	ICD-MM/ICD Code	Classification group No.	Title of group
Obstructed labour	064, 065, 066*	Morbidity	Contributory conditions
Long labour	063	Morbidity	Contributory conditions
Premature rapture of membranes	042	Morbidity	Contributory conditions
Prolonged pregnancy	048	Morbidity	Contributory conditions
Multiple gestation	030	Morbidity	Contributory conditions
Complications following abortions ectopic and molar pregnancy	008	Morbidity	Contributory conditions
Shock during labour and delivery	075.1	Morbidity	Contributory conditions

Source: (WHO 2012c).

** 064 - Obstructed labour due to malposition and malpresentation of foetus, 065 - Obstructed labour due to maternal pelvic abnormalities. 066 - Other obstructed labour due to either conjoined twins, shoulder dystocia, unusually large foetus etc.*

8.3 Contributory conditions to maternal deaths by panel of experts

The panel of experts identified contributing factors in 81.5% (123/151) of the maternal deaths. The contributory/associated factors were identified from case notes, verbal autopsy questionnaires and the deceased's health passports. Some MDs were attributed with multiple contributory conditions and each case was assigned codes and names according to ICD-MM and ICD-10 in Table 8.2.

The most common contributory cause of death attributed by applying the ICD-MM was obstructed labour which contributed to 35.0% (43/123) of the deaths. This was followed by all forms of prolonged labour with 14.3% (20/143) and severe anaemia which contributed to 15.4% (19/123) of cases [Table 8.2].

Table 8.2: Contributory causes of deaths by panel of experts (n=123)

ICD-MM/ICD-10 Code	ICD-MM group name	Frequency	Percentage
064	Obstructed labour due to malposition and mal-presentation of the foetus	23	18.7
065	Obstructed labour due to maternal pelvic abnormality	16	13.0
066.3	Obstructed labour due to other abnormalities of the foetus (hydrocephalus)	2	1.6
064 & 065	Septic shock and obstructed labour	1	0.8
075.1, 064.2	Septic shock, obstructed labour due to face presentation and prolonged labour	1	0.8
Morbidity	Severe anaemia	15	12.2
Morbidity	Severe anaemia and heart failure	2	1.6
Morbidity & 066	Severe anaemia and obstructed labour	2	1.6
063	Prolonged second stage of labour	13	10.6
063.9, 075.1	Prolonged labour and septic shock	9	7.4
075	Haemorrhagic/hypovolemic shock	9	7.4
030	Multiple gestation	8	6.5
042	Premature rupture of membranes	7	5.7
075	Infected caesarean section wound, peritonitis	4	3.3
86.0	Infected caesarean section wound and septic shock	4	3.3
084.4	Grandmultiparity	2	1.6
062.3	Precipitate labour	2	1.6
7075.1	Septic shock/ Puerperal psychosis	2	1.6
	Tuberculosis infection	**1**	0.8
Total		**123**	**100**

8.4 Comparing contributory conditions of maternal deaths by health professionals and the panel of experts

In this section, contributing factors to maternal deaths assigned by health professionals on MDA2 and panel of experts using the ICD-MM are each presented. Thereafter the agreement between the two methods is presented.

8.4.1 Contributory conditions of death assigned by health professionals

Out of 86 MDs documented in the HMIS, 69 (87.3%) MDs were assigned contributory conditions. The most common contributing condition was severe anaemia (15.9% (11/69)). HIV disease complicating pregnancy, childbirth and puerperium, and ruptured uterus, each contributed 13.0% (9/69) of the MDs. Obstructed labour contributed to 10% (7/69) of the cases [Table 8.3]. Other contributing causes are listed in Table 8.3.

Table 8.3: Contributory causes of maternal deaths extracted from maternal Deaths review forms

No	Name	Frequency	Percent
1	Severe anaemia	11	15.9
2	Ruptured uterus during labour	9	13.0
3	HIV	9	13.0
4	Obstructed labour	7	10.1
5	Septicaemia	6	8.7
6	Peritonitis	3	4.3
7	Eclampsia	3	4.3
8	Severe anaemia concealed	2	2.9
9	Severe malaria	2	2.9
10	Postpartum coagulation defects and grandmultiparity	2	2.9
11	Prolonged labour	2	2.9
12	Bacterial meningitis	2	2.9
13	Placenta abruptio with disseminated intravascular coagulopathy	1	1.2
14	Placenta accreta	1	1.4
15	Intravascular coagulopathy	1	1.4
16	Pneumonia	1	1.4
17	Pulmonary oedema and severe pre1eclampsia	1	1.4
18	Severe malaria and pre-eclampsia	1	1.4
19	Postpartum haemorrhage 2^0 to cervical tear	1	1.4
20	Antepartum haemorrhage and placenta previa	1	1.4
21	Eclampsia	1	1.4
23	Retained placenta with haemorrhage	1	1.4
24	Bowel obstruction	1	1.4
	Total	**69**	**100**

8.4.2 Classification of contributory conditions on the MDA2 by panel of experts according to ICD-MM and ICD-10

The panel of experts classified the contributory causes on the MD2 forms based on the ICD-MM codes as presented in table 8.4. Less than half of the MDs, 42.0% (29/69), are under a morbidity classification group and other codes which fell under contributory conditions. The majority of the cases 53.6% (37/69) belonged to the groups 7 (non-obstetric causes - 12), (Table 8.4). Contributing factors assigned to two cases belonged to underlying and contributory causes according to ICD-MM, [Table 8. 4].

Table 8.4: ICD-MM groups extracted from the maternal death review forms

ICD-MM group	ICD-MM group name	Number	Percentage
3	Obstetric haemorrhage	13	18.8
Morbidity	Contributory conditions	13	18.8
7	Non-obstetric complications	12	17.4
4	Pregnancy related infections	9	13.0
063	Prolonged labour	9	13.0
064, 065 & 066.	Obstructed labour	7	10.1
2	Hypertensive disorders	3	4.3
3 & morbidity[2]	Obstetric haemorrhage and contributory condition	2	2.8
7 &3[2]	Non-obstetric complication and Hypertensive disorders	1	1.4
Total		69	100

[2] More than one contributory cause

8.4.3 Measure of agreement between contributory causes by the panel of experts and the MDA2

It was not possible to calculate the Cohen's kappa statistic inter-rater agreement between contributory factors assigned by the panel and by the health professionals as kappa requires a two way table in which variables are of the same type and there was wide variability between contributory causes assigned by both groups of raters.

8.5 Associated factors of MDs according to three delays model

The three delay model was used to identify community and health services factors contributing to maternal deaths. Delays at different levels contributed to the maternal deaths. Data extracted from the verbal autopsy forms and case notes of maternal death review forms and narratives were analysed using IBM SPSS version 21.0.

The analysis was descriptive in nature. Type I, Type II and Type III delays each had a role in all maternal deaths and in most of the cases of maternal deaths, multiple types of delay were co-existing.

8.5.1.1 ***Type I delay***

Of the 151 MDs reviewed, delay in decision making due to traditional family norms was present in 39.7% (60/151) of MDs. Women needed the financial, logistical and moral support from their relatives and male partners to receive care in health facilities.

In Mangochi district, the relatives of the wife (especially the uncles and mother) are important decision-makers in a family and the husband has less influence because after marriage, the husband goes to live with his wife's family and has little control over his family. However in terms of financial support the husband takes responsibility. Among the MDs who experienced delay 1, 16.6% (10/60) died at home because their relatives had no financial capacity to take them to a health facility after deciding to seek health care.

Failure to recognise danger signs contributed to a total of 33.8% (51/151) MDs. Skin pallor, headache, vomiting, fever and dizziness, antepartum haemorrhage in early and late pregnancy were considered as normal signs of pregnancy because they were common among pregnant women in the district [Table 8.5]. One grandmother who was among deceased relatives during interviews, narrated in the case below:

Case #1 Respondent: Grand mother

She was discharged after delivery from a heath facility. Two days later she had fever and did not report to any health facility because she had the same experience with her second baby. We decided to buy paracetamol from a nearby grocery which made her feel better. Four days later fever continued and she noticed foul-smelling vaginal discharge and pain in her abdomen. She had no money for transport to go to the nearest health facility which was far away, about 7km. Her husband was away at the lake and she sought care from a neighbour who was knowledgeable about traditional medicine and he treated her with traditional medicine. She became more ill over the next days with increased fever and sweats. After one week her husband came back and hired a car to a hospital. On arrival at the health centre, we were told her case was complicated and that there were no drugs at the health centre. She was then referred to a next level of care where she died two days later.

Thirty three (21.9%) of the women delayed seeking professional care because they did not want to stay in the labour ward for a long period. Twenty (60.6%), of these women (n=33) were multigravidas with past labour experiences and were waiting for established labour at home and arrived at the health facility in second stage of labour. The remaining 8.6% (13/33) were primigravidas who reported at a facility with either prolonged premature rupture of membranes or obstructed labour because they were misguided by experienced guardians/relatives who felt they were not in established labour and may have exaggerated the signs and symptoms of labour due to lack of experience [Table 8.5].

Fourteen women (9.3%) consulted traditional healers first before visiting the health facilities and only reached facilities with complications [Table 8.5].

8.5.1.2 ***Type II delay***

Delay in reaching a health facility was present in 51.0% (77/151) of the MDs. The availability of transport and the cost of transport was a barrier in accessing healthcare. The needed to travel long distances (6-15 km, which took two hours) because of a lack of a health facilities in the vicinity contributed to 39.7% (60/151) deaths. Securing transport took a long time for 11.3% (17/151) of MDs. A total of

82.4% (14/17) women had no money to hire a vehicle and 3/17 (17.6%) delayed to find a vehicle because drivers did not agree to take the women who were bleeding [Table 8.5]. These three women reached a facility late because they used an ox cart, a slowest mode of transport for an emergency case. Some roads were impassable in rainy season [Table 8.5]. One narration below provides an account of the hardships faced by the women and their families while attempting to reach the nearest facilities.

Case #2 Respondent: Mother

She delivered at home in the morning. Towards the afternoon she started bleeding. So we got prepared to go to the hospital. We were far away and decided to hire the only car in our village, unfortunately the owner of the car refused to carry her because she was bleeding. He said one woman spoiled his car last time he was hired to a hospital. We got an oxcart late in the day because she could not manage on a bike. We arrived at the facility late in the night and she died some hours later.

8.5.1.3 ***Type III delay***

A total of 133/151 (88.7%) experienced problems associated to third delay. Twenty five barriers to receiving timely and appropriate obstetric care at the facility level were identified and categorised into two major categories (administrative factors and health worker related factors.

Barriers relating to the availability of essential drugs, equipment and blood were identified in 78.46% (118/151) of MDs. Providers were unable to refer 23.2% (35/151) of women with complications due to lack of transport. Three (8.6%) women died at Lulanga, Malembo and Makanjira health centres while waiting for transport to a referral hospital. Two women died on the way to a referral hospital which was more than two hours' drive. Ambulances were only available in 13.0% (6/46) of all facilities in Mangochi district [Table 8.5]. More than half of the health centres in Mangochi district do not have an ambulance to refer emergency cases.
Three women were delayed in reaching a referral hospital due to ambulance breakdown and these women had to use alternative public transport.

Furthers delays were due to lack of fuel in an ambulance which led to death of 23.1% (15/151) of women [Table 8.5].

About 11.2% (17/151) of women died due to lack antibiotics and magnesium sulphate. Magnesium sulphate was not available to treat 47.3% (9/19) of women with eclampsia. Women were told to buy the drug and the two women who managed to buy, came late because there was no pharmacy in the district selling the drug. Five health centres where MDs occurred had no functioning sphygmomanometer and women with a history of eclampsia were referred when convulsions occurred. Reasons for not having a sphygmomanometer were either they had ordered the equipment or sent it for repair at the district hospital

The unavailability of blood transfusion services at the referral hospital was another associated factors to MDs. Lack of blood for transfusion or supplies was identified in 10.6% (16/151) of MDs. There is no blood bank at Mangochi District Hospital. Blood is obtained from a blood bank in Blantyre, a tertiary hospital which is 150 kilometres away from Mangochi district.

During the study period, family members of five MDs had to walk on a long journey home to obtain blood donors, and it took from three to seven days to come back. Two of the relatives mentioned that donors were identified around the hospital and paid the blood donors a total of MK5, 000.00 ($10) for each donor. Taboos surrounding blood donation prevented two women from obtaining blood for emergency transfusion. The two women belonged to Jehovah's Witness church which does not allow its members to receive blood.

Lack of surgical gloves was another problem which resulted in insufficient examination of 6.6% (10/151) women. Details of other administrative barriers are in are shown in Table 8.5.

Delay in receiving care after arrival at health facility occurred in 37.8% (51/151) MDs. On average it took 1-3 hours for some health workers at health centres to attend to women when they reported at the facility. Twenty six women (17.7%)

were not examined on arrival to the facility on admission and were told to report again when in established labour.

Relatives of 20/151 (13.2%) women reported that they delayed to report to the facilities because staff in some facilities could shout at them when they brought a patient at night or late in the afternoon. Five women delivered at home at night and developed PPH and waited until morning to report for treatment [Table 8.5].

Some health professionals lacked adequate skills to manage emergencies. Six (6) women died because the health professionals lacked knowledge on management of retained placenta. Five (5) women with postpartum haemorrhage were referred from the primary level to the next level of care without any intervention.

Despite availability of resources, neither oxytocin nor intravenous infusion was commenced while waiting for the ambulance. Time to refer the cases to the next level of management ranged from 1-3 hours. This was coupled with a lack of guidelines in the facilities [Table 8.5].

Poor communication between health facilities also resulted in delayed treatment. Inadequacy of the referral system and the substandard obstetrical referral care was seen as the main contributor to deaths of 26.5% (40/151) women. The referral system was weak and the district hospital attended to all critically ill patients as they arrived on the maternity ward, without forewarning, from the referring health centre. This practice reduced the preparation time for medical consultation and life-saving surgical interventions at the district hospital.

Table 8.5 presents details of the specific delays

Table 8.5: Suboptimal factors associated with maternal death by type of delay (n=151)

Type of delay	Reason for delay	No of women	%
I (Care seeking)	Delay in seeking care due to family norms, cultural practices	60	39.7
	Failure to recognize obstetric danger signs	51	33.8
	Poor decision-making due to low economic status of women, lack of autonomy e.g. financial dependency	34	22.5
	Delay in getting to seek professional health care due to avoiding longer stay in labour ward	33	21.9
	Use of traditional healers due to beliefs in supernatural causes/curses	14	9.3
	Refusal to seek care due to previous facility delivery experiences	7	4.6
	Home delivery without skilled birth attendant (SBA)	3	2.0
II (Accessibility of services)	Expensive to hire a vehicle, lack of transport and challenging public transport	66	39.7
	Insecurity at night	6	4.0
	Unable to hire vehicle immediately (delayed transport)	3	2.0
	Impassable roads-bridge washed away in rainy season	2	1.3
III (Quality of medical care)	**Administrative factors**		
	CEmOC facilities		
	Lack of fuel for ambulance	15	23.1
	No blood products	4	2.6
	Lack of antibiotics	17	11.2
	Lack of sphygmomanometer	10	6.6
	Lack of gloves	10	6.6
	Lack of magnesium sulphate	9	6.0
	No malaria Rapid Diagnostic Test kits	3	1.9
	Surgical instruments not disinfected	3	1.9
	Interval between decision to do emergency surgery and the time of starting the surgery exceeding 30 minutes	6	3.9
	Lack of sutures in theatre	3	1.9
	BEmOC facilities		
	No ambulance to transport emergency cases	35	23.2
	Lack of treatment guidelines	6	3.9
	Poor referral system and substandard obstetrical referral care	3	1.9
	Lack of communication between facilities for referral site	4	2.6
	Inadequate human resource	11	7.3
	Health-worker related avoidable factors, missed opportunities and sub-standard care		
	CEmOC facilities		
	Poor clinical skills and competencies by skilled staff	13	8.6
	Delay in receiving treatment/inadequate	51	37.8
	Poor surgical infection prevention procedures	5	3.3
	BEmOC		
	Late referral	6	4.0
	Wrong assessment of risk, wrong diagnosis, wrong treatment	18	11.9
	Staff unavailable	4	2.6
	Managed by unskilled workers	6	3.9
	Unfriendly health providers - fear of ill-treatment by health providers, poor attitude towards pregnant women, in public facilities	30	19.7
	Patients not monitored as per standard	26	17.7
	Incorrect management (Incorrect diagnosis)	54	37.8
	Delayed consultation	36	23.8

Numbers do not add up to 100% due to multiple delays for some women.

8.6 Chapter Summary

This chapter has presented contributing conditions and factors associated with MD. The most common contributing conditions assigned by the panel of experts using ICD-MM and health professionals as written on the MDA2 are compared. The most common contributing condition assigned by panel of experts was obstructed labour. The health professionals assigned anaemia as the most contributing condition to MDs. There was a big difference between contributing conditions by health professionals and the panel of experts.

Women in the study experienced multiple delays with delay 3 affecting most women (88.7%). Administrative and health worker factors were some of the factors associated with this delay.

9 DISCUSSION

9.1 Chapter overview

This chapter discusses the main research findings in relation to the reviewed literature in chapter 3 and respond to the research questions, and objectives set out in chapter 1. The chapter will compare these study results with other previous studies' results. The chapter also outlines the contribution the thesis has made to the existing body of knowledge. The discussion has focused on key findings of the study, including: numbers of maternal deaths (MDs) identified by the RAMOS approach and comparison with the official maternal mortality (MM) estimates. The study reports on a place of death and factors associated with MDs based on the traditional three delay model. Cause of MD was assigned by using health facility MDA, panel of experts applying ICD-MM and InterVA-4 are discussed and compared. Possible explanation for the results attained and implications for clinical practice, public health and policy will be highlighted.

9.2 The RAMOS methodological approach and under-reporting of maternal deaths

The main purpose of this study was to estimate the number of MDs, identify place of death, causes, contributing conditions and associated factors with the MDs in Mangochi district in Malawi over the period of 12 months using a prospective RAMOS approach. To the best of our knowledge, this is the first study to use RAMOS approach in Malawi and probably one of few prospective studies to assess MM. It is also one of the first studies to use the ICD-MM published in 2012 to classify a cause of MD (WHO 2012c).

The prospective nature of the study confers an important advantage as most previous studies on MM have used retrospective design (Fawole et al. 2012). Our findings provide the most current and comprehensive estimate of MMR in Mangochi district. Previous studies in Malawi have estimated MM using the direct sisterhood method, population-based surveys and have provided estimates of MMR based on deaths identified at a health facility level (Chiphangwi, Zamaere & Graham 1992; Lema et al. 2005; MDHS 2011; van den Broek et al. 2003c).

It is well documented that estimates derived from household, and population-based surveys are subject to wide confidence intervals due to problems with sample sizes used in these methods. It is also important to note that the sisterhood method produces MM estimates for the period of 6–12 years before the survey. This includes a reference period of 0–six years for the direct sisterhood method and 10–12 years for the indirect sisterhood method (Graham, Brass & Snow 1989; WHO 1997). The use of multiple sources of data in a RAMOS approach is reported to have an added advantage of identifying more deaths compared to studies using one data source only.

This study identified 65 MDs in addition to the 86 MDs documented via the HMIS. Thus by using a RAMOS approach, it was revealed that that approximately 43% of maternal deaths had not been captured via HMIS. The number of MDs found in this study thus nearly doubled the officially reported figures. HMIS in Mangochi, as in many LIC and LMIC countries provide inadequate maternal mortality statistics even though such data are used to prioritize intervention. (Garces et al. 2012; Zakariah et al. 2009). This problem is not limited to LIC and MIC income countries only, but has also been reported, in developed countries with comprehensive vital registration systems for births and deaths such as in France, the UK and the Netherlands, though on a much lower scale though on much lower scale (Lewis 2007; Sombie et al. 2007). Similarly underreporting has been noted in studies from the USA, Sweden, Brazil, Spain, Surinam, Tanzania, Gambia, Mozambique, and Taiwan (Alves 2007; Deneux-Tharaux et al. 2005a; Esscher et al. 2013; Fortney et al. 1986; Kao et al. 1997; Mungra et al. 1998; Olsen et al. 2002b; Sombie et al. 2007; Songane & Bergström 2002b; Walraven et al. 2000). The publication on confidential enquiries into MDs in the UK in 2007 revealed that only 50% of the dead mothers were identified by conventional means (vital registration) and other methods such as CDEM. Birth to death linkages were used to identify the remaining half of MDs (Lewis 2007).

The degree of underreporting of MDs varied in different countries. Two studies from India and Ghana (Kim et al. 2009; Zakariah et al. 2009) each reported almost twice the official recorded number of MD.

Reasons for underreporting of MDs in other countries have been recorded; lack of information on the pregnancy status of a woman in case notes and/or on the death certificate, misclassification of abortion-related cases, and missed MDs that occur on wards other than maternity (Deneux-Tharaux et al. 2005b; Mungra et al. 1998; Zakariah et al. 2009).

However, the difference in the number of MDs identified in this study, and via official records was possibly due to different approaches used to identify MDs, gaps in the routine reporting system, lack of awareness that MDs can occur on wards other than the maternity ward. This confirms findings from other countries (Zakariah et al. 2009). In addition, it may have resulted from misunderstanding of health staff on how to classify maternal deaths and fill out the maternal death forms correctly.

There were gaps in the reporting system. The current HMIS in Mangochi captures MDs that occur at a health facility and in the delivery room. It is well documented that MDs in hospitals occur outside the maternity unit (Dao et al. 2003; Mbaruku & Bergstrom 1995), due of transfer of patients from the maternity unit to other wards (e.g. late abortion complications to medical ward) and because of direct admissions for women who are of pregnant or recently delivered to wards other than the maternity ward (e.g. women with Malaria) (Goswami et al. 2013). In this study five (5) MDs that occurred on a non-obstetric ward were missing in the HMIS register. The staff members from the female ward were not oriented to report MDs occurring in their ward. A study conducted in Indonesia identified 14% of MDs from non-obstetric wards, which were missed from routine hospital reports (Qomariyah et al. 2009a). Likewise, in the Copperbelt Province in 2004 in Zambia, 29% of MDs had occurred on other wards especially if women died in the post-partum period (Hadley & Tuba 2011). Sometimes hospitals may have deficient reporting systems due to inadequate registration of indirect deaths, pregnancy status and registered time interval between termination of pregnancy and death (Olsen et al. 2002a). Other studies have shown that MMR estimates that occur from obstetric wards underestimate the MMR by one-half to two thirds (Qomariyah et al. 2009a). All 86 MDs captured in the official HMIS records occurred at a health facility. Although health facility data provide information about epidemiology, underlying

causes of death and adequacy of existing health care facilities, and remains the main routine source of sub-national data on maternal mortality for many developing countries, studies have revealed that such data need to be interpreted carefully (Sombie et al. 2007). Hospital-based studies and data can either reflect a level of MMR that is extremely high (due to referrals), or very low, (either because women never accessed health facility care and cost of care not affordable by the poorest women) (Bouvier-Colle et al. 1991; Mola & Kirby 2013; Mswia et al. 2003).

MDs which occur outside a health facility are usually missed by official data collection systems as evidenced in this study where out of the 65 MDs missed in the official records, 57 (87.7%) occurred outside a health facility. This was found although the community-based reporting system does exist in Malawi and Mangochi. One of the roles of the HSAs, when the cadre was introduced, was to report MDs occurring at a community level to the health centre.

The 2013 world report statistics reported about 34% of deliveries in Malawi, occur outside health facilities without any skilled care (The World Bank Data Catalog 2013) and deaths among women who deliver outside a health facility may be missed if facility care is not accessed. Although community-based deaths should be reported by HSAs to the health facilities, this did not happen. In our study, however, due to the comprehensive and exhaustive nature of strategies used to capture MDs, omissions of MDs that occurred outside a facility is unlikely.

Underreporting of maternal deaths is thus a major concern, and this study highlights the importance of ascertaining the number of MDs by using multiple sources in countries without a registration system in place (Lewis 2003; Songane & Bergström 2002b). The result has also shown the importance of including more than the maternity unit in hospital-based estimates of MM, especially with regards to capturing MDs from indirect causes.

9.3 Deaths of women of reproductive age and maternal mortality

Another unique aspect of this study is that, to our knowledge, this represents the first study which identified MDs from a group of all death in WRA in Malawi.

Examining deaths among all WRA is one of the methods for identifying MDs because they will always be a subset of this group (Julia et al. 2011). Although continued focus on pregnancy-related mortality remains significant, attention to the burden of mortality unrelated to pregnancy among WRA is also relevant because the level of MDs may be influenced by general health risks faced by WRA. Thus, progress in reducing MM would certainly imply the capacity to identify and act on other causes of death of WRA (WHO 2009b). However, reliable data on mortality among WRA group is scarce in most countries (Kulkari, Chauhan & Manon 2010) and this study focused mostly on MDs with some aspects of non-pregnancy related deaths that will be discussed.

The overall mortality rate among WRA during the study period was 204 per 100,000 WRA. This is translates to 11.4 per 1,000 person-years. This mortality rate is similar to the rate reported in the MDHS of 2005. However, it is higher than reported in the most recent 2011 MDHS (1.4 per 1,000 years). It is also higher than reported other countries including Guinean-Bissau in (7.6 per 1000 person years), (Mane et al. 2013) and almost similar to a report in South Africa (14.6 per 1,000 person years) (Nabukalu et al. 2013).

In our study, the proportion of MDs among deaths of WRA (PM) was 35.6% (151/424). This proportion is higher than reported in the MDHS, (2010) which was at 15.5% and even higher than 14.8% reported in the recent MMEIG (WHO 2014b). Other countries such as Bangladesh, India, Ghana and South Africa have reported lower PM of 22%, 5.6%, 1.9 and 0.5% respectively (Kulkari, Chauhan & Manon 2010; Labrique et al. 2013; Nabukalu et al. 2013; Zakariah et al. 2009). The wide discrepancy would probably be due differences in data collection methods. This study used robust data collection methods which may have identified more deaths while a study in South Africa used demographic data from DHS which usually has sampling errors (Abukarig 2007).

The MMR for Mangochi district as identified in this study lied within the range 341-363 deaths per 100,000 live births and 95% CIs within the range 289-425 deaths per 100,000 ranged from 289 to 425 per 100,000 live births. This range was obtained using estimates from three different denominators; BCG registers, census

report and GFR as described in the methodology chapter. Triangulation of the estimates was done in order to add to the robustness of the MMR estimates due to unavailability of a birth registration system in the country. Lack of a denominator for calculating MMR has been reported from other countries without a registration system in place (Mungra et al. 1998; Zakariah et al. 2009). Due to high BCG vaccine coverage (96%) in Mangochi district, we considered this figure a good proxy for calculating number of live births. There is earlier evidence that BCG vaccine coverage can provide a reasonable proxy for number of live births in countries without reliable data (Songane & Bergström 2002b). The MMR was 362 per 100,000 (95% CI: 307-425) using this denominator. However, this MMR may be an underestimate as coverage with BCG depends on access and some parents may come for vaccination (underestimate) or some mothers may have come from neighbouring districts (overestimate). It is presumed this was minimal considering the expected number of live births in the district at the time of data collection calculated based on population in the district, and this figure was compared to the MMR estimates calculated using the other two estimates of the denominators.

The MMR was also estimated using the number of live births obtained from the census report. This was equally considered reliable as a census captures comprehensive data for everyone and the issue of random error would be reduced as a census is not sample-based (Stanton et al. 2001). However, the limitation of census data is the length of time taken to conduct the census. In Malawi, as elsewhere, census is conducted every ten years so recent data may not be available (Graham et al. 2008b). In this study number of live births used was from 2008 census projection for 2012. Population projections for less-developed countries tend to be more uncertain or less accurate partly because countries tend to have less reliable data on the current population size and incorrect assumptions about fertility and mortality (National Research Council 2000). Also future migration is more difficult to project than fertility or mortality because migration flows often result from short-term changes in economic, social, or political factors that are hard to predict or quantify.

The third MMR was calculated based on General Fertility Rate (GFR). The GFR suffers a disadvantage with regard to population structure. The differences in GFR

may be due to underlying differences in the age structure of the female population over time or across populations of interest (Rowland 2003). MMR based on GFR will change as a result of changes in fertility rate rather than by observed changes in the MM (Danel et al. 1996), but can be used in absence of reliable sources.

Based on the above strengths and limitations of each denominator, the MMR based on the number BCG vaccinated children (362 per 100,000, 95% CI: 307-425) probably reflects the most-recent number of live births and can be considered to yield the most reliable MMR estimate for Mangochi district.

The MMR range identified in this study 289 to 425 per 100,000 live births is comparable to previous population-based studies conducted in Malawi. A study conducted in three districts in rural southern Malawi (MMR 413, 95% CI: 260-820), (Van den Broek et al. 2003a) and in Mchinji district (MMR 299 per 100,000, CI: 247-363) (Colbourn et al. 2013).

However, the MMR range identified in this study is higher compared to the global MMR of 210 per 100,000 live births (WHO 2014b) and lower than the recent national MMR for Malawi of 510 per 100,000 as per the current WHO report (WHO 2014b). Evidence from a systematic review on MMR based on population studies in Malawi from 1977-2010 revealed a reduction of the national MMR in the years from 2006 to 2010 (Colbourn et al. 2013). However, this decline may only reflect the national-level estimate which conceals MMR at the district level. The reduction may be due to the methodological differences in the estimation of MMR (for example, in 2006 and 2010; national estimate were based on small numbers and obtained by sisterhood methods) or may mean interventions that are targeted towards reducing MMR in Malawi may be working well in some areas.

9.4 Characteristics of maternal deaths

Another important finding in our study was that the MMR was highest in the age-group 25-29 years and in women who were less educated.

Age

The majority of the deaths (496 per 100,000 live births) occurred in the age group of 25-29 years and lowest in the oldest age group 45-49 years, (37 per 100,00 live birth). The high MMR was extended to the peak of child-bearing age of 30-34, (428 per 100,000 live births). This suggests that maternal mortality occurred in the prime and the most reproductive part of life. This finding is similar to a ten-year retrospective hospital-based study in Nigeria, which showed the highest MDs of 27.3% (45/165) were in the age group of 25-29 years, and the lowest MDs of 6.7% (11/165) were recorded in women who were 40 years and above (Ezegwui et al. 2013). In this study, a review of 12,587 deliveries and 165 MDs in a public hospital was conducted. Similarly, a respective hospital-based study in Central Province in Kenya, where an audit of 111 deaths, showed the majority of the deaths had occurred in women between 25 and 34 years (Muchemi & Gichogo 2014). In contrast, a retrospective hospital-based study conducted at one tertiary hospital in Malawi, reported the majority, (56.4%), were aged 15-24 (Lema et al. 2005). Another three-year hospital-based study in Nigeria reported that most (23.5%) MDs were teenage mothers (Okusanya et al. 2007). Our findings are also contrasted with a systematic analysis of global, regional, and national levels and causes of maternal mortality during 1990–2013, which reported that the highest MMR was in the oldest age group of 45-49 and lowest in the age group 20-29 (Kassebaum et al. 2014). Additionally, evidence in the literature indicates increased risk of death among women less than 24 and older than 35 years **of age** (Okonofua et al., 1992; Audu and Ekele 2002).

The differences in study population could explain the difference between our study and other studies. In Mangochi, women marry at a relatively young age (Munthali AC 2004) and dying at the peak of child-bearing age may be associated with high parity. The highest mortalities were seen in multigravidas (gravid 3), (27.2%) followed by grand multiparas, (22.5%) and primigravidas (19.9%) which is in agreement with other studies in Malawi and other countries (Abdulla, Memon & Saboohi 2010; Hofman & Sibande 2005).

Furthermore, causes of death in the younger women were likely to be abortion which may be underestimated in this study due to failure to recognize early pregnancy complications. Another possible reason could be the few number of MDs

within the age group 15-19 identified in this study. It was also possible that implementation of girl education programs by some non-governmental organisation currently in the district like the Christian educators in Malawi and Save the Children (US) are working well.

Education

Almost half (49%) of the deceased women had not gone to school at all. The majority of women (64.5% %) who had gone to school delivered at a health facility. Illiteracy is a major contributor to MM as been previously stressed in literature (Karlsen et al. 2011; McAlister & Baskett 2006; Yego et al. 2014). Education is thought to influence health-seeking behaviour by, ensuring economic empowerment, creating awareness and improved ability and freedom to make health-related decisions including choice of maternal services for use (Caldwell 1979; Harrison & Bergstrom 2001). The MDHS for 2010 reported a strong correlation, (87% compared to 60% non-educated), between secondary education and skilled birth assistance in Malawi (MOH 2011b). Similarly, in Nepal, women with secondary-level or higher education were approximately two times more likely to utilize ANC services than illiterate women (Sakeah et al. 2014). Women's improved access to education is also indicative for of a more equal position in society (Shen & Williamson 1999). Educated women are more likely to access health care resulting in safer pregnancy and childbirth and less likely to engage in harmful practices (Karlsen et al. 2006). In this study population early marriage would lead to discontinuation of schooling and subsequently become dependent on husband for health related decisions and expenditure.

This finding has implications for mainstreaming the issue of MD, for example the Ministry of Education and Ministry of Gender and Women Affairs among others in an effort to combat MM in Malawi. The association between literacy and increased risk of MD highlights the need to educate young girls and women, as well as the need to increase women's self-esteem and their empowerment to make health-related decisions via women's groups, which have proven to help in reduction in MM in one district in Malawi (Rosato et al. 2006). This should complement the current policy for achieving MDG2 where the government of Malawi is implementing free primary education.

9.5 Access to maternity care

In this study population (number of MDs) 76.2% accessed ANC, 62.9% skilled care at birth and 17.2% received postnatal care. Earlier studies have shown that attending for antenatal care (ANC) and ensuring skilled birth attendant (SBA) (doctors, nurses, etc.) is associated with reduction in maternal morbidity and mortality (Clark 2012; Magadi, Madise & Diamond 2001; Mpembeni et al. 2007; Reynolds, Wong & Tucker 2006).

Antenatal care

ANC, in principle has the potential to improve maternal health, reduce maternal morbidity and reduce the risk of MD as well as promote emergency preparedness (Campbell & Graham 2006; Graham, Bell & Bullough 2001; UNFPA 2003).The contribution of antenatal care, to maternal mortality reduction has been challenged (Carroli, Rooney & Villar 2001).The justification of the benefits to the baby and mother has now shifted to emphasizing the promotion of health and health-seeking behaviour, including birth preparedness (Campbell & Graham 2006)

The proportion of women who had at least one ANC visit in our study was lower than the national level (76.2% vs 95%) (MDHS 2011). The difference could be attributed to the fact that our study only reports women who died while the national estimate proportion refers to all women who attended ANC. It could also be linked to low literacy rates we reported, which may have influenced the decision to seek care.

It is worth noting that adequate ANC during pregnancy significantly influenced SBA utilization during childbirth in this population. Women who had four or more ANC visits delivered more frequently with skilled personnel as compared to those who had only one ANC visit (47.6%, 1.6% p= 0.001). This finding is consistent with studies from other countries such as Bangladesh and Cambodia (Anwar et al. 2008; Yanagisawa, Oum & Wakai 2006). A randomized controlled trial in Tanzania showed that implementation of birth plans during ANC increased the uptake of SBA and post-delivery care (Magoma et al. 2013).

The majority of our study population (64.4%) had less than four targeted antenatal visits. The MDHS reported 49% of women with less than four visits. The WHO recommends that pregnant women should commence ANC during the first trimester of pregnancy. In this study, it was noted that only 2.6% of the women who died had attended for their first ANC during the first trimester and 97.4% in the second and third trimester. This finding compares well with national data for Malawi where most (84%) women initiate ANC in the second or third trimester (MDHS 2011). This is also consistent with findings from other African countries such as in Nigeria, Uganda and South Africa, which show that most pregnant women register for antenatal care in the second trimester (Idowu, Mafiana & Dapo 2005; Kiwuwa & Mufubenga 2008; Mayhew et al. 2008). In contrast, a population-based study in Nigeria where four hundred women aged 15-49 years that had delivered a baby within two years prior to the study were asked about birth attendance during antenatal care (ANC), childbirth and postnatal period of their most-recent birth **s**howed that more than half of the respondents (62.1%) had their first ANC during the first trimester (Adewemimo et al. 2014). This marked difference in ANC attendance would be due to outreach and home-based care services set up by the non-governmental organization working in the study area. Such outreach services may also be a good strategy to promote early ANC attendance in more remote areas in Mangochi district and other areas in Malawi.

The timing of the first antenatal visit can be an important entry point for delivery care, young women who initiate antenatal care early were more likely to use skilled professional assistance at delivery than their counterparts who initiated ANC late (Ochako et al. 2011). Importantly, timely initiation of antenatal care is a strong predictor of the total number of antenatal care visits (Hagey, Rulisa & Pérez-Escamilla 2014) and starting antenatal care late decreases the ability of health-care professionals to identify potential complications during pregnancy and/or treat sexually transmitted infections, HIV, malaria or anaemia (Birungi & Onyango-Ouma 2006).

A study in health care facilities in KwaZulu-Natal, South Africa documented that access to antenatal care depends on various circumstances: cost of travel to a health

care facility, quality of antenatal services, age, parity, access to social support, previous experiences with the health care system, and understanding of the importance of antenatal care (McCray 2004). Likewise, other studies in Africa revealed that low maternal age, low education, urban residence, unintended pregnancy and household income were all associated with lack of access to care (Babalola & Fatusi 2009; Dibaba, Fantahun & Hindin 2013; McTavish et al. 2010). These studies have also cited long distance coupled with lack of transport as reasons for late initiation of ANC. Unintended pregnancy has also been associated with late initiation and inadequate use of antenatal care services (Dibaba, Fantahun & Hindin 2013). However, this was not explored in our study.

Furthermore, since antenatal care is one of the most widespread health services and coverage is often high, it increasingly serves as a point of delivery for other health care packages, for example, the roll-out of antimalarial drugs and antiretroviral therapy in countries with high prevalence of malaria and HIV.

The findings from this study have significant programmatic and policy implications, especially in connection with the achievement of the MDG5. The second component of the MDG5 goal was to achieve universal access to reproductive health care by 2015. One of the main indicators for this goal is antenatal care (United Nations 2011a) (United Nations 2011a). The findings highlight the need to intensify efforts to sensitize and educate women to the importance of attending and timely initiation of antenatal care (in the first trimester) to afford health care providers an opportunity to provide the necessary care. Low antenatal care uptake could lead to decrease uptake of SBA and emergency obstetric care.

Skilled birth attendant (SBA)

Improving women's SBA is an important component of the MDGs with international targets for SBA-assisted births (set as 80% by 2005, 85% by 2010, and 90% by 2015) (United Nations 2011b). The proportion of births attended by skilled health personnel is used as a more appropriate proxy indicator to track progress towards MDG5, as measuring MM is often difficult (United Nations

1999). Studies from Ghana, Nepal, Nigeria and other developing countries have also reported low uptake of SBA at delivery among the women who died (Dhakal et al. 2011; Sakeah et al. 2014; Stanton et al. 2007a).

There was no significant difference between the proportion of women delivered under SBA in our study (62.9%) and at a national level (71% for all women) (p= 0.14 95% CI: 0:54-0.73). A substantial proportion of MDs (33.7%) delivered with a TBA. The low proportion could have resulted due to the fact that our study only reported results of women who died compared to total deliveries in Malawi. Studies have demonstrated a positive correlation between the proportion of deliveries taking place with an SBA and a reduction in maternal deaths (Graham, Bell & Bullough 2001; Scott & Ronsmans 2009). Skilled birth attendance is essential to save maternal and newborn lives and key to attaining MDG 4 and 5.

Postnatal care

Postnatal care is an important link in the continuum of care. Previous studies have shown that a large proportion of MDs occurs during the first 24 hours after delivery (Chen et al. 2014; Yamashita et al. 2014). Thus, prompt postnatal care is significant, for both the mother and her baby, to treat complications arising from the delivery as well as to provide the mother with important information on caring for herself and her baby (WHO 1999).

In this study, only 17.1% (17/99) received postnatal care from SBA. These were mainly women who delivered at a health facility 15.2% (n=99). Most MDs (65.6%) occurred in the postpartum period and 72.7% of MDs occurred in the first 24 hours after delivery. Other studies from Malawi (Hofman & Sibande 2006; Kongnyuy, Mlava & Nynke 2009; Lema et al. 2005; MDHS 2011; Vink et al. 2013) and other countries confirm this finding (Ghebrehiwot 2004; Indrani et al. 2014; Okusanya et al. 2013; Tao et al. 2011; Tuddenham et al. 2010).

The postnatal period is critical transitional period for a woman and her baby emotionally, physiologically and socially (MacArthur et al. 2002). WHO and the United Nations Children's Fund (UNICEF) guidelines recommend a postpartum care visit for the mother and her baby on day 1, day 3, and day 7 after birth, with

continuing contact throughout the first six weeks of life (Moran et al. 2013). Traditionally, in Malawi, strategies to reduce maternal and neonatal mortality have focused on pregnancy and delivery periods, which is reflected in high coverage rates for antenatal care (97%) and improved SBA in Malawi (71%) but considerably lower postnatal care visit coverage (52%) at a national level (MDHS 2011).

The fact that in this study, a high number of deaths occurred postpartum is an important finding that has policy and practice implications. Access to SBA is crucial to all women during pregnancy, childbirth and immediately after child birth, irrespective of their place of delivery. The current WHO guidelines could be adapted to improve on the existing postnatal care protocols (WHO 2014a) to require critical examination as most women in this study delivered at a facility but still died within 24 hours which could point to absence of and or poor quality of postnatal care. Concerning practice, supervisors of midwives should ensure mothers are booked for subsequent postnatal care and are provided with the necessary care.

9.6 Place of death

In our study 60.9% MDs occurred in health facilities, 31.8% at home and the rest on the way from home to the health facility, during referral between facilities or while at a traditional healer. This finding is consistent with a previous study in Mangochi district, which reported more deaths (56%) occurring in health facilities than in the community (Hofman & Sibande 2005). Other recent studies from Nigeria and China have reported similar results where 66.7% and 82% of MDs occurred in health facilities respectively (Adegoke et al. 2013b; Yang et al. 2014). In contrast, other studies have reported that women more often die at home (Bano et al. 2011; Barnes-Josiah, Myntti & Augustin 1998b; Kaur 2012). A reproductive health report on MDs in Nyanza province in Kenya indicated that 60% of MDs occurred in the community (Kenya Ministry of Health 2005).

Findings show that women are accessing care, but the quality of care may still be poor as evidenced by this study, which showed high case fatality rate of 4% which is higher than the UN recommendation of 1% (UNICEF, WHO & UNFPA 1997b).

This case fatality rate is also higher than the previous case fatality rate of 3% which was reported for Mangochi baseline EmOC survey conducted in 2010 (MOH, UNICEF & LSTM 2010) and the national level (2%) (MOH 2011b).

The baseline assessment study on EmOC, conducted in Mangochi district in 2010 reported that more health facilities were designated as BEOC or CEOC facilities in Mangochi district than the UN indicators recommendations, with none of them, however, performing all seven signal functions (MoH 2010).
It is worth noting that this study identified deficiencies in the health care delivery system such as unavailability of skilled workers, essential obstetric drugs, poor referral system, and lack of complete UN signal functions for treating life-threatening obstetric emergencies together with deficiencies in blood availability which may have contributed to women's deaths. Substandard care has been identified in most facilities providing maternal services in Malawi (MDHS 2011). A previous study in Malawi reported MDs were associated with healthcare worker factors, and administrative failures (Kongnyuy, Mlava & Nynke 2009). Other studies have shown similar deficiencies in health facilities (Bashour et al. 2009; Gohou et al. 2004; Lema et al. 2005; Mohammed et al. 2011a).

This result has a policy implication. The focus on encouraging institutional delivery will have been misplaced if efforts to improve the quality of care a woman receives once she comes to a health facility is not improved.

According to geographical distribution, most women died in TA Makanjira and TA Katuli. These are the furthest TAs from the referral hospital in Mangochi (110 and 135 kilometres distance). No transport is available at the existing health care facilities in these TAs to refer emergency cases. In case of an obstetric emergency, an ambulance is called from the district hospital, Mangochi. Studies from Indonesia and Bangladesh showed the odds of dying increased with increasing distance from health a facility (odds ratio per km; Indonesia: 1.07 (95% CI: 1.02-1.11), Bangladesh: 1.47 (95% CI: 1.22-1.78), (Ronsmans, Collin & Filippi 2008). Addressing geographic barriers is crucial to increase EmOC and to lower MM.

9.7 Assigning cause of death

In this study, cause of death as assigned by 1) a panel of experts, 2) health care professionals in Malawi using audit (MDA2) and 3) the WHO InterVA-4 software were compared.

There was a marked discrepancy with regard to deaths assigned by health professionals as compared to the panel of experts with minimal agreement (45.5%, k = 0.37. In contrast, the level of agreement between cause assigned by the computer program (interVA-4) and the panel of experts was substantial (67%, k= 0.66).

This study is one of the few which has compared cause of MD assigned by health care professionals at facility level via MDA with cause of death assigned by an external panel of experts (Midhet 2008). Most other studies have compared cause coded by physicians (referred to as experts in this study) with computer coded causes (Bauni et al. 2011a; Lozano et al.).

When the causes of death assigned by health care professionals using MDA in their place of work were grouped according to ICD-MM, most (36%, n=86) deaths had been categorised as belonging to group 7 (non-obstetric complications) with some causes assigned contributory conditions as cause of deaths On the other hand, an in-depth review of the same cases by a panel of experts using the ICD-MM, assigned the most common underlying cause of deaths (33.7%) as obstetric haemorrhage (the direct maternal death) followed by non-obstetric complications, pregnancy with abortive disorders and pregnancy-related infection. This is consistent with the current literature on the cause of maternal deaths in poorly resourced countries (Kassebaum et al. 2014; Khan et al. 2006).

These differences are due to the methods used to assign cause of death. The panel used the ICD-MM to assign cause of death and health professionals assigned cause of death based on their professional and clinical knowledge only. Health professionals in Malawi have not been trained in the use of and are not aware of the ICD-MM which was published only in 2012, when data for this study were collected. They were also not aware of ICD-10 classification. Health professionals

will not have had any training in assigning cause of death. In contrast, the panel of experts comprised of two obstetricians and a senior midwife experienced and knowledgeable about the ICD-MM. The other possible reason could be that MDA2 forms currently in use may not collect information in a way that reflects support the internationally accepted classification of cause of MD and therefore, needs revision.

Low kappa agreement (0.219) was also obtained when comparing the underlying cause of death assigned by health care provider on the MDA with causes attributed by experts using ICD-MM in Malawi (Owolabi et al. 2014). The finding is partly in agreement to study in Pakistan, which compared hospital assigned causes of death **(**HCOD) and physician coded verbal autopsy (PCVA). The study showed a complete agreement between the direct maternal deaths. However, the agreement was weak in all other cause categories such as indirect death (k=0.378, p= 0.055).

The above findings on the cause of death attribution have implications for policy making, planning programmes and resource allocation. Cause of death attribution is important to guide national and international efforts aimed at reducing MDs (WHO 2012c). Inconsistencies in assigning cause of MDs across countries make it difficult to correctly plan mortality reduction strategies and are also important for planning at a national level. Providing a maternal death review form that will aid in extracting all the necessary information that is needed to apply ICD-MM will make it easier for health professionals to correctly attribute a cause of death.

It is necessary to have a standard tool (in this case ICD-MM) to obtain comparable data. The ICD-MM has simplified the cause attribution and has led to a more accurate understanding of situations such as obstructed labour, suicide, HIV and anaemia. It is also applicable to different levels of care including community settings.

Cause of MD assigned by the panel of experts was compared with computer-coded verbal autopsy software (InterVA-4 model). There was a high level of agreement on a cause of death between the two (67%, k= 0.66). Other studies have reported similar high levels of agreement ranging from 50% to 83% for cause attribution of

MDs (Byass & Fottrell 2006; Byass, Huong & Van Minh 2003; Mesganaw et al. 2006).

Although the results revealed a good agreement in assigning the cause of death (COD) between the two groups, there were differences in cause attribution for some more specific causes. The panel of experts assigned more specific causes such as antepartum (APH) and postpartum haemorrhage (PPH) while the InterVA-4 assigned mostly groups, in this case obstetric haemorrhage for APH and PPH, which may make it difficult to plan for specific interventions towards reducing MM.

Furthermore, the InterVa-4 model identified anaemia as a cause of death in most cases assigned as malaria by the experts. This finding is not surprising because there is an overlap between both disease conditions in terms of causal relationship (Chang & Stevenson 2004; Snow & Omumbo 1997).

The differences could be due to the way the model was designed. This model is specifically designed to interpret VA data for deaths from all causes, and for all ages groups based on ICD-10 classification. It could also be that the panel may have benefited from reading the open narrative sections of the VA questionnaires and will have in addition applied clinical experience, which is especially evident in the clinical diagnosis of malaria-related anaemia.

Each method has advantages and disadvantages. Expert classification of cause of death remains the worldwide gold standard against which to monitor performance of other methods of cause attribution (Mesganaw et al., 2006). In addition, the panel classification was more specific in assigning the COD which would assist in targeting interventions.

On the other hand, legitimate concerns remain as to standardization between different experts, the risk of having to change experts over time, and the sheer volume of work involved in assessing large numbers of VA (Byass, Huong & Minh 2003). The process also demands a considerable amount of (often scarce) physician time, and frequently more than one physician analyses each VA case to increase the possibility of obtaining an objective consensus. This may be a problem in most

developing countries where physicians are few (Fottrell et al. 2007a; Mesganaw et al. 2006).

Currently, there is little justification for Inter-VA4 to replace the expert panel. Based on findings of this study, the InterVA-model could indeed reduce the amount of work that needs to be done by physicians and promote standardization of VA data. However, interVA-4 requires more refining to provide a more specific obstetric cause of death. Probably the InterVA-M would be more specific, however, we hardly identified any study in literature which used InterVA-M to classify cause of MDs. Availability of computers and training in poor resource countries may need to be improved for a successive use in future.

9.8 Underlying cause of maternal death

Direct obstetric causes were the leading causes of MDs by both the panel of experts and the InterVA-4. In agreement with this finding, Kongnyuy et al., in a review of facility-based MDs in three districts in Central Region of Malawi, reported that 65% of maternal deaths were attributable to direct obstetric causes, with 35% attributable to indirect causes (Kongnyuy, Mlava & van den Broek 2009). Other countries such as South Africa and India have identified similar results (Montgomery et al. 2014; National Committee for Confidential Enquiry into Maternal Deaths 2011). In contrast to our findings, one study from rural Malawi reported indirect underlying causes as the leading cause of MDs at the hospital (Vink et al. 2013). One possible explanation for the difference is an introduction of protocols and trainings directed towards reducing direct causes of MDs such as PPH and postpartum sepsis before the study was conducted at the facility. The results will depend on the methods used to attribute a cause of death as explained earlier. In addition, this study (Vink et al. 2013) only reported on data from one facility.

Haemorrhage (35.8%), pregnancy-related sepsis (14.6%), hypertensive disorders in pregnancy (12.6%) and pregnancy with abortive outcome (9.9%), were the common direct cause of MD and all of these can be managed if the health care system is better organised. The direct obstetric causes of maternal mortality in our study have also been cited to be the most common direct obstetric causes of maternal mortality

elsewhere (Kazaura, Kidanto & Massawe 2006). These findings are consistent with a recent hospital-based study conducted in the Thyolo district in Malawi, which reported similar causes with puerperal sepsis as the leading cause of death (van den Akker et al. 2011c). Other studies in Malawi and in other low-income countries have documented the same causes (Hofman & Sibande 2006; Khan et al. 2006; Kongnyuy, Mlava & Nynke 2009). However, these figures differ from those of high-income regions where indirect and other direct causes account for more deaths (Kassebaum et al. 2014).

9.8.1 Maternal deaths due to obstetric haemorrhage

Obstetric haemorrhage was the leading underlying cause of death in our study accounting for 35.8% of all deaths. The figure is high, considering that most deaths from obstetric haemorrhage are avoidable (Berg et al. 2005). Globally, obstetric haemorrhage is a major cause of direct MD especially in poorly resourced settings (UNICEF 2008) and this result confirms haemorrhage continues to be a major killer in Asia and Africa (Khan et al. 2006). These deaths may have resulted from inefficient blood-banking facilities, lack of skilled staff in some facilities and inadequate emergency obstetric care. A systematic review in sub-Saharan Africa on the contribution of ineffective blood transfusion services showed 26% (16–72%) of maternal haemorrhage deaths were due to lack of blood. Reasons included lack of blood donors, non-affordability of blood, unwillingness of relatives to donate and inadequate supplies and transport (Bates et al. 2008)

A though PPH secondary to atonic uterus has been reported as the most prevalent cause of maternal death (90%), in low- and middle-income countries (Carroli et al. 2008), retained placenta as the most common cause of PPH in this study (31.5%) in this study, and the majority of women who died of PPH secondary to retained placenta delivered and died outside the facility. The national EmOC assessment reported similar results (MOH et al. 2010). Successful treatment of PPH requires immediate, effective and resuscitative measures (Knuppel & Hatangadi 1995). Women with retained placenta at home are likely to die as they will not be able to get prompt active management of third stage of labour, which has been proven to reduce the risk of PPH (Rogers et al. 1998).

Our study also showed a higher incidence of uterine rupture (9.3%) compared to 7% at a national level (MOH 2011b). Ruptured uterus accounted for 29.9% of the 54 MDs due to obstetric haemorrhage. In agreement with this finding, Hofman and Sibande (2005), in a population-based study in Mangochi district, reported that ruptured uterus was one of the most frequent causes of death. The majority of uterine rupture cases occurred at a facility level which questions the quality of care received by women. The majority of uterine ruptures at a-hospital, reflects serious substandard care.

The main reasons for ruptured uterus in our study were cephalo-pelvic disproportion, mal-presentation and prolonged obstructed labour, or occurred in multigravidas with a previous caesarean section 42.9% (n=14). These causes are largely preventable. In countries with high-quality obstetric care, deaths from ruptured a uterus are rare (Zeteroglu et al. 2005). Increasing parity is known to be an important risk factor for uterine rupture and grand multiparas are especially prone and constitute a major risk group (Ould El Joud et al. 2002). In this study, 29.6% of the patients (n=14) who suffered a uterine rupture were grand multiparas. In contrast, a study in Tanzania reported more cases of ruptured uterus in parity 1-3 (69.9, n=163), (Kidanto, Mwampagatwa & Roosemalen 2012). Two women in this study had taken traditional herbal medicine to accelerate labour which health workers felt contributed to rupture of the uterus as it is a common practice in |Malawi. However, there is no clear evidence in the literature on how often traditional medicine contributes to RU.

These findings have policy, practical and public health implications. Obstetric haemorrhage is an obstetric complication which particularly tests the accessibility and functioning of the health system because its severity deteriorates so rapidly. These findings show important operational deficiencies in the provision of emergency obstetric care in the district and underscore the need for proper monitoring of women in health facilities and improvement of comprehensive emergency obstetric care at all levels to avoid unnecessary delays in treatment. In this study most women who died had presented themselves to the health facility where they should have received timely and effective management. Priority

attention needs to be given to addressing the large number of deaths due to bleeding associated with retained placenta and ruptured uterus both at community and facility level. Community sensitization on the dangers of obstetric haemorrhage is necessary.

9.8.2 Puerperal Sepsis

Puerperal sepsis was the second major cause of MDs and accounted for 14.6% according to the panel of experts. Puerperal sepsis was more than half (56%, n=140) among the MDs identified another study in rural Malawi (Thyolo district) (Van den Akker et al. 2011a). Some hospital-based studies have reported high numbers of puerperal sepsis among MDs in Africa ranging from 7.1% to 19.8% (Gumanga et al. 2011b; Menéndez et al. 2008a; Wandabwa et al. 2011). Sepsis is estimated to account for 10% of maternal deaths worldwide, with the greatest burden in Southeast Asia and sub-Saharan Africa. (WHO 2011a). In our study, puerperal sepsis was frequent among women who delivered at home (n=17, 62.6% [home] versus 37.4% [facility). This was possibly due to the unhygienic birth conditions during home delivery.

In addition, 22.7% of all cases of sepsis (n=22) developed after caesarean section (CS). This is concerning. CS has been identified as the most important risk factor for postpartum infection in Gambia (Chaim & Burstein 2003). This could possibly be due to lack of infection prevention procedures in health facilities, and lack of availability of antibiotics or medical supplies. There was erratic availability of antibiotics during the study period and unavailability of protocols for routine prophylactic antibiotics for CS. In one instance, reported in this study CS was not done as needed because there was no sterile gauze at the hospital theatre.

Among the 22 women who died of pregnancy-related infections 40.9% (9/22) were known to be HIV positive. Three (3/9) who were HIV positive, were women who had post CS infection. Studies have shown that women with HIV are more likely to have sepsis that is difficult to treat (Sangeetha & Bendigeri 2012). A study in Malawi, reported that among 140 infections in women studied, half of the women were HIV-positive. Multivariable analysis showed that non-obstetric infection was

the most important explanatory variable for mortality (adjusted odd's ratio [OR] 4.23, 95% CI: 1.53-11.73**).** HIV-positive women not on antiretroviral therapy were at higher risk of mortality (adjusted OR 3.02, 95% CI 1.06-8.60) and there was no significant mortality increase among those on treatment (adjusted OR 0.51, 95% CI 0.10-2.71). The most common infections were puerperal sepsis (obstetric, case fatality rate 7%) and pneumonia (non-obstetric, case fatality rate of 41%), (van den Akker et al. 2011b). Another previous hospital-based study in Malawi also reported that among women who died of puerperal and post-abortal sepsis in the whole study group 8.3% (n= 204) had HIV/AIDS (Lema et al. 2009). In a Rwandan study, infectious morbidity after caesarean section in HIV- positive women was increased, with associated higher maternal mortality (Bulterys et al. 1996).

The findings of this study call for collaborative efforts between health facilities and community health care providers to assist in reducing infection by following prevention procedures, ensuring the availability of antibiotics to treat infection. Encouraging pregnant women to access HIV/AIDs programs and encouraging skilled delivery would be essential.

9.8.3 Hypertensive disorders in pregnancy

Hypertensive disorders in pregnancy accounted for 12.6% of MDs in this study and were the third direct cause of death. Out of the 19 cases with hypertensive disorders in pregnancy, 16 women suffered eclampsia. This is higher than the incidence from other studies in Malawi (MOH 2011b; van den Akker et al. 2011c). Half of the women suffered eclampsia in the puerperium. Hypertensive disorders continue to cause MDs probably due to lack of sphygmomanometers in some health centres and late referrals without anticonvulsants. There was also erratic availability of magnesium sulphate in the facilities.

9.8.4 Abortion-related deaths

There were relatively few abortion-related deaths (9.9%) reported in our study, and the majority were within the age groups 15-19 through to 25-29 years. In a national EmOC study, abortion accounted for 7.6% of all direct MDs (MOH et al. 2010). Unsafe abortion remains a major health problem in Malawi due to restrictions and

laws, which prevent women and young girls from terminating unwanted pregnancies. Malawi's current law regulating abortion only allows abortion for preservation of a woman's life (Malawian Penal Code 1930a). In practice, the endorsement of two independent obstetricians is required before termination of pregnancy can be performed, and spousal consent is necessary. According to the law, any attempt to procure an abortion is punishable by 7–14 years imprisonment. Due to such laws Malawian women avoid public institutions and most seek abortion services from private clinics or traditional healers, or attempt to self-induce abortion using unsafe methods in private to ensure confidentiality (Juárez et al. 2008; Munthali, Zulu & Madise 2006). Furthermore, there are social and religious stigmatization and legal consequences attached to abortion, which pushes women to seek unsafe abortion and not disclose this when they present themselves at a health facility with complications. It is notable in this study that only 2 out of 13 abortion cases identified were reported as induced abortions. A study on the incidence and magnitude of complications due to abortion by the Ministry of Health in Malawi in 2009 reported that an estimated 70,474 induced abortions occurred in Malawi in 2009 yielding an induced abortion rate of 24.4 per 1,000 women aged 15-44 (range 17.6-31.2) (MOH 2011a). Other studies have shown that women are hesitant to seek medical services in the event of complications or reveal to family members the underlying cause of the complications in fear of the law and social and cultural stigma (Say & Shah 2008; Sedgh et al. 2012). In addition, because of legal consequences, some providers who provide abortion-related services were reluctant to report abortion-related deaths. Similar findings have been reported in other studies (Sedgh et al. 2011; Sedgh et al. 2012; Singh 2009).

Underreporting of abortion-related deaths has been noted in other studies from Malawi and in other countries (Family Planning Association of Malawi 2007; Gardeil & Sangala 1991; Haws et al. 2010; Rosenstein, Romero & Ramos 2008). In countries where legal restrictions on abortion have been reduced or removed, and safe services have become available, such as South Africa, USA and Romania, abortion-related complications and MM as a result of abortion-related complications , haemorrhage or sepsis have declined dramatically (Bartlett et al. 2004; Jewkes et al. 2005; Johnson, Horga & Fajans 2004).

Although post-abortion care is provided in most of Malawi's secondary and tertiary health care facilities as well as some primary health centres, policy makers must realize that post-abortion care can save lives by treating complications, however it cannot offer the same protection of health and life as safe, legal abortion. The findings warrant careful consideration as government and the civil society in Malawi continue efforts to fulfil the MDGs and improve the health of women and their families.

9.9 Maternal deaths due to Unknown cause

There were 7.9% MDs (classified expert panel) and 1.9% (by the InterVA-4) for whom a cause of death could not be identified. Of the Five deaths assigned as having unknown causes by the panel, the interVA-4 assigned malaria by the model. Most 9/12, occurred at home and there was insufficient information surrounding circumstances of the death to be able to attribute cause of death, despite the fact that these were maternal deaths.

9.10 Cause of Indirect maternal deaths

Indirect causes accounted for 17.2% of MDs in this study and were attributable to illnesses aggravated by pregnancy. Maternal infections and parasitic diseases, complicating pregnancy, childbirth and the puerperium were the major causes of indirect MDs assigned by both the panel of experts and the InterVa-4 model. This group comprises of non-pregnancy-related infections such as malaria (the most frequent), meningitis and pneumonia. In this study, malaria was recorded as the cause of death for 56.7% (n=26) among MDs due to indirect cause. All facility based malaria cases were confirmed by Rapid Diagnostic Tests (RDT). This figure may be an underestimate because for a period of three months during the study period, the district had no RDT kits and also because malaria-related deaths in the community are not confirmed by RDT. In contrast, a study conducted in rural Malawi found meningitis and AIDS as the most common indirect causes of indirect MDs (Hofman & Sibande 2005; Lema et al. 2009).

The highest number of malaria cases was found in the age group 15-24 (66.7%). This age- related trend is consistent with other studies which have reported seasonal patterns of malaria in Malawian and Kenyan school going non-pregnant female adolescents (12-18 years) with prevalence ranging from 24.4% in dry season to 33.7% during post-rainy season (Kalanda 2008; Leenstra et al. 2003).

Current recommended Malaria In Pregnancy (MiP) prevention and control strategies in areas of stable moderate to high malaria transmission include distribution of insecticide-treated bed nets (ITNs), appropriate case management and the administration of intermittent preventive treatment (IPT) with sulphadoxine-pyrimethamine (SP), (WHO 2012e). Despite the progress made in the last decade, the coverage of ITNs and IPT amongst pregnant African women remains inadequate (Van Eijk et al. 2011). The ITN coverage in Malawi is 55% (MOH 2012). Studies from Ghana, Kenya and Malawi in have reported that health messages on malaria tend to focus on the use of non-prescribed and non-biomedical treatment during pregnancy and little emphasis is placed on adherence to prescribed anti-malarial regimens (Pell et al. 2013).

These findings have important implication for prevention of malaria in pregnancy. There is need for control programmes and collaborating partners to expand their target group for ITNs and increase their availability to all women of child-bearing age. Policies to address the problem of malaria are already in place in Malawi which include Intermittent Preventive Treatment (IPT) with sulphadoxine-pyrimethamine (SP) (Conteh et al. 2010; Parise et al. 1998; Shulman et al. 1999) and use of insecticide-treated nets (ITNs) with iron, (Shulman et al. 1998; WHO & AFRO 2004).

Policies geared towards adolescent-friendly strategies to improve malaria-related health seeking behaviour in Malawi during pre-pregnancy period is necessary to improve understanding and use of anti-malarials and potentially reduce exposure in the first trimester.

AIDS-related deaths were the second leading indirect MDS (23.1%). These are women who died because of the aggravated effect of pregnancy on HIV. We

identified relatively few women with HIV in this study. This finding is surprising considering that Malawi is one of the countries in sub-Saharan Africa with a high HIV prevalence 11% (MDHS 2011). The UN states 29% of indirect maternal deaths are AIDS-related in Malawi (WHO 2012a) and our study identified 23.1% (6/26). The proportion of maternal deaths attributed to HIV infection in sub-Saharan Africa was 3.8% in recent data on the trends of maternal mortality 1990-2013 by WHO, UNICEF, the World Bank and the United Population Division (WHO 2014b).

However, the real contribution of AIDS to maternal mortality cannot be estimated from our study because HIV-status of most MDs (90%) was unknown and this could have resulted in an underestimate of the true number HIV related deaths. A study conducted in a tertiary hospital in Malawi found 10 % of women with an unknown HIV status (Combs Thorsen, Sundby & Malata 2012). HIV/AIDS impact both direct and indirect causes of maternal mortality by an associated increase in anaemia, puerperal sepsis, postpartum haemorrhage, and a predisposition to opportunistic infections such as tuberculosis (González et al. 2012; Malntyre 2003). A systematic review and meta-analysis on the contribution of HIV to pregnancy-related mortality in reported that HIV-infected women were eight times higher risk of a pregnancy-related death compared to HIV-uninfected women [pooled risk ratio 7.74, 95% confidence interval (95% CI) 5.37–11.16] and this meta-analysis predicted about 12% of all deaths during pregnancy and up to 1-year postpartum are attributable to HIV/AIDS in regions with a prevalence of HIV among pregnant women. This figure rises to 50% in regions with a prevalence of 15% (Calvert & Ronsmans 2013). This suggests that safe motherhood programmes should pay special attention to the needs of HIV-infected pregnant or post-partum women.

It is important to mention that the panel of experts identified five deaths in the study population that were actually non-maternal deaths but due to HIV and only incidentally in pregnancy. This finding, although the number of cases was small, may point to a potential underestimation of AIDS-related deaths in pregnancy, childbirth and the puerperium, but also among WRA. It also highlights the fact that women with advanced AIDS do still become pregnant, which is often not

acknowledged by experts, with the consequence that family planning for this group of women is neglected.

In addition 40% (6/15) of women who were confirmed HIV positive delivered at home and this has an has implications for PMTCT programmes, community and TBA sensitisation on IPC and follow up of infected mother and child pairs in Malawi.

9.11 Contributing conditions to maternal deaths

We noted important differences when we compared contributory conditions assigned by the panel of experts compared to those assigned by health care professionals following maternal death audit. Most contributory conditions assigned by the health professionals (Table 8.12) belonged under direct and indirect underlying causes of maternal deaths according to ICD-MM and the most common contributory causes of death attributed by the panel of experts for the same cases of MD on the same cases were obstructed labour, prolonged labour, anaemia and HIV. WHO developed the ICD-MM to standardize cause of MD classification to facilitate national and international comparability. The confusion between underlying cause of death and contributory conditions is a cause of concern. Confusion in cause classification among health workers was identified in a pilot study which applied the ICD-MM to cause of deaths assigned to 4,558 MDs from five countries (Malawi, Zimbabwe, Tanzania, Kenya and Republic of South Africa (RSA) (Ameh et al. in press). The study showed those terminologies such as contributory conditions and an underlying cause of death and was used differently in different countries and often specific underlying cause of MD was not recorded.

This finding has an implication for policy and practice. There is a need for a clear policy on the use of ICD-MM by those dealing with pregnant women. Health professionals urgently require an orientation on how to correctly complete maternal death notification forms based on a standard classification system (ICD-MM).

The most common contributory causes of death attributed by the panel of experts were obstructed labour (33.3 7%), anaemia (21.9%) and prolonged labour.

Obstructed labour contributed to 33.3% of the MDs and among the women with obstructed labour, cephalopelvic disproportion was the leading contributory cause. Most women died of ruptured uterus and puerperal sepsis. Similar findings have been identified in Sudan and Uganda (Kaye et al. 2014; MacKeith & Wur 2013). Obstructed labour due to cephalo-pelvic disproportion and malpresentation is one of the major contributing factors of maternal and neonatal mortality and morbidity in low-income countries (Kabakyenga 2012). If left untreated, obstructed labour will lead to fetal death, and to uterine rupture, haemorrhage, sepsis, obstetric fistulae and death in the mother (Kaye et al. 2014; Mathai 2009). Obstructed labour is usually preceded by prolonged labour, which can be managed, either resulting in a normal delivery, assisted vaginal delivery or a CS.

Usually, health systems fail detect and manage obstructed labour due to prolonged labour. Early recognition of obstructed labour using the partograph will promote timely referral and CS will be done in time (Engida et al. 2013; Lavender, Hart & Smyth 2013).

Anaemia was the second most important contributory condition to MD. Anaemia is prevalent in other parts of Africa, with up to three-fifths of pregnant women having some degree of anaemia and approximately one-third classified as having severe anaemia (Mohammed et al. 2011b). In sub-Saharan Africa, anaemia generally results from nutritional deficiencies, specifically with chronic infections (van den Broek & Letsky 2000). Similarly in Malawi, both hospital and population-based surveys have shown that anaemia is highly prevalent among pregnant women (Malawi Government 1999; van den Broek & Letsky 2000). Education on anaemia, IPT during pregnancy and management of chronic infections and provision of iron and folic acid supplements and are key strategies that are used to reduce the high prevalence of anaemia in this population.

9.12 Factors associated with maternal deaths/associated health systems and societal factors

One of the objectives of the study was to identify factors associated with MDs using the three delay model. By categorizing the factors, the three delays model helped

us determine where improvements could best be made to save lives of women. These included both the socio-cultural and health service factors associated with maternal deaths.

Findings of this study showed all three delays: 1) delay in the decision to seek care, 2) delays in reaching care, and 3) delay in receiving care at a health facility, was evident. For most MDs o more than one type of was identified with a majority of women affected delay three.

9.12.1 Delay in receiving quality emergency obstetric care (phase 3 delay)

The third delay is an indicative of suboptimal quality of care (Thaddeus & Maine 1994). This study reveals that the vast majority (78.46 %) had accessed health services when emergency occurred, but that there were many obstacles that delayed this process. Substandard care and administrative obstacles were the main reasons type 3 delays. This study revealed poorly functioning health systems that include: lack of essential EmOC drugs and equipment, inadequate monitoring, too few skilled staffs, missed and incorrect diagnoses, delayed or incorrect treatment, delayed referrals and transfers, lack of treatment guidelines, incompetence and outright negligence were the main delays.

Other studies have confirmed type 3 delays have contributed more significantly to MM than phase 1 and 2 delays. In a facility-based audit in Tigray, Ethiopia, 88% of the MDs were associated with medical failure (Samuel, Fikre & Yemane 2009). In a district-based audit in Indonesia, 60% (n= 130) of MDs involved a phase 3 delay (Supratikto et al. 2002). In a cohort study of pregnant Haitian women from 10 rural districts, inadequate care at a medical facility was a factor the contributed to 7 MDs that occurred (Barnes-Josiah, Myntti & Augustin 1998b). In another facility-based maternal death review in Malawi, 20 out of 28 maternal deaths were associated with healthcare worker factors, and a further six with administrative failures (Kongnyuy, Mlava & van den Broek 2009).

This result highlights that many health facilities in Mangochi and in the developing world are still chronically under-resourced and unable to cope effectively with serious obstetric complications.

It is important that health care providers are able to work in a well-functioning health system where good quality of care can be provided. Adegoke et al. described a well-functioning system as one that provides an "enabling environment" to health providers which includes sufficient financial resources, essential drugs, human and necessary equipment to provide EmOC to women (Adegoke et al. 2011). Training all healthcare providers in EmOC is also important. Policy-planners should ensure the presence of an enabling environment in facilities that are affordable and close to communities. There must be continuous efforts to improve and sustain the quality of care in EmOC facilities.

In this study, there were delays in referring mothers from one facility to another due to lack of emergency transport. At times, the ambulance could break down and no replacement, and sometimes the ambulances were assigned other errands (for example, collecting blood from another district or administrative work). The referral system was plagued with fuel shortages, which affected the whole country during the study period. Ambulances were grounded due to unavailability of fuel. Other studies in Africa have reported an association between MDs and delayed referrals from lower level facilities to referral hospitals (Fatusi & Ijadunola 2003).

In Nigeria, 40% (n=50) of cases were associated with the third delay (Orji et al. 2006). Delays due to faulty ambulances have been reported in other studies in Gambia and Haiti (Barnes-Josiah, Myntti & Augustin 1998b; Cham, Sundby & Vangen 2005). In Gambia, ambulances were used for alternative purposes, and relatives were asked to hire transport.

Besides this, it is also important to consider the condition of the women when they arrived at the hospital. Even in situations where the referral centres met some EmOC criteria, some women 10% (n=151) were offered the services when it was too late to save their lives. These findings are consistent with those of other studies

in sub-Saharan Africa, where delays in accessing EmOC remain a major contributor to maternal mortality (Essendi, Mills & Fotso 2011; Moodley 2010).

9.12.2 Delay in deciding to seek care (phase 1 delay) and delay in reaching the health facility (phase 2 delay)

Delay 1 was present in 39.7% (n=151) of MDs. Barriers related to healthcare-seeking behaviour were economic status, distance to facility, educational level, women's autonomy and knowledge of danger signs. These factors led to delays in recognition of the problem and subsequently in the decision and departure to seek care. Some women delayed seeking professional treatment because their choices about medical care when they experienced problems were rational within their own system of knowledge and beliefs. When symptoms were attributed to supernatural causes, modern medicine was considered inappropriate and ineffective, and so women choose alternative care. This is shown in our study where two women went to a traditional healer before visiting skilled health workers. A similar finding was identified in a study in Haiti (Barnes-Josiah, Myntti & Augustin 1998b).

Lastly, the second delay played a role in delaying women from reaching the health facility once the decision was made. Most women faced financial, organizational, and sociocultural barriers to accessing health care. This was influenced by the distribution of health facilities, distance (ranged from 1-4 hours travel), transport and costs. Even in developed countries with no transport problems, geographical distance is associated with more frequent negative pregnancy outcomes (Nesbitt et al. 1990). Cost and poverty played a central role in reaching a facility. Transport money to travel to the facility was a problem, although more than 50% of the facilities were free. Similar findings have been demonstrated in other studies (Filippi et al. 2009; Killewo et al. 2006).

The cumulative effect of phase 1 and 2 delays contributed to the number of women reaching facilities in a serious condition as evidenced by the fact that 10% of women died on arrival at the health facility from home. Poor quality of services in turn influences women's decision-making and mitigates against timely access to care (Killewo et al. 2006). Thaddeus and Maine observed that many pregnant women

reach health facilities in a poor condition such that they cannot be saved. Time taken to receive adequate care is the key factor to prevent MDs (Thaddeus & Maine 1994).

Contribution of delay 1 and 2 to MDs points to the fact that reducing MM needs not only the improvement of assistance for obstetric emergencies in facilities, but also a reduction in the interval between the onset of a complication and its management in all settings (Miller et al. 2003; Pacagnella et al. 2012b). This, therefore, calls for the need to educate community people on 'danger signs' so symptoms are recognised early and decisions to transfer are made promptly.

Findings of this study also call for intensified efforts to encourage pregnant women and their families to be financially prepared for possible emergencies to transfer patients to relevant health facilities for appropriate care. It also implies bringing services closer to communities can significantly shorten the time to reach facilities and, hence, improve their use. It is important to address supply-side alongside demand-side factors if further reduction in Mm is to be achieved.

9.13 Limitations of the study

Although the approach uses for estimating MM this study appears to be robust, like with all other methods for measuring MM, there are may be some limitations. Although our RAMOS approach nearly doubled the officially reported number of deaths, we cannot be sure regarding how many might have been missed even with the comprehensive data collection methods used. We would contend that it is unlikely to be a frequent event. However, it is generally accepted that some early pregnancies (abortions and ectopic pregnancies) may not be identified (Gerdts, Vohra & Ahern 2013; Horon 2005).

Additionally, verbal autopsies were not conducted on all WRA and the reliance on reported signs and symptoms of pregnancy in case-notes, registers and relatives of the deceased will have missed women with undisclosed or undiagnosed pregnancy as well as those where signs and symptoms were simply not written down or revealed. In other words, the real extent of underreporting of MDs may be even

greater than detected in this study; our estimates of underreporting are thus conservative.

Possibility of recall bias during verbal autopsies, where study participants could not remember some of the events which occurred during the time of deaths. However this might be minimal in this study because the VA used had several probing questions to uncover any information. In addition more than one people who were available during the time of death were interviewed in case one forgets the events.

Lack of the denominator for estimation MMR may underestimate or overestimate the true MMR however triangulation of sources improved the level of estimate in this study. Finally the study was conducted in Mangochi district only and the results cannot be generalised to other districts, however, the results provides valuable information on MM to base on intervention.

9.14 Chapter Summary

This chapter has discussed the main findings of this study with regards to MMR, the RAMOS approach used to identify the deaths, place of death, cause of MD based on the ICD-MM and contributory conditions as well as factors associated with MDs based on the three delay model. Comparisons have been made with the existing literature and areas that should inform policy and practice in Malawi have been highlighted

10 CONCLUSIONS AND RECOMMENDATION

10.1 Chapter overview

The study set out to determine the levels and causes of maternal deaths in rural Malawi using the RAMOS approach. The study has also sought to know where these women are dying and identified associated factors. The number of MDs identified is compared with those identified via official records and InterVA-4. The chapter presents main conclusions, recommendations and areas for future research.

10.2 Conclusions

Results of this study showed that the MMR for Mangochi district for the period December 2011 to November 2012 lie within the range of 341-363 deaths per 100,000 and 95% CIs are within the range 289-425 deaths per 100,000. This MMR is lower the national estimate which is 510 per 100,000 but higher than the current global MMR of 210 per 100,000. The high MMR identified in the district reflects the quality of maternal services (Friis & Sellers 2009).

Using the RAMOS approach, this study identified 65 more MDs compared to the 86 MDs reported via the HMIS for the district. The HMIS only captured MDs that occurred at a health facility while the RAMOS approach used in this study identified MDs both at health facility and community level. Experience from this study showed that the RAMOS approach is an effective method that is able to identify deaths that otherwise would have been missed. Indeed, 65 (43%) of the 151 MDs would have been missed in this district if we had considered facility based MD notifications only.

It was also discovered that the system of capturing MDs which occur outside a facility which has been introduced in Malawi by the MOH was dysfunctional. None of the women who died outside a health facility were included in the official records.

As Malawi continues its efforts to reduce maternal mortality, it is essential to have more accurate and reliable information on the number of MDs that occur. This study provides health planners and policy makers with baseline estimates of MMR. These results demonstrate that the existing recording mechanism and process seriously underestimate the magnitude of MM. Underreporting of MDs prevents proper evaluation of progress with regard the reduction of MM. (Ali & Kuroiwa 2007).

In Malawi, notification of MDs at a health facility level still needs improvement and there is a need to revise the existing systems of capturing MDs at community level. Using multiple (instead of single sources) would assist in this and in the successful introduction of a more comprehensive Maternal Death Surveillance and Review (MDSR) system.

Another important finding of this study was that most MDs occurred in a health facilities which is contrary to what other research has reported that more deaths occur in the community (Bano et al. 2011; Barnes-Josiah, Myntti & Augustin 1998a). This finding is also indicative of the state of preparedness of the healthcare system for obstetric emergencies. The high numbers of MDs occurring in health facilities and the high proportion of women who experienced type 3 delay are important findings that require action. On average, most women stayed in a health facility for 1-2 days before they died, which is a reasonable time to be able to in principle to benefit from appropriate assessment and care.

We identified some of the barriers to care experienced when women accessed health facility care. These include; failure in the provision of timely emergency obstetric care and poorly resourced health facilities, especially at health centre level. This includes inadequately skilled personnel, poor referral transport, and lack of essential drugs (antibiotics, magnesium sulphate) and blood. These deficiencies in the health system contributed to in avertable MDs in Mangochi District and make promotion of SBA ineffective. SBA requires a fully functional supportive environment.

Type two delays was documented in 10% of women. Failure to recognize the severity of the problem at community level, delays in starting the decision-making process to seek health care and lack of transport were the reasons for the delay.
Increasing the number of women who seek SBA remains one of the primary intervention advocated internationally to reduce maternal and neonatal mortality (WHO 2004e). The government of Malawi strongly encourages institutional delivery. This study highlights that many health facilities in Mangochi district are unable to deliver such skilled attendance and are unable to cope effectively with serious obstetric complications. The importance of addressing supply-side barriers alongside demand-side factors cannot be ignored if further reduction in MM is to be achieved. Improving quality of care in health facilities and educating women on the importance of early access to care is paramount.

Another interesting finding in our population-based study is that most women died in the prime and the most productive part of life, at 25-29 years through to 30-34 years. This result is in contrast with other population and facility based studies which have reported more MDs among women less than 24 years and above 35 years (Audu & Ekele 2003; Kassebaum et al. 2014; Lema et al. 2005). In contrast, in our study, there were few deaths among the adolescents and women over 40 years. This result underscores the need for programmes of maternal health to target all groups of women when implementing maternal health interventions and not only focusing on adolescents.

Almost half of the women who died did not go to school at all and women who went to school ended at primary level. Studies have shown that women with lower levels of education are at greater risk for severe maternal outcomes (Tunçalp et al. 2014). Education of women is associated with women's reproductive behavior enabling them to control their own fertility and promotes the utilization of health including SBA. Improving non-health sector factors such as poverty and female education is important to reduce maternal mortality.

Findings have also revealed that, on average ANC coverage was high among women who had died (76.2%). However, the content of ANC was not examined and it is likely this needs improvement. In addition, this study showed late initiation

of ANC (in the second and third trimester). Earlier ANC attendance would be a good opportunity to motivate women to use SBA and to ensure emergency preparedness incase complications occur. It is important to identify the key barriers and solutions to optimal antenatal care provision. Timely initiation of antenatal care can lead to the full four-visit regimen as recommended by the WHO.

Another important new finding was the huge inconsistencies when assigning cause of death. This was assigned by health professionals, a panel of experts and inter-VA. Specifically, among health care professionals carrying MDA in the field, there was there was confusion between underlying cause of death and contributing factor. Contributory causes were frequently mistaken for underlying cause of death. Health professionals were not aware of the current ICD-MM classification which has simplified cause classification (WHO 2012c). Our results imply that and focus on improving health care to ensure a reduction in MDs may have been based on incorrectly assigned causes. This would contribute to the slow progress in reducing MM. It is necessary that interventions are based on accurate and reliable data regarding cause of death and factors contributing to MD. Currently, the causes of death assigned at health facility level form the basis for policy review in Malawi and better practice. This highlights the need for correct cause attribution to guide national and international efforts aimed at reducing MM. It is also important for international comparability of data

Findings of this study confirm that the direct underlying causes of MDs continue to be: postpartum haemorrhage, pregnancy-related infections, and hypertensive disorders and pregnancies with abortive outcome. The interventions required to prevent and manage these complications are largely captured in the package of care referred to as EmOC.

The majority of MDS (65.6%) occurred in the postpartum period. MM mortality is perhaps unique among public health problem, in that its reduction depends on secondary prevention rather than primary prevention of illness (Font et al. 2000). Life-threatening situations may develop rapidly and without warning in obstetrics, often in previously uncomplicated pregnancies. It is because of the unpredictable nature of childbirth that EmOC has been called the ‘keystone in the arch of Safe

Motherhood'(Thorsen et al. 2014). The WHO estimates that at least 88–98% of maternal deaths can be averted with timely access to existing, emergency obstetric care interventions (WHO 1994b). To reduce these high direct causes of MDs, provision of quality EmOC in all designated EmOC health facilities, and improving EmOC coverage in rural areas would save more mothers.

The majority of cases of MDs (90%) with unknown HIV status were found in this study. HIV testing among women of child-bearing age and especially in pregnancy is mainly crucial in Malawi which has overall prevalence estimated at 10.5% (UNAIDS 2013). HIV testing is mandatory at the ANC during ANC (opt out only) and it is surprising that many women who died had received ANC but were not tested and /or did not know or reveal their HIV status.

An important number (13%) of women with HIV confirmed by testing or by using the WHO clinical staging classification delivered at home and had been assisted by relatives or TBAs. This has implications for horizontal HIV transmission as well as vertical transmission as it is unlikely that the newborns received prophylactic treatment after birth and TBAs and home based carers may not have used universal precautions. This finding needs the attention of PMTCT programme managers. It could result from stigmatization of women with HIV known status. This finding may point to issues concern adherence and access to medication but also treatment monitoring and needs further exploration.

The study showed that the most common contributory causes for MD were obstructed labour and anaemia. Usually obstructed labour is diagnosed after prolonged labour. Therefore, timely management by use of a partograph and access to timely CS are important interventions towards reducing complications of obstructed labour (Mathai 2009). Delayed recognition and management of obstructed labour may result in rupture of the uterus, injury to the bladder, haemorrhage, fistulas and death of both mother and her baby.

Anaemia was the second major contributory factor to MD cause of death in our study. Anaemia is common among pregnant women in Malawi due to malaria, chronic illnesses and poverty (van den Broek & Letsky 2000). Also shortage of

blood in hospitals means that anaemia was not managed. Lack of Hb testing kits during ANC could miss out anaemia cases.

In Malawi, the Ministry of Health has been implementing programs to prevent anaemia in pregnant women such as iron supplementation during pregnancy and IPT for pregnant women. IPT continues to be safe and effective in preventing malaria. The results call for the need to revise the programs and assess for adherence to both interventions and more information is needed why prevalence of anaemia continues to be high.

10.3 Recommendations

It is felt that the recommendations below, if implemented, would be important steps to improve documentation of MM in Mangochi and Malawi and are needed to ensure key actions are taken

10.3.1 Better maternal deaths reporting

Significant underreporting of MDs at health facility and community level was identified in this study. One of the ten recommendations of WHO's high level Commission on Information and Accountability for Women, and Children's Health is to improve measurement of maternal and child deaths by 2015 (WHO 2011b). As Malawi continues its efforts to reduce MM, the need for improved MM statistics cannot be ignored. Complete reporting allows all MDs to be audited, thus facilitating relevant changes in policy and practice. The following recommendations could assist in improving the current reporting system in Malawi:

National level

i. Speed up the process of putting place better methods for tracking maternal deaths such as MDSR and a civil registration system (Danel, Graham & Boerma 2011). Strengthening the surveillance system by using multiple sources of information will help clarify the magnitude of maternal deaths, the risk factors involved

District level

ii. It is a requirement that the Mangochi Safe Motherhood Coordinator with assistance from the DHO to formally orient all staff in the district on reporting all MDs from all sections of the health facilities. The district Safe Motherhood Coordinator could conduct VA for community deaths using the 2012 WHO standard tool. Assigning cause of death could be done during the ongoing MDA meetings.

iii. The RAMOS approach has proved to be feasible and acceptable better method for identifying MDs in this study. I recommend that DHO to builds on the ground already set by this RAMOS study at facility and community level to improve data capture of MDs in Mangochi District This study improved the reporting system of deaths of WRA using an existing system. A checklist [Appendix 4a and 4b] developed during data collection for this study could be adapted for death identification at facility (by health care providers) and community level (HAS).

10.3.2 Improve on Cause classification

Accurate classification of MDs is important to promote national and international comparability as well as proper resource allocation:

National level

i. The Ministry of Health in conjunction with the Reproductive Health Unit should facilitate the revision of the MDA2 form to explicitly include variables used in the ICCD-MM classification such as type, group, underlying and contributory cause. Adding the ICD-MM codes to guide it assigning accurate cause of death will be crucial. A section for the most frequently occurring contributory conditions recognised in Malawi could be added.

ii. The medical and nurses council in Malawi who prescribe the training curriculum in the pre-service for medical and nursing colleges should include training in the application of ICD-MM in midwifery and medical curricula

District level

iii. The DHO in conjunction with Ministry of Health staff should urgently train health staff in the attribution and cause classification of MDs using the prescribed ICD-MM to correctly assign cause and contributing factors to MDs.

10.3.3 Quality of care at EmOC facilities

Improving the quality of care provided at health care facilities must be seen as a key priority. Increased efforts should be directed at the following:

National and district level

i. Antenatal care registration

In Malawi ANC coverage on average is high (95%) and this is also true in Mangochi (76.2%), but women generally register in the second or third trimester. To improve early antenatal care registration a well-structured community health education strategy should be put in place. The strategy should target men and women, reaching out to all people in the community and not focusing only on pregnant women during antennal clinics. This will require the involvement of community leaders such as religious, women and youth leaders. To facilitate the process, the DHO, to include this task in the District Implementation Plan (DIP). This will allow the Safe Motherhood Coordinator to effectively plan and implement community education

ii. Quality of antenatal care services

- Urgent action is needed to improve the quality of antenatal care being provided. Basic equipment and supplies such as weighing scales, blood pressure machines, haemoglobin meters, urine testing kits and reagents to screen blood for HIV must be made available in all health facilities. The poor staffing pattern observed particularly on the side of nurses and midwives in the health centres deserves urgent action

- Another possible way to improve the quality of antenatal care services is to standardise the antenatal-care package. The MOH, partners in maternal health should design a comprehensive to be used in all facilities package which will include all the necessary components of focused antenatal care. This can facilitate the provision of a more focused care. Development of ANC leaflets containing all the components of ANC could be disseminated to women and men of reproductive age, to know exactly what to expect at each visit and demand for a service when it is not provided.

iii. Quality obstetric care services at peripheral health facilities

To improve access to essential obstetric care services major health centres should be fully operational and have the capacity to adequately provide all the required signal functions basic EmOC services. This will require the DHO, the Safe Motherhood Coordinator putting in place the needed essential equipment, personnel and ensuring all the signals are fully operational in BEmOC facilities. This if done will reduce the referrals and counter referrals that exists currently.

iv. Emergency obstetric care services

Provision of quality obstetric care services is a fundamental pillar in the reduction of maternal mortality. However, the quality of obstetric care services being provided in Mangochi requires urgent intervention. To that effect, standard guidelines and protocols for the management of emergency cases need to be distributed to all BEmOC and CEmOC facilities. Essential supplies such as magnesium sulphate, gloves, intravenous fluids, blood bags, delivery must be made available. Transfusion services need to be improved by ensuring blood availability. Above all the Ministry of Health should increase the training of midwives and deploy more midwives to rural areas to provide the needed enabling environment for emergency obstetric care. This enabling environment includes; performing ongoing in-service education and supervision of existing midwifery staff at all levels to improve and maintain the quality of services. This can include continuing education and on the job skills training on emergency obstetric care. This

should be made available to all midwives and other health workers involved in maternity care

- The District Health Management implementation Team (DHMT) should design a clear referral plan for the district to promote timely referral of emergency cases from the peripheral facilities. Efficient ambulance services with maintenance plan for all year round and service provision and good access roads will help reduce the delay in reaching the referral point from the peripheral health facilities. Perhaps, private sector involvement in ambulance services may augment the ambulance services and make ambulance services more widely available. In resource-poor countries motorcycle ambulances at rural health centres are a useful means of referral for emergency obstetric care and a relatively cheap option for the health sector. Motorbike ambulances have been evaluated in Mangochi (Hofman et al. 2008). Some health centres have motorbike ambulances which are not functional. The facility in-charges and the DHO should facilitate maintenance of the existing motorcycle ambulances and the Ministry of Health should provide more of these for all the health facilities as car ambulances could be expensive and take time to be purchased.

- To improve blood availability for managing obstetric emergencies in health facilities, a well-organized system of transfusion services must be adopted. This will require having a system which includes active methods of recruiting new donors and at the same time maintaining old and current donors. The health education team in the district could sensitize people on the importance of blood donation and dispel rumours surrounding blood transfusion.

- The postnatal period needs much more attention if maternal mortality is to be reduced. The task force on reproductive health at a national level in conjunction with the district hospitals should revise the current postnatal protocols as women continue to die despite receiving PNC (or) during the postnatal period. Using a multidisciplinary team that include health professionals of all grades in the development of the protocols may promote

successful implementation, ownership and sustainability (Kongnyuy, Mlava & van den Broek 2008). Women need to be educated on the importance of the postnatal check-up, during the antenatal period and soon after delivery.

v. Under the Malawi Penal Code of 1930 (Sections 149-151), the performance of abortions is generally illegal except when the mother's life is in danger. In countries where legal restrictions on abortion have been reduced or removed, and safe services become available, such as South Africa, USA and Romania, maternal mortality and abortion-related complications have declined dramatically (Bartlett et al. 2004; Jewkes et al. 2005; Johnson, Horga & Fajans 2004). We recommend the government of Malawi to review and reform Malawi's restrictive abortion law and strengthen the national family planning programme. Adequate provision of family planning is an important strategy for preventing unwanted pregnancy and reducing maternal mortality related to unsafe abortion (Singh, Darroch & Ashford 2009).

vi. Maternal death audit

- Routine review of all maternal deaths should be strengthened an effort to identify the avoidable factors to maternal deaths. This is necessary in putting in place evidence-based interventions in addressing maternal deaths. The safe motherhood coordinator should ensure involvement and active participation of well-focused; committed and technically competent people experienced in this field. The availability and willingness of the senior health management to listen to the information revealed and support the audit team in the implementation of planned actions.

- To strengthening the maternal death audit system in the hospital to in identifying basic flaws (if any exist) in the delivery of emergency obstetric services and eliminate phase 3 delays (delays that occur at the health facility) so that preventable maternal deaths can be reduced to the barest minimum.

V. Improve on health worker attitudes

- The DHO in conjunction with MoH should plan for trainings for client handling to reinforce positive attitudes and reduce negative ones. Regular support supervision sessions to encourage respectful handling of patients and solving the causes such as inadequate staffing, lack of adequate supplies and recruiting health workers with the intrinsic desire to help the sick

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- Encourage health worker and community dialogue meetings in each health facility catchment area to discuss the weakness and plan for interventions together

10.3.4 Education of midwives and practice

- Emphasize on the quality of obstetric care in the midwifery curricula so that women to receive proper care during pregnancy, labour and delivery and the puerperium
- The midwifery regulatory body to update the midwifery curricula and add in modules of: ethical behaviour in midwifery, effects of poor attitudes in midwifery, women rights and dignity to promote respect for human dignity and treat women as persons with full human rights.

10.3.5 Improvement of socio-economic status of women

- Higher educational status of women is associated with better access to obstetric care and if the quality of obstetric care would be sufficient, improving women's educational status might reduce maternal deaths by ensuring that they get care in time. The Ministry of Education should strengthen the program of girl education and revamp the adult literacy education to empower the out-of-school women and girls, especially in hard to reach areas. Improving literacy of women will effectively improve knowledge and care-seeking behaviour related to good reproductive health practices. Furthermore, improving non-health sector factors such as poverty

will strengthen health seeking behaviour of the whole population, especially women. The social welfare department in the Ministry of Local Government should encourage small scale business among rural women and provide women with loans to start business.

10.3.6 Community Initiatives

- The community health workers (Community nurses and HSAs) to give health education to both men and women of reproductive age on the importance of birth preparedness to prevent maternal death
- The community could raise money and buy own bicycle ambulances and have plan to be maintaining them, to assist in emergencies

10.4 Areas for further research

The findings of this thesis have highlighted knowledge gaps which need to be addressed:

- Among the deaths of women that occurred after delivery (n=99), 65.6% occurred during in the postpartum period. Among all women who died after delivery only 17.2% (17/99) received postnatal care. The MDHS highlighted that postnatal period is the most neglected time in the continuum of care delivery care. Review models and practice of postnatal care in Malawi provide baseline data regarding the current content and timing

- Most women started accessing ANC in the second and third trimester. Literature reveals early initiation of ANC is an opportunity to check health indicators and a forum to educate women on healthy pregnancy outcomes and complications that may arise. There is paucity of data in literature on factors that hinder the early initiation (first trimester) of ANC in Malawi. This suggests the need for research to understand the specific contextual, socio-economic, cultural, and behavioural factors affecting women's early initiation of ANC.

- There is a need also conduct an operational research to understand how quality of obstetric care can be improved and if quality of care is improved, does access improve?

- Exploring aspects of maternal care that women and communities themselves want to see improved to identify gaps for improvement in care that need to be addressed

10.5 Chapter Summary

In this chapter, conclusions are formulated based on main findings of the study with regard to MMR, reporting system, characteristics of women who died and place of death. Cause of MDs and associated factors with maternal deaths are highlighted. Recommendations have been suggested, and implications have been highlighted based on a critical analysis of the results. Finally, areas for further research have been suggested.

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APPENDICES

Appendix 1: Ministry of health Maternal Death Review Form (MDA2)

GENERAL INSTRUCTIONS

This form must be completed for all maternal deaths (including indirect deaths, abortions, molar and ectopic gestation) occurring up to 42 days following delivery / termination of pregnancy.

The District Maternal Death Review Committee must complete the form within 1 month and make a follow up on the implementation of the action plan within 3 months. The original should stay at district level and copies submitted to the facility where the death occurred and zonal/national level.

District and Central Hospitals should review their own maternal deaths and submit copies to the district where the maternal death originated from and zonal/national level.

The code must be the same code as that on the notification form, MDA1.

Compile quarterly reports on all maternal death reviews and submit to DHO, Zonal and national offices.

1. DETAILS OF DECEASED

1.1 MD Case Number: ☐☐☐ **1.2 Admissions No.:** ☐☐☐☐☐☐☐☐☐☐☐☐

1.3 Age (years): ☐☐

1.4 Physical Address or locality where patient lived:

1.5 Marital status: Married ☐ Single ☐ Divorced ☐ Widowed ☐ Separated☐

1.6 Educational level: None ☐ Primary ☐ Secondary ☐ Higher ☐

1.7 Condition at the time of death:

Undelivered: Gravida ☐☐ Para☐☐ Gestation (weeks) ☐☐

Delivered: Gravida ☐☐ Para☐☐ Days since delivery ☐☐ Gestation at delivery (weeks)☐☐

2. ADMISSION AT INSTITUTION WHERE DEATH OCCURRED

2.1 Date of admission to facility: ☐☐/☐☐/☐☐☐☐ (dd/mm/yr) **2.2 Time:**☐☐☐☐ AM/PM

2.3: Admitted from: Another facility ☐
TBA ☐
Community ☐
Other ☐ Specify _____

2.4 Reason for admission (√ appropriate boxes):

1. Ante partum Haemorrhage ☐
2. Post-partum Haemorrhage ☐
3. Obstructed/prolonged labour ☐
4. Ruptured uterus ☐
5. Postpartum sepsis ☐
6. Pre-eclampsia/eclampsia ☐
7. Complications of abortion ☐
8. Ectopic pregnancy ☐
9. Malaria ☐
10. HIV/AIDS ☐
11. Anaemia ☐
12. TB ☐
13. Hepatitis ☐
14. Others ☐ (specify) _____

2.5 Condition on admission: Stable ☐ Critically ill ☐ Dead on arrival (DOA) ☐

2.6 Date of death: ☐☐/☐☐/☐☐☐☐ (dd/mm/yr.) **2.7 Time**:☐☐:☐☐ AM/PM

2.8 Condition at moment of death: Antenatal ☐ Intrapartum ☐ Postpartum ☐ Abortion ☐

3. ANTENATAL CARE

3.1 Did she receive antenatal care? Yes ☐ No ☐ *(skip to section 4)*

If "Yes",

3.2 total number of visits: ☐

3.3 Any danger sign(s) identified: Yes ☐ No ☐ **3.4 If "Yes" specify:** _____

3.5 Any action taken on identified danger signs? Yes ☐ No ☐

3.6 If "Yes", tick all that apply:

Referred ☐
Given SP ☐
Given folic acid ☐
BP recorded ☐
VCT ☐
Other ☐ (specify): _____

4. DELIVERY AND PUERPERIUM

4.1 Did delivery occur? Yes ☐ No ☐ *(skip to section 5)*

If "Yes",

4.2 Date of delivery: ☐☐/☐☐/☐☐☐☐ (did/mm/yr.) **4.3 Time:** ☐☐:☐☐ AM/PM

4.4 Was a partograph used? Yes ☐ No ☐ph

Locality where labour <u>started</u>: (√ one box)

4.5 Level of facility: 1. Central Hospital ☐ 2. District/CHAM/Private Hospital ☐
3. Community/Rural Hospital ☐ 4. Health Centre/Private clinic ☐
5. Standalone Maternity Unit ☐ 6. TBA/Community ☐
7. On the way/before arrival to H/F ☐ 8. Other ☐

4.6 Ownership of health facility: (√ one box)

1. MOH ☐ 2. CHAM ☐ 3. Private-for-profit ☐ 4. Local Government ☐ 5. Other ☐

4.7 Duration of labour (hours:min):

1. Latent phase	2. Active phase	3. Second stage	4. Third stage
☐☐hrs ☐☐min	☐☐hrs ☐☐min	☐☐hrs ☐☐min	☐☐hrs☐☐min

4.8 Mode of Delivery: (√ appropriate boxes)

1. SVD ☐ 2.Breech ☐ 3. Vacuum ☐ 4. Forceps ☐ 5. Caesarean Section ☐
6. Destructive operation ☐ 7. Other ☐ *specify* _____

4.9 Delivered by: (√ one box)

1. Midwife☐ 2. Clinical Officer ☐ 3. Medical Officer ☐ 4. Obstetrician/gynaecologist ☐ 5. TBA ☐
6. Nurse ☐ 7. Medical Assistant ☐ 8. Other ☐ *specify* _____

5. CAUSE OF DEATH

5.1 Primary (immediate) cause of death: e.g. sepsis

5.2 Secondary (underlying) cause of death: e.g. obstructed labour

6. ASSOCIATED FACTORS THAT CONTRIBUTED TO DEATH

(√ appropriate boxes, to be extracted as far as possible from records)

Factors	Causes	Yes	No	Remarks
6.1Health worker factors	Lack of training in midwifery skills			
	Delay in deciding to refer			
	Initial assessment incomplete			
	Inadequate resuscitation			
	Wrong diagnosis			
	Wrong treatment			
	No treatment			
	Delay in starting treatment			
	Inadequate monitoring			
	Prolonged abnormal observations without action			
	Lack of obstetric life saving skills			
6.2 Administrative factors	Communication problem between health facilities			
	Transport problem between health facilities			
	Lack of qualified staff			
	Lack of antibiotics			
	Lack of other essential obstetric drugs			
	Lack of essential equipment			
	Lack of laboratory facilities			
	Lack of availability of blood transfusion			
	Absence of trained stuff on duty			
6.3 Patient / Family Factors	Delay in reporting to health facility			
	Lack of transport from home to health facility			
	Unsafe traditional/cultural practice			
	Unsafe medical treatment			
	Refusal of treatment			
	Delay in decision making			
	Use of traditional medicine / practices			
6.4 TBA/community factors	Failure to recognise danger signs			
	Failure to accept limitations			
	Use of traditional medicine			
	Lack of transport			
	Delay in deciding to refer			
6.5 Other factors - specify:				

7. NEONATAL INFORMATION

7.1 Was the baby weighed after delivery? Yes ☐ No ☐

If "Yes",

7.2 Birth weight (g): ☐☐☐☐

7.3 Was the Apgar score determined after delivery? Yes ☐ No ☐

If "yes",

7.4 5 min Apgar score: ☐☐

7.5 Outcome for newborn: (√ one box): Alive ☐ Fresh SB ☐ Macerated SB ☐ NND ☐

If NND,

7.6 Time of death: _____ 7.7 Date of death: _____

7.8 Cause of Death (√ appropriate boxes):

Preterm baby ☐
Low birth weight ☐
Asphyxia ☐
Hypothermia ☐
Sepsis ☐
Neonatal tetanus ☐
Diarrhoea ☐
Birth defect ☐
Others ☐ (specify) _____

ASSESSMENT OF THE MATERNAL DEATH BY

DISTRICT MATERNAL DEATH REVIEW COMMITTEE

8. CASE SUMMARY (supply a short summary of the events surrounding the death including quality of care at all levels)

DISTRICT MATERNAL DEATH REVIEW COMMITTEE (DMDRC) ACTION PLAN TO IMPROVE FUTURE CARE

Level of Care	**Proposed Activities**	**Proposed Time Frame**	**Resp. Person**
Hospital			
Health Centre			
TBA			
Family/Community			

10. COMPLETED BY:

10.1 Name (print):_____10.2 Position: _____

10.3 Telephone: ☐☐☐☐☐☐☐☐ 10.4 Fax:☐☐☐☐☐☐☐☐ 10.5 E-mail: _____

10.6 Date: ☐☐/☐☐/☐☐☐☐

10.7 Signature: _____ (Chairperson of Review Committee)

****

10.8 Name of CHD/DHO/DNO/CNO: _____ 10.9 Position: _____

10.10 Signature: _____ 10.11Date: ☐☐/☐☐/☐☐☐☐

Appendix 2: Mangochi zone and cluster distribution by health facility

Monkeybay zone	**Mangochi zone**		**Chilipa zone**	**Makanjira zone**		**Namwera zone**		
Nankumba Cluster	***Mangochi Cluster***	***Malombe Cluster***	***Chilipa Cluster***	***Lungwena Cluster***	***Makanjira Cluster***	***Katuli Cluster***	***Namwera Cluster***	***Nkumba Cluster***
Chilonga H/C	MDH	Assalam H/C	Katema H/C	St Martins Hospital	Kadango H/C	Maleta H/C	Chikole H/C	Chiponde H/C
Nankumba H/C	Mpondasi H/C	Kukalanga H/C	Mtimabii H/C	Lungwena H/C	Lugola H/C	Luwalika H/C	Iba H/C	Namcholi H/C
Malembo H/C	Namiasi H/C	Malukula H/C	Chilipa H/C	Namalaka H/C	Makanjira H/C	Katuli H/C	Jalasi H/C	Nangalamu H/C
Nkope H/C	Koche H/C	Mase H/C	Phirilongwe H/C		Lulanga H/C	Ngapani H/C	Namwera H/C	Mulibwanji Hospital
Nankwali H/C		Malombe H/C	Kapire H/C				Sr Martha H/C	Nkumba H/C
Monkeybay Hospital		Chiunda H/C	Chilonga H/C				Chiombangame	Sinyala H/C
								Mbalama H/C
								Somba Clinic

Key: MDH - Mangochi District Hospital H/C - Health Centre

Appendix 3: Summary table for publications included in literature review

No	Author(s), year	Setting	Title	Study Design	Data source/approach	Major Findings	Comments
1	Fengzihi et al 2012	China	MM in Henan Province, China: Changes between 1996 and 2009.	Cross-sectional (CS)	Vital registration (VR)	MMR declined by 78.4%, from 80.1 per 100 000 live births (LB) in 1996 to 17.3 per 100 000 live births in 2009. Main causes were OH (43.8%), PIH (15.8%) and amniotic fluid embolism (13.9%).The MMR was higher in rural areas, lower income, less education and poorer health care	Early abortion MDs outside the hospital were underreported,
2	Yang et al 2014	China	Progress on the MMR reduction in Wuhan, China in 2001-2012.	Cross-sectional	VR .	MMR dropped from 33.4 per 100.000 LB in 2001 to 10.63 per 100,000 LB in 2012 with a decline of 68.18%. Four major causes of MDs were OH (35.16%), Pregnancy complications (28.57%), amniotic fluid embolism (16.48%), and gestational hypertension (8.79%).	
3	Indu Chawla 2014	India	MM in Andaman and Nicobar Group of Islands: 10 Years Retrospective Study	Cross-sectional	VR	MMR was much lower than the national average of 250. Causes, eclampsia 30%, haemorrhage 23.33%, sepsis 6.66%, and 3.33% amniotic fluid embolism. Indirect causes, anaemia were the commonest (16.66%).	
4	Du Li et al 2012	China	Trends in MM in resident vs. migrant women in Shanghai, China, 2000-2009: a register-based analysis	Cross-sectional	VR	MMR, 20.5 per 100,000 LB. OH was major cause.	Reported MMR for specific causes
5	Adam et.al. 2003	Nigeria	MM in Northern Nigeria: a population-based study	Cross-sectional	VR	4,154 MDs among 171, 621 deliveries, MMR of 2,420 deaths per 100, 000 LB. Eclampsia, ruptured uterus and anaemia were responsible for about 50% of MDs.	
6	Zhu et al, 2009	China	Comparison of MMR between migrating population and permanent residents in Shanghai, China, 1996–2005	Cross-sectional	VR	MMR, 22.47 per 100,000 LB in 1996 to 1.64 per 100,000 live births in 2005 ($P < 0.01$), while the MMR in migrating population reduced only moderately from54.68 per 100,000 LB to 48.46 per 100,000 ($P > 0.05$). PPH (39.9%), PIH (9.8%), and puerperal infection (9.3%) were main causes of death.	Pregnancy status was missing in the death register
7	Kestler & Ramirez, 2000	Guatemala	Pregnancy-related mortality in Guatemala, 1993-1996	Cross-sectional	Active surveillance (AS)	MMR 156.2 deaths per 100,000 LBs. 35-39 years old women had a MD more risk than the 20-24. 40 or older had double risk than women 20-24 years old. Leading causes of MM were infection and haemorrhage	
8	Lewycka et al. 2011	Malawi	Effect of women's groups and volunteer peer counselling on rates of mortality, morbidity, and health behaviours in mothers and children in rural Malawi	Cluster-randomised trial	AS	29 MDs, MMR 585 per 100,000 LB (407-838). No causes presented	Delays in implementation of activities by the women's groups in year 1.

No	Author(s), year	Setting	Title	Study Design	Data source/approach	Major Findings	Comments
9	Liang et.al. 2010	China	MM in China, 1996-2005	Cross-sectional	AS	MMR decreased from 64.1 per 100, 000 LB in 1996 to 47.6 per 100, 000 LB in 2005. Leading causes of MDs were obstetric haemorrhage, pregnancy-induced hypertension, and amniotic fluid embolism.	
10	Kodio et.al. 2002	Senegal	Levels and causes of MM in Senegal	Cohort study	AS	MMR 436 per 100, 000 live births (95% CI: 209-802. 2/3 of the MDs were from direct obstetric causes, haemorrhage being the most common.	Death reporting was incomplete for some cases
11	Barnett et al 2008	India	A prospective key informant surveillance system to measure maternal mortality - findings from indigenous populations in Jharkhand and Orissa, India	Prospective surveillance	AS	13, 602 births, MMR of 722 per 100, 000 live births (95% CI, 591-882. 25% of MDs occurred antepartum, 50% intrapartum and a 25% postpartum. Haemorrhage was the commonest cause (25%).	Prospective variant of RAMOS. The cost of operating the surveillance system was US$386 a month, or US$0.02 per capita per year.
12	Qomariyah, 2013	Indonesia	A community-based surveillance system for MDs **i**n Indonesia	Prospective surveillance	AS	High level MMR, 435 deaths per 100,000 live births) and of indirect causes (43%). The two informant networks together captured about 91% of births and 92% of deaths.	
13	Nizamuddin and Pradhan, 2013.	India	Identifying factors associated with maternal deaths in Jharkhand, India: A VA study	Cross-sectional.	Sample registration and verbal autopsy (SRV)	MMR reduced from 527 to 376 per 100,000 LB. Most were poor (89%), non-literates (85%), and housewives (74%). 80% died in the community /at home, 28% during pregnancy while another 26% during delivery.	Some relatives refused verbal autopsies
14	Ziraba,et al.2009	Kenya	MM in the informal settlements of Nairobi city: what do we know?	Cross-sectional	SRV	MMRs for two slums were 706 per 100,000 LB which was higher than the national estimates (560 per 100,000) LB. Major causes: abortion complications, haemorrhage, sepsis, eclampsia, and ruptured uterus. Only 21% of the 29 MDs delivered with SBA.	14% of all female deaths did not have VA about 47% of the health care facility medical records were incomplete.
15	Mandez et.al. 2008	Mozambique	An autopsy study of MM in Mozambique: the contribution of infectious diseases	Cross-sectional (prospective)	SRV	Haemorrhage (16.6%), non-obstetric condition for 56.1% of deaths; HIV/AIDS, pyogenic bronchopneumonia, severe malaria, and pyogenic meningitis were the most common causes (12.9%, 12.2%, 10.1% and 7.2% respectively).	Only hospital deaths included
16	Desai et.al. 2013	Kenya	An analysis of PRM in the KEMRI/CDC health and demographic surveillance system in western Kenya	Cross-sectional	SRV	MMR, 740 (95% CI 651-838) per 100,000 LB, 34% were direct, predominantly PPH, abortion complications and puerperal sepsis. 2/3 was indirect; 3/4 were attributable to (HIV/AIDS), malaria and tuberculosis. More women of low socio-economic groups sought care from TBA (p=0.034), while less impoverished women were more likely to seek hospital care (p=0.001)	unable to fully ascertain the pregnancy status of some women

No	Author(s), year	Setting	Title	Study Design	Data source/approach	Major Findings	Comments
17	Hofman and Sibande ,2005	Malawi	Community-based MD in Mangochi	Longitudinal, descriptive	SRV	43 MDs, 44% hospital, 30% home. 7% TBA and 7% on the road. PPH, RU, Complications of abortions accounted for 79%. Delays-refusal to seek care, 77%, inadequate management by TBA 41%, no blood 32%	Only one TA out of 9 in included. No MMR
18	Jafarey et. Al., 2009	Pakistan	Verbal Autopsy of MDs in Two Districts of Pakistan - Filling Information Gaps	Cross sectional	SRV	2.3 of the deaths occurred in rural areas. High prevalence of anaemia Risk factors identified among 128 deceased women were: low socioeconomic status, illiteracy, low-earning. jobs, parity, and bad obstetric history. 19% of women died during pregnancy, i.e. before labour started, 12% during labour, and 69% after delivery. The most critical post-partum period was the first 24 hours after delivery, with 43% dying during this period and 33% within four hours of delivery	No single source had complete data on maternal deaths.
19	Barlett et al 2005	Afghanistan	Where giving birth is a forecast of death: MM in four districts of Afghanistan, 1999-2002.	Cross-sectional retrospective	Households survey (HS)	Most MDs were caused by antepartum haemorrhage; the MMRs (per 100 000 LB) were 418 (235-602) in Kabul, 774 (433-1115) in Alisheng, 2,182 (1451-2913) in Maywand, and 6,507 (5026-7988) in Ragh. In the 2 rural sites, no woman who died was assisted by a skilled birth attendant	There were no reliable routine sources of data to identify births
20	Qiu et al 2010	China Zhejiang province	Improving the MM ratio in Zhejiang Province, China, 1988–2008.	Cross-sectional	HS	MMR decreased from 48.50 in 1988 to 6.57 per 100,000 LB in 2008. Decline in direct obstetric causes and increase in proportion of indirect causes. Most women were of lower socio-economic status	Almost all deaths facility-based.
21	Campbell et.al. 2005	Egypt	National MM ratio in Egypt halved between 1992-93 and 2000	Cross sectional	HS	MMR dropped by 52% (from 174 to 84/100 000 LB). Major cause, haemorrhage	National study
22	Ujo et al 2014	South Africa	The 8503 respondents reported 22,473 sisters (average = 2.6 sisters for each respondent) who survived to reproductive age. Of the 2552 (11.4%) sisters who had died, 819 (32%) occurred during pregnancy and childbirth.	cross-sectional	Survey	MMR was of 764 per 100,000 LB in 2007. Maternal infections and parasitic diseases and pregnancy complicating, were the major causes.	
23	Garenne et. al 2011	South Africa	MM in South Africa: an update from the 2 007 Community Survey	Cross-sectional	HS	MMR was 702 per 100,000 LB. 30% more than the 2001 census. Main reasons for high levels were HIV/AIDS and accidents and violence.	

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24	Hyness et al 2012	Zambia, Bangladesh, Ethiopia, Kenya, Napal, Rwanda, Sudan, Tanzania, Uganda and Chad	A study of refugee MM in 10 countries, 2008-2010	Cross-sectional	Survey	Low proportion with four or more ANC visits (33%) 78% of MDs followed abortion, 56% occurred within 24 hours. Delays in seeking and receiving care were more prevalent	Included only refugee camps
25	Asamoah et al 2011	Ghana	Distribution of causes of MM among different socio-demographic groups in Ghana; a descriptive study.	Cross-sectional	Survey	Haemorrhage was the major cause (22.8 %). Married women had a significantly higher risk of dying from haemorrhage, compared with single women (adjusted OR=2.7, 95%CI=1.2-5.7). Married women showed a significantly reduced risk of dying.	
26	Van den Broek et all 2003	Malawi	Reproductive health in rural Malawi: a population-based survey	Descriptive population-based study	Survey	MMR, 413 per 100,000 deliveries (95% CI 144-682). Over 90% of women attended ANC with a mean of five visits. SBA was likely as education increased and was less likely as distance from the health centre increased.	largest community-based reproductive study in Africa
27	Singh, Pandey and Aggarwal, 2007	India	House-to-house survey vs. snowball technique for capturing MDS in India: A search for a cost-effective method	Cross-sectional	Survey	MMR for the five states was 356 per 100,000 LB, as compared to the national estimate of 400 per 100,000 LB.	The study covered only a small area
28	Gebreamlak et al 2012	Ethiopia	Patterns of MM and associated factors; A case-control study at public hospitals in Tigray region, Ethiopia, 2012	Case control	Survey.	SBA were 89% times lower risk non-SBA [AOR=0.11; 95% CI (0.03-0.42)].Women who received ANC, [AOR=0.26; 95% CI (0.12-0.57)] and women with labour less than 24 hours [AOR=0.27, 95% CI (0.07-0.89)] were less likely to die. Major causes were PPH and PIH which accounts 39% and 19% respectively.	
29	Garenne, et. Al., 2008	South Africa	MM in South Africa in 2001: from demographic census to epidemiological investigation	Cross-sectional	Census	MMR in 2001 was 542 per 100,000 LB. This level was much higher than previous estimates dating from pre-HIV/AIDS times	No causes
30	Bell et. al 2008	Burkina Faso	The epidemiology of pregnancy outcomes in rural Burkina Faso	Cross-sectional	Census	MMR was 441 per 100, 000 LB (95% CI: 397, 485), MMRs were associated with wealth quintile, age and distance from a health facility. Causes were sepsis (30%) and haemorrhage (7%).	pregnancy-related mortality
31	Hill et al, 2009	Latin America	Estimating PRM from census data: Experience in Latin America	Cross-sectional	Census	The PRMRs for Honduras (2001), Nicaragua (2005) and Paraguay (2002) were 168, 95 and 178 per 100, 000 LB, respectively.	Reported pregnancy-related deaths rather than maternal deaths

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32	Stanton 2001	Benin, Islamic Republic of Iran, Lao, Madagascar and Zimbabwe	Every death counts: measurement **of** MM via **a** census	Cross-sectional	Census d	MMRs Benin-168/100,000 births, Iran-39/100.000 LB, Lao 421 /100,000, Madagascar, and Zimbabwe 329/100,00 LB	No causes
33	Adegoke et al. 2013	Nigeria	Community Study of MM in South West Nigeria: How applicable is the Sisterhood Method.	Retrospective cross-sectional survey	Indirect sisterhood method (ISH)	MMR was 7,778 per 100,000 LB based on published TFR of 6.0 MMR 7-10 times higher than the sisterhood method	No causes
34	Font et. Al. 2000	Tanzania	MM in a rural district of south eastern Tanzania: an application of the sisterhood method	Cross-sectional	ISH	MMR was 448 per 100, 000 live births (95% CI: 363-534 deaths per 100 000 live births). Leading cause of death puerperal sepsis (35%) and postpartum haemorrhage (17%);	
35		Ethiopia	High MM in rural south-west Ethiopia: estimate by using the SM	Interviewed 8,870 adults, 15-49 years age, in 15 randomly selected rural villages of Bonke in Gamo Gofa	ISH	Lifetime risk was 10.2% from pregnancy and childbirth with a corresponding to MMR of 1667 (95% CI: 1564-1769) per 100,000 LB.	
36	Beltman et al. 2011	Malawi	Repetition of a sisterhood survey at district level in Malawi: the challenge to achieve MDG 5	Indirect sisterhood	ISH	MMR was 558 per 100, 000 LB (95% CI 260- 820). The hospital-based MMR was 994 per 100, 000 live births in 2005.	No cases
37	Doctor et al. 2012	Nigeria	Estimating MM level in rural northern Nigeria by the sisterhood method	Cross- Sectional	ISH	MMR of 1,271 MDs / 100,000 live births with 95% CI of 1,152–1,445. Much higher than the official national estimate of 608 MDs per 100,000 LB	
38	Oye-adeniran et. al., 2011	Nigeria	The use of the sisterhood method for estimating MMR in Lagos state, Nigeria	Cross-sectional	ISH	MMR, 450 per 100,000 LB with a 95% CI of 360 and 530. 31.5% occurred during pregnancy, 44.1% ,delivery and 24.3% within 6 weeks of delivery	No causes
39	Idris et.al., 2010	Nigeria	Estimation of Maternal Mortality using the Indirect Sisterhood Method in Three Communities in Kaduna State, Northern Nigeria	Cross-sectional	ISH	Maternal causes accounted for 46.8% of all deaths, with a 1:13 lifetime risk of dying from maternal causes, and an MMR of 1,400 per 100,000 LB	No causes
40	Mbaruku et. Al., 2003	Tanzania	Estimates of MM in Western Tanzania by the Sisterhood Method	Cross-sectional	ISH	MMR, 606 per 100,000 LB (95% CI 518-695). The highest MMR of 757 was in rural district and the most isolated parts	The method underestimated early pregnancy deaths

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41	Lech and Zwane, 2002	Swaziland	Survey on MM Swaziland using Sisterhood method	Cross-sectional	ISH	MMR was 229 and the life-time risk of maternal death was 1 in 69. These values were low and stable throughout the 6- to 7-year period before the study.	A lot of migration which took place in the country
42	Aa et al 2011	Mali	High MM estimated by the sisterhood method in a rural area of Mali	Cross-sectional	ISH	MMR, 3,000 per 100,000 LB, much higher national estimates of 1,000 per 100,000 LB.	Deaths due to abortions and ectopic pregnancies may have been misclassified.
43	Olsen et al. , 2000	Tanzania	Estimates of MMR by sisterhood method in rural northern Tanzania: a household sample and antenatal clinic sample	Cross-sectional	ISH	MMR per 100,000 LB was 362 (95% CI 269-456) and 444 (95% CI 371-517).	No causes
44	Bhat, 2002	India	MM in India: an Update	Cross-sectional	ISH	MMR was 448 deaths per 100,000 live births. The MMR was 15%	
45	Garimoi, 2000	Uganda	MM estimated using the Sisterhood method in Gulu district, Uganda	Cross-sectional	ISH	MMR, 662/100,000 deliveries [95% Cl 421-839], 1.3 times higher than national of 500 per 100,000 deliveries.	
46	Orach et.al., 2000	Uganda	MM using Sisterhood method in Gulu District in Uganda	Cross-sectional	ISH	MMR, 662/100,000 (CI 421-839) which was higher than the estimated national.	Used randomly selected areas.
47	Smith et. Al., 2001	Ghana	Estimates of the MMR in two districts of the Brong-Ahafo region, Ghana	Cross-sectional	ISH	MMR, 269 per 100, 000 LB for both districts higher than the national.	
48	Muchemi, and Gichogo, 2014	Kenya	MM in Central Province, Kenya, 2009-2010	Descriptive retrospective review of reported from health facilities maternal deaths	Hospital records (HR)	MMR, 124/100,000 LB. 66% deaths had been audited. (33%) aged 25 to 34 years. Mean age was 31 years (±6). 33% had a parity of less or equal to 2. 35% of deaths had delivered a LB, 34% died within 24 hours after admission. 27% were admitted antepartum, 39%died postpartum. 32% died of haemorrhage and 7% of Eclampsia	Incompleteness of data on most of the records
49	Ibeh and Okupara, 2013	Nigeria	MD where do they occur? A survey of health facilities in Abia state, south east Nigeria	Cross-sectional	HR	25,081 births and 43 MDs, MMR 171 per 100,000 LB.	Poor documentation

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50	Rahim et.al. 2006	Pakistan	Analysis of direct causes of MM at a tertiary hospital	Cross-sectional retrospective,	HR	MMR – 1,311 per 100, 000 LB. 86.2% had direct causes and 13.8% had indirect causes of maternal mortality. Haemorrhage was 42.16% , hypertensive disorders in 24.63% , ruptured uterus in 10.45% , septicaemia in 9.7% , thromboembolism in 7.8% and unsafe abortion in 3.4% cases	
51	Onesmus et all 2013	Kenya	MM in Central Province, Kenya, 2009-2010	Cross-sectional retrospective	HR	Common causes, haemorrhage (26%), puerperal sepsis (19%), and obstructed labour (5%). MM was more for unbooked patients (odds ratio 5.1, 95% CI 3.5-6.2, P < 0.0001).	There was a high proportion of missing information
52	Saleh et al. 2013	Cairo, Egypt	Audit of MMR and Causes of Maternal Deaths in the Largest Maternity Hospital in Cairo,	Retrospective observational study	HR	38 MDs, MMR 79 per 100,000 LB similar to Egypt's reported MMR of 84 per 100,000 LB. Main causes OH, HDP and cardiac arrest. The delay in seeking medical advice and substandard medical care were contributing. More MDs in 20 years or less in age and associated with multiparty	Method only described briefly
53	Yego et al. 2014	Kenya	A retrospective analysis of maternal and neonatal mortality at a teaching and referral hospital in Kenya	Cross-sectional Retrospective	HR	MMR, 426 per 100,000 LB 64% and in multiparous women, referred admissions, gestational age less than 37 weeks and in latent stage of labour. Indirect complications accounted for the majority of deaths. Eclampsia, leading direct cause.	Medical records Were incomplete and had missing data.
54	Ratan et al 2014	India	MM at a teaching hospital of rural India: a retrospective study	Cross-sectional Retrospective	HR	MMR was 518.48 per 100, 000 LB. The leading direct cause (81.64%) was Eclampsia (43.75%), while indirect leading cause was heart disease (6.64%). 60.92% of women died within 12 hours of admission The age group of below 25 years (67.17%), primigravidae (63.28%) and unbooked cases (89.84%) were mainly affected.	
55	Guerrier et al 2013	Nigeria	High maternal and neonatal mortality rates in northern Nigeria: an 8-month observational study	Cross-sectional	HR	MMR was 1,791/100,000 LB. Causes, haemorrhage (26%), puerperal sepsis (19%), and obstructed labour (5%). Higher in unbooked patients (odds ratio 5.1, 95% CI 3.5-6.2, P < 0.0001)	The centre admitted complicated cases with high risk of death
56	Olowonyo, et al 2005	Nigeria	Registering in a health facility for delivery protects against MM in a developing country setting	Cross-sectional Prospective	HR	MMR, 177.6 per 100,000 LB. 84% non-SBA. MMR comparable with previously reported. 81% of deaths were due to 3 main causes: haemorrhage, eclampsia and infection. MMR was three-fold in women >35 years.	
57	Der, et. al. 2013	Ghana	Pregnancy-related causes of deaths in Ghana: a 5-year Retrospective study	Cross-sectional	HR	5,247 deaths WRA aged 15-49, 12.1% PRD, .81% community deaths or within 24 hours of admission and 18.5% occurred in a health facility. Direct obstetric causes were 79.5%; haemorrhage was the leading cause (21.8%),	Relied on autopsy data only

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58	Bolnga et al 2014	Papua New Guinea	Insights into MM in Madang Province, Papua New Guinea	Retrospective cross-sectional	HR	MMR, 588 deaths per 100, 000 LB. 71.2% were direct. Haemorrhage and infection (46.2%, 30.8%) were the leading causes. MDs underreported.	Not all cases had notes
58	Okaek , 2009	Nigeria	Statistical analysis of the MD rate at the Ebonyi State University Teaching Hospital, Abakaliki, for the year ending 31 December 2007	Cross-sectional	HR	MMR, 735.6 per 100, 000 LB, Fifteen (37.5%). no antenatal primigravidae were found to have died of severe pre-eclampsia/eclampsia.	
60	Yadav et al 2013	India	A retrospective and prospective study of MM in a rural tertiary care hospital of Central India	Cross-sectional	HR	MMR range, 426 to 641/100,000 LB. Main causes haemorrhage (31.9%), pre-/eclampsia (24.4%) and anaemia (14.94%). More deaths (77.6%) –in 20-29 years of age, in postnatal period and among the unbooked and from rural areas.	Some records missing at the facility
61	Thonnaeou et al 2004	Three countries: Benin, Ivory Coast, Senegal	Distribution of causes of MM during delivery and post-partum: results of an African multicentre hospital-based study.	Cohort	HR	85 MDs and MMR of 800/100,000. Hypertensive disorders caused 29% of deaths, PPH 15%.	
62	Sanga et. al., 2010	Papua New Guinea	A review of maternal deaths at Goroka General Hospital (GGH), Papua New Guinea 2005–2008.	Cross-sectional Retrospective	HR	21 women died of PRC. Puerperal sepsis complicating unsafe abortion was the most common causes (48%). Contributing factors: rural area, geographical and transport difficulties , non-use of family planning and ANC services	Out of 29 MDs details of eight women were missing
63	Lee, et al., 2012	Ghana	MM in Ghana: a hospital-based review	Cross-sectional. Retrospective	HR	MMR, 1, 004 per 100, 000 LB (95% CI 895.0-1113.2). 71.1% direct, 22.4% were indirect and 6.5% were unclassified. HDP were the leading cause of mortality (26.4%)	A review from a busy tertiary hospital,
64	Surekha, et al., 2012	India	MD review to know the determinants of maternal mortality in a District Hospital of central India	Cross-sectional	HR	12 MDs, MMR of 242.27 per 100,000 LB. Pulmonary embolism was the leading cause of death. Most women died in the postpartum period, 19-29 years age group, were from s rural and illiterate.	
65	Gumanga et al., 2011	Ghana	Trends in MM in Tamale Teaching Hospital, Ghana.	Cross-sectional Retrospective	HR	MMR dropped,1,870 per 100,000 LB to 493 per 100,000 LB in 2010, a fall of nearly 74%.Main cases were sepsis (19.8%) HD (18.6%), haemorrhage (15.8%), unsafe abortion (11.5%), obstructed labour (5.7%), anaemia (8.7%), sickle cell disease (5.7%) and malaria (5.0%). Age range, from 14-48 years; with mean age of 26.5±4.6 years. 50% were aged 20-29 years and about 10% were 14-19 years. Eighteen (13%) from 150 km town.	A teaching hospital
66	Ezenguwi et al. 2013	Nigeria	Investigating MM in a public teaching hospital, Abakaliki, Ebonyi state, Nigeria	Cross-sectional	HR	MMR, 1,359 per 100,000 LB. Haemorrhage, accounted for 23.0%. Majority, unbooked (82.4%) 28.5% died following a C/S, 8.5%, abortion complications, and 10.9% died undelivered. 46.7%, no formal education.	For all mortality cases, no autopsies were done
67	Murthy et al., 2012	Pakistan	MM, a ten year review in a tertiary care set up	Cross-sectional	HR	MMR, 772 per 100,000 LB. Direct MDs constituted 87.7% and indirect, 12.3%. Haemorrhage, leading (43.55%) while eclampsia, 26.99%. 6.13% RU.	The details from labour ward register.

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68	Kazaura et al 2006	Tanzania	MM at Muhimbili National Hospital, Tanzania, 1999-2005: levels, causes and characteristics	Cross-sectional	HR	MMR 512 per 100, 000 LB (95%CI, 465/100 000-559/100 000 live births). Top direct obstetric causes, eclampsia, (23.5%), PPH (23.3%) and anaemia in pregnancy (11.3%)	50% of deaths were occurring in the community
69	Nellissen et al 2013	Tanzania	Maternal near miss and mortality in a rural referral hospital in northern Tanzania: a cross-sectional study	Prospective cross-sectional	HR	MMR, 350 per 100,000 LB (95% CI 243-488)	Single-centre study
70	Begun, 2003	Pakistan	Analysis of MM in a tertiary care hospital to determine causes and preventable factors	Retrospective cross-sectional	HR	MMR, 12.7 per1000, 000 LB OH and HDP were the major causes MDS. 69% were grand multiparas. Education, antenatal booking and socio-economic status were poor. The distance was between 10 and 100 KM	
71	Igwegbe et al. 2011	Nigeria	Improving MM at a university teaching hospital in Nnewi, Nigeria	Retrospective cross-sectional	HR	4,916 live births and 54 MDs, MMR of 1,098 per 100, 000 LB. Pre- clampsia/eclampsia (25.0%), haemorrhage (18.8%) and sepsis (8.3%). Anaemia (12.5%) was the most common indirect cause	Missing case notes
72	Lee et al., 2012	Ghana	MM in Ghana: a hospital-based review.	Retrospective cross-sectional	HR	322 MDs and 32, 069LB, MMR, 1,004 per100, 000 LB (95% CI: 895–1 113). Higher than the WHO's 2005 estimate of Ghana's MMR (560 per 100 000 live births. Direct causes leading	
73	Quresh et al. 2001	Pakistan	MDs in a developing country: a study from the Aga Khan University Hospital, Karachi, Pakistan 1988-1999.	Cross-sectional	HR	MMR, 20 per 100, 000 LB. Causes were eclampsia, puerperal sepsis and pulmonary embolism.42% were primigravidas, 44% died due to direct causes, and sepsis was the most common cause (25%) Indirect causes were responsible for 55.6%	
74	Omo-Aghoja et al. 2010	Nigeria	MM and emergency obstetric care in Benin City, South-south Nigeria	Cross-sectional	HR	MMR, 2,356/100,000 LB. Leading causes, HIV/AIDS (20.2%), eclampsia (12.4%), puerperal sepsis (11.9%), unsafe abortion (9.5%), and postpartum hemorrhage (4.8%). Associated causes Type III delay (61.9%), type I delay (28.6%), type II delay (0%) and 9.5% of the women had no delay. Type III delay was due largely to delayed referral. Lack of blood, oxygen, and necessary equipment in the hospital. And inadequate midwifery staff	
75	Fouzia et. Al., 2012	Pakistan	Trends in MM in tertiary care hospital in Peshawar - Pakistan	Cross-sectional	HR	MMR, 1,017 per 100,000 LB. Hemorrhage was the leading cause - 38 .89%. Lack of seeking ANC was observed.	

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76	Mairig &Sareh 2009	Nigeria	MM at the State Specialist Hospital Bauchi, Northern Nigeria.	Cross-sectional	HR	MMR, 1,732 per 100,000 LB. 81.0% in unbooked. Mean age was 27.8 years. Highest number of MDs was in adolescent mothers. Primigravidas, 28.9%. Direct 79.4% and major causes were eclampsia 31.9%, haemorrhage 19.2% and sepsis 10.4%. Leading Indirect causes anaemia (12.1 %.)	
77	Nwagha et.al., 2010	Nigeria	MM trend in South East Nigeria: less than a decade to the millennium developmental	Cross-sectional	HR	MMR 902.7/100,000 LB. Risk factors include grand multiparty, maternal age of ≥35 years, low socioeconomic status (SES), and unscheduled emergencies. Commonest cause of MD was sepsis (25.8%).	Multi-institutional study
78	Ganyaglo & Hill 2012	Ghana	A 6-year (2004-2009) review of MM at the eastern regional hospital, Koforidua, Ghana.	Cross-sectional	HR	MMR, 957 per 100,000 LB. Main causes of MDs were PPH (22.5%), abortion-related causes (19.3%), HDP (17.8%), and puerperal sepsis (8.9%). Highest number in postpartum	Record books had several omissions
79	Ehassan, 2009	Central Sudan	High MM and stillbirth in the Wad Medani Hospital, Central Sudan, 2003-2007.	Cross-sectional	HR	MMR of 442/100,000 LB. Common causes were septicaemia, obstructed labour and abortion-related sepsis,	
80	Abe &Omo-Aghoja, 2012	Nigeria	MM at the Central Hospital, Benin City Nigeria: a ten year review.	Cross-sectional	HR	MMR, 518 per 100, 000 LB, 30 times higher in unbooked than in booked patients, .60% occurred within 24 hours of admission. Leading causes, sepsis, haemorrhage, obstructed labour and preeclampsia/eclampsia, while the major indirect causes were and anaemia. Low literacy, high poverty levels, extremes of parity and non-utilization of maternity services were associated with maternal mortality	
81	Kullima et.al 2009	Nigeria	Trends in MM in a tertiary institution in Northern Nigeria	Retrospective	HR	MMR was 2,849/100,000 deliveries. Eclampsia consistently remained the leading cause, (46.4%) of MDs, followed by sepsis and PPH contributing 17% and 14.3%, respectively.	Some records not completely filled
82	Mc-Caw-Bnins et.al 2001	Jamaica	Access to care and MM in Jamaican hospitals: 1993-1995	Cross-sectional	HR	The MMR 106.2 per 100, 000 LB. Leading causes of death remained pre-eclampsia/eclampsia and haemorrhage.	95% of deaths were occurred in health facilities.
83	Igberase et.al. 2007	Nigeria	MM in a rural referral hospital in the Niger Delta, Nigeria	Cross-sectional	HR	MMR, 2,232/100, 000 LB. Common causes were puerperal sepsis, abortion complications, pre-eclampsia/eclampsia, obstructed labour, haemorrhage accounting for 33%, 22.6%, 17.4%, 13.0% and 7.8%, respectively. TBA managed some cases	
84	Lema et. al. 2005	Malawi	MM at the Queen Elizabeth Central Teaching Hospital, Blantyre, Malawi	Cross-sectional r	HR	MMR, 1,027.2/100, 000 LB. Common causes, puerperal sepsis (29.4%), post-abortion complications (23.5%), OH (10.6%) and eclampsia (6.4%). Delay in accessing and receiving emergency obstetric care, poor quality services, HIV infection/AIDS and unsafe induced abortion following unwanted pregnancy were identified as contributing factors. Adolescents comprised 20.6%. 56.4% were aged 15-24 years. 43.4%) had parity of 0 or 1. 5	

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85	Kongnyuy et al. 2008	Malawi	Facility-Based MD review In three districts in the central region of Malawi : An analysis of causes and characteristics of MDs	Cross-sectional	HR	65.1% direct and 34.9% indirect. Major causes were PPH (25.6%), postpartum sepsis (16.3%) and HIV/AIDS (16.3%). Factors that contributed to MDs were; inadequate resuscitation (69.8%), lack of obstetric life saving skills (60.5%), inadequate monitoring (55.8%), and initial assessment incomplete (46.5%), and delay in starting treatment (46.5%). Lack of blood for transfusion (20.9%).	Poor quality of data, and difficulty in implementing recommendations
86	Vink et al 2013	Malawi	MD reviews at a rural hospital in Malawi	Cross-sectional retrospective	HR	61 MDs. Most, indirect [58.6%]). Meningitis the most common (n = 13). Most patients experienced a delay in seeking care ([63.8%]), a transport delay [74.1%]), or a delay in receiving adequate care [58.6%]).	Only one private facility involved and no MMR presented
87	Oladapo et al 2007	Nigeria	MD in Sagamu in the new millennium: a facility-based retrospective analysis	Cross-sectional Retrospective	HR	MMR of 2,989.2 per 100, 000 LB. 84.0%, direct. Major causes HDP, (28.0%), haemorrhage (21.3%), and sepsis (20.0%). More MDs after operative deliveries , (27/545 vs. 22/2161; OR, 5.07; 95% CI, 2.77-9.31)	
88	Ona et...al. 2005	Nigeria	MM in health institutions with emergency obstetric care facilities in Enugu State.	Cross-sectional Retrospective	HR	141 MDs and 18, 257 LB, MMR 772 per 100, 000. 51.7% of cases were unemployed, 52.4% were referred from private hospitals. Type 3 delay was the commonest type especially referral delay (46.4%) . Major causes of death were obstetric haemorrhage (19.1%), sepsis (18.0%), prolonged obstructed labour/ruptured uterus (16.9%) and pre-eclampsia/eclampsia (16.9%)	
89	Shah et al 2008	India	Analysis of MM in a small teaching hospital attached to tertiary care hospital (a 10 year review).	Cross sectional Retrospective	HR	MMR was 47/100, 000 LB. Higher number of deaths was recorded in the 25-30 year age group with OR of 1.143. Primigravidas ,greater risk of dying OR 3.059 than multigravidas	Pregnancy-related deaths. Very small hospital with 24 functional beds.
90	Ujah et al . 2005	Nigeria	MM among adolescent women in Jos, North-Central, Nigeria.	Cross-sectional	HR	MMR 25/4,564 deliveries). Main causes unsafe abortion, eclampsia and sepsis. Risk factors were illiteracy, non-utilization of ANC and Hausa/Fulani ethnic group.	Included adolescents only
91	Oyieke et.al 2006	Kenya	Millennium development goal 5: a review of MM at the Kenyatta National Hospital, Nairobi		HR	MMR, 921.5 per 100, 000 LB. Direct obstetric causes (71%) with sepsis, haemorrhage, and hypertension as leading causes. Respiratory tract infections associated with HIV/AIDS infection was the prominent indirect cause. 67.5% MDs in ages 25 and 35	Some records incomplete

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						years and 78.7% were Para 2 or less. -Poor antenatal clinic attendance (28.6%).	
92	Shah et.al., 2009	Pakistan	Socio-demographic characteristics and the three delays of MM	observational study	HR	Projected MMR, 1,650/100,000 LB. Mean age, 28±6.2 years and median parity, 2. 68% were uneducated, 62.5% belonged to lower socioeconomic class and 58% had received no ANC. 94% had more than one delay, with 71%, the first delay, 74%, second delay and 48%, third delay.	
93	Aboyeji et. al . 2007	Nigeria	MM in a Nigerian teaching hospital - a continuing tragedy.	Cross-sectional	HR	MMR was 825 per 100, 000 LB. Common causes included severe pre-eclampsia/eclampsia, (27.8%); haemorrhage, (20.4%) and complications of unsafe abortion (14.8%).	
94	Mbassi, 2011	Cameroon	Use of routinely collected data to assess MM in seven tertiary maternity centers in Cameroon	cross-sectional	HR	11, 014 obstetric complications and 249 MDs were recorded, MMR of 713/100, 000 lower than the national estimate	
95	Tebeu et al, 2007	Cameroon	MM in Marouunia provincial Hospital	Cross-sectional	HR	MMR was 1,266/100,000 live births. CFR was 2.2%.Hemorrhage Leading, 72, % hypertensive disorders, 50, sepsis 35 and ruptured uterus 20.	
96	Airede and Ekele, 2003	Nigeria	Adolescent MM in Sokoto, Nigeria	Cross-sectional	HR	MMR, 4,863/100, 000 LB and 2,151/100, 000 LB in all age groups. Mean age was 17 years. Risk factors included absence of ANC, intrapartum and postpartum care, illiteracy and poverty. Eclampsia and obstructed labour were responsible for 76% of deaths.	
97	Nusarat et al. 2009	Pakistan	Socio-demographic characteristics and the three delays of MM	observational study	HR	MMR, 1650/100,000 LB. Mean age. 28±6.2 years and parity, two. 68%, uneducated, 65 (62.5%), lower socioeconomic class and 60 (58%) no ANC. 94%, more than one delays, with 70 (71%) the first delay, 73 (74%) second delay and 47 (48%) t third delay	
98	Mohammed et al. 2011	Sudan	MM in Kassala State - Eastern Sudan: community-based study using, RAMOS.	retrospective	RAMOS	43.2% deaths of WRA were PRD. MMR, 713.6/ 100,000 LB. Direct causes 58.4%. OH 15.6% obstructed labour, 14.1% and puerperal sepsis, 10.9%.Severe anaemia and acute febrile illness were the major indirect causes of maternal death. Delay of referral, 73.4%, and transportation problems, 54.7%. High illiteracy rate among deceased and their husbands.	

No	Author(s), year	Setting	Title	Study Design	Data source/approach	Major Findings	Comments
99	Walraven et al 2000	Gambia	MM in rural Gambia: levels; causes and contributing factors	Cross-sectional	RAMOS	MMR ranged from 1,005 to 2,362 per 100 000 LB. Direct causes-9. Haemorrhage, 6, early pregnancy2, and obstructed labour, 1. Indirect causes anaemia, hepatitis, and undetermined. Low standards of health care for obstetric referrals, failure to recognize the severity of the problem at the community level, delays in starting the decision-making process to seek health care, were identified	
100101	Songane et al 200	Mozambique	Quality of registration of MDs in Mozambique: a community-based study in rural and urban areas	Prospective surveillance	RAMOS	214, deaths of WRA (15-49 years), 40,MDs. Under registration in health institutions by 86%.	
101	Amarin et.al. 2010	Jordan	National MMR for Jordan 2007-2008	Cross sectional	RAMOS	MMR 19.1 deaths /100 000LB. 56.6% due to haemorrhage, thrombosis and thromboembolism, and sepsis. Avoidable factors were present in 53.9% of women, 52.6% had substandard care, and 31.5% had 3 or fewer antenatal visits.	Triangulated two powerful sources of data
102	Garces et al 2002	Phillipines	A comparison of vital registration and RAMOS in Bukidnon, Philippines, 2008	Cross- sectional	RAMOS	MMR (MMR) of 49 per 100 000 live births. MMR of 209 (95% CI:, 191-226) per 100 000 LB	Registries missed three-quarters of all maternal deaths
103	Jafarey, 2009	Pakistan	Verbal Autopsy of MM in Two Districts of Pakistan - Filling Information Gaps	Cross-sectional	RAMOS	Risk factors were: low socioeconomic status, illiteracy, low-earning jobs, parity, and bad obstetric history. 64% women died in health facilities (private and public). Thirty-three died at home and 13 on the way to hospital	The caretakers, could not document or keep records
104	Oslen, 2000	Tanzania	MM in northern rural Tanzania: assessing the completeness of various information sources	Cross-sectional	RAMOS	MMR was 382 (95%CI, 250–560) per 100,000 LB.20 % underestimation compared to previous data.	Incomplete hospital-based data
105	Zakaria et. al., 2006	Ghana	MM in the Greater Accra region in Ghana: assessing completeness of registration and data quality.	Cross-sectional	RAMOS,	148 MDs and 21,183 live births, MMR of 699/100,000 LB. This ratio is more than six times the officially reported MMR. 92% due to direct obstetric causes and 8% to indirect causes. Under-registration of 18%.	
106	Ghebrehiwet and Morrow, 2006	Eritrea	Determining the Level of MM in Eritrea using RAMOS	Cross-sectional;	RAMOS	MMR of 752 per 100,000 LB and a lifetime risk for maternal mortality of 1 in 28.	Difficulties in matching the numerator with an appropriate denominator for calculating MMR
107	Zakariah et al, 2009	Ghana	RAMOS in Accra, Ghana	Cross-sectional	RAMOS	An underreporting rate of 44%. 81.6% direct MDs and 17.9% indirect and 0.6% non-MDS. OH 32%, pregnancies with abortive outcome, 20.8%, (pre) eclampsia, (14.6%)and puerperal sepsis, 7.3%. indirect cause -sickle cell crisis	No adequate information on number of LB.

No	Author(s), year	Setting	Title	Study Design	Data source/approach	Major Findings	Comments
108	Lozano et.al 2011	The Population Health Metrics Research Consortium data	Performance of InterVA for assigning causes of death to verbal autopsies: multisite validation study using clinical diagnostic gold standards	Cross-sectional	Assesses the performance of interVA PCVA and Simplified Symptom Pattern (SSP)	InterVA performed worse than PCVA, both on an individual and population level. 24.2% for adults, 24.9% for children, and 6.3% for neonates. On a population level, InterVA achieved a cause-specific mortality fraction accuracy of 0.546 for adults, 0.504 for children, and 0.404 for neonates.	Not specific to MDs
109	Midhet 2008	Pakistan	Validating the VA questionnaire for MM in Pakistan	Cross-sectional	To determine level of agreement in cause and category of death assigned by the hospital and the obstetrician	Complete agreement between the hospital and reviewers on direct maternal deaths. However, the agreement was weak in all other cause categories (the kappa test p-value of 0.055).	Specific to MDs
110	Bauni et al. 201	India	Prospective cross-sectional Validated PCVA and the InterVA, hospital cause **of** death **(**HCOD).		Cross-sectional	HCOD, InterVA, and PCVA yielded the same top five underlying causes of adult deaths. The InterVA overestimated tuberculosis as a cause **of** death compared to the HCOD. On the other hand, PCVA overestimated diabetes. Overall, CSMF for the five major cause groups by the InterVA, PCVA, and HCOD were 70%, 65%, and 60%, respectively. PCVA versus HCOD yielded a higher kappa value (kappa = 0.52, 95% confidence interval [CI]: 0.48, 0.54) than the InterVA versus HCOD which yielded a kappa (kappa) value of 0.32 (95% CI: 0.30, 0.38). Overall, (kappa) agreement across the three methods was 0.41 (95% CI: 0.37, 0.48).	Not specific to MD
111	Leitao et al 2014	Low and middle income countries	Comparison of physician-certified VA with computer-coded verbal autopsy for cause of death assignment in hospitalized patients s: systematic review	Systematic review	A systematic review	Moderate Sensitivity of PCVA versus hospital-assigned COD varied widely by cause, but showed consistently high specificity. PCVA and CCVA methods had an overall chance-corrected concordance of about 50% or lower, across all ages and CODs.	
112	Oti and Kyobutungi, 2010	Kenya	VA interpretation: a comparative analysis of the InterVA model versus physician review in determining causes of death in the Nairobi DSS	Cross-sectional	Estimated the level of agreement between Physician review (PR) and Interval both methods using Kappa statistics	The level of agreement between individual causes of death assigned by both methods was only 35% ($\kappa = 0.27$, 95% CI: 0.25 - 0.30).	
113	Mesganaw et.al. 2006	Ethiopia	Assessing a new approach to VA interpretation in a rural Ethiopian community: the InterVA model	Cross-sectional	To determine the cause-specific mortality fraction for each important COD in the community, individual cases	The physicians differentiated between "pneumonia" and "sepsis", while the model used a single category for these conditions.	There were also good rank correlations between COD assigned by the physicians and by the model,

No	Author(s), year	Setting	Title	Study Design	Data source/approach	Major Findings	Comments
114	Dessai et al. 2014	Low and middle developing countries	Performance of four computer-coded verbal autopsy methods for cause of death assignment compared with physician coding	Cross-sectional	Compares InterVA-4 and the King-Lu to PCVA on five data sets.	At the population level, the King-Lu method had the highest average cause-specific mortality fraction accuracy across all five datasets (91%), followed by InterVA-4 (72% across three datasets), open-source random forest (71%) and open-source tariff method (54%). On an individual level, no single method was able to replicate the physician assignment of COD more than about half the time. At the population level, the King-Lu method was the best method the population),	

Appendix 4a: Health facility data extraction form for deaths of women of aged 15-49 years

Date of Extraction (dd-mm-yyyy) ☐☐ ☐☐ ☐☐

Field worker code ☐☐

Facility Name..... Facility code ☐ ☐☐☐

Facility type Hospital Health Centre ☐

Name of ward/Unit ..... Ward/Unit Code ☐☐☐

Name of the register..... Register code ☐☐

Time Extraction started ☐☐☐☐

Address of the Deceased. Name of the Village_____T/A_____Marital Status_____ Level of education_____

Occupation_____Next of kin in Name_____Phone Number if Available_____.

Address_____Religion_____Remarks_____Reported

by_____Phone Number_____

Case ID	In patient No 88=NR	Name of the deceased	Age (yrs) NR= 88	Date and Time of admission or arrival NR= 88	Date and time of death 88=NR		Was the woman pregnant? Did the woman have abortion? Was she recently delivered?	Final Diagnosis	Details Extracted from	Cause of death from case notes or other source	Maternal death Yes=1 No=2 Can't tell=88
							Date of delivery/ termination of pregnancy.		Nurses case Note/ Report ___ Register Book ____		
									Other Specify		

Appendix 4b: Community data extraction form for deaths of WRA (15-49 years)

List all deaths of women of reproductive (15-49 years) from November 2011 to October 2012. Each woman should have her own form. Complete the details below for all the deaths of women aged 15-49, married or not married who usually live in your catchment area and women who were temporarily staying in your village when died. Complete the form for all causes of death. Please complete all columns for each death

(a) Name of informant..... (b) Address of the Informant (Village and TA)……...(c) District……

(c) Position of the village. i. Urban ii. Town iii. Village (d) Occupation of the deceased……. (e) Level of Education of the deceased……..

……..(f) Religion of the deceased……(g) Marital Status of the deceased……(h) Health facility in the catchment area…….(l)Date form Completed ...../...../.....

(J) Completed by and phone number……..

No	1.Name of the deceased	2.Age at death in years (estimate of age if unknown)	3. Complete address of where she lived (usually permanent address and household head)	4.Address of where she was staying, if same as 3 write same	5.Date of death	6.Place of death 1=Own home 2. others home 3. TBA 4. Health Centre 5. Hospital 6 On way to the facility 7. Between health facilities 8.Other specify 9.Dont know	7. If she died at the health facility name of the health facility(leave it blank if she did not die at the hospital)	8.Cause of death (if died of an illness name the illness)	9. Was she pregnant when she died? No=0 Yes=1 Don't know=8	10. Did she die during childbirth? No=0 Yes=1 Don't know=8	11. if no to Q10 did she die within six weeks of pregnancy ending (Miscarriage ,or abortion No=0 Yes=1 Don't know=8	12.Condition at the time of death Delivered =0 Undelivered=1 Don't know=8	Was it a maternal death or not? Yes = 1 No =2 Not sure=3 Don't Know=8
1			Head of Household ..... Village ..... TA..... District	Head of Household ..... Village ..... TA..... District	Day ..... Month ..... Year								

Remarks: ……Reported by……Phone Number…….

Total number of Women of Reproductive Age in your catchment area/villages……

Appendix 4c: Facility record review form

Date of Extraction (dd-mm-yyyy) ☐☐ ☐☐ ☐☐☐☐

Field worker code ☐☐

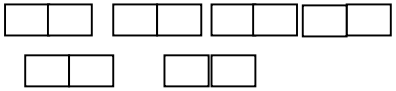
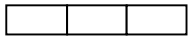
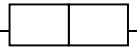
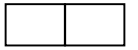
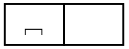
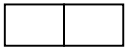
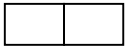
Facility Name ..... **Facility code** ☐☐☐☐

Name of ward/Unit ..... **Ward/Unit Code** ☐☐

Name of the register..... **Register code** ☐☐☐☐

Time Extraction started

No	Questions and filters	Response Categories	Response
	Section 1: identification details		
1	Facility type	Government hospital.....1 Government health centre.....2 Private Hospital.....3 Private health centre.....4	☐
2	First Name Surname		....
3	Folder (In patient) Number	Number Number not recorded=88	
4	Date of last admission that led to death Time of admission	dd-mm-yyyy Not recorded= 88-88-8888 hh.mm Not recorded = 88-88	☐☐ ☐☐ ☐☐☐☐ ☐☐ ☐☐

5	Date of death Time of death	dd-mm-yyyy = 88-88-8888 not recorded hh-mm Not recorded= 88-88	
6	Place of Residence	Name of the Village/Town	.....
7	Traditional authority Code	T A code	
8	Religion	.....	.....
9	Type of resident	1. Urban 2. Rural 3. Don't know	
10	Age	Years	
11	Chief complaint on admission		....
12	Diagnosis on admission (a) Preliminary (b) final	Not recorded=88	 a)..... .....  b)..... .....
13	How many days months or years ago did the last pregnancy end	Not recorded=88 Not applicable=77	Hours  Days  Months  years 
14	Were any of these complications recorded? 1. Prolonged labour 2. Obstructed labour	1=Yes 2=no 7= not applicable 8= not recorded	Prolonged labour.....1 Obstructed labour.....2 Ruptured uterus..... 3 APH.....4

	3. Ruptured uterus 4. APH 5. PPH 6. Preeclampsia 7. Puerperal Sepsis 8. Abnormal foetal presentation 9. Retains placenta 10. Retained products 11. Post abortion	(Tick as many as can apply)	PPH.....5 Preeclampsia..... ..6 Puerperal Sepsis.....7 Abnormal foetal presentation.....8 Retains placenta.....9 Retained products.....10 Post abortion.....11
15	Were any of the following procedure perfumed 1. Caesarean section 2. Hysterectomy 3. Manual removal of placenta 4. Repair of ruptured uterus 5. Removal of retained products 6. Dilatation & curettage 7. Salpingectomy 8. Culdocentesis 9. Posterior colpotomy 10. Laparatomy 11. Other (Specify)	1=Yes 2=no 7= not applicable 8= not recorded (Tick as many as can apply)	caesarean section.....1 Hysterectomy .....2 Manual removal of placenta.....3 Repair of ruptured uterus.....4 Removal of retained products.....5 Dilatation & curettage.....6 Salpingectomy.....7 Culdocentesis.....8 Posterior colpotomy.....9 Laparatomy.....10 Other (Specify.....11
16	Cause of death	8=Not recorded	.....
17	Records indicate woman's pregnancy status	1= Died pregnant 2= Died during delivery 3= Died within 6 weeks of the end of pregnancy (postpartum)	

		4= Died within 6 weeks of the end of pregnancy (post-abortion) 5= Death not pregnancy related 6= Pregnancy – related status unclear	
18	Give brief description of the evidence of this	Post Coded	....
19	Sources of information used a. In patient case notes b. Nurses report book c. Operating theatre records d. Out patient records e. Post mortem records f. Other (specify)	1= Yes 2= No	Sources of information used In patient case notes.....1 Nurses report book.....2 Operating theatre records.....3 Out patient records.....4 Post mortem records.....5 Other (specify.....6
Time extraction completed			
Checked by Supervisor.....			

Appendix 5: Verbal autopsy questionnaire (English version)

Part 1 Questionnaire

ID /CONTROL NUMBER ☐☐☐☐☐☐

SECTION 1: INTERVIEW VISITS

	1	2	3	
Date	_____	_____	_____	☐☐ DAY
Interviewers name	_____			☐☐ H
				2 0 ☐☐ YEAR
Result	☐	☐	☐	

Next Visit Date ☐

total no of visits

Time

1. Completed 2. Not at home 3. Postponed 4. Refused

5 partly completed 6. Not appropriate respondent 7. ~~Other~~ _____

specify

Supervisor

Name _____

Date ☐☐

Place Name _____

Address/directions to household _____

Demographic Information

District _____	District ☐☐
TA _____	TA
Village Name _____	Village Name ☐☐
Household Number _____	Household Number

Reference Person _____

Residential status of Deceased _____ Resident in Enumeration 1

Body Brought home for burial.....2

Home –Coming Sick.....3

QUESTION NO.	QUESTION FILTERS	CODING CATEGORIES	Go to
SECTION 2. BASIC INFORMATION ABOUT THE RESPONDENT			
1	RECORD TIME AT START OF INTERVIEW	HOUR..... ☐☐ MINUTES..... ☐☐	
2	ID of the respondent	..... (name)	
3	What is your relationship to the deceased?	Father.....1 Mother.....2 Wife..... ..... 3 Sibling..... 4 Relative.....5 No relation.....6 Other .....8 (Specify)	
4	Did you live with the deceased in the period leading to her death	Yes.....1 No.....2	
SECTION 3 :INFORMATION OF THE DECEASED			
5	What was the name of the deceased?	Name.....	
6	When was the deceased born Record 9 8 if don't know day or month Record 9 9 9 8 if don't know year	Day..... ☐☐ Month..... ☐☐ Year..... ☐☐☐☐	
7	How old was the deceased when she died	Age in Years..... ☐☐☐	
8	What was his occupation that is what kind of work did she mainly do?	Employed.....1 Business.....2 Casual work.....3 Piece work.....4 Farmer.....5	
9	What was the highest level of formal education the deceased attended?	None.....1 Primary.....2 Secondary.....3 Higher.....4 Don't know.....98	
10	What was her marital status?	Never married.....1	

		Married/living with partner..... . ....2 Widowed..... .....3 Divorced.....4 Separated.....5 Don't know.....98	
11	When did she die? Record 9 8 if don't know day or month Record 9 9 9 8 if don't know year	Day..... ☐☐ Month..... ☐☐ Year..... ☐☐☐	
11	Where did she die?	Hospital.....1 Other facility.....2 Home..... ...3 TBA..... ....4 On the way to the hospital. ....5 Other ....8 (specify) Do'nt know.....98	
SECTION 3 RESPONDENTS ACCOUNT OF ILLNESS/EVENTS LEADING TO DEATH			
12	Cause of death 1 according to respondent		
13	Cause of death 2 according to respondent		
14	What were the signs and symptoms before deaths?		
SECTION 4. HISTORY OF PREVIOUS KNOWN MEDICAL CONDITIONS			
I would like to ask questions concerning previous medical conditions the deceased had if known. Please tell me if the deceased suffered from the following illnesses			
15	Blood Pressure	Yes..... .....1 No.....2 Don't know.....98	
16	Diabetes	Yes.....1 No.....2 Don't know.....98	
17	Asthma	Yes.....1 No.....2 Don't know.....98	
18	Epilepsy	Yes.....1 No.....2 Don't know.....98	
		Yes.....1	

19	Malnutrition	No.....2 Don't know.....98	
20	Cancer	Yes.....1 No.....2 Don't know.....98	 Go to 22 Go to 22
21	Can you specify the type of cancer	Type/site.....	
22	Tuberculosis	Yes.....1 No.....2 Don't know.....98	
23	HIV/AIDS	Yes.....1 No.....2 Don't know.....98	
24	Did she suffer from any medically diagnosed illness	Yes.....1 No.....2 Don't know.....98	 Go to 26 Go to 26
25	Can you specify the illness	Illness.....	
SECTION 5 : HISTORY OF INJURIES			
26	Did she suffer from injury or accident which led to her death	Yes.....1 No.....2 Don't know.....98	 Go to 29 Go to 29
27	What kind of injury or accident did the deceased suffer?	Road traffic accident.....1 Fall.....2 Drowning.....3 Poisoning.....4 Burns.....5 Violence/Assault.....6 Other .....8 (Specify) Don't know.....98	
28	Do you know if the injury was intentionally inflicted by someone else? (explain)	Yes.....1 No.....2 Don't know.....98	
29	Did you think she committed suicide	Yes.....1 No.....2 Don't know.....98	
30		Yes.....1 No.....2	 Go to 32

	Did she suffer from any animal/insect bite that led to her death?	Don't know.....98	Go to 32
31	What type of animal/insect?	Dog.....1 Snake.....2 Insect.....3 Other .....8 (specify) Don't know.....98	
SECTION 6. SYMPTOMS AND SIGNS ASSOCIATED WITH ILLNESS OF WOMEN			
32	Did she have an ulcer or swelling in the breast?	Yes.....1 No.....2 Don't know.....98	 Go to 34 Go to 34
33	For how long did she have an ulcer or swelling in the breast	Days..... ☐☐ Month..... ☐☐ Don't know.....98	
34	Did she have excessive vaginal bleeding during menstrual periods?	Yes.....1 No.....2 Don't know.....98	 Go to 36 Go to 36
35	For how long did s/he have the excessive vaginal bleeding during menstrual periods?	Days..... ☐☐ Month..... ☐☐ Don't know.....98	
36	Did she have vaginal bleeding in between menstrual periods?	Yes.....1 No.....2 Don't know.....98	 Go to 38 Go to 38
37	For how long did she have vaginal bleeding in between menstrual periods?	Days..... ☐☐ Month..... ☐☐ Don't know.....98	
38	Did she have abnormal vaginal discharge	Yes.....1 No.....2 Don't know.....98	 Go to 40 Go to 40

39	For how long did she have abnormal vaginal discharge	Days.....☐☐ Month.....☐☐ Don't know.....98	
40	Did she die during	Pregnancy.....1 During labour and delivery ….....2 After delivery .....3 With abortion.....4 Other causes.... 5	 Go to 41 Go to 64 Go to 78 Go to 91 G0 to 96
SECTION 7 : **DEATHS DURING PREGNANCY: SYMPTOMS AND SIGNS ASSOCIATED WITH PREGNANCY**			
41	Did you say she was pregnant at the time of death?	Yes.....1 No.....2 Don't know.....98	Probe more and go to necessary option as above
42	How long was she pregnant?	Days.....☐☐ Month.....☐☐ Don't know.....98	
43	How many pregnancies had she had, including this one?	☐☐ Pregnancies Don't know.....98	
44	Did she attend antenatal clinics during her last pregnancy?	Yes.....1 No.....2 Don't know.....98	 Go to 50 Go to 50
45	Where did she go for antenatal visits	Hospital.....1 Other health facility.....2 Home..... ..3 Other..... ...8 (specify) Don't know..... 98	
46	Total No of visits (Check card if available)		☐☐
		Yes.....1	

47	Did she first attend antenatal clinic because she had a problem?	No.....2 Don't know.....98	Go to 50 Go to 50
49	What was the problem	Headache.....1 Bleeding.....2 Malaria.....3 Abdominal pains.....4. Vomiting.....5 Contractions.....6 Other .....8 (specify) Don't know.....98	
50	During the last 3 months of pregnancy, did she suffer from any of the following illnesses 1 Vaginal bleeding? 2 Smelly vaginal discharges? 3 Puffy face? 4 Headache? 5 Blurred vision? 6 Convulsions? 7 Febrile illnesses? 8 Severe abdominal pains that was not labour pain? 9 Pallor and shortness of breath (both present)? 10 Did she suffer from any other illness?	Yes No Dk Vaginal bleeding 1 2 8 smelly vaginal discharge 1 2 8 puffy face 1 2 8 headache 1 2 8 blurred vision 1 2 8 convulsion 1 2 8 febrile illness 1 2 8 severe abdominal pain (not labour pain) 1 2 8 pallor/shortness of breath (both) 1 2 8 other ..... (specify)	
51	Did she have any fits before she died?	Yes.....1 No.....2 Don't know.....98	
52	Did (name) have blood pressure before she died?	Yes.....1 No.....2 Don't know.....98	
53	Was she complaining of severe headaches?	Yes.....1 No.....2 Don't know.....98	
54	Did she have any swellings of the legs before she died?	Yes.....1 No.....2 Don't know.....98	

55	Did she have swelling of the face before she died?	Yes.....1 No.....2 Don't know.....98	
57	Did she complain of blurred vision before she died?	Yes.....1 No.....2 Don't know.....98	
58	Did she have oedema of the limbs during pregnancy?	Yes.....1 No.....2 Don't know.....98	
59	Did she have malaria during pregnancy?	Yes.....1 No.....2 Don't know.....98	
60	During her final illness was she bleeding per vagina?	Yes.....1 No.....2 Don't know.....98	
61	Was she in pain while bleeding?	Yes.....1 No.....2 Don't know.....98	
62	Did she have episodes of bleeding during this pregnancy?	Yes.....1 No.....2 Don't know.....98	
63	Did she lose weight?	Yes.....1 No.....2 Don't know.....98	
DEATHS DURING LABOUR AND DELIVERY ONLY			
64	Did she die during labour, but undelivered?	Yes.....1 No.....2 Don't know.....98	
65	How many days after delivery did she die?	Days .....☐☐ Don't know 98	
66	Was there excessive bleeding on the day labour started?	Yes.....1 No.....2 Don't know.....98	
67	Was there excessive bleeding during labour before delivering the baby?	Yes.....1 No.....2 Don't know.....98	
68	Was there excessive bleeding after delivering the baby?	Yes.....1 No.....2 Don't know.....98	

69	Did she have difficult in delivering the placenta?	Yes.....1 No.....2 Don't know.....98	
70	Was she in labour for usually long (more than 24 hours?	Yes.....1 No.....2 Don't know.....98	
71	Was it normal vaginal delivery?	Yes.....1 No.....2 Don't know.....98	Go to 54 Go to 54
72	What type of delivery was it?	Forceps/vacuum.....1 Caesarean section.....2 Other.....8 (specify) Don't know 98	
73	Did she have foul smelling vaginal discharge?	Yes.....1 No.....2 Don't know.....98	
74	Where did she give birth?	Hospital.....1 Other health facility.....2 Home.....3 Other.....8 (specify) Don't know..... 98	
75	Who conducted the delivery?	Doctor.....1 Clinical officer..... 2 Medical assistant.....3. Nurse/midwife.....4 TBA.....5 Relative.....6 Mother by herself.....7 Other.....8 (specify) Don't know.....98	
76	Was the baby alive?	Yes.....1 No.....2 Don't know.....98	
77	What part of the baby came first?	Head .....1 Leg..... 2	

		Hand..... .....3 Cord..... .....4 Other ....8 Don't know.....98	
	DEATHS AFTER DELIVERY ONLY		
78	Did she give birth recently?	Yes.....1 No.....2 Don't know.....98	**Go to 80** **Go to 79** **Go to 79**
79	How long after delivery did she die?	Days..... ☐☐ Month..... ☐☐ Don't know.....98	
80	Was there excessive bleeding after delivery?	Yes.....1 No.....2 Don't know.....98	
81	Were there convulsions after delivery	Yes.....1 No.....2 Don't know.....98	
82	Was there high fever after delivery	Yes.....1 No.....2 Don't know.....98	
83	Did the fever start immediately after delivery or after few days?	Immediately.....1 After few days.....2 Don't know.....98	
84	Did have fowl smelling discharge?	Yes.....1 No.....2 Don't know.....98	
85	Was she yellow at the time of deaths	Yes.....1 No.....2 Don't know.....98	
86	Was she short of breath at the time of death?	Yes.....1 No.....2 Don't know.....98	
87	Was she short of breath when she carried out regular households activities?	Yes.....1 No.....2 Don't know.....98	

88	Did she lose weight during her pregnancy?	Yes.....1 No.....2 Don't know.....98	
89	Did she have diarrhoea during her pregnancy?	Yes.....1 No.....2 Don't know.....98	
90	How long did diarrhoea last?	Days.....1 Weeks.....2 Don't know..... 98	
DEATHS DUE TO ABORTIONS ONLY			
91	Did she experience an abortion recently?	Yes.....1 No.....2 Don't know.....98	 Go to 96 Go to.96
92	Did she die during abortion?	Yes.....1 No.....2 Don't now.....98	
91	How many days before death did she have the abortion?	days..... ☐☐ Don't know.....98	
92	How many months pregnant was she when she had the abortion?	Months..... ☐☐ Don't know 98	
93	Did she have heavy bleeding after the abortion	Yes.....1 No.....2 Don't know.. 98	
94	Did the abortion occur by itself, spontaneously?	Yes.....1 No.....2 Don't know.....98	
95	Did she take medicine to induce?	Yes.....1 No.....2 Don't know.....98	
SIGNS AND SYMPTOMS NOTED DURING THE FINAL ILLNESS (ALL DEATHS)			
96	For how long was she ill before she died?	Days.....1 ☐☐ Months..... 2 ☐☐ Don't know.....98	
97	Had she have any fever?	Yes.....1 No.....2 Don't know.....98	

98	For how long did she have fever	Days.....1 ☐☐ Months..... 2 ☐☐ Don't know.....98	
99	Was the fever continuous or on and off	Continuous.....1 On and off..... 2	
100	Did she have fever only at night	Yes.....1 No.....2 Don't know.....98	
101	Did she have chills ?	Yes.....1 No.....2 Don't know.....98	
102	Did she have a cough?	Yes.....1 No.....2 Don't know..... 98	
103	For how long did she have a cough?	Days.....1 ☐☐ Months..... 2 ☐☐ Don't know.....98	
104	Was the cough severe	Yes.....1 No.....2 Don't know.....98	
115	Was the cough productive with sputum	Yes.....1 No.....2 Don't know.....98	
106	Did she cough out blood?	Yes.....1 No.....2 Don't know..... 98	
107	Did she have night sweats?	Yes.....1 No.....2 Don't know..... 98	
108	Did she have breathlessness	Yes.....1 No.....2 Don't know..... 98	
109	For how long did she have breathlessness	Days.....1 ☐☐ Months..... 2 ☐☐ Don't know.....98	
110	Was she unable to carry out daily routines due to breathlessness	Yes.....1 No.....2	

		Don't know.....98	
111	Was she breathless while lying flat?	Yes.....1 No.....2 Don't know.....98	
Review of Documents To be done after the interview guide			
112	Do you have any health passport or facility records for the deceased	Yes….....1 No….....2 Don't …….....98	
113	Can I see the health passport or facility records (copy any relevant information)	Date of death ☐☐ Month ☐☐ Year ☐☐☐☐	
114	Record the cause of deaths	…..	
115	Record the time at the end of the interview	Hours ☐☐ Minutes ☐☐	
116	Is there anything you want to add		
117	Any questions		

Part 2: Interview Guide

FACTORS THAT LEAD TO DEATH

Tell me about the events /illness that led to the death of (NAME)

Why do you think of that caused the death?

When you noticed the problem before she died and what did you do?

- Did you know where to go?
- Did you seek care
- Who made the decision to seek care

For those who did not seek care

Why did you not seek care?

Probe- transport

Cultural reasons

Never thought about it

For those who sought care

How long did it take you to decide on seeking care? Who made the decision to seek care?

Where did you seek care?

Why did you choose such a place?

How long did it take to arrive where you seek care?

What treatment did you get?

For those who sought care at the facility

How many contacts with the formal health services did you make a month before she died?

How did you travel to the health facility?

How long did it take you to reach the health facility?

Whom did you find/see at the health facility?

How long did it take for a health to come when you did not find any?

What treatment did you receive?

Those who were referred

How did you travel to the referral place?

How long did it take to reach there?

Whom did you find/see at the health facility?

How long did it take for a health worker when you did not find any?

What treatment did you receive?

How many times were you referred?

What delays did you experience when you arrived at the facility?

How can the care are improved to prevent deaths of women

Appendix 6: Underlying causes of maternal deaths assigned by health professionals and the panel of experts (n=86)

No	Case ID	Health facility underlying cause of death (on MDA forms)	ICD–MM code	ICD-MM group Number	Panel of experts cause of death (ICD-MM) on 86 facility based M
1	16	Eclampsia	015.0	2	Eclampsia in labour
2	17	Severe Malaria	098.8	7	Spontaneous abortion with infectio
3	6	Anaemia? Cause	099.0	7	Spontaneous abortion with haemorrhage
4	15	Severe anaemia	099.0	7	Malaria
5	18	Ectopic pregnancy			Undetermined/Unknown
6	22	Puerperal Sepsis	085	4	Puerperal Sepsis
7	12	Anaemia	099.0	7	Undetermined
8	44	Malaria	098.8		Eclampsia in labour
9	70	Meningitis			Meningitis
10	72	Ruptured uterus	071.1	3	Ruptured uterus
11	41	Pre-Eclampsia	014.9	2	Severe pre-eclampsia
12	42	Postpartum haemorrhage	072	3	Postpartum haemorrhage
13	51	HIV Encephalopathy	098.7	7	Puerperal Sepsis
14	67	Malaria	098.8	7	Malaria complicating pregnancy, childbirth, and puerperium
15	30	Malaria	098.8	7	Incomplete abortion with infection
16	35	Anaemia	099.0	7	Postpartum haemorrhage
17	36	Hypovolemic shock	075,1	Morbidity	Postpartum haemorrhage
18	99	Pneumonia	099.5	7	Pulmonary Embolism
19	96	Threatening abortion	00.3	1	HIV complicating pregnancy, childbirth, and puerperium
20	97	Antepartum Haemorrhage	046	3	Antepartum Haemorrhage
21	95	Septic Shock	075.1	Morbidity	Malaria complicating pregnancy, childbirth, and puerperium
22	98	Hypovolemic Shock secondary to ruptured uterus	075.1	Morbidity	RU during labour
23	101	Severe anaemia	O99.0	7	Ruptured uterus during labour
24	91	Puerperal Sepsis	085	4	Puerperal Sepsis
25	92	Postpartum haemorrhage	072.1	3	Ruptured uterus during labour
26	93	Puerperal sepsis	085	4	unspecified maternal infectious and parasitic disease complicating pregnancy, childbirth and the puerperium
27	94	Septic Shock	075.1	Morbidity	Ruptured Uterus during labour
28	100	Retained Placenta	No code	No code	Postpartum haemorrhage due to retained placenta
29	107	Anaemia	099.0	7	Postpartum haemorrhage due to retained placenta
30	115	Haemorrhagic shock due to ruptured uterus	075.1	morbidity	Ruptured during labour
31	113	Eclampsia	015.0	2	Eclampsia in puerperium

32	124	Anaemia	099.0	7	Undetermined/Unknown
33	126	Preeclampsia	014.9	2	Severe pre-eclampsia
34	143	PPH	072.1	3	PPH
35	155	Anaemia	099.0	Morbidity	PPH
36	121	Malaria	098.8	7	Malaria
37	147	Anaemia	099.0	7	Delayed postpartum haemorrhage
38	160	CCF	009.4	7	Puerperal Sepsis
39	166	Malaria	098.8	7	Malaria complicating pregnancy, childbirth, and puerperium
40	179	Severe Anaemia	099.0	7	Undetermined/Unknown
41	181	Pneumonia	099.2	7	Pneumonia complicating pregnancy childbirth, and puerperium
42	182	Postpartum haemorrhage	072.1	3	Postpartum haemorrhage due to retained placenta
43	251	Retained Placenta	No code	No code	Postpartum haemorrhage due to retained placenta
44	252	Severe Anaemia	099.0	7	Postpartum haemorrhage due to retained placenta
45	253	Obstructed Labour	066.9	Morbidity	Pregnancy related Infection after caesarean section
46	254	Puerperal sepsis	085	4	Pregnancy related Infection after caesarean section
47	255	Puerperal Sepsis	085	4	Pregnancy related Infection after caesarean section
48	256	Severe anaemia	099.0	7	incomplete abortion with haemorrh
49	257	Puerperal Sepsis	085	4	Pregnancy related Infection after caesarean section
50	258	anaemia secondary to abortion	099.0	7	SA Incomplete delayed excessive haemorrhage
51	259	Eclampsia	015.0	2	Eclampsia in puerperium
52	261	Malaria in pregnancy	098.8	7	Malaria complicating pregnancy, childbirth, and puerperium
53 **54**	260 229	Puerperal Sepsis Severe Anaemia	085 099.0	4 7	Puerperal Sepsis HIV complicating pregnancy, childbirth, and puerperium
55	239	Congestive cardiac failure	099.4	7	Eclampsia in Pregnancy
56	240	Sepsis	085	4	SA Incomplete infection
57	241	Ruptured uterus	071.1	3	Ruptured uterus during labour
58	242	Severe anaemia secondary to malaria	099.1	7	Malaria complicating pregnancy, childbirth, and puerperium
59	243	Ruptured uterus	071.1	3	Ruptured uterus
60	244	Eclampsia	015.1	2	Eclampsia in puerperium
61	245	ruptured uterus	071.1	3	Ruptured uterus during labour
62	247	Abortion	003.1	1	Incomplete abortion with haemorrh
63	248	Hypovolemic shock secondary to PPH	075.1	Morbidity	Postpartum Haemorrhage
64	249	?PTB ?Pneumonia	098.0, 098.8	7,7	Pneumonia complicating pregnancy childbirth, and puerperium
65	269	Complications of Anaesthesia	074	6	Complications of anaesthesia during labour and delivery
66	296	eclampsia	015.0	2	Eclampsia in puerperium
67	298	Hypovolemic shock secondary to PPH	075.1	morbidity	Puerperal Sepsis

68	299	Ruptured Uterus - Hypovolemic Shock	071.1, 075.1	3 &morbidity	Ruptured uterus during labour
69	300	Ruptured uterus	071.1	3	Raptured uterus during labour
70	301	Hypovolemic Shock secondary to retained placenta	075.1	Morbidity	Retained placenta
71	326	Malaria	098.8	7	Malaria complicating pregnancy, childbirth, and puerperium 098.8
72	327	Haemorrhagic shock sec to Cervical tear	075.5	morbidity	Postpartum Haemorrhage
73	328	Severe Anaemia secondary to ruptured uterus	099.0	7	Raptured uterus during labour
74	329	Incomplete abortion	003.1	1	Spontaneous abortion with infection
75	372	Bowel Obstruction	?	?	Undetermined/Unknown
76	332	Severe Anaemia	099.0	7	Antepartum haemorrhage
77	334	Amniotic Embolism	088.1	5	Amniotic Embolism
78	336	Antepartum haemorrhage	046	3	Incomplete abortion with haemorrh
79	337	Postpartum haemorrhage	072.1	3	Postpartum Haemorrhage
80	338	Anaemia	099.0	7	TB complicating pregnancy, childb and puerperium
81	370	HIV encephalopathy	098.7	7	Puerperal Sepsis
82	371	Haemolytic anaemia	099.0	7	Puerperal Sepsis
83	376	Abortion	003.0	1	SA Incomplete infection
84	412	Septic shock	075.1	morbidity	Pregnancy related Infection after caesarean section Obstetrical haemorrhage due to placenta abrapt
85	414	Postpartum haemorrhage	072.1	3	PPH
86	415	Severe malaria due to anaemia	098.8	7	Incomplete abortion with haemorrh

Appendix 7: Liverpool School of Tropical Medicine Ethics

LSTM
LIVERPOOL SCHOOL
OF TROPICAL MEDICINE

Pembroke Place,
Liverpool, L3 5QA, UK
Tel: +44 (0)151 705 3100
Fax: +44 (0)151 705 3370

www.liv.ac.uk/lstm

Florence Mgawadere
Liverpool School of Tropical Medicine
Pembroke Place
Liverpool
L3 5QA

Wednesday, 31 August 2011

Dear Florence Mgawadere

Re: Research Protocol (11.76) Estimating Maternal Mortality in rural Malawi: Reproductive Age Mortality Studies (RAMOS)

Thank you for your letter dated 16 August 2011 responding to the points raised by the Research Ethics Committee. The protocol now has formal ethical approval from the Chair of LSTM Research Ethics Committee.

The approval is for a fixed period of three years, renewable annually thereafter. The committee may suspend or withdraw ethical approval at any time if appropriate.

Approval is conditional upon:

- Submission of ethical approval from other ethics committees.
- Notification of all amendments to the protocol for approval before implementation.
- Notification of when the project actually starts.
- Provision of an annual update to the Committee. Failure to do so could result in suspension of the study without further notice.
- Reporting of all severe unexpected Adverse Events to the Committee
- Reporting of new information relevant to patient safety to the Committee
- Provision of Data Monitoring Committee reports (if applicable) to the Committee

Failure to comply with these requirements will result in withdrawal of approval. The Committee would also like to receive copies of the final report once the study is completed.

Yours sincerely

Prof David Lalloo
Co - Chair, Research Ethics Committee

cc: Adetoro Adegoke and Nynke van den Broek

Appendix 8: College of Medicine Ethics Approval, Malawi

UNIVERSITY OF MALAWI

Principal

K.M Maleta, MBBS PhD

Our Ref.:

Your Ref.:

College of Medicine
Private Bag 360
Chichiri
Blantyre 3
Malawi

Telephone: 01 877 245
01 877 291
Fax: 01 874 700

Email: comrec@medcol.mw

3 July 2011

Mrs. Florence Mgawadere

Kamuzu College of Nursing

P/Bag 1

LILONGWE

Dear Mrs. Mgawadere

RE: P.06/11/1087 – Estimating Maternal Mortality in rural Malawi: Reproductive Age Studies (RAMOS)

I write to inform you that COMREC reviewed your proposal mentioned above, which you submitted at its meeting on Wednesday, June 29, 2011. I am pleased to inform you that your proposal was **approved.**

As you proceed with the implementation of your study we would like you to take note that all requirements by the college are followed as indicated on the attached page.

Yours Sincerely,

Prof. J. Mfutso-Bengo
CHAIRMAN - COMREC

JMB/lmt

Appendix 9: Permission to conduct a pilot study in Machinga district

Tel: (265) 01542 035
Fax: (265) 01 542 446

All Communications to be addressed to:
The District Health Officer

The District Health Officer
Machinga District Hospital
P. O. Box 44
LIWONDE

25th October, 2011

Our Ref. No MDH/ADM/101

Florence Mgawadere
Kamuzu College of Nursing
Private Bag 1
LILONGWE

Dear Sir,

PERMISSION TO CARRY OUT A PILOT STUDY AT MACHINGA DISTRICT HOSPITAL AND SOME THALTH CENTRES

Reference is made to your letter dated 5th October, 2011 on the above subject.

I would like to inform you that your request for pilot study at this hospital has been approved.

Yours faithfully,

E.A. Mpheta
For: **DISTRICT HEALTH OFFICER**

Appendix 10: Mangochi District Health Office permission letter

Telephone: 01 594 344/716
Fax : 01 594 292
e-mail : mangochi-hmis@malawi.net

All correspondence should be addressed to
The District Health Officer

In reply please quote Ref. No .....

MINISTRY OF HEALTH
MANGOCHI DISTRICT Hospital
P.O. BOX 42
MANGOCHI.

4th May, 2011

Mrs. Florence Mgawadere,
Kamuzu College of Nursing,
Private Bag 1,
LILONGWE

Phone: 0888340634
Email: Florencemvula@kcn.unima.mw

Dear Mrs. F. Mgawadere,

RE: REQUEST TO CONDUCT A STUDY "ESTIMATING MATERNAL MORTALITY IN RURAL MALAWI: USING REPRODUCTIVE AGE MORTALITY STUDIES (RAMOS)" AT MANGOCHI DISTRICT HOSPITAL AND ALL GOVERNMENT HEALTH CENTRES IN MANGOCHI

I, on behalf of the management of Mangochi District Health Office, would like to inform you that you have been granted permission to conduct your study in the district.

It is our hope that the results of this study will be shared with the management of Mangochi District Health Office.

Sincerely,

Dr. Saulos Nyirenda
DISTRICT HEALTH OFFICER

Appendix 11: Mangochi District Commissioners permission letter

Telephone: +265 (0) 1 594 200
Fax: +265 (0) 1 593 947
All communications should be addressed to:
The District Commissioner

In reply please quote No Ref:
MANGOCHI DISTRICT COUNCIL
PRIVATE BAG 138,
MANGOCHI.
MALAWI.

Ref. No. 4/20/Vol. iv/

4th May 2011.

TO WHOM IT MAY CONCERN

LETTER OF INTRODUCTION FLORENCE NGAWADERE

The bearer of this letter is Mrs Florence Mgawadere, a lecturer at the Kamuzu college of Nursing in the department of Community and Mental Health. She is currently per suing her PhD at the Liver pool school of tropical medicine in the United Kingdom. She is doing a study on maternal mortality in Mangochi District. She will therefore be collecting information and data related to her case study. She will be collecting the data from now onwards. Let us provide her with all relevant information. In case of anything please contact the undersigned on 0888 890 408.

G. B. Shaibu
for: District Commissioner

DISTRICT COMMISSIONER
MANGOCHI DISTRICT COUNCIL
04 MAY 2011
P/BAG 138, MANGOCHI
MALAWI (2)

Appendix 12: Translators Agreement form

This Agreement is made between Florence Mgawadere a student of Liverpool School of Tropical Medicine (Researcher) and ..... (Translator) of .....

Mr/Mrs/Ms ..... has been invited to work as Translator in a study in Malawi which aims to estimate maternal mortality in Mangochi district. In this position the Translator will have access to confidential research data and material, including consent forms. This information must be kept confidential at all times. This includes personal details, identity and any information disclosed during the research and analysis.

1. Services to be performed

The Translator agrees to perform the following services:

Accompanying the researcher for a period of one year and translate between the researcher and participants in the Research.

Translation of written text and documentation to meet the requirements and standard idioms of the language used in Mangochi in Malawi

The Research will, as far as possible, be carried out within normal working hours, at time and place of convenience of the participants. However, if needed the Translator may be expected to assist during weekends and outside working hours, if participants may require so.

For this service the Translator will receive a financial reimbursement of MK.....

2. Terms of agreement

This agreement becomes effective when signed by both parties and the terms of agreement shall then be binding on both parties.

3. Intellectual property ownership

The Translator assigns to the Researcher all patent, copyright and trade secret rights in anything created or developed by the Translator for the Researcher under this agreement. This assignment is conditional upon full payment of the reimbursement due to the Translator under this agreement.

4. Confidentiality

During the term of this agreement and for 3 years afterwards, the Translator will use reasonable care to prevent unauthorized use or dissemination of confidential information. Reasonable care means at least the same degree of care the Translator uses to protect its own confidential information from unauthorized disclosure.

Statement (please sign): I agree that in my capacity as Translator I will maintain privacy to ensure that the confidentiality of all data is maintained.

Signed by the Translator		**Signed by the Researcher**	
Signature		**Signature**	
Name		**Name**	
Date		**Date**	

Appendix 13: Participant information sheet

My name is .....You are being invited to take part in a research study. Before you decide whether to take participate, it is important for you to understand why the research is being done and what it will involve. I will read the information to you regarding the study. I will tell you about the purpose of the study and what will happen if you decide to take part.

What is the purpose of the study?

The purpose of the study is to help us estimate the levels and causes maternal death. We aim to visit several hospitals and villages concerning women deaths. This information will be used to come up with strategies to prevent deaths of pregnant women in our district and in Malawi

Why have you been chosen?

You have been chosen because you are one/among the people who cared for NAME before she died. We want to discuss on circumstances which lead to the deaths so that such deaths should be prevented in future

Do you have to take part?

No. It is up to you to make a choice as to whether to take part in the study or not. If you choose to take part, you will be asked to give your consent by signing or thumb printing a consent form.

What will happen to you if you take part?

If you chose to participate in this study, you will be asked to answer a number of questions on concerning the death. This will take place within your home in a private area where other outsiders will not be able to hear the discussion. You do not have to answer any questions that you do not feel comfortable talking about and you may stop the interview at any time. The discussion will last approximately one and half hour. If you feel upset/distressed or unwell during the interview, we will stop .If you would like to talk to someone to get advice, we will arrange for you to see one of the counsellors. They are available to discuss your concerns and any other decisions you would want to make arising from the interview

What are the possible benefits of taking part?

There might be some benefits of taking part in this study. If we identify the causes we will find measures to prevent such situations to other women in future. Even if this is not the case, your taking part should have future benefits. The results will be used to inform government programmes with a view to improving health services and ensuring that women are treated properly when they are pregnant.

What are the possible risks for you taking part?

There are no known risks associated with this study. However, if you feel uncomfortable at any time during the discussion, the discussion stopped.

What if there is a problem?

If any time you have questions or problems related to this study, you may contact me, or Mrs. Mrs Florence Mgawadere (see contact number at the end) the Principal Investigator. I will try to resolve the problem in the first instance. If you remain unhappy and wish to complain formally, or if the problem relates directly to me or the principal investigator. (see contact number at the end).

Will my taking part in the study be kept confidential?

Yes. Only the researchers, me and the Principal Investigator (Mrs Florence Mgawadere) and her supervisors will have access to the information that you have given us and all the study documents containing your information will be kept under key and lock. All your personal information will be kept confidential. Consent forms will be stored in a locked cabinet and will only be accessible to the researcher. A study number will be used on the questionnaire instead of your name and this number will only be known to the researcher. Nobody from outside will be able to link the number to your identity. Data will be put onto a computer but only the researcher will know the password to start the computer. None of the data on the computer will have your name on it.

What will happen if you do not want to carry on with the study?

You are free to withdraw at any time during the study without giving reasons. A decision to withdraw at any time, or a decision not to take part, will not affect any future treatment or care you may require.

What will happen to the results of the research study?

This study is being undertaken as a higher degree (PhD) by Mrs Florence Mgawadere University of Liverpool in UK. The results will be presented in a thesis. In addition, the results may be published and presented at conferences. They will be used to come up with strategies of reducing maternal mortality.

Who is organizing and funding the research?

The government of Malawi has paid for the principal Investigator to study in England. She is being supervised by Dr Nynke van Den Broek (University of Liverpool, UK), Dr Margozata Chalupowski (University of Liverpool, UK), and Dr Abgail Kazembe (University of Malawi, Malawi).

Who has reviewed the study?

This study has been reviewed by Liverpool School of Tropical Medicine Research and Ethics committee, Kamuzu College of Nursing Research and Publications committee and College of Medicine Research and Ethics committee and has been given ethical approval to conduct the research.

Please keep this information sheet and should you wish to take part, you will also be given a copy of the consent form.

Thank you very much for taking time to read/listen to the information.

Appendix 14: Consent form

CONFIDENTIAL

Participant Identification Number

Please put an initial the box provided

1. I confirm I have read and understood the information sheet dated..... ..... for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that participation in this study is voluntary and I am free to withdraw consent at any time, without giving a reason, without any penalties. ☐
3. I understand that data collected during the study, may be looked at by individuals from LSTM and from regulatory authorities. I give permission for these individuals to have access to my records. ☐
4. I hereby declare that I have not been subjected to any form of coercion in giving this consent ☐
5. I agree / do NOT agree to the data about me collected in this study being stored for further use in the future (delete if not applicable) ☐
6. I voluntary agree to take part in this study. ☐

Signing this declaration does not affect your right to decline to take part in any future study.

Name of participant	Date	Signature
Name of person taking Consent	Date	Signature/Finger Print

When complete: 1 copy for participant; 1 copy (original) for research file.

Lead Researcher: Mrs Florence Mgawadere, Kamuzu College of Nursing, Private Bag 1,

Lilongwe, Malawi. Tel: 265 888340634 Email:florencemvula@kcn.unima.mw