Maternal Death Surveillance and Response in Sudan: an evidence-based, context-specific optimisation to improve maternal care.

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Abstract

Background: Maternal Death Review [MDR] and Maternal Death Surveillance and Response [MDSR] are a compilation of approaches such as verbal autopsy and confidential enquiries. They aim to identify, investigate, and derive lessons from cases of maternal deaths to help prevent future deaths. Prevention efforts or responses can take the form of targeted programmes or policies. In Sudan, MDR/MDSR have been in place for over a decade. However, capturing maternal deaths in the community, which is the first step in reviewing deaths, has consistently been reported as a major challenge. Without including these deaths, efforts to substantially reduce maternal mortality may remain futile because, in Sudan, most births occur at home.

Objectives: The thesis aims to identify means to improve the MDSR in Sudan and include the perspective of midwives. To achieve this, the following objectives were developed: to review the literature on MDR and identify reviews that could be modelled to optimise reviews in Sudan; to examine trends in the utilisation of skilled birth attendants to identify key providers that should be included in MDSR; to examine the correlation between maternal mortality ratio [MMR] and birth attendants and other indicators to aid prioritisation of providers to include in MDSR; to describe the organisation of community providers to help understand the maternal health care context; to describe and evaluate the current MDSR; to identify barriers to the inclusion of community providers using an interprofessional collaborative framework for MDSR; and to make recommendations for improvements of MDSR and inclusion of midwives.

Methods: Four separate studies were carried out. A comprehensive systematic review of published and grey literature was carried out and a qualitative narrative was reported; a trend analysis using three consecutive Sudan household surveys [SHHS] with multivariable logistic regression used for analysis; an ecological study that used non-parametric rank correlation measures to investigate the relationship between health and other indicators with MMR using

state-level indicators; and a qualitative study using semi-structured interviews with 54 maternal health providers and other officials and analysed using thematic content analysis.

Findings: The systematic review identified that MDRs were implemented worldwide, but no suitable MDR was identified for use in Sudan. Therefore, a logic model was developed to guide the optimisation of MDSR. Analysis of the latest SHHS showed that village and community midwives [trained birth attendants] attended nearly half of all births [55.5%], followed by doctors, health visitors, and nurse-midwives [skilled birth attendants] [22.8%], and the remainder [21.7%] were not attended by a health provider. Between 2006 and 2014, a downward trend was observed in the presence of a skilled birth attendance [Odds ratio 0.46, p=<0.0001] while an upward trend was observed for trained birth attendance [Odds ratio 2.2, p= <0.0001]. The ecological analysis showed that, at state-level, higher levels of facility birth [rho -0.49, p=0.04] and of skilled birth attendance [rho -0.57, *p*=0.01] were correlated with lower MMR but not for births attended by trained providers [rho 0.16 *p*=0.51]. The semi-structured interviews revealed that there are eight types of midwives in Sudan. The structure of MDSR facilitated its activities at health facilities but not in the community. Several barriers to the inclusion of midwives into MDSR were identified: the current state of midwifery, such as lack of harmonisation and standardisation of the profession and midwives' negative interactions with the medical system; structural barriers relating to the organisation and conduct of MDSR, such as reliance on individual doctors; and inter-professional barriers such as lack of collaboration between midwives and doctors.

Conclusion: Four interlinked recommendations are made to improve MDSR and to include midwives: [1] to invest in the development of an autonomous midwifery profession; [2] to promote early inter-professional learning and collaborative practice between maternal health providers; [3] to strengthen midwifery and other MDSR inputs, and [4] to review maternal health care provided by all practitioners in cases of deaths using provider-based reviews.

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Abbreviations

AHS	Academy of Health Sciences
ANC	Antenatal Care
BBC	British Broadcasting Corporation
CBS	Central Bureau of Statistics
CDC	Centre for Disease Control
CEDAW	Convention of the Elimination of All Forms of Discrimination Against Women
CEMD	Confidential enquiry into maternal deaths
CHW	Community health worker
CRVS	Civil registrations and vital statistics
EmOC	Emergency Obstetric Care
EPOC	The Cochrane Effective Practice and Organisation of Care Review Group
FFC	Forces for Freedom and Change
FGM/C	Female Genital Mutilation/ Cutting
FIGO	The International Federation of Gynaecology and Obstetrics
FMoH	Federal Ministry of Health
GDP	Gross domestic product
HIS	Health Information System
HIV	Human Immunodeficiency Virus
ICD	International classification of diseases
ICM	International Confederation of Midwives
IPL	Inter-professional Learning
LMIC	Low- and middle- income country
MDG	Millennium Development Goals
MDR	Maternal death review
MDSR	Maternal Death Surveillance and Response
MICS	Multiple Indicator Cluster Survey
MMR	Maternal Mortality Ratio
MMRate	Maternal Mortality Rate
NGO	Non-Governmental Organisation
O&G	Obstetrics and Gynaecology
OSOP	One sheet of paper
PAHO	Pan American Health Organisation
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PROSPERO	The international prospective register of systematic reviews
RAMOS	Reproductive Age Mortality Studies
RCT	Randomised controlled trial
RH	Reproductive Health
SBA	Skilled Birth attendants
SHHS	Sudan Household Survey
SMSB	Sudan Medical Specialisation Board
TBA	Traditional Birth attendants
TFR	Total fertility rate
TMC	Transitional Military Council
UI	Uncertainty intervals
UN	United Nations
UNFPA	The United Nations Population Fund
UNHCR	United Nations High Commissioner for refugees
UNICEF	The United Nations Children Fund
USAID	United States Agency for International Development
VA	Verbal autopsy
WFP	World Food Programme
WHO	World Health Organization

1 Introduction

1.1 Country Overview

1.1.1 Background

The Republic of Sudan is located in northeast Africa, occupying an area of 1.88 million square kilometres. It has 6 regions and 18 states- shown in Figure 1. Sudan is considered a lower middle income country with nearly half of its population living below the poverty line (CBS, 2016). The country has been embroiled in prolonged conflict since its independence: the first [1955-1972] and the second [1983-2005] civil wars between the Northern and the Southern states ended when a peace agreement was reached in 2005 (Malwal, 2015). Under its terms, the Southern states seceded, forming the Republic of South Sudan in 2011 (Malwal, 2015). In the Darfur regions, armed conflict started in 2003 that has since subsided but many of its parts remain insurgency prone and politically unstable (World Bank, 2019, Dina Smith, 2007).



Northern region: *1 Northern, 2 River Nile;* ***Eastern region:*** *3 Red Sea, 4 Kassala, 5 Al Qadarif;* ***Khartoum region:*** *6 Khartoum- the Capital;* ***Central region:*** *7 Al Jazirah, 8 White Nile, 9 Sennar, 10 Blue Nile;* ***Kordofan region:*** *11 North Kordofan, 12 South Kordofan, 13 West Kordofan;* ***Darfur region:*** *14 North Darfur, 15 East Darfur, 16 South Darfur, 17 Central Darfur, 18 West Darfur.*

Figure 1: States and Regions of Sudan.

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The secession of South Sudan led to the loss of most of the government's revenue, halting economic growth and contributing to double-digit inflation (Werr, 2020). A subsequent and gradual rise in prices of fuel and food triggered widespread protests that started in December 2018 (World Bank, 2019). Pressured by the protests, a Transitional Military Council [TMC] removed President Bashir from power in April 2019 ending his 30 year rule (International Crisis Group, 2019). After a tumultuous period, an opposition coalition named the Forces for Freedom and Change [FFC] and the TMC signed a new constitutional declaration in August 2019 paving the way for a new political era in Sudan (International Crisis Group, 2019).

The transitional government has since taken major steps to improve the situation of women. For example, some discriminatory laws, such as the Public Order Law that regulated how women can dress and behave in public were repealed (BBC, 2019a); Female Genital Mutilation/ Cutting was banned (Burke, 2020); and the 1979 Convention of the Elimination of All Forms of Discrimination Against Women [CEDAW] was ratified (Mohiedeen, 2021).

1.1.2 Population and Demographics

In 2018, the total population was estimated to be 39 million, with ten million women between 15 and 49 years old (CBS, 2018). Children less than 5 years of age represented 13.9% of the population and those less than 25 years of age represented 56% of the population. The life expectancy was 67 years for women and 63 years for men (CBS, 2018). Estimates regarding the number of pregnancies were not available from the Central Bureau of Statistics; however, the state of the world's midwifery reports estimates it have been1.8 million pregnancies in 2012 (Ten Hoope Bender et al., 2014). The population is unevenly distributed across the country: two-thirds live in rural areas while the capital, Khartoum, hosts 20% of the population but accounts for just 1% of the land (CBS, 2018, National Centre for Health Information, 2019). Sudan hosts over 1.1 million refugees and asylum-seekers. The majority come from South Sudan [77%], followed by Eritrea [11%], Syria [8%], and others (UNHCR, 2019).

1.1.3 Health care System

Sudan has a decentralised health care system. Its administration and management services are organised in three tiers, these are:

- **The Federal Ministry of Health [FMoH]:** that has the overall stewardship role, and is responsible for policymaking, strategic planning, and formulation of guidelines,
- **State Ministries of Health [MoH]:** these are responsible for the organisation of health services, the implementation of health policies and programmes, and the provision of financial and technical support to the localities, and
- **Primary health care localities** are responsible for the provision and management of health care services (FMoH, 2016).

In addition to health services provided through the Ministry of Health, other governmental and non-governmental bodies provide health services to a considerable portion of the population. These include the military, the police, civil society organisations, philanthropic bodies, private health care providers and non-governmental organisations (FMoH, 2016, NCHI, 2019). Regardless of the organising body, all providers are governed by the regulations and legalisations set by FMoH and the MoH in the state where they operate.

Sudan is estimated to spend between 1.4 – 6.5 % of its GDP on health. However, the majority [70%] of the total expenditure is borne directly by patients (FMoH, 2016, Ebaidalla and Ali, 2019, WHO, 2017). Health expenditure pushes a considerable portion of Sudanese households into poverty (Ebaidalla and Ali, 2019). Although health insurance schemes coverage is expanding, it remains limited to 37% of the population. The coverage of population by health facilities is 86% with great disparity between states (FMoH, 2016).

Regarding health care providers, there are 0.3 doctors and 0.8 nurses and midwives per 1,000 population (NCHI, 2019, Trading Economics, 2016). The country, thus, faces a critical shortage in health workforce- WHO's benchmark being 2.28 doctors, nurses, and midwives

per 1,000 population (WHO, 2006). The distribution of health workers is uneven, as the majority work in the urban areas, and at the secondary or tertiary levels of care. Most of the health care providers work in the public sector with 9.3% working exclusively for the private sector. Migration of the health workforce, namely doctors, is common (FMoH, 2016).

The Health Information System follows a bottom-up approach. Primary health care centres are required to collect data on services provided, and to send these data to the state Ministry of Health where it is merged and then sent to the FMoH (FMoH, 2016). Although efforts have begun to digitalise the health information system in Sudan, it is still paper-based (El-Nour et al., 2016).

1.2 Maternal Health

1.2.1 Maternal health indicators

Several indicators are used to globally by UN organisations and professional bodies to monitor maternal health, such as fertility rates, contraceptive prevalence rate, antenatal care coverage, skilled birth attendance, emergency obstetric care, and maternal mortality ratio (WHO, 2012b). Table 1 compares selected indicators for Sudan, the African region, and the world.

In Sudan, fertility measured by the total fertility rate [TFR], has dropped from 7.1 children per woman in 1973 to 5.2 children per woman in 2014 (CBS and UNICEF, 2016, Department of Statistics, 1991). It is more than twice the global average of 2.4 children per woman, and more than the average of the African continent of 4.6 (UN, 2015). This drop in fertility rates has occurred despite limited use of contraception methods as seen by the low contraceptives prevalence rate of 12%, which is a fifth of the global rate (CBS and UNICEF, 2016). These low rates could reflect women's unmet need for contraception, which is defined as women who are fecund and sexually active but are not using any method of contraception, and report not wanting any more children or wanting to delay the next child. According to the last household survey, over a quarter of Sudanese women who are married and want contraception have no access to it. On the other hand, antenatal coverage in Sudan is relatively high and is comparable to regional and global levels. Nearly four-fifth of women reported at least one antenatal care [ANC] visit and half of those received four ANC visits as per previous WHO recommendations (WHO, 2016d).

The last two indicators: access to a skilled birth attendant [SBA] and maternal mortality ratio [MMR] are discussed in more details in the next sections. MMR was chosen as it is the key indicators used by UN agencies to monitor the global progress towards reducing preventable maternal death and is reflected in target 3.1 of SDGs, which is to reduce MMR to less than 70 per 100,000 live births (WHO, 2018). Skilled birth attendance was chosen for

several reasons: first, it is recommended by WHO as a key strategy to reduce MMR; secondly, the Sudanese government has prioritised investing on SBA as part of universal health coverage and its commitment to reduce preventable maternal deaths; and lastly, due to availability of data on SBA for Sudan as collected by MICS – see chapter 3.

Table 1: Selected maternal health indicators in Sudan, Sub-Saharan Africa, and the world.

Indicator	**Sudan**	**Sub-Saharan Africa**	**The world**
Maternal mortality ratio and 80% uncertainty interval, maternal deaths per 100,000 live births [a]	295 [207-409]	542 [498-649]	211 [199-243]
Overall reduction in MMR between 2000 and 2017, % [a]	56.0	39.0	38.4
Lifetime risk of Maternal death [a]	1 in 75	1 in 38	1 in 190
Total fertility rate, births per woman [b]	5.2	4.6	2.4
Adolescent fertility rate, births per 1,000 women ages 15-19 [c]	87	100	42
Contraceptive prevalence, % [c]	12	31	60
Unmet need for contraception, % [c]	27	23	-
Antenatal care coverage, % [c]	79	82	87
Skilled birth attendance, % [c]	78	61	81
Literacy rate of females ages 15 and above, % [c]	61	59	83
Prevalence of females [15-49] with Female Genital Mutilation/ Cutting [c]	87	-	-

Percentages rounded to the nearest number.
a Trends in maternal mortality 2000-2017 (WHO, 2019)
b World fertility patterns (UN, 2015).
c Multiple indicator cluster survey, data collected for the years 2012 and 2013 (CBS and UNICEF, 2016)

1.2.2 Skilled birth attendance

A joint statement by the WHO and other professional and developmental organisations defined a Skilled birth attendant [SBA] as *"an accredited health professional such as a midwife, doctor or nurse who has been educated and trained to proficiency in the skills needed to manage normal [uncomplicated] pregnancies, childbirth and the immediate postnatal period, and in identification, management and referral of complications in women and newborns"* (WHO, 2004b, WHO, 2018).

SBA are expected to perform basic Emergency Obstetric Care [EmOC] that involves seven signal functions: administering parenteral antibiotics, administering uterotonic drugs, administering anticonvulsants, manually removing the placenta, removing retained products, performing assisted vaginal delivery, and performing basic neonatal resuscitation. Additionally, carrying out blood transfusion and performing Caesarean sections are two advanced EmOC skills that are expected from select skilled providers working in facilities. Both the advanced and basic EmOC skills make-up the Comprehensive EmOC functions (Bailey et al., 2009).

In Sudan, most births take place at home. However, most of these births were reported to be attended by SBA (CBS and UNICEF, 2016). This is not common in other African countries as shown by data from the Multiple Indicator Cluster Surveys carried out by UNICEF. Data on SBA and institutional birth are available for thirty-four countries, and the figures show great overlap [Table 2]. Sudan and Somalia are exceptions to this, there the proportion of institutional births is small when compared with the overall proportion of SBA, suggesting that most skilled care at birth occurs outside of health facilities/ institutions.

Table 2: Skilled birth attendance and institutional delivery, along with the difference between them, for countries in Sub-Saharan Africa using data from the Multiple Indicator Cluster Survey [MICS].

African Region/ Country	Latest Round	Year	Skilled Attendant at Delivery [%]	Institutional Delivery [%]	Difference in proportions [%]
Northern [a]					
Algeria	MICS 4	2013	97	96.8	0.2
Djibouti	MICS 3	2006	92.9	87.4	5.5
Egypt[1]	MICS 5	2014	89	82.1	6.9
Sudan	MICS 5	2014	77.7	27.7	50
Tunisia	MICS 6	2018	99.7	99.7	0
Eastern and Southern [b]					
Burundi	MICS 3	2005	33.6	28.5	5.1
eSwatini	MICS 5	2014	88.3	87.7	0.6
Kenya[2]	MICS 5	2014	46.4	44.2	2.2
Lesotho	MICS 6	2018	87.0	89.0	-2.0
Madagascar	MICS 6	2018	53.0	61.0	-8
Malawi	MICS 5	2014	87.4	88.9	-1.5
Mozambique	MICS 3	2008	55.0	58.0	-3
Somalia	MICS 4	2011	38.4	12.7	25.7
Somaliland	MICS 4	2011	44.1	30.6	13.5
South Sudan	MICS 4	2010	19.4	11.5	7.9
Zimbabwe	MICS 6	2019	86.0	86.0	0
Western and Central [c]					
Benin	MICS 5	2014	77.2	87.0	-9.8
Burkina Faso	MICS 3	2006	53.5	50.5	3
Cameroon	MICS 5	2014	64.7	61.3	3.4
Central African Republic	MICS 4	2010	54.0	53.0	1
Chad	MICS 4	2010	22.7	15.8	6.9
Cote D'Ivoire	MICS 5	2016	73.6	69.8	3.8
Democratic Republic of Congo	MICS 4	2010	74.2	74.9	-0.7
Gambia	MICS 4	2010	56.6	55.7	0.9
Ghana	MICS 6	2018	79.0	78.0	1
Guinea	MICS 5	2016	62.7	57.2	5.5
Guinea-Bissau	MICS 5	2014	45.0	44.0	1
Mali	MICS 5	2015	60.4	64.5	-4.1
Mauritania	MICS 5	2015	64.4	69.3	-4.9
Nigeria	MICS 5	2017	43.0	37.5	5.5
Republic of Congo	MICS 5	2015	94.4	91.5	2.9
Sao tome and Principe	MICS 5	2014	92.5	91.0	1.5
Senegal [Dakar City]	MICS 5	2016	97.4	97.2	0.2
Sierra Leone	MICS 6	2017	81.6	76.7	4.9
Togo	MICS 6	2017	69.4	80.0	-10.6

[1] MICS was carried out at the subnational level in the districts covered by an Integrated Perinatal Health and Nutrition Programme.

[2] MICS covered the following three counties: Turkana, Kakamega, and Bungoma.

Countries that did not carry out a MICS [N/A] or the MICS was carried out before the year 2005 or had a MICS that did not provide data for both the skilled attendants at birth and institutional deliveries are given below.

***a. Northern Africa:** Libya [MICS2-2003, SBA: 89.3%], Morocco [N/A]*

***b. Eastern and Southern Africa**: Angola [MICS2-2000, SBA: 45%], Botswana [MICS2-2000, SBA: 98.0%], Ethiopia [MICS1-1995], Eritrea [N/A], Comoros [MICS2-2000, SBA: 61.8%], Rwanda [MICS2-2000, SBA: 24.8%], Namibia [N/A], South Africa [N/A], Seychelles [N/A], Tanzania [MICS1- 1996], Uganda [N/A], Zambia [MICS2-1999].*

***c. Western and Central Africa:** Cape Verde [N/A], Equatorial Guinea [MICS2-2000, SBA: 65.1%], Gabon [MICS1-1996], Liberia [MICS1-1995], Niger [MICS2-2000, SBA:29%].*

1.2.3 Maternal mortality and Maternal Mortality Ratio

Maternal mortality is defined as "*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*". It is commonly measured using maternal mortality ratio (WHO, 2004a).

Globally, two-thirds of maternal deaths are due to post-partum haemorrhage, sepsis, pre-eclampsia and eclampsia, and abortion complications (Khan et al., 2006, Say et al., 2014). In Sudan, these causes account for two-third as well: haemorrhage [32.2%], hypertensive disorders [15.5%], sepsis [12.5%], abortion [4.2%] while indirect causes account for [24.0%] (Umbeli et al., 2018). Differences in the causes of death across the country were reported, albeit not recently, with sepsis being the most common cause in Darfur while severe anaemia was the most common reported cause in the Kassala (Haggaz et al., 2007, Mohammed et al., 2011).

Most maternal deaths worldwide could have been prevented using evidence- based and cost-effective interventions (Campbell et al., 2006, Piane, 2009, Black et al., 2016). The *Disease Control Priorities*, a compendium of health interventions, describes twenty-five cost-effective interventions to reduce maternal deaths, such as birth planning, nutrition education, nutrition supplementation, family planning, and labour and delivery management (Black et al., 2016). Table 3 gives examples of cost-effective interventions for the four main causes of maternal deaths worldwide.

As countries make progress in reducing maternal mortality, they often go through several stages. The obstetric transition framework outlines five stages [I-V] that describe countries' transition from a pattern of high maternal mortality to a pattern of low maternal mortality (Souza et al., 2014)- see Table 4. The framework aims to guide and support countries as they endeavour to accelerate their progress in reducing maternal deaths. For examples, most

countries in sub-Saharan Africa are in stage II of their obstetric transition while most of the high income countries are in stage IV (WHO, 2019). For countries in stage II, the main issue they face is access to health care. Thus, progress can be accelerated, amongst others, by scaling up access to skilled birth attendants and essential lifesaving interventions, and investing in infrastructure such as roads and transportation (Souza et al., 2014).

Sudan has reportedly achieved a considerable reduction in its MMR over the past three decades. It is estimated to have reduced its overall MMR by more than half between 1990 and 2017, higher reduction than regional and global averages (Alkema et al., 2016, WHO, 2019). Lack of data regarding effective interventions implemented locally coupled with limited data from vital statistics and civil registrations that underestimations deaths make it difficult to demonstrate these reductions. Nonetheless, despite its decline, Sudan's MMR is 295 maternal deaths per 100 000 live births. It remains high according to the obstetric transition framework and further action is needed to accelerate reductions (WHO, 2019).

Maternal deaths and birth complications can be prevented if the right kind of information that enables the prioritisation of risk factors and facilitates the best use of available resources is available. The WHO in 2004 published the "*Beyond the Numbers*: *Reviewing maternal deaths and complications to make pregnancy safer"* guide that recommends the use of maternal death review as a method to obtain such information (WHO, 2004a). The next section describes maternal death review.

Table 3: Evidence-based interventions to prevent the major causes of direct maternal deaths.

Cause of maternal death	Community Level	Primary Health Centres	Hospitals
Post-partum haemorrhage	• Birth planning, • SBA present during labour, • Iron, folate, and other vitamins supplementation	• Removal of placenta and products of conception	• Blood transfusion, • Removal of placenta and products of conception, • Parental administration of uterotonics
Sepsis	• Birth planning, • SBA present during labour, • Clean birth environment	• Clean birth environment, • Detection of sepsis, • Antibiotics for preterm or prolonged premature rupture of membranes	• Clean birth environment, • Parenteral administration of antibiotics, • Blood transfusion
Abortion	• Birth planning, • SBA present during labour	• Safe abortion services, • Management of post-abortion care	• Management of ectopic pregnancy
Preeclampsia and eclampsia	• Birth planning, • SBA present during labour, • Calcium supplementation	• Magnesium Sulphate [loading dose]	• Magnesium Sulphate, • Caesarean Delivery

Table 4: The five stages of the obstetric transition (Souza et al., 2014).

Stage	MMR	Characteristics of population	Main issue
I	> 1000	High fertility rates, direct causes of maternal death predominate, communicable diseases are common, and limited care at health facilities	Access to health care
II	999-300	High fertility rates persist, direct causes of maternal death predominate, increases in proportion of women, and seeking care at health facilities	Access to health care
III	299-50	Variable fertility, direct causes predominate, and greater proportion of women seek care at health facility	Access to health care and Intrahospital quality of care
IV	< 50	low fertility, indirect causes predominate	Intrahospital quality of care and overmedicalisation
V	Largely theoretical	low or very low fertility, and indirect causes predominate	Ensuring sustainability of excellence in quality of care

1.3 Maternal Death Review [MDR]

Maternal death review is a general term that refers to approaches, such as, verbal autopsy or community-based MDR, facility-based MDR, and confidential enquiries into maternal deaths. These approaches have been in practice for many decades: as early as the 1920s in the United Kingdom (Lewis, 2003, WHO, 2004a). They provide an opportunity for maternal health providers and policy makers to understand factors leading to deaths, they draw attention to high-risk groups of pregnant women, and they derive lessons that informs efforts to prevent similar deaths in the future. The goal, therefore, is for the review to lead to actions. It can be the first step in the process of planning, implementing, and evaluating strategies to help reduce maternal deaths (Dumont et al., 2013, Dumont et al., 2009). In resource-limited settings, actions developed should be simple, affordable, effective, and widely disseminated (WHO, 2004a).

1.3.1 WHO-recommended maternal death review approaches

Three recommended approaches, described below, for reviewing maternal deaths were recommended in the "*Beyond the numbers*" guide. All use the surveillance cycle as their guiding principle [Figure 2] (Lewis, 2003).

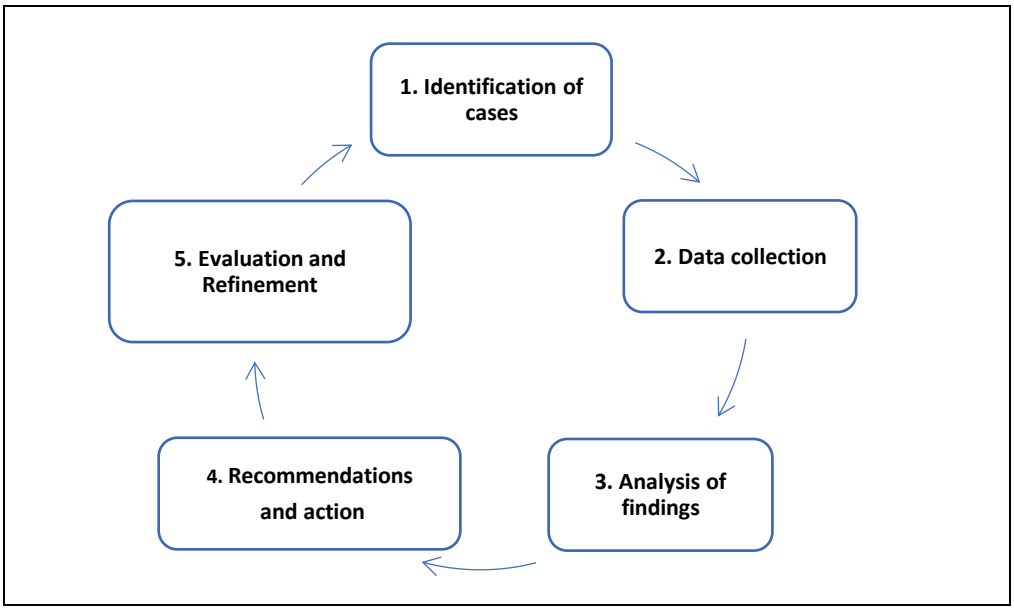


Figure 2: The surveillance cycle. Adapted from beyond the numbers guide (WHO, 2004a).

Approach 1: Community-based Maternal Death Review or Verbal Autopsy:

In a verbal autopsy [VA], lay individuals who know the circumstances leading to the death, such as family members, neighbours, and traditional birth attendants, are interviewed to establish the probable medical cause of death and to understand the non-medical factors that have contributed to it. A standard questionnaire developed by the World Health Organization [WHO] can be used to elicit the medical symptoms and signs that the deceased woman experienced or had (WHO, 2007). The data collected are used to infer a diagnosis (WHO, 2004a).

A verbal autopsy is useful in establishing medical causes of death in countries where a large proportion of deaths occur outside health facilities and/ or where civil registration and vital statistics [CRVS] systems are not well-functioning (Thomas et al., 2018, Pearson et al., 2009). It also has the added benefit that non-medical causes for maternal mortality are explored, and the opinions of family and community members are obtained on what can be done to prevent similar deaths in the future- a perspective that is difficult to obtain otherwise. Medical causes established through VA are not accurate because of issues, such as recall bias, and under- or over-reporting of some conditions (WHO, 2004a).

Approach 2: Facility-based Maternal Death Review:

This is a qualitative, in-depth investigation of the causes of and circumstances surrounding maternal deaths at health facilities. They can vary in scope, for example, it can include all deaths occurring over time in one facility; all, or a subset of deaths across several local facilities; it can expand to include cases of severe morbidity; or it can include community factors. Data are collected anonymously from facility records and reviewed in a multidisciplinary team meeting to identify contributing factors and appropriate responses for them. These meetings are not intended to apportion blame to the staff, the exception being if medical negligence is uncovered during the review (WHO, 2004a).

Facility-based MDR contributes to professional practice improvement, health providers training, and to the advocacy for resources at health facilities and beyond. However, it does not review cases occurring outside of health facilities so they cannot be regarded as population based, and it does not provide data on community factors contributing to maternal deaths - unless actively sought out (WHO, 2004a).

Approach 3: Confidential Enquiry [CE]:

Confidential enquiry is defined as "*a systematic multi-disciplinary anonymous investigation of all or a representative sample of maternal deaths occurring at an area, regional or national level*" (WHO, 2004a). It aims to capture women's health care seeking journey within the health system and beyond (WHO, 2004a). It differs from the above approaches in that it is conducted at a national or sub-national level and in its comprehensiveness. It requires a functioning CRVS structure or an equivalent to regularly identify maternal deaths.

A multi-disciplinary team carries out the CE using anonymised data in a "no name no blame" environment to encourage open and honest reporting of the causes of death and contributing factors. Results are then analysed to determine areas for possible change in the health care system or the community and policy recommendations are made. A CE requires commitment from all participants and may be resource-intensive, so it might not be feasible to review all the maternal deaths if they are large in numbers.

The limitations of CE include it inability to provide data on the maternity population or to address the underlying structural factors that contribute to maternal mortality, such as poverty, malnutrition or geographical location (WHO, 2004a).

The UK confidential enquiry into maternal deaths [CEMD] is considered the gold standard approach by the WHO. It started in 1952 and has had many iterations since then. It is now carried out by the "Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries collaboration [MBRRACE-UK]" (Kurinczuk et al., 2014).

1.3.2 Implementation of Maternal Death Review

United Nations agencies - WHO, United Nations Population Fund [UNFPA], United Nations Children's Fund [UNICEF] - in collaboration with governments, other developmental partners, and professional bodies introduced MDR in countries in Sub-Saharan Africa, Southeast Asia, and other regions (Pearson et al., 2009, Mathur et al., 2014, WHO, 2014a). This started since 2003 and was based on the WHO's *Beyond the Numbers* guidance. Orientation sessions were held in several countries with the attendance of identified key stakeholders (Pearson et al., 2009). Subsequently, many countries set-up national committees to implement activities and put in place policies to support their functioning (Pearson et al., 2009, WHO, 2014a).

Countries implemented one, two, or all of the WHO recommended approaches for reviewing maternal deaths. For example, in India all three approaches were implemented, but their implementation varied between states: in Kerala, a CE system was implemented that has been functioning for several years (Paily et al., 2014); in Tamil Nadu, the state employed a combination of both community- and facility-based MDRs (WHO, 2014a).

An evaluation study, supported by WHO, UNFPA, and UNICEF, was carried out to review the progress of MDR in Sub-Saharan African countries [N=30] and identify lessons and challenges (Pearson et al., 2009). It showed that facility-based MDR was the most popular approach- used in 15 countries, followed by CE that was used in South Africa and the Kingdom of eSwatini, facility based MDR coupled with VA was used in Angola, and the remainder had a non-specific method for reviewing maternal deaths. Pearson et al. argued that while the use of MDR is increasing, effective coverage is still low. Nonetheless, MDR has led to local policy changes and improvement in quality of maternal health services in several countries (Pearson et al., 2009, WHO, 2014a).

1.3.3 Transition to Maternal Death Surveillance and Response.

A systematic analysis was carried out in 2008 to assess trends in maternal mortality in 181 countries and progress towards the Millennium Development Goals [MDG] (Hogan et al., 2010). It found that despite substantial reductions in global maternal mortality [MMR], only 28 countries were projected to achieve MDG-5 of reducing MMR by 75% by 2015. This meant acceleration of progress in countries where substantial reductions in maternal mortality could be achievable with health-system reform was needed (Hogan et al., 2010). The projection led to local and international changes in policies, programmes, and interventions. One of them was the recommendations for reviewing maternal deaths. The commission on the information and accountability of the global strategy for women's and children's health recommended the establishment of national systems for registration of vital events and the implementation of an accountability framework. The recommended systems encompass many of the key features of surveillance and response systems traditionally used for communicable diseases. As a result, the Maternal Death Surveillance and Response [MDSR] technical working group was established in 2012, and the MDSR technical guidance was launched building on MDR (Hounton et al., 2013).

The added value of MDSR lies in its ability to provide data on maternal mortality in real time that could help with health planning and with improving accountability. As a continuous surveillance system, it links the health information system and quality improvement processes from local to national levels. It includes the identification, notification, quantification, and determination of causes and preventable factors of all maternal deaths, as well as the use of this information to respond with actions that will prevent future deaths (WHO, 2016c). This real time picture could assist in the evaluation of the effect of programmes aiming to reduce maternal mortality. Investing in MDSR is investment towards the

improvements in health information systems, as it may help improve the CRVS and boost quality of care improvement processes, contributing to better accountability (WHO, 2013).

Implementing MDSR requires human resources, financial resources, government support, leadership, staff training at all levels, and an enabling legal framework. A national MDSR system has four key administrative elements: [i] a national policy to notify all maternal deaths, [ii] a national policy to review all maternal deaths, [iii] a national MDR committee that meets at least biannually, and [iv] subnational MDR committees at the district and facility levels. A baseline survey carried out in 2015 showed that in low and middle income countries, 86% had a national policy to notify all maternal deaths, 85% had a national policy to review all maternal deaths, 60% had a national and sub-national MDR committee, and 46% had national MDR committee that meets at least biannually (WHO, 2016c).

Despite the fact that MDR were established in many countries, transitioning to MDSR presented many challenges especially where national health information systems are weak (Hounton et al., 2013). MDSR's focus on accountability could threaten the openness needed in MDR approaches that might be in place (Brouwere et al., 2013, Mathai et al., 2015). Other challenges facing MDSR reported in literature include acceptability by providers and officials lower down in the health system, lack of supporting legal frameworks, blame culture, and persistence of MDR limitations (Tura et al., 2020, Smith et al., 2017b). Challenges identified to implementation of MDSR are discussed further in chapters 2 and 6. As such, some argued that it might be early for many countries to implement MDSR and eliminate MDR (Brouwere et al., 2013).

1.3.4 Maternal Death Review in Sudan

Reducing maternal mortality is a top priority for the Ministry of Health, as seen in its most recent strategic plan [2017-2020]. The plan proposes several activities to achieve that, such as increasing coverage of antenatal care and family planning services, expansion of

comprehensive emergency obstetric services, training a midwife for every village, training and capacity building of maternal and child health care providers, documenting and investigating maternal deaths at the level of the health facilities and community (FMoH, 2016).

A national proposal was developed to introduce MDR, it is overall aim and objectives are shown in Box 1 below. A one-day workshop about MDR implementation took place in 2008, and stakeholders identified by the FMoH [senior obstetricians, registrars in obstetrics and gynaecology, hospital directors, state director general and Reproductive Health coordinators] were invited from all states to endorse and disseminate the plan for MDR implementation (Umbeli et al., 2018).

Maternal Death Review was established in 2009, and MDR committees were formed at national and state-levels. In support, a ministerial decree was issued, stating that all maternal deaths should be notified. However, there is no legal directive to review maternal deaths, and the effort that goes into all parts of the process from notification, reporting and review by focal people and committee members occur "*based on goodwill*" (Umbeli et al., 2018). The structure of the programme will be described in later chapters.

In each state, a trained Obstetrics and Gynaecology registrar was assigned as a focal person. They have to notify the state MDR committee and the MDR registrar of deaths, complete a standardised data collection form for every death that occurs, and present the cases at the state MDR committee meetings. The state MDR committee reviews deaths and makes recommendations for improvements in care. Data from all states are then submitted to the national MDR committee (Umbeli et al., 2014).The national committee analyses data and discusses results every three months and makes recommendations for national implementation (Umbeli et al., 2018).

Since its inception in 2009, the MDR report has been a main source of data on maternal mortality in Sudan, and the committee has reported on their achievements and the challenges

they faced. The committee measured MMRs and trends along with major causes of maternal death in Sudan. The major underlying causes identified by the committee for maternal deaths were late presentations, home delivery, poor antenatal care, poor referral system, non-adherence by the health care providers to management protocols, inadequate blood transfusion and lack of intensive care units. One of the achievements of the MDR was to generate local guidelines for the management of haemorrhage, hypertensive disorders and sepsis that were widely distributed (Umbeli et al., 2014, Umbeli, 2016, Umbeli et al., 2018).

The MDR committee reported numerous challenges to its functioning. These include: underreporting of community deaths, poor ascertainment of the causes of deaths, poor documentation and record keeping at facility level, lack of integration of the MDR into the health system, lack of staff working for the MDR office, lack of funding, frequent turnover of staff, and under appreciation of MDR's role in reducing maternal deaths (Umbeli et al., 2018).

In 2013, a national MDR situational analysis was carried out where a total of 65 interviews were conducted. The national MDR situational analysis report remains unpublished. A secondary analysis of about half of the interviews explored the conduct of the MDR and assessed health system changes because of its implementation (Musoke and Balogun, 2015). It highlighted limitations in the design of the MDR, its failure to leverage the strengths in the health system, and presence of several oversights, most notably a limited ability to capture maternal deaths occurring in private health facilities and in the community. It concluded that "*the design and the organisational structure of the MDR created systemic barriers that made MDR in Sudan ineffective to adequately improve quality of care*" (Musoke and Balogun, 2015).

In 2016, the Federal Ministry of Health moved from MDR to MDSR, which entails a focus on responding to each maternal death and emphasised the need for surveillance (Health, 2015). The first report from the new MDSR process was published in 2018. Many of the issues that faced the MDR in its years of operation persisted with the MDSR (Umbeli et al., 2018).

No regular evaluation and monitoring of the MDR/ MDSR in Sudan were identified. These are important to identify the barriers and facilitators to MDSR, to judge the adequate response to the committees' recommendations and the overall effect of the programme on maternal death reduction. Evaluation and refinement are a key component of the surveillance cycle, so both internal and external assessment of MDSR is needed to support its implementation.

Box 1: overall aim and objectives of the maternal death review committee

Overall aim: To contribute to the reduction of maternal mortality in Sudan by implementing MDRs in referral facilities and in communities in order to improve the quality of care.

Primary objectives:

- Identify gaps in service delivery to promote efficient use of resources and improve best practice
- Investigate community deaths
- Improve the working environment to increase motivation amongst health care staff
- Increase knowledge on the determinants of maternal death and mobilise communities to improve maternal health.

Secondary objectives:

- To count every maternal death in facilities and communities.
- To improve reporting on issues related to maternal health.
- To identify the most common causes of maternal death including sociocultural and socioeconomic factors

A note of terms used: throughout the thesis, MDSR will be used to refer to the programme in Sudan and it is the term predominantly used in Chapters 3-8 while MDR will be used predominantly throughout chapter 2.

1.4 Rationale for the DPhil project

Reviewing maternal deaths can inform practice and policy and lead to improvements in the quality of care provided to women, subsequently reducing maternal mortality. While it is important to review all maternal deaths, or a representative sample if the numbers are high, identifying deaths has proven particularly challenging in many countries. This may be because deaths are not reported, or CRVS are not fully-functioning. In Sub-Saharan Africa, for example, most MDRs are facility-based while a large number of maternal deaths still occur outside of facilities. Furthermore, skilled care is provided mostly at the facility level- Sudan and Somalia are possible exceptions to this as noted earlier.

Sudan has implemented maternal death review [MDR] since 2009, and its focus, perhaps inadvertent, has been on improving care provided by doctors in health facilities. The committee also reviews sporadically reported cases of maternal deaths from the community. The current structure of the programme does not include most out-of-facility health care providers and private facility providers to Sudan's efforts to review maternal deaths. This is a significant exclusion as out-of-facility care accounts for two-thirds of the care provided in the country. Complementing facility-based maternal death review by verbal autopsy as recommended by the WHO may be insufficient in the context of Sudan. Verbal autopsy does not review the quality of care but rather aims to infer a diagnosis from signs and symptoms reported by lay people and examine community risk factors.

For decades, midwives have provided care for pregnant women out-of-facility (Elhadd, 2011). The above-mentioned processes for reviewing maternal deaths systematically exclude midwives, thereby missing out on the meaningful and significant information on the quality of care offered to women giving birth in the community. An opportunity is thus lost to derive lessons from the care provided to the majority of women in Sudan, as highlighted in the last maternal death review committee report (Umbeli et al., 2018).

This exclusion of the majority of maternal care providers hampers efforts to reduce maternal mortality in Sudan, with a persistence of a high MMR. For the country to keep on track and achieve its national and international goals, it has to accelerate its current progress within its resources and organisational capabilities. Therefore, there is a need for the process to identify and comprehensively review care provided to all women. Specifically, there is a need for an approach to review the quality of care provided to women by health providers working in community settings as part of MDR.

1.5 Aim and objectives

1.5.1 Overall aim

To identify means to improve Maternal Death Surveillance and Response [MDSR] in Sudan and include the perspective of midwives.

1.5.2 Objectives

1. To systematically review the global conduct of MDRs and identify MDRs that include perspectives of community providers and can be adapted for use in Sudan.
2. To develop, informed by the systematic review, a logic model of well-functioning MDRs that can inform the optimisation of MDSR in Sudan.
3. To examine trends in the utilisation of skilled and trained birth attendants, from 2006 to 2014, using data from three consecutive Sudan household surveys to assess which groups of community providers should be included in MDSR.
4. To examine, through a state-level ecological analysis, the correlation between skilled and trained birth attendants and other factors with maternal mortality ratio using two databases to inform prioritisation of changes to MDSR.
5. To describe the organisation of midwives and the services they provide using interviews with health care providers, Ministry of Health officials, and United Nations [UN] officials to guide development of the optimised MDSR.
6. To describe and evaluate MDSR in Sudan using interviews with health care providers, Ministry of Health officials, and UN officials.
7. To identify barriers to the inclusion of the perspectives of the midwives to MDSR using an inter-professional collaborative framework.
8. To make recommendations informed by the systematic review, the quantitative, and qualitative analyses on means to improve MDSR in Sudan and for the inclusion of the perspectives of midwives.

2 Types and impacts of maternal death review [MDR] processes used worldwide: a systematic review.

2.1 Chapter Introduction

This systematic review identified processes used to review maternal deaths in different settings/ countries and their reported effects on practice, policy, and the health system. Specifically, the review aimed to identify the key characteristics of these processes to understand how they operate, and how these findings might be applied in the Sudanese context. Where reported, the impacts of the MDR in the settings where they were implemented were described. Processes that reported on impacts were analysed further to illustrate the relationship between the review activities and the desired impacts, making explicit the underlying assumptions of how they work using a logic model- the concept is described later in the chapter. The specific objectives of this chapter are: [1] to systematically review the global conduct of maternal death reviews and identify processes that include perspectives of community providers that can be adapted for use in Sudan, and [2] to develop a logic model of a well-functioning MDR. They correspond to thesis objectives 1 and 2, respectively.

2.2 Methods

2.2.1 Protocol and Registration

The protocol for this systematic review was registered in the international prospective register of systematic reviews [PROSPERO] on May 21st, 2018. It is accessible here: www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018095919. The review was conducted according to the registered protocol.

2.2.2 Inclusion and Exclusion Criteria

Studies or reports of MDR were eligible for inclusion if:

- The WHO maternal death definition was used "*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, 2012c).
- They described the process used to investigate maternal deaths.
- Used comparative, non-comparative, and qualitative studies or were review articles or country reports.

Studies or reports of MDR were excluded if:

- They were opinion pieces, expert review, commentaries, or abstracts without full text were not included.
- The process used to investigate deaths was not described.

2.2.3 Published Literature Searches

Three databases were searched from inception until the 10th of May 2018: PubMed [MEDLINE], Global Health Database, and WHO Global Health Library. Two reviewers [the DPhil student, NA, and a second reviewer, AML] discussed the search terms and strategy. The final search strategy for each database was reviewed by [NR], a Bodleian Outreach Librarian

at the University of Oxford. The search strategies for each database are provided in the appendices [Appendix A to D].

The search terms were piloted, and the inclusion criteria were applied to a sample [5%] of the papers to check their reliability in correctly identifying studies- this helped refine the protocol. Search results were then imported into Endnote and Covidence software. NA updated the searches on the 16th of April 2020 and identified 28 studies- just over half were new publications from already identified reviews. However, given the number of new studies/ reports identified, it is likely that some reviews updated their reports and new reviews have been published since the last update.

The following key search terms were used: maternal, pregnancy, women, mother, death reviews, confidential enquiries, verbal autopsy, social autopsy, audits, MDSR, and MDR. No language restrictions were applied: the reviewers were fluent in Arabic, English, French, and Spinach, and papers identified published in other languages were screened with the help of other DPhil students fluent in that language, for example, Portuguese.

2.2.4 Grey Literature Searches

An extensive grey literature search strategy was used that included the following:

1. The WHO "Maternal, newborn, child and adolescent health" database was searched to identify countries with a MDR in place. Three main sources were identified:
    a. The Maternal Death Surveillance and Response [MDSR] country profiles for MDSR implementation, which were available for 63 countries (WHO, 2015). Countries identified to have a national MDSR plan, a MDR committee, and to produce reports were included and their reports were searched for.
    b. The Maternal Mortality Interagency Estimation Group report (WHO and UNICEF, 2015). The report identified countries with specialised maternal mortality studies and/or programmes. References were hand searched to identify these countries.

c. The Pan American Health Organisation database to identify MDR in the Americas.

After countries were identified, a search was carried out: first, the website of the Ministry of Health of the identified country was searched. If the report was not retrieved then a search using Google search engine was carried out in English, and the results were searched up to the 10th page.

2. For theses and dissertations, the following databases were searched: University of Oxford's SOLO, Proquest, Ethos, and Directory of Open Access Repository [OpenDOAR].
3. Experts' opinions were sought.

2.2.5 Study selection

Title and abstract, and full-text screenings were carried out, independently, by the two reviewers. Disagreements on the inclusion of studies were discussed and resolved by consensus, and a plan was in place for third reviewer, one of the DPhil supervisors, to decide on inclusion in the case consensus was not reached regarding a study. Consensus was reached in all disagreements and a record of decisions made was maintained

2.2.6 Data extraction and items

A data extraction form was developed and tested on a sample of the included studies, then refined accordingly. Data extraction was performed by NA into an Excel spreadsheet, this was then checked by AML. If the necessary data were not available in the published paper 'Not described' was used. A description of the extracted fields is provided in Table 5. When more than one study reported results from the same review or when several papers/ reports were published from an ongoing review these were considered as a single review. Their characteristics were reported only once, with the most recent reference used to identify them.

No attempts were made to contact authors to obtain any further information due to the sensitive nature of the topic, which meant that additional data were unlikely to be released, and in view of the large number of studies/ reports included in the review.

2.2.7 Quality assessment of individual studies

No study design restrictions were applied, so heterogeneity in the design of the included studies was high. Several quality assessment tools were considered, such as the Newcastle-Ottawa Scale for quality assessment of observational studies, the Risk of Bias in Non-randomised Studies of Interventions [ROBINS-I], and the Cochrane Effective Practice and Organisation of Care Review Group [EPOC] quality criteria for interrupted time series. A table of the different tools considered, their components, and their applicability to the studies in this systematic review is given in Appendix E.

A modified version of the EPOC tool was chosen for assessing the quality of included studies as it did not require a comparator. Seven standard criteria were used to assess the methodology as given in Table 6. The two reviewers performed quality assessment independently.

2.2.8 Synthesis of the results

Qualitative description was used as the method of analysis to "*stay close to the data*" (Sandelowski, 2010). For each study, features of the process, such and reporting methods or level at which the review was carried out were identified and then coded. The codes were then organised into nine themes that captured the key characteristics of maternal death reviews.

Studies that reported on the outcomes and/ or impacts of MDR were further coded into five themes: inputs, activities, outputs, outcomes, and impacts to develop a logic model for well-functioning processes.

A meta-analysis was not feasible given the heterogeneity of the studies/ reports included as well as the limited available quantitative data to pool.

2.2.9 Reporting

In reporting the systematic review, the Preferred Reporting Items for Systematic reviews and Meta-Analyses [PRISMA] checklist was followed (Moher et al., 2009).

Table 5: Description of the data extraction tool's fields.

TITLE	DESCRIPTION
Authors	Authors of the article/ report
Year	Year of publication of the article/ report
Country	Country where the MDR was implemented
Language	Language used in data collection for the MDR
Start of the review	When the MDR was introduced
Duration	Period over which the MDR was conducted
Aim	Aim and objective of the MDR
Type	Design that was used in the study/ report of the MDR
No of deaths	The number of maternal deaths reviewed
Review approach	The MDR approach such as verbal autopsy or confidential
Level	Whether the MDR was conducted at the level of the community, facility, district or state, or the country
Materials and methods	Details of the MDR such as who conducts the review, personnel involved, and method for review
Outputs	Measuring what the MDR was able to produce
Outcomes	The short-term changes due to the MDR
Impact	The long-term changes due to the MDR
Commissioning	Who commissioned the MDR?
Funding	Source of Funding

MDR: maternal death review.

Table 6: The modified Cochrane Effective Practice and Organisation of Care [EPOC] review group quality criteria for interrupted time series.

No	Criterion	Scoring	
1	Protection against secular changes	D	Adjustments were made for secular changes
		NS	Not specified
		ND	No adjustments were made for secular changes
		NA	Not applicable
2	Data were analysed appropriately	D	Appropriate analyses were used. For each study type appropriate analyses are defined in Appendix F
		NS	Not specified
		ND	Appropriate analyses were not used
		NA	Not applicable
3	Reason for the number of points pre and post intervention given	D	Rationale given or sample size calculation performed
		NS	Not specified
		ND	Rationale not given or sample size calculations not performed
		NA	Not applicable
4	Shape of the intervention effect was specified	D	An explanation for the shape of intervention effect was given by the author[s]
		NS	Not specified
		ND	No explanation for the shape of intervention effect was given by the author[s]
		NA	Not applicable
5	Protection against detection bias	D	The assessment of maternal mortality was standardised, for example, done using explicit criteria or through an algorithm
		NS	Not specified
		ND	Condition above not done
		NA	Not applicable
6	Completeness of data set	D	Dataset covered 80-100% of total number of the identified maternal deaths
		NS	Not specified
		ND	Dataset covered less than 80% of the total number of maternal deaths identified
		NA	Not applicable
7	Reliable primary outcome measure[s]	D	A reliable method was used to assess the outcome for example: WHO formula for MMR calculations [with appropriate denominators]
		NS	Not specified
		ND	No reliable method was not used to assess the outcome
		NA	Not applicable

D: Done, NS: Not specified, ND: Not Done, NA: Not applicable.

2.3 Results

2.3.1 Study selection

The published literature search yielded 82 studies/reports for inclusion, and a further 16 were identified from searching the unpublished literature [Figure 3].

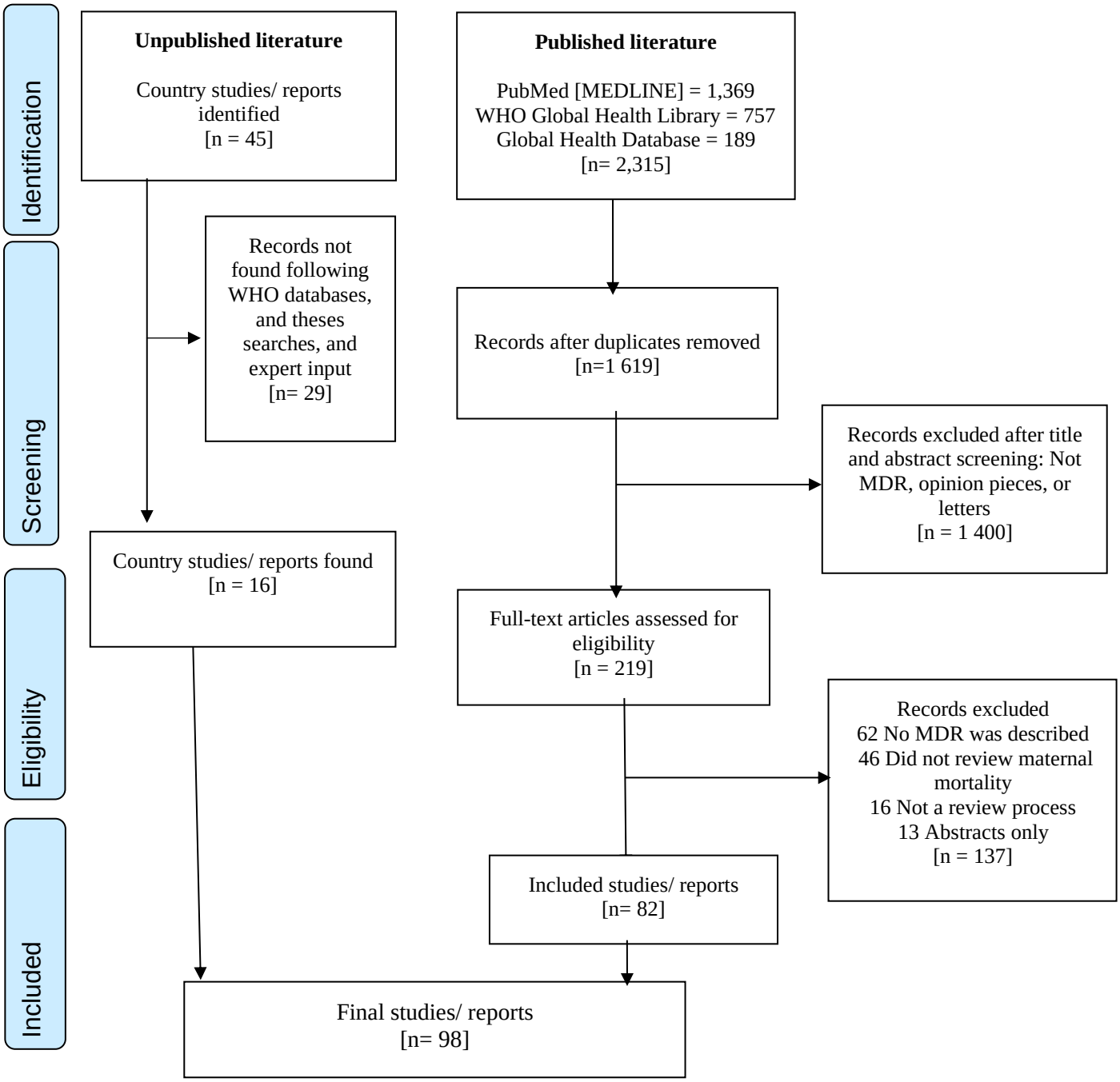


Figure 3: PRISMA Flow Diagram.

2.3.2 Study characteristics

Overall, 98 studies/ reports met the inclusion criteria, representing 75 different maternal death reviews [Table 7]. The studies/ reports were widely distributed, coming from 51 countries: 36 from 23 African countries; 11 from 8 countries in the Americas; 24 from 8 Asian countries; 3 from Australia and New Zealand; and 24 from 8 countries in Europe [Figure 4].

The majority of maternal death reviews reported were conducted sub-nationally, three were carried out in more than one country (Bouvier-Colle et al., 2001, D'Ambruoso et al., 2010, Dumont et al., 2013), and thirteen were carried out in a single health facility. One included study reported a MDR that was a part of a randomised controlled trial (Dumont et al., 2013). The duration of MDRs ranged from a minimum of a few months to the longest lasting for 50+ years (Knight, 2021).

A small proportion of MDRs reported on short- and long- term impacts, outcomes, and impacts, respectively. These MDRs were used to map out the key characteristics present in well-functioning MDRs. These definitions will be elaborated on later in the chapter [See 2.3.7]. Table below indicates whether studies/ reports documented any outcomes or impacts.

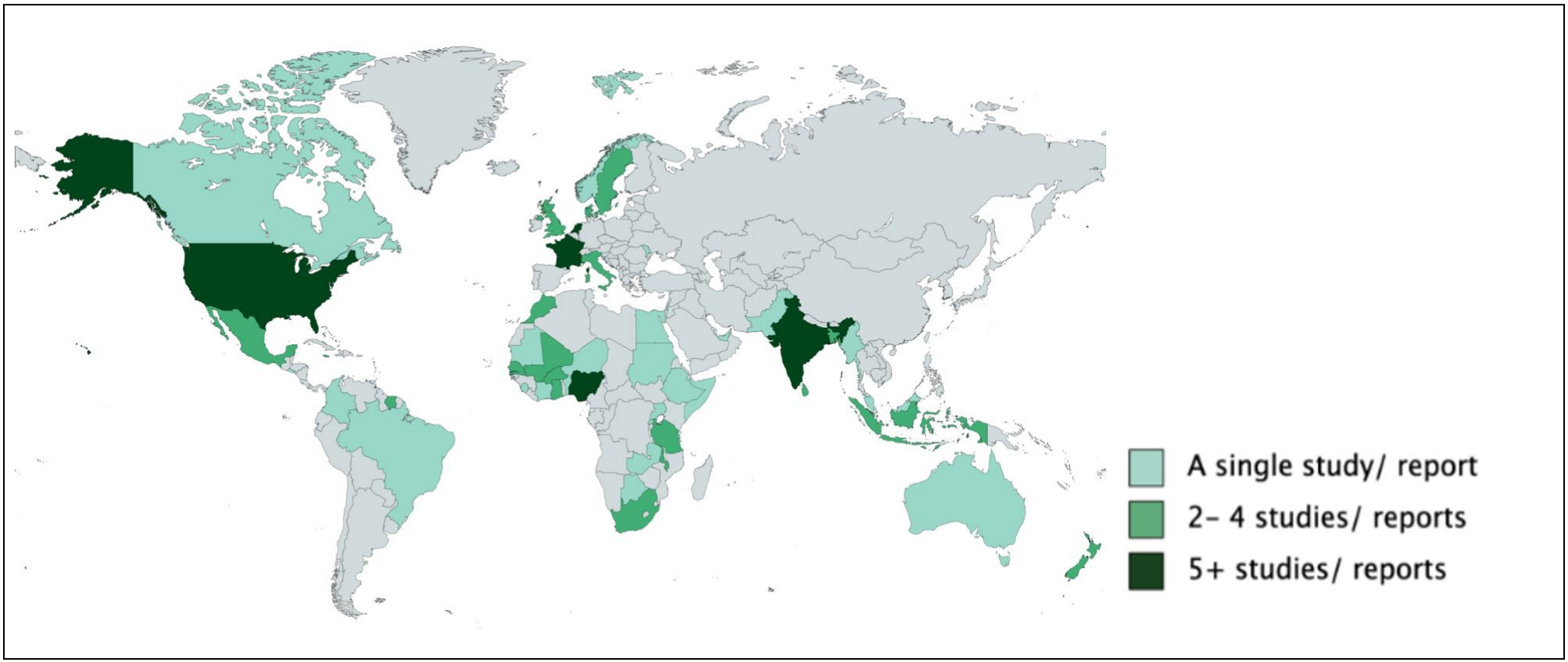


Figure 4: The geographical distribution and frequency of included studies.

Table 7: Summary of the studies included in the systematic review.

No	Reference	Country	Level and Type	THE MATERNAL DEATH REVIEW ACTIVITIES					Time	Outputs of the review process	Outcome/impact
				Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review			
1	Abdel-Hady et al., 2007 (Abdel-Hady et al., 2007)	Egypt	CE at district level	Notified to the MDR committee	Not described	Interviews with relatives and involved doctors, patient's notes, and reports from doctors and nurses	Not described	An independent committee of assessors	2004-2005	Main cause/s of death and categorisation of care into standard or substandard	No
2	Abouchadi et al., 2013 (Abouchadi et al., 2013a)	Morocco Other studies: (Abouchadi et al., 2013b)	CE at country Level	Maternal death surveillance system	Modified UK and French CEMD for hospital deaths, and VA tool modified from the MRC Farafenni Field Station tool	Hospital records and families	Trained medical doctors	National experts from the Ministry of Health	2009 -	Characteristics of the women cause of death and management.	No
3	Aden et al., 2019 (Aden et al., 2019)	Somalia	VA at regional level	Hospital records	Interviews using a VA questionnaire	Families and relatives, neighbours, TBA, CHW, and health facilities records	An interviewer – background not described	Three obstetricians	2017-2018	Pregnancy and birth characteristics of the cases, outcome of the pregnancy, medical causes of death, health care seeking process, funds to purchase medical care, contributing factors to maternal death, VA and the three delays model.	No
4	Aikpitanyi et al., 2019 (Aikpitanyi et al., 2019)	Nigeria	MDSR at one Central hospital	Not described	A validated questionnaire designed by the Ministry of Health	Data from case files of the deceased women	The head of O&G	The Medical Director, Head of O&G, Heads of Departments of Nursing/Midwifery, Paediatrics, Pathology, Anaesthesia, Haematology and Blood Bank, Labour/ Maternity ward, Medical Records, and Pharmacy.	2017-2019	Pregnancy-related characteristics of women, causes of deaths, contributory factors, recommendations to policy makers and policy response	No
5	Ande et al., 2012 (Ande et al., 2012)	Nigeria	A facility-based review at one teaching hospital	Medical records	Not described	A comprehensive maternal and perinatal database that contained detailed information on every delivery and maternal death that occurred in the hospital during the study period.	Not described	At a departmental MDR meeting attended by the consultants, resident doctors, nurses, midwives, social workers and senior management staff of the hospital	2005 - 2009	Characteristics of the woman, the circumstances surrounding the death, the primary cause of death, factors that contributed to the death including delay in accessing health care and made recommendations to improve patient care.	No

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
6	Andersen et al., 2009 (Andersen et al., 2009)	Denmark	Nationwide Data linkage study	Register linkage	Data collected form registries and hospital records were retrieved	Hospital records and death certificates	The researchers who are obstetricians	An audit group of Six obstetricians	1985-1994	MMR, causes of deaths, and characteristics of the deceased.	Yes
7	Ansong-Tornui et al., 2007 (Ansong-Tornui et al., 2007)	Ghana	A CE at facility level	Admissions and discharge book cross referenced with the delivery register	Modified maternal assessment form based on the South African form	Hospital records; clinical case and nursing notes, partographs, laboratory forms and billing accounts.	Not clear	A multidisciplinary committee containing an obstetrician, midwife, anaesthesiologist, internist, pathologist, and a public health specialist	Jan-Jul 2006	Characteristics of the women, cause of death, the care provided to women with focus on emergency management, community related factors, and health system factors	No
8	Baharuddin et al., 2019 (Baharuddin et al., 2019)	Indonesia	Facility-based review at 11 hospitals	Medical records	Medical records using a data collection form developed by the society of O&G	Medical records	A team of general practitioners and midwives	A review committee of 24 specialist from the society of the O&G	Jan-Jun 2014	Demographic and case characteristic, cause of death, factors contributing to the maternal death	No
9	Bayley et al., 2015 (Bayley et al., 2015)	Malawi	Community Linked Maternal Death Review CLMDR in one district	A Community CLMDR team member	VA and structured interviews	Woman's family, local community and health centre staff of the local health facility or hospital.	Community teams: village chiefs, CHW and Health centres teams	The MDR teams at district teams which was expanded to include non-health professionals, such as drivers, pharmacy, laboratory, and other support staff	1 year 2011-2012	Identification and review of deaths, quantity of information available, stakeholder involvement in the review process, community mobilisation an action, and accountability of health workers	No
10	Biswas et al., 2016 (Biswas et al., 2016)	Bangladesh	Social autopsy conducted at district level	Notifications from facilities and the community	Not described	Targeted participants; head of the households, women of reproductive age, representatives from adolescent groups, elders, and elite persons of the village	A facilitator: Health/Family planning inspector and a community representative	Community members	1 year 2010	Mothers' characteristics, preventable social factors. The community identified their own problems, shared within them and decide upon rectifying issues themselves for future death prevention.	No
11	Bodker et al., 2009 (Bødker et al., 2009)	Denmark	A country level register study and case audit	Danish obstetric departments, pathology units and medico-legal institutes	Modelled on the UK CEMD	Registers of the Danish Medical Health Board, death certificates and hospital records.	The MMC through linkage of data	A maternal mortality committee was formed consisting of five obstetricians and two midwives.	2002-2006	MMR, demographic characteristics, causes of death and suboptimal care	No
12	Böttcher et al., 2018 (Bttcher et al., 2018)	Palestine	Maternal deaths in Gaza-strip	Deaths are reported to the Ministry of Health	Data collection sheets developed by the research team were used	The available case notes, investigation reports and death certificates were reviewed as well as interviews with the family and clinicians who were involved in the case	The research team	The research team	2014-2015	Characteristics of the deceased women, causes and frequency of deaths over time, contributing factors to death	No

No	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
13	Bouvier-Colle et al., 2001 (Bouvier-Colle et al., 2001)	Seven west African countries	VA at regional level	Door to door population-based survey	WHO VA questionnaire translated to French	Survey data and interviews with families	Physicians	Three O&G and two public health researchers	1994-1996	MMR, characteristics of the women and HIV status, cause of death, and changes over time of antenatal HIV seroprevalence rate	No
14	Castro et al., 2000 (Castro et al., 2000)	Mexico	Subnational, Three states	Death certificates	A novel VA tool-aims to include more qualitative data	Death certificates to identify maternal deaths and interviews with the relevant relatives of the deceased	Female interviewers	The researchers using thematic analysis	1995	Structural, interactional, and subjective factors associated with deaths that may be modified through interventions and recommendations	No
15	Cham et al., 2005 (Cham et al., 2005)	The Gambia	VA at sub-national	Not clear	WHO VA questionnaire	People who witnessed any stage around the death	The researchers-not clearly mentioned	The researchers-not clearly mentioned-using grounded theory	Not clear	Circumstances that contributed to the deaths using the three-delay model	No
16	Cham et al., 2007 (Cham et al., 2007)	The Gambia	VA at subnational	Interviews with and review of records of community TBAs	VA questionnaire developed by the MRC in The Gambia and case note extractions	Health records, in-depth interviews with health professionals and other paramedical personnel with knowledge of the case and the deceased relatives	The principal investigator, a nurse-midwife, and research nurses	Three public health physicians with specialisation in obstetrics reviewed the cases independently	Jan to Sep 2002	MMR, characteristics of women, antenatal care details of deaths, medical causes of death, substandard emergency obstetric care	No
17	Confidential enquiry into maternal mortality, 2014 (Government of Malaysia, 2014)	Malaysia	CE at Country level	Not explicit – active notification	CEMD	Vital statistics, Ministry of Health data, box on certificates for women to indicate whether they were pregnant,	Not clear	Multidisciplinary team: O&G, Nurse/ midwife, Anaesthetist, family practitioner, and public health practitioner	1991-	MMR, trends in maternal mortality, medical causes of death, demographic characteristics, and recommendations	Yes
18	D'Ambruoso et al., 2010 (D'Ambruoso et al., 2010)	Burkina Faso & Indonesia	VA conducted Sub nationally in two countries	A survey	A VA questionnaire	Families of the deceased women	Trained public health graduates	The researcher – thematic analysis was carried out	2004-2005 / 2002-2006	Cause of death, and barriers to care during obstetric emergencies using the three delays models	No
19	D'Ambruoso et al., 2010 (D'ambruoso et al., 2010)	Indonesia	VA conducted at subnational level in two districts.	Women were identified from a previous survey	WHO VA and a semi-structured interview	Final caregivers	Public health graduates	The researcher	2008-unclear	Characteristics of the women and respondents, cause of delay- the three-delay model-through a thematic analysis	No
20	Donati et al., 2018 (Donati et al., 2018)	Italy	Sub-national record-linkage analysis	Registers and discharge databases	Record-linkage	From regional and national registers and discharge databases	The researchers	The researchers	2006-2012	MMR and cause of death	No
21	Dumont et al., 2006 (Dumont et al., 2006)	Senegal	A facility based MDR at a district hospital	Facility records	WHO facility based MDR	Hospital records, and interviews with staff involved, and family of the deceased	A senior O&G	Two senior obstetricians	1997-2000	Maternal mortality significantly reduced	Yes

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
22	Dumont et al., 2009 (Dumont et al., 2009)	Senegal	Five reference hospitals in the Capital city and other areas	Facility records	WHO proposed facility based MDR	Hospital records, and interviews with staff involved, and family of the deceased	Not cleat	Not clear	2004-2005	Medical cause of death, avoidability of the deaths according to the national standards of care	Yes
23	Dumont et al., 2013 (Dumont et al., 2013)	Mali and Senegal	Referral hospital across two countries	Facility records	WHO recommended MDR tool	Hospital records	Trained nurses or midwives	A multidisciplinary committee: physicians, midwives, nurses, and administrators	4 years	Reduction of risk of hospital-based mortality	Yes
24	Dutch Nationwide Confidential Enquiry into Maternal Death (Lameijer et al., 2020)	The Nether-lands	CE at country level (Schuitemaker et al., 1998, Schutte et al., 2008, Schutte et al., 2010a, Schutte et al., 2010b, Kallianidis et al., 2018)	Reports, cross checking different registries, request forms sent to all departments of the country	A standard questionnaire	Hospital records, antenatal charts, laboratory and bacteriology results, pathology and autopsy reports and professional correspondence	Voluntary reporting by obstetricians, midwives, and GPs in addition to active search	The MMC is made up of eight obstetricians and one internal medicine specialist working in the field of maternal medicine, appointed by the Dutch Society of O&G. The members are from both university and peripheral hospitals.	1981-	MMR, medical causes of deaths, characteristics of maternal deaths, substandard care	Yes
25	Ganyaglo et al., 2012 (Ganyaglo and Hill, 2012)	Ghana	Facility-based MDR at a regional hospital	Facility records	Facility-based MDR [Novel]	Hospital records	Not clear	The research team	2004-2009	MMR, and trend from 2004 to 2009 at the hospital, causes of maternal deaths, characteristics of the women who died	No
26	Garba et al., 2013 (Garba and Umar, 2013)	Nigeria	VA at a sub-regional level	Through a survey	A VA questionnaire	Close relatives and neighbours of the deceased	Ten field assistants	Data were analysed quantitatively	NA	The medical causes of deaths, characteristics of the women who died	No
27	Gebretsadik et al., 2019 (Gebretsadik et al., 2019)	Ethiopia	Facility based MDR at a hospital level	Hospital records were reviewed to identify maternal deaths	Using a structured data collection sheet	Medical records	The MDSR committee	A committee made of health professionals and administrative staff	Jan 2016-Aug 2017	Maternal characteristics, cause of death, reasons for referral, treatment, and avoidable factors.	No
28	Ghazal-Aswad et al., 2011 (Ghazal-Aswad et al., 2011)	UAE	A Confidential enquiry carried out sub nationally in Emirate of Abu Dhabi	A reporting system- not clear	Modelled after UK CEMD	Hospital records: labour, delivery, intensive care unit, and hospital mortality register were used to identify maternal deaths, then case note abstraction was carried out	The lead clinician in every study site	A committee of three senior obstetricians, with further input from other specialists including anaesthetist and physician as required.	1998-2003	MMR, Cause of maternal death and their classification, and the avoidability of the deaths.	No
29	Goswami et al., 2013 (Goswami et al., 2013)	India	A facility based MDR at one tertiary hospital	Hospital records were hand searched to identify cases	Not described	Hospital records	Not clear	Obstetricians, anaesthesiologists, nursing, and blood bank	2005-2010	Causes of maternal deaths, characteristics of the MD, standards of care, and its preventability	No

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
30	Grupo do Trabajo Regional Para la, 2015 (Grupo do Trabajo Regional Para la, 2015)	Jamaica, EL Salvador, Brazil, Colombia, and Mexico	Country level	Through notification and active search	WHO methods and country specific methods	Hospital or any medical records, specific forms, verbal autopsies and other	Various: clinicians, MDSR team members	Multidisciplinary MDSR teams that vary according to the area	Various from 1998-, 2001-, 2006 -, 2006, 2010	Causes of maternal deaths, characteristics of the MD, standards of care, and its preventability	No
31	Hodorogea et al., 2014 (Hodorogea and Friptu, 2014)	Moldova	Country level	Not clear	WHO CEMD	All health care workers involved in the management of these cases filed a form, the women's relatives or neighbours were interviewed.	Not described	A multidisciplinary committee of experts: senior obstetricians, anaesthesiologists, other clinicians, managers, and representatives of academia.	2006-2008	MMR, causes and circumstances surrounding each mother's death. Produced recommendations	Yes
32	Jafarey et al., 2009 (Jafarey et al., 2009)	Pakistan	VA at the level of two districts	Facility records and a community survey	Modified VA tool - WHO proposed tool and those used by the Population Council of Pakistan	Persons who were present with the deceased at the time of her death, other relatives, and neighbours	Female field workers	Three physicians, disagreement between the members, the Principal Investigator resolved it	2005-2007	Classification and causes of maternal deaths, levels of delays according to the three delays mode, characteristics of the deceased woman.	No
33	Jaques et al., 2006 (Jaques et al., 2006)	Benin	A retrospective Facility-based MDR in four university or regional hospitals	Facility records	A questionnaire, novel – not described	Medical records, admission records, hospitalisation, individual interviews with women and obstetricians who supported the patients.	Not described	Not described	1993-2003	MMR, trends, characteristics of patients and quality of care, causes of maternal death, factors contributing to maternal deaths	No
34	Kaur et al., 2018 (Kaur et al., 2018)	India	VA sub-nationally	Health facilities, Family welfare Bureau, cemeteries	WHO's VA questionnaire	Caregivers namely the husband or parents in law	Two graduate trained field investigators	The researchers	2007-2015	Characteristics of the women, medical causes, delay factors	No
35	Khan et al., 2013 (Khan and Pradhan, 2013)	India	VA at state-level	A community survey	A VA tool	Husband or mother-in-law	Trained research investigators	A team of doctors, including one obstetrician	2008	MMR, characteristics of the deceased women, factors associated with the deaths	No
36	Kodan et al., (Kodan et al., 2020)	Suriname Other: (Kodan et al., 2017)	Country level	CRVS and a reproductive age mortality survey	WHO VA tool,	Medical records, interviews with providers, and VA with family members	Archive employees, students, possibly others	Obstetricians, internal medicine specialist or anaesthesiologist, midwives, and the researchers	2010-2014	MMR, characteristics of maternal deaths, causes of maternal deaths, substandard care factors	No
37	Kokoty et al., 2018 (Kakoty and Das, 2018)	India	VA sub nationally	Independent surveillance workers and CRVS	Modified WHO VA with input from the Indian Council of Medical Research and researchers	Family members, neighbours, health service providers and in some cases, doctors involved in the care of patients	The researchers	The researchers	2015-2016	Characteristics of the women, maternal health services availed in the index pregnancy, and identified delays	No

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
38	Kongnyuy et al., 2009 (Kongnyuy et al., 2009)	Malawi	Facility-based maternal death audit in 9 hospitals in the central region	Facility records	WHO proposed facility based MDR	Hospital registers, referral letters, medical records, and interview of family members for additional information as required	Not clear	Anonymous MDR meetings attended by nurses, midwives, doctors, public health nurses, laboratory, and administrative staff	Jan – Dec 2007	Characteristics of pregnant woman, cause of deaths, factors that contributed to deaths: classified into 4 groups: health worker, administrative, patient/family, and TBA	No
39	Kumari et al., 2019 (Kumari et al., 2019)	India	Verbal and social autopsies sub nationally	CRVS and through using community informants	Community-based MDR and INDEPTH network social autopsy tool were used	For VA: family members, relatives, neighbours, and health workers.	The researchers	Two obstetricians, and a third obstetrician was consulted in case of disagreements.	April 2015-March 2016	Characteristics of women, cause of death, cause of death in relation to levels of delay, "Pathway to death" analysis.	No
40	Macleod et al., 1998 (MacLeod and Rhode, 1998)	Tanzania	A retrospective area-based recording of maternal death	Reports from a heterogeneous group of interested village people	A questionnaire and a VA.	A family member or an informed individual, and any attending health personnel.	The researcher who is a doctor in the district	The researcher	Jan-dec 1993	Number of deaths, MMR, characteristics of the deceased women, and causes of death	No
41	Mahmood et al., 2018 (Mahmood et al., 2018)	Indonesia	Root-cause analysis through a VA	Deaths were notified through a notification system	Interview schedule, clinical records review tool, and an audit tool informed by safe motherhood concepts and three delays model	VA interviews, terminal event reports, clinical records, maternal deaths audit committee reports, the Pink Book, a pregnant women-held medical record book	Three doctors and three midwives collected VA data	A hospital director, midwifery coordinator, an obstetrician, a midwife, and a public health specialist. Root cause analysis done by the researchers	2014-2015	Characteristics of the women, immediate cause of death, maternal obstetric profile of the woman, root causes analysis, and recommendation to address the contributing factors	No
42	Martey et al., 1993 (Martey et al., 1993)	Ghana	Facility based Review of deaths due to haemorrhage in one hospital	Not clear-probably from facility records	Not described	Inpatient case notes, labour ward delivery notes and operative records of all cases of maternal haemorrhage admitted at the Maternity Block.	Biostatistics unit	The research team includes two obstetricians, a public health physician, a nurse-midwife, and a social scientist	1981-1989	MMR, prevalence of obstetric haemorrhage, type of haemorrhage, case-fatality rate, institutional factors related to and influencing mortality	No
43	Maternal and Perinatal Death Surveillance & Response, 2019 (Ayele et al., 2019)	Ethiopia	Facility-based review and VA at country-level	Community and health facility reports and review of registers and other medical records	VA tools and a facility based maternal death abstraction form	Medical records and health care providers in the facility. For community deaths from any community member, someone who was around the deceased during the time of death	An identified focal person/ reviewer	In the community: midwives, MCH nurses. In the facility: midwives, GPs, health officers, obstetricians, neonatologist and other.	2013-	MMR, causes of death and contributing factors to maternal deaths	No
44	Maternal and Perinatal Death Surveillance and Response, 2020 (Biswas et al., 2020)	Bangladesh (Halim et al., 2014)	VA in four districts	Notification by trained health assistants, and family welfare assistants	WHO-recommended VA	Three respondents from the family of the deceased and/or the TBA present	Trained health inspectors or assistant inspectors	Two obstetricians	2010	MMR, characteristics for the women who died, causes of death, Factors contributing to maternal death: associated delays	No

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
45	Maternal death review in Myanmar, 2013 (Division, 2013)	Myanmar	Country level, MDR Community and facility based	Reporting system	VA and Facility-based tool	From families, home-based maternity records. Hospital records, post-partum examination, comments from the hospital doctors and other staff.	Not clear	Multidisciplinary team	2005-	MMR, trends in maternal mortality, medical causes of death, demographic characteristics, and recommendations	No
46	Maternal Death Surveillance and Response, 2016 (Health, 2016)	Sierra Leone	Country level-MDSR	CRVS as well as a 117-call system	Facility-based tool	Midwives or maternal health care providers	Not clear	District MDSR committees – no clear membership	2005-	MMR, medical causes of death, characteristics, preventability, and recommendations	Yes
47	Maternal Death Surveillance and Response, 2018 (Umbeli et al., 2018)	Sudan	Country level, MDSR	Notification system from facilities and the community	Data collection form	Hospital records	State focal person	Not clear	2009-	MMR, trends, causes of maternal mortality, and recommendations	Yes
48	Maternal Mortality Review Committees, 2018 (CDC, 2018)	USA Other (Mitchell et al., 2014) (Schellpfeffer et al., 2010)	Subnational, carried out in nine states using data linkage	Yes-notification system	Novel tool Standardised abstraction forms, CDC recommended Pregnancy-Associated Mortality Review	Data linkage, medical and social records	MMRC	Multidisciplinary: obstetricians, anaesthesiology, neonatology, midwifery, nurses, emergency medicine, and cardiology.	Various between 2008 and 2017	MMR, trends, medical causes of death, demographic characteristics, preventability, and recommendations,	No
49	Mittal et al., 2019 (Mittal et al., 2019)	India	Facility-based MDR at one hospital	Not clear	Facility based MDR forms	Individual case records and facility based MDR forms which were filled by the treating doctor	The researchers	Experts from different fields of medicine	Jan 2013-Dec 2016	Characteristics of maternal death, MMR per year, type of delay. Recommendations to reduce the national MMR.	No
50	Mothers and Babies: Reducing risk through Audits and Confidential Enquiries (Knight, 2021)	UK Other studies: (Cantwell et al., 2011, Knight et al., 2015, Knight et al., 2018)	Country level Confidential enquiry	Reporting system and CRVS	CE	Obstetricians, anaesthetists, pathologists, GPs, midwives, and other professionals who were involved in the care of the woman, case notes are obtained, and where relevant, autopsy reports, internal reviews and, in some cases, additional written statements are supplied.	Self-completed reports	A multidisciplinary team	1952-on going	MMR, main causes of and trends in maternal deaths, avoidable factors that could be changed to improve care, recommendations to improve clinical care and service provision, suggest directions for future areas for research and audit at a local and national level.	Yes

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
51	National Maternal Mortality Audit Committee, 2017 (Committee, 2017)	Botswana Other studies: (Madzimbamuto et al., 2014)	Country level-case note extraction and VA	Not clear	WHO, VA not clear	VA for brought in dead cases, and hospital records	District Maternal Mortality Audit Committee	Multi-disciplinary: O&G, nurse/ midwife, PMTCT, pharmacist, laboratory personnel, radiologist, physicians, anaesthetist, private practitioner, and paediatrician	2012-2014	MMR, medical causes of death, demographic characteristics, and recommendations	No
52	Olsen et al., 2002 (Olsen et al., 2002)	Tanzania	Facility and population level study in rural northern Tanzania.	A Varity of methods and informants were used	Modified WHO tool for VA+ Case notes extractions	VA, hospital records, and oral histories	A doctor fluent in Swahili and a field assistant fluent in local languages	An expert committee involving four of the authors, consensus was sought.	1995-1996	Classifications and medical causes of death, circumstances of maternal deaths, Pregnancy-related characteristics of maternal deaths,	No
53	Onakewhor et al., 2011 (Onakewhor et al., 2011)	Nigeria	Facility based review conducted in one facility	Facility records	Not described	Hospital records	Not described	Multidisciplinary departmental audit by the consultant and resident staff.	Jan 2005-Dec 2009	MMR, trends in MMR, causes of HIV related deaths, and characteristics of deceased women HIV/AIDS.	No
54	Oyeneyin et al., 2019 (Oyeneyin et al., 2019)	Nigeria	CEMD in one State	Notification from facilities by designated staff and from focal people in the community	Confidential VA and notification forms	Medical records and interviews at the level of the community	Medical record officers in facilities, and surveillance officers in communities.	A multidisciplinary team of maternal death experts and advocates-the researchers were members of the committee that reviewed the delays	June 2012-May 2015	MMR, causes of deaths maternal death delays by place of death, maternal deaths by local government area, maternal death by age, maternal death by parity	Yes
55	Paily et al., 2014 (Paily et al., 2014)	India	CE at state-level	A reporting system in place	A Confidential Review of Maternal Deaths modelled on the UK CEMD.	Medical records	Not	A multi-disciplinary team, midwives and anaestheologists are not included	2004	MMR, main causes of and trends in deaths, avoidable factors, recommendations to improve clinical care and service provision	Yes
56	Paul et al., 2011 (Paul et al., 2011)	India	Facility based at one hospital	Facility records	WHO tools based questionnaires for VA and facility-based studies	Semi-structured questionnaires were used for interviewing the relatives and the health care providers present	Not described	Not described	2006-2007	MMR, causes of maternal deaths and to explore the factors and/or circumstances contributing, characteristics of the deceased women	No
57	Perinatal and Maternal Mortality Review Committee, 2017 ((PMMRC), 2017)	New Zealand	CE at country level Publishes triennial reports	CRVS and reporting system. Varies by region	The Maternal Mortality Review Working Group developed a data collection tool	Clinicians' notification, other sources include pathologists, coronial services, and media reports. Often multiple notifications are received. Specific tick box on the death certificate	Local coordinator	Multi-disciplinary committee	2006-	MMR, medical causes of death, demographic characteristics, and recommendations	Yes

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
58	Raj et al., 2015 (Raj et al., 2015)	India	Community and facility-based audit at district level.	CHW as part of the department of health and family welfare	A modified VA tool and a standardised tool was developed to the facility review	Families of the deceased women and hospital records abstraction	A team of six medical doctors	Two obstetricians reviewed the VA and decided independently, and a third obstetrician to settle differences.	June 2009-May 2010	Characteristics of the deceased women, causes of maternal death, delay factors, and mode of transport used	No
59	Rusen et al., 2004 (Rusen et al., 2004)	Canada	Sub national	Data were obtained from three administrative databases	Similar principles to that developed in the UK	Medical records in addition to a data collection tool	Chief corner or the MDR committees	Multidisciplinary: Obstetrics, obstetric nursing, coroner, provincial/ National surveillance	1997-2000	MMR, cause of death	No
60	Sageer et al., 2019 (Sageer et al., 2019)	Nigeria	MDSR at state-level	Notified from health facilities	A semi-structured, pre-tested and validated data collection questionnaire	Medical record from the health facility and data from the local government area.	Health facility staff	Not clear	2015-2016	Characteristics of women medical and non-medical causes of deaths	No
61	Sayinzoga et al., 2016 (Sayinzoga et al., 2016)	Rwanda	Facility based MDR at country level	Not clear	Not described. facilities conduct the audit	Hospital records	Not described	Chair and staff of the maternity department, neonatology departments staff, all health staff who provided care to a woman	2009-2013	MMR, causes of maternal deaths, characteristics of the women, contributing factors to substandard care, community factors, and recommendations were made	No
62	Sk et al., 2019 (Sk et al., 2019)	India Other studies: (Sk et al., 2018)	Community and facility MDR at sub national level	Medical records of selected facilities	VA and facility based MDR form	Medical records and interviews from family and relatives or anyone who witnessed the process leading to the death	The researchers	The researchers	2013-2015	Death by levelsof delay; causes for delays; causes of deaths; delays by selected risk factors	No
63	Somigliana et al., 2011 (Somigliana et al., 2011)	Uganda	Facility based review at one hospital	Not reported, all deaths that occurred were prospectively recorded	A standardised questionnaire based on WHO's beyond the number's guidelines	Not described	Three expert obstetricians at hospital	Fifteen health workers at the hospital, including at least one of the two gynaecologists and one anaesthetist	2009-2010	Clinical characteristics at referral, clinical course, pregnancy and neonatal outcome, presumable cause of death and possible delays responsible for the event.	No
64	Sorensen et al., 2010 (Sorensen et al., 2010)	Tanzania	A CE at hospital level	Facility records	Not clear	Hospital statistics, case records, and local maternal death audit forms. Observations and interviews.	Not described	A committee of three external obstetricians	2006-2008	MMR, causes of deaths, care, staff reflection on care, comparison with hospitals internal maternal audit	No
65	State and Territory Maternal Mortality Committees, 2017 (AIHW, 2017)	Australia Others: (Johnson et al., 2014)	CE at country level	Reporting system and CRVS	No agreed-on methodology	Varies by state and territory but include direct notification by health services, hospital records, civil registries, coroner's reports, media reports and word of mouth.	State and territories committees then a national committee	A committee of obstetricians, midwives, anaesthetists, epidemiologists, and others	1964 -	MMR, medical causes of death, demographic characteristics	No

	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
66	Stekelenburg et al., 2002 (Stekelenburg and van Roosmalen, 2002)	Zambia	Facility-based review carried out at a District level	Facility records	MDR meetings with a standard agenda	Hospital records	Not described	Medical officers, nursing officer, nurses, midwives, operating theatre staff and laboratory technician	1999 – mid 2001	Causes, and contributing factors to maternal mortality, substandard care factors, recommendations, and implementation of recommendation status	No
67	Surveillance and Response system for maternal deaths in Sri Lanka, 2014 (Kapila and Deepthi, 2014)	Sri Lanka	MDSR at country level	All deaths are notified to the Family Health Bureau	VA, a structured field investigation report format, facility based MDR, and clinical audit	Public health midwives, media surveillance, hospitals, reports from health care providers	Field health care workers conducted the VA	Multidisciplinary teams at the field and institution	1981/9 -	MMR, trends in maternal mortality, medical causes of death, demographic characteristics, preventability of the deaths, and recommendations	Yes
68	The California Pregnancy-Associated Mortality Review, 2019 (CDPH, 2019)	USA Other: (Morton et al., 2019, VanOtterloo et al., 2019a, VanOtterloo et al., 2019b)	Record linkage at state-level	Maternal and foetal death certificates, infant birth certificates, and patient hospital discharge records were linked	Medical records linkage	Medical records and coroners' reports	The researchers	Multidisciplinary group comprised of experts in nursing, obstetrics, maternal-foetal medicine, midwifery, cardiology, anaesthesiology, emergency medicine, public health, and sociology.	2006-	MMR, Cause of death, contributing factors, preventability, and quality improvement opportunities	No
69	The CEMD in South Africa (Moodley et al., 2014)	South Africa Other: (Soma-Pillay et al., 2016)	CE at country level	A notification system	Modelled on the UK CEMD	All clinical recordings in addition to forms	Facilities	A multi-disciplinary team: obstetricians, experienced medical officers, midwives, and anaesthetists when indicated	1998 - ongoing	MMR, medical causes of maternal deaths, avoidable factors, missed opportunities, and substandard factors, and makes recommendations.	Yes
70	The Italian Obstetric Surveillance System (Dell'Oro S, 2019)	Italy Other studies: (Donati et al., 2019)	CE at a sub-national level	Notification from facilities coupled with record-linkage	An anonymous form is filled from medical records	Participant clinicians and medical records	Not clear	Carried out at three levels: at facilities, regionally by a multidisciplinary committee, and centrally	2013-	Women's characteristics, obstetric history and cause of death, quality of care, preventability, and the organisational characteristics of the obstetrics units.	No
71	The National Confidential Enquiry on maternal mortality (Saucedo et al., 2020)	France	CE at country level	A notification system	A standardised form modified from UK CEMD	Interviews with staff involved in patient care, hospital records review of all the available documents such as hospital records, surgery, anaesthesia, and autopsy reports.	Two external assessors including an anaesthetist and an obstetrician	Obstetricians, midwives, anaesthesiologists, critical care and internal medicine specialists, and epidemiologists.	1996-	Trends over time in MMR, underlying cause of death, risks factors, quality of care provided, and avoidability of maternal deaths	No

No	Reference	Country	Level and Type	Identifications of deaths	Data collection tool	Source of data	Who collected the data	Who conducted the review	Time	Outputs of the review process	Outcome/impact
72	The Swedish Maternal Mortality group (Esscher et al., 2014)	Sweden	Country level using data from national registries	CRVS linkage	A modified UK CEMD	Hospital records	Hospital records	Two obstetricians independently reviewed each case file	1988-2007	MMR, causes of maternal deaths	No
73	Vangen et al., 2004 (Vangen et al., 2014)	Norway	Country level, data linkage	From medical birth and cause of death registry	Data linkage supplemented with data from maternity clinic	Civil registry and maternity clinic records	The head of the project who is a senior O&G	Researchers working in pairs – backgrounds not clear	2005-2009	Number of maternal deaths, cause of deaths, MMR, lessons learnt and recommendations	No
74	Vora et al., 2018 (Vora et al., 2018)	India	Community and facility-based audits in one district	Through a community survey	The WHO validated MDR tool	Medical records and interviews with family and neighbours	Trained data collectors-social workers	The researchers	July 2013-Nov 2014	Sociodemographic characteristics and maternal health utilisation of the women, and factors leading to type III delays	No
75	Walker et al., 1986 (Walker et al., 1986)	Jamaica	Country-level confidential enquiry	Deaths identified through various means	A modified UK CEMD	Hospital records, police records, coroner's court, and public mortuary records	Researchers	A committee of obstetricians	1981-1983	MMR, medical causes of maternal deaths, and classification, characteristics of the women, avoidability of maternal deaths	No

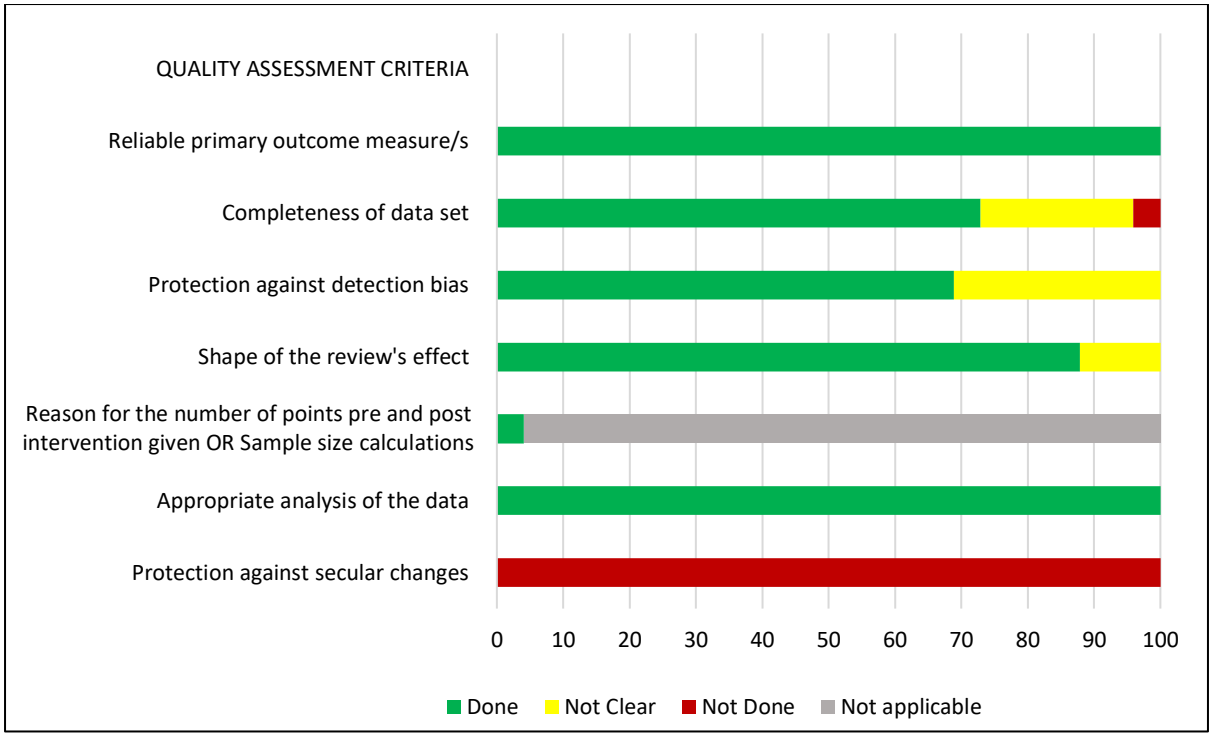
CDC: Centre for Disease Control. CEMD: Confidential Enquiry into Maternal Deaths. CHW: Community Health Worker, CLMDR: Community Linked Maternal Death Review. CRVS: Civil Registration and Vital Statistics. GP: General practitioner. HIV/ AIDS: Human immunodeficiency virus/ Acquired immunodeficiency syndrome MCH: Maternal and Child Health. MDR: Maternal Death Review. MDSR: Maternal Death Surveillance and Response. MMR: Maternal Mortality Ratio. MRC: Medical Research Council. O&G: Obstetrician and Gynaecologist. PMTCT: Prevention of mother-to-child. TBA: Traditional Birth Attendants. UK: The United Kingdom. VA: Verbal Autopsy. WHO: World Health Organization.

2.3.3 Quality assessment of the included studies

Figure 5 and Figure 6 provide a summary of the quality of all the studies/ reports, and for studies that reported on outcomes/ impacts, respectively, using the modified Cochrane EPOC tool assessment. Studies that reported on long term effects scored higher on the quality assessment tool compared with the overall studies. The results of the quality assessment for each individual study are presented in Appendix F.

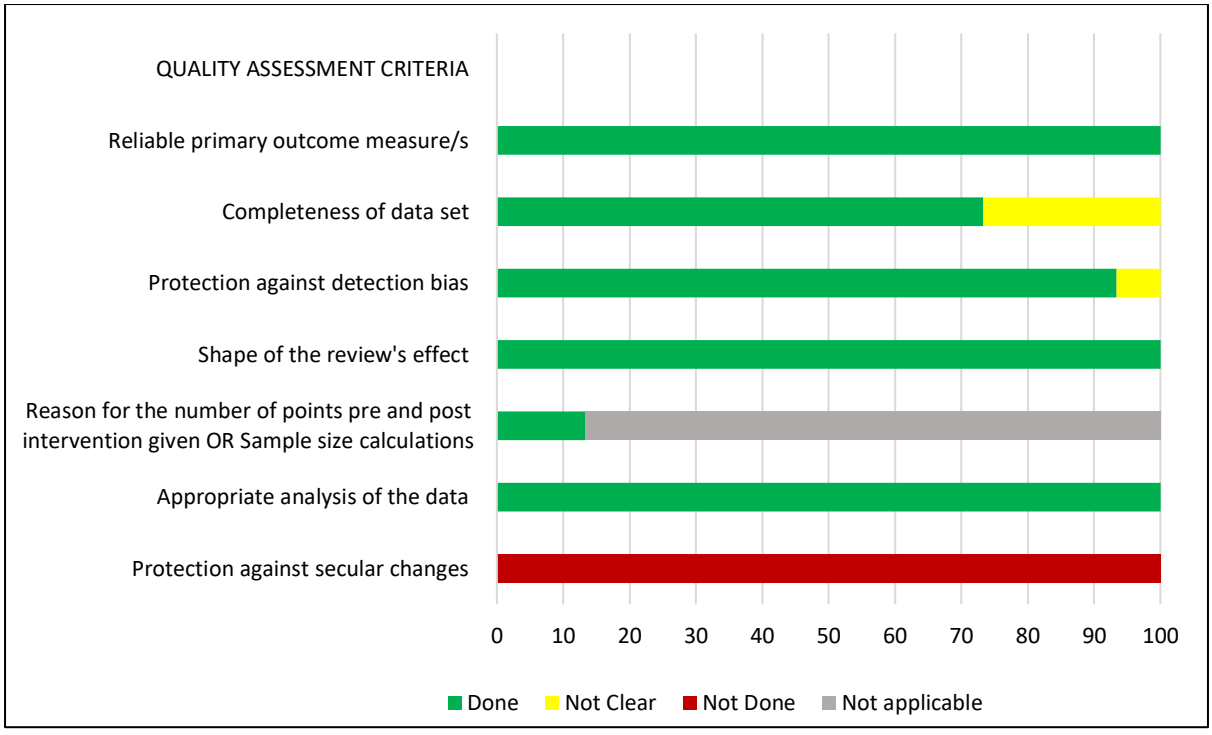
All studies conducted appropriate analyses for their study design, Appendix G provides examples of analyses, statistical or non-statistical, deemed appropriate. All studies used reliable measures, such as maternal mortality ratio, for assessing the maternal mortality. Detection bias, which could lead to over or underestimation of maternal deaths, was mitigated in 69% of the studies, but it was not clear for the remainder of the studies. Given maternal deaths are often underestimated in global reports, for this study detection bias was considered to have been mitigated when studies rely on several sources to identify maternal deaths. Studies did not always report on whether they reviewed all identified cases of maternal deaths, most [73%] reviewed 80% or more of the identified maternal deaths.

The majority [88%] of the studies reported the effects of the MDR such as its output, outcomes, and/ or impacts. Sample size calculations were not applicable to almost all studies particularly for population-level studies. However, three [4.1%] of the studies performed sample size calculations (Dumont et al., 2013, Dumont et al., 2006, Dumont et al., 2009).
None of the studies/reviews accounted for secular changes, which are independent to the review but can influence maternal mortality levels such as a general improvement in socioeconomic status. Although one study is a randomised controlled trial, which by virtue of its design should control for secular changes, its intervention was not limited to the MDR and it was coupled with on-site trainings, making it difficult to attribute the effects of the combined intervention to the review alone (Dumont et al., 2013).



Values on the X axis are in percentage.

Figure 5: Risk of bias graph.



Values on the X axis are in percentage.

Figure 6: Risk of bias graph for studies used in the logic model.

2.3.4 Key features of Maternal Deaths Reviews

Nine features captured the differences between maternal death reviews were identified from the qualitative analysis: commissioning, maternal death population, case ascertainment, data sources, review approach, review committee, confidentiality or anonymity, review duration, and feedback mechanisms [see Table 8 and Table 9]

Table 8: Key features of maternal death reviews identified from the systematic review.

NO	FEATURES	DETAILS
1	Commissioning	• Government agencies • Others such as professional groups, universities, or non-governmental organisations
2	Maternal death population	• Based on place of death • Based on the cause of death • Based on specific risk factors
3	Case ascertainment	• Basic case ascertainment • Enhanced case ascertainment
4	Data sources	4. Routine sources 5. Routine sources and other data 6. New data sources

5	Review approach	• Explicit
		  ○ Novel
		  ○ A WHO recommended approach
		  ○ UK CEMD adapted
		• Not clear

6	Review committee	• Multidisciplinary • One group of health professionals • Researcher or unclear
7	Confidentiality or anonymity	• Reviews are confidential or anonymous • Not clear
8	Duration	• Defined time period • Ongoing or continuous process
9	Feedback mechanism	• Clear • Unclear

UK: United Kingdom; CEMD: Confidential enquiry into maternal deaths

1. Commissioning of the maternal death review

The reason for introducing the MDR varied between studies/ reports. Ministries of Health or public health institutes were responsible for the commissioning of 24 [32%] of the MDRs reported in the included studies; Obstetrics and Gynaecology societies commissioned five MDRs in Canada, Denmark, India, and Sweden (Rusen et al., 2004, Bødker et al., 2009, Andersen et al., 2009, Paily et al., 2014, Esscher et al., 2014); UNFPA commissioned two MDRs (Bttcher et al., 2018) (Böttcher et al., 2018, Sageer et al., 2019); two MDRs were part of non-governmental organisations' projects (Bayley et al., 2015, Vora et al., 2018); the rest either were research projects or their commissioning was not reported.

2. Maternal deaths population

By definition, maternal deaths were the main population reviewed, yet some MDRs investigated specific deaths that shared similar characteristics, for example:

- Place of death. This was the most common grouping identified, for example, reviewing deaths that occurred in health facilities.
- Other classifications included:
    - Medical cause of death. Some reviews focused on deaths due to haemorrhage (Martey et al., 1993, Bonnet et al., 2011, Biswas et al., 2016), sickle cell disease (Lesage et al., 2015), or HIV (Onakewhor et al., 2011).
    - Specific risk factors such as being born outside of the country (Esscher et al., 2014) and access to emergency obstetric care for women in rural areas (Cham et al., 2005).

3. Identification of maternal deaths

The methods and sources used to identify maternal deaths are a major differentiating feature of MDR. Most of them 58 [78%] used basic case ascertainment, 16 [21%] used enhanced case ascertainment, and one did not report the method used to identify cases (Hodorogea and Friptu, 2014).

- Basic case ascertainment: deaths are either reported to a specific body such as MDR committee by an informant (Bayley et al., 2015) or they are identified from administrative records (Donati et al., 2018).
- Enhanced reporting: deaths were identified through:
  - A combination of reporting and searching medical records (Dumont et al., 2006, Dumont et al., 2013, Raj et al., 2015).
  - Record linkage: Data from civil registration and vital statistics [CRVS] databases, such as birth and death registers, hospital records, autopsy reports, and death certificates, are linked to identify maternal deaths. This is combined with the reporting system of maternal deaths (Vangen et al., 2014) or the use of a check box on the death certificate to indicate recent pregnancies (Mitchell et al., 2014, Malaysia, 2014)
  - Surveys: Some MDRs identified deaths from the results of previous surveys (D'Ambruoso et al., 2010, Kodan et al., 2017), or they carried out their own prospective population-based surveys (Bouvier-Colle et al., 2001, Vora et al., 2018).

4. Data collection for the maternal death review

Data used by MDR can be divided into routine data only, review-specific data only, and a combination of both.

- Routinely collected data, such as case notes, autopsy reports and/or death certificates were used in 26 [35%] of the MDRs identified.
- Review-specific data, such as data collected through questionnaires, standardised data collection forms, or interviews, were used in 17 [23%] of the MDRs identified. Data were collected from various sources, including doctors, midwives, nurses, other health providers, support staff, family and neighbours of the deceased woman, and traditional birth attendants- where applicable.

- Routine data were supplemented with review-specific data in 31 [41%] of the MDRs identified. For example, case notes abstraction were supplemented with interviews with hospital staff (Dumont et al., 2009, Abouchadi et al., 2013b), or hospital records were supplemented with interviews with the family of the deceased (Cham et al., 2007, Bayley et al., 2015, Biswas et al., 2016, Böttcher et al., 2018).

5. The maternal death review approach

The approaches described in section 1.3.1 constituted the majority 56 [75%] of the approaches used in MDRs identified: 15 used a confidential enquiry, 16 used a verbal or social autopsy, 10 used a facility-based MDR approach, and 15 used a combination of approaches. A quarter of the identified MDRs did not adopt a clear approach.

6. The maternal death review committee

The committees tasked with analysing maternal deaths were:

- Multi-disciplinary: Half of the committees included, to varying degrees, obstetricians, physicians, anaesthesiologists, midwives, nurses, epidemiologists, lab technicians, support staff, and/or others involved in the care of mothers. Some studies reported not including specific providers such as midwives or anaesthesiologists (Paily et al., 2014).
- One group of professionals, such as obstetricians (Halim et al., 2014, Raj et al., 2015, Aden et al., 2019, Baharuddin et al., 2019, Kumari et al., 2019, Andersen et al., 2009, Esscher et al., 2014), or public health physicians (Jafarey et al., 2009).
- Researchers or unclear: the MDR committee was either not described or was made up of the research team in 29 [39%] of the identified MDR.

7. Confidentiality

Thirty [40%] MDR identified reported that they carried out the review in a confidential manner, and two reported that it was not confidential. The majority 43 [57%], however, did not report on whether the MDR was confidential or not.

8. Continuity of the maternal death review

The MDR were either fixed in their duration or were continuous:

- Fixed: nearly three-quarters of the MDRs identified were of a specific duration. For example, to update the knowledge of the main causes of death in a particular context (Böttcher et al., 2018) or to evaluate a program or an intervention (Vora et al., 2018).
- Ongoing/ continuous: after their initial inception, these MDRs capture deaths, collect data on them, and reviews them regularly. They may have periodic reporting.

9. Feedback mechanism

This refers to whether a MDR had a clear mechanism to report its outputs. Most of the MDRs included in this systematic review did not have a clear feedback mechanism or did not report one 55 [73%]. The feedback mechanisms reported in the remaining MDRs included annual meetings to share findings and recommendations, publications in peer-reviewed journals (Hodorogea and Friptu, 2014, Moodley et al., 2014), or community meetings (Bayley et al., 2015).

2.3.5 Distinct types of maternal death review:

Based on the nine features above, four distinct types of maternal death review were identified- see Table 9. These are [1] reviews of all maternal deaths, [2] reviews of facility-based deaths, [3] reviews of community-based deaths, and [4] reviews based on data linkage.

Table 9: Description of the included maternal death reviews.

MDR type / MDR characteristics	All maternal deaths N [%] 30 [100]	Facility Deaths N [%] 24 [100]	Community Deaths N [%] 14 [100]	Data linkage N [%] 7 [100]	Total N [%] 75 [100]
1 Commissioning					
Government	20 [67]	2 [8]	0 [0]	2 [29]	24 [32]
Other or Unidentified	10 [33]	22 [92]	14 [100]	5 [71]	51 [68]
2 Level					
Country	9 [30]	2 [8]	0 [0]	4 [57]	26 [35]
Subnational	21 [70]	9 [38]	14 [100]	3 [43]	36 [48]
One hospital	0 [0]	13 [54]	0 [0]	0 [0]	13 [17]
3 Approach					
Confidential enquiry	12 [40]	3 [13]	0 [0]	0 [0]	15 [20]
Verbal/ Social autopsy	2 [7]	1 [4]	13 [93]	0 [0]	16 [21]
Facility based	0 [0]	10 [42]	0 [0]	0 [0]	10 [13]
Combination of above	12 [40]	2 [8]	1 [7]	0 [0]	15 [20]
Unclear	4 [13]	8 [33]	0 [0]	7 [100]	19 [25]
4 Case Ascertainment					
Enhanced	13 [43]	0 [0]	3 [21]	0 [0]	16 [21]
Basic	16 [54]	24 [100]	11 [79]	7 [100]	58 [78]
Unclear	1 [3]	0 [0]	0 [0]	0 [0]	1 [1]
5 Data source					
Routine	5 [17]	14 [58]	0 [0]	7 [100]	26 [35]
New	3 [10]	3 [13]	11 [79]	0 [0]	17 [23]
Combination	21 [70]	7 [29]	3 [21]	0 [0]	31 [41]
Unclear	1 [3]	0 [0]	0 [0]	0 [0]	1 [1]
6 Committee					
Multi-disciplinary	20 [67]	11 [45]	3 [21]	4 [57]	38 [50]
One group of professionals	1 [3]	4 [17]	2 [14]	2[29]	8 [11]
Researchers or Unclear	9 [30]	9 [38]	9 [65]	1 [14]	29 [39]
7 Confidentiality					
Confidential	17 [57]	7 [29]	0 [0]	6 [86]	30 [40]
Not confidential	1 [3]	1 [4]	0 [0]	0 [0]	2 [3]
Not reported	12 [40]	16 [67]	14 [100]	1 [14]	43 [57]
8 Continuity					
Defined	10 [33]	24 [100]	14 [100]	6 [86]	54 [72]
Ongoing	20 [67]	0 [0]	0 [0]	1 [14]	21 [28]
9 Feedback mechanism					
Clear	11 [37]	5 [21]	1 [7]	3 [43]	20 [27]
Unclear	19 [63]	19 [79]	13 [93]	4 [57]	55 [73]

Type 1: Comprehensive reviews of maternal deaths

Thirty MDRs, 40% of total, belonged to this group. The majority were commissioned by governments [67%], carried out sub-nationally [70%], were either confidential enquiries or used a combination of approaches [40% each], were carried out confidentially [57%], used basic case ascertainment [54%], collected data from routine and review-specific sources combined [70%], had multi-disciplinary committees [67%], and were continuous [67%]. However, most did not have a clear feedback mechanism and did not report on outcomes and impacts.

The confidential enquiry approach was used in 12 [40%] of these MDRs, including the UK confidential enquiry into maternal deaths [CEMD] (Knight, 2021) and four reviews from Morocco, United Arab Emirates, South Africa and India that modified and used the UK CEMD approach (Abouchadi et al., 2013b, Ghazal-Aswad et al., 2011, Moodley et al., 2014, Paily et al., 2014). Twelve MDRs [40%] combined approaches, such as hospital records and VA (MacLeod and Rhode, 1998, Olsen et al., 2002, National Maternal Mortality Audit Committee, 2017), or facility based MDR and VA (Maternal and Reproductive Health Division, 2013, Kapila and Deepthi, 2014, Health, 2016, Umbeli et al., 2018, Kodan et al., 2020). Two MDRs used a VA and a social autopsy method to investigate all maternal deaths (Halim et al., 2014, Kaur et al., 2018).

Data used were gathered from a combination of new and existing sources in 21 [67%] of the MDRs, relied only on routinely collected data in 5 MDRs [17%] (Ghazal-Aswad et al., 2011, Malaysia, 2014, Moodley et al., 2014, Paily et al., 2014, Donati et al., 2019), and collected data specifically for the review in three MDRs [10%] (MacLeod and Rhode, 1998, Kaur et al., 2018, Kumari et al., 2019).

Type 2: Facility-based maternal death reviews

This type accounted for a third of MDRs included. Most took place in one hospital [54%], used WHO recommended facility based MDR approach [42%], used routine data sources [58%], had a multidisciplinary review committee [45%], had no clear feedback mechanism [62%] and did not report on outcomes and impacts [56%]. All used basic case ascertainment and had a fixed duration. Only two were commissioned by the government (Sayinzoga et al., 2016, Walker et al., 1986).

Thirteen facility-based MDRs were carried out in a single health facility (Martey et al., 1993, Stekelenburg and van Roosmalen, 2002, Dumont et al., 2006, Sorensen et al., 2010, Onakewhor et al., 2011, Paul et al., 2011, Somigliana et al., 2011, Ande et al., 2012, Ganyaglo and Hill, 2012, Goswami et al., 2013, Aikpitanyi et al., 2019, Gebretsadik et al., 2019, Mittal et al., 2019), nine were in more than one hospital sub-nationally (Jaques et al., 2006, Ansong-Tornui et al., 2007, Dumont et al., 2009, Kongnyuy et al., 2009, Aden et al., 2019, Baharuddin et al., 2019, Sageer et al., 2019, Sk et al., 2018, Dumont et al., 2013), two covered all hospitals in the country (Sayinzoga et al., 2016, Walker et al., 1986), and one was carried out in 46 hospitals across two countries (Dumont et al., 2013).

Most MDRs identified used a WHO recommended approach, with or without modification: ten used facility-based MDR (Dumont et al., 2006, Dumont et al., 2009, Kongnyuy et al., 2009, Onakewhor et al., 2011, Somigliana et al., 2011, Ande et al., 2012, Goswami et al., 2013, Dumont et al., 2013, Aikpitanyi et al., 2019, Mittal et al., 2019), three used CE (Walker et al., 1986, Ansong-Tornui et al., 2007, Sorensen et al., 2010), two carried out a facility based MDR supplemented with VA (Paul et al., 2011, Sk et al., 2018), and one used a VA (Aden et al., 2019). The remaining eight MDRs did not clearly report on the approach they used.

The MDRs reported on the sources of their data: fourteen used existing data without supplementations (Martey et al., 1993, Stekelenburg and van Roosmalen, 2002, Dumont et al., 2006, Ansong-Tornui et al., 2007, Sorensen et al., 2010, Onakewhor et al., 2011, Somigliana et al., 2011, Ande et al., 2012, Ganyaglo and Hill, 2012, Dumont et al., 2013, Goswami et al., 2013, Aikpitanyi et al., 2019, Baharuddin et al., 2019, Gebretsadik et al., 2019); seven used existing data but supplemented them from other sources, such as by using standardised forms (Kongnyuy et al., 2009), modified verbal autopsy questionnaires (Paul et al., 2011), and interviews (Jaques et al., 2006, Sorensen et al., 2010, Mittal et al., 2019, Sageer et al., 2019, Sk et al., 2018); the last three collected their own data with no reference to whether routinely collected data were used (Dumont et al., 2009, Somigliana et al., 2011, Aden et al., 2019).

The deaths were reviewed by a multi-disciplinary committee in 11 MDRs (Ansong-Tornui et al., 2007, Dumont et al., 2013, Dumont et al., 2006, Dumont et al., 2009, Goswami et al., 2013, Kongnyuy et al., 2009, Somigliana et al., 2011, Stekelenburg and van Roosmalen, 2002, Aikpitanyi et al., 2019, Gebretsadik et al., 2019, Sorensen et al., 2010)- among them only one committee had community representatives (Dumont et al., 2006); by O&G consultants only in four MDRs (Walker et al., 1986, Cham et al., 2007, Raj et al., 2015, Aden et al., 2019); and the committee was not clear in the remainder.

The majority of MDRs did not report on whether they carried out the review confidentially, but it was confidential in seven (Ansong-Tornui et al., 2007, Dumont et al., 2013, Dumont et al., 2009, Sayinzoga et al., 2016, Sorensen et al., 2010, Walker et al., 1986, Baharuddin et al., 2019) and it was not confidential in one (Kongnyuy et al., 2009). All but five (Dumont et al., 2013, Dumont et al., 2006, Dumont et al., 2009, Somigliana et al., 2011, Stekelenburg and van Roosmalen, 2002) MDRs did not report on a clear feedback mechanism. Three MDRs (Dumont et al., 2013, Dumont et al., 2006, Sayinzoga et al., 2016) reported an impact.

Type 3: Community based maternal death reviews

Fourteen MDRs, a fifth of the total, were in this group. None of these MDRs were commissioned by a government body, but all were carried out sub nationally, did not report on whether the review was confidential, and were of fixed duration. The majority used a verbal or social autopsy [93%], used basic case ascertainment [79%], collected review-specific data [79%], had no clear committee [65%], and had no clear feedback mechanism [93%].

Although all used VA, some MDRs expanded their approach: one used a social autopsy approach (Biswas et al., 2016), another combined VA with reviewing the health records of community traditional birth attendants, community nurses, hospital records, and conducting in-depth interviews with community and facility professionals and paramedical staff (Cham et al., 2007), a third developed a new approach termed Community-Linked Maternal Death Review [CLMDR] to improve reporting of out-of-facility deaths and to improve the quality of the MDR (Bayley et al., 2015).

All MDRs used basic case ascertainment to identify maternal deaths- except three (D'Ambruoso et al., 2010, D'ambruoso et al., 2010, Kakoty and Das, 2018). Most collected MDR specific data and three combined new data with existing ones (Castro et al., 2000, Bayley et al., 2015, Biswas et al., 2016). The majority did not define their review committee, but three had a multi-disciplinary committee (Bouvier-Colle et al., 1995, Khan and Pradhan, 2013, Bayley et al., 2015) and in two the committee was made up of a group public of health physicians (Jafarey et al., 2009) or of obstetricians (Halim et al., 2014).

One MDR reported a clear feedback mechanism (Bayley et al., 2015). Bayley and colleagues developed a community linked MDR that had feedback activities to the community and facility inbuilt into their novel design. The remainder did not report on a clear feedback mechanism for their findings and recommendations.

Type 4: Reviews based on linkage of Civil registration and Vital statistics.

This type was carried out in Denmark (Andersen et al., 2009, Bødker et al., 2009), Italy (Donati et al., 2019), Norway (Vangen et al., 2014), Sweden (Esscher et al., 2014), and the USA (CDC, 2018, CDPH, 2019). All of these MDRs used basic case ascertainment, relied on routinely collected data, were of fixed durations, did not have a clear feedback mechanism, and they did not report on outcomes/ impacts although one MDR reported anticipated outcomes/ impacts (CDC, 2018).

The approaches used did not align with the WHO recommended approaches but four reported using the classification of the UK CEMD (Andersen et al., 2009, Bødker et al., 2009, Esscher et al., 2014, Vangen et al., 2014) and the United States' MDRs used resources provided by the Centre for Disease Control (CDC, 2018, CDPH, 2019).

Two MDRs were commissioned by a health authority (Donati et al., 2019, CDPH, 2019), three were commissioned by Obstetrics and Gynaecology societies (Andersen et al., 2009, Bødker et al., 2009, Esscher et al., 2014), and commissioning was unclear for the remainder. Three MDRs were conducted sub nationally (CDC, 2018, CDPH, 2019, Donati et al., 2019).

The committee analysing deaths consisted of a multidisciplinary team in four MDRs (Bødker et al., 2009, CDC, 2018, Donati et al., 2019, CDPH, 2019), a group of obstetricians in two (Andersen et al., 2009, Esscher et al., 2014), and was unclear in one (Vangen et al., 2014).

2.3.6 Outcomes and impacts of maternal death reviews

Overall, fifteen MDRs [20%] reported on outcomes and/ or impacts. Twelve of them were commissioned by a government body, conducted at country-level, used a WHO recommended approach, used several data sources to obtain information on the maternal deaths, had a multidisciplinary review committee, were continuous and had a clear feedback mechanism (Schutte et al., 2010a, Hodorogea and Friptu, 2014, Kapila and Deepthi, 2014, Malaysia, 2014, Moodley et al., 2014, Health, 2016, Sayinzoga et al., 2016, (PMMRC), 2017, Committee, 2017, CDC, 2018, Umbeli et al., 2018, Knight, 2021). Table 10 lists the outcomes and impacts reported.

Table 10: Outcomes and impacts reported by included maternal death reviews.

No	Review	Country/ Level	Outcomes	Impacts
1	Building US Capacity to Review and Prevent Maternal Deaths*, (CDC, 2018)	USA- Subnational	Informing policy, for example, for prevention initiatives, patient management for specific high-risk groups, and policies that improve the social and environment of women	Predicted to reduce MMR, and social inequalities
2	Confidential Enquiry into Maternal Deaths (Hodorogea and Friptu, 2014)	Moldova- countrywide	Clinical guidelines were developed based on the review's recommendations	Prevented future deaths
3	Confidential review of maternal Deaths in Kerala, (Paily et al., 2014)	India- one state	Health care staff trained, guidelines and protocols for managing obstetrics emergencies produced, referral transport improved, and essential drugs provided	Improved maternal health
4	Dumont et al., (Dumont et al., 2006)	Senegal- Subnational	The review process led to changes in the organisational structure which improved the life-saving interventions with a relatively large financial contribution from the community	Reduction in the overall maternal mortality
5	Dumont et al., (Dumont et al., 2013)	Senegal and Mali- Subnational	Onsite training based on the results of the audit.	Reduction in MMR
6	Maternal Death Surveillance and Response (Health, 2016)	Sierra Leone- countrywide	Training committee members on best practices for MDSR, refining the MDSR, community participation and involvement by engaging local leaders to integrate MDSR into the existing community structure, and integrating MDSR into the health system	
7	Maternal Death Surveillance and Response, (Umbeli et al., 2018)	Sudan- countrywide	Training and recruitment of village midwives, training of doctors and other health care providers on emergency obstetric care, availing of essential requirements for emergency obstetric care improvement in obstetric care in most states	

No	Review	Country/ Level	Outcomes	Impacts
8	Mothers and Babies: Reducing risk through Audits and Confidential Enquiries, (Knight, 2021)	The UK-nationwide	Numerous actions following the release of the reports, such as bridging knowledge gaps through open access e-learning modules and websites, improving or creating new guidelines for practice, and contributing to governments and national strategic plans	Maternal mortality declined steadily; reports highlight that due to the small numbers of maternal deaths the effect of the CE cannot be proven statistically
9	National Maternal Mortality Audit, (Committee, 2017)	Botswana-countrywide	Policy level changes, increases in human resources, such as training of skilled birth attendants	
10	Sayinzoga et. al, (Sayinzoga et al., 2016)	Rwanda-countrywide	Implementation of recommendations made on the management of obstetric complications, the availability of medicines and infrastructure, referral system, population sensitisation to positive health behaviours, human resources at the facility, and communication at different levels.	The implementation of the audit recommendations is likely to have contributed to the reduction in maternal mortality in the past few years [of the study]
11	Surveillance and Response system for maternal deaths in Sri Lanka, (Kapila and Deepthi, 2014)	Sri Lanka-countrywide	Informing clinical guidelines' development, capacity building of health personnel, and system changes, for example, developing a triage system and strengthening multidisciplinary care for critically ill pregnant women.	
12	The Confidential enquiries into Maternal Deaths in Malaysia, (Government of Malaysia, 2014)	Malaysia-countrywide	Improve reporting by encouraging active capture of maternal deaths and collaboration with the Department of Registration, training manuals for management of major causes of death are available and health care providers have more opportunity for training and updating skills, empowering midwives, identifying priority areas for targeted budget allocation, and revising key performance indicators to help ensure remedial action and improvements in care are sustained.	There is a changing trend in maternal deaths from direct obstetric causes towards indirect maternal deaths, indicating that remedial actions including training and quality of care improvements have had impact.
13	The confidential enquiry into maternal deaths in South Africa (Moodley et al., 2014)	South Africa-country level	Developing a reporting system for maternal death, and incorporating it into districts' health information system data to capture all maternal deaths, implementing a quality assurance programme in all health facilities, informing development of national guidelines and their dissemination, and developing training programmes on managing obstetric emergencies	Overall reduction in MMR
14	The Dutch Maternal Mortality Committee (Schutte et al., 2010a)	The Netherlands-countywide	Bridging identified knowledge gaps, for example, through lectures and case reports in the Netherlands Journal of Obstetrics and Gynaecology; informing updates in national guidelines.	The implementation of the recommendations and guidelines should lead to a decline in maternal mortality
15	The Perinatal and Maternal Mortality Review Committee, ((PMMRC), 2017)	New Zealand-countrywide	Regular multidisciplinary training in management of obstetric emergencies, improved communication between primary and secondary services, integrating maternal mental health services into maternity services, and informing the development of clinical guidelines for management of diseases.	

* For the USA the outcomes and impacts are the reported anticipated outcomes and impacts of the MDR

2.3.7 Logic model of well-functioning maternal death review

MDRs that reported on their outcomes and impacts i.e., completed the loop in the surveillance-response cycle (WHO, 2016c), were used to develop a logic model for well-functioning MDRs [N=15]- see Table 11. A logic model is "*a systematic and visual way to present and share understanding of the relationships among the resources used to operate a programme, the activities planned, and the changes or results the programme hopes to achieve*" (WK Kellogg Foundation, 2004). Logic models have traditionally been used by programme planners or evaluators to show how a programme achieves its intended goal- it is a "*picture*" of how a programme works. They are being increasingly used in systematic reviews to help capture the complexity of programmes/ interventions studied (Anderson et al., 2011).

Logic models includes inputs and activities that describe the programme, and outputs, outcomes and impacts that relate to the anticipated results. The terms are defined below using definitions from the logic development guide (WK Kellogg Foundation, 2004), with examples relevant to MDR:

- Inputs [Resources] are the human, financial, organisational, and community resources a programme has available to direct toward doing the work. For example, staff and funding.
- Activities are what the programme does with the resources available. They are the processes, tools, events, technology, and actions that are an intentional part of the programme implementation. These interventions are used to bring about the intended changes or results. For MDR, this could be identifying cases of maternal deaths through reporting or linking databases and collecting data on deaths using data collection tools.
- Outputs are the direct products of the activities and may include types, levels, and targets of services to be delivered by the programme. For example: levels of maternal mortality measured, or MMR calculated from deaths identified.

- Outcomes are the specific changes in programme participants' behaviour, knowledge, skills, status, and level of functioning. Short-term outcomes are attainable within 1 to 3 years while longer-term outcomes are attainable in 4 to 6 years. Here, these can be changes to clinical management guidelines or changes to the organisational structure of the health facility.
- Impacts are the fundamental intended, or unintended, change that occurs in organisations, communities, or systems because of programme activities. They usually happen within 7 to 10 years. Reducing maternal mortality and improving maternal health are the fundamental intended goals of MDR programmes

Table 11 illustrates the inputs and activities of a well-functioning MDR, its outputs, its short and long-term outcomes and impact. However, it should be recognised that MDR is not a linear process as the logic model depicts but rather a cyclical and dynamic process.

Table 11: Logic model for well-functioning maternal death reviews.

INPUTS	ACTIVITIES	OUTPUTS	OUTCOME	IMPACTS
Supportive policy such as making deaths notifiable Legal frameworks to enable the review activities Clear guidelines and protocols to standardise the process so each review is methodical, replicable and of high quality Trained personnel to perform the activities of the review Reporting system: routine or enhanced reporting Funding	Identification of maternal death through various sources Data collection on maternal death from various sources Reviewing maternal deaths by a multidisciplinary committee and involving all relevant people Production of a maternal death review report- an output of the review Providing feedback on maternal mortality for the relevant body Dissemination and/ or publishing of the report [outputs of the review] Advocate for utilisation of the outputs of the review process to inform policy and practice Evaluate the implementation of recommendations. Coordination between different process goals Refine the process	Measures maternal mortality Identifies causes and risk factors for maternal mortality Describes characteristics of the deceased women Assesses the quality of care provided to women Identifies lessons learnt and quality improvement opportunities Recommendations – involving other key stakeholders Evaluates the implementation of recommendations	Short term changes: • Self-reflection and continuous learning • Empowering local staff • Staff training • Health education [Health care system level] • Improved surveillance of maternal mortality • Integration of the MDR process into other maternal and reproductive health services • Improved data quality: documentation and collection • Improved resource allocation • Evidence-informed policy, budgets, programmes, and practice Long term changes: [Facility-level] • Structural or organisational changes • Improved resource allocation • Improved quality of care [Process related] • Refining the review process	Ending preventable mortality, morbidity, and disability. Improving maternal outcomes and quality of life Safe pregnancy and childbirth
Supportive environment from ministry level to review meetings at local levels [community or facilities]				

2.4 Discussion

This systematic review identified 97 published and unpublished studies and reports, representing 75 distinct maternal death review processes. Nine key features of MDRs were identified [see 2.3.4]. According to the identified key characteristics, four distinct types of MDRs emerged. Only a fifth of the MDRs identified reported outcomes and impacts, and they were used to develop a logic model that illustrates how MDRs operate to influence maternal mortality and maternal health in general.

2.4.1 Coverage and Timing

MDRs identified were widely distributed and were carried out in 49 countries- most of them low- and middle-income countries [LMICs]. Notably many MDRs took place after the year 2004, this may be because of WHO's recommendations for reviewing maternal deaths published in '*Beyond the numbers'* guidelines (WHO, 2004a). Additionally, the WHO and other developmental partners have supported governments to institutionalise MDR in their countries. A 2009 study that evaluated the implementation of MDR in Africa showed that MDR are increasingly used across countries (Pearson et al., 2009). This systematic review identified countries such as Ethiopia, Rwanda, Somalia, and others that established MDR after that evaluation study, indicating that more and more countries are implementing MDR. The WHO has similarly promoted the implementation of MDR in South East Asia and reviews were implemented in India, Myanmar, Nepal and Sri Lanka (Mathur et al., 2014). They reported that these countries have implemented MDR to varying degrees of coverage and quality.

According to the WHO's country profiles for MDSR implementation document, more countries than identified in this review have implemented some MDR approach (WHO, 2016c). However, they were not captured by the comprehensive search strategy possibly because countries might not publish or publicly report on their MDRs. It is important to note that while

most of the MDRs identified here were preceded by the WHO recommendations, the approaches used have been in practice for many years, for example, confidential enquiries (Knight, 2021, Walker et al., 1986), facility-based reviews (Olsen et al., 2002), and verbal autopsy (MacLeod and Rhode, 1998).

2.4.2 Quality of the included studies

MDRs were identified from the published literature and unpublished sources. The latter accounts for 15% of all the included MDRs. None of the MDRs accounted for secular changes, as a result it was not possible to assess their independent effect or attribute any reported change solely to MDR. Most of the studies that reported a MDR fulfilled three or more of the quality criteria detailed in the quality assessment tool- total of 7. Studies that reported on outcomes and impacts scored higher using the quality assessment criteria compared with all studies.

2.4.3 Key characteristics and types of studies identified

Four types were identified: comprehensive reviews of maternal deaths, reviews of facility-based maternal deaths, reviews of community-based maternal deaths, and reviews using linkage of CRVS. They aligned, to varying degrees, with the WHO recommended MDR approaches, MDSR, and the UK CEMD.

Type 1: Comprehensive maternal deaths reviews

The comprehensive MDRs aimed to provide complete and representative data on maternal death. Confidential enquiry [CE] and/or a combination of WHO approaches were commonly used. CEs have been in place in some European countries, Australia, New Zealand, and Canada for many years, and, more recently many LMICs have adopted them, such as Egypt, South Africa, India, and Malaysia. These MDRs reported having a clear leadership and high-level commissioning, data were available on deaths identified, a multidisciplinary committee carried

out the reviews, MDRs were carried in a non-threatening environment, committee concluded with recommendations, and these recommendations were then implemented and followed up.

Limitations faced by these MDRs include underreporting of maternal deaths albeit to varying degrees between countries. For example, in many LMICs, most maternal deaths reported came from hospitals while community maternal deaths were underreported. The presence of a well-functioning CRVS system can help identify community deaths that might be underestimated using community informants only. Furthermore, it can prove helpful in capturing deaths due to indirect causes that might be missed. Underreporting of deaths in early pregnancy was present, as some MDRs did not report any maternal deaths related to abortion.

To review all deaths countries like Botswana used a combination of facility based MDR and VA for community deaths (Committee, 2017). However, medical records were not supplemented with community data and vice versa, so the limitation of both approaches were not mitigated. This is of particular importance in countries where most deliveries take place in the community such as Sudan and Somalia- see Table 2. For Sudan's MDSR, underreporting of community, early, and indirect maternal deaths is a major issue. Facility deaths are reported to the MDR committee through focal persons, there is an assigned focal person in all major public hospitals across the country. However, similar arrangements in the community were not reported. In 2016, the committee identified 1,198 maternal deaths across the country, while the interagency estimation group estimated that there would be 4,100 maternal deaths in that year (WHO, 2019, MDSR, 2016). Despite the latter being an estimate only, the stark difference could indicate that community deaths may be grossly underestimated.

Type 2: Reviews of facility-based maternal deaths

These MDRs captured deaths that occurred in health facilities either following WHO recommended facility based MDR approach or used the UK CEMD approach modified for facilities. A key limitation for MDRs in this group was reliance on data abstracted from routine

sources without supplementation from other sources. Facility records would need to be of good quality, contain relevant and comprehensive information, be well formatted, and data would need to be easily identifiable (von Saint André-von Arnim et al., 2017). However, inadequate medical recordkeeping has been reported in some LMICs (Pirkle et al., 2012). Given that MDRs captured under this group, were only conducted in LMICs, poor record keeping can constitute a significant limitation. Furthermore, assessing the quality of clinical practice is difficult from medical records alone, as they tend to underestimate actual care provided (Shah et al., 2010). Using medical records as the only source to assess clinical practice might result in an overestimation of poor quality of care in maternal deaths. Thus, using multiple sources to investigate maternal deaths such as interviews, which were conducted in a non-threatening environment, with staff and routinely collected facility data has the potential to strengthen the validity of the reviews and the recommendations they produce.

The environment where MDRs are conducted is very important (Lusambili et al., 2019). The WHO recommends that facility based MDR should be non-anonymous, non-confidential and conducted in a non-recriminatory atmosphere to improve accountability (WHO, 2004a). When conducted adequately, the health practitioners involved would be more willing to cooperate in the subsequent corrective measures (De Brouwere et al., 2013, Gebrehiwot and Tewolde, 2014). However, details about the MDR's environment were commonly not reported, and some reviews were conducted in a confidential or an anonymous manner. This was likely done to overcome fear of penalisation that staff may have in settings where a non- recriminatory atmosphere was not present (Bain and Kongnyuy, 2018). Fear from litigation and medical malpractice was also reported (Melberg et al., 2020). The legal and ethical factors need to be optimised for adequate functioning of the MDR. For example, in South Africa, materials used for maternal deaths reviews cannot be used for litigation. Similar solutions are needed, at least initially, to improve transparency within MDR (Moodley et al., 2014).

This group of MDRs was limited to facility factors that contributed to death and reported on medical or organisational factors only. Consequently, data on community factors that could have contributed to the maternal death were not available. The WHO recommends collection of community-related data during admission or from relatives after the death, and that forms should capture wider social and environmental factors, which was not followed in most MDRs identified here (WHO, 2004a). One MDR that supplemented the facility-based MDR approach with data from the community found that community delays played a role in nearly two-thirds of the deaths compared with facility delays that contributed to about half of the deaths (Paul et al., 2011). Thus, more efforts are needed when conducting a facility based MDR to include community data.

Although these MDRs did not consistently report details on data collection, committee composition, review environment, and accountability issues, this was common in papers reporting audits of clinical practice that used existing records (Sarkar and Seshadri, 2014). The introduction of clear reporting guidelines have been recommended (Sarkar and Seshadri, 2014). This may be extended to the reporting of MDR using facility or hospital records to improve transparency and potentially assist in replication for future reviews.

Recent studies found that half of deaths in some developing countries still take place out of health facilities (Hanson et al., 2015). Thus, findings from facility based MDRs in such settings, may not provide a complete understanding of the magnitude of the problem. For example, they do not provide data on which groups in the population are at higher risk of dying. This limits the usability of their findings. Therefore, LMICs should not rely on facility based MDRs alone as their main approach to review maternal deaths and inform actions.

Type 3: Reviews of community-based maternal deaths

This type of MDRs captured deaths that were not captured in facility based MDR as well as those that occur outside the health sector. Several studies in LMICs showed large discrepancies

between MMR derived from hospitals and those based on community surveys (Horon, 2005, Adomako et al., 2016). There was no standard method of capturing deaths from the community, and the involvement of the communities' themselves in reporting varied substantially. The WHO recommends identifying community deaths through CRVS systems, where possible, or by an ongoing surveillance system (WHO, 2004a). However, MDRs of community deaths identified here were conducted in settings where CRVS systems were weak, and focal persons were tasked with reporting deaths of women in the reproductive age in the community. One MDR relied on the community's intrinsic motivation to prevent maternal deaths to ensure sustainability of the reporting (Bayley et al., 2015). However, the MDR did not detail how this was done in practical and scalable terms. Generally, the issues of underreporting maternal deaths highlight the need for more investments in health information systems in LMICs.

Quantitative and qualitative data were collected from those who were present around the time of death to capture medical and non-medical causes and risk factors. Medical causes identified through VA face a number of issues such as misclassification of cause of death and the over or under estimation of some causes of death (Menéndez et al., 2020, Chandramohan et al., 2001). Where possible, data from facilities should be used to ascertain medical risk factors and validate potential causes of death.

Social dynamics are important in this type of MDRs, as there might be a conflict of interest, for example, the family might not want to take responsibility for factors leading to death resulting in an underestimation of the role of family and community factors. This can further be exacerbated by the interpersonal power dynamics as the interviewers may represent the structure of the "Medical authority" (D'ambruoso et al., 2010, Gutschow, 2016). Recall bias can be an issue in determining the cause of death if the VA was used after a year from the death (Hussain-Alkhateeb et al., 2016). Data collectors need to be aware of the timing and setting when planning and conducting VA to minimise bias that could affect the reliability of the data.

Type 4: Reviews that use record linkage

Few countries can review maternal deaths using record linkage as this requires the presence of multiple high-quality data sources. However, the reliance on record linking alone to measure maternal mortality presents some challenges, such as trends being influenced by changes to the CRVS system and underreporting of maternal deaths. In these reviews, it is difficult to determine whether changes observed in maternal mortality levels or causes are because of improved identification of maternal deaths or because of changes in the risk factors. Additionally, underreporting is still present, for example, underreporting of early-pregnancy, abortion related or indirect deaths where the pregnancy status might have not been documented by providers. The UK CMED proposed the addition of a pregnancy box to death certificates. This will affect providers and contribute to more accurate official statistics. This addition has increased the number of maternal deaths detected (Horon and Cheng, 2011).

In these reviews, a multidisciplinary team reviewed the deaths to identify lessons learnt and to make recommendations. The use of multidisciplinary committees to review cases of maternal deaths helps in minimising interpretation bias that could happen if reviews were restricted to one group of specialists (Kallianidis et al., 2018). However, it is not clear if there were local MDR committees. Those involved in the care of women at the local level are those who are best positioned to comprehensively assess deaths and identify opportunities for prevention. Thus, opportunities for improvements can be lost if local MDRs are not carried out.

2.4.4 Logic Model for Maternal Death Reviews

MDRs that reported long-term effects on maternal mortality have provided robust and accurate data and analyses for maternal mortality and made recommendations for addressing issues identified. A well-functioning MDR must have clear guidelines, scope of practice, and a defined structure of the committee. MDR committees should have broad representation and

involve all care providers in the review process to mitigate interpretation and representation biases and to make appropriate recommendations. Furthermore, they require a supportive environment, access to high quality relevant data, logistical and legal support, and funding to carry out their activities. Committee members must be competent to review cases and derive lessons in a team without fear of punishment. Data and recommendations are disseminated to key stakeholders such as mothers and families, practitioners, and policy makers.

Political and other leadership buy-in is imperative for the adoption of the review's recommendations and action plans, such as the adoption of policy and organisational/ structural changes to the health system, and adoption of evidence-informed guidelines. The consistent implementation of these evidence-based changes will over time lead to better care provided to women throughout pregnancy and the post-partum period.

It is important to note that challenges hampering "full-functioning" of MDR can vary substantially between countries and sometimes within in a single country. Thus, this systematic review informed logic model is intended to serve as a general guide for the design, implementation, evaluation, or refinement of other MDRs worldwide.

2.4.5 Strengths and limitations of this systematic review

This systematic review aimed to identify MDR carried out around the world, so wide inclusion criteria and multiple databases were used. No language, location, or timeframe restrictions were applied. Furthermore, an extensive grey literature search strategy was used. To minimise selection bias inclusion criteria were clearly defined, abstracts and full texts were screened by two reviewers, and a quality assessment tool was used. Reviews from developing and developed countries were used to synthesise the logic model increasing its generalisability and applicability.

Despite carrying out extensive searches, a number of reviews might have been missed since many countries do not publish their reports or their reports were not available online.

Misclassification is another possibility specifically for reviews published prior to the WHO guidelines as there was no standardised terminology for MDR. A meta-analysis was not feasible because quantitative data were limited and because of the heterogeneity of the studies included.

2.4.6 Conclusion

The implementation of MDR is commonplace worldwide. This systematic review highlighted gaps in the conduct and reporting of MDRs. The WHO recommended MDR approaches are widely used either in isolation or in combination. There are shared challenges facing MDRs: underestimating of maternal deaths in the community, early pregnancy maternal deaths, and those from indirect causes; the quality and breadth of data used; MDR specific competencies; MDR environment; and ethical and legal frameworks. These challenges require systematic and contextual solutions. As LMICs are transitioning from maternal death review to maternal death surveillance and response, studies, and reports of MDR/ MDSR should endeavour to document short, medium, and long terms outcomes. Achieving such outcomes requires the involvement and communication between all maternal health providers and other stakeholders.

This systematic review did not identify any MDR that targets skilled or trained providers working in out-of-facility settings that can be adapted for use in Sudan. Thus, the logic model of fully functioning MDR was developed to guide the optimisation of MDSR in Sudan. The next two chapters will further justify the inclusion of community-level maternal health providers in MDSR in Sudan.

3 Trends in birth attendance and facility births in Sudan from 2006 to 2014.

3.1 Chapter Introduction

Evidence from observational studies and historical analyses shows an inverse correlation between coverage of skilled birth attendants [SBA] and maternal mortality ratio [MMR] (De Brouwere et al., 1998, Van Lerberghe and De Brouwere, 2001, Fretheim and Hviding, 2008, Girum and Wasie, 2017, Alvarez et al., 2009). Thus, the WHO deems access to a SBA at childbirth as the most critical intervention to improve maternal survival (WHO, 2004b).

Improving access to skilled birth attendance through increasing the number of skilled providers has been a key strategy for improving maternal survival in Sudan (FMoH, 2012a). The number of personnel providing maternal health services increased from 5,979 in 1990 to 15,297 in 2018 (FMoH, 1990, FMoH, 2018). Over the same period, Sudan Household Survey data indicate that the proportion of births attended by skilled personnel, increased from 68.5% to 77.5% (FMoH, 1991, CBS, 2016). These investments have likely contributed to improvements in maternal health.

The aim of this chapter corresponds to thesis objective 3 that is to investigate trends in birth attendance and place in Sudan using data from three Sudan Household Surveys [2006-2014]. The specific chapter objectives are: [1] to describe birth attendance and place of birth for women in Sudan per survey year, [2] to investigate the trends in childbirth attendance in Sudan between 2006 and 2014, overall and by place of birth, and [3] to investigate the trends in place of childbirth in Sudan between 2006 and 2014.

3.2 Methods

3.2.1 The Sudan Household Survey/ Multiple Indicator Cluster Survey: An Overview.

This analysis used data from the Sudan Household Survey [SHHS], a national cross-sectional survey, and a modified version of the Multiple Indicator Cluster Survey [MICS] designed by UNICEF and other partners (UNICEF, 2020). The MICS was first conducted in Sudan in 1995 and it was changed to the SHHS in 2006, then back to MICS in 2014. The survey will be referred to as SHHS throughout this chapter. It had three rounds to date: the first in 2006, the second in 2010, and the third in 2014 (Central Bureau of Statistics and UNICEF, 2016). The recent political unrest in Sudan likely delayed the fourth survey round that is now expected to take place in 2021.

In preparation for each survey round, a comprehensive sampling frame was compiled using up-to-date census data and supplemented, where available, with additional sources. Surveys used a two-stage stratified clustered sampling method where, the sample was stratified by state and then by urban and rural area. In the first stage, forty clusters were selected from each stratum with probability proportional to the cluster's size. For the second stage, a household listing was carried out within each cluster and a sample of 25 households was drawn. In total, one thousand households were sampled from every state (CBS and UNICEF, 2016, FMoH, 2012b, FMoH, 2007). The sample for each state is, thus, self-weighting, but the total sample for Sudan is not self-weighting since a fixed sample of households was drawn from each state irrespective of its population size. Therefore, weights for the data were calculated by the SHHS team based on the selection probabilities. Table 12 compares the sample and survey methodology for each survey round.

The anonymised datasets for the 2010 and 2014 survey years are freely accessible online through the UNICEF website: http://mics.unicef.org/surveys. The 2006 survey dataset is not available online and was obtained from the Federal Ministry of Health.

Table 12: Sample and survey methodology for Sudan Household Surveys in 2006, 2010, and 2014.

SURVEY ROUND [YEAR]	FIRST [2006]	SECOND [2010]	THIRD [2014]
Number of states	15	15	18
Clusters per state	40	40	40
Households per cluster	25	25	25
Enumeration lists sources	The 1993 census data	The 2008 census data	The 2008 census data
Household listing	N/A	N/A	Field visits to enumeration areas
Household sampled	15,000	15,000	18,000
Overall response rate	98.1%	98.0%	98.0%
Women's response rate	92.9%	92.8%	89.9%
Populations excluded from the sampling frame	Populations living in institutions such as hospitals, military bases, and prisons		

Source: (CBS and UNICEF, 2016, FMoH, 2012b, FMoH, 2007)

3.2.2 Study population

Data from the 2006, 2010, and 2014 surveys were used. Each survey has five different sets of questionnaires: the household, the women, the children under the age of five, the community, and the food security questionnaire. For this analysis, the women and household questionnaires from each survey year were merged to ensure the use of all women's data. Questions about conception and childbirth were not asked to all women of the reproductive age [15-49 years]; only married women were asked -except in the 2006 survey that was used in Sudan and South Sudan women who lived with a man were also asked. In the 2006 survey, only 28 [0.15%] unmarried women reported living with a man in Sudan. The implication of this exclusion is discussed in the strengths and limitations section of the discussion. Women who were asked about the outcome of interest were women of the reproductive age, were either currently married or previously married, and whose most recent childbirth was in the last two years before the survey interview. Figure 7 illustrates how the final study population was derived.

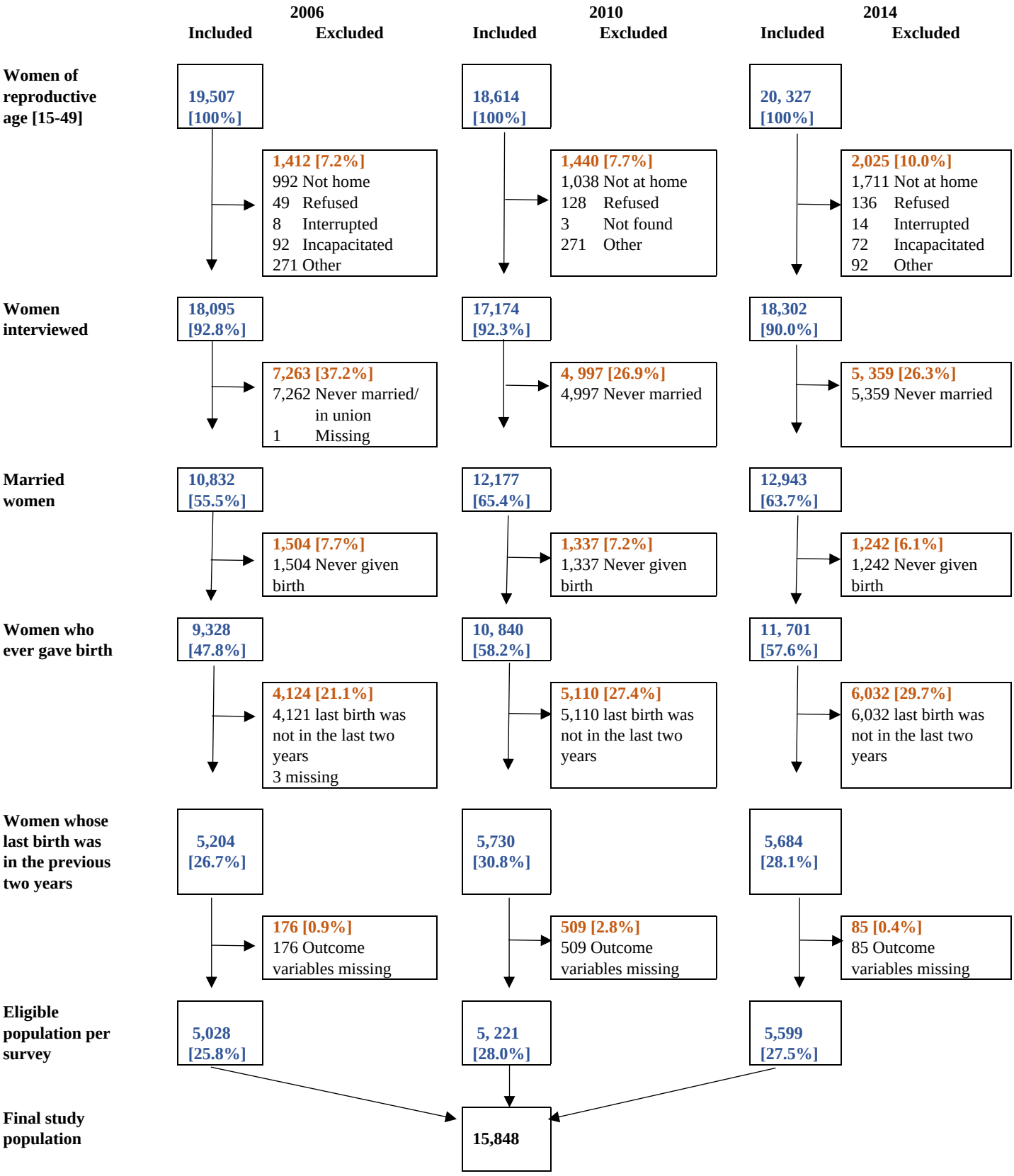


Figure 7: The derivation of the final study population.

Denominator for all percentages is the number of women in reproductive age for that survey year.

A total of 5,204 women in 2006, 5,730 women in 2010, and 5,684 women in 2014 were eligible, but outcome data were missing for 176, 509, and 85 women, respectively. Given the small numbers of missing data in each year, differences in the characteristics of women for whom outcome data were present and for whom they were missing were not expected. Nonetheless, differences explored using a Chi squared test analysis for each survey year [Appendix H]. No systematic differences were identified between each variable and the missing and non-missing outcome groups.

3.2.3 Study outcomes

Place of birth. The following question was used: '*Where did you give birth to your last child/ completed pregnancy?"*. Answers [a] and [b] below were coded as home birth, and answers [c] through to [i] as health facility birth.

a. *Respondent's home*
b. *Other, home*
c. *Government Hospital*
d. *Primary Health Care Centre*
e. *Primary Health Care Unit*
f. *Other, public*
g. *Private hospital*
h. *Private clinic*
i. *Other, private*

Birth attendants. Two outcome variables were generated for birth attendants –described below- using the following question "*Who assisted with the delivery of your last child/ completed pregnancy?*"

a. *Doctor*
b. *Nurse/ midwife*
c. *Trained/ certified midwife*
d. *Health visitor*
e. *Medical assistant*
f. *Traditional birth assistant*
g. *Community health worker*
h. *Relative/ friend*

The question indicates the person who assisted in the birth of the last child. Initially, a binary variable [attendant_1] informed by the classification used by SHHS was created. Answers [a] to [e] were considered as skilled birth attendants and answers [f] to [h] were considered as traditional birth attendants. However, the results from the qualitative study [Chapter 5] suggest that trained/ certified midwives do not fulfil the international definition of a SBA and it would, therefore, be inappropriate to combine them. In view of these findings, a categorical variable [attendant_2] was generated. Answers [a, b, and d] were coded as skilled birth attendant, [c] and [e] as trained birth attendant, and [f] to [h] as other birth attendant.

In 1,585 [10%] births, more than one attendant was present, these births were coded as attended by the most qualified attendant present. For example, if a birth was attended by a traditional attendant and a skilled provider, it was coded as attended by a skilled provider.

Combining birth attendance and place of birth: Birth setting. This dummy variable was generated to provide a comprehensive picture of the distribution of care during childbirth. Given that there are two birth attendant variables, two birth setting variables were generated:

- Place of birth variable and birth attendant variables [attendants_1] that is classified as per SHHS guidance were combined to generate the variable [birthsetting_1]. It had three plausible combinations: health facility birth attended by a skilled provider coded as 1, home birth attended by a skilled provider coded as 2, and home birth not attended by a skilled provider coded as 3.
- This was repeated using the birth attendant variable classified as per results from the qualitative study [attendants_2] to generate the dummy variable [birthsetting_2] that had five plausible combinations: health facility birth attended by a skilled provider coded as 1, health facility birth attended by a trained provider coded as 2, home birth attended by a skilled provider coded as 3, home birth attended by a trained provider coded as 4, and home birth not attended by a skilled or a trained provider coded as 5.

A total of 29 [0.18%] of the facility births were not attended by a skilled or trained provider: 17 were attended by a traditional birth attendant, 3 by a community health worker, 2 by other person not a health professional, 6 were unattended and one was undetermined. These 29 observations were excluded from the final dataset.

3.2.4 Potential confounders

A recent systematic review that identified factors influencing the utilisation of maternal health services in low- and middle- income countries [LMICs] informed the choice of the explanatory variables (Banke-Thomas et al., 2017). Although the systematic review focused on adolescent mothers, its findings were used to investigate factors associated with health service utilisation in mothers of all ages in several studies in LMICs (Bhattarai, 2019, Kifle et al., 2018). Therefore, it was thought to be suitable for use in this study.

Variables predicting maternal health services utilisation that were available in the SHHS dataset were maternal age, wealth index, mother's education, parity/ birth order, place of residence, use of antenatal care, and pregnancy's status [wanted/ unwanted]. The variables identified from the systematic review and their availability in the Sudan household survey are listed in Appendix I.

To guide conceptualising the relationship between the survey year, potential confounders and the outcome, the Andersen and Newman Framework of Health Services Utilisation model was used [Figure 8] (Andersen and Newman, 1995). Modified versions of the framework have been used recently to investigate the drivers of maternal health service utilisation in Sudan, South Sudan, and Ethiopia (Tesfaye et al., 2018, Mugo et al., 2016, Mustafa and Mukhtar, 2015).

According to the framework, an individual's access to and use of health services are affected by: [1] **Predisposing factors:** these are the sociocultural characteristics of the individuals that exists prior to the illness such as, social structures, health beliefs, and

demographics; [2] **Enabling factors:** these refer to the logistical aspects of obtaining care whether personal or from the family, from the community or other possible additions; [3] **Need factors:** this is the most immediate cause of health services use, from functional and health problems that generate the need for health care services. Variables available in the data and aligned with the framework were included in the study. Table 13 describes the variables included, their definition, and coding.

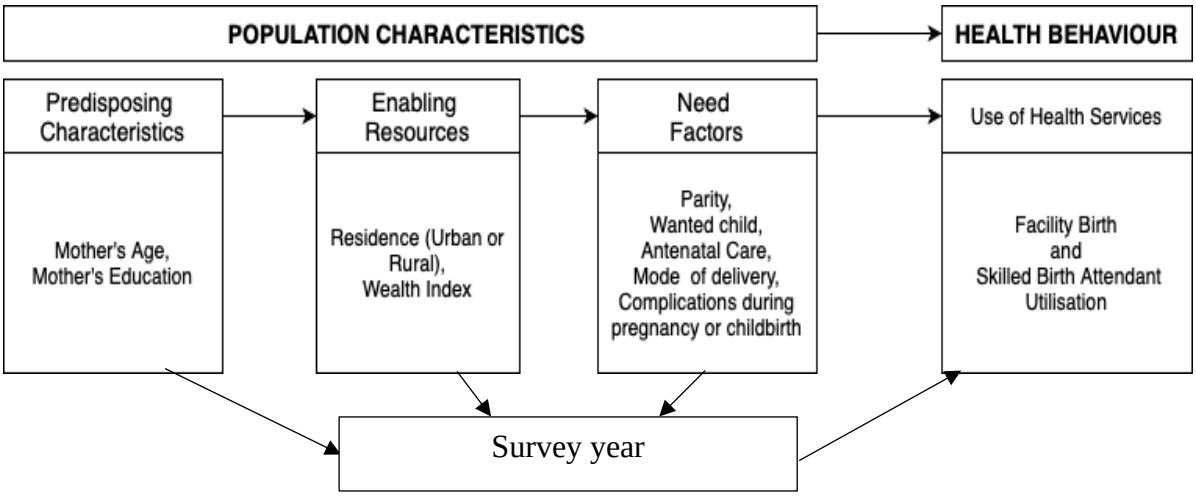


Figure 8: A modified Anderson-Newman framework for service utilisation in Sudan (Andersen and Newman, 1995).

Table 13: Explanatory variables for childbirth care utilisation, their operational definitions and coding.

Classification	Variable	Operational definition	Coded as
Predisposing characteristics	Mother's age	Completed woman's age in years at the time of the interview	Five-year bands [15-, 20-, 25-, 30-, ≥35]
	Mother's education	Formal schooling status starting from attending elementary school	No formal education, primary school, secondary school, and tertiary education or above.
Enabling resources	Wealth index	Generated from other variables [household assets ownership, household characteristics and access to utilities] from the dataset using factor analysis.	Quintiles with first being the poorest and fifth being the richest.
	Place of residence	The area where the woman lives	Urban or Rural
Perceived need	Pregnancy status [wanted/ not wanted]	Whether the last pregnancy was planned or not	Yes or no
	Use of antenatal care [ANC]	Did the woman see anyone for antenatal care during the last pregnancy?	Yes or no
	Birth order/ Parity	Birth order of the last child [also the number of children the woman has had at the time of the survey]	First, second – fourth, and five or more
	Mode of delivery	How was the last child delivered?	Vaginal delivery or Instrumental or Caesarean section.
	Pregnancy complications	Excessive vaginal bleeding/ very high fever/ convulsions [not from fever]/ jaundice	Yes or no
	Labour complications	Prolonged labour lasting more than 12 hours/ excessive vaginal bleeding/ very high fever/ convulsions	Yes or no

3.2.5 Statistical Methods

Prior to commencing analyses, data were cleaned separately for each survey round to ensure that there were no implausible values or outliers. The variables were recoded to achieve consistency in coding between the datasets. A "*surveyyear*" variable was generated to denote the survey round and the datasets were appended. Potential confounders not captured in all three years were described but were not included in the analyses. Only three variables had missing data, and it ranged between 0.08% to 0.2% of the women. All the main analyses accounted for the stratified, clustered nature of the data, and all proportions and ratios were

adjusted for the sampling design. All statistical analyses were conducted using Stata version 15, SE.

For each explanatory variable, summary statistics were calculated for the 2006, 2010, and 2014 survey rounds, and a chi-squared test for trend with one degree of freedom was used to assess change across the survey years. Then, pairwise correlation coefficients between explanatory variables were calculated to identify issues of collinearity; none were identified [Appendix J]. The weighted proportions and their 95% confidence intervals for distribution in facility birth and the utilisation of skilled birth attendants were calculated for the 2006, 2010, and 2014 survey years. A chi-squared test for trend with one degree of freedom was carried out to assess the statistical significance of a trend.

Multivariable logistic regression was used to investigate the trends in facility births, the utilisation of birth attendants, and the utilisation of birth attendants in communities and facilities. The trend analyses were carried out using the two birth attendants' classifications, to provide a more robust basis for comparison and for subsequent recommendations. First, I calculated crude odds ratio and their 95% confidence intervals for the association between survey year and the outcome variable. Then, to determine the variables to be included in the multivariable model, the association between each potential confounding variable and the outcome variable was investigated in a univariable model. All variables that were either statistically significantly associated with the outcome variable at $P < 0.1$ at the univariable stage or were theoretically important were included in the multivariable model.

Next, a forward model building strategy was used: the outcome and variable survey year as a categorical variable were fitted, this was followed by adding the population characteristics in groups, starting with the predisposing factors, then enabling factors, and the need factors as per the Anderson and Newman framework to examine the level of confounding by each group. After the addition of the groups, variables with Wald tests p value of > 0.05

were removed from the model. Categorical variables were kept in the model if they had at least one significant Wald test [i.e., if any category level such as “no education” differed significantly from baseline “primary education”]. An interaction term between wealth and education was identified a priori and was fitted into the model.

Lastly, the final model’s goodness-of-fit was assessed using a modified Hosmer-Lemeshow test that is appropriate for clustered data. Power calculation for all outcome variables were performed using eligible participants from the three survey years for the respective outcomes. The calculations identified the range of odds ratios that the analysis was adequately powered to detect i.e., had 80% or more power [Appendix K].

3.3 Results

3.3.1 The distribution and change in the characteristics of women: 2006-2014.

Table 14 shows the distribution of key characteristics of women, and the change in these characteristics in Sudan from 2006 to 2014. A total of 15,848 women were included. In all survey years, most women were between 25 and 29 years of age, had no formal education, lived in rural areas, had from 2 to 4 children, and their last childbirth was a vaginal birth.

Between 2006 and 2014, the proportion of women who were 35 years and older increased from 19.6% to 23.2%, while that of women who were younger than 20 years decreased [P <0.0001]; the proportion of women who completed secondary education or above increased from 18.6% to 24.4%, while that of women who had no formal education declined [P= 0.0003]; the proportion of women whose last childbirth was their fifth or more increased from 33.6% to 40.4% [P <0.0001]; the proportion of instrumental deliveries, forceps or ventose, or a Caesarean section increased from 6.8% to 9.3% [P =0.02].

Table 14: Distribution and change in the characteristics of women, per survey year, using Sudan Household Survey for 2006, 2010, and 2014.

	SURVEY YEAR 2006		SURVEY YEAR 2010		SURVEY YEAR 2014		
[N]	**5,028**		**5,221**		**5,599**		
Variables	**N**	**[% [95%CI]]**	**N**	**[% [95%CI]]**	**N**	**[% [95%CI]]**	**P value**
Mother's age, years							
15-19	470	8.3 [7.3-9.5]	373	7.5 [6.7-8.4]	393	6.8 [6.0-7.7]	<0.0001
20-24	1,137	22.5 [21.0-24.1]	1,180	23.0 [21.6-24.5]	1,133	20.0 [18.6-21.5]	
25-29	1,441	28.6 [26.9-30.4]	1,489	29.0 [27.5-30.6]	1,606	28.8[27.2-30.3]	
30-34	1,016	21.0 [19.5-22.5]	942	17.0 [15.7-18.2]	1,184	21.2 [19.9-22.7]	
35+	964	19.6 [18.1-21.3]	1,237	23.6 [22.2-25.1]	1,283	23.2 [21.8-24.7]	
Mother's education							
None	2,650	49.8 [46.7-52.9]	2,576	47.3 [44.0-50.5]	2,476	39.9 [36.6-43.3]	0.0003
Primary	1,599	31.6 [29.3-34.0]	1,683	33.1 [30.9-35.5]	1,927	36.1 [33.5-38.7]	
Secondary	608	14.2 [12.2-16.4]	724	14.4 [12.7-16.2]	851	16.7 [15.0-18.6]	
Tertiary or above	171	4.4 [3.4-5.7]	238	5.3 [4.2-6.6]	344	7.3 [6.0-8.9]	
Missing	-	-	-	-	1	-	
Area of residence							
Rural	3,561	64.2 [60.0-68.3]	3,740	73.0 [68.7-76.8]	4,121	73.5 [69.6-77.2]	0.009
Urban	1,467	35.8 [31.7-40.1]	1,481	27.0 [23.2-31.3]	1,478	26.5 [22.9-30.4]	
Wealth index							
First [Poorest]	507	10.4 [8.7-12.2]	1,096	23.7 [20.7-27.0]	1,223	22.3 [19.1-25.9]	<0.0001
Second	1,012	19.2 [17.3-21.2]	1,208	21.8 [19.7-24.1]	1,507	21.8 [19.4-24.4]	
Third	1,451	26.5 [24.5-28.7]	1,238	21.6 [19.5-23.9]	1,272	21.2 [18.7-23.9]	
Fourth	1,288	25.2 [22.8-27.7]	1,002	19.6 [17.2-22.2]	903	19.5 [16.4-23.1]	
Fifth [Richest]	770	18.8 [16.2-21.5]	677	13.3 [11.0-15.9]	694	15.2 [12.7-18.1]	
Number of Children							
1	1,050	19.9 [18.3-21.4]	946	18.5 [17.1-19.8]	906	16.1 [14.9-17.4]	<0.0001
2-4	2,299	46.6 [44.7-48.5]	2,312	44.9 [43.3-46.4]	2,426	43.5 [41.8-45.2]	
5+	1,679	33.6 [31.9-35.4]	1,963	36.7 [35.1-38.3]	2,267	40.4 [38.6-42.2]	
Wanted last child							
Yes	-	-	4,371	83.0 [81.5-84.4]	4,541	80.4 [78.5-82.1]	0.3
No	-	-	850	17.0 [15.6-18.5]	1,049	19.5 [17.8-21.4]	
Missing	-	-	-	-	9		
Mode of delivery							
Vaginal delivery	4,733	93.2 [91.7-94.4]	4,854	92.7 [91.4-93.7]	5,099	90.7 [89.3-91.9]	0.02
Instrumental/ CS	295	6.8 [5.6-8.3]	358	7.2 [6.2-8.5]	498	9.3 [8.1-10.7]	
Missing	-	-	9	0.1 [0.07-0.3]	2	-	
Any antenatal care use							
Yes	3,985	81.9 [79.8-83.7]	4,144	79.7 [77.6-81.7]	4,555	80.7 [78.1-83.1]	0.5
No	1,038	18.2 [16.3-20.2]	1,077	20.3 [18.3-22.4]	1,043	19.3 [16.9-21.9]	
Missing	5		-		1		
Antenatal complications [a]							
Yes	2,165	43.6 [41.2-45.9]	2,018	40.1 [37.7-42.6]	-	-	0.06
No	2,851	56.3 [53.9-58.6]	3,184	59.7 [57.2-62.0]	-	-	
Missing	12	0.2 [0.01-0.4]	19	0.2 [0.1-0.5]	-	-	
Labour Complications [b]							
Yes	2,105	43.2 [40.8-45.5]	1,990	39.0 [36.8-41.3]	-	-	0.02
No	2,918	56.7 [54.4-59.1]	3,215	60.8 [58.5-63.0]	-	-	
Missing	5	0.08 [0.03-0.2]	16	0.2 [0.1-0.4]	-	-	

%: weighted proportions of women, Dash: the variable was not available in that survey round, P value: A chi-squared statistic test for trends. [a] Pregnancy complication: excessive vaginal bleeding, high fever, convulsions -not from fever, and jaundice. [b] Labour complications: prolonged labour, excessive vaginal bleeding, high fever, and convulsions -not from fever.

3.3.2 The distribution and change in facility births: 2006- 2014.

Table 15 presents the proportions and 95% CI for facility births per survey year. Less than a third of births took place at a health facility in each survey year, but the proportion of health facility births increased between 2006 and 2014 from 21.2% [95%CI: 18.5-24.3] to 28.1% [95%CI: 25.2-31.1] P = 0.002.

Table 15: Facility births in Sudan, by Sudan Household Survey year 2006, 2010, and 2014.

	Survey year 2006		Survey year 2010		Survey year 2014		
	N	[% [95%CI]]	N	[% [95%CI]]	N	[% [95%CI]]	P value
Place of birth							
Health facility	891	21.2 [18.5-24.3]	1,169	22.4 [20.0-24.9]	1,431	28.1 [25.2-31.1]	0.002
Home birth	4,137	78.8 [75.7-81.5]	4,052	77.6 [75.1-80.0]	4,168	71.9 [68.9-74.8]	

Percentages and their 95% confidence intervals are presented.

3.3.3 The distribution and change in birth attendance, using two classifications: 2006- 2014.

For comparison purposes, the distribution of and change in birth attendance is presented first using the variable [attendant_1], which is informed by the SHHS classification, then using the variable [attendant_2], which is informed by the results of the qualitative study. Table 16 shows the distribution of birth attendants using the two classifications.

Table 16: Birth attendants in Sudan using two classifications, by Sudan Household Survey year 2006, 2010, and 2014.

	Survey year 2006		Survey year 2010		Survey year 2014		
	N	[% [95%CI]]	N	[% [95%CI]]	N	[% [95%CI]]	P value
Birth attendant [1]							
Skilled birth attendant	3,421	68.9 [65.7-72.0]	4,036	77.8 [74.2-80.9]	4,275	78.3 [75.0-81.3]	0.0001
Other	1,607	31.1 [28.0-34.3]	1,185	22.2 [19.1-25.8]	1,324	21.7 [18.7-25.0]	
Birth attendant [2]							
Skilled birth attendant	1,555	32.6 [28.6-37.1]	1,278	24.1 [21.1-27.4]	1,145	22.8 [20.0-26.0]	<0.0001
Trained birth attendant	1,866	36.3 [33.7-38.9]	2,758	53.7 [50.7-56.6]	3,130	55.5 [52.4-58.6]	
Other	1,607	31.1 [28.0-34.3]	1,185	22.2 [19.1-25.8]	1,324	21.7 [18.7-25.0]	

Percentages and their 95% confidence intervals are presented.

When using SHHS classification, over two-thirds of all births were attended by a skilled birth attendant in all survey years, and the proportion of births attended by a skilled provider increased from 68.9% [95%CI: 65.7%- 72.0%] in 2006 to 78.3% [95%CI: 75.0%- 81.3%] in 2014. By contrast, when using the classification informed by the qualitative findings the results change markedly, most births were attended by a trained birth attendant in all survey years and the proportion of births attended by a skilled provider decreased from 32.6% [95%CI: 28.6%- 37.1%] in 2006 to 22.8% [95%CI: 20.0%- 26.0%] in 2014.

3.3.4 Birth setting: combining birth attendance and place of birth

Birth setting informed by the SHHS classification- Figure 9: Between 2006 to 2014, there was an increase in the proportion of births attended by a skilled provider at health facilities from 20.8% to 28.0% and at home from 48.2% to 50.3%.

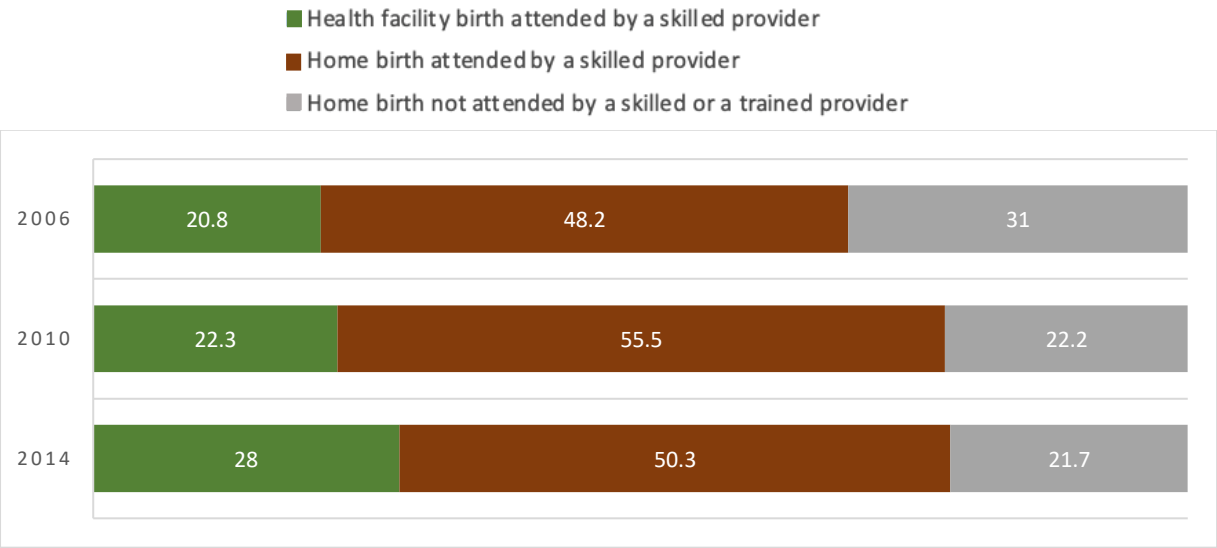


Figure 9: Distribution and change in birth setting using Sudan Household Survey classification, Sudan, 2006-2014.

Birth setting classification that is informed by the findings from the qualitative study- Figure 10: Between 2006 and 2014, births attended by skilled providers increased in facilities from 17.7% [95%CI: 15.3%-20.4%] to 20.0% [95%CI: 17.6%-24.4%], but it decreased five-

folds in the community from 15.0% [95%CI: 13.4%-16.9%] to 3.0% [95%CI: 2.3%-3.7%]. Births attended by trained providers increased both at facilities from 3.2% [95%CI: 2.3%-4.4%] to 8% [95%CI: 6.9%-9.4%] and in the community from 33.2% [95%CI: 30.8-36.0%] to 47.3% [95%CI: 44.5%-50.5%]. Services in health facilities were mainly provided by the skilled providers but the proportions of trained providers have also increased in the health facilities across the years. The overall decrease in births attended by skilled providers was mainly driven by a decrease in services provided by the skilled birth attendants in the community.

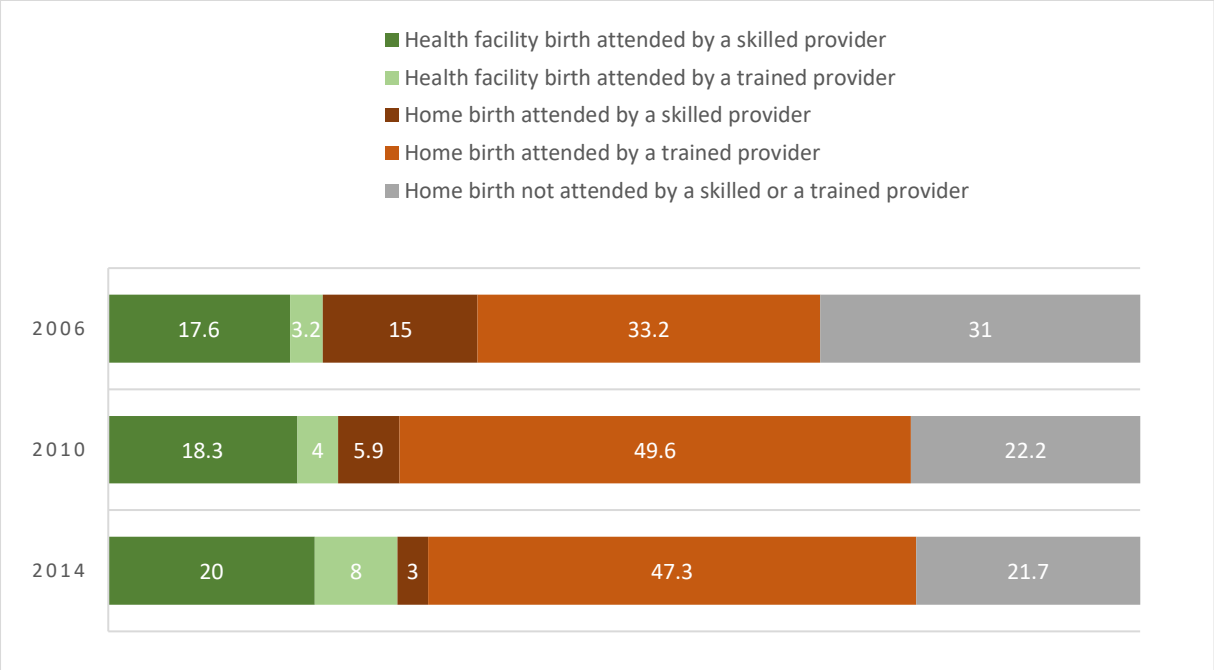


Figure 10: Distribution and change in birth setting using the classification based on the qualitative study findings, Sudan, 2006-2014.

Sections 3.3.3 and 3.3.4. show that the two outcome variables vary substantially. Therefore, trend analyses using the definition informed by the qualitative study are expected to produce different results compared with those using the SHHS definition. Given that the SHHS based definition is the one used in government reports, the next sections will present analyses using both outcomes to provide robust results of the extend of such differences and to form a strong basis for recommendations.

3.3.5 Trends in facility births: 2006- 2014.

In 2014, compared with 2006, and prior to adjusting for confounders women were 45% more likely to give birth at a health facility than at home [Unadjusted odds ratio [OR]: 1.45; 95%CI: 1.15-1.81; P= 0.002]. The odds ratio more than doubled after adjusting for confounders [adjusted odds ratio [aOR]: 2.07 95%CI: 1.61- 2.66; P <0.0001], see [Table 17].

Table 17: Unadjusted and adjusted odds ratios for trends in facility births from 2006 to 2014.

Outcomes	Unadjusted Odds Ratio [95%CI]	P value	Fully adjusted [a] Odds Ratio [95%CI]	P value
Trends in facility births [vs home births]				
2006	1.0 [baseline]	0.002	[baseline]	<0.0001
2010	1.07 [0.85-1.34]		1.73 [1.35-2.24]	
2014	1.45 [1.15-1.81]		2.07 [1.61-2.66]	

[a] adjusted for age at the time of survey, age at marriage, education, antenatal care utilisation, wealth score, parity, and mode of delivery

3.3.6 Trends in births attendants: 2006- 2014.

Using the SHHS classification, women were 63% more likely to give birth attended by a skilled provider in 2014 compared to 2006 prior to adjusting for confounders [OR: 1.63; 95%CI: 1.28-2.07; P <0.0001]. The odds ratio increased following adjustment for confounders [aOR: 2.12; 95%CI: 1.67-2.69; P <0.0001].

When the classification informed by the qualitative study was used, it showed that contrary to the previous classification, women were 39% less likely to give birth with a skilled birth attendant in 2014 compared to 2006, prior to adjustment for confounders [OR: 0.61; 95%CI: 0.50-0.74; P <0.0001], and were 54% less likely to give birth with a skilled birth attendant over the same period following adjustments for confounders [aOR: 0.46; 95%CI: 0.37-0.56; P <0.0001]. Additionally, it showed that women had about twice the odds of having a trained provider present at birth in 2014 than in 2006 compared to other providers prior to and after adjusting for confounders. Results are shown in Table 18.

Table 18: Unadjusted and adjusted odds ratios for trends in skilled birth attendants from 2006 to 2014 using two different classifications.

Outcomes	Unadjusted Odds Ratio [95%CI]	P value	Fully adjusted [a] Odds Ratio [95%CI]	P value
Sudan Household Survey classification				
Skilled Birth Attendant [vs traditional birth attendants]				
2006	[baseline]	<0.0001	[baseline]	<0.0001
2010	1.58 [1.23-2.02]		2.63 [2.06-3.37]	
2014	1.63 [1.28-2.07]		2.12 [1.67-2.69]	
Qualitative study informed classification				
Skilled Birth Attendant [vs trained and traditional birth attendants]				
2006	[baseline]	<0.0001	[baseline]	<0.0001
2010	0.66 [0.54-0.80]		0.70 [0.58-0.85]	
2014	0.61 [0.50-0.74]		0.46 [0.37-0.56]	
Trained birth attendants [vs skilled and traditional birth attendants]				
2006	[baseline]	<0.0001	[baseline]	<0.0001
2010	2.03 [1.72-2.39]		1.92 [1.61-2.30]	
2014	2.19 [1.85-2.59]		2.19 [1.82-2.63]	

[a] adjusted for age at the time of survey, age at marriage, education, antenatal care utilisation, wealth score, parity, and mode of delivery

3.3.7 Trends in births attendants at health facilities: 2006- 2014.

This analysis was not possible using the SHHS informed birth attendant variable because all providers in health facilities were considered skilled. Results are available for the variable informed by the qualitative study [see Table 19]. Compared to 2006 and prior to adjusting for confounders, women who gave birth in facilities in 2014 were 50% less likely to be attended by a skilled provider compared to a trained provider [OR: 0.50; 95%CI: 0.37-0.72; P <0.0001]. After adjustments for confounders, there was no substantial change in the ORs.

Table 19: Unadjusted and adjusted odds ratios for trends in skilled birth attendants in health facilities from 2006 to 2014.

Outcomes	Unadjusted OR [95%CI]	P value	Fully adjusted[a] OR [95%CI]	P value
QUALITATIVE STUDY INFORMED CLASSIFICATION				
Trends in skilled birth Attendance at the health facility [vs trained birth attendants][c]				
2006	[baseline]	<0.0001	[baseline]	<0.0001
2010	0.91 [0.62-1.34]		1.01 [0.67-1.52]	
2014	0.50 [0.35-0.72]		0.45 [0.31-0.65]	

[a] adjusted for age at the time of survey, age at marriage, education, antenatal care utilisation, wealth score, parity, and mode of delivery.

3.3.8 Trends in birth attendants in the community: 2006- 2014.

Using the SHHS classification showed that in 2014, compared with 2006, and prior to adjusting for confounders and compared with traditional birth attendance, women were 52% more likely to give birth attended by a skilled provider [unadjusted OR: 1.52; 95%CI: 1.21-1.90; P <0.0001]. After adjustments for confounders, the effect size of the ORs increased [aOR: 1.98; 95%CI: 1.57-2.50; P <0.0001]. Results are presented in Table 20.

The use of the birth attendant variable that is informed by the qualitative study findings showed opposite trends. Compared to births attended by a trained and traditional provider, women were 82% less likely to give birth attended by a skilled provider in 2014 than in 2006, prior to adjusting for potential confounders [OR: 0.18; 95%CI: 0.14-0.24; P <0.0001]. After adjustments for potential confounders, there was no substantial change in the ORs. Compared to births attended by a skilled and traditional provider, women were 2.66 times more likely to give birth attended by a trained in 2014 than in 2006, prior to adjusting for potential confounders [unadjusted OR: 2.66; 95%CI: 2.14-3.30; P <0.0001]. After Adjustment for potential confounders, the ORs increased [aOR: 3.42; 95%CI: 2.74-4.27; P <0.0001].

Table 20: The unadjusted and adjusted odds ratios for trends in birth attendants in the community from 2006 to 2014.

Outcomes	Unadjusted OR [95%CI]	P value	Fully adjusted[a] OR [95%CI]	P value
Sudan Household Survey classification				
Trends in Skilled Birth Attendant				
2006	[baseline]	<0.0001	[baseline]	<0.0001
2010	1.85 [1.46-2.35]		2.91 [2.29-3.71]	
2014	1.52 [1.21-1.90]		1.98 [1.57-2.50]	
Qualitative findings informed classification				
Trends in Skilled Birth Attendant [vs all other]				
2006	[baseline]	<0.0001	[baseline]	<0.0001
2010	0.35 [0.28-0.44]		0.35 [0.28-0.44]	
2014	0.18 [0.14-0.24]		0.17 [0.12-0.23]	
Trends in Trained Birth Attendant [vs all other]				
2006	[baseline]	<0.0001	[baseline]	<0.0001
2010	2.43 [0.62-1.3]		3.32 [2.66-4.14]	
2014	2.66 [2.14-3.30]		3.42 [2.74-4.27]	

[a] adjusted for age at the time of survey, age at marriage, education, antenatal care utilisation, wealth score, parity, and mode of delivery.

3.4 Discussion

3.4.1 Main findings

This analysis investigated trends in facility births and the utilisation of skilled birth attendance in Sudan using three SHHS carried out in 2006, 2010 and 2014. A total of 15,848 women were included, nearly a third from each survey year. Despite an increase in the uptake of institutional delivery between surveys, most women still gave birth at home. Births attended by traditional birth attendants are declining. Assessing trends in SBA was challenging because of differences in how SBA are classified– discussed below. Two sources were used to classify providers, which showed different and contradictory findings: the SHHS reports and the qualitative study [Chapter 5]. The SHHS- based classification, showed promising, albeit misleading, trends. It showed that most births were attended by an SBA and showed an upwards trend in institutional births and in skilled birth attendance between 2006 and 2014. By contrast, the second classification revealed that, in all survey years, most maternal health care was provided by trained providers. Trained providers have some training but do not meet the definition of SBA. An upward trend in trained birth attendance and a downwards trend in skilled birth attendance were seen in home and facility settings.

3.4.2 Who is a skilled birth attendant?

The SHHS in its three rounds included several maternal health care providers, and all were categorised as SBA. This categorisation was used by some studies that used SHHS/MICS data (Bashir et al., 2013, Mugo et al., 2016). However, this classification was challenged by participants interviewed for the qualitative study [See 5.5.1] and other reports (Miyake et al., 2017). Some community providers could administer antibiotics, manually remove the placenta and resuscitate newborns (Miyake et al., 2017), satisfying three out of the seven signal functions of basic EmOC required of SBA (Bailey et al., 2009). This suggests that midwives working in the community should be considered separately as trained providers. Grouping

trained midwives as SBA in this analysis, inflated the proportion of births attended by SBA from 22.8% to 78.3% in 2014. Thus, the use of SHHS classification overestimates SBA, and should not be used to represent skilled birth attendance.

Inconsistencies in the reporting of SBA are not unique to Sudan. Two studies that mapped maternal health providers in nine sub-Saharan and four South-Asian countries, respectively, identified 21 and 13 providers with varying titles, training, and competencies who were reported as SBA but did not perform all EmOC signal functions (Adegoke et al., 2012, Utz et al., 2013). It is possible that use of SBA as a key indicator for SDG goal 3.1 could have contributed to such discrepancies. Countries might include providers who meet some but not all of the international standards of SBA in their progress reports. This is likely as many funding organisations allocate funding based on performance (Vorisek and Yu, 2020).

Another possible reason for this could be that SBA is defined differently in different contexts (Hobbs et al., 2019). Indeed, the basic EmOC functions that require instrumentation: removal of retained products and assisted delivery, were least available in the nine African countries (Adegoke et al., 2012). This means that countries might limit the functions a provider can perform based on the setting where they work. Thus, those who might have been trained to perform EmOC functions do not end up performing them in practice.

Nonetheless, the aforementioned discrepancies raise concerns about the comparability of SBA across countries (Harvey et al., 2004). Indeed, heterogeneity in reported SBA might be why recent increases in the SBA coverage were not always matched with improvements in maternal and neonatal mortality in many LMICs (McClure et al., 2007, Scott and Ronsmans, 2009, Singh et al., 2014, Campbell et al., 2016).

3.4.3 Trends in skilled birth attendance at health facilities and in the community

The coverage of SBA in Sudan is low when compared with the region's average [22.8% vs 61%] (World Bank Open Data). Alarmingly, coverage is also decreasing. Some sub-Saharan

countries have reported increasing SBA coverage such as in Ethiopia (Regassa et al., 2020, Woldeamanuel and Aga, 2021), Malawi (Atuoye et al., 2017), and Ghana (Asamoah et al., 2014) while others reported similar trends to Sudan, for example Nigeria (Atuoye et al., 2017).

For health facilities, this trend could be explained by the economic migration of Sudanese health care providers to high-income countries. Studies have linked the large-scale economic migration of health providers, to a crisis in human resource for health in Sudan that could hamper any efforts to achieve universal health coverage (Assal, 2010, Abu-Agla et al., 2013). Nearly half of Sudanese doctors practice abroad (Abuagla and Badr, 2016). To curb migration, the FMoH banned doctors from leaving the country, albeit short-lived, in 2015 (Alnilin Newspaper, 2015). Another possible explanation is internal brain drain. It has been reported in other countries where highly skilled health personnel are being lost to international health organisations or non-governmental organisations (Rubagumya et al., 2016).

Difficulties in retaining skilled care workers in LMICs is a critical issue (Serour, 2009, Kuehn, 2007). In Zimbabwe, an economic crisis contributed to the migration of health professionals, resulting in a reduction in SBA and a corresponding increase in MMR (Choguya, 2015). The economic crisis in Sudan might have had a similar effect (World Bank, 2020). This downward trend in SBA threatens to undo progress made to reduce maternal mortality.

The decline in SBA in the community was predominantly driven by a steady decrease in the number of health visitors without replacement. The numbers of health visitors peaked in 1996 at 770 practicing health visitors, but this number has been reducing steadily over the past decades (FMoH, 1996). Health visitors' training programmes have not been running consistently (Elhadd, 2011). Findings from the qualitative study, reveal a shift in the roles of current health visitors from providing services to teaching, training, and supervising new trained midwives. This suggests that in the community the focus has shifted away from training

skilled provider to training trained providers, and that the roles of current SBA in the community shifted away from service provision in the community.

3.4.4 Trends in trained birth attendance at health facilities and in the community

This analysis revealed a steady increase in births attended by trained providers at health facilities. In 2014, trained providers attended a third of facility births. It is not clear whether trained providers at facilities have additional training or whether they can provide basic emergency management to women if a complication occurs. In regions where most women give birth at home, seeking institutional delivery is often the result of a complication that could not be managed at home (Moran et al., 2007, Worku et al., 2013). Such a trend means that women presenting to health facilities are increasing likely to be attended by a trained birth attendant who may not be equipped with the necessary skills to provide appropriate treatment.

Studies from Senegal and Mali (Radovich et al., 2019), the Gambia (Kreyberg and Helsingen, 2010), and Zambia (Biemba et al., 2014) showed similar findings. There non- SBA attended between a third to a half of childbirths in health facilities. In Bangladesh, India, Kenya, Malawi and Nigeria, providers who did not receive training on skilled birth attendance assisted in childbirth against their governments policies (Olaniran et al., 2019). These findings suggest that in countries that face critical shortages in SBA, non-SBA may have to undertake duties for which they have not been trained. This also means that, in many settings, a health facility birth does not equate skilled birth attendance.

Another reason for this trend could be the way health facilities are defined in national surveys. Health facilities could range from a small health posts to tertiary hospitals (Biemba et al., 2014). Indeed, a health facility in this analysis could mean a health centre with a sole health provider or a tertiary hospital with a multidisciplinary team. It is possible that trained providers are present in health facilities in rural areas where skilled providers are scarce, raising further concerns about emergency care provision and quality of care in these settings. Providing

additional training in basic EmOC may enable trained midwives working in facilities to manage emergencies, thus, improving access to lifesaving maternal health interventions.

Trained midwives have been the main providers of maternal health care services and their role is likely to only increase in importance. They are comparable to auxiliary midwives or auxiliary nurse midwives in other countries (Ten Hoope Bender et al., 2014). Studies have shown that they can deliver maternal health interventions, especially in hard-to-reach rural areas, leading to improved service provision and outcomes (Karvande et al., 2020, WHO, 2014b). However, this requires, amongst other factors, further training or well-functioning referral systems, comprehensive support systems, constant community engagement, and strengthened linkages between health facilities, skilled birth attendants, and trained providers working in the community (Karvande et al., 2020, WHO, 2014b, Wangmo et al., 2016).

3.4.5 Strengths and limitations

The study has three key limitations. First, data are based on women's self-reports. It required women to know the qualifications of the care provider who attended their childbirth and to recall that correct information after up to two years. This can particularly be an issue in health facility births where more than one health provider might be involved in providing care during childbirth. This could result in overestimation of skilled care in facilities if women assumed that community midwives do not work in facilities. Additionally, the most skilled person who attended the birth was used in this study, and little data were available on the extent of their involvement. This again could result in overestimation of skilled care.

Second, some important factors that were identified from the literature review were either not available in the dataset or were not available for all the years, limiting the variables that could be adjusted for in the multivariable analyses. For example, data on the presence of referral systems or data on complications during labour that would influence trained birth attendants' decisions to refer women to health facilities were not available for this analysis.

Studies have shown that the presence of referral indications and/ or system can influence maternal and perinatal outcomes via influencing the numbers of facility births (Pembe et al., 2010, Benson et al., 2019). As a result, residual confounding probably exists in our data, it is likely that the observed effect is higher than the true effect i.e., biased away from the null.

Third, data were collected for married women- except in 2006, unmarried women who become pregnant will likely face challenges accessing health care and may have poorer quality of care at birth. Excluding this group of women may have introduced bias and led to overestimating the births attended by skilled or trained providers. Interpretation of results should thus consider all the above limitations.

Despite these limitations, the study had many strengths. It used three SHHS rounds to investigate trends. All surveys used the same sampling methods enabling comparability between surveys and assessment of change over time. They are large nationally representative surveys with minimal sampling bias, minimal missing data, and high response rates. Additionally, the groups of women who were excluded because outcome data was not available were compared to the final study group in each survey and, overall, the groups did not vary systematically; thus, ensuring minimal selection bias. Therefore, the findings are generalisable to the entire country. Data were available on most determinants of health service utilisation identified from the literature. A major strength of this study came from using the results of the qualitative study to identifying differences between providers; thus, improving the accuracy of this study compared to other studies that used the same survey but grouped the trained and skilled providers together.

3.4.6 Implications and Recommendations

This analysis highlighted limitations to the use of skilled birth attendance as an indicator for progress in access to quality maternal health care. A call for greater transparency in how skilled birth attendance is defined in national documents is needed to enable informed cross-country

comparisons. For Sudan, SHHS classification of maternal health providers needs to be more reflective of international standards of SBA. Additionally, trained, and skilled providers need to be presented separately for Sudan to enable an accurate understanding of the delivery of care and future needs.

A baseline assessment of the skills and capabilities of maternal health care providers in Sudan is needed to understand the quality of care provided to women in facilities and the community, to assess the country's capacity to meet its population's reproductive and maternal health needs, and to guide interventions to improve quality of care. Urgent and long-term interventions are needed to train and retain skilled providers such as investing in training facilities, improving continuous education, providing commensurate compensation, and task shifting where possible (Pang et al., 2002). Interim interventions are needed to improve the quality of services by trained birth attendants in the community, as they make up a large portion of attendants at birth.

3.5 Conclusion

Increases in facility births were not matched with increases in skilled birth attendance. Trained midwives are the backbone of the maternal health service delivery in Sudan, particularly in rural and hard to reach areas. However, little data are available regarding their current skills, competencies, and the quality of care they provide. In Sudan's efforts to reduce maternal mortality, equipping capable trained providers with the skills to manage obstetric emergencies is paramount. Without a comprehensive strategy that places trained midwives at its centre, Sudan could fall short of meeting its national strategic targets to reduce maternal mortality.

This chapter demonstrated the substantial and growing contribution of trained midwives to maternal health care provision. It supports the need for including their perspectives into MDSR. The next chapter examines the correlation between providers present during childbirth, place of childbirth, and other factors with the maternal mortality ratio. It builds on

findings from this chapter regarding the role of midwives and other providers in maternal health care by providing insights into their relation to MMR at state-level and, thus, potential contribution to the MDSR.

4 Prevalence and factors associated with maternal mortality ratio at state-level in Sudan: An ecological study.

4.1 Introduction

In 2017, maternal mortality ratio [MMR] in Sudan was estimated to be 295 maternal deaths per 100,000 live births [80% uncertainty estimate 207- 408], with an annual rate of decline of 3.4% since 2005 (WHO, 2019). If "*business as usual*" continues, MMR is predicted to further reduce to 185 maternal deaths per 100,000 live births by 2030 (McArthur et al., 2018). Thus, Sudan would need to triple its current rate of decline if it is to contribute to the achievement of the sustainable development goals [SDG] target 3.1, which is to reduce the global maternal MMR to less than 70 per 100,000 live births (SDGs, 2015). Although tripling the current rate of decline might be aspirational, it is possible to increase its current rate of decline.

For Sudan, data on risk factors for maternal mortality are available from cross-sectional studies of health facilities (Mohammed et al., 2018, Umbeli, 2004, Ounsa and Mohamed, 2011, Dafallah et al., 2003, Ali et al., 2011) or from regional surveys (Haggaz et al., 2007, Mohammed et al., 2011). Recently, data have become available through the national maternal deaths review reports [2006-2016] and the maternal death surveillance and response reports [2016-present] (Umbeli et al., 2014, Umbeli, 2016, Umbeli, 2018). However, the latter provide only descriptive data on the causes of death and characteristics of women who had a maternal death. To date, there are no population-level studies that identify major risk factors and determinants of maternal mortality for the country. This chapter aims to address this gap in literature and to examine the factors associated with maternal mortality at a national level, corresponding to thesis objective 4. The study objectives are: [1] to examine variations in MMR at state-level in Sudan, and [2] to investigate the relationship between birth attendants and other indicators and MMR at the state-level.

4.2 Methods

4.2.1 Study design, data sources, and variables

This was an ecological analysis where the 18 states of Sudan were used as the unit of analysis. Two routinely collected and publicly available data sources were used: the Maternal Death Surveillance and Response [MDSR] report for the year 2016 and the last completed Multiple Indicator Cluster Survey [MICS] of 2014. Both sources provide the most recent and comprehensive data on maternal health and developmental indicators for Sudan.

The outcome for this study was maternal mortality ratio [MMR] calculated as the number of maternal deaths per 100 000 live births. Data for the outcome were calculated using MDSR reports. The data for the remaining variables were obtained from the MICS datasets. Birth attendance and place of childbirth were the key exposure variables of interest. Birth attendance was divided into skilled birth attendants and trained birth attendants to alien with the categorisations used in the previous chapter 3, which were informed by the qualitative study findings. Other risk factors investigated include household wealth using a composite wealth index, literacy rates for women ages 15 – 24 years old, total fertility rate, contraceptive use, antenatal care use, age at marriage, and female genital cutting. Table 21 provides descriptions of the variables used.

Table 21: Descriptions of biological, biodemographic, socioeconomic and health system-related risk factors for maternal mortality and their availability within the dataset.

Variable	Description	Availability in any surveys	Availability in all surveys
Obstetric complications	Any health condition attributed to pregnancy and childbirth that has a negative impact on the woman's wellbeing and/or functioning. Includes all complications during pregnancy, childbirth, and/ or postpartum	Yes	No
Infection	All bacterial, viral, and parasitic infections that a woman during pregnancy, childbirth and the postpartum. Can be acute such as: influenza, or chronic such as HIV/AIDS	A proxy available	No
Pre-existing conditions	Any health condition exacerbated by pregnancy and childbirth, such as: heart disease, which has a negative impact on the woman's wellbeing and/or functioning	No	No
Age	This refers to the woman's age at the last birth	Yes	Yes
Child marriage	Marriage before the age 18 years old	Yes	Yes
Female genital mutilation	Comprises all procedures that involve partial or total removal of the external female genitalia, or other injury to the female genital organs for non-medical reasons	Yes	No
Gravidity	The number of times that a woman has been pregnant, including the last birth	Yes	Yes
Parity	The number of times that a woman gave birth to a foetus with a gestational age of 24 weeks or more, regardless of the outcome	Yes	Yes
Malnutrition	Malnutrition refers to deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients. The term malnutrition covers 2 broad groups of conditions. One is 'undernutrition', the other is overweight, obesity and diet-related non communicable diseases	No	No
Quality of care during pregnancy, childbirth, and post-partum	This refers to the extent to which health care services provided to individuals and patient populations improve desired health outcomes. To achieve this, health care must be safe, effective, timely, efficient, equitable and people-centred	No	No
Health education	Any combination of learning experiences designed to help individuals and communities improve their health, by increasing their knowledge or influencing their attitudes.	No	No
Health seeking behaviour	A sequence of remedial actions that individuals undertake to rectify perceived ill-health. In this context, it refers to: utilisation of antenatal and post-natal care services, institutional delivery and/ or the presence of skilled birth attendants.	Yes	Yes
Wealth	This is the wealth of the community	Yes	Yes
Education	The general literacy level of the country	Yes	Yes
Legal frameworks	Laws that influence the health of women for example: free antenatal care, and abortion laws	No	No
Infrastructures	Roads, general development of the country	No	No
Medical Resources	This refers to the health system of the country, the number of the hospitals and it's staffing the number of doctors, nurses, midwives, community health workers. In addition to, diagnostics and treatment availability	No	No
Cultural and religious sources	Cultural norms, traditional and religious practices that influence the health of women	No	No

4.2.2 Statistical analysis

Data from the MDSR report and the MICS were compiled into a single dataset that contained 18 rows: one for each state. The median and interquartile range [IQR] were calculated for each risk factor because variables were non- normally distributed. The MMR per 100,000 total births and the 95% confidence intervals were calculated for each state and for Sudan overall. The MMR was treated as a continuous variable, so it was checked for normality visually using a histogram and then by using the Kolmogorov–Smirnov test. It was non-normally distributed.

Given that a considerable number of statistical tests assume a normal distribution, the use of parametric tests was initially explored. Parametric tests can be used for data that are not normally distributed if the conditions of the Central Limit Theorem are met. However, the theorem requires a minimum of 30 observations (Ross, 2017). This sample size of 18 was too small, and this method was, therefore, inappropriate. Two further methods were considered to deal with MMR's non-normal distribution: transforming MMR variable to a normal distribution then analysing the transformed MMR variable using parametric tests or using non-parametric tests. Transforming MMR was explored next. However, the sample size was too small, and the data remained non-normally distributed following different transformations. Thus, the use of non-parametric tests was deemed most appropriate for this data as they make no assumptions about the distribution. The linear relationship between MMR and each risk factor was examined using scatterplots [not presented] and Spearman's rank correlation.

All tests were considered statistically significant at p value <0.05 but given the fixed and small sample size of this dataset and the known relationship between the significance level [alpha] and sample size, *p* values above the significance level will be interpreted with caution. Statistical analyses were conducted using Stata version 15, SE.

4.3 Results

4.3.1 Maternal Mortality Ratio

A total of 1,198 maternal deaths and 902,056 livebirths were reported in 2016, yielding an overall MMR of 133 [95%CI: 125-141] maternal deaths per 100,000 livebirths. MMR varied between states: River Nile state had the lowest MMR and East Darfur had the highest, 44 [95%CI: 20-83] and 399 [95%CI: 288-539] maternal deaths per 100,000 livebirths, respectively - See Table 22 and Figure 11.

Table 22: Maternal mortality ratio and their 95% confidence intervals for Sudan overall and per state, using data from the maternal mortality review report 2016.

STATE	MATERNAL DEATHS	LIVE BIRTHS	MMR [95% CI]
Northern	17	17785	96 [56-153]
River Nile	9	20636	44 [20-83]
Red Sea	53	18630	284 [213-372]
Kassala	83	53264	156 [124-193]
Al Qadarif	69	63758	108 [84-137]
Khartoum	176	227310	77 [66-90]
Al Jazerah	93	91870	101 [81-124]
White Nile	45	45853	98 [72-131]
Sinnar	54	33233	162 [122-212]
Blue Nile	53	44858	118 [89-155]
North Kordofan	94	29014	324 [261-396]
South Kordofan	52	21858	238 [178-312]
West Kordofan	81	66620	122 [97-151]
North Darfur	67	25753	260 [202-330]
West Darfur	61	33537	182 [139-234]
South Darfur	94	59807	157 [127-192]
Central Darfur	55	37740	146 [110-190]
East Darfur	42	10533	399 [288-539]
Overall	1 198	902 056	133 [125-141]

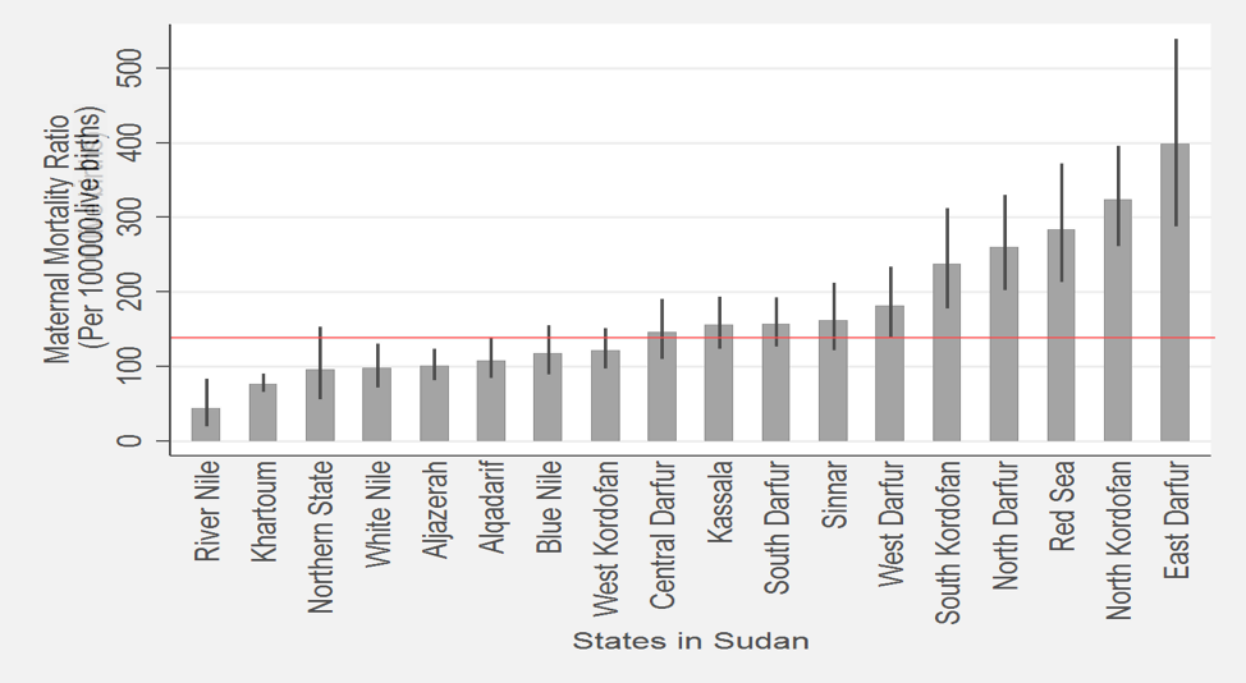


Figure 11: Maternal Mortality Ratios for Sudan overall and by state, using data from the maternal deaths review committee 2016.

Sudan average of 133 per 100 000 live births shown by the straight line across the graph.

4.3.2 Birth attendance and place of birth at state-level

Overall, the median proportion of childbirths that were attended by a trained provider was 53.7% [IQR: 41.2-64.2] while for births in a health facility it was 22.2% [IQR: 13.1-37.1]. Table 23 summarises percentages of state-level childbirth characteristics.

Table 23: State-level birth attendance and place of birth from the Multiple Indicator Cluster Survey 2014.

Variable	Median [IQR]	Range [Min - Max]
Presence of a skilled birth attendant, %	19.9 [9.0-39.6]	3.0 - 57.8
Presence of a trained birth attendant, %	53.7 [41.2-64.2]	33.4 - 71.0
Childbirth in a health facility, %	22.2 [13.1-37.1]	7.5 - 72.5

IQR: Interquartile Range, Min: minimum, Max: maximum

4.3.3 State-level health and socioeconomic indicators

The distribution of health and socioeconomic indicators varied between states as well- see Table 24. Female Genital Mutilation/ Cutting was prevalent, with the highest median 87.5% [IQR: 78.7-96.4]. A small proportion of households belonged to the richest wealth quintile with a median of 7.3% [IQR: 2.9-21.3]. There was a considerable inter-state variation in literacy rates among females ages 15 – 24 years old, ranging from 27.4% in Central Darfur state to 91.5% in the Northern States, comparatively the rates of child marriage did not vary much across the states, ranging from 5.1% in the Northern state to 18.6% in Kassala state.

Table 24: State-level health and socioeconomic variables from the Multiple Indicator Cluster Survey 2014.

VARIABLE	MEDIAN [IQR]	RANGE [MIN - MAX]
Belonging to the richest wealth quintile, %	7.3 [2.9-21.3]	0.6-58.8
Literacy rate for females aged 15 to 24, %	54.0 [42.8-67.5]	27.4-91.5
Child marriage- less than 15 years old, %	13.5 [9.1-16.4]	5.1-18.6
Any contraceptive use, %	9.3 [6.1-14.7]	2.9-26.5
Any Antenatal care use, %	80.0 [73.3-85.6]	76.4-97.6
Total fertility rate, child per women	5.3 [4.3-6.2]	3.2- 6.9
Female genital mutilation/ cutting, %	87.5 [78.7-96.4]	45.4-97.7

IQR: Interquartile Range, Min: minimum, Max: maximum

4.3.4 Correlation between birth attendants and place of birth and MMR

Table 25 shows the correlation between birth attendants and place of birth and MMR at a state-level. A strong statistically significant inverse correlation was observed between facility birth and MMR [Spearman's correlation coefficient [rho]: -0.49, p: 0.04] and between SBA and MMR [rho: -0.59, p: 0.01]. However, MMR had a direct correlation with births attended by skilled birth attendants, but the relationships were not statistically significant at $p<0.05$ [rho: 0.16, *p*: 0.51].

Table 25: Correlation between birth attendance and place of birth and maternal mortality ratio at state-level using the 2016 maternal death review report and the2014 multiple indicator cluster survey.

Variable at state-level	Correlation with MMR Spearman's correlation coefficient [rho]	P value
Presence of a skilled attendant at birth	-0.57	0.01
Presence of a trained attendant at birth	0.16	0.51
Childbirth in a facility	-0.49	0.04

4.3.5 Correlation between health and socio-demographic indicators and MMR

A strong statistically significant inverse correlation was observed for wealth quintile [rho: -0.52, p: 0.03] and use of contraceptive methods [rho: -0.51, p: 0.03] with MMR while a direct correlation was observed between child marriage and MMR [rho: 0.53, p: 0.02]. The relationship between the rest of the indicators and MMR was not statistically significant at p <0.05 [See Table 26].

Table 26: Correlation between state-level indicator variables [MICS 2014] and maternal mortality ratio 2016.

Variable at state-level	Spearman's correlation coefficient [rho]	P value
Belonging to the richest wealth quintile	-0.52	0.03
Literacy rate for females aged 15 to 24 [%]	-0.36	0.13
Early marriage- less than 15 years old	0.53	0.02
Total fertility rate [child per women]	0.38	0.11
Any Antenatal care use	-0.30	0.21
Any contraceptive use	-0.51	0.03
Female genital mutilation/ cutting	0.18	0.43

4.4 Discussion

4.4.1 Main findings

This study aimed to investigate the relationship between birth attendance, place of birth and other indicators with maternal mortality ratio [MMR] at state-level in Sudan. The overall MMR was found to be 133 [95% CI: 125.4-140.5] per 100,000 live births. MMR showed wide variation between the states, ranging from 44 to 399 maternal deaths per 100,000 live births. Higher levels of skilled birth attendants, health facility birth, wealth, and contraceptive use correlated with lower MMR at state level while higher levels of child marriage correlated with higher MMR at state level. Although it was statistically non-significant, higher levels of trained birth attendance correlated with higher MMR. Higher levels of female genital mutilation/ cutting and higher total fertility rate correlated with higher MMR while higher literacy rates correlated with lower MMR, but they were not statistically significant.

4.4.2 Findings in context

The overall MMR of 133 maternal deaths per 100,000 livebirths is lower than MMR figures estimated by the Maternal Mortality Interagency estimation group of 295 (WHO, 2019). It is also lower than the MMR reported from studies carried out in different regions of Sudan. In Kassala state, for example, this analysis reported an MMR of 185 maternal deaths per 100,000 livebirths, which is considerably lower than MMR reported from facility-based and community-based studies carried out in the state few years prior, they put is at 432 and 714 maternal deaths per 100,000 livebirths, respectively (Ali et al., 2011, Mohammed et al., 2011). Under-reporting and misclassification of maternal deaths could explain the low rates of MMR in this analysis. The MDSR uses a passive system of data collection that reported challenges in identifying maternal deaths, especially deaths in the community (Umbeli et al., 2018). Misclassification of maternal deaths has been reported in other studies (Ganatra et al., 1998,

Ronsmans et al., 2006, Abouchadi et al., 2018). The underestimation of maternal mortality could inadvertently shift focus from improving access to health care, as suggested by the obstetric transition (Souza et al., 2014), by understating its persistent importance.

The marked variation in MMR between states in Sudan indicates that the challenges to reducing maternal mortality differ between states as well (Souza et al., 2014). For example, East Darfur had the highest MMR, and Darfur's recent history of conflict could have contributed to this either through disruptions to health services provision and systems, or through an increase in rates of gender-based violence and other human rights violations (Elzarov, 2020). On the other hand, studies carried out in Khartoum state have identified delays to receiving care at health facilities as a major risk factor for maternal deaths (Mohammed et al., 2018). Thus, different strategies are needed to reduce maternal mortality across the country: efforts to reduce maternal mortality in Darfur would have to consider access to health care while in Khartoum it would have to consider quality improvement issues.

Higher levels of utilisation of maternal health care services such as facility birth and SBA in this analysis correlated with lower MMR, which is consistent with the literature (Campbell et al., 2006, Piane, 2009, Black et al., 2016). This is likely because they indicate access to the lifesaving interventions needed are to reduce maternal mortality. Albeit statistically non-significant, higher levels of trained birth attendance correlated with higher MMR in this study. This could signify that trained birth attendants in Sudan do not possess the skills needed to save lives. Thus, efforts should focus on increasing access to SBA and to facility births rather than increasing access to trained birth attendants. Several evidence-based approaches that can increase utilisation of facility birth should be considered, such as maternity waiting homes in Ethiopia (Gaym et al., 2012) or financial incentives for maternity care and transport used in India and Brazil (Randive et al., 2013, Rasella et al., 2021). Additionally, training of skilled providers is needed to match any increase in utilisation of care.

Socioeconomic factors such as wealth and education are important determinants of maternal mortality (Girum and Wasie, 2017). This analysis shows that wealthier states in Sudan had lower MMR levels. Studies have shown within country variations related to income in several developing and developed countries (Alvarez et al., 2009). Wealth may help reduce maternal mortality by facilitating access to health care. Although it was not statistically significant in this analysis, higher literacy rates correlated with lower MMR in the literature (McAlister and Baskett, 2006, Bhalotra and Clarke, 2013). Women with higher education are likely to be aware of the importance of seeking health care during pregnancy and childbirth (McTavish et al., 2010). Furthermore, education could be a proxy for economic empowerment and decision-making ability for women (Gabrysch and Campbell, 2009). Thus, interventions aiming to reduce poverty, reduce financial barriers to access health care, and improve female education can lead to reductions in maternal mortality.

Higher rates of young adolescents' marriage in Sudan, a proxy for pregnancy in young adolescence, correlated with higher maternal mortality ratio in line with previous studies (Nove et al., 2014, Chen et al., 2007). A "J-shaped" relationship between maternal mortality and maternal age has commonly been described in the literature with adolescents <15 years old and women >30 years old are at a higher risk when compared with women between 20 to 24 years old (Ganchimeg et al., 2014, Nove et al., 2014). This is thought to be because pregnancy in young adolescents puts girls at a higher risk of maternal complications, such as, pregnancy-induced hypertension or obstructed labour (Shaikh et al., 2012). Another possible explanation is that young pregnant adolescents might lack access to relevant health knowledge and to health care services (Gabrysch and Campbell, 2009).

Nulliparity and high numbers of births were associated with maternal mortality (Sonneveldt et al., 2013, Bauserman et al., 2020, Merdad and Ali, 2018) while increases in the use of contraceptives were associated with reduction in maternal mortality (Ahmed et al., 2012,

Stover and Ross, 2010). The findings of this analysis are in line with previous literature. Contraceptive use can reduce a women life-time risk of maternal mortality. Thus, scaling up primary prevention initiative and promoting culturally appropriate family planning should be considered to reduce maternal mortality (Chola et al., 2015, Stover and Ross, 2010).

The contribution of antenatal care [ANC] in preventing maternal deaths is limited by the fact that many causes of maternal deaths are difficult to detect antenatally, such as post-partum haemorrhage or sepsis (Oyerinde, 2013). Nonetheless, ANC can promote facility births and manage identified risk factors. Thus, ANC should be coupled with interventions that promote access to skilled providers and to emergency obstetric care.

Female genital mutilation [FGM] can lead to adverse maternal outcomes, including increased risk of maternal mortality (Klein et al., 2018). Although statistically non-significant, higher rates of FGM correlated with higher MMR in this analysis. A possible mechanism for this is that women who had FGM experience more complications during childbirth such as post-partum haemorrhage, infections, and prolonged labour (Chibber et al., 2011). Actions to end the practice of FGM in Sudan could lead to reductions in maternal mortality.

4.4.3 Strengths and limitations

The chief limitation of this analysis is its inability to link risk factors to maternal mortality in individuals because the data used here represent state averages. The overall positive or negative association might mask a complicated relationship at the individual level. This ecological fallacy can only be overcome by repeating the analyses using individual-level data. Another limitation was the small sample size, which means the study might have been underpowered to detect differences when differences between states were small.

Despite its ecological design, this is the first study to provide national-level data on determinants of maternal mortality in Sudan. The study used data that is routinely collected,

nationally representative, and readily available. Its design is useful for hypothesis generation and can lay the foundation for more rigorous studies.

4.4.4 Data-sharing challenges

This analysis was planned as a case-control study design using individual level data from MDSR on maternal deaths cases and from MICS for controls. However, difficulties in obtaining individual-level data were encountered despite having established an oral agreement to collaborate on with MDSR in 2016, prior to the start of this DPhil. Nonetheless, efforts to access individual level data from the MDSR database were not successful. This necessitated a change in the study design from a case control study using individual data to an ecological study using state level data.

Concerns regarding data-sharing could explain the limited access to MDSR data granted to external researchers. Indeed, to date, only three published studies were identified that have analysed individual-level data on maternal deaths in Sudan collected by the MDSR, and all were carried out by the MDSR programme itself (Umbeli et al., 2014, Umbeli, 2016, Umbeli, 2018). In hindsight, such setback could have been avoided by initiating a formal agreement defining the responsibilities and rights of both parties shortly after the verbal agreement, developing the study in collaboration with MDSR officials considering their priorities, and clearly addressing any concerns.

Data-sharing concerns are well-documented in LMICs (Chawinga and Zinn, 2019, Kaewkungwal et al., 2020). A study from Thailand found that researchers' concerns related to inappropriate acknowledgment of their work and contribution and the possible lack of control over data usage (Kaewkungwal et al., 2020). Additionally, the Ministry of Health lacks infrastructure for data sharing (Ahmed, 2020). No formal application processes were identified to apply for the individual-level data collected by the MDSR, so attempts to obtain the data required in person travel to Sudan to meet with concerned individuals [March – April 2018].

Together they indicate the need for fair data-sharing policies, legal safeguards, and clear administrative procedures to facilitate optimal use of the available health data for research and beyond.

4.4.5 Conclusion

Maternal mortality remains a public health priority in Sudan given its high levels when compared to the global average and to national and global targets. Different interventions are needed in the different states to reduce maternal mortality with focus on improving access to skilled birth attendance and facility births in humanitarian settings. Although facility births and skilled attendants present during childbirth are associated with lower MMR, the relationship with trained birth attendants is uncertain. Further studies are needed to investigate the association between trained birth attendants and MMR using individual-level data. Cultural, social, and economic factors play a major role in determining maternal mortality. Therefore, non-health specific interventions can also contribute to the reduction in MMR.

The next three chapters examine maternal health service organisation and the current MDSR programme based on interviews with key informants and the use of an inter-professional collaboration framework to examine the barriers and facilitators to the inclusion of midwives into the MDSR programme. The next chapter will focus on maternal health services in Sudan and the health providers. The differences between trained and skilled providers, which were introduced in earlier chapters, are discussed in detail. The chapter focuses on the challenges facing midwives and the midwifery profession and on their implications for the inclusion of midwives into the MDSR process.

5 Maternal health care in Sudan: Providers, care pathways, and challenges.

5.1 Introduction

Knowledge of maternal health care providers is necessary when considering local action to reduce maternal mortality (Adegoke and Van Den Broek, 2009). Historically, countries' choices regarding the "*encouragement or dissuasion of midwifery*" to provide care have been linked to the rates of maternal death decline (Van Lerberghe and De Brouwere, 2001). In the 18th and 19th century, countries where midwifery thrived had faster rates of maternal mortality ratio [MMR] reduction compared with countries where it did not - before medical and technological advances. Similar patterns can be seen, more recently, in low- and middle-income countries [LMICs] such as Sri Lanka, Malaysia, and Indonesia (Van Lerberghe and De Brouwere, 2001). Thus, midwives play a key role in reducing preventable maternal deaths.

Despite midwives' significant role, the development of the midwifery profession has faced challenges worldwide. The subordination of midwifery by medicine and to a lesser extent by nursing was reported in the USA, Canada, and Australia in the previous decades (Willis, 2020, Fahy, 2007, Van Lerberghe and De Brouwere, 2001, Winkup, 1998). According to a recent WHO global survey of midwives [N= 2,470], midwives regardless of their location still experience disrespect, subordination, and gender discrimination from the medical profession (WHO, 2016b). To include midwives in maternal death surveillance and response [MDSR] in Sudan, a clear understanding of their practice, settings, current role in MDSR, and barriers to their inclusion is needed. Thus, the aim of this chapter is to describe maternal health care providers, their organisation, and the challenges they face, and it corresponds to thesis objective number 5.

5.2 Methods

5.2.1 Study design

Qualitative research designs can generate a deep understanding of participants' experiences and uncover complex processes related to a phenomenon (Creswell and Poth, 2016, Green and Thorogood, 2018). Thus, it was deemed the most appropriate methodological design to achieve research objectives [5,6, and 7]. Through capturing the perspectives of various health care providers, Ministry of Health [MoH] officials, and United Nations [UN] officials who are familiar with and/ or involved in MDSR, understanding MDSR in Sudan, its various activities, and the context where it is implemented becomes possible. The topic of maternal mortality is a sensitive one, so, after discussion with my supervisors, I identified individual semi-structured interviews as the most suitable method to approach this sensitive topic (DeJonckheere and Vaughn, 2019, Oppermann, 2000).

5.2.2 Participant selection

Maximum variation sampling was used to identify and select participants with various perspectives and experiences (Etikan et al., 2016, Patton, 2002). They were identified either by their roles as care providers or by their relationship to the MDSR process. A list of potential participants was prepared, expanding on the list of participants used by a previous national situational analysis of maternal death reviews [MDR] – described in Chapter 1 (Musoke and Balogun, 2015). The list included community and facility providers, MDSR staff, relevant MoH officials, and UN officials. Initially, it included federal and state Ministers of Health, but during the data collection period the government was dissolved at the federal and state levels (BBC, 2019b). Thus, the holders of these posts were dismissed, and they were vacant for most of the data collection period.

Geographical variation of participants was also considered. One state was selected from each region except from the Darfur region for security reasons (FCDO, 2021). In total, five states out of 18 and 15 localities out of 133 were covered, and approximately 3,000 kilometres were travelled between states for data collection.

Participant interviews were organised and conducted between June and November of 2019. Ministry officials were contacted first and in person to participate. Next, MDSR staff based at the Reproductive Health offices were contacted in person and usually during the same visit to the MoH. The contacts of the MDSR officials based at health facilities were obtained from the MoH, and they were contacted by phone then in person at the health facilities where they worked. At the health facilities, MDSR officials, obstetrics and gynaecology [O&G] specialists or registrars, and midwives were identified and interviewed. Several approaches were used to identify midwives working in the community: recommendations of respondents, visiting midwifery schools, accompanying inspectors for inspection visits, and waiting in hospital emergency departments where midwives would present with women who are having complications. UN officials in the capital were emailed then visited in person. They provided contacts for their UN counterparts in the states of interest who were in turn contacted via phone then in person.

In total, 58 potential participants were approached, of them 56 agreed to participate in the study- the two who refused were an O&G specialist who was busy, and a village midwife who did not volunteer the reason. Of the fifty-six who agreed to participate in the study a further two were not interviewed because appointments could not be made within the data collection period – one state-level director of the Reproductive Health unit and one UNICEF staff member.

5.2.3 Interviews

An interview guide with open-ended questions and probes was used to elicit responses [Appendix L]. The contents of the topic guide were informed by the findings of the systematic review reported in Chapter 2. It included questions on the maternal care providers, MDSR activities, the role of midwives in the MDSR, and the inclusion of the midwives into the MDSR. The topic guide was piloted in three face-to-face interviews [two village midwives and an O&G registrar involved with the MDSR] to ensure that the questions were appropriate. As the interviews progressed, the questions were adapted to elaborate on emergent themes.

Most interviews took place at participant's place of work, but a few were carried out in the participant's home. On one occasion only, the interview was attended by a third party, which might have influenced the respondent and their responses. Every participant was offered a calling card worth 375 Sudanese Pounds on average, approximately 6 Great British Pounds, as compensation for their time and effort. Many participants declined the compensation.

I conducted all interviews in Arabic. They took an average of 30 minutes, were audio-recorded, and were saved under a code to maintain anonymity. No repeat interviews were carried out. All interviews were transcribed verbatim by transcribers, I then cross-checked the transcripts with the audio-recordings and translated them to English. This helped with the data familiarisation step of the analysis. All English transcripts were managed using NVivo software.

5.2.4 Data analysis

Thematic analysis was used to examine the data for commonalities and differences (Braun and Clarke, 2006). The analysis was continuous and iterative, and the coding framework and emerging themes were discussed with the DPhil supervisors at various stages of the data collection and analysis. Some identified themes were driven by the research question and anticipated by the topic guide, and some emerged from the data. The one sheet of paper [OSOP]

method was used to summarise the data within themes to help identify patterns (Ziebland and McPherson, 2006). I prepared summaries of all the data, including deviant cases for all themes that were shared with and commented on by my DPhil supervisors. An independent researcher who was informed about the aim and objectives of the study and had prior knowledge of qualitative data analysis coded five interview transcripts to check data coding. The codes were compared for new themes and discussed.

To determine whether saturation was achieved during data collection two concepts were used: code saturation, where a range of thematic issues is identified, and meaning saturation, where developing richly textured understanding of issues is realised (Hennink et al., 2017). Participants in this study were sampled until no new theme emerged from the interviews, resulting in a total sample size of 54 participants.

5.2.5 Reflexivity

In qualitative studies, the researcher is considered the primary instrument of data collection and analysis (Creswell and Poth, 2016). This makes reflexivity a critical component of qualitative research, as it allows for reflection on what one observes and the meanings one applies to those observations, informing both what the researcher observes and how they observe it (Green and Thorogood, 2018). Green and Thorogood describe two levels of reflexivity: reflecting on the research itself and on the role of the researcher in generating and analysing the data.

First, reflecting on the research itself. When I started this study, I sought to understand why the perspectives of skilled birth attendants [SBA] were not included in MDSR in Sudan, and to identify ways to incorporate these valuable perspectives. However, throughout the data collection and early analysis period, I discovered that despite being portrayed as SBA in government reports, midwives working in the community were not SBA. I realised that there was a need to step back and address both challenges facing midwives in the community and

challenges with MDSR conduct to support any inclusion efforts. Thus, my research focus expanded to address barriers to midwives' inclusion both in how the MDSR is carried out and the wider context using an inter-professional collaborative practice framework.

Second, reflecting on my role in the data generated. Prior to designing the research study, I received training in qualitative research design and conduct, I developed an appreciation of the research topic through conducting a systematic review, and I incorporated what I have learnt from both into the research design. As a Sudanese doctor, I am familiar with the facility-based maternal service provision, but I had little experience working in primary health care centres and none in out-of-facility settings. Thus, I familiarised myself with these settings by spending extended time there during visits, by asking questions, and by going through any available written information about them. This helped me refine my questions as data collection progressed, and I gained an appreciation of the context that was helpful during the analysis stage.

Furthermore, having trained and worked as a doctor in Sudan, I was aware of power relations between doctors and midwives in facilities. In some interviews with midwives, power imbalances became apparent, for example, two midwives perceived the interview as a test of their knowledge and asked how they did afterwards and if their answers were correct; in two interviews with senior midwives, they apologised for offending me when they talked about disrespect they experienced from young doctors. To deal with these issues during interviews, I spent ample time to explain my role as a DPhil student, explain the purpose of the interview and the study, to emphasise that participation was voluntary and confidential, and that declining to participate would not have any consequences.

In interviews with MoH and MDSR officials, I was at the other end of the power imbalance, and I had to balance collecting relevant data while not threatening officials. For example, I found it difficult to fully challenge statements made by MoH officials about the

impacts of MDSR that were contradicted by other participants in previous interviews. Although the choice to be restrained might have affected the depth of data collected, I choose this because, on balance, challenging them too much could jeopardise my ability to collect data in their state. Any discrepancies were explored and highlighted during the data analysis stage.

5.2.6 Ethical considerations

Miles et al, outlines eleven ethical issues for reflection in qualitative studies: the worthiness of the research; competence; informed consent; benefits, costs and reciprocity; harm and risk; honesty and trust; privacy, confidentiality and anonymity; intervention and advocacy; research integrity and quality; ownership of data and conclusions; and use and misuse of results (Miles et al., 2020). Table 27 summarises how ethical issues were addressed in this qualitative study.

5.2.7 Reporting

The Consolidated criteria for Reporting Qualitative research [COREQ] checklist was used to report the results of this study (Tong et al., 2007). A copy of the checklist is provided in the appendix [See Appendix M].

Table 27: Ethical issues considered in the qualitative study (Miles et al., 2020).

No	Ethical issue	Comment
1	Worthiness of the research	Reviewing maternal deaths is part of Sudan's national strategy to reduce maternal mortality: a public health priority.
2	Competence	I received training on the conduct of qualitative studies and sought support from my DPhil supervisors during the design, data collection, analysis and write up of the qualitative study.
3	Informed consent	Participant information sheets and consent forms were used to elicit consent from the participants [Appendices N- S].
4	Benefits, costs, and reciprocity	Participation requires time and effort from participants, so a small token of appreciation, a calling card was offered. By participating, they benefit by having their opinions listened to, and they could help improve how maternal deaths are reviewed in Sudan.
5	Harm and risk	Discussions about maternal deaths are sensitive. During interviews, one midwife became visibly upset when speaking about a woman she attended recently who then died from post-partum haemorrhage. The interview was stopped promptly but restarted shortly afterwards based on the midwife's request. This incident was discussed with supervisors. Questions about specific cases of maternal deaths were avoided after this incident in view of concerns over access to timely support for participants.
6	Honesty and trust	The purpose of the research, my affiliations, and how will the results of the study be used were explained to the participants prior to obtaining consent.
7	Privacy, confidentiality, and anonymity	Except for one interview, all other interviews were carried out with only the participant and myself present. To maintain strict confidentiality of all data, a unique identification code was used for each participant and all participant identification data were de-linked from the files before analysis. In addition to myself, only my supervisors and the second coder had access to the complete dataset. Interview transcripts, and audio recordings are stored in a server at the University of Oxford that can only be accessed using an authenticated login ID and password available only to the study researchers.
8	Intervention and advocacy	This issue relates to response in case the researcher observes harmful, illegal, or wrongful behaviour during the data collection/ study. Such instances were not encountered nor were they expected during the study.
9	Research integrity and quality	Ethical guidelines were followed throughout the design and conduct of this study. Ethical approvals were obtained from [1] National Research Ethics Review Committee- Health Research Council- Federal Ministry of Health, Republic of Sudan, [2] Ministry of Health in each of the five included states, [3] Ahfad University for Women, and [4] Oxford Tropical Research Ethics Committee- University of Oxford [Appendix T and U].
10	Ownership of data and conclusions	Data are the property of the University of Oxford.
11	Use [and misuse] of results	The results are used for this DPhil thesis, and findings will be published in peer-reviewed journals.

5.3 Description of the included participants

Table 28 shows the key characteristics of the included participants. Overall, 54 participants were included: 12 community and village midwives, 9 assistant health visitors and health visitors, 5 hospital midwives, 6 O&G registrars and specialists, 7 MDSR focal persons, 12 midwifery inspectors and ministry officials, and 3 UN officials. Most participants were female [81%] while all community providers were females, reflecting the gender of community providers. The youngest participant was 26 years old and the oldest was 74 years old. MDSR focal persons were the youngest group [between 27 to 33 years]. Eight midwives [38%] worked in rural areas. The years of professional/work experience of participants ranged between 1 to 44 in their reported profession at the time of interview. MDSR focal persons and UN officials had the least years of experience.

Table 28: Selected characteristics of participants by participant group.

	Community providers [a] [N = 21]	Hospital providers [b] [N = 11]	MDSR focal persons [c] [N = 7]	Government officials [d] [N = 12]	UN officials [e] [N = 3]	Total [N= 54]
Female, N [%]	21 [100]	6 [55]	5 [71]	11 [92]	1 [33]	44 [81]
Age, range in years	26-74	32-68	27-33	29-63	33-42	26-74
Rural, n [%]	8 [38]	-	-	-	-	-
Years of experience, range	5-44	2-31	1-7	2-31	3-10	1-44

MDSR: Maternal Death Surveillance and Response, UN: United Nations
[a] Includes village midwives, community midwives, and health visitors.
[b] Includes nurse-midwives, obstetrics and gynaecology registrars who are not MDSR focal persons, and obstetrics and gynaecology consultants and specialists. Some of the members of this group are members of the MDSR technical and/ or high committees.
[c] Includes both obstetrics and gynaecology registrars who are MDSR focal persons and their counterpart at the Ministry of Health.
[d] Includes midwifery inspectors [based at the primary health care administrative locality], midwifery supervisor [based at the level of the Ministry of Health], directors of Reproductive Health units, directors of maternal and child health units, directors of primary health care units, and MDSR office members [not focal persons]. Some of the members of this group are members of the MDSR technical and/ or high committees.
[e] officials belong to UNICEF and UNFPA

5.4 Themes

Three themes were identified from the analysis in relation to maternal health care [Table 29].

Table 29: Themes and sub-themes derived from the interviews.

Themes	Sub-themes
Providers of maternal health care	- Types of midwives - Organisation of midwives working in the community
Maternal health care	- Settings for maternal health care provision - Maternal health models of care
Challenges facing midwives working in the community	- Delays in referrals to hospitals - Negative interactions with other providers - Financial insecurity

5.5 Providers of maternal health care

Table 30 shows the different maternal health care providers identified from the interviews. Eight types of midwives, and two types of physicians were identified: junior doctors, ranging from recently qualified doctors to speciality trainees, and O&G specialists.

Table 30: Key characteristics of maternal health care providers in Sudan from interviews.

Providers	Qualification type	Minimum educational requirement	Minimum training duration in years	Is considered a skilled birth attendant?	Relevant Career progression
Traditional providers					
Traditional midwives	None	Not applicable	Not applicable	No	Not applicable
Midwives					
Village midwife	Direct entry [vocational]	None	≤ 1	No	None identified
Community midwife	Direct entry	Able to read and write	1.5- 2	No	Assistant Health visitor
Assistant health visitor	Direct entry	Community midwife qualification	3	No	None identified
Professional midwife	Direct entry	High-school certificate	4	Yes	Unclear
Nurse-midwife	Post-Nursing	Diploma in Nursing	4	unclear	Health visitor, can obtain a BSc degree or above
Sister-midwife	Post-Nursing	Bachelor of Science in Nursing	5	unclear	State Midwifery supervisor
Health visitor	Post-Nursing	Nurse-midwife	6	Yes	Inspector or teacher of midwives and/ or health visitors
Physicians					
Junior doctor	Primary Medical degree	High-school certificate	5-6	Yes	Obstetrician
Obstetrician	Specialist qualification	Primary Medical degree	9	Yes	Consultant Obstetrician

5.5.1 Types of midwives

The analysis revealed that there are eight different types of midwives in Sudan, yet no unanimous definition for a midwife was identified. Furthermore, respondents highlighted discrepancies between who is considered a midwife on the ground, in government reports, and in global standards. One discrepancy is that although all eight providers were called midwives

in interviews only few met the definition of a midwife as set by the International Confederation of Midwives [ICM].

> "*According to the ICM definition of the midwife, the community midwife that we have is a trained midwife not a skilled midwife … community midwives don't meet it [ICM definition]. Health visitors do.*" - Inspector 2

The second discrepancy is that midwives who have received any form of training were considered skilled birth attendants [SBA] in national reports, such as, in the Multiple Indicator Cluster Survey [MICS] country report. Again, only few qualify as SBA when compared to the global definition of an SBA.

> "*The MICS says that 77% of the births take place in the presence of a skilled birth attendant. This is debateable because in the community we don't have skilled birth attendants… the curriculums of the village midwife and the community midwife don't align with the [standards] of the international federation of midwives, so we can't say that they are skilled birth attendants.*" - Ministry official 7

The eight types of midwives are:

1) **Traditional midwives** have no formal midwifery training and are not licenced to practice midwifery. They are commonly known as "the rope midwives" because they hang a rope on a tree or a ceiling for the pregnant woman to hold onto during labour.

   > *"They tie a rope like this [points upwards]. Then, the woman would hold onto it and kneel, and the midwife would be under her, delivering her"* – Trained midwife 4

2) **Village midwives'** training varied between states and cohorts but is usually less than a year. No minimum education level is required of candidates, and MoH officials reported that most village midwives are illiterate. Their teaching relied on continuous repetition of materials until they memorise it, the use of pictures, and the use of color-coded devices.

   > *"It is like at kindergarten, we make them memorise things"* - Inspector 6

   > "*They are illiterate … so we teach them using sphygmomanometers that are colour coded: green, yellow, and red.*" - Inspector 2

3) **Community midwives** train for up to two years and must be literate. Their training duration also varied by state and by cohort from 15 to 24 months. Ministry of Health officials reported that few literate women were trained as community midwives.

> "*We have the village midwife whose curriculum is for nine months … also the community midwife … they have a 15-months curriculum"* – Ministry official 7

Both village and community midwives are trained to work in the community. However, given that community midwives are literate, some found opportunities to work in hospitals. One community midwife interviewed completed a professional diploma, then retrained as a community midwife. She mentioned being offered a job to work at the department where she trained because the specialist was very impressed with her work, how she communicates with nurse-midwives, and with the doctors.

> "*We are supposed to work in rural areas, but the doctor asked for us to work with him [at the hospital], after he saw our work."* – Trained midwife 11

Inconsistent titles were used throughout interviews to refer to midwives working in the community that made distinguishing between midwives working in the community challenging. Other titles used include technical midwives, legal midwives, certified midwives, licenced midwives, and trained midwives. Trained midwives or trained birth attendants was proposed by some respondents as a general term to refer to village and community midwives to differentiate them from traditional midwives and from skilled birth attendants. Thus, these terms will be used interchangeably throughout this thesis to refer to both village and community midwives.

> *"They are trained, trained midwives or trained birth attendants. There is a big difference between someone who trained for 12 or 18 months and that who is skilled [studied] for 3 or 4 years".* – UN official 2

4) **Assistant health visitors** are community midwives who receive additional training. They work mainly in primary health care centres and have supervisory roles over midwives working in the community. They report to and assist health visitors who are described below.

> "*There is another cadre, assistant health visitors … all are midwives, it goes like this I am a midwife then I study to become an assistant health visitor … as for responsibility, the midwife report to the assistant health visitor*" – Inspector 4

5) **Nurse-midwives** are nurses with a diploma in nursing who study midwifery afterwards. They work in obstetrics departments at hospitals and attend uncomplicated births.

> *"Some births are attended by hospital health cadre who are either nurse-midwife or sister-midwife"* – Ministry official 7

6) **Sister-midwives** are nurses with a Bachelor of Science degree in nursing who study midwifery afterwards. They also work in hospitals. MoH officials reported that there are fewer sister-midwives trained compared with nurse-midwives. Only one participant included in the study qualified through this route, she has a BSc in nursing, an MSc in Nursing in Obstetrics and Gynaecology, and at the time of the interview she was a PhD student in Nursing in Obstetrics and Gynaecology. She worked at the Ministry of Health and did not have any clinical roles.

> *"She is a sister who has a bachelor's degree"* -Ministry official 1

7) **Health visitors** are nurse-midwives who undergo further training, they train for a total of 6 years. They can take a variety of jobs: teaching midwifery and health visiting students, coordinating maternal and child health services at primary health care centres, attending births at hospitals, inspecting the work of midwives and health visitors [see 5.5.2]

> "*The health visitor is a nurse-midwife who studied nursing and midwifery courses and the [health] visiting course."*- Hospital midwives 1

"At the school, the health visitor teaches and supervises students … outside the school we work in health centres and hospitals … at the hospital… she would deliver women … at the health centre she is responsible for the midwives… she can be at the locality, and is called the inspector… she would be responsible for all the midwives … for the health visitors" – Health Visitor 3

8) **Professional midwives** train for four years to earn a Bachelor of Science degree in Midwifery, they must have at least a high school diploma to be accepted into the programme. They are equipped to provide the full range of midwifery services and their qualifications align with that of international midwives and SBA. Their training programme is relatively new in Sudan, so the full scope of their practice is yet to be recognised within the health system for administrative reasons. This means their current job is the same as other hospital midwives. One professional midwife was identified during the data collection period. She worked at the MoH and did not provide maternal health services or was involved in MDSR activities, as a result she was not interviewed.

"There is a number of the bachelor midwives, but, truly, there is a problem with including them in the system … they aren't part of it because their job description doesn't exist … we are fighting to include them." – Ministry official 1

A senior MoH official reported that the long-term plan is to phase out all trained midwives and replace them with professional midwives.

"The policies of the country are that, at some point, they [traditional midwives] will disappear, as well as the midwifery schools themselves that are a year and a half for someone who can only [read and write]. We want it to change into nurse-midwife, and then to a bachelor's degree [professional midwife]." - Ministry official 1

5.5.2 Organisation of midwives working in the community: A hierarchical system.

This section describes how trained midwives are organised- see Figure 12. A hierarchical structure was reported by respondents where trained midwives are at the first level, followed

by assistant health visitors, then health visitors [top-level]. Supervision, reporting, and any data collection followed this hierarchy, including reports of maternal deaths.

> *"You have the midwife who is the least [qualified], then the assistant health visitor, and there is the health visitor"* – Inspector 4

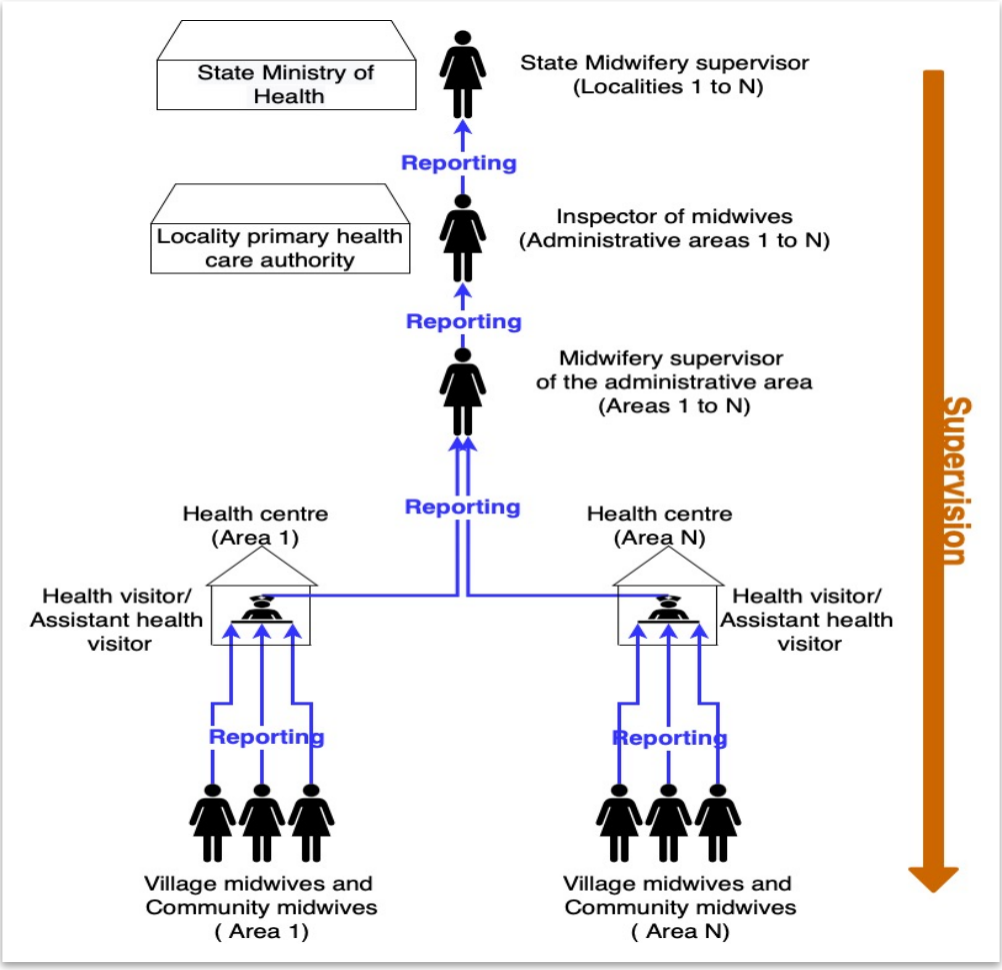


Figure 12: Organisation of midwives in the community and their reporting and supervision pathways.

One day a week, trained midwives work in a health centre with an assistant health visitor or a health visitor. They report the services they provided over the week either in writing or verbally to the health visitors [Figure 13]. These reports include the antenatal check-ups they have provided, births they have attended, outcomes of births, and any complication the mother or baby faced during or after labour.

"I can't write, but I memorise it until the health visitor asks" – Trained midwife 6

"For those who can't read, they have illustrations of a body of a woman … if there is [a death] then she ticks [the illustration of the] dead woman." - Inspector 6

"The reports are about: regular check-ups, uncomplicated/normal births, births with anomalies, stillbirths … the number of live and dead babies … males and females … the number of vitamins that they have distributed … if women had proteinuria … jaundice they would report it …"- Health Visitor 5

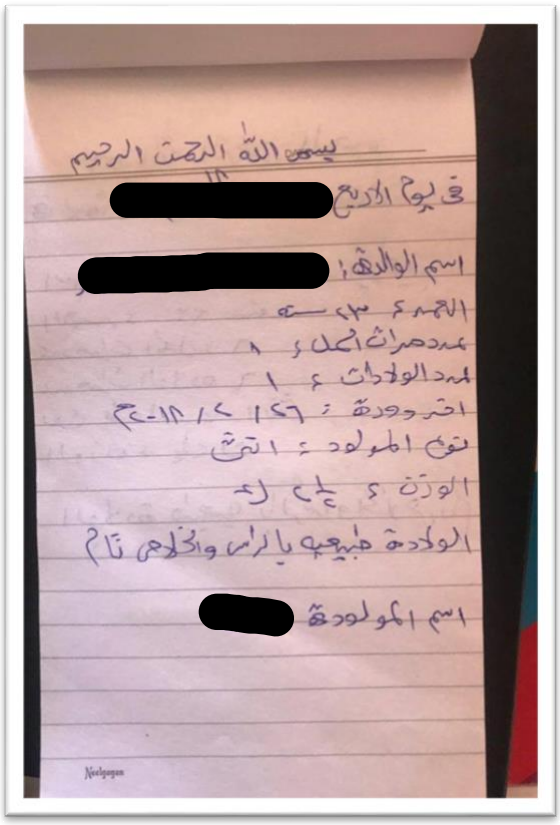


Figure 13: An example of a community midwife's note, following a birth.

Translation: The report is of the delivery of a 23-year woman. She had previously given birth to a female baby. Current childbirth was uneventful, cephalic presentation and the placenta was delivered completely. It also documents the name of the new-born and her weight.

The assistant health visitor or the health visitor, at the health centre, prepares a monthly report of services provided in their area by bringing together trained midwives' reports and the health centre's records. The report is then sent from supervisor to supervisor until it reaches the state midwifery supervisor.

"*I have a monthly meeting with the health visitors and the assistant health visitors where I would see their reports*" - Inspector 1

"As administrative units we submit to our locality. Then, the locality has a meeting at the Ministry of Health on the X of every month, they submit a report to the Ministry and the Ministry takes the report to the Federal Ministry." – Health Visitor 5

Each trained midwife has a supervisor who is either a health visitor or an assistant health visitor. Health visitors or assistant health visitors are themselves supervised by health visitors at the administrative units then by the inspector at the locality level. Inspectors are responsible for a large number of health visitors, trained midwives, as well as hospital midwives.

"I supervise 37 health centres, 16 delivery rooms, and 200 midwives"- Inspector 1

All inspectors report to the state midwifery supervisor who is based at the Ministry of Health. State midwifery supervisors must hold a minimum of a bachelor's degree. As described above, there are few bachelor's degree training pathways for current midwives. Half of the state supervisors interviewed were nurses who did not receive additional training in midwifery, and none of the state midwifery supervisors reported any experience of working in out-of-facility settings. Assistant health visitors are the only midwives who hold supervisory roles over trained midwives and have themselves been trained to work in the community.

Although an accountability framework for midwives exists, MoH officials reported that it was challenging to implement in practice because of the big differences in skills and competencies between midwives. Inspectors are the main officials identified who carry out disciplinary actions against midwives working in the community. One of three actions is possible depending on the seriousness of the situation: issuing a formal warning, sending the midwife back to midwifery school and in this event her box and license are confiscated temporarily, and permanent confiscation although this was reported to be rare.

"[It is] very rare … one or two … I took a midwife's box because she circumcised [a female] … We went there at 3 p.m. and I took her box for good" - Inspector 5

5.6 Maternal health care

5.6.1 Settings for maternal health care provision

Interviews revealed that maternal health services are provided in different settings: the pregnant woman's home, the midwife's home, primary care health centres, and hospitals. Table 31 summarises maternal health care providers and services by setting. Respondents stated that most women preferred to give birth at their homes. Care provided in the community/ homes is delivered by the least qualified providers while the highly qualified providers worked in health facilities.

Table 31: Maternal health care providers and services provided by setting.

	Woman's Home	Provider's Home	Primary Health Care Centre	Hospital
Providers				
Traditional midwives	Yes	unclear	No	No
Village midwife	Yes	Yes	Yes	No
Community midwife	Yes	Yes	Yes	Possible
Assistant health visitor	Yes	unclear	Yes	Possible
Professional midwife	unclear	unclear	No	Yes
Nurse-midwife	Yes	unclear	No	Yes
Sister-midwife	unclear	unclear	No	Yes
Health visitor	unclear	unclear	Yes	Yes
Junior doctor	unclear	unclear	Yes	Yes
Obstetrician	unclear	unclear	Yes	Yes
Services				
Antenatal care	Yes	Yes	Yes	Yes
Intrapartum care	Yes	Yes	No	Yes
Post-natal care	Yes	Yes	Yes	Yes
Emergency care	No	No	No	Yes

Source: interviews

5.6.2 Key maternal health models of care

Three distinct care pathways that women follow during pregnancy and childbirth were identified [Table 32]. Women can change pathways during a single pregnancy, use a single service like intrapartum care, or use none.

Table 32: Main models of care identified from interviews.

	HOME BIRTH MODEL OF CARE	FACILITY BIRTH MODEL OF CARE	OBSTETRICIAN-LED MODEL OF CARE
Population	Low clinical risk	All clinical risk population	All clinical risk population
Setting, main	Home	Facility	Facility
Setting, additional	Health centre/ or health unit	-	Home or facility
Provider, main	Trained midwife	Doctors and midwives	Obstetrician
Provider, additional	Assistant health visitor, a health visitor, junior doctors and nurse midwives, or obstetricians as needed	Obstetricians and a multidisciplinary team as needed	Intrapartum care provider
Intrapartum care	Home	Facility	Home or facility
Continuity of care	Named midwife providing one-to-one antenatal care, intrapartum care and post-natal care visits at home; consultation and referral as required	Antenatal care at outpatient clinic and 24-hour cover for intrapartum care at the hospital both supervised by an obstetrician, and an appointment for post-natal care at 6 weeks post-partum	Named obstetrician providing one-to-one antenatal care, referral for intrapartum care to a hospital or home birth, and an appointment for post-natal care at 6 weeks post-partum

Home birth model

Trained midwives care for low-risk women in the community and refer high-risk women to the hospital. The pregnant woman has one midwife who knows her and provides care throughout pregnancy and after. Together, they prepare a birth plan [Figure 14].

"*Those who follow up with me will give birth with me*" – Trained midwife 1

Following an uneventful delivery, the midwife observes the woman for 4-6 hours and examines the new-born. This counts as the first out of four post-natal care visits.

> *"The first day, we stay with her for 6 hours. Then, we visit her on the third day, this is the second visit. Then we visit her on the seventh day, the third visit. … You check her condition is well until she completes the 40 days."* – Health visitor 1

If the woman or the baby experiences any complications during or shortly after childbirth, they are referred to the nearest health facility accompanied by the midwife.

Facility birth model

In hospitals, doctors provide ANC, intrapartum care, and post-natal follow-up to women in all clinical risk groups. Women attend outpatient clinics for ANC and are cared for by available doctors. When in labour, the birth would be attended by doctors and hospital midwives.

Following an uncomplicated birth, the woman is observed for few hours before discharge, and is scheduled for a follow-up visit in six weeks.

> *"There will be some post-natal care that is carried out on the 40th day post-partum. Unless there is something else that would require her to come in earlier"* – O&G Registrar 1

Because home births are popular and trained midwives only attend childbirth of women of low clinical risk, doctors interviewed believed that a large proportion of hospital births are of high-risk women.

> "*The number of normal deliveries is not big … those who are low-risk usually give birth in places other than hospital but those with complications or issues come to the hospital*" – O&G specialist 2

Although both doctors and hospital midwives attend hospital births, little collaboration was reported between midwives and doctors who attend women. One O&G specialist described that each would focus on their job and their specific duties. In the case of an emergency or a complication, the doctor would take over as they are ultimately responsible for the women.

Obstetrician-led birth model

In this model, an obstetrician is the main care provider. They care for women in all clinical risk groups. Women attend ANC and based on their risk level and preference the obstetrician either refers them to deliver at hospital or clears them for a home birth attended by a trained midwife.

> *"She would follow-up … with the doctor, he would examine her and then they would decide … if the delivery is at home… and if he says the delivery will be at the hospital then she would go and deliver at the hospital*" – Trained midwife 8



Figure 14: Poster summarising the birth plan.

[The numbering was added to the poster by the DPhil student].

Translation: [1] the pregnant woman is to save some money in preparation for an emergency; [2] In the case of a home delivery, the woman should prepare clean water containers, washing container, a container to boil the water, clean cloths, covers, cloths for the mother, soap, and a plastic bag to get rid of the placenta; [3] identify a trained [licenced] midwife and her address; [4] identify a method of transportation and alternatives in the case of an emergency; [5] decide the place of birth whether at home or a health centre; [6] identify who will look after the house; [7] identify someone who will accompany the mother in labour.

5.7 Challenges facing midwives working in the community

This section highlights key challenges facing midwives that emerged from the interviews and were relevant while considering their inclusion in MDSR.

5.7.1 Referrals to hospitals

Various respondents highlighted late presentation of obstetric emergencies to the hospital as a challenge to reducing maternal mortality. However, midwives and doctors had different opinions as to where this delay occurs. Delayed recognition of danger signs by trained midwives, was commonly cited by doctors and MoH officials as a key reason. They suggested that refresher training and courses are needed to improve trained midwives' knowledge of danger signs. Another reason cited by ministry officials was that midwives feared being blamed if they brought a woman with a complication to the hospital, so they may hesitate before bringing the woman to the hospital causing a delay.

Trained midwives acknowledged that there are delays in reaching hospitals but reported multifaceted contributors to delays after a danger sign has been recognised. Resistance from women or their families was a key contributor to the delay. Midwives reported that many women or their families would insist that they give birth at home, and when a complication arises, they might not be flexible or change their mind. Valuable time that could have been spent transporting the woman is used to convince the family of the seriousness of the situation. Sometimes, to no avail. Difficulty in arranging transportation, challenges posed by geographical elements, poorly maintained roads all contribute to delays after a red flag is detected.

> "*She was a primigravida with pregnancy induced hypertension… the midwife … told them that she will not deliver her, [she told them] you should let me take her to the hospital. Eventually, after she had gotten worse, they took her to the hospital where she died. [the midwife] … told them she must take her to be treated and to save her, but they told her we won't go, it is impossible.*" - Inspector 5

5.7.2 Negative interaction with other maternal health care providers

Trained midwives need to work with health visitors and doctors to effectively care for women. However, the interactions they have with other providers can either encourage or deter future engagement. From interviews, frequent negative interactions between midwives and other health care providers were identified.

Firstly, negative interactions within the midwifery profession between trained midwives and health visitors. These were identified as early as their first interactions in midwifery schools. A Dean of a midwifery school emphasised the need for sternness when dealing with student midwives to instil in them good work ethics and develop their sense of responsibility. Tough treatment is also thought to reflect the harsh conditions under which midwives are likely to work in the community, so it is part of preparing the midwives for their working lives.

> *"We are tough on them. We reprimand them, humiliate them, and shame them ... to test their morals and whether or not they will be able to handle the community."* – Health visitor 3

A similar approach was adopted by other supervisors of midwives. They reported treating midwives harshly because if midwives feared them, this would ensure that they do their job properly. This led to some midwives avoiding interactions with supervisors altogether. Ministry of Health officials and MDSR officials gave examples of when they found it difficult to contact midwives, of low attendance to meetings with supervisors, and of midwives hiding to avoid interactions with supervisors.

> *"When it is the [inspection] day, the village midwife knows that the inspector is coming to visit her, so she would hide at the neighbours ... they feared her, and it used to improve the work."* - Inspector 4

Examples of midwives being reprimanded at supervision meetings were reported. If a midwife reports an adverse event such as a maternal death, she will be asked to present the case

to her colleagues. Although this is intended as a teaching activity, it may lead to professional embarrassment when the midwife is blamed for the outcome publicly.

> *"I tell them this midwife delivered a woman, and I would explain what happened. If the woman was a primigravida, then we blame the midwife. But, if she had multiple births, then we will give her a chance to tell us what happened … her colleagues would comment … everyone would give their opinion … we exchange opinions and come up with solutions."* - Inspector 1

Secondly, inter-professional negative interactions were also reported. Trained midwives and health visitors reported being treated poorly by doctors, especially young doctors. When trained midwives referred women with a complication arising during childbirth or post-partum, they reported being met with blame, suspicion, and outright accusations of causing harm. One midwife took her client to the hospital after the client complained of a mass protruding from her vagina. This was later diagnosed as a postpartum uterine prolapse. However, the midwife was accused of harming her client.

> *"When we got there, the doctor, the doctor was very young, she told me this is a crime… they told me that you must have done something"* – Trained midwife 6

Midwives working in hospitals felt that their contributions were not respected or appreciated by doctors. They reported that doctors rejected their help especially in emergency situations, even though they had the knowledge and experience to contribute to the management. A senior health visitor stated that when she is treated badly by doctors, she would stop assisting even though it might mean the patient's condition may worsen.

> *"…these young doctors … if you say to them let me help or insert [a canula] they would yell go away! When in fact they don't know. If they tell me to go away, and I want to help insert the canula, then I will leave him, yes! They will keep trying until her [blood pressure] drops and then what will they do? Nothing! Nothing!"* – Health visitor 8

Few senior respondents challenged this pervasive punitive culture that influences midwives and their work and highlighted the need for better intra- and inter-professional

relationships. One O&G specialist warned that such interactions can erode trust between midwives and doctors, alienate midwives, and the care women receive in the community would inevitably suffer. As such, better communication and larger reforms to the work culture are needed.

> *"Accountability should be carried out in a decent way that doesn't repel."* – O&G specialist 1

> *"This has to happen on a large scale, we have to build a culture of no blame, a no blame culture or a right to fail culture"* – Ministry official 7

5.7.3 Financial insecurity

Respondents stated that midwives working in the community are financially vulnerable. Their lack of remuneration was constantly brought up in interviews with midwives, doctors, ministry officials and UN staff. In one state, the MoH officials interviewed declined to answer on record whether trained midwives had salaries. Many midwives working in the community did not receive any pay from the MoH, and those approaching retirement expressed concerns about the lack of pensions. Overall, midwives felt that they lacked financial security, and many had to take on additional jobs to support themselves and their families.

> "*The midwife has no salary and no pension. We have nothing! They are supposed to support us*." – Trained Midwives 4

There seemed to be an expectation from the MoH officials that after a midwife graduates and returns to her village where there is a need for her services, she will attract paying clients and will secure an income. However, for midwives securing an income came with many challenges. As compensation for their work, women give them gifts or money. There is no fixed rate and women would pay the midwife based on their economic situation. Trained midwives reported instances where they would provide their services for free to women who cannot afford it.

"*Some families would pay, and some would not be able to because of their circumstances … when you find that this is their situation, then you won't ask them for anything, you would just wash your hands and leave*."- Trained midwife 10

"*She is given what is available, such as sugar, and some who might be very poor, would call her and she would attend the birth, but they might not give her anything. She can't request it because of her morals and professionalism.*" - Ministry official 2

Furthermore, attending a childbirth costs midwives as they use gloves, gauze, needles, sutures, anaesthesia, and more. These consumables are sometimes provided free of charge from the MoH, but midwives frequently have to purchase them. Thus, without a fixed rate, the cost of attending a childbirth for trained midwives might sometimes outweigh the payment they receive.

"She would deliver without getting paid … but she would consume things in the delivery." - Ministry official 2

Some MoH officials and doctors suggested that lack of income could influence midwives care decisions. This is because if she refers a woman to the hospital she will not be paid. A senior official suggested that because of her financial need, a midwife might not refer a high-risk woman to hospital and choose to deliver her at home or not refer her until it is too late.

"[If referred to the hospital] … they won't pay her because the hospital has its own expenses. This is, by the way, one of the reasons that might lead the midwife to keep the woman." – Ministry official 2

However, this was challenged by other MoH officials, highlighting that this is just an assumption, and there could be other explanations.

"They are not keeping her for the incentives that they would get unlike what most people would see … this is not how the situation is always like, this is our assumption" – Ministry official 7

5.8 Discussion

5.8.1 Main findings

The aim of this chapter was to enrich our understanding of maternal health care in Sudan. Eight types of midwives were identified: traditional midwives, village midwives, community midwives, assistant health visitors, nurse midwives, sister midwives, health visitors, and professional midwives. Three key care pathways were identified that ranged from care provided by a midwife in the community to care offered by a multidisciplinary team at hospital. The chapter focused on midwives working in the community, describing their hierarchical organisation that facilitates supervision and reporting, and the challenges they face, such as delays to hospital referrals, negative interactions with health care providers, and financial insecurity as they have implications for the incorporation of midwives into MDSR.

5.8.2 Harmonising and Strengthening Midwifery in Sudan

Midwives varied greatly in terms of their educational attainments prior to midwifery training, the duration of their training, and their career trajectories upon graduation. These differences are likely a reflection of the frequent changes to midwifery education in Sudan. Indeed, since its inception in 1921, midwifery education has been characterised by periods where midwifery schools flourished and trained cohorts of midwives followed by long periods where they were closed (Elhadd, 2011, Eldin and Abdallha, 2011). Furthermore, a substantial proportion of midwifery training was carried out by international NGOs (Eldin and Abdallha, 2011). The fragmented training of midwives, along with short-term midwifery education projects funded by external bodies possibly resulted in the training of a heterogenous midwifery profession in Sudan.

The present stark differences between midwives have contributed to confusion about the profession within the health system, as providers and MoH officials often confused their titles, and possibly their capabilities. Such a heterogenous picture of the midwifery workforce

can hinder its development (Kemp et al., 2020, Kennedy et al., 2018). Thus, harmonising the profession is needed, and the two key areas that would benefit from harmonisation are titles and educational qualifications.

Agreeing on a national definition for a midwife is an essential step to harmonise the profession. According to the ICM, the title "midwife" should only be awarded to those who have obtained basic midwifery competencies (ICM, 2017). A recent study that was carried out in two states in Sudan [N=180], found that literate community midwives performed poorly when compared against basic midwifery competencies. For example, nearly half of the midwives could not accurately measure women's vital signs (Abu-Agla and Vallières, 2020). Thus, accepting the ICM definition of a midwife would have serious implications for the current midwifery cadre in Sudan. The number of active midwives and subsequently the proportion of births attended by a skilled provider on government reports would reduce drastically - see 3.4.2.

Maternal health care providers who do not meet the national definition could be offered opportunities for further training to meet the definition. Upskilling of community providers in skilled care attendance has been implemented in various countries to increase coverage, with varying levels of success (Olaniran et al., 2019). In the context of Sudan, upskilling might be optimistic given that a significant proportion of midwives are "functionally illiterate" (Arabi et al., 2016), so other solutions such as re-naming providers who cannot be upskilled to provide basic midwifery services should be considered. This is crucial to ensure that the title of midwife is protected and to raise the bar of the profession. However, such change in the title should not be followed by a change in their responsibilities until an appropriate replacement is arranged. This would prevent deteriorations in maternal health care in the community due to lack of providers as reported in India (Mavalankar and Vora, 2008). Thus, a gradual shift in roles and responsibilities should follow changes in title.

The second area for harmonisation is midwifery education. In 2001, a presidential decree to upgrade the education of midwives and nurses marked the start of governmental efforts to standardise and advance midwifery education in Sudan - FMoH 2001 cited in Abu-Agla et al. (Abu-Agla et al., 2013). To carry out this role, the Academy of Health Sciences [AHS] was established (Abu-Agla et al., 2013). However, community midwives who are the main graduates of the AHS, are not trained to ICM standards as suggested from the interviews. This indicates that although efforts are in place to standardise midwifery education, the new cadre still falls short of global midwifery education standards.

The introduction of bachelor's degrees for midwifery is a real step towards the professionalisation of midwifery in Sudan. For example, in Canada, when highly skilled, university educated midwives joined the workforce, it was the tipping point in changing the status of the midwifery profession (Winkup, 1998). However, the small number of educated women entering midwifery training in Sudan poses a challenge to the development of the profession. Strategies to attract educated candidates with secondary education are needed. Such investment, although more costly when compared with investments in lesser skilled cadre, is cost-effective in the long-term (Sandall et al., 2016). Indeed, several African and Asian countries are making effort to align their midwifery education with international standards (Edwards et al., 2018, Bogren et al., 2020, Jan et al., 2016). Thus, even though the education of community midwives is being standardised, policies should focus on training skilled midwives to provide maternal care both in the community and at facilities.

5.8.3 Fostering a supportive work environment for midwives

A supportive work environment is critical for the practice of midwives. Literature suggests that supervisors of midwives should have technical expertise in the area they are leading to ensure a supportive midwifery practice environment (Thumm and Flynn, 2018). Thus, the organisational hierarchies, of the kinds revealed in interviews, are known to hinder supportive

environments for midwives in the community. Furthermore, they may lead to power imbalance within the midwifery profession between direct entry midwives and post nursing midwives. For example, trained midwives who work primarily in the community are taught, supervised, and represented by health visitors who trained as nurses and work primarily in health facilities. Thus, the two groups vary substantially setting-wise despite having similar basic midwifery skills, and health visitors may not possess the skills necessary to support trained midwives with their work in the community. This mismatch has been documented in other African countries. A study across Ethiopia, Ghana, and Malawi found a shortage in qualified midwifery educators in all three countries, and educators were from other professions namely nursing (Fullerton et al., 2011). Investing in training capable midwives with experience working in the community to take on supervisory and teaching roles can contribute to building a supportive practice environment.

This analysis identified that midwives working in the community are often criticised by health facility providers for the care they provide and for delays in referrals decisions. The absence of a collegiate and collaborative relationships between midwives and other health care providers can contribute negatively to the work environment of midwives. Previous studies have shown that potential solutions include introducing early interprofessional courses and workshops and increased opportunities for collaboration (Ratti et al., 2014)- see further discussion chapter 8.

The analysis also identified lack of consumables, appropriate compensation, and of transparent accountability frameworks, all of which can negatively affect quality of care (Ith et al., 2012, Hulton et al., 2016). Providing midwives with their basic work needs must be made a priority for trained midwives in Sudan, to ensure safe and adequate care is provided to women and to protect midwives.

Furthermore, midwives lacked support in dealing with reluctant women or families, and access issues from women's perspectives are not often acknowledged. Similar findings were reported in Guatemala where home births are common and are attended by "*Lay midwives*" who have received some formal midwifery training (Juarez et al., 2019). Lay midwives were often stigmatised and blamed by "*the biomedical system*" for late presentations when they referred women despite women's strong preferences for home deliveries. Reasons why women might avoid facility deliveries are well documented in the literature, such as lack of respectful care at health facilities, discrimination and physical abuse, unaffordability of care or the perception that care is unaffordable, care responsibilities, and the status of women in the community (Bradley et al., 2016, Kruk et al., 2018, Fawole and Adeoye, 2015, Shrestha et al., 2012, Kyei-Nimakoh et al., 2017).

5.9 Limitations and challenges in conducting the qualitative study

This section discusses the challenges and limitation faced in carrying out the qualitative study that is reported in chapters 5, 6, and 7. Sudan's political situation [December 2018- August 2019] constituted a significant challenge to the conduct of this study. During that period, there were nationwide mass protests, civil disobedience, government enforced curfews, weeks long internet bans, and a state of emergency declared by the government. This political situation affected data collection in three main ways.

First, safety was a significant consideration, I always travelled with a companion and was restricted in where I could go and how long I could stay there. I followed the Foreign, Commonwealth and Development Office's travel advice, which advised against all travel to the Darfur region given its unpredictable security status (FCDO, 2021). Midwives working in remote villages that would have required an overnight stay were not accessible to me. However, the perspectives of MoH officials, midwifery supervisors, MDSR officials and UN officials were based on their experience with midwives from across the country including areas that I

could not reach. Thus, it could mitigate this lack of coverage. Nonetheless, the inability to include midwives in remote areas and in the Darfur limits the transferability of these findings, and they may also be limited to non-conflict settings in Sudan.

The second challenge was because Health Ministers that I planned to interview for this study were dismissed from their positions. I replaced them by other senior officials who had knowledge of the system and the MDSR, such as directors of primary health care or directors of maternal and child health.

Lastly, the tense political situation might have affected MoH official's willingness to be open during interviews. Some senior ministry officials gestured for me to stop recording when they did not want to answer questions on-record - all answered the questions off-record voluntarily. I made note of points discussed off-record and discussed them with my DPhil supervisors. Based on their advice, points discussed off-record were brought up and discussed with other participants in later interviews.

In addition to the political situation, another limitation of this study is that participation was limited to maternal health care providers and those familiar with MDSR. Thus, women and their families were not interviewed. Limited information was available about their experience of midwifery services at home. The perspectives of women on care they receive could have strengthened the findings of this study by providing a more comprehensive picture of maternal health care in Sudan.

5.10 Strengths of the qualitative study

The strengths of the qualitative study that is reported in chapters 5, 6, and 7 are discussed here. Fifty-four participants from diverse backgrounds, settings, and geographical locations were included. This relatively large sample provided rich and detailed data on the experiences, opinions, and feelings of respondents. They have provided a unique insight through accounts of the midwifery profession and the challenges it faces in terms of recognition and training, the

MDSR and barriers it faces in terms of structure and activities [Chapter 6], and the inter-professional barriers and facilitators to including midwives [Chapter 7]. Such knowledge and insights are difficult to obtain otherwise as most information about the Sudanese health care system is *"only available in hardcopies located within the Federal Ministry of health in Khartoum"* (Abu-Agla and Vallières, 2020).

Additionally, the data collection started when a new government was appointed following a 30-year authoritarian regime, an air of optimism and a desire for change were widespread across the country. I think this has affected the interviews as some participants felt they could be critical of the MDSR and the government, something that might have not been possible a few months prior. Another strength came from collaboration with Ahfad University for Women in the conduct of this study. The collaboration facilitated obtaining ethics permits, and access to MoH in the different states.

5.11 Conclusion

The midwifery profession is Sudan faces numerous challenges that must be addressed if midwives are to make their most positive contribution to improving maternal health in Sudan. The path to develop the midwifery profession in Sudan is promising but requires a clear and ambitious vision, effective leadership, and a supportive environment. Rapid reductions in maternal mortality are difficult to envisage if Sudan's focus remains on training lesser skilled providers without strengthening the midwifery workforce, especially in the community. As midwifery education enters its second century, bold decisions are needed to align midwifery education in Sudan with global standards.

The following chapter describes and evaluates the MDSR in Sudan. The logic model developed in Chapter 2 is used to compare the MDSR in Sudan with fully functioning maternal death reviews worldwide.

6 Maternal Death Surveillance and Response in Sudan.

6.1 Chapter introduction

Sudan transitioned from maternal death review [2009-2015] to maternal death surveillance and response [2016- present]- See section 1.3.4 for more details (FMoH, 2015). This represents an extension to the programmes focus to reviewing and responding to all maternal deaths, thereby completing the surveillance-action cycle. Given the recent transition, little information is publicly available about the new maternal death surveillance and response [MDSR] in Sudan, and no study have evaluated the transition from maternal death review [MDR] to MDSR in Sudan. The aim of this chapter is to bridge this gap in literature, corresponding to thesis objective 6. The chapter describes the structure, activities, and outcomes of the MDSR programme in Sudan, as well as the key challenges it faces.

6.2 Methods

The data were collected through semi-structured interviews from fifty-four health care providers working in health facilities and in the community, Ministry of Health officials, MDSR programme staff, and UN officials. Five states, representing five of the six regions of Sudan, were covered. A semi-structured interview guide was used to collect data from respondents with the aim of understanding the context of maternal health care delivery and the MDSR process. Interviews were audio-recorded, transcribed verbatim, then translated from Arabic to English. Thematic content analysis was carried out.

The sampling methods, data collection, data analysis, issues of rigour, and ethical considerations are described previously [see Chapter 5.2], and a description of included participants is presented earlier [see Chapter 5.3].

6.3 Themes

Four themes were identified from the analysis of the interview data in relation to MDSR in Sudan [See Table 33].

Table 33: Maternal death surveillance and response [MDSR] themes and sub-themes derived from the interviews.

Themes	Sub-themes
MDSR structure	- MDSR Committees - MDSR Key persons
MDSR activities	- Identification and notification of maternal deaths - Data collection and the data collection tool - Maternal death review meeting - Feedback and response
MDSR outcomes	- Outcomes of MDSR
Challenges and oversights of the MDSR programme	- Dependence on state MDSR registrars - Threatening environment for midwives

6.4 The structure of the maternal death surveillance and response programme

6.4.1 Maternal death surveillance and response committees

MDSR committees are in place in each of the 18 states, and all report to the National MDSR committee at the Federal Ministry of Health [FMoH]. At the national level, two MDSR committees, a "*technical committee*" and a "*high committee*", and a maternal death registrar coordinate and oversee the MDSR programme's activities across the country. At state-level, the structure of MDSR varied slightly, but, generally, it consists of [i] a technical committee that meets monthly; [ii] a high committee that meets quarterly to annually; and [iii] MDSR focal persons.

The technical committee and a high committee both review maternal deaths and generate recommendations, but vary in their representation and frequency of meetings. The technical committee is made up of directors of relevant departments at the state Ministry of Health, hospital directors, obstetricians, and the MDSR focal persons while the high committee has a broader and more high-profile representation of maternal health stakeholders, such as Ministers of Health. The technical committee ideally convenes monthly while the high committee convenes annually.

> *"the technical committee… at state-level … the head of the committee is of course the general director [of the Ministry of Health], the rapporteur is the RH coordinator, the supervisor of midwives is a member, the senior obstetrics and gynaecology specialist in the state is also a member, and the registrar… IT, health information, the director of curative medicine and the director of preventive medicine … the blood banks people, the hospital directors and so on."* - Inspector 2

6.4.2 Maternal death surveillance and response key personnel

Three key actors were identified who carry out most of the MDSR activities, and are described below: the national MDSR registrar, the MDSR registrar at state level, the MDSR focal person at the Ministry of Health at state level.

The first is *the national registrar* who is a senior obstetrics and gynaecology [O&G] consultant. The role of the national registrar, as compiled from various respondents, includes assigning the state MDSR registrars and supervising them, receiving notifications of facility and community maternal deaths, receiving and reviewing data collection forms, travelling to states to attend annual maternal death review meetings, and contributing to the MDSR reports and recommendations.

The second are *the state MDSR registrars*. These are junior doctors in the second year of their O&G training. In addition to their training, they are tasked, for one year, with identifying maternal deaths in the facilities where they work, and with collecting data on the deaths using a standard data collection form. Although the registrars are not employed by the MDSR programme, they individually benefit from this arrangement. One state MDSR registrar described it as a "win-win" situation because each state MDSR registrar uses the data they have collected about maternal deaths to write-up a thesis for partial fulfilment of their Doctor of Medicine [MD] degree in Obstetrics and Gynaecology.

> *"Part of the MD requirements is a thesis … The [research] council would acknowledge it if you were in charge of the maternal review for a full year … for you this is a part of the requirements of your MD, the research [component]"* – O&G Registrar 4

On one hand, this arrangement ensures a constant supply of candidates for the role of state MDSR registrar. Every year, a new O&G registrar gets assigned to the role to support the activities of the MDSR programme.

> *"The process is strengthened by the fact that there is an ongoing research topic with the National Medical Specialisation Board. All registrars when they specialise, they must complete some research, so every time they give this topic to someone … this has been going on for a long time. I think it is a good mechanism because it becomes a research topic for a MD degree candidate who is very well oriented and concerned about the work itself and they would be active …"* - O&G Specialist 1

On the other hand, the Sudan Medical Specialisation Board [SMSB], which is the body responsible for the training of speciality doctors, has been receiving a minimum of eighteen theses on maternal mortality every year since the programme's establishment according to one MoH official. They further added that the SMSB is "saturated" with research on maternal mortality submitted by MDSR focal persons and might not accept similar submissions in the future. Without such an incentive for O&G registrars, the sustainability of the programme could be threatened [see also section 6.7.1].

> *"The system still depends on … obstetrics registrars as it became part of their curriculum and training … the issue … has already started, the medical specialisation board says they no longer want any study about maternal deaths to be submitted to them, and that they have received enough studies … but we don't have an alternative. We didn't create the alternative who will take over."* – Ministry Official 7

The third actors are the *MDSR focal persons based at the Reproductive Health [RH]* directorate at the state Ministry of Health [MoH]. These are employees of the MoH, and as MoH officials they must have a bachelor's degree at minimum. Those interviewed had various educational backgrounds such as nursing and public health. They are tasked with identifying maternal deaths in the community, collecting data on the deaths - with the support of the state MDSR registrars – and preparing summary reports of the death for the MDSR committee meetings.

6.5 Activities of the maternal death surveillance and response programme

Although MDSR follows the surveillance cycle [see Figure 2], the interviews provided insights into how the MDSR structure and activities are carried out [see Figure 15].

6.5.1 Identification and notification of maternal death

It is mandatory to report each maternal death, whether in the community or in a health facility, to the MDSR focal persons or directly to the national MDSR registrar [Figure 16]. In health facilities, maternal deaths are reported by the doctors who attended the deaths or by the hospital's director to the state MDSR registrar. Doctors or hospital directors also report deaths if a woman was brought dead to the hospital, but these cases are not considered as facility deaths by the MDSR committee and are counted as community deaths.

> *"If she is brought dead to the health centre this is considered to be a community death"* – Ministry official 1

For community deaths, various reporting pathways were identified. If the woman was cared for by a midwife, then the midwife should report the death either to her supervisors [see Figure 12] or to the MDSR focal person at the MoH. Many MDSR and MoH officials interviewed expressed their frustration with trained midwives because they claimed trained midwives do not report deaths in the community. One official stated that the main source of identifying community deaths in their state was not from community providers but rather from health facility staff who reported the cases of women who were brought dead to their facility.

> *"If she died at home, then there is the possibility that the midwife would report it to you or not report it … They fear reporting… that is why in most cases they will not report … I did not come across any midwife, maybe just two midwives… who attended the birth and called us"* – Ministry official 2

> *"The deaths reports that I receive as home deaths would come from the hospital … No midwife would come to me."* – Inspector 4

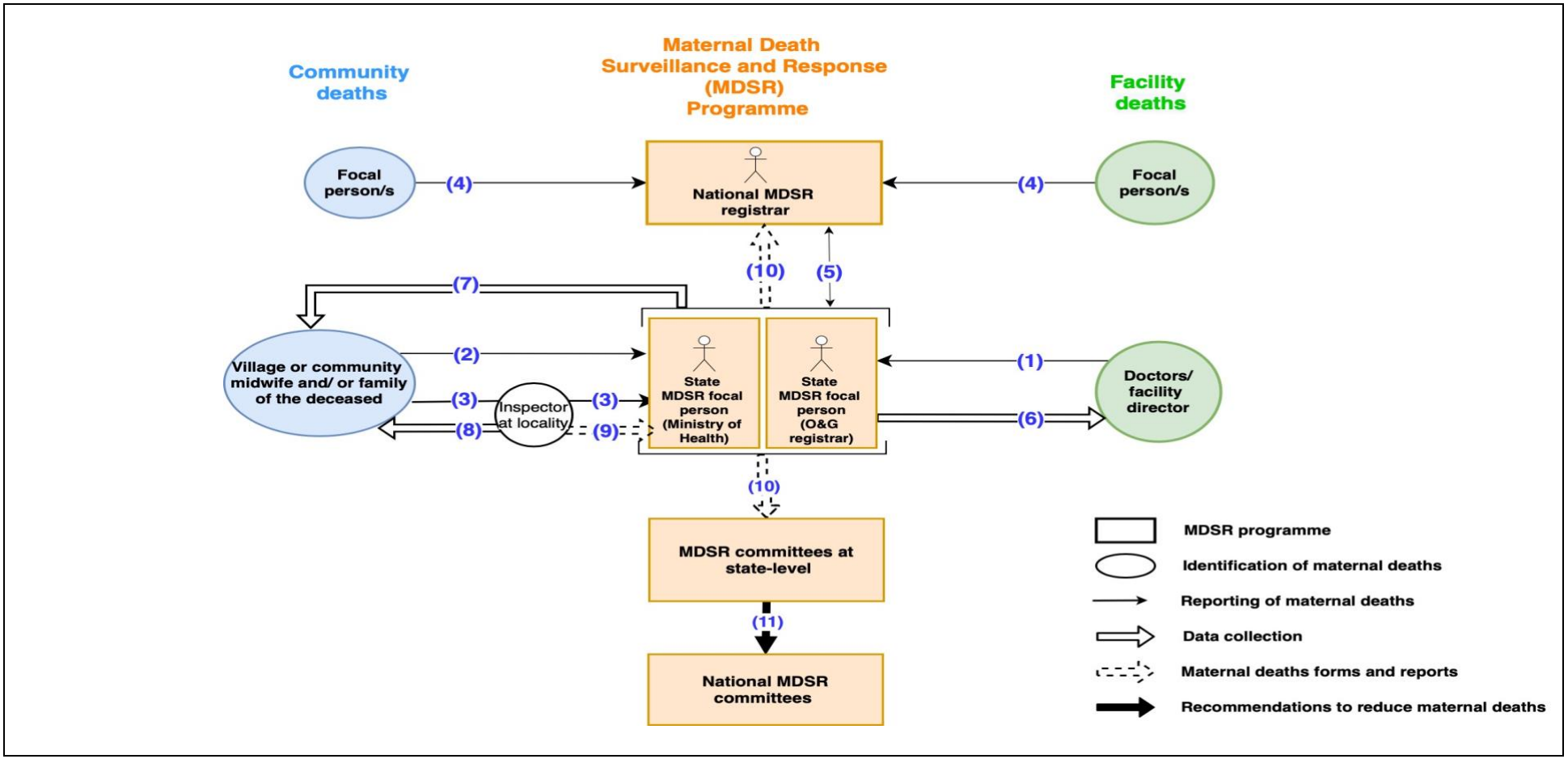


Figure 15: Maternal death surveillance and response activities as developed from interviews.

*Arrows: **Notifications** [1] notifications from doctors or directors of health facilities to state MDSR registrar [facility focal person], [2] [3] notification from trained midwives or family of the deceased women directly to the MDSR focal person at the Ministry of Health or through the supervisors of the midwife, respectively, [4] notifications from other focal person directly to the national MDSR registrar, [5] notifications received by MDSR focal persons are communicated to the national maternal deaths registrar and vice versa; **Data collection** [6] the MDSR facility focal person collects data from doctors, [7] both focal persons – at Ministry of Health and the O&G registrar- visit the family of the deceased and/ or the midwife who cared for the women prior to her death, [8] data collection is delegated to inspectors at the locality where the woman died; [9] the inspector sends the data collection form/s to the MDSR focal person at the Ministry of Health, [10] data analysed by state MDSR focal persons and reports sent to the national registrar and the MDSR committees at the state-level; [11] state-level committee would review maternal deaths and make recommendations to the MDSR committees nationally.*

In addition to low reporting from midwives who attended the births, other midwives in the community who know about the maternal death would not report it to the MDSR programme. Some midwives perceived the reporting of the maternal death in this situation as a betrayal to the midwife who attended the birth.

> "*I can't report that there is woman who gave birth in that area and so and so delivered her. I don't dare go and say that! Maybe she doesn't want to report, so I go and tell? I will not report. I will only report for the area I am responsible for*" – Health visitor 1

Furthermore, some reported that in rural communities where midwives are usually known to everyone, there community members would not report maternal deaths to protect the midwife. The reason is that they think they would lose the services that the midwife provides if the death is reported. One ministry official commented on this:

> *"this is their midwife, and they will not give her up, they might have given up the [deceased woman?] but they will not give up the midwife. If they report the midwife, then she could be jailed, and this will harm them. They would stand with the midwife, who is the reason that the woman died, right? they would stand with her because for them if she is taken away … she will not be able deliver anymore and they will be harmed."* – Inspector 4

To improve identification of maternal deaths in the community, trusted members, such as, teachers, religious leaders, and community leaders were incentivised to report any maternal deaths. These incentives were reported to have increased reporting of community deaths in some settings.

> "*For the past two years, we have been incentivising the notification of deaths. If anyone reports, then an incentive is issued for them. This has encouraged people who are not part of the committee to report, but notification from individuals from outside the system is not much … especially in the community*" – UN officer 1



Figure 16: A poster providing the contacts details of the national maternal death surveillance and response registrar for reporting maternal deaths.

The poster was found in the office of a health visitor in a health centre.
Translation: Immediate notification of a maternal death saves the life of another mother.

6.5.2 Data Collection and Data collection tool

The state MDSR registrars and the MDSR focal persons at the MoH gather data about deaths from facilities and the community using a specific data collection form. Clear differences were reported between how data is collected in facilities compared with how data is collected in the community. In hospitals, the MDSR registrars liaise with the doctor/s who cared for the woman and gather information with the aim of identifying the cause of death and if it was avoidable. Such a meeting is relatively easy to organise, and entails meeting the MDSR registrar who is a relatively junior doctor to fill in the data collection form.

> *"He would sit with those who attended to the patient, he would review and check her file for the information that he needs to know."* – O&G Registrar 2

> "*We would collect the data… people would try to find the cause of death."* - O&G specialist 4

For community deaths, the aim of data collection is also to identify the cause of death. However, data collection can be logistically challenging to organise because of long distances, difficult roads, and lack of MoH resources to carry-out data collection visits. As a result, MDSR focal persons at the ministry often delegated data collection to the inspector[1] of the locality where the death has occurred or to other officials.

> *"The MDSR person coordinates with the registrar … sometimes this would be a major thing, for example, if the place is far, they will need to hire a car and may spend the night there. Other times, they are maybe lazy and not go, which is what happens in most cases, or they would send another official"* – Ministry officials 9

Inspectors are often contacted if a death has occurred in their locality. They would fill in the data collection form and send it to the MDSR programme. However, given their disciplinary capacity- see 5.5.2, they could carry out disciplinary actions against the midwife at the same meeting. Thus, this delegation means that inspectors must play two contradictory roles, the first is to collect data on maternal death for the MDSR that adopts a "no name no blame" policy, and the second is to uphold the tough inspector role who disciplines midwives.

> *"The MDSR isn't a punishment tool"* – Ministry official 7

Generally, the only exception to the "no name no blame" policy is if negligence was identified. One nurse-midwife who works at a tertiary hospital mentioned that it is not possible for negligence to occur at the hospital because there the woman is cared for by the midwife and the doctor together. The term 'negligence' was widely used by respondents almost exclusively in relation maternal deaths in the community.

> *"There's no punishment unless there's negligence"* – O&G registrar 5

> *"The hospital is better because there would be no negligence, why? because both [midwife and doctor] are there working together".* – Hospital midwife 3

[1] Inspectors are health visitors who are based at the primary health care authority at district level, and they supervise midwifery supervisors who in turn supervise village and community midwives.

When prompted to describe negligence, respondents gave examples of first, second, and third delays. Negligence seemed to imply any avoidable cause of deaths.

> *"Either there was negligence from the patient herself and her family: a delay from them to call the midwife or to reach the hospital"* – Ministry official 2

> *"Lack of transportation is the first and foremost reason that causes a midwife to be negligent of the woman, and for the woman to die."* - Inspector 5

> *"There are areas where there should be a specialist, but there wouldn't be a specialist so the negligence would come from the area itself"* – O&G Registrar 3

Thus, if an inspector collects data from a midwife and identifies areas of delay, they can deem the midwife as negligent. The inspector can then punish her by sending her back to the midwifery school for further training.

> *"If the woman died because of her negligence, they would punish her. Sometimes they send them back to us at the school… we revise with her the areas in which she was negligent, for example, if there was a delay in the referral, or if she didn't manage the bleeding"* – Health visitor 3

The findings regarding negligence are presented under "data collection" not under "review meeting" because inspectors assess whether there has been negligence during the data collection stage rather than at the review stage. The next activity, the review meeting, takes place at the health ministry where a quantitative summary of the information collected is reviewed.

One data collection form is used to gather information about community and facility deaths. The form has two sections: the first covers general information about the deceased woman and cause of death and the second is specific to hospital deaths with questions on management to determine if the death was avoidable. Respondents reported several issues with the data collection form: firstly, the form is not suitable for community deaths, as it does not capture care provided by trained midwives.

"There should be a form specific for community deaths, with all of its data coming from the midwife." – Inspector 4

Secondly, the form captures little information on non-medical causes of death [social, economic, cultural, or organisational], and allows little opportunity for qualitative input. This limits what can be learnt about maternal deaths beyond potential medical cause, and thus, has implications for what can be reviewed by the MDSR committees and for the potential recommendations.

"The form is fixed, and I would tick what applies." – O&G Registrar 1

"Generally, the questionnaire includes the medical causes of maternal deaths, and it doesn't discuss social factors" – O&G Registrar 3

Forms collected are analysed by the MDSR key persons, and a report of summary statistics, such as MMR, distribution of cause of death, and location of death, is prepared. The report is presented at the review meeting.

6.5.3 Maternal Death Review meeting

The technical and the high MDSR committees at state-level would convene at different intervals to review cases of maternal deaths. The meetings are attended by ministry officials, hospital directors and doctors. Respondents reported that at these meetings, no individual cases of maternal deaths are reviewed. Instead, a quantitative summary of all the causes of maternal deaths and the available non-medical factors leading to deaths are discussed.

"The aim of the meeting is to identify the most common causes of deaths, and whether the causes are medical, social or administrative … If they are medical causes, then this aspect will be discussed in-depth at the hospital by the specialists… The meeting at the ministry would discuss the social or administrative causes of deaths … people would make recommendations … most social causes were about the roads and ambulances" – O&G Registrar 3

The source of data about the non-medical factors that have contributed to deaths under-review is not clear, given that such data were not reported to be collected using the MDSR data

collection form. Furthermore, the main providers in the community, trained midwives, who could have contributed such information, are not invited to the review meetings.

> *"This meeting has no midwives at all. The meeting would have the general director, the director of [primary health] care, the coordinator of reproductive [health], anaesthesiologists, the director of medical laboratories and the bodies that are related to maternal mortality."* - Inspector 4

> *"I think that when they formulated the plan [for MDSR] they didn't think to include the community midwife and the supervisors, but if they think about it, then the midwife is supposed to be with them"* - Inspector 3

There seemed to be an expectation that individual cases of maternal deaths should be discussed locally, at facility or community levels. Hospitals, especially teaching hospitals, hold routine meetings to review adverse outcomes including maternal deaths for educational purposes. Such meetings are not part of the MDSR programme, but they may contribute to MDSR.

> *"Every Thursday, we discuss all the deaths that occurred from a medical aspect… everyone involved in the management is mentioned by name, we don't say X did, no! we say this treating specialist did. This is so that the conversation is directed and there is accountability, but not in the legal sense … it ends by the end of the meeting … there are forms that are collected and these were designed by the ministry and are then taken straight to the ministry."* – O&G Specialist 2

Doctors not directly involved with the MDSR who were interviewed for this study often referred to hospital meetings when asked about maternal death review meetings while the MDSR process was referred to as a research project conducted by an O&G registrar [discussed below in 6.7.1]

> *"There is yearly research, there would be a registrar carrying out this research on maternal mortality. They would collect all the maternal deaths [data], and they work with a professor in Khartoum."* – O&G Specialist 5

It is worth noting that hospital review meetings were exclusive to doctors. They are not attended by midwives working at the O&G department. One possible reason for this could be

a language barrier as stated by a junior doctor. Review meetings in hospitals are conducted in English, which makes them inaccessible for midwives working in the hospital who train in Arabic, thus preventing their participation.

> "*Those present are registrars and sometimes medical officers … so the discussion would be in English and maybe a word or two in Arabic*" – O&G Registrar 4

The review meetings are not intended to assign blame. However, a FMoH official and MDSR official who regularly attends MDSR meetings in the different states observed that doctors often blame trained midwives. Although trained midwives are never present in MDSR meetings, they are represented by the state midwifery supervisor. As a result, confrontations between doctors and midwifery representatives took place in MDSR meetings.

> *"Each cadre would unite, and they would defend themselves"* - Ministry official 8

> *"[State midwifery supervisors] would want to defend midwives from all the allegations against them, the same way that doctors would defend themselves … this the scenario that you would see, that we are the doctors, and you are the midwives"* - Ministry official 8

6.5.4 Feedback and Response

The main feedback from the MDSR programme is through an annual report the programme releases on maternal deaths in Sudan. It provides data on deaths, as well as, recommendations to reduce maternal mortality. No other clear feedback mechanism was identifed.

> "*yearly we produce the maternal death surveillance and response report*"- Ministry official 9

Attendees of the MDSR committee meetings, who are leaders, managers, and decision-makers, act on the recommendations or communicate them to the relevant authorities. For example, recommendations relevant to trained midwives in the community are communicated from the state supervisor down the supervisory chain to individual midwives.

"There are some recommendations that the hospital would implement. Everyone would take their recommendations and they would implement it." -Inspector 4

"The focal person of the RH is present in the MDSR committee, whatever happens she can communicate through meetings to the inspectors of the locality. The inspector … meets with the health visitors from the health centres so any recommendations will get to them directly"- Ministry official 1

However, inspectors and other supervisors of midwives reported not being aware of what was discussed at these meetings and their outcomes – see "*Communication*" under 7.4.3.

"After they have conducted the review, they don't get back to us, they don't feedback, and they don't inform us of what happened" – Inspector 3

Examples of responses carried out by the MDSR programme include producing clinical guidance for managing major obstetric complications for facility care, and at the community level this included community mobilisation, community education campaigns, and starting emergency funding schemes for obstetric emergencies.

6.6 Outcomes of the MDSR programme

The MDSR was established in 2009, and respondents' views about what it achieved during that period differed. During the data collection period, political reforms were underway. Some senior ministry officials interviewed were appointed prior to the reforms while others were appointed following the governmental changes. There were clear differences in their responses particularly at the national level. According to one ministry official who is also a senior MDSR committee member, the programme's recommendations were taken up by the Ministry of Health, leading to major improvements. For example, their recommendations led to improving the training of midwives and to increasing the numbers of trained midwives, improving coverage.

> *"The maternal death review programme ... has major achievements. It provides information and helps in generating recommendations ... there was a major jump in midwives [numbers]... which is one of the recommendations that we make yearly ... they should increase the training of the midwife especially through the in-service training ... the curriculum of the midwives was updated"* – Ministry official 9

The contribution of the MDSR's recommendation to the training of midwives is difficult to discern since these actions were reported by respondents to be part of the country's policies preceding MDSR. For example, increasing the number and training of midwives featured as recommendation by the MDSR committee but respondents mentioned that the numbers of midwives substantially increased because of the "a midwife for every village" policy.

Additionally, a senior director, who was newly appointed from within the directorate and is familiar with MDSR, challenged the notion that the MDSR has informed the work of the Ministry of Health. They stated that the MDSR did not provide data to inform policy or actions rather it provides a general idea of maternal deaths in Sudan.

"From 2009 until now, this review … gives us the main causes of deaths, and it tells us the weaknesses, for example, which state has low notification. But, up until now we don't depend on it for our reports or to inform our plans." – Ministry official 7

6.7 Challenges and oversights of the MDSR programme

6.7.1 Dependence on the state MDSR registrars

Interview data show that the MDSR programme depends largely on the national registrar and the O&G trainees to carry out the day-to-day activities. The national registrar supervises the data collection on maternal deaths and the thesis that comes out of it. This raised several concerns about the MDSR: first, concerns about MDSR's reliance on one person's influence and connections; Second, which is linked to the previous concern and that is the partial integration of MDSR into the MoH. Together they threaten the sustainability of the MDSR, and some respondents predicted that the MDSR would fail if the current leadership leaves.

"This system is not institutionalised yet… we still talk about specific individuals … it still depends on individuals who benefit from it directly … whether this benefit is in the form of prestige … or publication of studies … when I look at the program now, I feel that it will collapse if the person in charge leaves" - Ministry official 7

"The national registrar is a very experienced person and has held this position since its establishment in 2009. So, he knows its history, and all aspects of the system … it is completely dependent on one person. If anything happens to this person then they will no longer be able to continue with the work, and this system will collapse. There is no one else who has the institutional memory, the experience, or even access to all the resources and information other than this person" – UN official 1

Few months following completion of the data collection, potentially in the wake of the political changes, the national registrar resigned from their role [2009-2020] [written communication, Ministry of Health official, 06.03.2021].

6.7.2 Threatening MDSR environment for midwives

When a midwife reports the death of a woman she attended in the community, she faces several issues: being sent back to a midwifery school, loss of wages as her delivery box could be

confiscated while at school, lack of anonymity and professional embarrassment from having to discuss the incident publicly in the presence of other midwives, and punishment if deemed negligent. Respondents agreed that fear prevents midwives in the community from reporting deaths, but no mechanisms were identified to legally protect midwives and ensure anonymity. A senior committee member relayed that a common recommendation of the MDSR committee to control the practice of midwives is to call for tougher supervision on midwives to ensure reporting of deaths.

> "*We emphasise that there should be tougher supervision, follow-up, and meetings with midwives*" - Ministry official 9

Collectively, the data from interviews indicate that these factors result in a vicious cycle that support a threatening environment for midwives and limits their willingness to engage with MDSR activities [Figure 17].

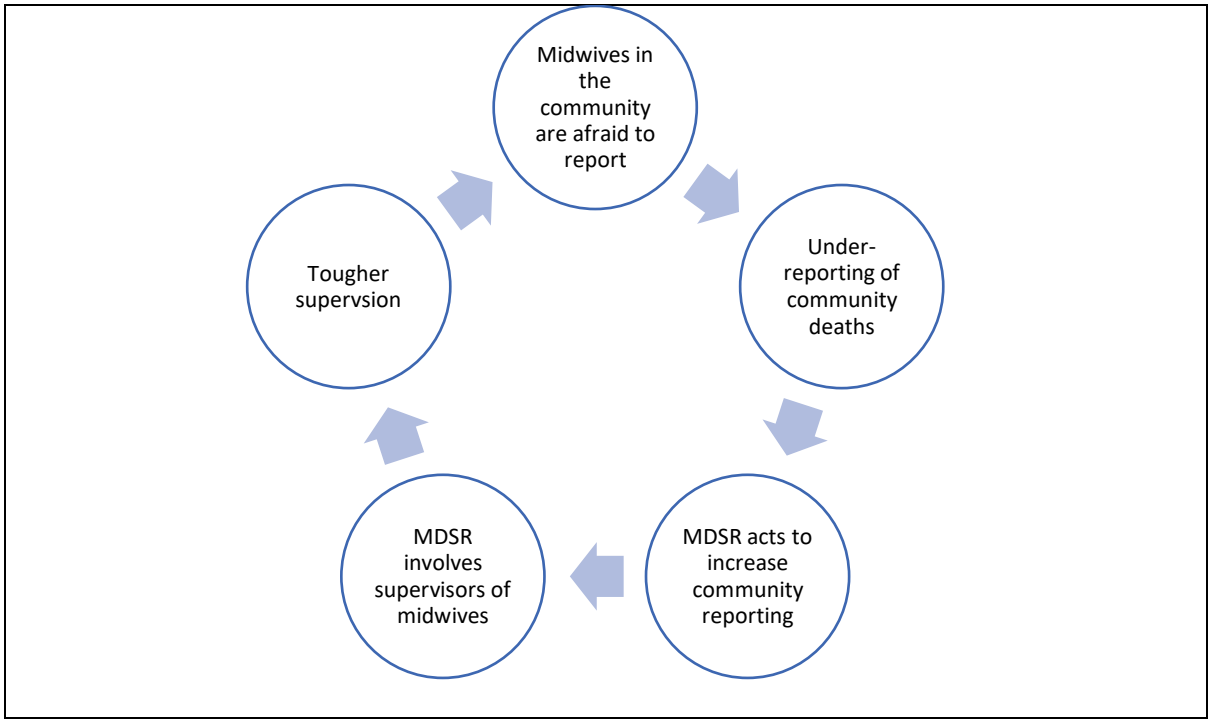


Figure 17: A vicious cycle that maintains a threatening MDSR environment for midwives.

6.8 MDSR programme in Sudan compared to the systematic review informed logic model

The inputs, activities, outputs, and outcomes of the MDSR programme identified from the interviews were compared to the logic model developed in section 2.3.7. The logic model was developed by analysing the characteristics of maternal death reviews that reported on short- and long- term outcomes, such as changes to the health system, identifying and bridging knowledge gaps, and reducing maternal mortality. Table 34 illustrates this comparison between MDSR in Sudan with the logic model for a well-functioning maternal death review.

Overall, MDSR in Sudan as described by respondents, had many of the key inputs, activities, and output of a well-functioning MDSR as described by the logic model. However, MDSR in Sudan had little effect on individuals, facilities, and the health care system.

Table 34: Mapping Maternal Death Surveillance and Response in Sudan to the logic model of fully functioning maternal deaths reviews.

INPUTS	ACTIVITIES	OUTPUTS	OUTCOME	IMPACTS
Policy Legal frameworks Clear guidelines and protocols Involving key stakeholders Trained personnel A surveillance system Funding	Identification of maternal deaths Data collection on maternal deaths Reviewing maternal deaths Production of a maternal death review report [outputs of the review] Providing feedback on maternal mortality for the relevant body Dissemination and/ or publishing of the report [outputs of the review] Advocate for the use of the outputs of the review process to inform policy and practice Evaluate the implementation of recommendations Coordination between different process goals	Measures of maternal mortality Characteristics of the deceased women Causes of maternal mortality Risk factors for maternal mortality Preventability of deaths Quality of care Identifies lessons Makes recommendations	Short term changes: • Self-reflection and continuous learning • Empowering local staff • Staff training • Health education [health care system level] • Improved surveillance of maternal mortality • Integration of the MDR/MDSR process into other Maternal and Reproductive Health services • Improved data quality: documentation and collection • Improved resource allocation • Evidence-informed policy, budgets, programmes, and practice Long term changes: [facility-level] • Structural or organisational changes • Improved resource allocation • Improved quality of care [Process related] • Refining the review process	Ending preventable mortality, morbidity, and disability. Improving maternal outcomes and quality of life Safe pregnancy and childbirth
Supportive environment from ministry level to review meetings at local levels [community or facilities]				

Green: present in MDSR in Sudan. Red: absent from MDSR in Sudan. Black: unable to determine from interviews

6.9 Discussion

6.9.1 The MDSR programme in Sudan: Key findings.

This chapter described and evaluated the structure, activities, outputs, and short- and long-term outcomes of MDSR in Sudan. The analysis revealed that MDSR committees carry out their activities at national and state levels. The main strengths/ benefits of the programme were that it raised the profile of maternal death review in Sudan, especially in health facilities, provided data on maternal deaths such as levels and medical causes, disseminated the information through annual reports and academic papers, produced guidelines for the treatment of major causes of maternal mortality based on local standards of care and available resources, it contributed to building capacity in research of O&G trainees involved, and made general recommendations to improve maternal care.

Despite its accomplishments, the analysis identified critical gaps and oversight. The MDSR is loosely integrated into the existing health system, is largely facility-based and physician-led, it focuses on medical causes of deaths, has weak mechanisms for feedback and for monitoring the effectiveness of recommendations, and it struggles to achieve long-term effects on maternal mortality.

6.9.2 How does Sudan's current MDSR compare to WHO indicators?

A baseline assessment was carried out by WHO in 2015 to assess the implementation of MDSR in 64 LMICs (WHO, 2016c, WHO, 2016a). The assessment looked for the presence of national policies for the notification and for the review of maternal deaths, and for implementation indicators: the existence of a national maternal death review committee, the production of a national annual report with recommendations, the existence of a sub-national committee, the production of a sub-national annual report with recommendations, community representation in sub-national MDR committees, and the existence of a national MDSR plan. Only four

countries, out of 64, were found to meet all assessed indicators: Sudan, China, Niger, and Uzbekistan (WHO, 2016c, WHO, 2016a).

This analysis found that on paper Sudan's MDSR has all core components of an MDSR system as recommended by the WHO. The high-level political buy-in facilitated the introduction of national policies to support the MDSR programme in Sudan, and health ministers were involved in the MDSR committees, and annual reports were published in their name (FMoH, 2015). However, this analysis also identified critical gaps in MDSR implementation that hinder its proper functioning and hinder completion of the identification to response loop. This discrepancy suggests the need for more robust MDSR implementation indicators, beyond identifying if a particular policy or committee exists, to discourage tick-box culture (WHO, 2012a). Alternative indicators could be based on expected outcomes of the MDSR, for example, changes to providers, services, or facilities. Although outcome-based measures come with their own challenges, they provide an assessment both of the commitment to MDSR and of its ability to lead to change. A key challenge to this type of indicators was seen in the systematic review in chapter 2 where it was difficult for MDRs to separate their effects on maternal mortality from that of secular changes. Understanding this challenge, however, can provide a balanced approach to reporting the outcomes of MDRs and to evaluating them.

6.9.3 How does Sudan's current MDSR compare to the wider literature and the systematic review informed logic model?

The logic model developed in Chapter 2 provided a template for fully functioning maternal death reviews worldwide against which the key characteristics MDSR in Sudan identified from interviews were compared. MDSR in Sudan had some key inputs, carried out most activities, and had similar outputs when compared to the logic model. However, advanced characteristics identified in the logic model were largely absent. These include, enhanced case ascertainment,

use of standardised systems to classify maternal deaths, in-depth qualitative data collection, detailed review of individual cases or of a representative sample of maternal deaths by a multi-disciplinary team, upholding confidentiality and anonymity, feedback mechanisms, and short- and long-term outcomes.

The MDSR programme is partially integrated into the health system. Although the MDSR office and staff are physically hosted by the Ministry of Health and the programme relies on the ministry's resources, it is not integrated into to the health information system or the disease surveillance national programme. The WHO recommends integrating MDSR into the health system in LMICs, as seen in Ethiopia, to ensures its sustainability and reduce its operating costs (WHO, 2016c, Pearson et al., 2009, Abebe et al., 2017). The current organisation of MDSR in Sudan may keep its operating costs low as most activities are carried out by individuals "based on goodwill" (Umbeli et al., 2018), but it limits its impact and threatens its sustainability.

The integration into the health system is not necessary for a fully functioning maternal death review as seen in the systematic review- See Chapter 2. However, a robust administrative framework and/ or a surveillance system should be in place to ensure the adequate running of programme activities (Mitchell et al., 2014, Government of Malaysia, 2014). Thus, programme-level linkages, such as with the national surveillance programme, are needed to strengthen the operation of the MDSR programme.

The MDSR programme relies on individuals' networks, rather than on integration into the system or programme level linkages. This corroborates findings from an evaluation study of the previous MDR [2009-2015]. It described maternal death review as a "*one-man show*" given the central role played by the national registrar (Musoke and Balogun, 2015). Minor change has been made to the programme's structure in response, which respondents explained was due to lack of alternatives.

The MDSR programme in Sudan operates better in health facilities than in the community as suggested by interviews. This is likely because health facilities namely public hospitals are highly organised in Sudan, so even with limited resources, identifying maternal deaths and data collection is feasible. The limited inclusion of private health facilities identified in a previous study of MDR in Sudan further supports this (Musoke and Balogun, 2015). This is consistent with other studies where the lack of regulation of community care and the private sector constituted a barrier to the identification of maternal deaths (Naik et al., 2020, Muvuka, 2019).

Service provision in the community remains largely provider based- see Chapter 5. Thus, a single MDSR focal person, similar to the MDSR registrars in health facilities, cannot meet the complexities surrounding identifying maternal deaths in the community. This will result in low identification of community deaths. Challenges in capturing community deaths are commonplace in LMICs given inadequate active surveillance in the community (Abouchadi et al., 2013b, Horon, 2005). Countries that invested in active community engagement with MDSR, such as Malawi, recorded an increase in the identification of maternal deaths (Bayley et al., 2015).

From this and previous chapter, in Sudan, misclassification and underestimation of maternal deaths are major challenges to accurate and complete registration of maternal deaths for MDSR, the first step of the surveillance cycle- see Figure 2. Improving the identification of maternal deaths requires more concerted surveillance efforts, as opposed to the passive identification approach currently in place. In Pakistan, Malawi, and Tanzania, for example, efforts were made to collect data from community households using trained officials or community health workers, and from private and public health facilities in an attempt to capture all deaths (Anwar et al., 2018).Therefore, enhanced surveillance systems, the likes of which were described in the systematic review [see 2.3.4], are needed to improve deaths' registration.

Lack of data collected on community level health care and causes of deaths limit the scope of community reviews. A study by the African Union in Chad, Ethiopia, Nigeria, South Africa, and Tunisia found that none of the MDSR committees in these countries included community representatives. The study recommends the inclusion of community representatives with insights into the socio-cultural circumstances leading to maternal deaths (African Union Commussion and UN Women, 2015). Studies where community representatives were included reported that they had significant contributions to identifying sociocultural factors to deaths and in ensuring community buy-in to address these factors (Bayley et al., 2015). Improving community representation in MDSR in Sudan is needed to appropriately review community deaths.

The MDSR programme relied on quantitative data with limited qualitative input. The WHO recommends the use of both quantitative and qualitative input to gain deep insights into causes of maternal deaths (WHO, 2004a). The lack of qualitative analysis limits understanding of the specific causes why women die that would in turn result in lack of specific recommendations (Smith et al., 2017a). This is likely because collecting and reviewing qualitative data on maternal health is a resource intensive task and requires resources that are beyond the current structure of the MDSR. Such implementation gaps are not unique to Sudan, and the majority of LMICs that have adopted MDSR have reported challenges in its conduct due to lack of resources (Koblinsky, 2017). Therefore, adequate investments in MDSR are needed to support its activities and goals.

Fear of punitive action has been identified in the literature to be a major barrier to the involvement in MDSR (Abebe et al., 2017, Muvuka, 2019, Bain and Kongnyuy, 2018, Tura et al., 2020). This analysis showed a dual picture with the presence of non-punitive approaches in health facilities but the presence of punitive approaches in the community. The lack of a general accountability framework and a pervasive blame culture in the community, as seen in

Chapter 5, could have contributed to this. Thus, a supportive legal environment in the community could facilitate MDSR activities. The importance of addressing the legal and ethical challenges have been emphasised in several studies globally and by the WHO (Bain and Kongnyuy, 2018, Tura et al., 2020, Hodorogea and Friptu, 2014, Paily et al., 2014, Lusambili et al., 2019).

The terminology used by the MDSR in Sudan can be threatening. Reviews of community deaths often used the term "negligence", which can perpetuate fear and defensive behaviours. In the literature, terms such as "substandard care" were replaced with less threatening terms such as "lessons to be learned" and "remediable factors" in efforts to shift the focus from blame and to reduce fear (Bamber and Kinsella, 2015, Ravichandran and Ravindran, 2014, Knight, 2021). A clear definition of what constitutes negligence is needed, as well as a focus on the use of less threatening terms, especially in the community.

In Sudan, Arabic has been the medium of instruction in midwifery schools, and all public educational institutes since 1990s, but doctors are taught in English (Saeed, 2017, Suliman, 2004, Fahal, 2007). Differences in the language in which technical knowledge is possessed can create barriers in communication between health care providers and can negatively affect quality of care and collaborative practice (Al-Harasis, 2013). This is a unique challenge to the conduct of MDSR in Sudan that to my knowledge has not been reported in the literature. The education of midwives and doctors in Sudan needs to be prepare them for this functionally bilingual work environment – see recommendations 8.3.2.

Mapping the MDSR onto the logic model revealed limitations in influencing individual behaviours, practice, or the health system. This is consistent with recent WHO findings (WHO, 2016c). The MDSR baseline survey carried out by WHO reported that countries focused on reviewing deaths and making recommendations without appropriate follow-up on

recommendations to “close the loop” (WHO, 2016c). In the context of Sudan, this finding is not surprising given the numerous challenges the MDSR programme faces. Sudan should ensure that all elements of the MDSR programme function properly, with a particular focus on the response element to close the notification response loop; thus, saving lives.

The next chapter builds on previous chapters by using a midwife-physician inter-professional collaborative framework to identify barriers to the inclusion of midwives into the MDSR.

7 Understanding factors affecting the incorporation of the perspectives of midwives into maternal death surveillance and response.

7.1 Introduction

Chapter 5 highlighted some of the challenges that midwives face that are relevant to their participation in the maternal death surveillance and response [MDSR], such as a pervasive punitive culture in which they operate and an unwelcoming medical system. Chapter 6 identified further challenges to including the perspective of midwives, such as limitations due to MDSR's structure. This chapter aims to identify limitations to the inclusion of the perspectives of midwives into the MDSR using an inter-professional collaborative practice framework, corresponding to thesis objective 7. This framework would provide insights into the internal functioning of the MDSR and identify obstacles to inter-professional collaboration that can be addressed to facilitate the inclusion of the perspectives of midwives.

Several conceptual and theoretical frameworks of collaboration between health professions have been described (D'Amour et al., 2005, D'amour et al., 2008, Mulvale et al., 2016, Smith, 2015). Common concepts, such as communication between members, were identified in all domains to affect inter-professional collaboration. However, only one framework was tailored towards the midwife-physician relationship (Smith, 2015). Thus, it was used for this analysis.

7.2 The midwife-physician collaboration: a conceptual framework for inter-professional collaborative practice.

Smith borrows the following definition for collaboration for their framework "*an evolving process whereby [two] or more social entities actively and reciprocally engage in joint activities aimed at achieving at least one shared goal. [It] occurs between individuals, groups, units, or a cross-level combination of them*" (Thomson et al., 2009) cited in (Smith, 2015). According to this definition, the MDSR process is a form of collaboration between key maternal health stakeholders, namely doctors, midwives, and ministry officials. The framework has four main dimensions: organisational, procedural, relational, and contextual, and each dimension is subdivided into concepts [See Table 35].

Table 35: Dimensions and concepts of the Midwife-Physician collaboration framework as defined in Smith, 2015 (Smith, 2015).

DOMAINS	DEFINITIONS
ORGANISATIONAL	
Shared vision	Both professions agree on the goals of the collaborative practice.
Shared interests	Knowledge and resources from both professions are combined and utilised so that all benefit from the collaboration.
Commitment	Both professions feel that it is worthwhile to stay and work in the collaborative practice rather than leave.
PROCEDURAL	
Shared decision-making	Both professions partner to develop solutions to mission-related problems.
Coordination	Tasks are well coordinated between professions.
Role clarity	Each profession understands role and responsibility as a member of the collaborative practice.
RELATIONAL	
Communication	Information is shared between the professions that strengthens the collaboration's overall operations and programs.
Trust	Members of the collaborative practice trust each other, despite different professional perspectives.
Respect	The knowledge and skills each profession bring to the collaborative practice is appreciated and respected by all members of the practice.
Synergy	The collaborative practice achieves its goals better by both professions working together rather than apart.
Reciprocity	Members of the collaborative practice can count on both professions to meet obligations to the practice.
CONTEXTUAL	
Shared power	Working together does not hinder the independence of either profession.

7.3 Methods

Fifty-four respondents from various backgrounds were interviewed. The methods for this study as well as a description of included participants are described in detail in Chapter 5 [see 5.2 and 5.3, respectively]. Thematic content analysis was used (Braun and Clarke, 2006). The twelve concepts of the midwife-physician collaboration framework were used as predefined categories for coding. The one sheet of paper method, described earlier, was used to summarise the data within each concept (Ziebland and McPherson, 2006)- see Appendix V.

7.4 Results

7.4.1 Organisational dimension

In Smith's framework this dimension has three concepts that influence the relationship between midwives and doctors within MDSR: shared vision, shared interests [knowledge and resources], and commitment.

Shared vision

The importance of MDSR in improving maternal health was widely acknowledged by respondents, and there was agreement that its goal is to reduce maternal mortality.

"*It will have benefits for the mothers. It will reduce mortality*" – Trained midwife 1

"*The committee's main purpose is to reduce maternal mortality*" – O&G Registrar 4

MDSR's goal to reduce maternal mortality paralleled the reported professional goals of the midwives and doctors interviewed. Midwives felt that the aim of their practice is to ensure the safety of the mothers they attend and their newborns, and some doctors reported that to them the goal of obstetrics and gynaecology is to reduce maternal mortality.

"The goal of obstetrics is to reduce maternal mortality" – O&G specialist 2

Shared interests [knowledge and resources]

In addition to professional responsibilities, respondents agreed that achieving the goal of the MDSR is a collective responsibility. They called for the involvement of health professionals from different fields and the community to save women's lives.

> *"We involve all the responsible parties … a mother's death is not something that only concerns the Reproductive Health [Directorate] or something that only concerns the Ministry of Health, it is something that matters to the entire community"* – Ministry official 6

Commitment to the MDSR

Despite agreement that health professionals should participate in reducing maternal mortality through MDSR, commitment to MDSR activities was low. Issues reported in interviews such as underreporting of community deaths, delegation of MDSR duties, low attendance to review meetings, and reducing the number of meetings, all point towards the lack of commitment to MDSR activities from MDSR committee members, key persons, and maternal health providers. For example, in one state, the MDSR technical committee meetings were often held in the attendance of only two committee members who share the same office.

> *"The technical committee includes people here, there is me [director of Reproductive Health], the [state] supervisor of maternal health, the director of primary health care, … the general director, but they don't attend all the time, there is also the director of curative medicine, … an obstetrics and gynaecology specialist, the registrar …. This is the technical committee that is supposed to discuss deaths that happen, we should gather the deaths and discuss them … generally, … we would take decisions here, the supervisor and I, given that we are both technical people."* – Ministry official 2

The state MDSR registrars showed commitment to MDSR activities, possibly because it fulfilled a mandatory training that affected their progression in their speciality [see 6.4.2]. Furthermore, they were directly supervised by the national registrar who contacted them when a maternal death was reported and followed-up with them regarding data collection.

> *"The [data collection] forms would go back to the research supervisor. He checks it and if there is any defect, he would tell you that this is not possible or that you missed something, and that you should go ask about it. This would be regular and timely."* – O&G registrar 1

7.4.2 Procedural dimension

This dimension contains concepts relevant to the implementation and management of the MDSR activities. The concepts are shared decision-making, coordination, and role clarity.

Shared decision making

Two events were identified where MDSR decisions are made: the MDSR committees' meetings and verbal autopsy visits. The MDSR committees are composed mostly of doctors, and the degree to which the different types of midwives are involved in decision-making varied. An O&G specialist who sits on the MDSR committee explained that the committee identifies solutions for problems facing midwives in the community without the need to involve the midwives. The specialist further explained that this is because their problems are mostly related to transportation and require ambulances to be solved.

> "*I don't think that there would be much improvement if we include the opinions of the community midwives. There are community factors that we can help them with, these are first, transportation … through ambulances"* – O&G specialist 4

Although lack of transportation was indeed reported by midwives as a barrier to reaching facilities in complications, they also reported other challenges that resulted in delays, such as women seeking care from a midwife in final stages of labour, abuse from families, and unwelcoming facility environment for community midwives [described in 5.7]. None of these other challenges were discussed in MDSR committee meetings as garnered from interviews with respondents who sat on these committees. The role of midwives or midwifery supervisors in setting or influencing the meeting agenda was not clear.

Some ministry official and doctors believed that community midwives lack scientific knowledge. Although they seemed to acknowledge the importance of midwives' opinions, they still felt they would not add benefit to the MDSR because the opinions would be based on subjective experiences rather than on medical knowledge. Some even felt that midwives' knowledge and contributions would not benefit the MDSR.

> *"Their opinions are not scientific … they are important opinions to be honest, but they need further inspection because sometimes they are from experience and not from studies."* – Ministry official 5

> *"There is an issue with the level of their education, … it still isn't at the level where we would incorporate them because their views umm I don't want to say weak, but maybe it won't benefit us"*- Supervisor 4

These comments suggest that even if midwives working in the community are included in meetings this would not translate to their involvement in decision making. Doctors' perceptions about midwives would make it challenging for midwives to contribute to the discussion, make suggestions, and influence decisions.

> *"Doctors have an issue, they underestimate the importance of midwives, they think that they are good for nothing … they won't object to the inclusion of community midwives, but they will not think that they could be important in anyway"* – UN official 1

At the level of the community, midwives seemed to be directly involved in decision-making. In one state, a former MDSR focal person at the Ministry of Health explained that during community visits to carry out verbal autopsies, the midwife and the community leadership identify factors related to death and propose solutions. Following the discussion, but at the same visit, responses are implemented. For example, ministry officials started emergency funds [money pot] for obstetric emergencies and the community agreed to sustain the fund by regular contribution. The midwife would be named in charge of the emergency fund.

> *"We created pots for referral. She [the midwife] is the person responsible for the referral pot… we train the communities that we select as vulnerable communities. We bring together the village leadership including the midwife and … we train them on how to manage the fund and we provide*

them with an amount of money for example 1000 [Sudanese pounds] and a box, we leave the money and the box … this is something that we tried and with god's blessing we have funds that have reached 100,000 [Sudanese pounds]" – Ministry official 3

On the surface, this appears as involvement of midwives in decision-making and response, but a few factors suggest that such responses might have been developed without their involvement. First, responses were consistent with the premise that transportation is the main cause of delay; second, the responses were implemented during the same visit, but it required seed money and a box which were brought by the ministry officials beforehand, and that the same response was implemented in many villages. Thus, it is not clear whether responses were generated from discussion with midwives and the community or were pre-determined.

Coordination and Role Clarity:

The lack of resources earmarked for the MDSR described earlier affected the coordination and role clarity of its activities. The responsibility for identifying and collecting data on community deaths was not always clear. Tensions were reported between state MDSR registrar and the focal person at the Ministry of Health. Ministry officials did not always take ownership of MDSR activities and felt that it is the role of the O&G registrar involved. Additionally, Ministry of Health officials frequently delegated data collection tasks to midwifery supervisors - some of its consequences were discussed in 6.5.2.

> *"The person at the ministry would say that this is the job of the registrar not my job"* – Ministry official 7

7.4.3 Relational dimension

This dimension is concerned with how professionals interact with each other, their relationship, and it includes the following five concepts: trust, respect, communication, synergy and reciprocity.

Trust

Lack of mutual trust is a major barrier to collaboration and can undermine MDSR activities and efforts. Many doctors and MDSR members interviewed were sceptical of midwives, and suspected that they hide the truth about maternal deaths, compromising the data collection process. Thus, O&G registrars tasked with data collection thought of it as a mission to "*find the truth*". Indeed, most of the state O&G registrars interviewed explicitly compared their role to that of a detective and the data collection process to an investigation. They emphasised the need to get the story from different sources, then to compare accounts, and if accounts match then it taken as the truth.

> *"There may be different stories because everyone is protecting themselves and won't tell you exactly what happened. So, if you take the story from more than one person and it is the truth then all the statements will match, just like what detectives do."* - O&G Registrar 1

Midwives in the community were aware of the approach to data collection and the need for the midwife's story to match that of the family.

> *"They ask the family, and they ask the midwife to match [stories]. If they are similar, then it is okay. But if they are different then there will be an issue"* – Trained midwife 6

Midwives frequently talked of not trusting the MDSR process, even though the programme sought to communicate otherwise. The multiple instances of midwives being punished reported in the interviews and described in 5.5.2, supported this lack of trust.

> *"They have this fixed understanding that the ministry will punish them … and needs time to change, and it needs a lot of work through workshops and lectures"* – O&G registrar 4

Building mutual trust was recognised by participants as an important goal for the MDSR programme and beyond. A senior O&G consultant emphasised the need for doctors to become allies of midwives and to be proactive in building their trust as this would improve the

working relationship and lead to more accurate maternal death reportings and early referrals, both of which can contribute to reducing maternal deaths.

> *"We need to build major trust between the official bodies, the ministry, the hospital, the director of the hospital, the specialists, and them [midwives]. If we build major trust between the two, then … it would be easier for her to report her cases and to refer them early"* – O&G Specialist 1

Respect

As discussed above the knowledge of midwives working in the community were not respected. Notably, hospital midwives were held in higher regards and had a higher status than community midwives by doctors and ministry officials.

> *"They [nurse midwives] have a slightly different status; they are more respected by the doctors and managers."* – UN officer 1

Generally, midwives said they wanted more appreciation for their contributions and work. One inspector expressed frustration regarding the current situation of midwives and hoped for it to change. The inspector believed that this should be done by raising their level of education.

> *"We would like it if people gave midwives their status/ place" – Inspector 6*
> "This is through training… she should be someone who is trained … can confidently answer questions … we should build their confidence from the start" – Inspector 6

Communication

Limited discussion regarding MDSR findings and recommendation were reported outside of MDSR committee meetings, and no feedback mechanisms were identified. This limited the flow of information between the different professionals involved in MDSR. Key messages might not be communicated from MDSR committee members to focal persons who carry out the bulk of MDSR activities.

> *"There is a meeting at least twice a year at the HQ of the state. The first-line bureaucrats and the first-line officers at the level of the locality they will not attend, and they will not be aware of what is happening*"- Ministry official 7

Synergy and Reciprocity

The last two concepts in this dimension are synergy and reciprocity. From the interviews, there was no evidence of synergy, which is when achieving the collaboration goal is improved because of effective collaboration, or reciprocity, which is that each profession is fulfilling its responsibility to achieve the goals. This casts doubts on how effective the collaboration in the MDSR is in Sudan.

7.4.4 Contextual dimension

Shared power

Given the reliance of the MDSR process on existing resources and the hierarchical relationships between maternal health providers described in previous chapters, power relations in operation outside the MDSR process are echoed within MDSR's various activities. For example, recommendations from the MDSR committee resulted in positive changes for doctors when compared with midwives, possibly reproducing imbalances in power.

For doctors, the agenda of the MDSR meetings reflected issues they face in their day-to-day practice. They made recommendations to improve work in facilities and advocated for support for doctors.

> *"If … the patient was supposed to do certain tests but these tests were not available at the hospital then this would be one of the recommendations … if a certain treatment that should be available for emergencies, was not found … it would be said that there is an issue with the pharmacy or … the lab … people would come up with recommendations, for example, there should be about this many registrars, the number of the house officers, how many hours per day should the specialist be available*." – O&G Registrar 3

The MDSR also changed the conduct of reviews of maternal deaths in hospitals. For doctors, the MDSR is less punitive compared to previous procedures for reviewing maternal deaths. By alleviating doctors of the fears of culpability, it potentially improved transparency around hospital deaths.

> *"The MDSR was established in 2009, before 2009 … it was very bad even at the hospitals let alone at the community. Professors working at the hospital would be scared if a death happened because they would be questioned at the Ministry of Health*" – Ministry official 7

Conversely, representatives of midwives were frustrated by how midwives in the community and the care they offered were depicted in meetings. They felt that midwives were blamed unfairly for many of the issues causing maternal deaths.

> "*We wish for people to change their perspective about midwives, and to not just blame everything on midwives*." – Ministry official 6

Health visitors reported that doctors were often not held accountable in cases of maternal deaths. This is perhaps the most explicit example of power asymmetry between doctors and midwives that was reported in interviews.

> *"They would just get themselves out of it … they are doctors they don't hold them accountable. We are there with them and we haven't seen a doctor who was held accountable."* – Health Visitor 8

7.5 Discussion

This chapter examined factors that influence the collaboration between midwives and doctors within MDSR, building on results from chapter 5 and chapter 6. An inter-professional collaborative framework is used to elucidate the different dimensions of collaboration within the MDSR and provide guidance for the way forward. The framework has twelve concepts organised under four main dimensions: organisational, procedural, relational, and contextual. Overall, there was agreement between the interview data and the framework in all concepts except for two: synergy and reciprocity. The framework takes account of power relations at play in the wider context where collaboration takes place. The discussion starts with the contextual dimension that shapes the collaborative undertaking using the concept of medical dominance, followed by the organisational and procedural dimensions that are directly affected by medical dominance, and ends with the relational dimension that is indirectly affected by medical dominance.

Contextual dimension

This analysis identified power imbalances between midwives and doctors that can limit inter-professional collaboration and risk the achievement of MDSR's goals. To explore these imbalances, two interlinked concepts are used: professional autonomy and medical dominance.

Professional autonomy encompasses several aspects, such as the profession's ability to define its own code of practice, to regulate its own training, education, management, representation, and the autonomy of individual practitioners (Øvretveit, 1985). Studies that investigated the relationship between midwives and nurses with doctors in clinical settings show that lower levels of professional autonomy of midwives or nurses were associated with lower inter-professional collaborations (Papathanassoglou et al., 2012, Pursio et al., 2021). Although the differences between midwives, described in Chapter 5, presented a challenge to examining the autonomy of midwifery as a profession, the present findings do not support that

the midwifery profession regulates its own training, education, management, and representation. The lack of profession autonomy of midwifery limits it capability for collaborative practice with medicine in Sudan. Thus, promoting autonomy of midwifery would benefit collaborative practice.

By contrast, the medical profession is autonomous, and has historically had power over other health professions, described as medical dominance (Freidson, 1970, Coburn et al., 1983, Willis, 2006, Willis, 2020). Literature on medical dominance is largely based on the experience of developed countries. Medical dominance peaked in the 1960s and 1970s, but reportedly declined since then due to changes in the organisation of health care amongst other causes (Willis, 2006). Studies on medical dominance also focused on the relationship between health care professionals and doctors in health facilities with limited consideration for community health care. Nonetheless, it was used recently to investigate the relationship of non-medical health care professionals with doctors in developing countries, such as Nigeria, India, and Iran (Alubo and Hunduh, 2017, Badejo et al., 2020, Sheikh, 2012, Moosaeifard et al., 2020). Despite its limited explanatory potentials for this Sudanese context, medical dominance can still provide useful insights into relationships between doctors and midwives.

Medical dominance represents a hindrance to the collaborative practice (Alubo and Hunduh, 2017, Wranik and Haydt, 2018). In Nigeria, non-medical health professionals have been resisting medical dominance for decades. Reported inter- professional rivalries have considerable effects on teamwork within health facilities and on the functioning of the health system as a whole because of frequent strikes (Alubo and Hunduh, 2017).

Midwifery's lack of professional autonomy and medical dominance are linked. This is because medical dominance can manifest as control over the scope of practice of other professions, restricting the setting where they practice, or through resisting their professionalisation (Willis, 2006, Winkup, 1998, Sena, 2017). In Canada, the advancement of

midwifery through professional regulation and university level educational requirement contributed to the decline of medical dominance (Coburn et al., 1983, Winkup, 1998). This suggests that professional autonomy of non-medical health professions contributes over time to the decline of medical dominance. However, as identified from interviews, a considerable proportion of midwives do not have basic literacy skills, which creates a huge power differential with medicine, limiting their ability to challenge medicine's dominant position. If the subordination of midwifery is maintained, genuine inter-professional collaboration would be difficult to achieve.

An example from interviews to illustrate this interlinkage is midwife's absence from leadership positions at the Ministry of Health, health facilities, and MDSR. Although no regulations were identified that explicitly restricts midwives from taking up these managerial and leadership positions, limitation due to educational qualifications existed. A similar pattern was reported in Nigeria. In their study, Badejo et al, found that leadership positions were reserved for consultants only, and, until recently, specialisation programmes to achieve consultancy status were available for doctors only (Badejo et al., 2020). Thus, only doctors could assume these roles. They also observed that when other health professions trained their members to specialisation level and challenged doctors' monopoly of leadership and managerial positions, doctors lobbied for the creation of a new position at the top of the leadership hierarchy that can only be occupied by a doctor (Badejo et al., 2020). For midwives to assume maternal health leadership positions, strategies must consider midwifery education, professional development, career pathways, as well as the role of the medical profession.

Organisational dimension

Interviewees agreed on a shared vision for the MDSR, and on the need for collaboration between different health providers, representing a strength for the collaborative practice. By promoting the involvement of various health professions into the MDSR, this allows them the

opportunity to contribute and influence MDSR activities, recommendations, and achievements. Good MDSR meetings are characterised by multidisciplinary professional teams, and by an environment that ensures all participants can communicate honestly and openly and can participate equally (Lewis, 2014). Emphasising the importance of representation of midwives and ensuring appropriate representation can support efforts to incorporate their perspectives within MDSR.

Procedural dimension

This analysis did not identify midwives' contributions to MDSR decision-making while that of doctors prevailed. Medical hegemony in decision-making is reported as a barrier to inter-professional work in different clinical settings (Benoit et al., 2010, Coombs and Ersser, 2004). These studies looked at decision-making in in-patient clinical settings. Coombs and Ersser investigated the role of nurses in decision-making in multidisciplinary team rounds, they identified differences in how nurses and doctors valued different types of knowledge. However, doctors' medical worldview was the view used in decision-making during team rounds (Coombs and Ersser, 2004).

Where differential treatments between professionals exists and a group is given less voice, recognition, and authority compared to the other, this can lead to conflict- as identified in MDSR meetings (McNeil et al., 2013). MDSR leadership must play a key role in promoting a zero-tolerance policy for bullying, and in conflict management and resolution between doctors and midwives within MDSR to enable shared decision making.

Relational dimension

Numerous examples of mistrust were identified in the implementation of MDSR between midwives and doctors. Mistrust precludes the development of trust (Lewicki and Wiethoff, 2000), and constitutes a barrier to collaborative efforts. Pullon argues that the development of

inter-professional trust progresses through three stages: first, professionals demonstrate their competences; then, once their competences are understood this leads to respect; lastly, and over time this develops into trust (Pullon, 2008). The limited opportunities for midwives and doctors to interact within MDSR deprives them of the opportunities to understand each other's competences and adversely affects the development of respect and trust. Creative strategies are needed to promote communication between midwives and doctors and to highlight competencies of different professionals in improving maternal health and reducing maternal mortality, to build inter-professional respect and trust.

7.6 Conclusion

Imbalances in power relations between midwives and doctors are a major barrier to inter-professional collaboration within MDSR. Promoting the autonomy of midwives and calling for collaboration between professions working in maternal health care could lead to a decline in medical dominance.

The next chapter summarises the thesis, discusses the overall conclusions, and highlights the strengths and weaknesses of the DPhil thesis. It outlines the potential impact of the findings and makes recommendations for practice and future research.

8 Overall Discussion

8.1 Main Findings

This thesis set out to achieve eight objectives relating to MDSR in Sudan. A summary of the research objectives addressed so far, the methods, and findings can be found in Table 36. The systematic review [Chapter 2] provided a comprehensive appraisal of maternal death reviews used worldwide. Generally, maternal deaths reviews were widely available with coverage increasing rapidly since 2004. The systematic review informed the development of an evidence-based logic model for fully functioning maternal death reviews, which was subsequently used as a template to improve MDSR in Sudan. The trend analyses, using three consecutive Sudan household surveys, identified key maternal health providers and their changing contributions between 2006 and 2014 [Chapter 3]. It revealed the significant and increasing role of trained midwives in the community who provide maternal health care for nearly half of the Sudanese women. The ecological study investigating the relationship between the health care providers at birth and MMR at state-level found an inverse correlation between MMR and births attended by skilled providers, but not with trained providers [Chapter 4]. Chapters 3 and 4 support the need to review care provided by trained midwives, as improving their services could lead to major improvements in maternal health and accelerate progress towards reducing MMR. The qualitative study provided first-hand accounts of how community maternal health care is organised with a focus on midwives in the community [Chapter 5], how the MDSR is organised and implemented [Chapter 6], and barriers to the inclusion of midwives into the MDSR using an inter-professional collaborative practice framework [chapter 7]. Several challenges that midwives faced were identified, the structure and implementation of MDSR, and midwife-doctor inter-professional collaboration, all constituting barriers to the meaningful inclusion of midwives and their perspectives into MDSR.

Table 36: The research objectives, methods, findings, and contribution to the overall thesis aim.

Chapter	Research Objectives	Method	Summary of findings	Contribution to overall aim
Chapter 2	To systematically review the global conduct of maternal death reviews, and to identify reviews that include care of community providers that can be adapted for use in Sudan	Systematic review	- The WHO proposed approaches were widely used - Most MDRs struggled to complete the WHO surveillance cycle, namely they did not report on outcomes and impacts	No MDR was identified that specifically reviewed the care that women received in the community, by community providers
Chapter 2	To develop, a logic model of a well-functioning maternal death review that can inform the optimisation of the MDR in Sudan	Systematic review	- Studies that reported on outcomes and impacts shared several key characteristics that were used to develop a logic model	A logic model was used to identify areas for improvements in MDSR in Sudan and make recommendations
Chapter 3	To examine trends in the utilisation of birth attendants in Sudan from 2006 to 2014	Trend analysis using data from three consecutive household surveys	- Most women give birth at home, but this is decreasing - Trained providers are the main maternal health care providers - The role of trained providers is increasing, overall, at health facilities and in the community - Alarmingly, care provided by SBA is decreasing	Given the significant contribution of trained providers to maternal health care provision, reviewing the care they provide is key to accelerating progress in reducing preventable maternal deaths in Sudan
Chapter 4	To examine the correlation between skilled and trained birth attendants and other health indicators with MMR in Sudan	Ecological analysis	- Different states face very different challenges to reducing maternal mortality - Lower MMR correlated with higher levels of SBA and facility births but not with trained birth attendants	Effect of skilled and trained birth attendance on MMR differed. Thus, reviewing care provided by skilled providers is not sufficient
Chapter 5	To describe the organisation of midwives and the services they provide to guide development of an optimised maternal death review for Sudan	Qualitative study- thematic analysis	- No definition for a midwife was identified - The hierarchical organisation of midwives in the community facilitated supervision and reporting - Midwives faced several challenges such as negative interaction with the health system, lack of support in the community, and financial insecurity	Aligning the midwifery profession with international standards, and building a supportive environment for midwifery would contribute to the improvement of maternal health and, subsequently, the reduction of preventable maternal deaths
Chapter 6	To describe and evaluate the current process for reviewing maternal deaths in Sudan using interviews with health care providers, Ministry of Health officials, and UN officials	Qualitative study- thematic analysis	- Strengths and limitations in the implementation of the MDSR were identified. - The structure of MDSR facilitated its activities in facilities and to a lesser extent in the community. - Threatening MDSR environment for midwives was identified	Community deaths remain under-represented in MDSR following the shift from MDR
Chapter 7	To identify barriers to the inclusion of the perspectives of midwives to the maternal death review process using an inter-professional collaborative framework	Qualitative study- thematic analysis using an inter-professional collaborative framework	- Support for the vision of MDSR was commonly expressed - Challenges to the inclusion of midwives were identified in organisational, procedural, relational, and contextual dimensions	Lack of professional autonomy of midwives coupled with medical dominance preclude inter-professional collaborative practice of MDSR

8.2 Theoretical and methodological contributions of this thesis

The systematic review expands on the uses of logic models; it is one of few studies that employed it in the study of MDR, and the first to my knowledge to develop an evidence-based logic model on MDR. Logic models have wide applications in health programmes and interventions, ranging from developing to evaluating programmes (Sharma et al., 2017). It can support the design, optimisation, monitoring, and evaluation of MDSR in other countries, and it can also inform the development of standard reporting procedures for MDR.

The thesis presents a unique use of an iterative quantitative- qualitative method to strengthen the findings and conclusions. It could provide a model for use when broad categories that are used in large surveys are thought to obscure important differences. This is important for researchers working with secondary data. Furthermore, this study adds to our knowledge regarding patterns of SBA and place of birth in LMICs and provides explanations for the unusual pattern observed in Sudan. Thus, supporting the need for more robust indicators to detect the complex nature of care delivery (Radovich et al., 2019).

The qualitative study adds to the growing literature on the status of and challenges facing the professionalisation of midwifery in developing countries. Understanding such challenges is necessary to provide support to midwives, midwifery organisations, and health systems in Sudan and countries with a similar set up.

An original contribution of this thesis to the knowledge base is through outlining how medical dominance undermines the goal of MDSR by excluding trained midwives. Although medical dominance as a barrier to the development of midwifery has been described in the literature (Willis, 2020), this study is the first to my knowledge that utilises the medical dominance perspective in MDSR. Acknowledging the subordination of midwifery as a contextual barrier to the conduct of MDSR could promote interventions to address it.

8.3 Recommendations for optimisation

The maternal health care system can be visualised as a foundation, upon which a house, the MDSR, is built. The foundation is made up of the contextual factors that influence the design and conduct of MDSR and ultimately its impact. A shaky foundation could compromise any efforts to optimise the functioning of MDSR or render them ineffective long-term. Therefore, such efforts ought to consider strengthening the foundation as well. Here, the exclusion of midwives has been identified as a major barrier to MDSR functioning, as well as, medical dominance, lack of professional autonomy, and reliance of MDSR on doctors play a key role. Four interlinked recommendations that strengthen both the foundation and the MDSR and offer short- and long-term strategies to transition from dominance to collaboration are presented. This section addresses the last thesis objective, objective 8.

8.3.1 Invest in the development of an autonomous midwifery profession

Investing in midwifery's attainment of professional autonomy is needed as a long-term strategy to strengthen the maternal health care system (Friedman et al., 2015). An autonomous midwifery profession would lead directly and indirectly to improvements in maternal care through better care provision and by ensuring collaborative work between providers, respectively (ten Hoope-Bender et al., 2014). Resistance from the medical profession, however, is to be anticipated as historically seen (Fahy, 2007, Willis, 2020, Van Lerberghe and De Brouwere, 2001, WHO, 2016b). Thus, evidence-based advocacy, strong midwifery leadership, and allyship from medicine and nursing are needed.

While progress has been made to train some midwives working in health facilities to international standards i.e., to attain a BSc in midwifery, the training of midwives working in the community is far behind. Without unified progress, inadvertent consequences such as division within the profession or increasing the gap in quality between home and facility care, further disadvantaging vulnerable women, could emerge. Access to skilled midwives in the

community is crucial to reduce preventable maternal deaths and improve maternal health in Sudan. Speedy progress is difficult to achieve without a clear plan to strengthen the profession, radical changes to the education of midwives, and political and financial commitment.

8.3.2 Promote early inter-professional learning and collaborative practice

This recommendation is particularly relevant for practitioners working in health facilities. However, it extends to maternal health leadership, such as the Ministry of Health director, hospital directors, and professional associations. Early introduction of inter-professional learning activities should be encouraged as it would pave the way for collaborative practice (Furber et al., 2004). Providing opportunities for inter-professional learning, for example, through problem-based learning sessions between doctors and midwives strengthens the collegiate relationship and promotes cooperation (Furber et al., 2004).

To support the introduction of interprofessional learning and practice, readiness assessment tools have been used in developing and developed countries (Lestari et al., 2016, Tamura et al., 2012). The readiness of health care students for interprofessional learning [RIPLES] (Parsell and Bligh, 1999) can identify settings that are more receptive to the introduction of inter-professional learning. Similarly, assessment tools can be used to identify obstetrics practitioners that are ready for collaborative work, such as the newly developed Readiness to Collaborate Scale [RCS] (Murdoch et al., 2018).

The language gap between doctors and midwives that resulted from different languages used to train them must be addressed as well. For example, by generating an Arabic/English medical dictionary for commonly used terminology, such as medical conditions, investigations, and medications (Al-Harasis, 2013). This could facilitate communication between practitioners and establishes a common ground for discussing patient care or reviewing maternal deaths. In the long term, the same language should be used as a medium of instruction to educate all health professionals.

8.3.3 Strengthen Maternal Death Surveillance and Response inputs and activities

Strengthening inputs for the MDSR are needed to support its activities, outputs, and impact. Key inputs identified by the logic model are used as basis for recommendations – see Table 37 below. The dependence of the MDSR on individuals hinders its ability to "complete the loop" of surveillance to response (WHO, 2016c). Thus, practical steps are needed to strengthen the structure of MDSR, such as integration into the health care system. Further research is needed to guide successful integration into health systems in LMICs, as the experience differed across countries. In Congo, for example, it facilitated MDSR activities (Muvuka, 2019) while in Ethiopia integration presented additional challenges to its functioning (Abebe et al., 2017).

Strengthening key MDSR inputs would lead to improvements in its activities. Investing in enhanced surveillance methods would lead to increased identification of maternal deaths. Extending committee composition to include obstetricians, community midwives, hospital midwives, neonatologists, anaesthesiologists, and MDSR programme representatives would enable rich discussions into causes of deaths and subsequent recommendations. Studies have documented varying degrees of agreements regarding cause of maternal death attribution between committees of various compositions (Pasha et al., 2018). This would in turn lead to further multi-disciplinary discussions to build consensus and strengthen outputs and outcomes (Kodan et al., 2021).

8.3.4 Review maternal health care provided by all practitioners in cases of death

This study identified several barriers to the inclusion of the perspectives of midwives, affecting the review of a significant proportion of the care women receive both in the community or at facilities. Furthermore, power dynamics observed between midwives and doctors can deter midwives from engaging in MDSR activities. Thus, independent approaches for reviewing care provided by midwives in cases of maternal deaths, both at the community and in health facilities, are needed to overcome current limitations.

Three separate provider-based maternal death review approaches should be considered to overcome the identified challenges preventing midwives' participation. Although the transition from one MDSR fraught with challenges to three reviews might seem impractical, it stands Sudan the best chance to achieve as much feasible coverage of care as possible given the limited resources. The proposed provider-based reviews target doctors, hospital midwives, and community midwives are described in Table 38. They would ensure care provided to women who died in different settings are reviewed, accommodating a diverse maternal health care work force, and responding to many of the challenges facing the single MDSR.

Provider-based reviews alone may not be sufficient to create change across the care continuum. Thus, joint meetings should be planned at regular intervals, and long-term plans to integrate all three provider-based maternal death reviews are also needed. This would allow for areas of improvement to be identified across the entire system and could lead to a synergistic effect.

Table 37: Recommendations for improving the inputs of the maternal death surveillance and response.

Inputs	Current practice	Recommendations for optimisation
Policy	- National policy to notify all maternal deaths - National policy to review all maternal deaths	- Ensure appropriate implementation of policies
Legal frameworks	- No legal framework - Threatening MDSR environment for midwives	- Establishing a legal framework e.g., review materials cannot be used for litigation - Anonymised reports and case summaries - Confidential reviews of community deaths - Ensure midwives are not punished by e.g., being sent back to school - Clearly define what constitutes negligence
Clear guidelines and protocols	- Standard operation procedure present - One data collection form for all deaths - No clear review meeting structure - No clear monitoring and evaluation plan	- Provide detailed guidelines for reviews - Review maternal death cases in detail using anonymised reports and case summaries– a sample if numbers are large, but avoid discussing summary statistics only - Different data collection forms to capture care provided by different practitioners - Evaluate MDSR at regular intervals
Involving key maternal health care providers	- Various / limited/ unbalanced representation	- Appropriately represent maternal health care providers - To meaningfully involve community maternal health care providers
Trained personnel	- Sporadic/ one-off trainings - High, and yearly, turn over	- Invest in MDSR specialised staff to carry out day-to-day activities who can be ambassadors/ champions for the programme - Train committee members to carry out reviews - Consider use of online resources to develop capacity of providers
Surveillance system	- Passive surveillance	- Use combination of sources to identify deaths, such as local authorities, burial permits, hospital records - Add pregnancy check box to death certificates, on hospital records, and on burial permits - Consider expanding reporting in the community to include all deaths of women of reproductive age
Funding	- Unclear	- Specific funding for MDSR to fund personnel, transportation, communication, and day-to-day activities

Table 38: Recommendations for provider-based maternal death reviews.

Provider [Contribution to care in 2016]		**Doctors [17%]**	**Midwives in facilities [10%]**		**Midwives in community [48%]**
Activities	**Current practice in facilities**	**Doctor based maternal death review**	**Facility midwives based maternal death review**	**Current practice in the community**	**Community midwives based maternal death review**
Identification of maternal deaths	Notification by physicians, hospital directors, and focal persons	Consider regular surveys of hospital records of public and private health facilities	Similar to doctors' reviews, plus involve facility midwives in the reporting of maternal deaths	Various sources: midwives, midwifery supervisors, facilities, and community leaders	Consider reporting pathways that does not include supervisors
Data collection on maternal deaths	O&G registrar who fills in a data collection form from medical records and with help of doctors' present during deaths	Consider forms that are filled by the provider present at birth; design to allow for qualitative input; and focus on medical management and beyond	Similar to doctors' review, data collection focuses on first-line management of complications, channels of communications with doctors, handovers, and other aspects of midwives' care	O&G registrar, and ministry officials and midwifery supervisors, fills in a data collection form using input from midwife and the family of the deceased	MDSR officials who do not have authority over midwives; data collected to cover delays, care provided by midwife, first line management of complications and referral procedures, and review records of midwives
Reviewing maternal deaths	Summary statistics are reviewed by a multidisciplinary team of physicians, MoH directors, with minimal representation of communities	Review cases in details, or a sample if number are large; make specific recommendations based on detailed reviews; continue to include multidisciplinary teams	Similar to doctors' reviews, plus committee should involve facility midwives	Summary statistics data are reviewed by a multidisciplinary team of physicians, MoH directors, with minimal representation of communities	Similar to doctors' reviews Committee to include midwives working in the community, supervisors, other community providers, and other relevant actors
Feedback on maternal deaths	No clear channels	Establish clear and regular channels for feedback	Establish clear and regular channels for feedback	No clear channels	Establish clear and regular channels for feedback.
Maternal death review report	Annual report that provides descriptive data about maternal deaths	Consider using quantitative and qualitative data, as well as advanced statistical methods to look for trends and associations	Consider using quantitative and qualitative data, as well as advanced statistical methods to look for trends and associations	Annual report that provides descriptive data about maternal deaths	Consider using quantitative and qualitative data, as well as advanced statistical methods to look for trends and associations
Dissemination the report	Not clear	Disseminate key messages in an accessible form through different mediums	Disseminate key messages in an accessible form through different mediums	Not clear	Disseminate key messages in an accessible form through different mediums
Advocacy	None	Consider generating advocacy plans based on MDSR findings	Consider generating advocacy plans based on MDSR findings	None	Consider generating advocacy plans based on MDSR findings
Monitoring and evaluation	None	Develop a monitoring and evaluation plan	Develop a monitoring and evaluation plan	None	Develop a monitoring and evaluation plan
Coordination between activities	None	Hold regular joint meetings	Hold regular joint meetings	None	Hold regular joint meetings

8.4 Recommendations for future research

This study provides evidence to understand the design, implementation, and oversights of maternal health care provision and MDSR in Sudan- both understudied areas. It revealed opportunities for further research. Future studies should seek to interview women and their families to build a comprehensive picture of how maternal health care services are used, or not used, in Sudan. Only by understanding how women and their families make decisions about health care and navigate access to skilled birth attendance can we truly understand the causes of first and second delays in this context.

Given that MDSR in Sudan is now under new leadership, recommendations from this study can be piloted at a small scale in future studies. A combination of qualitative and quantitative data is needed to evaluate the implementation of provider-based maternal death reviews and to assess their feasibility and acceptability. Thus, methodological considerations are important to enable the generation of useful and comprehensive data, for example, using mixed methods, process evaluation, or implementation science research.

This thesis used concepts of professional power and collaboration to study the relationship between midwives and doctors within the context of MDSR. It enabled examining multiple dimensions of the professional relationship as it was deemed most relevant to MDSR optimisation and to the overall aim of the DPhil. However, other contextual power relations such as those based on gender, level of education, or social class that although pertinent to the broader function of MDSR were not captured by the framework and were, thus, not explored in the discussion. Future studies ought to examine other contextual factor that affect the MDSR for example, the use of feminist theories would enable the exploration of the status of women the in Sudanese society and how that influenced MDSR functioning given that midwives are all women in Sudan providing care for women.

8.5 Overall strengths and limitations

The strengths and limitations of each study design were discussed in their respective chapters. This thesis leveraged the strengths of both qualitative and quantitative methods to produce robust analyses of maternal health care provision and of MDSR in Sudan. The use of an inductive approach, starting with a comprehensive systematic review and ending with a large qualitative study permitted a nuanced analysis of the MDSR process and provided a strong basis for recommendations.

The qualitative data collection focused on MDSR conduct, care provided in the community, and relevant interactions between practitioners, for example in cases of referral. However, limited data were collected regarding maternity care and organisation of care in facilities. Thus, power relations and hierarchical relationships within the medical profession were not identified. Additionally, power relations between doctors working solely in administrative roles, for example at the Ministry of Health or hospital directors, and doctors in hospitals were not identified. Lastly, contextual factors included were limited to health sector factors, and wider socioeconomic factors were not included. More importantly, perspectives of mothers were not explored.

8.6 Conclusion

Maternal death reviews have been in place for over a decade in Sudan but their impact on maternal health is elusive. Structural as well as contextual changes are needed to improve maternal health and reduce preventable mortality. The focus in Sudan should remain on expanding access to skilled birth attendance and on building infrastructure. Therefore, strengthening the midwifery profession should be a priority for the country. Addressing power imbalances between midwives and doctors and promoting a supportive environment could enable midwives to play a bigger role in improving maternal health, especially in the community where they are the major providers. Specific changes to the current inputs of the MDSR could facilitate its operation, potentially improving its effects and outcomes. Given the different settings and providers of maternal care in Sudan, provider-based maternal deaths reviews could be a feasible solution to ensure a comprehensive review of maternal deaths in the different settings.

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10 Appendices

Appendix A: The PubMed [MEDLINE] search strategy.

No	Searches	Results
1	Maternal mortality [MeSH Terms]	9 298
2	[[maternal[Title/Abstract] OR mother*[Title/Abstract] OR "pregnant woman"[Title/Abstract] OR "pregnant women"[Title/Abstract] OR pregnancy[Title/Abstract]]] AND [death*[Title/Abstract] OR mortality[Title/Abstract] OR dying[Title/Abstract] OR fatalit*[Title/Abstract] OR demise[Title/Abstract]]	63 940
3	1 OR 2	66 623
4	Audit, clinical[MeSH Terms]	20 985
5	["death review"[Title/Abstract] OR "death reviews"[Title/Abstract] OR "mortality review"[Title/Abstract] OR "mortality reviews"[Title/Abstract]OR "review committee"[Title/Abstract] OR "surveillance[Title/Abstract] AND response"[Title/Abstract] OR enquir*[Title/Abstract] OR inquir*[Title/Abstract] OR "verbal autopsy"[Title/Abstract] OR "verbal autopsies"[Title/Abstract]]	31 671
6	4 OR 5	52 379
7	3 AND 6	1 204

Appendix B: The updated PubMed [MEDLINE] search strategy.

Filters: **Publication date from 2018/02/01 to 2020/03/31**

No	Searches	Results
1	Maternal mortality [MeSH Terms]	599
2	[[[maternal [Title/Abstract] OR mother*[Title/Abstract] OR "pregnant woman"[Title/Abstract] OR "pregnant women"[Title/Abstract] OR pregnancy[Title/Abstract]]] AND [death*[Title/Abstract] OR mortality[Title/Abstract] OR dying[Title/Abstract] OR fatalit*[Title/Abstract] OR demise[Title/Abstract]]]	8 973
3	1 OR 2	9 050
4	Audit, clinical [MeSH Terms]	763
5	[["death review"[Title/Abstract] OR "death reviews"[Title/Abstract] OR "mortality review"[Title/Abstract] OR "mortality reviews"[Title/Abstract]OR "review committee"[Title/Abstract] OR "surveillance[Title/Abstract] AND response"[Title/Abstract] OR enquir*[Title/Abstract] OR inquir*[Title/Abstract] OR "verbal autopsy"[Title/Abstract] OR "verbal autopsies"[Title/Abstract]]]	4 641
6	4 OR 5	5 393
7	3 AND 6	165

Appendix C: The WHO Global Health Library and the Global Health Database search strategy.

No	Searches	Results
The WHO Global Health Library	[maternal OR mother] AND ["death review" OR "death reviews" OR "mortality review" OR "mortality reviews" OR "verbal autopsy" OR “confidential enquiry" OR "confidential inquiry"]	632
The Global Health Database		147

Appendix D: The updated WHO Global Health Library and the Global Health Database search strategy.

Filters: **Publication date from 2018 to 2020**

No	Searches	Results
The WHO Global Health Library	[maternal OR mother] AND ["death review" OR "death reviews" OR "mortality review" OR "mortality reviews" OR "verbal autopsy" OR “confidential enquiry" OR "confidential inquiry"]	125
The Global Health Database		42

Appendix E: Quality assessment tools considered for the systematic review and their applicability.

The Newcastle-Ottawa Scale Case-control studies	**The Newcastle-Ottawa Scale Cohort studies**	**the Critical Appraisal Skills Programme [CASP] tools for Case-control studies**	**the Critical Appraisal Skills Programme [CASP] tools for Cohort studies**	**National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-sectional Studies**	**Risk of Bias in Non-randomised Studies - of Interventions [ROBINS-I]- Version for cohort-type studies**	**Cochrane Effective Practice and Organisation of Care Review Group [EPOC] quality criteria for interrupted time series**
SELECTION	SELECTION	Section A: Are the results of the study valid?			Stage I: At protocol stage	
Is the case definition adequate	Representativeness of the exposed cohort	Did the study address a clearly focused issue?	Did the study address a clearly focused issue?	Was the research question or objective in this paper clearly stated?	Specify the review question [participants, intervention, Comparator and Outcomes]	Protection against secular changes
Representativeness of the cases	Selection of the non-exposed cohort	Did the authors use an appropriate method to answer their question?	Was the cohort recruited in an acceptable way?	Was the study population clearly specified and defined? Was the participation rate of eligible persons at least 50%?	List confounding domains relevant to all or most of the studies	Data were analysed appropriately
Selection of controls	Ascertainment of exposure	Were the cases recruited in an acceptable way?	Was the exposure accurately measured to minimise bias?	Were all the subjects selected or recruited from the same or similar populations [including the same time period]? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	List co-interventions that could be different between intervention groups and that could impact on outcomes	Sample size calculation
Definition of controls	Demonstration that the outcome of interest was not present at the start of the study	Were the controls selected in an acceptable way?	Was the outcome accurately measured to minimise bias?	Was a sample size justification, power description, or variance and effect estimates provided?		Shape of the intervention effect was specified
COMPARABILITY	COMPARABILITY				Stage II: for each study	
Comparability of cases and controls on the basis of the design or analysis	Comparability of the cohorts on the basis of the design or analysis	Was the exposure accurately measured to minimise bias?	Have the authors identified all important confounding factors?	For the analyses in this paper, were the exposure[s] of interest measured prior to the outcome[s] being measured?	Specify a target randomised trail specific to the study [Design, participants, experimental interventions, comparator]	Protection against detection bias
		Aside from the experimental intervention were the groups treated equally?	Have they taken account of the confounding factors in the design and/or analysis?	Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Is the aim of your study? to assess the effect of an intervention, or to assess the effect of starting and adhering to intervention	Completeness of data set

The Newcastle-Ottawa Scale Case-control studies	**The Newcastle-Ottawa Scale Cohort studies**	**the Critical Appraisal Skills Programme [CASP] tools for Case-control studies**	**the Critical Appraisal Skills Programme [CASP] tools for Cohort studies**	**National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-sectional Studies**	**Risk of Bias in Non-randomised Studies - of Interventions [ROBINS-I]- Version for cohort-type studies**	**Cochrane Effective Practice and Organisation of Care Review Group [EPOC] quality criteria for interrupted time series**
		Have the authors taken account of the potential confounding factors in the design and/or in their analysis?	Was the follow-up subjects complete enough?	For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome [e.g., categories of exposure, or exposure measured as continuous variable]?	Specify the outcome	Reliable primary outcome measure[s]
			Was the follow-up of subjects long enough?	Were the exposure measures [independent variables] clearly defined, valid, reliable, and implemented consistently across all study participants?	Specify the numerical results being assessed	
OUTCOME		Section B: What are the results?				
Ascertainment of Exposure	Assessment of outcome	How large was the treatment effect?	What are the results of this study?	Was the exposure[s] assessed more than once over time?	Preliminary considerations of confounders [confounding domain, measured variable [s], is there evidence that controlling for this variable is unnecessary? Is the confounding domain measured validly and reliably by this variable [or these variables]? Optional: is failure to adjust for this variable [alone] expected to favour the experimental intervention or the comparator?	
Non-Response Rate	Was follow-up long enough for outcomes to occur	How precise was the estimate of the treatment effect?	How precise are the results?	Were the outcome measures [dependent variables] clearly defined, valid, reliable, and implemented consistently across all study participants?	Preliminary consideration of co-interventions [the co-intervention, is there evidence that controlling for this co-intervention was unnecessary [e.g. because it	

The Newcastle-Ottawa Scale Case-control studies	The Newcastle-Ottawa Scale Cohort studies	the Critical Appraisal Skills Programme [CASP] tools for Case-control studies	the Critical Appraisal Skills Programme [CASP] tools for Cohort studies	National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-sectional Studies	Risk of Bias in Non-randomised Studies - of Interventions [ROBINS-I]- Version for cohort-type studies	Cochrane Effective Practice and Organisation of Care Review Group [EPOC] quality criteria for interrupted time series
					was not administered], is presence of this co-intervention likely to favour outcomes in the experimental intervention or the comparator]	
	Adequacy of follow-up of cohorts	Do you believe the results?	Do you believe the results?	Were the outcome assessors blinded to the exposure status of participants?	Risk of bias assessment [due to confounding, bias in selection of participants into the study, bias in classification of interventions, due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes, bias in selection of the reported result, overall bias]	
		Section C: Can the results help locally?				
		Can the results be applied to the local population?	Can the results be applied to the local population?	Was loss to follow-up after baseline 20% or less?		
		Do the results of this study fit with other available evidence	Do the results of this study fit with other available evidence	Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure[s] and outcome[s]?		

Green: Applicable; Red= Not applicable

Appendix F: Quality assessment of the included studies.

No	Reference, Country	Protection against secular changes	Appropriate analysis of the data	Sample size calculations	Shape of the intervention effect was specified	Protection against detection bias	Completeness of data set	Reliable primary outcome measure/s
1	Abdel-Hady et al., 2007 (Abdel-Hady et al., 2007), Egypt							
2	Abouchadi et al., 2013 (Abouchadi et al., 2013a), Morocco							
3	Aden et al., 2019 (Aden et al., 2019), Somalia							
4	Aikpitanyi et al., 2019 (Aikpitanyi et al., 2019), Nigeria							
5	Ande et al., 2012 (Ande et al., 2012), Nigeria							
6	Andersen et al., 2009 (Andersen et al., 2009), Denmark							
7	Ansong-Tornui et al., 2007 (Ansong-Tornui et al., 2007), Ghana							
8	Baharuddin et al., 2019 (Baharuddin et al., 2019), Indonesia							
9	Bayley et al., 2015 (Bayley et al., 2015), Malawi							
10	Biswas et al., 2016 (Biswas et al., 2016), Bangladesh							
11	Bodker et al., 2009 (Bødker et al., 2009), Denmark							
12	Böttcher et al., 2018 (Böttcher et al., 2018), Palestine							
13	Bouvier-Colle et al., 2001 (Bouvier-Colle et al., 2001), West Africa							
14	Castro et al., 2000 (Castro et al., 2000), Mexico							
15	Cham et al., 2005 (Cham et al., 2005), The Gambia							
16	Cham et al., 2007 (Cham et al., 2007), The Gambia							
17	Confidential enquiry into maternal mortality, 2014 (Government of Malaysia, 2014), Malaysia							
18	D'Ambruoso et al., 2010 (D'ambruoso et al., 2010), Indonesia and Burkina Faso							
19	D'Ambruoso et al., 2010 (D'Ambruoso et al., 2010), Indonesia							

No	Reference, Country	Protection against secular changes	Appropriate analysis of the data	Sample size calculations	Shape of the intervention effect was specified	Protection against detection bias	Completeness of data set	Reliable primary outcome measure/s
20	Donati et al., 2018 (Donati et al., 2018), Italy							
21	Dumont et al., 2006 (Dumont et al., 2006), Senegal							
22	Dumont et al., 2009 (Dumont et al., 2009), Senegal							
23	Dumont et al., 2013 (Dumont et al., 2013), Senegal and Mali							
24	Dutch Nationwide Confidential Enquiry into Maternal Death (Lameijer et al., 2020), The Netherlands							
25	Ganyaglo et al., 2012 (Ganyaglo and Hill, 2012), Ghana							
26	Garba et al., 2013 (Garba and Umar, 2013), Nigeria							
27	Gebretsadik et al., 2019 (Gebretsadik et al., 2019), Ethiopia							
28	Ghazal-Aswad et al., 2011 (Ghazal-Aswad et al., 2011), UAE							
29	Goswami et al., 2013 (Goswami et al., 2013), India							
30	Grupo do Trabajo Regional Para la, 2015 (Grupo do Trabajo Regional Para la, 2015), Latin America							
31	Hodorogea et al., 2014 (Hodorogea and Friptu, 2014), Moldova							
32	Jafarey et al., 2009 (Jafarey et al., 2009), Pakistan							
33	Jaques et al., 2006 (Jaques et al., 2006), Benin							
34	Kaur et al., 2018 (Kaur et al., 2018), India							
35	Khan et al., 2013 (Khan and Pradhan, 2013), India							
36	Kodan et al., 2020 (Kodan et al., 2020), Suriname							
37	Kokoty et al., 2018 (Kakoty and Das, 2018), India							
38	Kongnyuy et al., 2009 (Kongnyuy et al., 2009), Malawi							
39	Kumari et al., 2019 (Kumari et al., 2019), India							

No	Reference, Country	Protection against secular changes	Appropriate analysis of the data	Sample size calculations	Shape of the intervention effect was specified	Protection against detection bias	Completeness of data set	Reliable primary outcome measure/s
40	Macleod et al., 1998 (MacLeod and Rhode, 1998), Tanzania							
41	Mahmood et al., 2018 (Mahmood et al., 2018), Indonesia							
42	Martey et al., 1993 (Martey et al., 1993), Ghana							
43	Maternal and Perinatal Death Surveillance & Response, 2019 (Ayele et al., 2019), Ethiopia							
44	Maternal and Perinatal Death Surveillance and Response, 2020 (Biswas et al., 2020), Bangladesh							
45	Maternal death review in Myanmar, 2013 (Division, 2013), Myanmar							
46	Maternal Death Surveillance and Response, 2016 (Health, 2016) , Sierra Leone							
47	Maternal Death Surveillance and Response, 2018 (Umbeli et al., 2018), Sudan							
48	Maternal Mortality Review Committees, 2018 (CDC, 2018), USA							
49	Mittal et al., 2019 (Mittal et al., 2019), India							
50	Mothers and Babies: Reducing risk through Audits and Confidential Enquiries (Knight, 2021), United Kingdom							
51	National Maternal Mortality Audit Committee, 2017 (Committee, 2017), Botswana							
52	Olsen et al., 2002 (Olsen et al., 2002), Tanzania							
53	Onakewhor et al., 2011 (Onakewhor et al., 2011), Nigeria							
54	Oyeneyin et al., 2019 (Oyeneyin et al., 2019), Nigeria							
55	Paily et al., 2014 (Paily et al., 2014), India							
56	Paul et al., 2011 (Paul et al., 2011), India							
57	Perinatal and Maternal Mortality Review Committee, 2017 ((PMMRC), 2017) ,New Zealand							
58	Raj et al., 2015 (Raj et al., 2015), India							
59	Rusen et al., 2004 (Rusen et al., 2004), Canada							

No	Reference, Country	Protection against secular changes	Appropriate analysis of the data	Sample size calculations	Shape of the intervention effect was specified	Protection against detection bias	Completeness of data set	Reliable primary outcome measure/s
60	Sageer et al., 2019 (Sageer et al., 2019), Nigeria							
61	Sayinzoga et al., 2016 (Sayinzoga et al., 2016), Rwanda							
62	Sk et al., 2019 (Sk et al., 2019), India							
63	Somigliana et al., 2011 (Somigliana et al., 2011), Uganda							
64	Sorensen et al., 2010 (Sorensen et al., 2010), Tanzania							
65	State and Territory Maternal Mortality Committees, 2017 (AIHW, 2017), Australia							
66	Stekelenburg et al., 2002 (Stekelenburg and van Roosmalen, 2002), Zambia							
67	Surveillance and Response system for maternal deaths in Sri Lanka, 2014 (Kapila and Deepthi, 2014), Sri Lanka							
68	The California Pregnancy-Associated Mortality Review, 2019 (CDPH, 2019), USA							
69	The CEMD in South Africa (Moodley et al., 2014), South Africa							
70	The Italian Obstetric Surveillance System (Donati et al., 2019), Italy							
71	The National Confidential Enquiry on maternal mortality (Saucedo et al., 2020), France							
72	The Swedish Maternal Mortality group (Esscher et al., 2014), Sweden							
73	Vangen et al., 2004 (Vangen et al., 2014), Norway							
74	Vora et al., 2018 (Vora et al., 2018), India							
75	Walker et al., 1986 (Walker et al., 1986), Jamaica							

Red: Not done; Yellow: Not clear; Green: done; Grey: Not applicable

Appendix G: Appropriate analyses per study design.

Type	Study Design	Appropriate analyses
Observational	Cross-sectional	Descriptive statistics, [+/-] Calculate MMR/ MMRate [95%CI]
	Surveillance	Descriptive statistics, [+/-] calculate MMR/ MMRate [95%CI], [-/+] tests for trends
	Cohort study	Descriptive statistics, [+/-] calculate MMR/ MMRate [95%CI], [-/+] tests for trends
Experimental	Interrupted time series	Descriptive statistics, Calculate MMR/ MMRate [95%CI], Time series regression models
	Non-controlled before and after trials Randomised Controlled Trials	Descriptive statistics, Calculate MMR/ MMRate [95%CI], Risk measures [difference, reduction]
Qualitative studies		Framework/thematic analysis OR Grounded theory OR Narrative analysis OR Other qualitative methods for analysis

Appendix H: Differences between women with missing outcome variable data and those with available outcome variable data.

Year		2006			2010			2014	
Variables N [%]	**Outcome data present 5,028**	**Outcome data missing 176**	**P value**	**Outcome data present 5,221**	**Outcome data missing 509**	**P value**	**Outcome data present 5,599**	**Outcome data missing 85**	**P value**
Mother's age, years									
15-19	470 [9.4]	3 [1.7]	<0.001	373 [7.1]	37 [7.3]	0.07	393 [7.0]	8 [9.4]	0.19
20-24	1,173 [22.6]	22 [12.5]		1,180 [22.6]	106 [20.8]		1,133 [20.2]	15 [17.7]	
25-29	1,441 [28.7]	50 [28.4]		1,489 [28.5]	132 [25.9]		1,606 [26.7]	16 [18.8]	
30-34	1,016 [20.2]	47 [26.7]		942 [18.0]	84 [16.5]		1,184 [21.2]	20 [23.5]	
35+	964 [19.1]	54 [30.7]		1,237 [23.7]	150 [29.5]		1,283 [22.9]	26 [30.6]	
Mother's education									
None	2,650 [52.7]	83 [47.2]	0.37	2,576 [49.3]	373 [73.3]	<0.0001	2,476 [44.2]	46 [54.1]	0.49
Primary	1,599 [31.8]	65 [36.9]		1,683 [32.2]	69 [13.6]		1,927 [34.4]	25 [29.4]	
Secondary	608 [12.1]	20 [11.4]		724 [13.9]	45 [8.8]		851 [15.2]	10 [11.8]	
Tertiary or above	171 [3.4]	8 [4.5]		238 [4.6]	22 [4.3]		344 [6.1]	4 [4.7]	
Missing							1 [0.02]	-	
Area of residence									
Rural	3,561 [70.8]	106 [60.2]	0.002	3,740 [71.6]	378 [74.3]	0.2	4,121 [73.6]	60 [70.6]	0.53
Urban	1,467 [29.2]	70 [39.8]		1,481 [28.4]	131 [25.7]		1,478 [26.4]	25 [29.4]	
Wealth index									
First [Poorest]	507 [10.1]	9 [5.1]	0.06	1,096 [21.0]	87 [17.1]	<0.001	1,223 [21.8]	20 [23.5]	0.61
Second	1,012 [20.1]	32 [18.2]		1,208 [23.1]	141 [27.7]		1,507 [26.9]	27 [31.8]	
Third	1,451 [28.9]	46 [26.1]		1,238 [23.7]	168 [33.0]		1,272 [22.7]	20 [23.5]	
Fourth	1,288 [25.6]	54 [30.7]		1,002 [19.2]	51 [10.0]		903 [16.1]	9 [10.6]	
Fifth [Richest]	770 [15.3]	35 [19.9]		667 [13.0]	62 [12.2]		694 [12.4]	9 [10.6]	
Number of Children									
1	1,050 [20.9]	32 [18.2]	0.62	946 [18.1]	63 [12.4]	0.001	906 [16.2]	13 [15.3]	0.46
2-4	2,299 [45.7]	86 [48.8]		2,312 [44.3]	221 [43.4]		2,426 [43.3]	32 [37.7]	
5+	1,679 [33.4]	58 [33.0]		1,963 [37.6]	225 [44.2]		2,267 [40.5]	40 [47.0]	

% are the **non-weighted proportions**, Dash indicates that the variable was not available in that survey round, P value: A chi-squared test statistics.

Appendix I: Variables predicting utilisation of maternal health services in low- and middle-income countries by their availability in the data and inclusion in the analysis.

Variables	Available in dataset?	Used in final analysis?	Notes
Women's education	Yes	Yes	
Wealth quintile	Yes	Yes	
Parity/ birth order	Yes	Yes	
Husband's education	No	No	Data for husband's were not linked
Mass media exposure	No	No	
Rural/ urban residence	Yes	Yes	
Socio-ethnic group	No	No	Not asked
Four ANC visits	Yes	Yes	Any ANC visit was used
Region	Yes	Yes	
Religion	No	No	Not asked
Maternal age	Yes	Yes	
Women's employment status	No	No	
Health worker visit	No	No	
Use of SBA	Yes	Yes	A study outcome
Family structure	No	No	
Influence of household head	No	No	
Child status [wanted/ unwanted]	Yes	Yes	
Women's personal barrier index	No	No	
Husband's employment status	No	No	Data for husband's was not linked

Appendix J: Correlation matrix between the explanatory factors.

	Mother's Age	Mother's education	Area of residence	Wealth score	Parity/ birth order	Child [wanted/ unwanted]	Antenatal care	Mode of delivery	Antenatal complications	Labour complications
Mother's age	1	-	-	-	-	-	-	-	-	-
Mother's education	-0.01*	1	-	-	-	-	-	-	-	-
Area of residence	0.05	0.27	1	-	-	-	-	-	-	-
Wealth score	0.08	0.59	0.45	1	-	-	-	-	-	-
Parity/ birth order	0.7	-0.25	-0.02	-0.13	1	-	-	-	-	-
Child [wanted/ unwanted]	-0.09	-0.08	-0.08	-0.1	-0.13	1	-	-	-	-
Antenatal care	-0.02	0.25	0.15	0.24	-0.09	-0.02	1	-	-	-
Mode of delivery	0.05	0.24	0.11	0.24	-0.11	-0.01*	0.11	1	-	-
Antenatal complications	-0.02	-0.12	-0.05	-0.13	0.05	0.02*	0.02	-0.04	1	-
Labour complications	-0.01	-0.08	-0.05	-0.11	0.03	-0.04	0.02	0.00*	0.32	1

Asterix: linear trend P ≥ 0.05

Appendix K: Power calculation for the binary outcomes.

	Proportion of other in 2006	Detectable Odds Ratio equals to or greater than	Detectable Odds Ratio equals to or less than
Facility birth [vs other]	0.788	1.15	0.88
SBA [vs other]1	0.311	1.13	0.89
SBA [vs other]2	0.674	1.12	0.89
Trained [vs other]	0.637	1.13	0.89

Appendix L: Topic guide.

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INTERVIEW TOPIC GUIDE

Incorporating Perspectives of Community Skilled Birth Attendants in the Current Process of Reviewing Maternal Deaths in Sudan: A Qualitative Study.

Topics for the interview:

a. Tell me about the current process for reviewing maternal deaths [in your State/ Sudan]?
    i. For hospital/ factility care [Public and Private]
    ii. For skilled care in community
    iii. For other care in the community

b. How do you think the current process for reviewing maternal deaths can be changed to enable inclusion of the perspectives of community skilled care providers [in your State/ Sudan]?
    i. For hospital/ facility care [Public and Private]
    ii. For skilled care in community
    iii. For other care in the community

c. What do you think are the resources needed to make such changes [in your State/ Sudan]?

d. What factors might influence successful implementation of these changes [in your State/ Sudan]?

e. What adverse effects could occur as a result of successful implementation of these changes [in your State/ Sudan]?

Appendix M: The Consolidated criteria for reporting qualitative research [COREQ].

Table 1 Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist

No	Item	Guide questions/description
Domain 1: Research team and reflexivity		
Personal Characteristics		
1.	Interviewer/facilitator	Which author/s conducted the interview or focus group?
2.	Credentials	What were the researcher's credentials? *E.g. PhD, MD*
3.	Occupation	What was their occupation at the time of the study?
4.	Gender	Was the researcher male or female?
5.	Experience and training	What experience or training did the researcher have?
Relationship with participants		
6.	Relationship established	Was a relationship established prior to study commencement?
7.	Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. *personal goals, reasons for doing the research*
8.	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. *Bias, assumptions, reasons and interests in the research topic*
Domain 2: study design		
Theoretical framework		
9.	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? *e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis*
Participant selection		
10.	Sampling	How were participants selected? *e.g. purposive, convenience, consecutive, snowball*
11.	Method of approach	How were participants approached? e.g. *face-to-face, telephone, mail, email*
12.	Sample size	How many participants were in the study?
13.	Non-participation	How many people refused to participate or dropped out? Reasons?
Setting		
14.	Setting of data collection	Where was the data collected? e.g. *home, clinic, workplace*
15.	Presence of non-participants	Was anyone else present besides the participants and researchers?
16.	Description of sample	What are the important characteristics of the sample? *e.g. demographic data, date*
Data collection		
17.	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?
18.	Repeat interviews	Were repeat interviews carried out? If yes, how many?
19.	Audio/visual recording	Did the research use audio or visual recording to collect the data?
20.	Field notes	Were field notes made during and/or after the interview or focus group?
21.	Duration	What was the duration of the interviews or focus group?
22.	Data saturation	Was data saturation discussed?
23.	Transcripts returned	Were transcripts returned to participants for comment and/or correction?
Domain 3: analysis and findingsz		
Data analysis		
24.	Number of data coders	How many data coders coded the data?
25.	Description of the coding tree	Did authors provide a description of the coding tree?
26.	Derivation of themes	Were themes identified in advance or derived from the data?
27.	Software	What software, if applicable, was used to manage the data?
28.	Participant checking	Did participants provide feedback on the findings?
Reporting		
29.	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. *participant number*
30.	Data and findings consistent	Was there consistency between the data presented and the findings?
31.	Clarity of major themes	Were major themes clearly presented in the findings?
32.	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?

Table is a screen capture from the Tong et al., paper (Tong et al., 2007)

Appendix N: Participant information sheet – Arabic.

موجهات إقرار موافقة الشخص الخاضع للبحث

أنا د/ نون التجاني باحثه بجامعة اوكسفورد في المملكة المتحدة، باحثه زائره بجامعه الأحفاد للبنات في السودان، هذا البحث جزء من رسالتي لنيل درجه الدكتوراه في مجال صحة السكان.
شكراً جزيلاً على اهتمامكم بهذا البحث، الرجاء تخصيص جزء من وقتكم لقراءة المعلومات أدناه عن البحث والنظر فيها قبل أن تقرروا ما إذا كنتم ترغبون المشاركة.

ما هو الغرض من هذا البحث؟
هذه الدراسة تهدف إلى تقص طرق تضمين مقدمي خدمات صحة الأمومة المدربين الذين يعملون خارج إعدادات المستشفيات او المراكز الصحية إلى عمليات مراجعة وفيات الأمهات. توصى منظمة الصحة العالمية بمراجعة حالات وفيات الأمهات والرعاية التي تلقتها المرأة قبل الوفاة من مراجعه الحمل والولادة وما بعد الولادة، وذلك بهدف استخلاص دروس لتحسين الرعاية التي تُقدم للنساء. ولكن لا توفر منظمة الصحة العالمية أي طرق مخصصة لمراجعة الرعاية المُقدمة للنساء في منازلهم من قِبل مقدمي الخدمات الصحية المدربين.
لقد أوضح آخر مسح للأسرة السودانية لعام 2014 أن 72٪ من النساء اللاتي أنجبن في العامين ما قبل المسح انهن أنجبن آخر مولود لهن في المنزل. وأوضح المسح أيضاً أن 55٪ من النساء قد استخدمن قابلة معتمده عند الولادة و19٪ استخدمن طبيباً، أما البقية فلم يتلقين أية رعاية من قبل أشخاص المدربين. يأمل هذا البحث إلى تضمين أكبر نسب من مقدمي الرعاية المدربين في المرافق الصحية والمنازل إلى عمليات مراجعة وفيات الأمهات في السودان.

لماذا دعيت للمشاركة؟
لقد تمت دعوتكم للمشاركة في هذا البحث إما لأنكم من مزودي خدمات صحة الأمومة، أو لأنكم تعملون في مجال خدمات صحة الأمومة، أو من شركاء التنمية في السودان، أو أنه قد أوصى بكم مشاركون أخرون في هذه المجالات بسبب مساهمتكم في تحسين صحة الأمومة. نتوقع بمشاركتكم أن نتحصل على نتائج تفيد في مراجعة وفيات الأمهات في السودان، وبمجرد اكتمال هذه الدراسة، سوف نرسل لكم تقريراً يوضح نتائجنا.

ماذا تتطلب مشاركتي؟
سأتواصل معكم إما شخصياً أو عبر الهاتف لأجيب على أي أسئلة قد تكون لديكم حول البحث وترتيب موعد للمقابلة. قبل بدء المقابلة سأقوم بأخذ موافقتكم على المشاركة بهذا البحث، ستستمر المقابلة ما بين 60 إلى 90 دقيقة وستسجل صوتياً. بعد المقابلة، سأرسل لكم نص المقابلة ليتثنى لكم الفرصة لتصحيحه أو التعليق عليه قبل بدء تحليل البيانات.

كيف سيتم استخدام بياناتي؟
كل المعلومات التي سيتم جمعها منكم خلال هذه الدراسة ستكون سرية للغاية، قد نقتبس بشكل مباشر بعضاً من أقوالكم لكن سيتم ذلك بطريقة مجهولة لا تمكن من تتبع الأقوال إليكم. التسجيلات الصوتية ونصوص المقابلة سيتم تخزينها على أجهزة كمبيوتر مخصصة للدراسة تابعه لجامعة أكسفورد، ولن يتم نسخها على أي جهاز تخزين آخر. سيتم حذف جميع البيانات المُعرفة بعد ثلاث سنوات من تسليم أطروحة الدكتوراه، و لن تُستخدم إلا لغرض البحث المبيّن أعلاه.
لمزيد من المعلومات عن حقوقكم فيما يتعلق بمشاركتكم بهذه الدراسة، الرجاء النظر في هذا الموقع الخاص بجامعه أوكسفورد: http://www.admin.ox.ac.uk/councilsec/compliance/gdpr/individualright

هل هناك مخاطر من مشاركتي؟
تعتبر المشاركة في هذه الدراسة آمنة ولها مخاطر محتملة قليله جداً، أهمُها سرية المشاركة. سيتخذ فريق البحث جميع التدابير التي تضمن السرية التامة لبياناتكم كاستخدام أجهزة مشفرة لتسجيل المقابلات وإخفاء أية معلومات تُمكن من التعرف عليكم. كما أننا أيضا سنستخدم رقما بدلا عن اسمكم للاستدلال على كل البيانات والوثائق الخاصة بكم ولن يظهر. الكمبيوتر المخصص لهذا البحث سيكون محمي بكلمة مرور والوصول إلى بياناتكم سينحصر علي فريق البحث واللجنة القومية للأخلاقيات. جامعة أكسفورد وجامعة الأحفاد للبنات مسؤولون عن ضمان الاستخدام الآمن والسليم لأية معلومات قدمتموها لأغراض البحث فقط.

ما هي الفوائد المحتملة لمشاركتي؟
ستساعد مساهماتكم في العثور على طرق لتمديد نهج مراجعة وفيات الأمهات في السودان. بمجرد اكتمال هذا البحث سوف نرسل لكم تقريراً يوضح نتائج هذه الدراسة.

هل سيتم تعويضي عن وقتي؟
المشاركة في هذا البحث قد تتطلب منكم بعض الوقت والجهد وربما ستأخذ وقتاً من عملكم، لذلك سيتم إعطاءكم رمزية للتقدير وسيتم تعويضكم عن نفقات السفر إن وجدت مع التأكيد على أنه لن يتم منحكم أي قيمة نقدية مقابل المشاركة.

هل يجب على المشاركة؟
المشاركة في هذا البحث طوعية ورفضكم المشاركة لا تترتب عليه أي عواقب. بمشاركتكم ستكونون من المتطوعين في هذا البحث وعددهم حوالي 45 مشارك/ة. نؤكد لكم أيضاً إمكانية الانسحاب من البحث في أي وقت شئتم ودون الحاجة لتوضيح الأسباب ويتم ذلك بمراسلة د/ نون التجاني من خلال طرق التواصل الموضحة أدناه والتوقيع على طلب الانسحاب. في حالة الانسحاب سيتم التخلص من التسجيلات الصوتية ونص المقابلة الخاصين بكم، لكن في حالة انه قد تم تحليل وترميز بياناتكم فسيتم الاحتفاظ بالرموز لأنها ستكون مجهولة المصدر.

هل تمت إجازة هذا البحث من قبل لجان أخلاقيات البحوث؟
لقد تمت إجازة هذا البحث من قبل لجنة أخلاقيات البحوث بكل من: جامعة الأحفاد للبنات وجامعة أكسفورد ووزارة الصحة الاتحادية بالسودان.

هل سيتم نقل بياناتي دولياً؟
سوف أقوم بمشاركه البيانات والوثائق التي جمعتها منكم مع فريق البحث في جامعة أكسفورد وجامعة الأحفاد مما يعني انه سيتم نقلها إلى المملكة المتحدة. أي نقل للبيانات للمملكة المتحدة سيتم بشكل آمن ووفقاً لقوانين حماية البيانات المطلوبة في المملكة المتحدة.

من هو الراعي لهذا البحث؟
أي ضرر يمكن ان يحدث سيكون مغطي بالتأمين المناسب.

ماذا لو كان لدي أي أسئلة تخص هذا البحث أو أي تعليق؟
يمكنكم التواصل مع د/ نون التجاني عن طريق البريد الإلكتروني:noon.altijani@gtc.ox.ac.uk ، الهاتف وال [WhatsApp]: 0912641413 أو بمدرسه الطب بجامعه الأحفاد للبنات على البريد الإلكتروني: medicine@ahfad.edu.sd، الهاتف: 0187579117 سنجيب على أسئلتكم أو استفساراتكم في أسرع فرصة.

Appendix O: Participant information sheet – English.

PARTICIPANT INFORMATION SHEET

Incorporating Perspectives of Community Skilled Birth Attendants in the Current Process of Reviewing Maternal Deaths in Sudan: A Qualitative Study.

Thank you very much for your interest in our study. Before you decide whether you want to participate, it is important that you understand why we are conducting this study and what participating would involve for you. Please take your time to read and to consider the following information and to ask questions to the researcher if there is anything that is not clear or if you would like more information.

1. What is the purpose of this research?

This study aims to investigate ways of including the community perspectives in Sudan's current process for reviewing maternal death through consultations with key stakeholders. The current World Health Organisation [WHO] recommended process does not provide specific tools for reviewing skilled care provided in communities [women's homes]. According to the latest Sudan household Survey the majority of women [72%] in Sudan in 2014, have delivered their most recent birth at home. The same survey showed that 55% of the women named certified midwives as the person assisting at delivery, only 19% had a medical doctor, and the remainder received no skilled care. It is important to include the care provided to women in communities by certified midwives as reviewing the care provided allows identifying lessons and where improvements to care can be made. This research hopes to enable the review of larger proportions of the skilled care provided to women in health facilities and communities.

***2.* Why have I been invited to take part?**

You have been invited to participate either because you are a provider for maternal health services, work on maternal health at the Ministry of Health or developmental partners or have been recommended by someone in those fields due to your contribution to improving maternal health in Sudan.

3. What is involved for me?

The researcher will contact you either in person or via the phone. Firstly, to take your consent, answer any questions you might have about the study and your participation in it, and to arrange a time for the interview. The interview will last between 60-90 minutes, it will be audio-recorded.

After the interview, the researcher will transcribe the interview and she will send you a copy of the interview for your comments or corrections.

4. What will happen to my data?

All your responses and all the information that is collected about you during this study will be kept strictly confidential. We might directly quote some of the things you tell us during the study, but we would do this in a strictly anonymous way i.e., it cannot be traced back to you. The original audio recording files and the transcripts of the interview will be stored on the University of Oxford secured computers and will not be copied onto any other storage medium/ device. Access will be given to the supervisors for the aim of data analyses support. All data collected will be deleted three years after the student submits their doctoral thesis.

5. Are there any risks in taking part?

Participating in this study is considered to be safe and to have very few potential risks. Still, we would like you to consider confidentiality risks. The research team will take all measures to ensure strict confidentiality of your data, including used encrypted devices for recording interviews, concealing identifying information, separating concealed personal information from the research data, protecting computer files with passwords, and limiting

access to the data to authorised personnel. The University of Oxford is responsible for ensuring the safe and proper use of any personal information you provide, solely for research purposes

6. What are the possible benefits of taking part?

Once this research is complete, we will send you a report explaining our findings. Your contributions will help to improve the process of reviewing maternal deaths in Sudan.

7. Will I be compensated for my time?

We understand that participating to this study may require you to invest some time and effort and maybe take time away from work. Therefore, a small token of appreciation will be given.

8. Do I have to take part?

No, whether or not you decide to participate is entirely up to you. If you agree to participate, you can still withdraw from the study at any time and without giving a reason. At your request we will delete any information we hold about you. You will have no penalty as a result of your decision to withdraw. But if we have already coded your data i.e. created themes, we will retain the anonymised codes and themes.

9. Has the study been reviewed by an ethics committee?

This study has been reviewed by the ethics committee of Ahfad University for Women, University of Oxford, and the Federal Ministry of Health – Sudan. The study received approval from all of the aforementioned ethics committees.

10. On what basis will my personal information be processed?

The University of Oxford is the data controller with respect to your personal data, and as such will determine how your personal data is used in the study. The University will process your personal data for the purpose of the research outlined above. Research is a task that we perform in the public interest.

Further information about your rights with respect to your personal data is available from http://www.admin.ox.ac.uk/councilsec/compliance/gdpr/individualrights

11. Will my data be transferred internationally?

I will be sharing the information that I collect from you with other investigators at Ahfad University and the University of Oxford. I will make sure that identifiable data is removed whenever possible, and that any data transfer is done securely and with a similar level of data protection as required under UK law.

12. Study sponsor:

This study is sponsored by the University of Oxford. As the sponsor the University of Oxford has appropriate insurance in place to cover any unlikely harm.

13. What if I have any questions or want to raise a concern?

If you have any concerns about this study, please initially contact the student researcher, Dr Noon Altijani [e-mail: noon.altijani@gtc.ox.ac.uk, Phone: + 249 912641413] or Ahfad University for Women-School of Medicine research office [e-mail: medicine@ahfad.edu.sd, Phone: + 249 187 579117] we will do our best to answer your questions or to acknowledge your concerns within ten working days, and to give you an indication of how we intend to deal with your concern.

Appendix P: Informed consent form 1 – Arabic.



إقرار موافقة الشخص الخاضع للبحث

هذه الدراسة حاصله على موافقة من اللجان الأخلاقية للبحوث ب جامعه الاحفاد للبنات- السودان وجامعه أوكسفورد بالمملكة المتحدة، ووزارة الصحة الاتحادية- السودان.

	بنود الموافقة	التوقيع
1	لقد إطلعت على المعلومات الحالية والتي تم شرحها لي وأتيح لى طرح الأسئلة عنها كيفما شئت , و قد تلقيت الإجابات الوافية عن كل الأسئلة.	
2	أنا علي علم بان المشاركة **طواعية** فى هذه الدراسة و أعلم بحقي في التوقف عن المشاركة في أى وقت دون أن يؤثر ذلك على حقوقي في أي وقت لاحق.	
3	أوافق علي ان يتم تخزين بيانات المقابلة خارج السودان [في بريطانيا].	
4	أوافق علي ان يتم تخزين استمارة موافقتي بشكل أمن في جامعه أوكسفورد.	
5	أوافق على التسجيل الصوتي.	
6	أنا أقر بالموافقة على المشاركة في هذه الدراسة.	

رمز المشارك _____ اسم المشارك _____ توقيع المشارك _____ التاريخ _____

اسم الباحث _____ توقيع الباحث _____ التاريخ _____

Appendix Q: Informed consent form 2 – Arabic.



إقرار موافقة الشخص الخاضع للبحث- الأبحاث المستقبليه

هذه الدراسة حاصله على موافقة من اللجان الأخلاقية للبحوث ب جامعه الاحفاد للبنات- السودان وجامعه أوكسفورد بالمملكة المتحدة، ووزارة الصحة الاتحادية- السودان.

	بنود الموافقه	التوقيع
1	أنا أوافق على نصوص مقابلتي - بعد تجريده من اي المُعرّفات الشخصية - ليتم الاحتفاظ بها واستخدامها في الدراسات البحثية المستقبلية.	

رمز المشارك _____ إسم المشارك _____ توقيع المشارك _____ التاريخ _____

إسم الباحث _____ توقيع الباحث _____ التاريخ _____

Appendix R: Informed consent form 1 – English.



INFORMED CONSENT FORM

Incorporating Perspectives of Community Skilled Birth Attendants in the Current Process of Reviewing Maternal Deaths in Sudan: A Qualitative Study.

Study approved by ethics committees of the Federal Ministry of Health- Sudan, the University of Oxford, and Ahfad University for Women.

No	Consent domains	Initials
1	I confirm that I have read the information sheet for the above study. I have had the opportunity to consider the information and ask questions and have had these answered satisfactorily.	
2	I know that participation is voluntary, and I can withdraw at any time or request for the information I provided to be removed from the analysis.	
3	I consent to my interview data being stored overseas. .	
4	I agree to my consent form being stored securely at the University of Oxford.	
5	I consent to being audio-recorded.	
6	I agree to take part in this study.	

Participant's name	Date	Signatures
Student researcher	Date	Signatures

Participant's code

Appendix S: Informed consent form 2 – English.

INFORMED CONSENT FORM- FUTURE RESEARCH

Incorporating Perspectives of Community Skilled Birth Attendants in the Current Process of Reviewing Maternal Deaths in Sudan: A Qualitative Study.

Study approved by ethics committees of the Federal Ministry of Health- Sudan, the University of Oxford, and Ahfad University for Women.

No	Consent domains	Initials
1	For future research, I give consent for my interview transcripts -after being stripped from all personal identifiers- to be retained and used in future research studies.	

Participant's name	Date	Signatures
Student researcher	Date	Signatures

Participant's code

Appendix T: Oxford Tropical Research Ethics Committee study approval.

Oxford Tropical Research Ethics Committee

University of Oxford
Research Services, University Offices
Wellington Square, Oxford OX1 2JD
Tel. +44 (0)1865 (2)82106
E-mail: oxtrec@admin.ox.ac.uk

Dr Noon Altijani
National Perinatial Epidemiology Unit
Old Road Campus
Oxford
OX3 7LF

19 March 2019

Dear Dr Altijani

Full Title of Study: Incorporating Perspectives of Community Skilled Birth Attendants in the Current Process of Reviewing Maternal Deaths in Sudan: A Qualitative Study

OxTREC Reference: 515-19

Thank you for your email of the 8 March 2019, and for your minimal risk application form.

I am pleased to confirm that approval has now been granted for this study. This is valid for the first five years and is subject to receiving the local ethical approval (if this approval has not yet been received).

The documents approved for this study are as follows:

Documents:	Version:	Date:
Minimal risk application form		
PIS	V2.0	08/03/19
ICF	V2.0	08/03/19
ICF – future research	V1.0	08/03/19
Interview topic guide	V1.1	28/02/19

Any subsequent changes to the application must be submitted to the Committee as an Amendment. This should include a letter to give the reasons for the proposed modifications and all revised documents with changes tracked.

Please ensure that you submit a completed Annual Report form on every anniversary of this approval and a final End of Study Report. The relevant forms can be found on the OxTREC website: https://researchsupport.admin.ox.ac.uk/governance/ethics/apply/oxtrec.

Finally, please note the following **important information**:

Data safety—all studies
It is the responsibility of the PI to ensure that all data collected during the course of the study is stored and transferred safely and securely. Further guidance and advice is available from the Research Data Team.

Tel: +44 (0)1865 (2)82106
Email: oxtrec@admin.ox.ac.uk
Web: https://researchsupport.admin.ox.ac.uk/governance/ethics

Studies that will involve storing human tissue samples in Oxford
As you are planning to import the samples into England, you will need to make arrangements before the samples are transferred to store them under the governance of a Human Tissue Authority (HTA) licence. It is a legal requirement that any tissue or fluid made up of or containing human cells to be used for the purpose of research is stored on premises licensed by the HTA unless covered by an exemption. OxTREC approval is not a recognised exemption. Further information may be found on the University's human tissue governance web pages: https://researchsupport.admin.ox.ac.uk/governance/human-tissue.

Yours sincerely

Dr Rebecca Bryant
Research Ethics Manager, OxTREC

Appendix U: Ethical clearance certificate from the Federal Ministry of Health - Sudan.

Republic of Sudan
Federal Ministry of Health

HEALTH RESEARCH COUNCIL

NATIONAL RESEARCH ETHICSREVIEW COMMITTEE

Date 30/4/2019

Ethical Clearance Certificate

This is to certify that the proposal No (1-4-19) entitled **(Incorporating perspectives of community birth attendants in the current process of reviewing maternal deaths in Sudan. A qualitative study)** submitted by **Dr. Noon Altijani Osman Abbakar** From **Nuffield Department of Population Health, University of Oxford ,** Has been approved by **the National Health Research Ethics Committee, Federal Ministry of Health** to be conducted in Sudan.

NB

The principal investigator is requested to submit the final report to the Research Directorate-Federal Ministry of Health.

Dr. NaiemaAbdallaWagialla
Rapporteur of the
National Research Ethics Review Committee

Appendix V: An example of "One sheet of paper".

