Health systems determinants of maternal and neonatal health in Rwanda

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Colophon

The work presented in this thesis was carried out within the Radboud Institute for Health Sciences and the manuscript has been prepared by Radboud Institute for Health Sciences, Department of Primary and Community Care, Department for Health Evidence and Department of Obstetrics and Gynaecology, Radboud University Medical Centre, Nijmegen, the Netherlands

Cover: Felix Sayinzoga
Layout: Twanny Jeijsman-Rouwhorst
Printer: Ipskamp Drukkers
ISBN: 978-94-028-1726-3

Much of the field work conducted as part of this thesis was made possible through a grant from the Netherlands Organisation for Scientific Research (NWO/WOTRO), which funded the Maternal Health and Health Systems in South Africa and Rwanda research project, as part of a larger programme entitled 'Global Health Policy and Health Systems Research' (2012-2017).

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Proefschrift

ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus Prof. dr. J.H.J.M. van Krieken,
volgens besluit van het college van decanen
in het openbaar te verdedigen op
dinsdag 5 november 2019
om 15.00 uur precies

door

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geboren op 15 mei 1977
te Bujumbura, Burundi

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Doctoral Thesis

to obtain the degree of doctor
from Radboud University Nijmegen
on the authority of the Rector Magnificus Prof. dr. J.H.J.M. van Krieken,
according to the decision of the Council of Deans
to be defended in public on
Monday, November 5, 2019
at 15:00 hours

by

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CHAPTER 1

General introduction

INTRODUCTION

1.1 Overview of global maternal status

Maternal health refers to the health of women during pregnancy, childbirth and the postpartum period. While motherhood is often a positive and fulfilling experience, it is filled with suffering, ill-health and even death for many women [1].

In 1990, the United Nations (UN) put maternal health on the agenda of the millennium development goal as high priority and the global commitment was made to reduce the maternal mortality ratio (MMR) worldwide 75% by 2015. This initiative is a part of the Millennium Development Goals (MDGs). This objective (MDG 5A), along with achieving universal access to reproductive health (MDG 5B), formed the two targets for MDG 5: improve maternal health [2].

MDG 5A was not achieved despite the global effort to reduce maternal mortality. Since 1990, the MMR has fallen by nearly 44%, from 385 to 216 maternal deaths per 100 000 live births in 2015. The annual number of maternal deaths decreased from approximately 532 000 to 303 000 and the approximate global lifetime risk of a maternal death fell considerably from 1 in 73 to 1 in 180 in the same period [3].

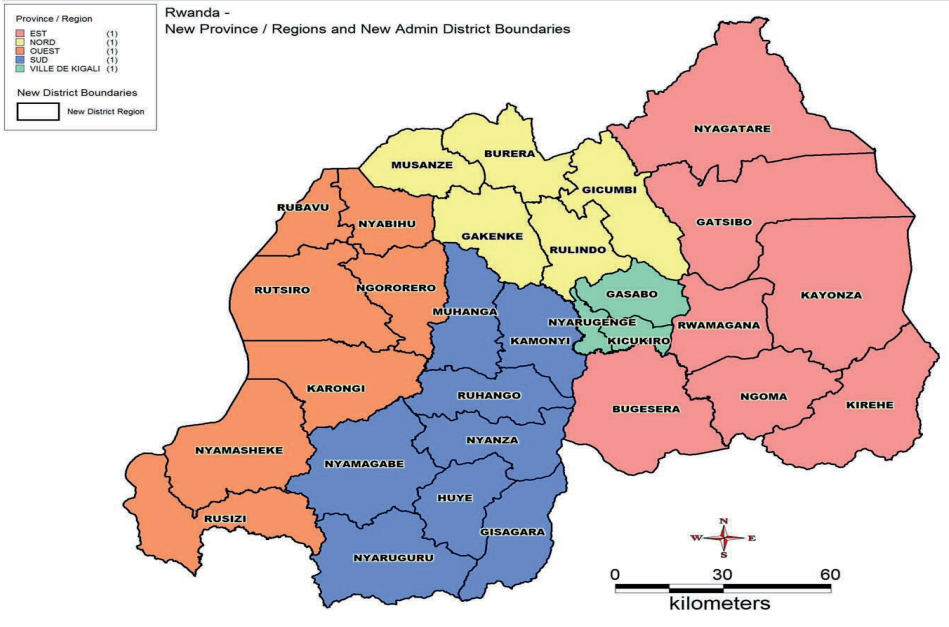
Although there has been improvement globally, there are huge disparities between countries in the fight to better maternal health. Developing countries account for approximately 99% of all maternal deaths, with sub-Saharan Africa alone accounting for roughly 66%, followed by Southern Asia [3]. In addition, disparities are seen within countries [4].

In September 2015 during the United Nations General Assembly, heads of state and governments agreed to set the world on a path towards sustainable development through the adoption of the 2030 Agenda for Sustainable Development [5]. This agenda includes 17 Sustainable Development Goals, or SDGs, that set out quantitative objectives across the social, economic, and environmental dimensions of sustainable development—all to be achieved by 2030. The goals provide a framework for shared action: “for people, planet and prosperity,” to be implemented by “all countries and all stakeholders, acting in collaborative partnership” [5].

Achieving the SDG target 3.1 of a global MMR below 70 will require reducing global MMR by an average of 7.5% each year between 2016 and 2030. This will require more than three times the 2.3% annual rate of reduction observed globally between 1990 and 2015 [3]. Working towards SDG 3.1 and ultimately towards ending preventable maternal mortality requires amplifying the efforts and progress catalysed by MDG 5[3-4].
Understanding the care of women who died due to pregnancy-related causes and outcomes of women with severe morbidity who survive could provide insight into ways to improve care for all women and reduce both severe morbidity and mortality.

1.2 Rwandan Health system

Figure 1; Rwanda map



The Republic of Rwanda is situated in central Africa, south of the Equator, between 1°4' and 2°51' latitude south and 28°53' longitude east. With an area of 26,338 square kilometres, it is bordered to the north by Uganda, to the south by Burundi, to the west by the Democratic Republic of Congo, and to the east by Tanzania. Lacking access to the sea, Rwanda is land-locked and is located 1200 km from the Indian Ocean and 2000 km from the Atlantic Ocean. Its topography is mountainous and the average altitude is 1700 meters.

In terms of climate, Rwanda enjoys a subtropical climate that is tempered by altitude. The mean temperature is approximately 18.5° C and the annual rainfall averages 1200 mm. The year is divided into two rainy seasons of unequal length that alternate with a short and long dry season.

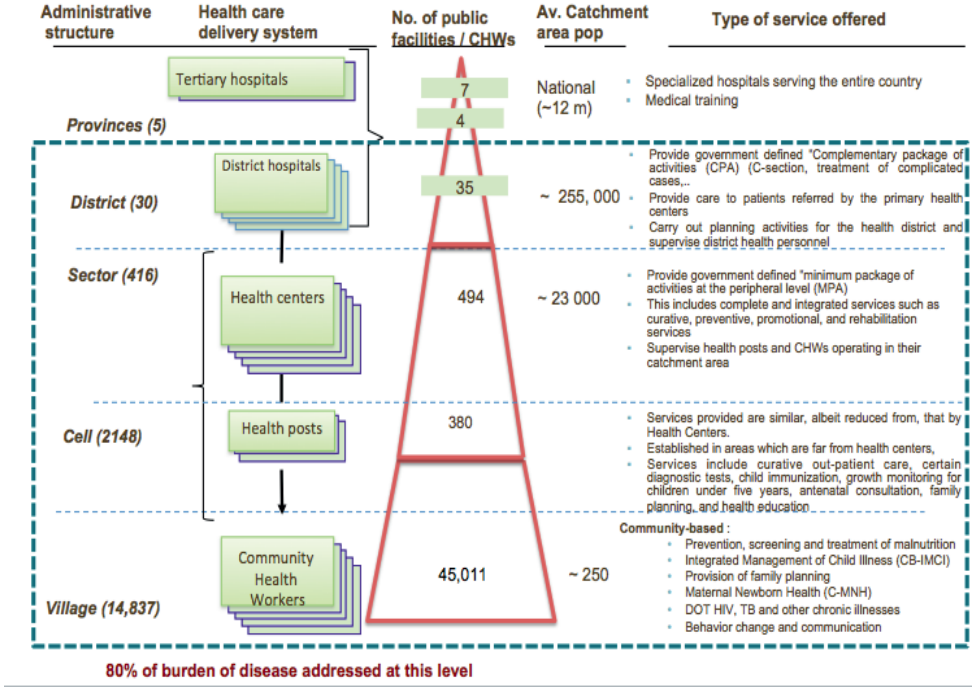
Administratively, Rwanda is divided into four provinces plus the city of Kigali, 30 districts, and 417 sectors. The smallest administrative unit is the cell, which is composed by 4 to 6 villages [6].

The results of the 4th population and housing census of Rwanda reports a population of 10,537,222 [7]. This is an increase of about 29.6% from the results of the 2002 Census [8] and indicates an average annual growth rate of 2.6% [7]. The population density was estimated at 416 habitants per km^2 in 2012 census at national level making it the highest in the East African Region [7].

In Rwanda, the development of the health system was completely disrupted at the time of the 1994 Tutsi Genocide. Much of the infrastructure, equipment, personnel, and the health system itself were destroyed. With the advent of peace, the government has been working to rebuild the health system [9]. In 1995, the government issued a new policy to guide the reconstruction of the health system and in 2000 steps were taken to restructure and decentralize management. The district health offices have operated as autonomous entities providing services to well-defined populations in urban and rural zones. The decentralization of financial and logistic resource management has been implemented universally [10].

The health system in Rwanda is organized as a three-level pyramid consisting of central, intermediate, and peripheral levels. The central level includes the directorates of the Ministry of Health and the national reference hospitals. The intermediate level is represented by health districts and district hospitals. The peripheral level is represented by health centres, which include community-based organization and community volunteers.

Figure 2; Rwanda Health system *[11].*



The central level, based in the capital city of Kigali, is responsible for the development of health policy; it is also in charge of establishing strategies and guidelines that are provided to health services. Its role is also to conduct monitoring and evaluation of the overall status of health situation, as well as to coordinate resources at the national level.

The intermediate, or district, level is represented by health district administration and the referral district hospitals. The district hospital is responsible for managing all health problems for a well-defined population, supervises health centres and communities and reports to the health district administration, which is under the district administrative.

The peripheral level located at the sector and cell levels is the operational unit represented by the health centres and the community-based organizations. It is comprised of first-level health facilities, particularly health centres. With participation from the community, the health facility plans, coordinates, and carries out health activities in its catchment area. Each village has three community health workers: two binomes dealing with child health issues and one "Animatrice de Santé Maternelle" (ASM) in charge of maternal and neonatal health. The peripheral level reports directly to the district hospital.

The overall priority of the Health Sector Strategic Plan III (HSSPIII 2013-2018) [12] was to increasingly mainstream all Ministry of Health (MOH) services to allow for quality and comprehensive care. This implies that all priority programmes and all support systems (planning and budgeting, human resources for health, medical products, health technologies, health financing, quality assurance and information management) offer their services at all levels of service delivery in a coordinated manner [12].

The following priorities have been adopted for HSSP III implementation:

1. Achieve MDGs 1 (nutrition), 4 (child), 5 (maternal) and 6 (disease control) by 2015
2. Improve accessibility to health services (financial, geographical, community health)
3. Improve quality of health provision (Quality Assurance, training, supervision)
4. Reinforce institutional strengthening (especially towards district health services, DHU)
5. Improve quantity and quality of human resources for health (planning, quality, management).

In the last 15 years, Rwanda has witnessed unprecedented improvement in many health outcomes including those related to maternal health [9, 13-16]. This success is in part a result of the government's commitment to achieve both national and international objectives. As such, the Ministry of Health has continued to implement pioneering health system reforms. In collaboration with development partners, MOH has invested in innovative interventions within an increasingly decentralized healthcare delivery system. Impressive performance has been posted in infant and child survival, maternal health [15-16], HIV, TB and malaria. The community health insurance scheme known as "*mutuelles de santé",* infrastructural developments and maternal health-related indicators such as improved emergency obstetric and neonatal care (EmONC) have been prioritized. The number of trained medical personnel

has steadily risen and their motivation and retention within the healthcare system has been addressed through unique interventions such as performance-based financing [16].

Table 1; Trends of key indicators 2000–2015 *[17-22].*

INDICATORS	2000	2005	2010	2015
Source of Information	**DHS 2000**	**DHS 2005**	**DHS 2010/ HMIS 2011**	**DHS 2015/ HMIS 2015**
IMPACT INDICATORS				
Population (in millions)	7.7	8.6	10.5	11.3
Life Expectancy	49		55	64.7
Infant Mortality Rate / 1,000	107	86	50	32
Under Five Mortality Rate / 1,000	196	152	76	50
Maternal Mortality Ratio / 100,000	1,070	750	487	210
Total Fertility Rate	6.5	6.1	4.6	4.2
Contraceptive Prevalence Rate	7	17	49	52
HIV Prevalence Rate in 15–49 yrs	1.3	1.0	3.0	3.0
OUTCOME / OUTPUT INDICATORS				
% Births Attended in Health Facilities	26.5	39	69	91
% PW Receiving 4 ANC Visits	10	13	35	44
% HHs with at Least One LLIN		18	82	81
INPUT INDICATORS				
% GOR Budget Allocated to Health		8.2	11.5	15
% Population Covered by CBHI		12	91	90
Doctor /population ratio	1 / 75,000	1 /50,000	1 / 17,240	1/10,055
Nurse / population ratio	1 / 6,250	1 / 3,900	1 / 1,294	1/1094
Midwives / population ratio	NA	NA	1 / 66,749	1/4064

1.3 Rwanda Maternal health system

Maternal Health Status

Rwanda's maternal mortality ratio is estimated at 210 deaths per 100,000 live births [21]. Rwanda is among nine countries that had a MMR of more than 100 in 1990 and are now categorized as having "achieved MDG 5A" based on MMR reduction point estimates indicating a reduction of at least 75% between 1990 and 2015: The other countries that have met this milestone are Bhutan, Cambodia, Cabo Verde, the Islamic Republic of Iran, the Lao People's Democratic Republic, Maldives, Mongolia, Rwanda and Timor-Leste [23].

The 2015 Demographic and Health Survey (DHS) presents a picture of the current maternal health successes and challenges in Rwanda [21]. While 99% of mothers in Rwanda received

antenatal care (ANC) from a skilled provider in 2015, only 44% met the WHO standard of at least four ANC visits. 44% of pregnant women delayed their first antenatal visit until four months into their pregnancy, reducing the chances of early detection of risk factors. The percentage of health facility deliveries has increased dramatically to 91% in 2015. Fifty seven percent of women however do not return for a postnatal check-up, augmenting the risks of undiagnosed postpartum complication [21].

Although the maternal mortality rate has fallen greatly from 1,071 deaths per 100,000 in 2000 [17], childbirth-related deaths are still common and need to be cut down in order to reach the SDG 3.1 target MMR of less than 70 per 100,000 LB.

Maternal Health policy

In accordance with the health directives in the Vision 2020 development program, Economic Development and Poverty Reduction Strategy II (2013-2018) [24-25], the Ministry of Health (MOH) has set specific priorities in HSSPIII as follows [12]:

- To improve the provision of EmONC services and the working conditions of health workers.
- To set up a commodity security system for reproductive health and improve infrastructure and equipment, especially the delivery room and in-patient obstetric and neonatal services that will lead to improved ANC, delivery and post-partum care.
- To provide the MOH with effective information, particularly with regards to EmOC, human resources for SRH, monitoring and quality assessment.
- To promote and sustain innovations towards maternal and neonatal mortality reductions, such as the provision of safe post abortion care services (PAC), Prevention of Post Partum Haemorrhage (PPH), rapid SMS and m_Ubuzima (reporting system using mobile phone by CHWs)

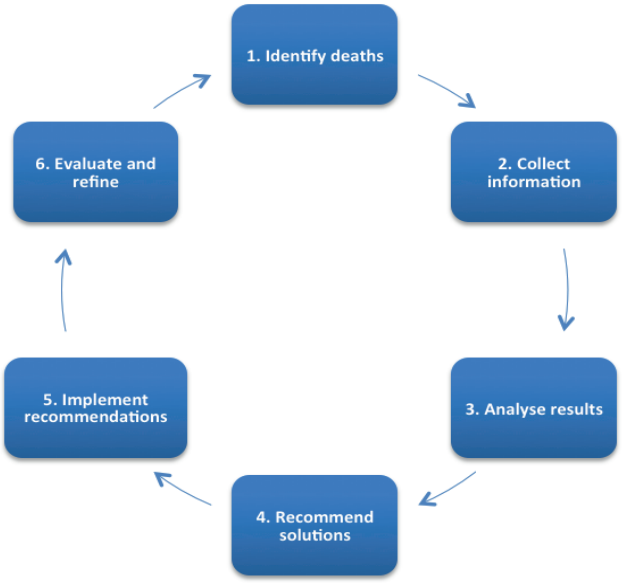
The Rwandan Ministry of Health with the support of WHO, UNICEF, UNFPA and other development partners adopted the maternal death audit (MDA) approach in November 2008 and adapted the implemented it the same year. Three of the five methodologies of conducting maternal death audit namely verbal autopsy (community-based audit), facility-based audit, and confidential enquiry into maternal deaths were selected and health personnel in all hospitals trained to use the three methodologies to conduct maternal deaths audits. All hospitals in the country started conducting MDA in January 2009 and have since been making recommendations aimed at reducing maternal and neonatal mortality based on the results of audits [26].

In order to improve and continuously monitor the actions taken by the audit committee, Maternal Death Surveillance and Response has been adopted as the strategy to understand why mothers and newborns are continuously dying despite concrete interventions in place [27]. The strategy was integrated into the national health system in 2013 and the national Maternal Death Surveillance and Response (MDSR) committee was formed to oversee and support implementation in the health facilities [27]. In 2014, MDSR system was introduced within the Rwanda health systems. The National Technical Guideline for maternal death surveillance and response, including notification and review forms (reporting form) was

developed and distributed to all health facilities for use. In 2015, perinatal audit procedure was introduced for stillbirths as well as early and late neonatal deaths [27].

Such important surveillance systems incited the healthcare providers and other implementers in the health sector to understand the magnitude of maternal deaths in their own communities [28].

Figure 3; Maternal mortality or morbidity surveillance cycle *[28].*



The first Confidential Enquiry into Maternal Death (CEMD) was conducted in Rwanda in 2015 [27]. For the purpose of this survey all maternal deaths that occurred during the period of January to December 2014 were identified through the MDSR reporting system. All cases across the country were primarily included in the study regardless of if death was inside or outside the health facility. Thirty medical professionals serving on MDSR committees have been trained to conduct and analyse maternal death audits in Rwanda [27].

At present (2018), the Ministry of Health is in process of integrating near miss audit in health facilities with emphasis on the key causes of maternal death [29].

1.4 Thesis rationale and objective

In Rwanda, progress has been made to improve the health status of the population in the last 15 years including maternal and perinatal heath [17-19, 21]. The maternal mortality ratio has been tremendously decreasing over the past years but Rwanda is still among countries with high maternal mortality. Childbirth-related deaths are common and need to be cut down in order to reach the SDG MMR target [23].

A better understanding of what has driven the Rwandan success and identification of the scope of improvement in its health system is critical for the Rwanda's post-2015 maternal morbidity and mortality agenda. Information regarding factors that have contributed to the occurrence of severe maternal outcome (maternal death and near miss), newborn health outcomes and the variations between districts in maternal health will contribute to the elimination of avoidable maternal and newborn deaths and ensure no women and children are left behind.

The overall goal of this thesis work is to identify and contextualize health system features that have influenced Rwanda's performance in maternal and neonatal health and suggest interventions that will improve the quality and use of maternal and neonatal health services.

1.5 Research question

The main research question of this thesis is: what are the health system determinants of maternal and neonatal health and interventions for improvement in Rwanda?

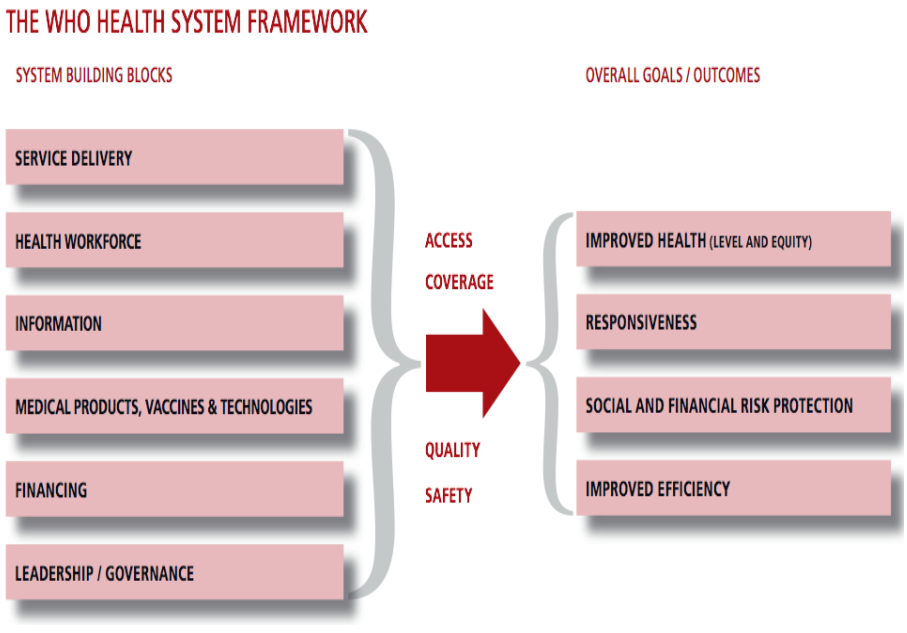
The sub questions of this thesis are:

1. What were the main drivers of improved health sector performance and what scope for further improvements?
2. What are factors that explain variations between districts in maternal and newborn health outcomes and certain emergency obstetric and newborn care indicators?
3. What is the incidence, the characteristics and determinants of severe maternal outcome (maternal death and near miss) and newborns deaths?

1.6 Analytical framework and methodology

To assess and contextualize health system features that have influenced Rwanda's performance in maternal and neonatal health and suggest interventions that will improve the quality and the use of maternal and neonatal health services, the WHO health system framework is used to determine the level of which the system building blocks have impacted maternal and neonatal health outcomes [30].
The questionnaire for key informant interviews, focus group discussions were elaborated to guide the response of respondents according to the six system building blocks on their impact on the access and quality of maternal and neonatal health services and what interventions should be implemented to improve the outcome.
On the other hand, the maternal health outcomes were assessed through the review of severe maternal outcomes by identifying factors according to the system building blocks that have contributed to maternal death or maternal near miss.

Figure 4; The WHO Health system framework *[30].*



1.7 Outline of the thesis

This thesis is divided into 7 chapters: Chapter 1 provides a general introduction to the maternal health in Rwanda. It also includes the rationale of the thesis and the research questions that have guided the research work.

The Chapter 2 responds to the sub question 1**,** by identifying the main drivers which have contributed to Rwanda's health sector performance and exploring the scope for further improvements through a web-based survey among district health managers in Rwanda. The questionnaire covered the six health systems building blocks that make up the WHO framework for health systems analysis, and two additional clusters of factors that are not directly covered by the framework: community health and determinants beyond the health sector.

The thesis addresses sub question 2 ***In chapter 3***, bin the form of a multifaceted study that combines individual interviews and focus group discussions in four districts. The districts were chosen on the basis of their performance in maternal health indicators based on HMIS data from the year 2013 to assess factors that explain the difference in districts performance. Participants in FGD and interviews were community health workers, nurses working at district hospitals (maternity, antenatal clinic, neonatology department), the hospital director together with senior nurse managers from health centers, and the director of health together with social affairs officers working at sector level.

The thesis responds to the sub question 3, ***in chapter 4,*** by conducting a retrospective cohort of nearly 1000 maternal death audits made by hospital-based audit teams between January 2009 and December 2013. Maternal deaths that happened over this period which were subjected to audit occurred at district hospitals or one of the surrounding health centres. It is complemented ***in chapter 5***, by a prospective case-control study of severe maternal outcome, conducted between November 2015 and April 2016 in four rural district hospitals.

In chapter 6, InterVA4 was used to determine probable causes of death and cause-specific mortality fractions, and conditional logistic regression was utilized to identify clinical, family, and household risk factors for under five mortality. A matched case-control study was conducted of all children who died before 5 years of age in two districts in eastern Rwanda between 1st March 2013 and 28th February 2014 were conducted. Information was obtained through a verbal social autopsy by interviewing caregivers of deceased children and controls matched by area and age.

In Chapter 7, the main findings from different studies that make this thesis are discussed and the main research question on what are the health system determinants of maternal health and interventions for improvement in Rwanda is addressed. Furthermore, the limitations of this thesis are discussed and recommendations for future research are proposed in this chapter.

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CHAPTER 2

Drivers of improved health sector performance in Rwanda: a qualitative view from within

Published as:
Sayinzoga F, Bijlmakers L.
Drivers of improved health sector performance in Rwanda: a qualitative view from within.
BMC Health Services Research 2016; 16: 123

Abstract

Background: Rwanda has achieved great improvements in several key health indicators, including maternal mortality and other health outcomes. This raises the question: what has made this possible, and what makes Rwanda so unique?

Methods: We describe the results of a web-based survey among district health managers in Rwanda who gave their personal opinions on the factors that drive performance in the health sector, in particular those that determine maternal health service coverage and outcomes. The questionnaire covered the six health systems building blocks that make up the WHO framework for health systems analysis, and two additional clusters of factors that are not directly covered by the framework: community health and determinants beyond the health sector.

Results: Community health workers and health insurance come out as factors that are considered to have contributed most to Rwanda's remarkable achievements in the past decade. The results also indicate the importance of other health system features, such as managerial skills and the culture of continuous monitoring of key indicators. In addition, there are factors beyond the health sector per se, such as the widespread determination of people to increase performance and achieve targets. This determination appears multi-leveled and influenced by both intrinsic and extrinsic motivation.

Conclusion: It is the comprehensiveness and combination of interventions that drive performance in Rwanda, rather than a single health systems strengthening intervention or a set of interventions that target a specific disease. There is need for policy makers and scholars to acknowledge the complexity of health systems, and the fact that they are dynamic and influenced by society's fabric, including the overall culture of performance management in the public sector. Rwanda's robust model is difficult to replicate and fast-tracking elsewhere in the world of some of the interventions that form part of its success will require a holistic approach.

Keywords: Rwanda, Health system building blocks, Sector performance, Governance, District health, Web-based qualitative study

Background

Over the past 5–10 years, Rwanda has seen great improvements in several key health indicators, including most health outcomes in the domain of maternal health. Maternal mortality decreased significantly: the 2010 Demographic and Health Survey (DHS) estimated Rwanda's maternal mortality ratio (MMR) at 476 deaths per 100,000 live births, down from 1071 deaths per 100,000 in the year 2000 [1]. The 2012 report of the Countdown to 2015 Collaboration ranked Rwanda as the country with the highest average annual rate of maternal death reduction, at 9 % [2]. Recent estimates by several UN agencies and the World Bank categorized Rwanda among 11 countries that are 'on track' to achieve target 5A of the Millennium Development Goals, which involves a decline of the MMR by at least 75 % between 1990 and 2013 [3].

These achievements are often attributed to a combination of improved population coverage and improved health service quality. In terms of coverage of maternal health services, the proportion of institutional deliveries is increasing (69 % according to the 2010 DHS; 90 % in 2013 according to the national health management in- formation system [4]), while 98 % of pregnant women attend antenatal clinics at least once during their pregnancies [1]. The proportion of women who have their first antenatal consultation (ANC) during the first trimester of their pregnancy, though, was only 41 % in 2013, while only 31 % attended ANC at least four times before delivery [4].[1] Other areas in which Rwanda achieved good progress include the national human Papillomavirus vaccination programme for the prevention of cervical cancer [5], the provision of antiretroviral therapy to pregnant and breastfeeding women who are HIV positive [6], and the national malaria control programme.

While improvements in service quality are much less reported in the literature, data from the national health management information system (HMIS) indicate substantial increases in the past few years in the percentages of pregnant women tested for anaemia, taking iron supplements to prevent anaemia, receiving tetanus toxoid immunizations, and the percentages of women detected with high risk pregnancies and those detected with (pre) eclampsia who are treated with magnesium sulphate [4]. Despite all these achievements, there is also evidence of deficiencies in Rwanda's health system; for instance in the delivery of emergency and essential surgical services, particularly at district hospitals, which underlines the scope to further improve maternal and neonatal health [7].

Much has been said and written about Rwanda's remarkable achievements in the domain of health. Several papers have appeared in prestigious international journals. Binagwaho et al. [8], Farmer et al. [9], Bucagu et al. [10] and Logie et al. [11] link the improved performance to governance—including donor coordination and the alignment of external aid to government policy—as well as to concrete initiatives such as com- munity health insurance (mutuelles de santé) and performance-based financing (PBF). Other papers deal with particular features of the Rwanda health system, such as health research infrastructure [12], PBF [13] and community-based health insurance – not only in peer-reviewed journals, but also in contributions to newsletters, weblogs and online communities of practice.

The central question that then arises is: what makes Rwanda so unique? Are the views of those who to a large extent control the knobs at the operational level of the country's health system – i.e. the districts – any different from what has transpired so far in the inter- national literature? We translated this into the following research question: what do Rwandan district health managers themselves consider to be the main drivers of improved health sector performance? And what scope do they see for further improvements?

It is the district health managers that have less voice, in conferences and in journal articles, yet they are the key agents who lead district health teams and supervise hospital staff so as to achieve targets and contribute to better overall health sector performance. It is important to note that district directors of health (DDH) and hospital directors (HD) in Rwanda have distinct roles and responsibilities. Both are members of the District Health Management Team (DHMT) and their positions are in principle equal in stature. The DDH, who is trained in public health and/or management, provides leadership, along with the Vice-Mayor in charge of social affairs of the district concerned, to the DHMT; while the HD is always a medical doctor and responsible for clinical matters. Both the DDH and the HD report to the Mayor, and through the Mayor to two different minis- tries: the Ministry of Health and the Ministry of Local Government. Mayors have performance contracts with the President that stipulate certain targets which are deter- mined at the beginning of each fiscal year and reviewed periodically. Similarly, Ministry of Health officers as well as health staff employed at hospitals and health centres, all have their own performance contracts, with salaries that are partly fixed and partly variable, depending on their performance.

Methods

In August-September 2014, we administered a web-based survey among district directors of health and district hospital directors to solicit their opinions and experiences. We invited all 30 districts directors of health and all 42 district hospital directors in Rwanda, through a personal email, to participate in a web-based survey. The invitation contained a brief description of the purpose of the study and a unique hyperlink, which gave the invited persons direct internet access to the survey questionnaire. We used LimeSurvey, which is an open source survey application [https://www.limesurvey.com/], that allows respondents to save their responses at any given moment and, if desired, to resume completion of the questionnaire at a later point of time. The software allows researchers to monitor progress in the number of completed surveys and send customised email reminders to those who have not yet responded. No incentives were offered to participate, other than that we promised participants they would receive a summary of the findings as a token of our appreciation.

In designing part I of the questionnaire we distinguished between nine clusters of health system factors: they comprise the six building blocks, as defined by WHO [14], complemented with community health and intersectoral collaboration. The latter two have been cited in critiques of the WHO framework, which is on the one hand considered incomplete and too static, and on the other hand does not sufficiently take into account the interaction between a health system and the wider environment in which it operates [15–17]. We further divided the WHO building block infrastructure & supplies into two: physical

infrastructure and medical technologies & supplies. The survey was in English and consisted of five parts, as shown in Table 1.

Table 1; The five parts of the questionnaire with corresponding number of questions asked

I.	Drivers of performance *within* the health system in Rwanda	38 questions, covering 9 clusters
II.	Drivers of performance beyond the health system	15 questions
III.	Particular reasons why the performance in your district (or district hospital) with respect to maternal health may be different from the national average in Rwanda	4 statements
IV.	Personal viewpoints on health systems strengthening	6 open-ended questions
V.	Some personal background information	13 items, a combination of closed and open-ended questions

The first three parts contained questions and statements with Likert-type scales, ranging from 1 (not important at all) to 5 (very important) for questions; and for statements from 1 (strongly disagree) to 5 (strongly agree). All questions in parts I to IV had a provision to add free text and respondents were encouraged to ex- plain their answers – in either English or in French – particularly for factors and statements about which they held strong opinions (scores 1 and 5).

No sampling was required: the directors of health of all 30 districts in Rwanda were invited as well as the directors of 42 district-level hospitals.[2,3] We obtained their email addresses through the Ministry of Health. The email invitation to take part in the survey provided details about the purpose of the study and emphasised that all answers would be anonymised and treated confidentially. It was explicitly stated that by starting to complete the questionnaire participants consented to participate in the study.
Approval for the study was granted by the National Health Research Committee (NHRC; reference number NHRC/2015/PROT/006), and the Rwanda National Ethics Committee (RNEC; reference number 105/ RNEC/2015).

Results

Response rate and background of participants

We obtained fully completed questionnaires from 24 Directors of Health and 33 Hospital Directors for a total of 57 respondents out of 72 persons targeted; which translates into a response rate of 79.2 %.[4] Almost half of the respondents (47 %) had been in their positions (as DDH or HD) for more than four years (before 2010), while only three of them had been appointed earlier in the year (2014). In terms of years of professional experience, the two groups of respondents were very similar: 10 years on average in both group, ranging from four years to 26 and 24 years, for DDH and HD respectively. DDH were 39 years of age on average, HD were slightly older (41 years). Only one HD out of 33 who participated in the survey was female, compared to nine females out of 24 DDH (38 %).

All of the hospital directors had a medical background: 16 held a master degree (MPH, M-Med or M-Epid), ten held a bachelor's degree and one a PhD (missing information for the remaining six). Among the DDH, there were 12 bachelors (of which seven public health, four A-0 license and one other), outnumbering nine others who held a master title (six MPH, three other), with three missing data.

Drivers of performance within the health sector itself

Respondents were asked to give their personal judgement (on a scale of 1 to 5) about the extent to which a series of 38 health system factors have contributed to Rwanda's improved health sector performance. The top five factors that received the highest scores are listed in Table 2. The five health systems factors considered to have contributed least are listed as well.

Figure 1 illustrates the relative importance of nine clusters of health system factors, as per the judgment of the respondents. Community health activities came out as having contributed most to better health sector performance, followed by improvements in human resources for health. Expansion of physical health infrastructure scored lowest, but it is to be noted that the differences in average scores between the nine clusters are limited, with average scores ranging from 4.0 to 4.5.

Box 1; Top five features in which the Rwanda health system distinguishes itself from health systems in other countries, according to respondents (N = 57)

1. Leadership (22 respondents)
2. Community health insurance/*mutuelles de santé* (18 respondents)
3. Community health/CHW (15 respondents)
4. Focus on vulnerable groups, including mothers and children, and equitable access (9 respondents)
5. Performance monitoring and accountability (9 respondents)

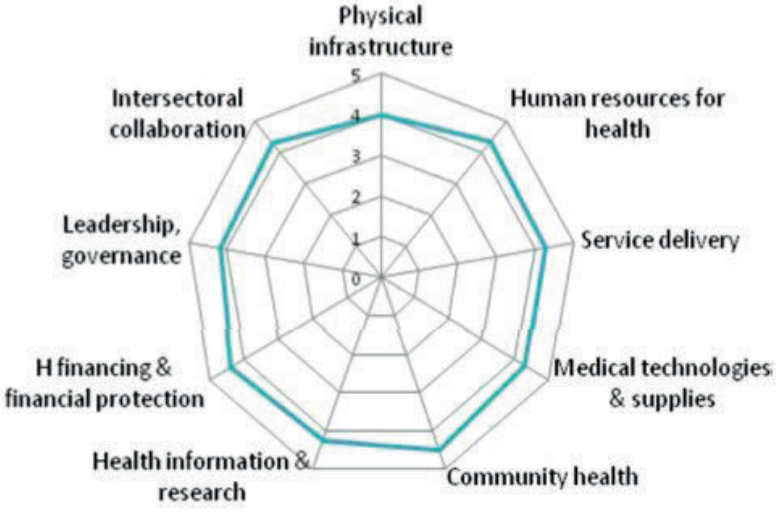
Table 2; Factors considered to have contributed most and least to Rwanda's improved health sector performance

Top 5 factors
1. widespread presence of community health workers
2. Expansion of the service package covered by community-based health insurance
3. Increase of the density of health centres country-wide
4. Improved diagnostic methods (laboratory investigations, rapid tests, radiology) at various levels of the health system
5. Improved patient referral system
Bottom 5 factors:
1. Increase in private health facilities country-wide
2. Improved specialist services at district hospitals
3. Health research
4. Health legislation and enforcement
5. Improved technologies for medical treatment

In narrative comments that respondents provided to explain their scores, some argued explicitly that it is the combination of factors that has led to success. One respondent expressed it as follows:

"It's our health system as a whole, with the various activities that we undertake, the way the system is organised and our overall policy and leadership; it isn't for just one reason that we manage to improve our health indicators."

Figure 1; Average scores assigned by responders (N=57) to nine clusters of health system drivers of performance



Other drivers of performance, beyond the health sector

Respondents were also asked to give their personal judgement about the importance of other factors, not limited to the health sector per se. Table 3 presents averages of the scores obtained for 15 such factors, ranked from the highest average score to the lowest. Here again, the differences are quite small.

The central government's determination to build a better society is perceived as the main driver of health sector performance, followed by local governments' determination to build a better society. This is illustrated by the following quotes from respondents:

"*When central government is committed, any target can be achieved*."

"*Local leaders are key in health improvement*."

"*Performance contracts have made a big difference*."

Table 3; Average scores assigned by respondents (N = 57) to other drivers of performance, beyond the health system, ranked in order of importance

Rank	Factor	Average score[a]	Range
1	Determination by central government to build a better society	4.5	3 to 5
2	Determination among local govt. administrators to build a better society	4.3	2 to 5
3	Increased awareness among population about health rist	4.3	2 to 5
4	Improved water &sanitation and hygienic conditions	4.3	3 to 5
5	Improved literacy levels, particularly among women	4.2	2 to 5
6	Increased child spacing and family planning; lower fertility levels	4.2	2 to 5
7	Better individual behavior and protection against health hazards	4.2	2 to 5
8	More focus of local leaders and programme managers on vulnerable groups	4.2	1 to 5
9	Improved economic conditions of Rwandan households	4.1	2 to5
10	Stronger collective effort of the population to build a better society	4.1	3 to 5
11	More external support from donors and international agencies	4.1	2 to 5
12	Increased population awareness about rights and duties	4.1	1 to 5
13	Determination among non-state actors to build a better society	4.0	2 to 5
14	Improved diets, better nutritional status	4.0	2 to 5
15	Increased sense of responsibility of people to manage their own lives	4.0	2 to 5

[a]Scoring on a scale from 1 (not important at all) to 5 (very important)

Improved water supply & sanitation are also considered important determinants, along with several individual cognitive-behavioural factors, such as the general public's increased awareness of health risks, improved literacy levels (in particular among women), increased child spacing (lower levels of fertility), and more conducive individual behaviour and personal protection against health hazards.

We list some illustrative quotes from respondents:

"*In the past, community behaviours contributed much to preventable illnesses, but now people have changed their dietary pattern and they are protecting themselves against potential risks*"

"*Mass campaigns and frequent health education have increased awareness among the general population about health issues*."

"*Literacy levels, particularly among women, have improved as shown by the 2012 census report of our National Institute of Statistics*."

"*We have seen an impressive progress in population health in < name of district>, and this has been boosted by child spacing, even though our fertility rate is still higher than the national average*."

"*People in our district take more responsibility for their own lives, e.g. ensuring personal hygiene, motorcyclists wearing helmets*."

Collective efforts, with specific objectives or aimed at certain target groups, were recognised as well:

"*District administrators try to identify and assist vulnerable people at the district hospital, while sector administrators help vulnerable people to access health services at health centres*."

"*There many examples of ways in which we make collective efforts to build a better society: e.g. through the Agaciro development fund,*[5] *the Ndi Umunyarwanda scheme,*[6] *the Umuganda community service.*[7]"

An interesting divergence of opinions emerged about the role of external aid in achieving health sector improvements, as illustrated by the following two quotes:

"*External aid has been of great added value and has helped to maintain momentum in health, water and sanitation issues; development partners are increasingly aligning their interventions to government priorities*."

"*Foreign aid has not been so important*."

Deviations of district health performance from the national average, and reasons given

Respondents were asked how their districts performed in the area of maternal health compared to the national average in terms of service coverage, service quality and health outcomes and in particular maternal mortality.

More than half of the respondents (57 %) said their districts performed better than the national average on service coverage indicators, such as % of assisted hospital deliveries and % of women attending antenatal consultation (ANC); a quarter (26 %) believed their district's performance was below the national average; while the remaining 17 % indicated it was similar or they were not sufficiently familiar with their districts' performance in order to judge. The two factors mentioned most as reasons for high coverage indicators are:

1. Good collaboration between district/sector administration, community health workers (CHW) and health facility staff; and, related to that,

2. Strong commitment of CHW to register all pregnant women and encourage them to attend ANC at an early stage.

Community sensitisation and higher levels of awareness in general were also mentioned, without referring to any of the actors involved. Several of the respondents who indicated their coverage rates were relatively low, attributed this to the low rates of enrolment in community-based health insurance in their districts.

- With regard to service quality, respondents were asked to comment on the following statement: 'My district's (or district hospital's) performance on service quality indicators – such as % of pregnant women tested for anaemia, the % of pregnant women taking iron supplements to prevent anaemia, the % of women receiving tetanus-toxoid immunisations – is better than the national average for Rwanda.'
  This time, more than two-thirds (70 %) claimed their districts performed better than the national average. Some specifically singled out the contribution of CHW to achieving good results. Among those who disagreed with the statement (15 %), some admitted that the health facilities in their districts were not doing enough to systematically provide the full range of antenatal care services, mostly because of shortages of trained staff and/or medical supplies.

- Almost two-thirds of the respondents (63 %) reacted affirmatively to the following statement on health outcomes: 'My district's (or district hospital's) performance on maternal health outcomes – in particular maternal mortality – is better than the national average for Rwanda.' Others referred to the much improved patient referral system, with ambulances based at certain remote health centres, mainly to facilitate obstetric emergency referrals. Most of those who neither agreed nor disagreed with the statement (16 %) indicated they would not want to speculate about maternal mortality rates, with some looking forward to seeing next year's DHS results. Among those who disagreed (22 %), hence indicating their health outcomes were worse than the national aver- age, one respondent pointed to the tendency of pregnant women in his district to register late for

ANC, or to come to the hospital at a late stage in case of complications during delivery; another one referred to the widespread belief in traditional medicine which would deter certain people from using modern health facilities.

Two-thirds of the respondents (68 %) were generally optimistic about the possibilities to achieve good maternal health results in their districts, compared to places elsewhere in Rwanda, with many of them referring to a very high level of commitment among health staff and strong leadership; for instance:

"*We have a strong willingness among all stakeholders, including politicians, to work together and increase our performance*."

Others pointed at the presence of well-trained staff, the proximity of health facilities that provide basic obstetric care and the availability of ambulances to take care of obstetric emergencies. Some respondents were very adamant in their statements:

"*We have everything that enables us to achieve good maternal health results*."

"*There is no special reason why we can't achieve good results; we have to work hard*".

Personal viewpoints on health systems strengthening

Asked for examples from their own experience that best illustrate Rwanda's good achievements in the health sector over the past five years, almost half of the respondents (42 %) referred to declines in mortality rates, in particular maternal mortality, but also neonatal, infant and child mortality. Others mentioned declines in the incidence and/or mortality from infectious diseases (malaria, HIV), the increase in assisted deliveries or the use of family planning methods.

Improvement in access to health services was mentioned by 30 % of the respondents, where some referred to physical infrastructure, but the majority to the high coverage of community health insurance. Not less than 37 % pointed to Government political commitment, the strong leadership and governance issues (improved policies and guidelines) as factors that had made it possible to make progress. One person emphasised the very close monitoring at all levels of trends in key indicators and the corrective measures that were being taken if targets were not attained:

"*It's controlled every day*".

Community health workers (CHW) and increased levels of community participation were mentioned by a quarter (26 %). With regard to human resources for health (23 %), some emphasised the increased numbers of trained professionals, while others referred to higher levels of technical capacity, motivation and commitment. Still others singled out specific health system improvements, such as the community health information sys- tem (SISCOM) and rapid SMS alerts; or broader factors, such as increased budget allocations to health and improved resource management.

Lessons learned and further learning needs

When asked what was the most important thing they had learned in their professional careers about health systems strengthening, 58 % of the respondents mentioned governance or governance related topics, such as leadership and political commitment at the highest level, a clear organisational/ institutional framework and co- ordination, strategic/target-based planning, accountability, team work and stakeholder engagement, including involvement of mid-level health care providers and com- munity health workers.

The second most frequently mentioned health systems feature that respondents cited as something they had learned in their professional careers was health information and the use of data for informed decision making (14 %).

The favourite areas in which respondents said they would personally like to learn more are monitoring & evaluation and HMIS (16 %), followed by research (11 %). Others would like to learn more about health planning & management, hospital administration, health financing, health insurance, human resource management, quality assurance, innovation, e-health. Some respondents (16 %) wanted to improve their clinical competence (as opposed to managerial skills), and this was mostly in the domain of maternal & child health or emergency obstetric care.

Barriers and proposed changes

Respondents were then asked to mention, from their own personal perspective, the two most important barriers to further improvements in health sector performance in Rwanda. Human resource related barriers were mentioned most frequently (60 %): mostly staff shortages and the high rates of attrition. Some mentioned specific cadres of which there were shortages: medical doctors, nurses, specialists and laboratory technicians. Other barriers that were mentioned frequently are: general poverty and ignorance on the side of the community; the funding gap in the health sector, with some saying this posed challenges for the procurement and maintenance of medical equipment; the low rates of adhesion to community-based health insurance; and inadequate physical infrastructure.

When asked to mention 'the one thing you would like to see changed in the current set-up of the Rwandan health system', 13 respondents (23 %) referred to human resources for health. Some wanted the number of trained professionals to be further increased, others suggested measures to reduce staff turnover and/or help retain staff. Still others wanted better or more equitable employment conditions, non-monetary incentives for health staff, inclusion of district health managers in PBF, and protection of service providers from litigation. Only one person expressed discontent, by saying he did not like

"*... the manner in which some of the higher level health authorities treat their personnel*".

Some respondents suggested structural changes in decentralisation or in coordination among actors: between the Ministry of Health headquarters and districts, or be- tween the Ministry and the Rwanda Biomedical Centre.

Others wished for more realistic planning; improvements in the patient referral and counter-referral system; and better information to the general public, not only about their entitlements, but also about their own responsibilities and obligations as far as health is concerned.

Discussion

District health managers consider a wide variety of health system features and factors as reasons for the recent successes in Rwanda's health sector. While some elements had somewhat higher scores than others, the differences were actually quite small, and it appears to be the complementarity of various interventions and sub-systems that is important. Respondents mention the widespread presence of community health workers (CHW) and health insurance as the main factors that have led to Rwanda's improved health sector performance. Rwanda does have a dense network of CHWs who deliver a broad range of preventive and curative services in their own communities. For every 800-1000 people in Rwanda, there is one maternal health CHW who monitors pregnant women and their newborns, and two multi-disciplinary CHWs (binômes) who carry out integrated community case management, malnutrition screening, and other preventive and behaviour change activities [18]. The Ministry of Health has also established a standardized community health information system (SISCOM) which makes data collected by CHWs available at the (sub-)national levels and which complements the health facility-based data in the national health information system. Enrolment in community based health insurance is very high, with 90.6 % of the population that was enrolled as of June 2012, with another 7 % covered by civil service, military or private insurance schemes [9]. Many preventive interventions, such as bed nets and vaccinations, are fully covered by the insurance package, along with treatment for HIV, tuberculosis and some cancers. Apart from the annual premiums, subscribers pay 10 % co-payments at the point of care for services that are not fully covered. Poor people pay smaller premiums.

Our results further indicate the importance of other health system features, such as improved managerial skills and a monitoring & evaluation culture nurtured by a widespread and multi-leveled determination to in- crease performance, which is not solely driven by individuals' financial interest.

PBF, which was adopted as a nationwide strategy in 2005, rewards community health worker cooperatives, health centres, and district hospitals for improved patient follow-up and certain primary care indicators, such as the proportion of women delivering at health facilities and children completing the full course of immunisations. Somewhat to our surprise, PBF was mentioned less as one of the key drivers of performance than we had expected.

This survey is unique in the sense that it is the first of its kind to interrogate district health managers about factors that drive performance. They are of the opinion that it is a multitude of factors, inside and outside the health sector, that have determined Rwanda's steep progress towards achieving universal health coverage and meeting most of the Millennium Development Goals by 2015.

Limitations

The survey has three methodological limitations. Firstly, a validated research instrument was not available, and we therefore designed the questionnaire based on what is reported in the literature about the complexity and dynamics of health systems and determinants of health sector performance. The possibility for respondents to explain their responses in narrative form, especially their scores on Likert scales, made it possible for us to analyse to some extent how questions were actually understood.

Secondly, the survey did not make use of any comparator group or situation, of which the internal validity might have benefited. The choice to direct the survey to two different types of respondents (district directors of health and hospital directors) was not with the intention to compare them.

Third, although the survey was web-based, it did not allow any interaction among the respondents, or be- tween researchers and respondents. The questions were primarily close-ended, with ample opportunity for participants to explain their responses, but some indicated that their writing skills (in English or French) limited them in expressing themselves.

The survey's external validity is not much of a problem: at 79 %, the response rate was very high by inter- national standards for web-based surveys [19] and also much higher than the response rates usually found in postal surveys [20–22]. We were proven right in our a priori assumption that in Rwanda, which has a good information technology infrastructure and a culture in which civil servants feel obliged to participate in initiatives coming from the central government, a web-based survey among health professionals should be feasible. This is not to be taken for granted though in other countries in Sub- Saharan Africa. We found no indication that the non- respondents – 15 in total – might be different in any way from those who participated in the survey.

Attribution

Several authors have tried to link Rwanda's successes in health to specific initiatives, but attribution remains tricky.

- Bucagu et al. [10] reviewed evidence of the impact of health systems strengthening on coverage of maternal health services in Rwanda. In their description of health sector reforms, they identified the year 2006 as the point in time when three important policies were scaled up: facility-based childbirth (assisted deliveries), performance-based financing (PBF) and community- based health insurance (CBHI). From their analysis of trends in service coverage indicators over two periods (2001–2005 and 2006–2010), they identified four main factors that drove changes in four different indicators of maternity care coverage: health workforce, PBF, CBHI and leadership & governance. The relative weight of each of these factors could not be established, and it is not quite clear what the possible contribution was of other factors, such as CHW and health information management for informed decision making, or whether they were considered at all.
- Basinga et al. [13] assessed the effect of performance-based payment of health care

providers on the use and quality of child and maternal care services in health care facilities in Rwanda. They conducted a survey of 166 facilities, half of which were randomly assigned to begin pay-for- performance (P4P) funding in 2006, with the other half continuing the traditional input-based funding, for a period of almost two years. The P4P scheme turned out to have had the greatest effect on those services that had the highest payment rates and needed the least effort from the service provider. The authors concluded that financial performance incentives can indeed improve both the use and quality of maternal and child health services.

- Farmer et al. [9] observed a certain disagreement among scholars and opinion leaders globally about the reasons for Rwanda's success. Analysing the country's quest to rebuild the health system after the 1994 genocide, they identified lessons learned in relation to six key factors: National leadership, Health systems approach, Country ownership, Community-based care, Evidence-based policy making, and Cross-sector collaboration. The health systems approach remains loosely defined, and typically misses out on health service delivery.
- The pivotal role of CHW's, and especially the routine utilisation of CHW data to ensure performance monitoring and quality assurance were highlighted by Mitsunaga et al. [18]. This ties in well with an attribute of Rwanda's health system that has not received much attention in the literature, namely self-assessment and peer evaluation.

Our survey confirms an observation reported recently by Janssen et al. [23] that health workers themselves reviewing statistics and monitoring adherence to guidelines, both for clinical work and managerial tasks, is characteristic for Rwanda and an important aspect of the overall culture of public sector performance management. It received a boost with the adoption and expansion of PBF, and it thereby offered opportunities for shared learning and continuous improvement of performance. PBF should therefore not be simply seen as a financing mechanism, or an initiative that enhances staff motivation and/or community involvement, but also as an instrument that nurtures a climate of continuous performance appraisal and problem solving. Rwanda has the conditions in place for PBF to play this role.

Uniqueness of Rwanda

The uniqueness of the Rwanda model is three-fold. Firstly, the health system has been built around the notion that it is not a single health systems strengthening intervention, or a focus on a particular condition or a disease that drives performance [24], but rather the comprehensiveness and combination of interventions that complement and reinforce each other, particularly in maternal health. Secondly, there is strong political commitment in Rwanda – with the national leadership, district health managers and local government administrators cognisant of their inter- dependence – to improve maternal health, and health more in general. Combined with this, the central government has put in place mechanisms of close over- sight and control of the performance of health institutions and individual health workers, primarily through performance contracts that stipulate certain financial rewards and punitive measures. This means that staff motivation is to some extent extrinsic. Added to this, there is a strong sense in Rwanda that factors beyond the health sector – such as literacy, nutrition and water & sanitation – cannot be ignored. Such strong political will has been

called for globally for a long time, and its importance continues to be reemphasised, both in the context of general health systems strengthening [25] and that of maternal health specifically [26]. And thirdly, there is widespread cognisance of the fact that the fabric of society has an important role to play in achieving better health. In particular the strong involvement of women in collective health actions within local communities around reproductive health and safe delivery – often in close collaboration with local health workers – is remark- able. Internationally, the latter type of action is increasingly being emphasised as a sine qua non for improving maternal health [27].

It will be interesting to see the results of the 2015 Demographic and Health survey, which might be expected to confirm the health impact of Rwanda's multi- faceted approach to achieving its health and development goals.

Conclusion

The present study has elicited how Rwanda has translated its policy intentions into a set of comprehensive and complementary actions embedded in a culture of performance management that are meant to strengthen the health system; and which have actually resulted in a steep increase in performance. In the meantime, there is need for policy makers and scholars to acknowledge the complexity of health systems, the interdependency of what is often referred to as 'health system building blocks' and the overall culture of performance management in the public sector. It calls for more holistic analyses and a tuning down of the high expectations from single interventions and from randomised controlled trial designs as the most powerful type of study. One of the big pitfalls for policy makers is to ignore local con- text and complexity when trying to replicate or fast- track the scaling-up of promising trial results and pilot projects. As much as the Rwanda experience has a lot to offer as a model that appears robust, it will be difficult to replicate it elsewhere in the world unless the bigger picture is taken into account.

Endnotes

[1]Recent HMIS data however show a reduction of ANC coverage between 2011 and 2012, especially for those who attend ANC clinics during the first quarter of their pregnancies and those who have a minimum of four visits. This could be due to underreporting of ANC visits at national referral hospitals and/or private health facilities; or to an inaccurate projection of expected pregnancies (4.1 % of total population), which does not take into consideration the rapid adoption of family planning services.

[2]Some of the larger districts have more than one hospital.

[3]The directors of the five national-level referral hospitals were not included in the survey: the university hospitals in Kigali and Butare, King Faysal hospital in Kigali, the neuro-psychiatric hospital in Ndera and the Rwanda military hospital.

[4]Response rate 80.0 % among DDH, 78.6 % among hospital directors; difference not statistically significant.

[5]A Solidarity Fund, launched by the Rwanda Government in 2012, to which citizens and friends of Rwanda can donate money. 'Agaciro' is a Kinyarwanda word that can best be translated as 'dignity'.

[6]A Government initiative launched in 2013 aiming at reconciling Rwandans ahead of the 20th anniversary of the genocide in 2014. 'Ndi Umunyarwanda' means 'I am Rwandan'.

[7]Mandatory day of community service, the last Saturday of each month. 'Umuganda' means 'coming together for a common purpose'.

Abbreviations

ANC: antenatal care;
CBHI: community-based health insurance;
CHW: community health worker;
DDH: district director of health;
DHMT: district health management team;
DHS: demographic and health survey;
HD: hospital director;
HMIS: health management information system;
MMR: maternal mortality ratio;
P4P: pay-for-performance;
PBF: performance- based financing.

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CHAPTER 3

Understanding variation in health service coverage and maternal health outcomes among districts in Rwanda – a qualitative study of local health workers' perceptions

Accepted for publication in PloS ONE as:
Sayinzoga F., Bijlmakers L., Tetui M., van der Velden K., van Dillen J.
Understanding variation in health service coverage and maternal health outcomes among districts in Rwanda – a qualitative study of local health workers' perceptions.

Abstract

Objective: To obtain the perspectives of health professionals and community health workers on factors that determine health service coverage and maternal health outcomes so as to understand variations between districts.

Methods: 16 Focus group discussions involving four different groups of participants were conducted in May 2015 in four purposively selected districts, complemented by three key informant interviews in one of the districts.

Results: The solidarity support for poor people and the interconnectedness between local leaders and heads of health facilities were identified as enablers of health service utilization. Geographical factors, in particular location close to borders with mobile populations and migrants, and large populations with sparsely distributed health infrastructure, exacerbated by hilly topography and muddy roads were identified as barriers. Shortages of skilled health providers at the level of district hospitals were cited as contributing to poor maternal health outcomes.

Conclusion: There is a need to take into account disparities between districts when allocating staff and financial resources in order to achieve universal coverage for high-quality maternal health services and better outcomes. Local innovations such as the use of SMS and WhatsApp text messages by health workers and financial protection schemes for poor patients improve solidarity and are worth to be scaled up.

Keywords: Rwanda, maternal health, district performance, disparities, local innovations

Introduction

Worldwide in 2015, an estimated 303,000 women died due to complications of pregnancy or childbirth [1]. Most of them died because of severe bleeding after childbirth, infections, hypertensive disorders or unsafe abortions. Low and middle income countries account for 99% of these deaths, with sub-Saharan Africa alone accounting for roughly two-thirds (201,000 deaths in 2015) [2,3]. Maternal mortality is one of the health outcomes that typically show very wide gaps between rich and poor populations [4-6].

The 2014/15 Demographic and health survey (DHS) in Rwanda estimated the maternal mortality ratio (MMR) at 210 deaths per 100,000 live births [7], which is significantly less than the ratios reported in the 2010 DHS (476 per 100,000) and the 2000 DHS (1071 per 100,000) [8,9]. Although everything points to significant improvements, deaths related to pregnancy and childbirth are still too common and will need to be reduced further in order to reach the sustainable development goals (SDG) target for MMR of 70 per 100,000 by the year 2030.

Globally, health service coverage rates have increased but many countries are still a long way from universal coverage for most essential reproductive, maternal, newborn and child health (RMNCH) interventions. Furthermore, intra-country variations in service coverage rates are reducing in most countries but the pace is slow. The main impediments to the delivery of high-quality services are a combination of health sector specific and non-health sector drivers [10]. Reliable and timely information is required for effective remedial action at local, regional and national health sector management levels, in order to address intra-country inequalities in maternal health care. There is a knowledge gap about the perspectives of local health professionals themselves about the prevailing barriers and enablers to improve maternal health.

The aim of the present study was therefore to obtain the perspectives of health professionals and community health workers on factors that determine health service coverage and maternal health outcomes so as to understand variations between districts and identify the prevailing barriers and enablers to improve maternal health.

Materials and Methods

Study setting

We performed a mixed-methods study combining health information statistics and focus group discussions (FGDs) that were conducted in May 2015 in four districts: Bugesera, Gicumbi, Nyagatare and Rwamagana. These districts had a combined population of around 1.65 million people [11-14; see Table 1].

Table 1; Demographic and geographic information

	Bugesera	Gicumbi	Nyagatare	Rwamagana
Province	Eastern	Northern	Eastern	Eastern
Area	1,288 km^2	829 km^2	1,741 km^2	682 km^2
Population in 2013	361,914	395,606	466,944	313,461
Population density	280/km^2	480/km^2	243/km^2	460/km^2
# of health centres	16	24	21	15
# of hospitals	1	1	1	1
Distance to Kigali	35 km	55 km	161 km	60 km

The districts were chosen on the basis of their performance on a set of key maternal health indicators, which included four service coverage, four service process indicators and four health outcomes, according to data reported in 2013 through the national health formation system (Table 2) [15]. Bugesera district was selected because of its relatively good performance on all three types of indicators. Gicumbi district was chosen because of its good performance on health outcome indicators, but poor performance on service coverage indicators, which seemed rather contradictory. For Rwamanaga it was the reverse: high service coverage rates, but poor health outcome indicators. Nyagatare was included in the study because of its relatively poor overall performance in 2013.

Data collection techniques and tools

Four focus group discussions (FGDs) were conducted in each district, for a total of 16 FGDs: one FGD in each district with community health workers (six to seven participants per district; recruited by their district coordinator); one with nurses working at the district hospital (four to seven participants per district; recruited from the maternity, antenatal clinic and neonatology department); one with nurses in charge of health centres (from three to five facilities, from different sectors chosen randomly per district); and the fourth FGD with social affairs officers working at sector level (four to five participants from three sectors per district, selected by the district director of health. In Bugesera district, three additional individual key informant interviews were conducted, of which the purpose was to complement the information collected through FGDs, particularly on how maternal health services are organised and coordinated in the district: one interview with a technical assistant from one of the development partners, the second with the district hospital director and the third with a senior political leader (the vice-mayor in charge of Social Affairs).

Table 2; Selected key indicators for the four districts in 2013 and the national average (rank numbers indicated in brackets, <1> indicating the best performing district, and <30> the worst performing district).*

	Bugesera district	**Gicumbi district**	**Nyagatare district**	**Rwamagana district**	**National average (range)**
Service coverage indicators					
Pregnant women with 1st antenatal care visit in 1st trimester of pregnancy	51% <11>	34% <22>	46% <12>	69% <3>	45% (15-84)
Pregnant women with four or more standard antenatal care visits	42% <9>	27% <20>	22% <24>	62% <3>	35% (9-74)
Deliveries at home	4.5% <17>	3.1% <11>	9.1% <28>	4.4% <15>	4.5% (0.6-10.3)
Women who delivered and attended at least one postnatal care visits	65% <11>	60% <18>	63% <13>	63% <14>	58% (22-86)
Process indicators					
2-5 Tetanus toxoid vaccinations received	66% <26>	67% <24>	59% <30>	70% (18>	74% (59-100)
High-risk pregnancies detected during antenatal care visits	3.9% <n/a>	9.4% <n/a>	6.1% <n/a>	6.9% <n/a>	9.4% (3.9-32.3)
High risk pregnancies referred during antenatal care visits	76% <1>	20% <27>	27% <22>	26% <24>	43% (7-76)
Women with (pre-)eclampsia who received magnesium-sulphate	77% <16>	28% <27>	80% <14>	71% <18>	95% (0-100)
Caesarean sections	14% <n/a>	11% <n/a>	11% <n/a>	16% <n/a>	14% (3-34)
Health outcomes					
Still births fresh, ≥22 weeks or >500 grams	0.7% <7>	0.9% <16>	1.2% <27>	1.1% <23>	0.9% (0.4-1.5)
Still births macerated, ≥22 weeks or >500 grams	1.0% <17>	0.8% <8>	1.3% <28>	1.2% <26>	1.0% (0.5-1.5)
Reported cases of maternal death in health facilities	7 <15>	3 <6>	16 <25>	5 <12>	269 (2-32)
Reported cases of maternal death in community	3 <24>	2 <16>	6 <30>	0 <1>	48 (0-6)

* *source: National health management information system (references 11-14 and 15)*

In order to provide structure to the discussions, a topic list was developed, containing questions on achievements in maternal health that participants were particularly proud of (or not so proud of) and on particular reasons that explained in their perception the district's most prominent scores and rankings (presented in Table 2). This topic list was used in a flexible manner, with ample room to comment on these scores and ranking and to elaborate on

specific actions that had been undertaken to improve maternal health service coverage and health outcomes.
One of the members of the research team present during the interviews is a senior Ministry of Health officer (FS). Apart from bringing in why this study was being conducted, he did not actively take part in the interviews. All FGDs and interviews were conducted in English (by TM) with translations in Kinyarwanda (by a Rwandan research assistant). Interviewees and FGD participants were allowed to express themselves in Kinyarwanda, English or French. All interviews were voice-recorded and afterwards transcribed verbatim (in English) by a research assistant.

Ethical considerations
At the start of each FGD and interview informed consent was obtained from all participants after explaining that all information provided would be kept confidential and used only for the purposes of the study; that participation was voluntary; and that participants were free not to answer certain questions, or to even completely withdraw from the discussion at any time.

Data analysis
A code manual was compiled inductively, based on the interview topic list with key questions and the verbatim reports of each of the FGD. The actual coding, which involved assigning codes to relevant data segments, was carried out by one of the researchers (MT) with the help of MAXA QDA software (version 2.1.2 for Macs). The coded data were then collated into provisional themes. These were then reviewed by two of the other researchers to verify whether the themes were appropriate in relation to the coded extracts and the entire dataset, before arriving at the final set of themes.

Results
The study results are presented in two parts, of which the first involves common enablers and barriers across the four districts. The second part presents unique factors that explain variations in performance across the four districts.

Common enablers and barriers
The increased rates of antenatal care attendance and delivery at a health facility observed over the past decade and – at least in part – the relatively low numbers of reported maternal deaths can be attributed partially to the community meetings that are being organized by local leaders. Community health workers (CHWs), whose role is to educate and sensitize communities about health and other social matters, take part in these meetings and actively discuss their experiences in the field. The following quote illustrates this.

"Community mobilization by community health workers and local leaders has really helped us. The community health workers go to every mother in the community and they encourage them to make use of maternal health services; our leaders are always supporting us and people listen to them a lot." (FGD with nurses in Nyagatare district.)

FGD participants argued that concrete actions such as building health centres so as to bring services closer to the population, ensuring emergency referrals through an efficient ambulance

system, and promoting enrolment into community health insurance are being implemented across the country so as to increase geographical and financial access to maternal health services.

"… I thank the Rwandan government for the programme of decentralization since this has helped in bringing services nearer to us, citizens. We have been able to achieve this by working together and collaborating with the community. Our local politicians have become more and more responsible and they make sure to sensitize our communities." (FGD with the director of health and social affairs officers in Bugesera district.)

In addition, the government's efforts to increase staffing levels, train health workers, motivate them, and establish performance contracts that stipulate zero tolerance of negligence and substandard services were cited as key factors that had a positive influence on service quality.
Respondents across the four districts demonstrated a high level of interconnectedness between actors within the health system and good teamwork between health workers and social welfare officers, particularly in maternal health. This was illustrated with examples such as: mixed teams of medical doctors, nursing staff and administrators from the district hospital conducting weekly supervision tours to health centres within their district; and the monthly coordination meetings, in which staff give an account of their respective activities and performance. This had enhanced transparency of operations and accountability for underperformance, and led to more solidarity across teams. It was enhanced by what some of the respondents termed as 'a supportive political environment'.
In addition, the '*rétro-information*' received by health centres on patients they had referred to the district hospital was reported to enhance learning and motivate service providers both at the referring health centre and those at the hospital. The use of short message service technology (rapid SMS) through mobile telephones allowed CHWs to easily contact health centre staff (and vice versa), report on key health indicators, respond to emergencies and mobilize life saving medical care. SMS messages were also being used to remind CHWs who among the pregnant women in their respective villages (*secteurs*) was due for her next antenatal consultation.

"When we send a rapid SMS, we get the response immediately. If you send a message with a request for help when one of your patients has a problem, you get an ambulance very quickly. This very important for us." (FGD with CHW in Nyagatare district)

All the respondents emphasized the importance of having a district governance system in place that is responsive to local needs. Respondents expressed a high level of trust in their local leaders, particularly in maternal health matters. They sometimes created local by-laws to deal with local problems and generally applied zero tolerance to adverse practices, such as long waiting times for patients or absence from work among health workers. Respondents in all four districts described themselves as 'highly motivated' to do a good job and achieve targets, not only for maternal health indicators but also for everything else listed in their performance contracts. These contracts comprise personal and collective targets, which are evaluated periodically. For professional health workers, the salary payments are contingent on their performance, which is evaluated twice a year or every quarter.

There also appeared to be a strong internal motivation and personal drive. This was illustrated by many respondents who emphasized they were keen to serve their communities and claimed to strive for excellence. Some said they would not be satisfied unless the antenatal consultations coverage rate attained 100%. Others were proud not to have had a single case of maternal death in their area for a year or more.

One of the community health workers explained her personal motivation:

"I feel lucky to be a CHW, because it serves my community, Imana (God) *will reward us. I'm proud; it's not for the money that I'm doing this. Sometimes we sacrifice by neglecting farming or our own household chores."* (FGD with community health workers in Bugesera district)

Three distinct operational barriers for providing good quality services were brought up, which all had a financial dimension: partial performance of the community health insurance scheme (*mutuelles de santé*), non-functional medical equipment and inadequacy of water supply at hospitals and health centres. Some of the health workers interviewed were of the opinion that the insurance premiums paid by members of the public were barely sufficient to cover the cost of services that health facilities are expected to provide. Patients who do not have health insurance at all put this system further under pressure.

"There is a limit to which the cost of services can be covered by the revenues from health insurance premiums. For a delivery, for instance, we use up to ten pairs of gloves; beyond that, the health insurance doesn't cover the cost." (FGD with nurses, Rwamagana district.)

Unique factors

While some of the enablers and barriers to delivering quality services and achieving favourable maternal health outcomes are common across the four districts, some factors are unique and seem to explain some of the variation in performance among districts.

The relatively high coverage of maternal health services attendance in Bugesera district can be explained by the solidarity support for poor people to utilise health services through a local scheme that FGD participants termed as "*ingobyi*". This scheme can take the form of payment of transport costs or exemption to pay the annual premium for health insurance. It is illustrated by the following quote from one of the FGD:

"The community contributes 300 francs per week; if it is a poor family of ten people, we may pay the health insurance premium for six of them. Ingobyi is highly valued in the community and supported by our local leaders."(FGD with CHW, Bugesera district.)

The good performance in coverage indicators in Rwamagana district was explained, at least in part, by the interconnectedness between local leaders and the heads of health facilities, which is facilitated by a WhatsApp group. It is being used by nearly 50 people to exchange information, coordinate activities and support each other on various topics. The group has been critical in responding to logistical challenges and providing advice to its members.

The low maternal health service coverage rates in Gicumbi and Nyagatare districts were attributed to their locations, close to Rwanda's borders with Uganda and Tanzania,

respectively. These two districts have large mobile populations and migrants, from Rwanda itself or from nearby countries. According to the respondents, migrants are often not enrolled in health insurance and they are mostly poor people, which limits their access to care. The problem of mobile populations is illustrated by the following quote:

"They don't have permanent settlements; they can be away for three or four weeks before coming back again. This makes follow up very difficult. Some of them don't even have insurance. This has increased the number of home deliveries in our district." (FGD with CHWs in Gicumbi district)

The same two districts also have relatively large populations, compared to the other two districts included in the study and most other districts in Rwanda, along with sparsely distributed health infrastructure. This is exacerbated by the hilly topography (in Gicumbi) and the poor network of muddy roads (Gicumbi and Nyagatare). It delays the response to requests for emergency ambulance transport and eventually makes it difficult to reduce the number of home deliveries. This, it was argued, limits access to maternal health services.

"Our district is the biggest and we have only one district hospital. We receive pregnant mothers who have walked long distances; many cannot afford the cost of transport by motor bike." (FGD with CHWs, Gicumbi district)

The size and composition of the health workforce is not adequate compared to the population size and the disease profile. The shortage of clinical specialists at district hospitals was a cause for concern, especially in Nyagatare district which is relatively far away from referral hospitals in the capital Kigali. This also happens to be the district with the largest population.

Respondents in Gicumbi and Rwamagana indicated that having a nursing school gives them extra nurses and midwives who come for practice sessions. They seem to be a bit better off in terms of workload of their nursing staff, as they have the advantage of interns who complement their regular staffing levels. Medical equipment was reported to be in short supply in some of the district hospitals and health centres. In Rwamanaga district, several health facilities experienced shortages of running water, which some respondents considered a health hazard.

Discussion

This multifaceted qualitative study has identified factors that explain variations between districts in maternal health outcomes, as well as enablers and barriers to improve maternal health. The interconnectedness between local leaders and head of health facilities and the solidarity support for poor people (in one of the districts) were identified as enablers of health service utilisation. Having large mobile populations, high numbers of migrants, and geographical remoteness of sparsely distributed health infrastructure, exacerbated by hilly topography and muddy roads, were identified as barriers. Shortages of health providers skilled at the level of district hospitals were cited as contributors to poor outcomes.

Similar to most other low- and middle-income countries, Rwanda has shaped its national health system according to the framework promulgated by WHO, which is composed of six building blocks [16]. While most of these building blocks are relatively easy to conceptualize,

it is not always easy to operationalise and make them work at all levels of the health system. An earlier study has shown that district health managers in Rwanda hold rather strong opinions about what works well in the health sector and what actually makes it work: they considered the dense network of community health workers and the health insurance system as factors that have contributed most to Rwanda's good achievements [17]. They also indicated the importance of good managerial skills and the culture of continuous monitoring of key indicators. The present study confirms this.

It is uncontested that good governance and leadership are key ingredients of a well functioning health system [18,19]. It includes for instance clarity of direction at the national level, strategic planning, effective oversight and accountability for performance. The present study has shown that this also applies to the local level. FGD participants demonstrated strong commitment to achieving national goals and adhering to national strategies, embodying a great deal of purpose and trust in the activities that they and their colleagues undertake to promote health in their respective districts. They also expressed solidarity with people in society who do not have easy access to health services, and emphasized the importance of intersectoral collaboration and good communication with local leaders. This is what one could refer to as 'responsiveness'. It is this readiness to respond to local needs and to indications that certain targets might not be met without some extra effort, which might explain the overall increase in health service utilization in Rwanda, observed for already more than a decade [7].

Without a functional health information system, which relies on the timely provision and close monitoring of a selected number of key health indicators, the district-level stakeholders interviewed in this study would not have been in a position to display the vigilance that transpired in the interviews and FGD. The provision of mobile phones to community health workers and the use of rapid SMS to promote antenatal consultations has motivated community health workers to do what is expected of them and it has increased their self-esteem [20].

Adequate health care financing, including funding of all the necessary support services, such as supervision, supply chain management and transportation, are widely considered essential for a health system to thrive [21]. The present study has brought out some challenges at the district level to provide adequate coverage to immigrants and internal migrants who in many cases do not have medical insurance. This explains the low coverage of use of maternal health services in Nyagatare and Gicumbi districts, at least in part. One district (Bugesera) has its own local social solidarity mechanism in place in an effort to ensure equitable access, which has contributed to the high maternal health service coverage rates.

Health workforce adequacy is an issue in Rwanda, as the number of staff with clinical expertise does not always seem to match the requirements [22]. In the case of Nyagatare district, some interviewees and FGD participants did mention that the district was much less popular among health workers than other districts due to its geographical location (far from Kigali, with few opportunities for leisure) compared to the other districts included in the study. The fact that two of the other district hospitals have nursing schools attached to them –

which is also the case for Nyagatare district hospital – was cited as a factor that helped alleviate the high workload of nurses and midwives.

The promotion of maternal and child health was seen as a joint responsibility of several Government departments and this has translated into very close, almost day-to-day working relations between civil servants, community health workers and village/sector leaders. The critical role of frontline workers as intermediates between the community and the formal health sector has recently also been confirmed in a study that explored how relationships influence performance in Malawi [23]. In another recent study on health district productivity in Cambodia, Ensor et al. considered the impact of health policy changes on health sector efficiency. Higher efficiency was associated with more densely populated areas and with the presence of health equity funds [24]. While the former may not apply to Rwanda – as virtually the entire country is densely populated – the latter may hold as well.
A methodological limitation of the study is the sampling method: different perceptions might have been obtained if different districts had been selected. Another limitation is that the study did not look in an in-depth manner at quality of care issues. Interviewees did acknowledge that poor quality of care may impact on patients' demand for services, but they did so mostly by referring to circumstances beyond their own control that affected the quality of care negatively in a general manner.

It is worth noting that Rwanda has a mechanism in place to conduct maternal death audits, and the country is currently in the process of institutionalizing 'near-miss' audits and confidential enquiries into maternal deaths [25]. Some studies recently reported rather high rates of postpartum haemorrhage and infection, as causes of maternal near miss and death [26,27]. This indicates a need for improvement of quality of care at the level of district hospitals, where the majority of deliveries occur.

Conclusions

Disparities between districts in maternal health outcomes are partly attributed to environmental factors, such as topography, population pressure and migration. The two dimensions over which district managers have control are: (1) the functionality of the district health system, in particular local leadership, health information, funding of support services and health workforce issues; and (2) the extent to which supportive intersectoral activities are being undertaken. There is a need to take into account disparities between districts when allocating staff and financial resources in order to achieve universal coverage for high-quality maternal health services and better outcomes. Further research would be useful to explore the potential of scaling up successful local initiatives, such as the use of SMS and WhatsApp group messages and local financial protection schemes.

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CHAPTER 4

Maternal death audit in Rwanda 2009–2013: a nationwide facility-based retrospective cohort study

Published as:
Sayinzoga F., Bijlmakers L., van Dillen J., Mivumbi V., Ngabo F., van der Velden K.
BMJ Open 2016;6:e009734. doi:10.1136/bmjopen-2015- 009734

ABSTRACT

Objective: Presenting the results of 5 years of implementing health facility-based maternal death audits in Rwanda, showing maternal death classification, identification of substandard (care) factors that have contributed to death, and conclusive recommendations for quality improvements in maternal and obstetric care.

Design: Nationwide facility-based retrospective cohort study. Settings: All cases of maternal death audited by district hospital-based audit teams between January 2009 and December 2013 were reviewed. Maternal deaths that were not subjected to a local audit are not part of the cohort.

Population: 987 audited cases of maternal death. Main outcome measures: Characteristics of deceased women, timing of onset of complications, place of death, parity, gravida, antenatal clinic attendance, reported cause of death, service factors and individual factors identified by committees as having contributed to death, and recommendations made by audit teams.

Results: 987 cases were audited, representing 93.1% of all maternal deaths reported through the national health management information system over the 5- year period. Almost 3 quarters of the deaths (71.6%) occurred at district hospitals. In 44.9% of these cases, death occurred in the post-partum period. Seventy per cent were due to direct causes, with post- partum haemorrhage as the leading cause (22.7%), followed by obstructed labour (12.3%). Indirect causes accounted for 25.7% of maternal deaths, with malaria as the leading cause (7.5%). Health system failures were identified as the main responsible factor for the majority of cases (61.0%); in 30.3% of the cases, the main factor was patient or community related.

Conclusions: The facility-based maternal death audit approach has helped hospital teams to identify direct and indirect causes of death, and their contributing factors, and to make recommendations for actions that would reduce the risk of reoccurrence. Rwanda can complement maternal death audits with other strategies, in particular confidential enquiries and near-miss audits, so as to inform corrective measures.

Strengths and limitations of this study

▪ Rwanda is the first among low-income countries to implement maternal death audits (MDA) on a routine basis nationwide.

▪ Five years of MDA implementation in Rwanda provides a huge body of evidence on causes of death, substandard service factors and recommendations made to reduce the chance of reoccurrence, even though the occurrence of various forms of substandard case management and systemic flaws remains not entirely clear.

▪ This nationwide initiative to conduct audits of all cases of maternal death that occurred in health facilities is a demonstration of strong political will to improve maternal and newborn health.

▪ Not all maternal deaths were audited: cases that occurred in the community and some cases in health facilities are not included.

▪ Some information was incomplete or missing altogether; for instance, data on antenatal care attendance, gestational age, whether or not the woman was referred, and initial diagnosis and classification of the cause of death according to the International Classification of Diseases, 10th Revision (ICD-10).

INTRODUCTION

Globally, the maternal mortality ratio (MMR) has fallen by 45% between 1990 and 2013[1]. In the past 10 years, Rwanda has witnessed unprecedented improvements in many health outcomes, including those related to maternal health. The United Nations (UN) listed Rwanda as one of 11 countries that are 'on track' to achieve the Millennium Development Goal 5 (MDG5)[2].

The WHO Countdown to 2015 report ranked Rwanda as the country with the highest average annual rate of maternal death reduction at 9%. From 1071 deaths per 100 000 live births in 2000[4], the MMR decreased to 320 per 100000 live births in 2013[2].

Despite this achievement, Rwanda needs to do more for mothers and newborns in order to sustain the trend and achieve the MDG5 target, set at 268 per 100 000 live births in 2015. One way of reducing maternal mortality is by improving the availability, accessibility, quality and use of services for the treatment of complications that arise during pregnancy and childbirth[5]. Maternal death audit (MDA) is one of the strategies that have proven effective in improving the quality of obstetric care in Ethiopia, Nigeria and Senegal, and there are indications that the audits have helped reduce maternal mortality[6-10].

More than 90% of all deliveries in Rwanda nowadays take place in health centres and are assisted by trained health workers. Women who are detected with high-risk pregnancies are

advised to deliver at the nearest district hospital. Those who are referred and in the possession of a community health insurance card pay a reduced fee when they deliver at a district hospital. Rwanda has 30 district hospitals that each serve a population of 200 000–350 000 and provide emergency obstetric care.

Since 2008, the Rwanda Ministry of Health has adopted three distinct approaches to MDA, namely Confidential Enquiry into Maternal Deaths (CEMD), facility-based death reviews, and community-based death reviews (also called verbal autopsy). Standard tools for these three approaches were adapted to the local context and health providers from all hospitals were trained. MDA committees have been established in all hospitals.

The objective of this study is to present the results of the first 5 years of MDA implementation in Rwanda including maternal death classification, identification of substandard (care) factors that have contributed to death, and conclusive recommendations for quality improvement in maternal and obstetric care.

METHODS

Maternal death audit

Since 2008, MDA committees have been established in all Government-owned, private-owned and church- owned hospitals in Rwanda. These committees are chaired by the medical chief of staff or the head of the maternity department and they further typically comprise staff working in the maternity and/or neonatology departments. All health staff who provided care to a woman who died of pregnancy-related causes while pregnant or around delivery are supposed to attend the audit session. Cases that occurred at health centres are audited by the MDA committee of the nearest district hospital; the committee will then include staff who were involved in case management at that particular health centre.

All hospitals started conducting facility-based MDA in January 2009 and have since been making recommendations aimed at reducing maternal and neonatal mortality. The soft or hard copies of all audit session reports are being collected at the central level (Ministry of Health), where a designated focal person from the Maternal and Child Health department saves these in an electronic database. The individual case reports are com- piled by the local audit committees. They contain information on women's individual characteristics, the place of delivery and death, the reported causes of death, any substandard factors detected and the recommendations made by the respective hospital MDA committees. When auditing a maternal death, the committee reviews and sometimes further specifies the cause of death recorded in the patient notes. The cause of death is reported in narrative form, without necessarily using the International Classification of Diseases, 10th Revision (ICD-10) classification. The audit committee sessions attempt to distinguish factors on the side of health services that have contributed to maternal death from behavioural factors on the side of the patient and the community. Confidentiality of both the patient and the clinician is maintained during the auditing process. The standard form that is used and the reports that are

submitted to the Ministry of Health do not indicate any names; and the protocol stipulates that 'no one should be blamed'.

Study design

All cases of MDA by hospital-based audit teams between January 2009 and December 2013 were reviewed. These constituted our retrospective cohort. Maternal deaths that happened over this period at district hospitals or one of the surrounding health centres, but which were not subjected to a local audit, are not part of the cohort. The latter cases might have been reported through the routine health management information system.

Data analysis

The data were stored in Microsoft Excel, and the variables included age of the woman, residence, number of children alive and number who had died, timing of onset of complications, place of delivery, place of death, parity, gravida, antenatal clinic attendance, reported cause of death, service factors and individual factors identified by committees as having contributed to maternal death and recommendations made by the district MDA committee. All cases saved in the database over the 5-year period were analysed. Data on the number of maternal deaths and births reported by health facilities were obtained from the national Health Information Management System (HIMS), which captures data from public and private facilities. Maternal characteristics and causes of death were compared between the five 1-year periods using $\chi 2$ test for dichotomous variables and Student t test for numerical variables; 95% CIs for maternal mortality rates were calculated using Fisher's exact test.

RESULTS

Over the 5-year period, 1060 maternal deaths were recorded through HIMS on a total of 1 533 177 births that occurred in health facilities. Over the same period, 987 MDA reports were received from three referral hospitals, 42 district hospitals and 62 health centres. Table 1 shows the health facility-based MMR and the proportion of deaths audited by local committees. The overall facility-based MMR using maternal deaths and births reported by HIMS was calculated at 69.1 per 100 000 live births (95% CI 65.1 to 73.4) with 93.1% of all deaths that were audited. Since 2011, there has been a decrease in facility-based MMR.

Maternal characteristics

The mean age of the women who died was 29.7 years (±7.0). Only 26 (2.7%) of the audited cases involved women aged 18 years or less. Women were on average at their third pregnancy (±2.4). The median parity was 2 (range 1–14). Among the audited cases, women had an average of 2.2 children alive (±2.0). The average number of antenatal care (ANC) visits was 2.1 (±1.3), with 12.4% of women who had never attended ANC and 7.5% who had attended four times or more (table 2).

Table 1; health facility based MMR and proportion of maternal deaths audited

	2009	2010	2011	2012
Health facility deliveries	334 510	341 066	277 508	285 385
Maternal deaths reported through HIMS	174*	198*	248	221
Deaths audited	171	229	198	175
Percentage audited	98.3	115..7	79.8	79.2
Facility based MMR per 100 000 live births (95% CI)	52.0 (44.8 to 60.4)	67.1 (69.0 to 76.4)	89.4 (78.9 to 101.2)	77.4 (67.9 to 88.4)

*Up to 2010, maternal deaths reported through HIMS were limited to cases that had happened in maternity departments; from 2011 onwards, maternal departments were included.
HIMS, Health Information Management System; MMR, maternal mortality ratio

The cases were similar across the five calendar years (excluding missing data) with respect to age, marital status, gravida and number of children alive, but they were different with respect to parity and number of ante- natal consultations. The proportion of women who did not attend ANC decreased significantly over time (p=0.03). Over time, there was a significant decrease in missing data for all relevant maternal characteristics.

Place of death, place of delivery and onset of complications

Of all maternal deaths, 71.6% occurred at district hospitals, 7.2% at health centres and 21.1% at referral hospitals. Only 4.6% of women had delivered at home and most deliveries (57.1%) occurred at a district hospital. Of the cases who died at a health centre, 62% had also delivered at a health centre; likewise, 67.7% of cases who died at a district hospital had delivered their baby at the same place. In 44.9% of the cases, death occurred in the post-partum period with 33.9% who died during pregnancy, while 21.2% died in the intra-partum period (not shown in the tables).

Cause of death

Seventy per cent of maternal deaths were due to direct causes, with post-partum haemorrhage as the leading direct cause (22.7% of all cases; table 3). Obstructed labour was the second most important direct cause (12.3%), followed by obstetric infection (10.3%) and eclampsia (9.4%). The proportion of cases due to abortion increased significantly in the latter 2 years, from around 3% earlier on to 5.7% in 2012 and 7% in 2013 ($p<0.001$). Indirect causes accounted for 25.7% of maternal deaths, with malaria as the leading cause (7.5%), followed by non-obstetric infection, such as pneumonia and other sepsis (4.5%). While malaria as the reported main cause of death was very low in 2011, a huge increase was observed in 2013 ($p<0.001$). The proportion of unknown causes of death decreased over the 5 years, from 6.4% in 2009 to 1.4% in 2013, although this is not statistically significant.

Table 2; Characteristics of deceased women

	2009 (N=171)	2010 (N=229)	2011 (N=198)	2012 (N=175)	2013 (N=214)	Total for 5 years (N=987)	Significance (p-value)
Age, mean 29.7 years (±7.0)							
≤ 18	4.1	0.9	1.5	4.6	2.8	2.6	NS
19-34	64.9	69.9	66.7	65.7	74.3	68.6	
≥ 35	28.7	28.4	31.3	29.1	22.0	27.8	
Missing	2.3	0.9	0.5	0.6	0.9	1.0	
Marital status							
Maried	71.3	72.1	84.3	85.7	93.0	81.4	NS
Unmarried	8.2	8.3	7.1	7.4	6.1	7.4	
Missing	20.5	19.7	8.6	6.9	0.9	11.2	
Gravida, mean 3.4 (±2.4)							
G1	7.0	29.3	23.7	29.7	26.2	23.7	NS
G2-G4	12.9	31.9	42.9	36.0	44.9	34.3	
G5+	9.4	33.6	31.3	31.4	26.6	27.1	
Missing	70.8	5.2	2.0	2.9	2.3	14.9	
Parity, median: 2, (range 1-14)							
P0	5.8	15.3	8.1	9.7	7.9	9.6	0.003
P1	7.0	22.7	25.8	32.0	31.8	24.2	
P2-P4	8.8	35.8	38.4	33.1	44.4	33.0	
P5+	7.6	20.5	25.8	22.3	13.6	18.1	
Missing	70.8	5.7	2.0	2.9	2.3	15.0	
ANC visits, mean 2.1 (±1.3)							
0	24.6	12.7	9.1	3.4	12.6	12.4	0.03
1	9.9	8.3	7.1	6.9	6.5	7.7	
2-3	29.8	26.6	29.8	22.3	18.2	25.2	
4 or more	8.8	7.9	9.6	6.9	4.7	7.5	
Missing	47.2	26.9	44.5	44.4	60.6	57.9	

ANC, antenatal care; NS, not significant

Substandard care versus community factors

Factors related to provision of substandard care were identified for 61.1% of the cases, against almost one-third of the cases (30.3%) in which the main contributory factors were patient or community related; for the remaining 7.9%, the committees did not or were not able to assess the main contributory factor and in seven cases (0.7%) they did not identify any factor.

Table 3; Causes of maternal death

	2009	2010	2011	2012	2013	Total for 5 years	Significance (p value)
Direct causes	63.7	68.6	71.7	72.6	71.0	69.6	NS
Post-partum haemorrhage	15.8	20.1	25.8	27.4	24.3	22.7	NS
Obstructed labour	14.6	11.8	11.6	9.1	14.0	12.3	NS
Obstetric infection*	9.9	8.7	13.6	10.9	8.9	10.3	NS
Eclampsia	8.8	8.3	9.1	14.3	7.5	9.4	NS
Abortion	2.9	3.1	3.0	5.7	7.0	4.4	<0.001
Anaesthesia complication	3.5	4,8	2.5	1.1	2.8	3.0	NS
Amniotic embolism	1.8	5.2	1.0	0.0	2.8	2.3	0.005
Intra-partum haemorrhage	2.0	1.3	1.5	2.3	0.9	1.7	NS
Abnormal pregnancy†	2.3	2.2	0.5	1.7	1.4	1.6	NS
Ante-partum haemorrhage	0.6	2.2	3.0	0.0	0.0	1.2	0.013
Other direct causes	0.6	0.9	0.0	0.0	0.9	0.5	NS
Indirect causes	29.8	26.2	23.2	21.7	27.6	25.7	NS
Malaria	11.1	8.3	0.5	6.3	11.2	7.5	<0.001
Non-obstetric infection‡	4.7	4.4	6.6	2.3	4.2	4.5	NS
AIDS	5.3	3.9	4.5	1.1	1.9	3.3	NS
Other indirect causes	2.3	3.1	4.0	2.9	2.3	2.9	NS
Cardiac failure	1.2	3.1	3.0	2.3	1.9	2.3	NS
Anaemia	2.9	2.2	1.5	2.9	1.9	2.2	NS
Pulmonary embolism	0.6	0.9	1.0	1.7	3.3	1.5	NS
Gynaecological cancer	1.8	0.0	0.0	1.1	0.9	0.7	NS
Other cancers	0.0	0.9	1.5	0.6	0.9	0.8	NS
Unknown cause	6.4	5.2	5.1	5.7	1.4	4.7	0.135

*Obstetric infections: postoperative peritonitis, post-partum peritonitis, amnionitis.
†Abnormal pregnancy: ectopic pregnancy, molar pregnancy
‡Non-obstetric infection: pneumonia, meningitis
NS, not significant

Recommendations made by audit committees

Table 4 summarises the types of recommendations made by the respective audit committees for 902 cases, out of the total of 987 maternal deaths. For the remaining 85 deaths, the audit committees did not make any recommendation, mostly because the death could not be attributed to any factors or the cause of death was not established.

Table 4; Recommendations made by maternal death audit committees

Management of obstetric complications	*Population sensitization on*
➢ Reinforce postoperative follow-up	➢ Consulting health facility on time
➢ Close monitoring after anaesthesia injection	➢ Complying with medical advice and treatment
➢ Reinforce post-partum follow-up	➢ Use of mosquito net by pregnant women
➢ Reinforce the use of partograph	➢ Delivering at a health facility
➢ Reinforce hygienic measures in the post-operative period	➢ Improving hygiene especially in the post-partum period
➢ Reinforce follow-up for patient admitted for obstetrical pathology	➢ Not relying on traditional medicine
➢ Reinforce quality of ANC	➢ Preparing for delivery and bying their medical insurance
➢ Adhere to protocols	
➢ Close follow-up in case of blood transfusion	
➢ Reinforce HIV patient follow-up by including home visit	
➢ Reinforce preoperative preparation	
Availability of medicines and infrastructure	*Human resources*
➢ Ensure the availability of blood, especially Rhesus negative	➢ Training on emergency obstetric and neonatal care, especially on surgery
➢ Avail emergency kits, laboratory tests	➢ Increase number of health providers
➢ Avail resuscitation materials and anaesthesia equipment	➢ Hire an anaesthesia technician
➢ Avail intravenous antihypertensive treatment	➢ Training on resuscitation procedures
➢ Refer patient in a critical condition to the ICU	
Referral system	*Communication*
➢ Refer patient with complications on time to a higher level	➢ Reinforce communication among staff and between departments within the hospital
➢ Provide adequate pretransfer treatment	➢ Reinforce communication between health facilities
➢ Avail more ambulances	➢ Reinforce communication between health providers and patients

ANC, antenatal care; ICU, intensive care unit

DISCUSSION

This is the first study that reports the results of a national health facility-based review of maternal deaths in a low- income country for such a long period (5 years). In resource-constrained environments, MDA may be done in certain types of health facilities only, in some regions only and not for an extended period of time[6-18]. Our study provides an analysis of nearly 1000 women who died during pregnancy, childbirth or in the post-partum period, and of the reported causes of death, the factors surrounding their death and the recommendations made by the respective audit committees to avoid similar deaths in the future. This nationwide initiative to conduct clinical audits of all cases of maternal death that occur in health facilities is a demonstration of strong political will to improve maternal and newborn health. As has been shown elsewhere, political will is of prime importance to bring about change[19-20]. MDA as a nationwide strategy in Rwanda is part of a much broader package of interventions aimed at improving maternal and child health indicators and strengthening the national health system as a whole. These include national-level support to a dense network of community health workers, community-based health insurance, the use of Information and Communication Technology (ICT) and mobile telephones for performance monitoring and performance- based financing, among others[21-23].

The 5 years average health facility-based MMR (64.4 per 100 000) found in this study is much lower than the ratio reported in the 2010 Rwanda Demographic and Health Survey (DHS; 476 per 100000)[24] and other estimates[2,25]. This could be due to the under-reporting of maternal deaths through HIMS, especially before 2011, when only deaths that occurred in maternity departments were reported. This also explains why there were more audited maternal deaths in 2010 than cases of maternal mortality reported through HIMS (table 1). In addition, there may be other maternal deaths that happened in the community and these are neither captured in the HIMS nor by audits. One could assume that the direct and indirect causes of death, and the role of community versus service factors, among cases that do not get notified are different from the picture that emerges from the MDA. Under reporting of maternal morbidity and mortality is a very common phenomenon, even in specialised healthcare facilities in Europe, where sometimes over half of the deaths are missed[26-27].
Even though the national health policy in Rwanda recommends that all cases of maternal death be reviewed, this does not always happen. However, the pro- portion of maternal deaths actually audited was high compared with that in other low-income countries, where facility-based maternal death review is usually introduced in some parts of the country only (eg, in Senegal, Ethiopia, Nigeria)[8-10].

The percentage of unknown causes decreased, which suggests an improvement in the quality of the internal audits. Characteristics of deceased women were similar to those found in maternal death reviews conducted in other countries[11-15]. Only 2.7% of deceased women were aged 18 years or below, unlike in other countries, where teenagers formed a much larger proportion of maternal deaths[9,10,16]. This may be due to the relatively low rate of teenage pregnancies in Rwanda (6% of all pregnancies)[4]. In many low-income countries, low ante-natal clinic attendance is considered a risk factor for maternal death and this also holds for

Rwanda[10,11,17]. According to the 2010 DHS, 98% of women visited antenatal clinics at least once, while only 35% attended at least four times (the minimum recommended number), which is high compared with the population study[4]. Having the first antenatal consultation during the first trimester of pregnancy with regular follow-up visits allows for early detection of risk factors for eclampsia and other conditions that are dangerous for mother and child, such as HIV and malaria, and there- fore it can contribute to maternal mortality reduction[16]. The fact that only 4.6% of the women who died delivered at home does not warrant any conclusions about home deliveries as a risk factor. The figure is in line with HIMS data (<10% of home deliveries in 2013)[28], although it is much lower than the latest DHS estimate (31% home deliveries in 2010)[4]. We may expect a much lower proportion of home deliveries in the next DHS in 2015.

Direct obstetric causes were found to be the under- lying cause in the majority of cases of maternal death reviewed during the 5-year period; this finding is in line with studies in other low-income and middle-income countries[7,12,13,15]. Some European countries experienced similar situations; for instance France, where direct causes accounted for 66.2% of all maternal deaths[29]. Indirect causes accounted for about a quarter of all maternal deaths, with malaria as the leading cause in that category, followed by non-obstetric infection such as pneumonia and other sepsis. In some African countries[30-31], especially in Southern Africa, HIV-related infection is the predominant indirect cause and also indirect causes were the major causes in many developed countries[25,32]. The present study identified post- partum haemorrhage as the leading cause of maternal death and this is similar to the case in many other African countries[15,33]. In other studies, haemorrhage is reported as a cause of death without specifying the time of its occurrence (before, during or after delivery)[11,13]. In other settings, hypertensive disorders were the leading cause[12,16]. In our case, obstructed labour was the second most important cause of death. However, Rwanda has a caesarean section rate of 14%[28], which is on the higher end of the WHO recommended range of 5–15%. This calls for further investigation[34-36].

The proportion of cases due to complications around abortion increased significantly since 2011. The latter two causes need further research to analyse the underlying reasons. The government of Rwanda has recently started to decentralise post abortion care services at health centres and our findings underscore the importance of doing so. The fluctuation in maternal deaths due to malaria can be attributed to the general variation in morbidity due to malaria in the whole population. Malaria was the third most frequent cause of death in 2013 (7.2%) among the general population and also the third most important cause of morbidity among outpatients at health facilities (10.6%)[28]. The significant decrease in the proportion of unknown causes of death over the 5 year period suggests that the audit committees gradually gained more confidence in establishing and reporting the cause of death. Some of the changes observed over time, however, may not reflect real trends because of inadequate diagnostic capacity, under- reporting of induced abortion as a cause of death, or increased awareness of a particular condition following training and/or closer monitoring.

The committees identified various aspects of substandard care as contributing to the majority

of deaths, many of which are avoidable (see online supplementary figure S2). This is in line with findings from other studies from both high-income and low-income countries[7,15,29,30,32,37,38]. However, there is room to improve the template used in Rwanda to audit and report maternal deaths; in particular, the precise inadequacies in obstetric case management would need to be spelt out in greater detail, which could help the audit teams to come up with remedial actions that are more concrete. Implementation of the recommendations highlighted in table 4 should be prioritised in order to further improve the quality of maternal and obstetric services.

CONCLUSIONS

MDA can be implemented routinely and nationwide even in low-income countries as shown by the high coverage of maternal deaths audited in Rwanda. Implementation of audit recommendations is likely to have contributed to the reduction of maternal deaths in the past few years. There do not seem to be major barriers among clinicians and other health workers to conduct audits and investigate the possible role of systemic or incidental flaws in service delivery. The audits have helped to classify the causes of maternal deaths and identify factors surrounding them, and to make recommendation for changes in professional care and behaviour in the community. The standard forms that are used for such audits should be reviewed in order to capture important information that is currently missing, such as the gestational age, whether or not the woman was referred as well as the initial diagnosis and classifica- tion of the causes of death according to the ICD-10. There is scope for inclusion of information from verbal autopsy in order to complete the facility-based approach by assessing community factors contributing to maternal death. A national maternal death surveillance committee would need to be put in place so as to regularly inform policymakers. Since maternal death can be seen as the tip of an iceberg of wider problems in maternal and obstetric care, near-miss audits could be considered so as to better understand the processes leading to poor maternal outcomes. The experience gained from facility- based approaches provides a good opportunity to intro- duce both confidential enquiry and near-miss audit as complementary methods to address maternal morbidity and mortality.

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CHAPTER 5

Severe maternal outcomes and quality of care at district hospitals in Rwanda– a multicentre prospective case-control study

Published as:

Sayinzoga F., Bijlmakers L., van der Velden K., and van Dillen J.
Severe maternal outcomes and quality of care at district hospitals in Rwanda– a multicentre prospective case-control study.
BMC Pregnancy and Childbirth (2017) 17:394

Abstract

Background: Despite a significant decrease in maternal mortality in the last decade, Rwanda needs further progress in order to achieve Sustainable Development Goals (SDG)3 which addresses among others maternal mortality. Analysis of severe maternal outcomes (SMO) was performed to identify their characteristics, causes and contributory factors, using standard indicators for quality of care.

Methods: A prospective case-control study was conducted for which data were collected between November 2015 and April 2016 in four rural district hospitals. The occurrence of SMO with near miss incidence ratios was established, followed by an analysis of the characteristics, clinical outcomes, causes and contributory factors.

Results: The SMO incidence ratio was 38.4 per 1000 live births (95% CI 33.4–43.4) and the maternal near-miss incidence ratio was 36 per 1000 live births (95% CI 31.1–40.9). The leading causes of SMO were postpartum haemorrhage (23.4%), uterine rupture (22.9%), abortion related complications (16.8%), malaria (13.6%) and hypertensive disorders (8.9%). The case fatality rate was high for women with hypertensive disorders (10.5%; CI 3.3–24.3) and severe postpartum haemorrhage (8%; CI 0.5–15.5). Stillbirth (OR = 181.7; CI 43.5–757.9) and length of stay at the hospital (OR = 7.9; CI 4.5–13.8) were strongly associated with severe outcomes.

Conclusions: Despite the use of life saving interventions, SMO are frequent. Mortality index was found to be low at the level of district hospitals. SMO were associated with long stay at the hospital and stillbirth. There is a need for improvement of quality of care, referral practices and certain types of infrastructure, especially blood banks, which would ensure truly comprehensive emergency obstetric care and reduce the occurrence of SMO.

Keywords: Severe maternal outcome, Maternal near miss, Obstetrics, Quality of care

Background

Globally, the Maternal Mortality Ratio (MMR) has fallen by nearly 44% over the past 25 years, to an estimated 216 maternal deaths per 100,000 live births in 2015. Despite this global decline, the magnitude of the reduction differed substantially between regions, with low and middle- income countries accounting for approximately 99% of global maternal deaths and sub-Saharan Africa alone accounting for roughly 66% [1]. Rwanda is one of only four countries that have achieved the Millennium Development Goals 4 and 5 (MDGs 4 and 5) [2].

According to the Rwanda Demographic Health Survey (RDHS) 2014–2015, the MMR decreased from 1071 in 2000 to 210 in 2015, while the percentage of institutional deliveries increased from 27% to 91% over the same period [3, 4]. However, a fast increase of deliveries in health facilities may compromise the quality of care that mothers receive, especially in primary care facilities [5].

The Sustainable Development Goals (SDGs) now call for an acceleration of progress in order to achieve a global MMR of 70 maternal deaths per 100,000 live births or less by 2030 [1]. Rwanda has demonstrated a strong political will to improve maternal and newborn health. One of the measures taken to achieve this was the introduction in 2009 of maternal death audits (MDA) on a routine basis nationwide [6]. However, since maternal mortality reveals only the tip of the iceberg, several countries have initiated maternal near-miss audits [7]. Rwanda might be able to further improve its performance by reviewing the circumstances that led to maternal near miss events where the women survived. By evaluating such cases much can be learnt about the processes in place and systemic deficiencies that cause failure to deal with maternal morbidities. For this purpose WHO recommends the near-miss approach for maternal health [8].

Few studies have been done on maternal near miss in Rwanda. They were conducted in tertiary hospitals situated in Kigali [9–11], or in provincial referral hospitals that are better equipped than district hospitals in terms of infrastructure (e.g. intensive care units, ICU) and human resources [12]. District hospitals in Rwanda normally handle only cases that are referred by health centres, because of high-risk pregnancy or the occurrence of complications. Approximately 80% of all deliveries occur at the level of health centres [13]. Due to this risk selection system, near-miss data from tertiary or provincial hospitals do not reflect common practice at lower level health facilities. In addition, most studies on maternal near-miss are descriptive, based on case series. We conducted a multicentre, case-control study of severe maternal outcome (SMO) and women without SMO at district hospital level. Apart from the health outcomes, we also assessed process indicators, using standard indicators for quality of care.

Methods

Study design

This was a prospective case-control study, for which data were collected between November 2015 and April 2016 in four rural district hospitals. The four districts were purposively selected based on their performance on a selected set of key maternal and child health indicators from the national Health Management Information System (HMIS) in 2013: two of them were good performers (Bugesera and Rwamagana districts) and two performed poorly (Nyagatare and Gicumbi) regarding maternal health. The four district hospitals serve a total population of more than 1.5 million people (approximately 10% of the country's total population) and in total they have 76 rural health centers in their catchment areas.

Definition

A woman with a severe maternal outcome (SMO) could be either a maternal near-miss case or a woman who actually died [8].

Maternal near-miss (MNM) is defined as 'a woman who nearly died, but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy.' [7]

Sampling

All cases fulfilling the criteria of severe maternal out- come during the study period were included in the study. The WHO criteria adapted in the Haydom study in Tanzania were applied [14, 15]. Cases were identified by health providers who were on duty at the time of admission or who noticed a deterioration in the woman's condition during her stay at the hospital. Controls were selected from in-patient women who had given birth or were admitted for pregnancy complications and who did not have a severe maternal outcome within 48 h of the occurrence of the case. At least one of the following characteristics similar to the case was used to select the control: age, parity, gestational age and mode of delivery. The number of near-miss cases required was estimated using the sampsi_mcc function in Stata for sample size calculation [16]. The parameters for the calculation were: power of 80% at 5% statistical significance level and odds ratio of 2. The minimum sample size required was 120 near-miss cases and two controls per case, giving a total of 240 controls.

Data collection

Relevant data for cases and controls were extracted from patient medical files (personal characteristics, clinical in- formation) and entered into a template developed from the WHO near-miss approach for maternal health guide [7]. Missing information, if any, was obtained mostly from the health centre that had referred the case; especially information about the patient's arrival time at the clinic, at what time the ambulance was called and when it actually arrived, and the medical status of the mother and the fetus/infant prior to referral. Additionally, data were collected on maternal and neonatal outcomes and on particular interventions that had been undertaken to prevent and/or manage complications (for example use of oxytocin for the prevention and treatment of postpartum haemorrhage among cases and controls who gave birth at hospital; use of magnesium sulfate for treatment of eclampsia; use

of antibiotics for prophylaxis and treatment of sepsis). The inclusion criteria were displayed in the maternity departments of the four hospitals as a reminder to health staff who were required to identify cases and controls. Data collection forms were made available at the place where patient registers were kept, in order to facilitate completion by health staff who had identified patients with SMO.

The head of the maternity served as the focal point for the study and was trained along with several other staff from each hospital. He/she was also responsible for collecting any missing information from the health centre that had referred the patient.

Every 4 weeks, the principal investigator (FS) visited the hospitals for verification of the completed forms with the maternity team: this involved checks on the correct application of inclusion/exclusion criteria and checks for completeness and consistency of data. The forms were reviewed case by case with the respective hospital teams.

Data analysis

Data were entered into an Excel template and then reviewed for inconsistencies. Statistical analysis was performed using SPSS Statistics, version 23 (SPSS Inc. Chicago, Illinois). Univariate analysis was carried out to characterize the SMO cases and controls in terms of demographic and clinical variables and the underlying causes. Statistical differences between SMO cases and controls were compared using chi- square test. Outcome indicators were calculated as proposed by WHO [8], using the total number of live births during the study period and the total number of maternal near- miss and maternal death in the same period. All descriptive data, including the identified underlying causes, are reported both as absolute numbers (n) and frequencies (%).

As for process indicators, the principal researcher in collaboration with the local maternity team identified the target population for each of the specific interventions of interest, on the basis of which the proportion of the target population that actually received the recommended intervention was calculated. High proportions of women receiving appropriate interventions indicate better quality of care. Crude (cOR) and adjusted (aOR) odds ratios (including 95% confidence intervals) were calculated for predictive factors using logistic regression. Only factors that were statistically significant in univariate analysis were considered for logistic regression. Associated factors were also examined for statistical significance, using chi-square tests and bivariate logistic regression. The dependent variable was severe maternal outcome and the independent factors were the status of the infant at birth and the duration of admission.

Results

Characteristics of women with SMO and controls

During the 5 months data collection period, 5577 live births were recorded in the four district hospitals. Out of these, 214 cases of severe maternal outcomes were identified, of which 201 maternal near-miss cases and 13 maternal deaths. A total of 428 controls were selected and included in the study. In total the study population comprised 642 women.

The comparison of SMO cases and controls shows statistically significant differences in age, marital status and profession (Table 1). Seven-and-a-half percent of the cases were younger than 20 years (3.5% among controls) and 28.4% older than 35 years (12.6% among controls).

Unmarried and unemployed women are seen more among the cases than in the control group (15.0% versus 5.6%, and 4.2% versus 0.2%, respectively). The two groups differ significantly with respect to some clinical characteristics of pregnancy, such as parity, gravidity, number of antenatal consultation (ANC) and gestational age. The proportion of SMO was high among women who did not attend any ANC (27.4%), and in women with gestational age less than 36 weeks (21.7% for <24 weeks and 18.5% for 24–36 weeks). The proportion of stillbirths among the cases was very high (46.1% versus 0.5% in the control group). Similarly, cases were ad- mitted for a longer period (70% for 4 days or more) than controls (31.7%; figures not shown in the table). There were no statistically significant differences between the two groups regarding educational level, medical insurance status, previous abortion, previous caesarean section and mode of delivery.

Outcome indicators

The severe maternal outcome incidence ratio was 38.4 per 1000 live births (95% CI 33.4–43.4) and the maternal near-miss incidence ratio was 36.0 per 1000 live births (95% CI 31.1–40.9) (Table 2). For every maternal death there were 15.5 near-miss cases. The hospital-based MMR was 233 per 100,000 live births (95% CI 110–360), with a mortality index (MI) of 6.1% (95% CI 2.9–9.3).

Of the 214 SMO cases (near-miss and maternal deaths combined), 188 (87.9%; CI 83.5–92.3) presented the life- threatening condition on arrival or within the first 12 h of hospital admission; 94.1% (CI 90.7–97.5) of these cases were referred from health centers. Death within 12 h occurred in 9 women (4.8%; 95% CI 1.7–7.9;) of 188 women who were ill on arrival or within 12 h. Twenty-six women developed life-threatening conditions in the hospital after 12 h of admission and four of them (15.4%; 95% CI 1.5–29.3) died. Almost all patients (97.8%) were referred from a health center: only 2.2% of women came straight to the district hospital.

Table 1; Socio-demographic and clinical characteristics of the SMO cases and controls

	Cases (%)	Controls (%)	Total	Chi-square	*P*-value
Age					
<20	16 (7.5)	15 (3.5)	31 (4.8)	22.02	0.000
20-35	145 (67.8)	359 (83.9)	504 (78.5)		
>35	53 (28.4)	54 (12.6)	107 (16.7)		
Marital status[a] (*N*=630)					
Married	182 (85.0)	402 (94.4)	584 (91.3)	15.49	0.000
Unmarried	32 (15.0)	24 (5.6)	56 (8.8)		
Profession[a] (*N*=641)					
Farmer	200 (93.5)	423 (99.1)	623 (97.2)	17.92	0.000
Other profession	5 (2.3)	3 (0.7)	8 (1.2)		
Unemployed	9 (4.2)	1 (0.2)	10 (1.6)		
Education level[a] (*N*=637)					
Never been to school	15 (7.1)	21 (4.9)	36 (5.7)	7.36	0.25
Primary education	174 (82.5)	327 (76.8)	501 (78.6)		
Secondary school and higher	22 (10.4)	78 (18.3)	100 (15.7)		
Medical Insurance					
No	13 (6.1)	38 (8.9)	51 (7.9)	1.53	0.216
Yes	201 (93.9)	390 (91.1)	591 (92.1)		
Clinical characteristics					
Parity					
0	60 (28.0)	179 (41.8)	239 (37.2)	15.18	0.002
1	41 (19.2)	78 (18.2)	119 (18.5)		
2 to 4	84 (39.3)	140 (32.7)	224 (34.9)		
≥5	29 (13.6)	31 (7.2)	60 (9.3)		
Gravidity					
1	65 (30.4)	181 (42.3)	246 (38.3)	13.25	0.001
2 to 4	105 (49.1)	197 (46.0)	302 (47.0)		
≥5	44 (20.6)	50 (11.7)	94 (14.6)		
Previous C/S					
No	152 (71.0)	325 (75.9)	477 (74.3)	1.80	0.18
Yes	62 (29.0)	103 (24.1)	165 (25.7)		
Previous abortion					
No	204 (95.3)	401 (93.7)	605 (94.2)	0.70	0.402
Yes	10 (4.7)	27 (6.3)	37 (5.8)		

Table 1 continued

	Cases (%)	Controls (%)	Total	Chi-square	P-value
ANC[a] (*N*=626)					
0	55 (27.4)	44 (10.4)	99 (15.8)	31.91	0.000
1	27 (13.4)	50 (11.8)	77 (12.3)		
2 to 3	95 (47.3)	263 (61.9)	358 (57.2)		
≥4	24 (11.9)	68 (16)	92 (14.7)		
Gestational age[a] (*N*=594)					
<24 weeks	40 (21.7)	1 (0.2)	41 (6.9)	179.67	0.000
24-36 weeks	34 (18.4)	1 (0.2)	35 (5.9)		
≥37 weeks	(110 (59.8)	408 (99.5)	518 (87.2)		
Outcomes					
Baby's condition at birth[a] (*N* = 568)					
Alive (501)	76 (53.9)	425 (99.5)	501 (88.2)	212.13	0.000
Still birth (67)	65 (46.1)	2 (0.5)	67 (11.8)		
Mode of delivery[a] (*N* = 532)					
Vaginal delivery (*n* = 274)	44 (45.8)	230 (53.9)	274 (52.4)	2.03	0.155
Caesarean section (*n* = 249)	52 (54.2)	197 (46.1)	249 (47.6)		
Length of hospital stay[a] (N = 641)					
0 to 1 day	17 (8)	140 (32.7)	157 (24.5)	104.97	0.000
2 to 3 days	47 (22.1)	152 (35.5)	199 (31.0)		
4 to 7 days	126 (59.2)	132 (30.8)	258 (40.2)		
More than 7 days	23 (10.8)	4 (0.9)	27 (4.2)		

[a] Missing information for some cases

Table 2; Maternal outcome indicators in four district hospitals in Rwanda

Live births[a]	5577
Severe maternal outcome indicators	
Women with maternal near-miss (MNM)[b]	201
Maternal death (MD)[c]	13
Women with severe maternal outcomes (SMO)[d]	214
Overall near-miss indicators	
Severe maternal outcome ratio (SMOR) per 1000 live births[e]	38.4 (33.4–43.4)
Maternal near-miss incidence ratio per 1000 live births[f]	36.0 (31.1–40.9)
Maternal near-miss mortality ratio[g]	15.5
Maternal mortality ratio per 100,000 live births[h]	233 (110–360)
Mortality index (%)[i]	6.1 (2.9–9.3)
Hospital access indicators	
Women with SMO at arrival or within 12 h of hospital arrival[k]	188
Proportion of SMO at arrival or within 12 h of hospital arrival (%)[l]	87.9 (83.5–92.3)
Women with SMO at arrival or within 12 h of hospital arrival and referred from HC[m]	177
Proportion of SMO at arrival or within 12 h of hospital arrival referred from HC (%)[n]	94.1 (90.7–97.5)
SMO at arrival or within 12 h of hospital arrival who died[o]	9
SMO at arrival or within 12 h of hospital arrival mortality index (%)[p]	4.8 (1.7–7.9)
Intra hospital care indicators	
Women who developed SMO more than 12 h after hospital arrival (intra hospital SMO)[q]	26
Intra hospital SMO rate (per 1000 live births)[r]	4.7 (2.9–6.5)
Women with SMO developed after 12 h of hospital arrival who died[s]	4
Intra hospital mortality index (%)[t]	15.4 (1.5–29.3)

[a]Live birth (LB): the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life. Each product of such a birth is considered live born
[b]Number of women with maternal near-miss
[c]Number of maternal death
[d]Women with severe maternal outcome (SMO) the sum of maternal near-miss and maternal deaths. d = (b + c)
[e]Severe maternal outcome ratio (SMOR): the number of women with life threatening conditions per 1000 live births. e = (d/a)*1000LB
[f]MNM incidence ratio: the number of maternal near-miss cases per 1000 live births. [MNM IR = MNM/LB]. f = (b/a)*1000LB

[g]Maternal near-miss mortality ratio: the proportion between maternal near-miss cases and maternal deaths. g = (b/c)
[h]Maternal mortality ratio per 100,000 live births
[i]Case fatality rate: the number of maternal deaths divided by the number of women with SMO, expressed as a percentage. i = (c/d)*100
[k]Number of women with SMO at arrival or within 12 h of hospital arrival
[l]Proportion SMO at arrival or within 12 h among all SMO: the number of SMO who are ill on arrival or within 12 h divided by the total number of SMO. l = (k/d)*100
[m]Number of women with SMO at arrival or within 12 h of hospital arrival and referred from HC
[n]Proportion of SMO at arrival or within 12 h coming from other health facilities: the number of SMO who are ill on arrival or within 12 h and coming from a health center divided by the total number of SMO at arrival or within 12 h. n = (m/k)*100
[o]Number of SMO at arrival or within 12 h of hospital arrival who died
[p]SMO at arrival or within 12 h mortality index: the maternal deaths within 12 h after arrival divided by the number of women with SMO who were ill on arrival or within 12 h, expressed as percentage. p = (o/k)*100
[q]Number of Women who developed SMO more than 12 h after hospital arrival (intra hospital SMO)
[r] Intra hospital SMO rate (per 1000 live births): the number of women with SMO who developed these life-threatening conditions after 12 h in the hospital per 1000 live births. r = (q/a)*1000LB
[s]Number of women who developed SMO more than 12 h after hospital arrival
[t]Intra hospital mortality index: the number of maternal deaths who were not ill on arrival or within 12 h, divided by the number of women with SMO who were not ill on arrival or within 12 h, expressed as a percentage. t = (s/q)*100

Predictive and associated factors

In multivariate logistic regression analysis (Table 3), only marital status (unmarried; aOR = 3.53; CI 1.43–8.71) and gestational age (<24 weeks: aOR = 190.15; CI 22.62– 1598.87; and 24–36 weeks: aOR = 167.48; CI 21.94– 1278.32) remained as predictive factors for SMO. Stillbirth (OR = 181.74; CI 43.47–757.99) and length of stay at the hospital (OR = 7.86; CI 4.49–13.76) were strongly associated with severe outcomes.

Underlying causes for SMO and associated case fatality rates The leading direct causes of several maternal outcomes, as shown in Table 4, are postpartum haemorrhage (accounting for 23.4% of all underlying causes), followed by uterine rupture (22.9%), abortion related complications (16.8%), and hypertensive disorders (8.9%). Malaria (laboratory con- firmed) was the leading cause for indirect obstetric causes, accounting for 13.6% of all underlying causes. The CFR was high for women with hypertensive disorders (10.5%; CI 3.3–24.3), followed by severe postpartum haemorrhage (8.0%; CI 0.5–15.5) and malaria (6.9%; CI 2.3–16.1). During the study period, only one hospital (Rwamagana) had its own blood bank. Among the 49 cases with uterine rupture, 32 (65.3%) had a previous caesarean section and for 6 cases (12.2%) hysterectomy was performed.

Previous caesarean sections and anaemia were the two predominant contributory factors, accounting for 26.9% and 26.6%, respectively. In 42.1% of SMO cases any contributory factor was identified (not shown in the table).

Table 3; Multivariate analysis of the predictive factors for SMO

	crude OR (95%CI)	adjusted OR (95%CI)
Age (*N* = 642)		
< 20	**2.45 (1.18–5.1)**	1.20 (0.37–3.86)
20–35	1	1
> 35	**1.47 (0.99–2.15)**	1.63 (0.99–2.68)
Marital status (*N* = 640)		
Married	1	1
Unmarried	**2.95 (1.69–5.14)**	**3.53 (1.43–8.71)**
Profession (N = 641)		
Farmer	1	1
Other profession	**3.52 (0.83–14.89)**	4.33 (0.69–27.37)
Unimployed	**19.04 (2.39–151.28)**	0.68 (0.01–47.62)
ANC (N = 626)		
0	**3.54 (1.92–6.53)**	0.51 (0.21–1.21)
1	**1.53 (0.79–2.96)**	0.48 (0.19–1.13)
2 to 3	**1.02 (0.61–1.72)**	0.68 (0.39–1.20)
≥ 4	1	1
Gestational age (N = 594)		
< 24 weeks	**148.36 (20.17–1091.30)**	**190.15 (22.62–1598.87)**
24–36 weeks	**126.11 (17.07–931.54)**	**167.48 (21.94–1278.32)**
≥ 37 weeks	1	1

cOR and aOR in bold are statistically significant

Health providers used oxytocin as part of active management of third stage of labor in 94.9% of SMO cases and controls combined (Table 5). Among those who were diagnosed with severe PPH (58 cases and controls), about two-thirds (65.5%) received oxytocin only, while among the other third, three women received ergometrine and/or misoprostol in addition to oxytocin; in seven cases removal of retained placenta was performed in combination with oxytocin; six cases underwent hysterectomy (10.3%).

All severe (pre-) eclampsia cases received an anticonvulsant at the hospital, mostly magnesium sulphate (94.7%). Antibiotics were used for all women with an infection (15 cases) and almost all women who underwent a caesarean section or laparotomy received prophylactic antibiotics (98.6%). In total, 171 (80%) women of all SMO cases required blood transfusion; laparotomy was performed in 51 cases (23.8%).

Table 4; Underlying causes of severe maternal outcomes (near-miss and maternal deaths) and their associated CFR

Direct causes	MNM ($n = 201$)	MD ($n = 13$)	Total	CFR
Severe postpartum haemorrhage	46 (22.9%)	4 (30.8%)	50 (23.4%)	8.0% (0.5–15.5)
Ruptured uterus	46 (22.9%)	3 (23.1%)	49 (22.9%)	6.1% (0.6–12.8)
Severe complications of abortion	35 (17.4%)	1 (7.7%)	36 (16.8%)	2.9% (2.6–8.4)
Hypertensive disorders	17 (8.5%)	2 (15.4%)	19 (8.9%)	10.5% (3.3–24.3)
Puerperal sepsis	15 (7.5%)	0	15 (7%)	0
Abnormal/ectopic pregnancy	3 (1.5%)	0	3 (1.4%)	0
Severe intrapartum haemorrhage	1 (0.5%)	1 (7.7%)	2 (0.9%)	50%
Antepartum haemorrhage	1 (0.5%)	0	1 (0.5%)	0
Indirect causes				
Malaria (laboratory confirmed)	27 (13.4%)	2 (15.4%)	29 (13.6%)	6.9% (2.3–16.1)
Unknown causes of anaemia requiring blood transfusion	10 (5.0%)	0	10 (4.7)	0

Discussion

This is the first prospective multicentre case control study combining maternal death and maternal near miss in Rwandan district hospitals, where geographic access to emergency obstetric care is more of an issue than in Kigali capital city [9, 10]. Based on an analysis of SMO that occurred in four district hospitals, this study assessed the quality of care provided, using the WHO criteria adapted to the local context [14, 15].

The hospital based maternal mortality ratio was 233 (CI 110–360) per 100,000 live births. SMO and near-miss case ratios were relatively high at 38.4 (CI 33.4–43.4) and 36.0 (CI 31.1–40.9) per 1000 live births, respectively. Our study found a low mortality index (6.10) and a high maternal near-miss mortality ratio (15.5). Oxytocin was used for PPH prevention at 96.5% of all evaluated cases; magnesium sulphate as anticonvulsants in case of severe pre-eclampsia or eclampsia at 94.7%; and almost in all cases antibiotics were used in prophylaxis of sepsis in the event of a caesarean section or laparotomy, and in treatment of puerperal sepsis. Severe postpartum haemorrhage (23.4%), uterine rupture (22.9%), severe complications of abortion (16.8%), malaria (13.6%) and hypertensive disorders (8.9%) were the predominant causes of SMO. Case fatality for hypertensive disorders (eclampsia/pre eclampsia) was high in our settings at 10.5%. Being unmarried and developing a complication while gestational age was less than 36 weeks were identified as predictors for developing SMO and cases were associated with long stay at the hospital and stillbirth.

Table 5; Adherence to clinical standards for management of obstetric complications

Use of uterotonics for Prevention of postpartum haemorrhage	
Target population women giving birth at DH	$N_1 = 511$[a]
Oxytocin	485 (94.9%)
Misoprostol	7 (1.4%)
All uterotonics	492 (96.3%)
Treatment of PPH	
Target population women severe PPH	$N_2 = 58$
Oxytocin	38 (65.5%)
Oxytocin/Removal of retained placenta	7 (12.1%)
Oxytocin/Misoprostol	3 (5.2%)
Misoprostol	1 (1.7%)
Hysterectomy	6 (10.3%)
Use of anticonvulsants	
Target population women with severe (pre-) eclampsia	$N_3 = 19$
Magnesium sulfate	18 (94.7%)
Diazepam	1 (5.3%)
Prevention of caesarean section /laparotomy related infection	
Target population undergoing Caesarean section/laparotomy	$N_4 = 300$[b]
Prophylactic antibiotics	456 (98.6%)
Treatment of sepsis	
Target population women with sepsis	$N_5 = 15$
Parenteral therapeutic antibiotics	15 (100%)

[a]511 cases among SMO and controls gave birth at district hospital
[b]249 cases of caesarean sections (Table 1) plus 51 cases of laparotomy

We found a hospital based maternal mortality ratio which corresponds with the 2015 DHS findings [4] and estimates in a recent UN report [1] which were 210 and 290 per 100,000 live births respectively. However, severe maternal outcome and near-miss case ratios were much higher than those found in a hospital-based study con- ducted in one of the tertiary hospitals in Kigali and in Musanze district hospital, which reported, SMO ratios of 11.0 and 24.8, and MNM ratios of 8 and 21.5 per 000 live births, respectively [9, 12]. The near miss prevalence of our present study falls within the range of findings reported in the two systematic reviews of near- miss studies, one for Sub-Saharan Africa and the other for Africa as a whole, which

found prevalence rates ranging from 1.1% to 10.1% and from 0.05 to 15.0%, respectively [17, 18]. Both ratios were high, though, compared to the WHO multi-country survey on maternal and newborn health, which found SMO and MNM ratios of 6.2 and 8.6 per 1000 live births respectively for high MMR countries, and 13.1 and 15.9 per 1000 live births for very high MMR countries, with overall rates of 8.3 and 9.9 per 1000 live births, respectively [19]. The high ratios in our study may be explained by the fact that almost all women who deliver at district hospitals in Rwanda are referred, either because of high-risk pregnancy or complications that have occurred. However, they indicate a third phase delay [20]: either in making a diagnosis or deciding to refer the patient; or delays in the referral process at health centre level.

Also, the threshold of blood transfusion (≥1 unit) used in our study, as per Haydom criteria, is much lower compared to the WHO criteria for near-miss (≥5 units), which may further explain the high ratios [15].

The combination of a low mortality index found in our study compared to other studies [17, 19] and high maternal near-miss mortality ratios compared to other settings [9, 12, 21–26], could be attributed, at least in part, by the frequent use of lifesaving interventions observed in our study. A high coverage of those interventions alone does not avoid the occurrence of SMO as shown in our study. Different studies have highlighted that high coverage of essential interventions is not sufficient to reduce maternal morbidity and mortality; they suggest that universal cover- age of life-saving interventions needs to be matched with comprehensive emergency care and overall improvements in the quality of maternal health care [19, 27, 28]. Case fatality for hypertensive disorders in pregnancy and/or labour was also high in other studies, illustrating that better treatment of hypertension and starting induction of labour as soon as possible is needed to improve health outcomes [15, 21, 24, 29].

Except for marital status, other studies also identified age, educational level, parity, booking for ANC and gestational age as predictive factors for SMO [11, 22, 30, 31]; and stillbirth, long duration of admission, caesarean section, assisted vaginal delivery, birth asphyxia and low birth weight as associated factors [17, 32, 33].

While we used the four predictive characteristics identified in other studies as criteria for matching, we were unable to apply them simultaneously [11, 22, 30, 31]. This was due to the time limitation for the selection of the controls (maximum 48 h). Therefore, we selected controls that were similar to the cases for at least one of the four matching criteria; this is a limitation of the study. Although we did analyse the coverage of life saving interventions, we were not able to assess whether the interventions were implemented appropriately. Also, we used only SMO cases to determine the relatively CFRs, instead of all cases with particular obstetrical complications and this could explain the high rate found in our study as not all cases fitted the SMO criteria.

Conclusions

Severe maternal outcomes are frequent. The high ratios of SMO and coverage of life saving interventions call for improvements in the quality of case management and follow up of pregnant women in order to reduce maternal morbidity and mortality. PPH, eclampsia and ruptured uterus are conditions that need particular attention as these are major causes of SMO and their case fatality rates are high.

Unmarried women and women with gestational age below 36 weeks are more likely to develop an SMO and this is associated with a longer stay at the hospital and with stillbirth. Surveillance of near miss events would be a useful addition to maternal death audits. Ideally, the two instruments should be integrated into routine monitoring and surveillance, not necessarily with the intention to examine all near-miss events, but focused on maternal conditions that are known to have the highest CFR, especially PPH, eclampsia and ruptured uterus. Increasing the coverage of life-saving interventions – such as using oxytocin in the management of third stage of labour, which is currently a policy in many countries and which is also recommended by WHO – is appropriate but insufficient. There is a need for improvement of quality of care at the level of district hospitals, through improved referral practices and certain types of infrastructure such as blood banks; this would go a long way in providing true comprehensive emergency obstetric care. Health centres will continue to refer women with obstetric complications to district hospitals, and although certain delays are unavoidable they should be minimised as much as possible. There is much to be gained from routine confidential enquiry into obstetric cases, including near-miss events, so as to learn from the way they are managed at the various levels of the referral chain.

Abbreviations

CI: Confidence intervals; HMIS: Health management information system; ICU: Intensive care unit; MD: Maternal death; MDA: Maternal death audits; MDG: Millennium development goals; MI: Mortality index; MMR: Maternal mortality ratio; MNM: Maternal near-miss; MNMR: Maternal near-miss mortality ratio; RDHS: Rwanda demographic health surveys; SDG: Sustainable development goals; SMO: Severe maternal outcome; SMOR: Severe maternal outcome ratio; WHO: World Health Organization

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CHAPTER 6

Causes of death and predictors of childhood mortality in Rwanda: a matched case-control study using verbal social autopsy

Published as:
Gupta N., Hirschhorn L., Rwabukwisi F, Drobac P., Sayinzoga F, Mugeni C. et al
Causes of death and predictors of childhood mortality in Rwanda: a matched case-control study using verbal social autopsy
BMC Public Health (2018) 18:1378

Abstract

Background: Rwanda has dramatically reduced child mortality, but the causes and sociodemographic drivers for mortality are poorly understood.

Methods: We conducted a matched case-control study of all children who died before 5 years of age in eastern Rwanda between 1st March 2013 and 28th February 2014 to identify causes and risk factors for death. We identified deaths at the facility level and via a community health worker reporting system. We used verbal social autopsy to interview caregivers of deceased children and controls matched by area and age. We used InterVA4 to determine probable causes of death and cause-specific mortality fractions, and utilized conditional logistic regression to identify clinical, family, and household risk factors for death.

Results: We identified 618 deaths including 174 (28.2%) in neonates and 444 (71.8%) in non-neonates. The most commonly identified causes of death were pneumonia, birth asphyxia, and meningitis among neonates and malaria, acute respiratory infections, and HIV/AIDS-related death among non-neonates. Among neonates, 54 (31.0%) deaths occurred at home and for non-neonates 242 (54.5%) deaths occurred at home. Factors associated with neonatal death included home birth (aOR: 2.0; 95% CI: 1.4–2.8), multiple gestation (aOR: 2.1; 95% CI: 1.3–3.5), both parents deceased (aOR: 4.7; 95% CI: 1.5–15.3), mothers non-use of family planning (aOR: 0.8; 95% CI: 0.6–1.0), lack of accompanying person (aOR: 1.6; 95% CI: 1.1–2.1), and a caregiver who assessed the medical services they received as moderate to poor (aOR: 1.5; 95% CI: 1.2–1.9). Factors associated with non-neonatal deaths included multiple gestation (aOR: 2.8; 95% CI: 1.7–4.8), lack of adequate vaccinations (aOR: 1.7; 95% CI: 1.2–2.3), household size (aOR: 1.2; 95% CI: 1.0–1.4), maternal education levels (aOR: 1.9; 95% CI: 1.2–3.1), mothers non-use of family planning (aOR: 1.6; 95% CI: 1.4–1.8), and lack of household electricity (aOR: 1.4; 95% CI: 1.0–1.8).

Conclusion: In the context of rapidly declining childhood mortality in Rwanda and increased access to health care, we found a large proportion of remaining deaths occur at home, with home deliveries still representing a significant risk factor for neonatal death. The major causes of death at a population level remain largely avoidable communicable diseases. Household characteristics associated with death included well-established socioeconomic and care-seeking risk factors.

Background

The Millennium Development Goal #4 to reduce child mortality by two thirds by the end of 2015 resulted in an unprecedented focus on child health and a 52% reduction in sub-Saharan Africa between 1990 to 2015, from 179 to 86 deaths per 1000 live births [1]. Despite global achievements, only one-third of the priority countries in sub-Saharan Africa reached their child mortality target. This achievement gap translated into an estimated 2.9 million child deaths in 2015 in sub-Saharan Africa, of which two-thirds were likely from preventable causes [2] and 45% occurred in the neonatal period. Poverty and maternal education continue to play a key role in deter- mining child mortality, and severe challenges remain in health care financing, human resources, service utilization, and information systems [3–5].

Rwanda, a country of 11.4 million people in the Great Lakes region of Africa, has made dramatic improvements in child mortality, moving from 37 neonatal and 152 under-5 deaths per 1000 live births in 2005 to 20 and 50 per 1000 live births, respectively, in 2015 [6]. This reduction in child mortality occurred in the context of multiple cross-sectional national and decentralized interventions designed to increase access to care, improve health resources, and strengthen the provision of effective care. These included the national introduction of a community health insurance program, high coverage for vaccination and vitamin A supplementation, implementation of community-based Integrated Management of Childhood Illness (IMCI), provision of insecticide treated nets, near elimination of mother to child HIV infections, increase in facility-based deliveries, and mobile phone reporting/support for emergency pre- and post-natal care [7–9].

Despite these efforts, child mortality in Rwanda, as in other countries in resource-poor regions of sub-Saharan Africa, varies widely across the country. Child mortality remains higher in the Eastern Province of Rwanda, which has the highest infant (51 deaths per 1000 live births) and under-5 mortality (86 deaths per 1000 live births) as compared to other provinces [6]. Nationally, under-5 mortality is largely associated with poverty (84/ 1000 live births in the lowest wealth quintile vs. 40/1000 live births in the highest quintile), maternal education (89/1000 live births in mothers with no education vs. 43/1000 for women with secondary education or higher), and residence (70/1000 in rural areas vs. 51/1000 in urban areas) [7]. However, the immediate causes and sociodemographic drivers for mortality particularly among those in the lowest wealth quintiles are poorly understood.

In order to fill this knowledge gap, we implemented a verbal social autopsy (VSA). In addition to the biologic factors identified in traditional verbal autopsy interviews, VSA allows for in-depth understanding of social, behavioral, and systems determinants of childhood death, as well as the caregiver's experience and perspectives, thereby identifying potential modifiable targets in the home, community, and health system [10–12]. We conducted a matched case-control study utilizing an enhanced VSA interview tool to determine probable cause of and predictive factors for childhood deaths in an area of high rates of childhood mortality in Rwanda.

Methods

Study setting

This study was conducted in two rural Eastern Province hospital catchment areas covering approximately 529,000 individuals. In this intervention area, the Minis- try of Health (MOH) facilities have been financially and technically supported by the non-governmental organization Partners In Health/Inshuti Mu Buzima (PIH/IMB) since 2005.

In Rwanda, the health system includes three main levels: community, health center, and district hospital. Community health workers (CHWs) provide household level health education, case finding for acute and chronic illness, community IMCI (including diagnosis and treatment of pneumonia, diarrhea, and malaria), female contraception, and linkage to health facilities for pre- natal care, deliveries, and other medical services [13]. Each of the 23 health centers serve a catchment area of approximately 20,000–30,000 people and are staffed by general nurses who provide basic diagnostics, outpatient acute services, family planning, prenatal care, and routine deliveries. The average walking distance from households to the nearest health facility is estimated at just over an hour in Kayonza and over an hour and a half in Kirehe [14]. Reflecting national standards, district hospitals in Eastern Province are staffed by general practitioners and nurses who provide secondary care for advanced or inpatient care for patients referred from health centers, including comprehensive obstetric emergencies requiring cesarean section, neonatal care, and in- patient treatment for severe childhood illness and severe malnutrition.

Study design and data collection

We conducted a matched case-control study of all children who died before 5 years of age in the study area between 1st March 2013 and 28th February 2014. We identified deaths using multiple sources including facility registers, community health worker reports, monthly review of CHW held community death records, and a database from a mobile phone-based reporting system, the Monitoring of Vital Events using Information Technology (MoVe-IT), which was introduced in these two districts in 2012 to improve vital events reporting [15].

After confirming childhood deaths with local CHWs, we conducted interviews with caregivers of the deceased child in their households. Trained data collectors approached caregivers between three weeks to one year following the child's death. Each case was matched to two controls selected from the nearest households with a child in a comparable age group (for neonates, children aged 1–30 days; for infants, children aged 31 days up to 1 year; and for children older than one year, matched to those between 1 and 5 years) to the deceased child. Neonatal cases without an available control under 30 days of age were matched with infants up to 180 days of age. Prior to the VSA, interviewers asked families of neonatal deaths additional questions in order to screen out potential cases of stillbirth. We obtained written informed consent from the caregivers of the deceased children and those selected as controls. The current caregiver of the child was not necessarily the biological mother if the biological mother was not available or was deceased. Using a questionnaire

based on the 2012 World Health Organization verbal autopsy (VA) tool [16] supplemented with questions from the Rwanda MOH's Under-5 Death Audit Tool and the 2010 Rwanda Demographic and Health Survey, we obtained information on the case or control child's demo- graphic characteristics, information on the child's birth, illness, care seeking, and the family's perceptions of care.

Analysis

We used InterVA4 [17] to determine probable causes of death and cause-specific mortality fractions (CSMF) for each cause of death. The InterVA algorithm uses a range of health indicators taken from interviews as input and applies Bayes' Theorem to determine the likeliest cause of death. The CSMF is an output from the algorithm and can be interpreted as the total number of deaths attributable to a specific cause. Prevalence of HIV and malaria were entered as "high" in the InterVA model, based on national level facility reporting indicating an estimate of greater than one in 100 deaths due to each of these diseases [18]. We estimated odds ratios for a range of child, caretaker, household, and care-seeking characteristics using conditional logistic regression. We retained variables with p-value less than or equal to 0.2 significance level in the univariate analyses in a multivariate model. We performed multiple imputations to infer values of missing data, which were considered missing completely at random. We used a bidirectional elimination stepwise method, which uses both forward selection and backward elimination in succession to determine optimal variables, to arrive at a final model in which the remaining variables were significant at the $\alpha = 0.05$ level. Risk factors with potential collinearity were not included in multivariate analysis. We analyzed deaths in neonates (day of life 0 to 28) and non-neonates (day of life 29 to 5 years) separately. We used Global Burden of Disease level 1 categories [19] to organize causes of death by communicable, maternal, neonatal, and nutritional disorders (Group 1), non-communicable dis- eases (Group 2), and injuries (Group 3).

Ethical approval

This study was approved by the Rwanda National Ethics Committee and Partners Institutional Review Board under the Population Health Implementation and Training program, a partnership between PIH/IMB, the University of Rwanda, and the Rwanda MOH. All care-givers who participated provided informed consent and were informed that they were able to discontinue participation at any time during the interview.

Results

Mortality results

Overall, 618 deaths were identified during the study period: 174 (28.2%) in neonates and 444 (71.8%) in non-neonates. For neonates, the median age of death was 2 days (interquartile range [IQR]: 0–7); 49.4% occurred in the first 48 h and 75.9% in the first week of life (Table 1). Nearly one-third (32.8%) of neonates did not visit a hospital or health center during the course of illness; 39.9% of neonates received no treatment for the illness that preceded their

death. Among those that did seek care prior to the death, 16.7% were first evaluated by a community health worker; more than half were first evaluated either at a health center (43.7%) or district hospital (12.6%). Of the 174 neonatal deaths, data regarding discharge were present for 127 neonates. Of those, 97 (76.4%) were never discharged from the hospital following birth. Sixteen percent of the neonates were born through non-facility delivery. One hundred and eight (62.1%) of the neonatal deaths were in health facilities and 54 (31.0%) were at home. The majority (CSMF 66.7%) of identified causes of neonatal death were from Group 1 communicable or neonatal causes including pneumonia and birth asphyxia. The CSMF for deaths from Group 2 (non-communicable diseases) was 2.0%; 31.3% could not be assigned a specific cause (Table 2).

Among non-neonates, just under one-third (32.7%) of cases did not visit a hospital or health center during the course of illness; 29.5% received no treatment for the ill- ness that preceded their death (Table 1). Among those that did seek care prior to the death, 36.9% were first evaluated by a community health worker; about one in three were first evaluated either at a health center (29.9%) or district hospital (2.0%). The median age of death was 515 days (IQR: 192–998); 122 deaths (27.5%) were in health facilities and 242 (54.5%) were at home.

More than three-quarters of these deaths (CSMF 82.9%) were classified as due to Group 1 diseases including malaria, acute respiratory infections, HIV/AIDS related deaths, and diarrheal diseases (Table 2). Other avoidable causes included Group 2 diseases (CSMF 3.9%) and Group 3 causes (injuries) (CSMF 3.7%); 9.5% deaths could not be assigned a specific cause.

Table 1; Characteristics of under-5 deaths

	All U5 (*N* = 618) *N* (%)	**Neonate (*N* = 174) *N* (%)**	**Non-Neonate (*N* = 444) *N* (%)**
Sex (*n* = 618)			
Male	347 (56.2)	104 (59.8)	243 (54.7)
Female	271 (43.9)	70 (40.2)	201 (45.3)
Timing of neonatal death (*n* = 170)			
Died within 24 h of birth	–	69 (40.6)	–
Died between 24 and 48 h of life	–	15 (8.8)	–
Died between 48 h and 1 week of life	–	45 (26.5)	–
Died between 1 week and 28 days of life	–	41 (24.1)	–
First type of care sought (*n* = 618)			

	All U5 ($N = 618$) N (%)	Neonate ($N = 174$) N (%)	Non-Neonate ($N = 444$) N (%)
Traditional healer	50 (8.1)	8 (4.6)	42 (9.4)
Community health worker	193 (31.2)	29 (16.7)	164 (36.9)
Health center	209 (33.8)	76 (43.7)	133 (29.9)
District hospital	31 (5.0)	22 (12.6)	9 (2.0)
Private pharmacy	5 (1.0)	0 (0.0)	5 (1.1)
Other	19 (3.1)	4 (2.3)	15 (3.4)
Unknown	32 (5.2)	12 (6.9)	20 (4.5)
No care sought	79 (12.8)	23 (13.2)	56 (12.6)
Attended health facility (hospital or health center) during illness ($n = 616$)			
No	202 (32.7)	57 (32.8)	145 (32.7)
Yes	416 (67.3)	117 (67.2)	299 (67.3)
Received any treatment at a health facility for the illness that led to death ($n = 608$)			
No	197 (32.4)	67 (39.9)	130 (29.5)
Yes	411 (67.6)	101 (60.1)	310 (70.5)
Place of death ($n = 618$)			
Hospital	156 (25.2)	80 (46.0)	76 (17.1)
Health center	74 (12.0)	28 (16.1)	46 (10.4)
Home	296 (47.9)	54 (31.0)	242 (54.5)
Other	91 (14.7)	12 (6.9)	79 (17.8)
Unknown	1 (0.2)	0 (0.0)	1 (0.2)
Discharged from health facility following birth ($n = 127$)			
No (died in health facility)	–	97 (76.4)	–
Yes	–	30 (23.6)	–

Risk factors for death among neonates

In the univariate analysis, we identified the following as risk factors for neonatal death: female child (OR: 0.8; 95% CI: 0.7–1.0), home birth (OR: 1.8; 95% CI: 1.3–2.7), multiple gestation birth (OR: 1.9; 95% CI: 1.1–3.3), both parents deceased (OR: 3.8; 95% CI: 1.2–12.7), non-use of family planning methods (OR: 0.8; 95% CI: 0.6–1.0), and barriers to care including lack of accompaniment to a health facility (OR: 1.5; 95% CI: 1.1–2.1) and caregiver assessment of services received as moderate to poor (OR: 1.5; 95% CI: 1.1–2.0) (Table 3).

Table 2; Cause-specific mortality fractions for neonats (day of life 0 to 28) and non-neonates (day of life 29 to 5 years)

Age group	GBD Group 1 (Communicable, maternal, neonatal, and nutritional disorders)		GBD Group 2 (Non-communicable diseases)		GBD Group 3 (Injuries)	
	Cause of death	**CSMF**	**Cause of death**	**CSMF**	**Cause of death**	**CSMF**
Neonates	Neonatal pneumonia	26.5	Congenital malformation	1.0		
	Birth asphyxia	11.3	Epilepsy	0.6		
	Other and unspecified neonatal COD	8.5	Other and unspecified cardiac disease	0.4		
	Meningitis and encephalitis	7.9				
	Prematurity	6.4				
	Neonatal sepsis	5.6				
	Acute abdomen[a]	0.5				
	TOTAL	66.7	TOTAL	2.0	TOTAL	–
Non-neonates	Malaria	34.7	Epilepsy	2.3	Accidental drowning and submersion	1.3
	Acute resp. infections, including pneumonia	19.7	Congenital malformation	0.9	Road traffic accident	0.7
	HIV/AIDS-related death	12.0	Asthma	0.7	Other and unspecified external COD	0.6
	Acute abdomen[a]	7.6			Other transport accident	0.6
	Diarrheal diseases	5.9			Assault	0.5
	Meningitis and encephalitis	1.2				
	Other and unspecified infect disease	0.9				
	Severe malnutrition	0.9				
	TOTAL	82.9	TOTAL	3.9	TOTAL	3.7

31.3% of neonatal deaths and 9.5% of non-neonatal deaths identified as "indeterminate"
COD cause of death, *CSMF* Cause-specific mortality fraction, *GBD* Global Burden of Disease
[a]May have mixed etiologies

Table 3; Risk factors for neonatal death as compared to matched controls

Univariate Analysis					Multivariate Analysis			
Child, Caretaker, or Household Characteristic	**Odds Ratio**	**95% Confidence Interval**		***p*-value**	**Odds ratio**	**95% Confidence Interval**		***p*-value**
Female child	0.8	0.7	1.0	0.091	0.8	0.7	1.0	0.084
Mother with primary education or less	0.9	0.6	1.4	0.655	–	–	–	–
Mother age ≤ 18	1.4	0.5	3.9	0.506	–	–	–	–
Mother age > 35	0.8	0.4	1.6	0.564	–	–	–	–
Mother with health insurance	0.8	0.6	1.2	0.340	–	–	–	–
Both parents deceased	3.8	1.2	12.7	0.027	4.7	1.5	15.3	0.01
Household size ≥5	1.2	0.9	1.5	0.206	–	–	–	–
No electricity in the house	0.9	0.5	1.6	0.744	–	–	–	–
Natural/rudimentary walls in the house	0.8	0.6	1.2	0.310	–	–	–	–
No mosquito nets in the house	1.0	0.7	1.5	0.962	–	–	–	–
Mother not using family planning	0.8	0.6	1.0	0.041	0.8	0.6	1.0	0.042
Home delivery	1.8	1.3	2.7	0.002	2.0	1.4	2.8	0.000
Multiple gestation delivery	1.9	1.1	3.3	0.016	2.1	1.3	3.5	0.005
Mother with ≤1 antenatal care visit	1.3	0.9	1.8	0.233	–	–	–	–
Caretaker reported financial barrier to care	1.1	0.9	1.5	0.372	–	–	–	–
Caretaker reported seeking permission as a barrier to care	1.0	0.5	1.8	0.991	–	–	–	–
Caretaker reported distance to health facility as a barrier to care	1.0	0.7	1.4	0.946	–	–	–	–
Caretaker reported not having an accompanying person as a barrier to care	1.5	1.1	2.1	0.015	1.6	1.1	2.1	0.007
Caretaker reported a poor to moderate perception of health facility services	1.5	1.1	2.0	0.004	1.5	1.2	1.9	0.002

Table 4; Risk factors for non-neonatal death as compared to matched controls

Univariate Analysis					Multivariate Analysis			
Child, Caretaker, or Household Characteristic	**Odds Ratio**	**95% Confidence Interval**		***p*-value**	**Odds ratio**	**95% Confidence Interval**		***p*-value**
Female child	0.9	0.8	1.1	0.241	–	–	–	–
Mother with primary education or less	1.9	1.2	3.0	0.006	1.9	1.2	3.1	0.005
Mother age ≤ 18	0.8	0.4	1.7	0.554	–	–	–	–
Mother age > 35	1.3	0.8	2.0	0.235	–	–	–	–
Mother with health insurance	0.9	0.7	1.0	0.111	–	–	–	–
Both parents deceased	1.2	0.7	1.8	0.490	–	–	–	–
Household size ≥5	1.2	1.0	1.4	0.029	1.2	1.0	1.4	0.037
No electricity in the house	1.4	1.0	1.8	0.052	1.4	1.0	1.8	0.041
Natural/rudimentary walls in the house	0.9	0.8	1.2	0.566	–	–	–	–
No mosquito nets in the house	0.9	0.7	1.2	0.475	–	–	–	–
Mother not using family planning	1.6	1.4	1.8	<.0001	1.6	1.4	1.8	<.0001
Multiple gestation delivery	2.8	1.7	4.7	<.0001	2.8	1.7	4.8	<.0001
Child not adequately vaccinated	1.7	1.2	2.3	0.003	1.7	1.2	2.3	0.003
Caretaker reported financial barrier to care	1.1	1.0	1.3	0.155	1.1	0.8	1.3	0.109
Caretaker reported seeking permission as a barrier to care	0.9	0.7	1.3	0.714	–	–	–	–
Caretaker reported distance to health facility as a barrier to care	1.0	0.8	1.1	0.649	–	–	–	–
Caretaker reported not having an accompanying person as a barrier to care	1.1	0.9	1.3	0.482	–	–	–	–
Caretaker reported a poor to moderate perception of health facility services	1.0	0.9	1.2	0.962	–	–	–	–

In multivariate analysis, neonates who died were more likely than controls to have been born at home (aOR: 2.0; 95% CI: 1.4–2.8), born as part of a multiple gestation (aOR: 2.1; 95% CI: 1.3–3.5), and to have both parents deceased (aOR: 4.7; 95% CI: 1.5–15.3). They were less likely to have a mother who reported using family planning methods (aOR: 0.8; 95% CI: 0.6–1.0), and were more likely to have a caregiver who reported that not having a family member available to accompany them to a health facility was a barrier to care (aOR: 1.6; 95% CI: 1.1–2.1), and who assessed the medical services they received as moderate to poor (aOR: 1.5; 95% CI: 1.2–1.9).

Non-neonates case-control results

In the univariate analyses, children who died were more likely than controls to have been a part of a multiple gestation birth (OR: 2.8; 95% CI: 1.7–4.7), not to have received adequate vaccinations (OR: 1.7; 95% CI: 1.2– 2.3), and to come from a larger household (OR: 1.2; 95% CI: 1.0–1.4). Mothers of non-neonatal cases were more likely than age-matched controls to have primary education or less (OR: 1.9; 95% CI: 1.2–3.0) and not use family planning methods (OR: 1.6; 95% CI: 1.4–1.8). Caregivers were less likely to have health insurance (OR: 0.9; 95% CI: 0.7–1.0) and more likely to report no household electricity (OR: 1.4; 95% CI: 1.0–1.8) as well as financial barriers to care (OR: 1.1; 95% CI: 1.0–1.3) (Table 4). In the multivariate model, children who died were more likely than controls to have been born as part of a multiple gestation (aOR: 2.8; 95% CI: 1.7–4.8), to not have received all scheduled vaccinations (aOR: 1.7; 95% CI: 1.2–2.3), and to come from a large household (aOR: 1.2; 95% CI: 1.0–1.4). Caretakers were also more likely to report lower maternal education levels (aOR: 1.9; 95% CI: 1.2–3.1), mothers not using family planning (aOR: 1.6; 95% CI: 1.4–1.8), and electricity lacking in the household (aOR: 1.4; 95% CI: 1.0–1.8). The variable “mother health insurance” was not included in the multivariate analysis due to potential collinearity with “caretaker reported financial barrier to care”.

Discussion

In the context of rapidly declining childhood mortality in Rwanda and increased access to and utilization of formal health care, we found a large proportion of remaining deaths occur at home, and home deliveries still representing a significant risk factor for neonatal death. The major causes of death at a population level remain largely avoidable communicable diseases. House- hold characteristics associated with death included well-established socioeconomic and care-seeking risk factors. To our knowledge, this is the first study to explore the causes of death in Rwanda using household-level VSA, including a case-control design to also explore the association of socio-demographic and access factors with the risk of neonatal and childhood deaths.

Although the proportion of neonatal deaths in the first week of life in this cohort (75.9%) was similar to previous reports based on vital registration data, [20, 21] our results showed a lower proportion of neonatal asphyxia and prematurity-related deaths than both regional estimates

and previous results in Rwanda [22, 23]. These findings may reflect the contribution of programs in these districts targeting survival of premature and full-term infants through improved neonatal resuscitation techniques and immediate newborn care, including introduction of continuous positive airway pressure at the hospital level [24]. For non-neonatal deaths, the causes of death estimated from our study continue to attribute a high overall cause of death to preventable communicable disease, driven in large part by malaria, pneumonia, and diarrheal diseases. Despite national malaria control efforts, there are higher rates of malaria incidence in the Eastern region of Rwanda [25]; in addition, the country experienced an upsurge in cases of malaria during the time of data collection, attributed to climate changes, pyrethroid resistance, sub-standard insecticide-treated bednets, and inconsistent application of indoor residual spraying [18, 26]. The relative proportion of deaths attributable to pneumonia was consistent with both regional and historical rates [21, 23]. In contrast, a lower proportion of deaths were attributable to diarrhea than previously reported [23], likely due in part to the expansion of community IMCI and efforts to improve quality of facility-based IMCI [27].

In multivariate analysis, home birth was a significant risk for neonatal mortality, and 16% of cases of neonatal death identified in this study occurred in neonates with non facility delivery. This supports findings among cohorts in Uganda [28] and Indonesia [29] which showed substantially elevated mortality risk associated with birth at home. This increased risk may be due to the lack of immediate access to emergency clinical obstetric or neo- natal care among home births without skilled attendants as well as low utilization of post-partum care and services [30]. Orphanhood, or both parents deceased, was also associated with higher odds of death among neonates, and has been reported elsewhere to be a major risk factor for childhood mortality [31]. A previous study in Tanzania found that children whose mothers died during the early maternal period had a 50% chance of surviving to one year of age compared to a 94% probability among children with living mothers [32].

Several established risk factors were confirmed in our research, including multiple gestation birth [31, 33], lower maternal education [4, 34, 35], larger household size [34, 36], absence of family planning use [37, 38], and incomplete vaccination [39]. Lack of household electricity was another significant factor for non-neonatal deaths, which may be directly associated with greater indoor air pollution from other energy sources [40], an increase in injuries and accidents related to solid fuel use [41], or be a surrogate for other house- hold vulnerabilities. Household electricity may also be associated with greater family or community resources that provide a protective effect on under-5 health out- comes [42, 43].

Self-reported barriers to accessing care were significantly associated with deaths in the neonatal age group. Lack of a family member or other person to accompany a caregiver to the health facility was independently associated with neonatal death, which likely resulted in delays in care seeking and may also be reflected in the higher risk of death associated with home birth.

Lack of insurance was not significantly associated with deaths in either age category in the analysis. Given the high rates of insurance coverage for mothers in cases and controls, our

study may have lacked sufficient power to detect significant risk factors for death. Whereas a community-based health insurance scheme has been associated with increased utilization of child services at health facilities in Rwanda [44], user fees still exist in the form of co-payment, which may to some degree still limit access to care [45], findings supported from initial qualitative analysis of the VSA interviews [46]. Inadequate utilization of family planning, which was independently associated with childhood deaths in this study, may reflect lower health seeking-behaviors or poorer access to care by caretakers of children who died compared to caretakers of the control children.

Our study had a number of limitations. While the up- dated 2012 WHO VA tool and InterVA4 algorithm in use are confirmed to have high reliability compared to other vital case reporting standards [47, 48], the accuracy of the identified cause of death from the algorithm in this country and context is unknown, especially for neonates, where a large proportion of deaths were categorized as indeterminate cause, or for particular conditions, such as malnutrition, which may go under-detected using this methodology. Additionally, VSA relies on caregiver recall of events surrounding the death, which introduces issues related to caregiver memory of the events and responder bias, particularly given the sensitivity of an event as significant as the death of a child. In particular, this bias may influence assessment of barriers to care. The InterVA4 algorithm requires prevalence assumptions for the rate of deaths attributed to HIV in the background population. According to national facility-based reporting, 1% of childhood deaths and 6% of all deaths in 2014 were associated with HIV/ AIDS, though this may have overestimated the proportion of overall childhood deaths related to HIV/ AIDS, where a rapidly declining HIV vertical transmission rate and improving diagnostics and access to treatment have dramatically reduced HIV/AIDS-related death in the pediatric population in Rwanda [49]. Additionally, while efforts were made to collect data from multiple new and existing data sources, some deaths may have been missed, particularly deaths initially thought to be stillbirths in both facility and community settings, thereby potentially underestimating the proportion of neonatal deaths. Childhood vaccination coverage was not corrected for survival, and therefore it is possible that the relationship between complete vaccination coverage and childhood mortality may have been overestimated due to the additional time that passed between the death date of the case and the interview date for the control, during which the control may have received additional vaccinations. Despite standardized procedures to collect interview data, data is missing for several variables; however, we believe these data are missing at random, and do not bias our findings. Finally, while we had caregiver report of perceived quality, we do not know the technical quality of care provided and the relative contribution to amenable deaths.

Conclusion

Despite significant health system improvements and rapid declines in childhood mortality in Rwanda, a large proportion of child deaths in this study occurred at home. While there was a high proportion of facility- based deaths for neonates, home deliveries still represent a major risk factor for neonatal death. Significant financial and care-seeking barriers remain with a high proportion of deaths occurring outside of the health system for non-neonates, which

present clear targets for focused interventions at both the community and health facility levels. Despite overall gains in childhood mortality, well informed policies, guidelines, and system improvements targeting key risk factors identified in this study could accelerate gains for neonatal and childhood survival in rural Rwanda and similar contexts across sub-Saharan Africa.

Abbreviations

CHW: Community health worker; CSMF: Cause-specific mortality fraction; GBD: Global Burden of Disease; IMB: Inshuti Mu Buzima; IMCI: Integrated Management of Childhood Illness; MOH: Ministry of Health; MoVe- IT: Monitoring of Vital Events using Information Technology; PIH: Partners In Health; VA: Verbal autopsy; VSA: Verbal social autopsy; WHO: World Health Organization

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CHAPTER 7

General discussion and conclusion

The goal of this thesis is to explore factors within the health system influencing the outcome of maternal and neonatal health in Rwanda and to suggest interventions that would improve the quality and use of maternal and neonatal health services.
Our main research question is: what are the health system determinants of maternal and neonatal health in Rwanda?

Using the WHO health system framework we strived to answer the following specific questions:

1. What are the main drivers of health sector performance and what is the scope for improvements?
2. Which factors best explain variations between districts in maternal and neonatal health outcomes and certain emergency obstetric and newborn care indicators?
3. What is the incidence, the characteristics and determinants of severe maternal outcome (maternal death and near miss) and neonatal deaths?

To respond to these questions, we used mixed research methodologies to identify factors behind the health sectors' performance. We also investigated and further defined areas of improvement for maternal and neonatal health.

7.1 Overall findings

***Drivers of* of improved health sector performance**

Chapter 2 of this thesis reported the health system features that drive health sector performance, particularly those determining maternal health coverage and outcomes. In this section we show that a combination of interventions drive performance in Rwanda rather than a single health system strengthening intervention or a set of interventions that target a specific disease. The web-based survey distributed to district health mangers [Chapter 2] found several factors beyond the health system that significantly contribute to the improvement of mothers' and their newborns' health. One such factors is the widespread determination of stakeholders to increase performance and achieve set targets. This determination appears to be multi-leveled and is influenced by both intrinsic and extrinsic motivations. Other authors have described factors outside the health sector that improve women's and children's health [1,2].

The Rwandan community health system relies significantly on **community health workers (CHWs)** who conduct their activities at the village level with a particular focus on maternal and child health [3]. Community health workers' activities have been documented as contributors to the Rwanda's 'health achievement' [4-8]. CHW's contribution has resulted in a significant increase in the use of health facilities, especially maternal health services [9,10].

Community based health insurance (CBHI) helps people overcome financial barriers to access health services. The CBHI covers health facility deliveries as well as interventions provided during antenatal and postnatal care. The Rwanda CBHI is considered one of the most successful schemes in sub-Saharan Africa because of its high enrolment rates, strong

partnership between government and the community, good financial management and enrolment for free for the poor [11-14].

As reported in Chapter 2 reports, district health managers are conviced that the central and local government's determination is influenced by both intrinsic and extrinsic motivation to increase performance and achieve the targets included in their **performance contracts.** Health indicators are part of the performance contracts that districts sign with the central government, whereby both the administrative districts and the health facilities in their respective catchment areas are accountable for achieving annual targets.
District health managers also provided their opinions on areas outside the health sector that require improvement such as water supply and sanitation, public awareness of health risks, literacy levels (in particular among women), child spacing (lower levels of fertility), and more conducive individual behaviour and personal protection against health hazards.

Geographic disparities

Although the country is experiencing a general improvement in maternal and child health [9; 10; 15], the variation of district health performance from the national average based on individual stakeholder interviews and focus group discussions conducted in four districts [Chapter 3]. Within this study we found that access to health facilities is and can be improved by the financial protection of poor people, made possible through a strong interconnection between health facility management teams and local leaders [**Chapter 3**]. Even though the poorest individuals receive community-based health insurance for free, they still need to pay a ten percent service fee for each visit to a health facility plus the cost of transport. Some district authorities, in collaboration with local administration, are organizing social saving schemes to support those in need in paying the ten percent service fee and transport. This movement contributes to the effective use of health services and improved health seeking behaviour by the district population.

Some district interviewees mentioned lower healthcare participation rates amongst migrants (lower clinic attendance rates, lower health insurance enrolment), and linked this to poor health outcomes [**Chapter 3**].
They further argued that the mountainous landscape and bad road conditions, which are factors that fall beyond the control of the health sector, limit geographic access to to health services including maternal care. These limitations are further exacerbated by high population density and health facilities not being well dispersed [**Chapter 3**].

Disparities between in maternal services between regions are also seen in other low and middle-income countries [16,17,18,19].

Maternal and neonatal health

In our multicenter prospective case-control study analyzing severe maternal outcome and quality of care at district hospitals in Rwanda [Chapter 5], we confirmed that Rwanda is still

experiencing high maternal morbidity and mortality. The high incidence of both maternal mortality and morbidity is also seen in other African countries [20,21]. The severe maternal outcome (maternal death and near miss) incidence ratio was at 38.4 per 1000 live births and the maternal near-miss incidence ratio at 36 per 1000 live births in the four district hospitals.

Occurrence of severe maternal outcomes was found to be associated with lack of social support as more cases were seen among unmarried women (15% versus 5,6% in controls) and unemployed women (4.2% versus 0.2% in controls) [Chapter 5]. The lack of social support was also found to have contributed to the occurrence of neonatal death in the matched case-control study [Chapter 6], which used verbal social autopsy to analyse causes of death and predictors of childhood mortality. Women who came unaccompanied to the health facility to deliver (aOR: 1.6) and experienced the death of both parents (aOR: 4.7) were more common among cases than in controls.

Women below 20 years of age (7.3 % vs 3.5% in controls) and those older than 35 years (28.4% Vs 12.6% in controls) were found to be at risk of developing severe maternal outcomes [**Chapter 5**]. Their vulnerability was even greater in case of non-use of preventive services as indicated by the fact that only 27.4% of women with severe maternal outcomes had attended any antenatal care visit while 16% of infants who died in the neonatal period were born outside health facilities and were without medical assistance [C**hapter 6].** A study in Ethiopia found that maternal age, residential area, educational status and occupation were associated with SMO [20].

Post-partum hemorrhage continues to be the top cause of both maternal mortality and severe morbidity, with 22.7% of all deaths in the 5 years retrospective study of maternal death audits [**Chapter 4**] and 23.4% of all severe maternal outcomes [**Chapter 5**]. Although post-partum hemorrhage is a preventable cause of maternal death, it was associated with a high case fatality rate (8%). The same was seen with hypertensive disorders (10.5%) **[Chapter 5]**. Moreover, both conditions can be prevented by early detection of warning signs and timely provision of emergency obstetric care. The mortality index of 6.1 reported in Chapter 5 formed the basis to make recommendations for better management of similar cases, so as to reduce some of the top causes of maternal mortality [**Chapter 5**].

The analysis of severe maternal outcome in Chapter 5 has shown that lives saving interventions are widely used in Rwanda, with 96.3% of women delivering at health facilities receiving an uterotonic in the management of third stage of labor. The use of anticonvulsants in case of severe (pre-)eclampsia and of prophylactic antibiotics in caesarean section cases is almost universal (100% and 98.6% respectively). Even so, women continue to die and experience severe obstetric conditions that can be prevented. It was found in the retrospective analysis of maternal death that occurred at health facilities. Over the 5-year study period 61% of contributing factors to maternal death were attributed to health system failures [**Chapter 4**]. This indicates that the near universal use of life saving interventions is not sufficient.

These problems are only exacerbated by staff shortages, partly caused by high rates of attrition particularly among medical doctors, nurses, specialists (obstetricians and

pediatricians), and laboratory technicians as reported in Chapter 3. The same situation is also seen in many low and middle-income countries [22-26].

The study reported in Chapter 5 found poor quality of care around delivery as a contributor to neonatal deaths, of which 11.3% were due to birth asphyxia because of substandard management of delivery and failure to observe infection control principles leading to neonatal sepsis (5.6%) as reported in Chapter 6. The same study revealed that some obstetrical conditions that are part of the emergency obstetric and neonatal care services provided at health facility level, like multiple gestation (aOR: 2.1), are associated with newborn death. The same accounts for the non-use of preventive services like family planning (aOR: 0.8) due to unassisted deliveries happening outside health facilities. Despite the progress seen in the overall use of health facilities, we observed that 31% of neonatal deaths still happen outside of health facilities, as indicated by the finding that the death risk of neonates born at home is twice as high as that of neonates born in hospitals (aOR: 2.0) [Chapter 6]. The study reported in Chapter 5 revealed that stillbirth was common (46.1%) among severe maternal outcomes (OR = 181.7). Also, prolonged stays at the hospital (OR = 7.9) were strongly associated with maternal and near miss cases compared to the control group.

7.2 Strengths and limitations

The main strength of this thesis is the usage of mixed methods and complementary studies that shed light on the full range of health system and environmental factors that determine maternal and neonatal health outcomes: nationwide maternal death audits analyzing almost 1000 deaths, a maternal near miss study in four hospitals, verbal social autopsy for infant mortality and qualitative research, through case studies and a web-based survey among district health managers. To our knowledge no such comprehensive analyses have been conducted in other countries.

This thesis also has some limitations. The primary limitation is that some of the data used originates from routinely collected data in the national Health Management Information System. They were not designated for the studies. During interviews some respondents may not have revealed their true private experience and opinions on sensitive matters, like systemic weakness, substandard care and failure to achieve targets.

Secondly, the actual quality of care has not been assessed. Our analysis was largely based on perceptions of the possible role of substandard quality of services and its determinants such as number of skilled health personnel, status and availability infrastructure and equipment according to the standard requirements.

Thirdly, most of our studies on maternal mortality focused on delays occurring in health facilities, rather than first and second types of delay. We did not investigate deaths that may have happened in communities (first and second degree delays), which could bring more information on factors surrounding maternal deaths [27].

7.3 Implications of the findings: what does it add to scientific literature

The comprehensiveness and combination of interventions that drive maternal and neonatal health outcomes in Rwanda is an important finding. It concurs with the WHO health system framework [28]. Apart from health system factors, it is also important to acknowledge the role that societal factors and specific settings play. Other authors detail this as well [29].

Disparities between districts regarding the use of maternal health services and maternal health outcome are important and are due to a combination of health system factors and broader factors like topography, status of road and mode of life of the population like migrants. This also brings the recognition of importance of considering the setting context in the health system framework.

This thesis shows that facility-based maternal death reviews can be implemented countrywide in low-income settings. It concurs with other studies showing that the analysis of severe maternal outcomes (SMO) can be complementary to maternal death reviews. The use of best practices for near miss cases can be used to improve quality of care [30; 31]. Maternal death and near miss review are potentially powerful tools that can also serve as an accountability mechanism to exercise and operationalise the health system's leadership and governance functions.

Despite the use of accessible essential medicines like oxytocin, magnesium sulfate and antibiotics, post partum hemorrhage, infections and eclampsia continue to be the leading causes of maternal deaths and factors within the health facilities related to substandard care on the side of health providers are largely contributing to maternal deaths.

SMO are still frequent in other low-income countries [8; 32-38] despite the widespread use of life saving interventions. Its occurrence is associated with long stay at the hospital, stillbirth and neonatal death. This is a testimony of the importance of the combination of medical products and service delivery as two building blocks in the WHO health system framework for quality of maternal health services to ensure better maternal health outcome.

Unsupervised home deliveries still represent a significant risk factor for neonatal death and poor maternal outcomes due to obstetrical complications that can be managed at most health facilities. This is in line with existing literature [39], which reveals that access to maternal health services is an important output for better maternal health outcomes.

The negative perception of health services from patients and financial barriers are compromising the use of health facilities and lead to poor maternal and newborn outcomes [39; 40].
Finally, the issue of human capital is perceived by health mangers as aggravating issues around quality of care of services provided in low-income countries.

7.4 Recommendations for clinical practice, policy and research

Clinical practice

Despite the extended use of life saving interventions, women continue to die and experience severe obstetric conditions that can be prevented. Their occurrence is due to failure within the health system. This indicates that even the use of life saving interventions is appropriate but it is not sufficient alone. There is a need for improved quality of care to be provided to mothers during antenatal care, delivery period and in the post-partum period.
Adherence to protocols and standards for essentials obstetric and neonatal care and provision of emergency obstetric and neonatal care services by sufficient skilled health providers can improve maternal and newborn outcomes.
In addition, improvement of referral practices and certain types of infrastructure, especially blood banks, would ensure truly comprehensive emergency obstetric care and reduce the occurrence of severe maternal outcome.

Implementation of recommendations made during the review of death audit should be prioritized and well monitored. For many years, post-partum hemorrhage has been the leading cause of maternal mortality in Rwanda and other developing countries. However from audit findings to the improvement of quality of care is challenging. Studies from high income countries have identified barriers to PPH guideline implementation [41-45]. In low income countries blood supply shortages can be a challenging obstacle to proper treatment. [46; 47] In these countries, efforts to ameliorate transportation problems by using drone transport might be effective [48; 49]. Future studies should focus on the use of new tools that could be used to manage refractory hemorrhage like uterine balloon as temporizing measures until substantive care is available and also the use of other alternative medicines like tranexamic acid to guide countries on making available a large range of methods to manage PPH. Use of medical technology like uterine artery embolization should be considered to ensure all necessary means to address the main cause of maternal death are available at health facilities providing comprehensive emergency obstetrical care.

Health facilities should prioritize patient-centered services to improve the perception of health services by clients. As recommended by WHO, respectful maternity care during labor and childbirth should be provided to all women for a better experience of labour and childbirth and address health inequalities [50].

Policy

Rwanda should strengthen the drivers that have brought a positive trend so far as observed in this thesis:
- Community health: a recent evaluation of the community health workers program in Rwanda has shown that this programme is successful but also raises issues such as incomplete use of the program, geographic inequities in delivering services and lack of replacement policy for CHWs ' equipment [51]. In addition, supply chain issues of commodities and

inconsistence of supervision were identified by the evaluation as programme challenges'. These issues need to be addressed to make Community health programme more powerful and sustainable [51].
- Community-based Health Insurance: CBHI has contributed to the increase of health services usage. It needs to be strengthened. To maintain high packages covered by the CBHI should be increased and be self-financed. The government must put more effort into making this a reality [11].
- Implication of local leaders in joint management of local health issues with other stakeholders should be prioritized and formalized by learning from initiatives of well performing districts. This could lead to more involvement of local administration and create a clear and strong accountability mechanism through the performance contract between district and central government aimed at achieving set maternal and newborn indicators.

Human capital for needs to be prioritized as the demand of maternal and newborn services increase. The quality of care of mothers and newborns contributes to maternal and newborn morbidity and mortality. Having a sufficient number of qualified personnel at all levels is paramount for implementing key lives saving effective interventions. Without prioritizing this issue, it will be difficult to satisfy the high demand of maternal health services such as health facility delivery and also end preventable deaths. The Rwandan situation reflects the third stage of obstetric transition [52], which is a complex stage as accessibility remains an issue. A great proportion of pregnant women in Rwanda attend preventive and curative services at health facilities, this high attendance compared to the insufficient number of health providers can compromise the quality of care and contribute to the poor health outcomes due to overloaded health facilities [35]. The role of intrahospital issues (i.e. third delay) in maternal mortality becomes more important [52]. Quality of care is critical for improving maternal health outcomes in this stage.

Planning process in equitably distribution financial and infrastructures resources should consider regional particularities and be guided by geographic and population data, use of health facilities and the ways of life of the population. This is also important for human capital as qualified personnel tend to avoid working in remote areas. Unfortunately, this is where they are more needed. Governments and local leaders should look for new ways of motivation and retention of health personnel.

There are some improvements that could be made to the Rwandan health system outside of the health sector. Improved water supply and sanitation, increased health awareness, improved literacy levels (in particular among women), increased child spacing (lower levels of fertility), and more conducive individual behaviour and personal protection against health hazards [Chapter 2] could all potentially improve treatment outcomes.

Research

Further research is needed on the health system framework in general by analyzing the contribution of factors beyond the health sector such as the determination of people and

government to increase performance and achieve targets, water supply and sanitation and different context such as geographic location, road status and life style of the local population. This could enrich the current WHO model since this model emphasises the six systems building blocks, but does not consider the settings' context and factors beyond the health sector.

Most of the available literature analyses deaths occurring in health facilities. This is due the wide availability of data on maternal and newborn mortality in health institutions. (Mostly phase 2 and 3 delay). Research should also focus on phase 1 delay by gathering information on deaths occurring outside health facilities. In addition, review of severe maternal morbidity is complementary to the review of maternal deaths. This could support the effort made in tackling factors surrounding deaths related to the quality of care received by mothers and newborns as well as others unknown factors that contribute to community deaths.
Further research should also focus on regional context and explore new ways of providing quality maternal and newborn care services by considering geographic location and lifestyle, .

7.5 Conclusion

Rwanda has experienced an impressive improvement in maternal and newborn health, which has placed it among few countries that achieved both Millennium Development Goals 4 and 5 [53].
However, Rwanda still has a high maternal and newborn mortality and further improvement is needed to achieve the sustainable development goal 3.1 and 3.2 This can be done by sustaining factors that have contributed to strengthening the health sector, such as the community health program and community-based health insurance, but also by addressing the quality of maternal and newborn care services provided during pregnancy, delivery and in the post-partum period. The number of healthcare workers needs to be increased amongst all types of healthcare professionals. District's geographic, lifestyle, cultural and infrastructures particularities need to be taken into consideration to ensure no one is left behind. Delivery at health facilities should be encouraged to avoid maternal and newborn death due obstetrical conditions that can be managed by skilled health providers. Also health facilities should prioritize patient-centered services by providing respectful maternity care to improve the perception of health services by clients. This initiative would also improve patient reported experience and patient reported outcome (Patient Reported Outcome Measures and Patient Reported Experience Measures).

Further analyses are needed on the factors beyond the health sectors that can be improved for better maternal health outcome. The current WHO health system framework with its model of six building blocks needs to consider setting context and factors beyond the health sector. Maternal deaths and near miss cases occurring in communities should be subject of review in order to close the gap related to information known around maternal death.

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SUMMARY OF THE THESIS

MDG 5A was not achieved despite the global effort to reduce maternal mortality. Since 1990, the MMR has fallen by nearly 44%, from 385 to 216 maternal deaths per 100 000 live births in 2015. Also the huge disparities between regions are alarming, where developing countries account for approximately 99% of all maternal deaths, with sub-Saharan Africa alone accounting for roughly 66%, followed by Southern Asia.

The new 2030 Agenda for Sustainable Development which includes 17 Sustainable Development Goals, or SDGs. The SDG target 3.1 of a global maternal mortality ratio (MMR) below 70 will require reducing global MMR by an average of 7.5% each year between 2016 and 2030.

This will require more than three times the 2.3% annual rate of reduction observed globally between 1990 and 2015. Working towards SDG 3.1 and ultimately towards ending preventable maternal mortality requires amplifying the efforts and progress catalyzed by SDG 5.

Rwanda, experienced in 1994 the genocide against Tutsi and the health system was completely disrupted at the time. Much of the infrastructure, equipment, personnel, and the health system itself was destroyed. With the advent of peace, the government has been working to rebuild the health system. Since 1995, the government issued a new policy to guide the reconstruction of the health system and in 2000; steps have been taken toward restructuring and decentralizing management.

Rwanda experienced remarkable progress regarding maternal and child health in the last 15 years by reducing maternal mortality from 1071 to 210 per 100000 live births as attested by the Rwandan demographic health survey 2010 and 2015. A similar trend was observed regarding the use of maternal services where deliveries at health facilities raised from 69% to 91% respectively from 2010 to 2015. This lead Rwanda to be among few countries that have achieved SDG 5A based on MMR reduction point-estimates indicating a reduction of at least 75% between 1990 and 2015.

Authors have attributed this achievement to various initiatives implemented in the last 15 years, like community based health insurance, community health program, and performance based financing.

Rationale of the thesis

Despite the progress made in last 15 years regarding maternal and child health, Rwanda is still among countries with high maternal mortality. Childbirth-related deaths are still common and need to be cut down in order to reach the SDG MMR target.

A better understanding of what has driven the Rwandan success and identification of scope of improvement in its health system is critical for the Rwandan post 2015 agenda regarding further reduction of maternal morbidity and mortality. Information regarding factors that have contributed to the occurrence of severe maternal outcome (maternal death and near miss), the variations between districts in maternal and newborn health outcomes will contribute to the elimination of avoidable maternal and newborn deaths and ensure no women and newborns are left behind.

The overall goal of this thesis work is to identify and contextualize health system features that have influenced Rwanda's performance in maternal health and suggest interventions that will improve the quality and the use of maternal health services.
This thesis addresses the main research question to respond to the overall objective (Chapter 1): What are the health system determinants of maternal and neonatal health in Rwanda?
To answer to this question, this thesis describes five studies using mixed methodologies. This thesis first identifies the main drivers which contributed to the health sector performance and what is the scope for further improvements through a web-based survey among district health managers in Rwanda (Chapter 2). The next chapter then determines factors that explain variations between four districts in maternal and newborn health outcomes and certain emergency obstetric and newborn care indicators in a multifaceted study, combining individual interviews and focus group discussions (Chapter 3). This is followed by three empirical studies, one of which analyses the incidence, characteristics and determinants of severe maternal outcome (maternal death and near miss) and infant death through a retrospective review of five year maternal death audit sessions (Chapter 4) ; a prospective case-control study of severe maternal outcomes in four rural district hospitals (Chapter 5); and a matched case-control study of all children who died before 5 years of age in two districts in eastern Rwanda (Chapter 6).
The five studies are discussed together (chapter seven) and general conclusions are drawn.

Drivers of improved health sector performance

It clearly come out that it is the comprehensiveness and combination of interventions that drive performance in Rwanda rather than a single health systems strengthening intervention or a set of interventions that target a specific disease. It emerges also that factors beyond the health system are significantly contributing to the health system to improve life of mothers and newborns, such as the widespread determination of civil servants to increase their performance and achieve targets. This determination appears multi-leveled and influenced by both intrinsic and extrinsic motivation.
Community health workers (CHWs), community based health insurance (CBHI) and performance contracts were found to be the factors that have contributed most to Rwanda's remarkable achievements in the past decade.
Among factors areas that needed improvement for the Rwanda health system, this thesis realized that water supply & sanitation need to be improved, as well as several individual cognitive-behavioural factors, such as the general public's increased awareness of health risks, improved literacy levels (in particular among women), increased child spacing (lower levels of fertility), and more conducive individual behaviour and personal protection against health hazards.

Performance disparities between districts

This thesis reveals that access to health facilities is being increased through district-level initiatives to financially support people who are unable to pay for health services and this was possible due to a strong interconnection between local leaders and health facilities. Districts with local administration playing a key role in organizing the decentralized level to create social saving schemes for supporting needed population has been identified as contributor to

the use of health services. The thesis identifies issues with migrant's participation in seeking health services and adherence to health insurance, especially in districts close to Rwandan borders, and links this to the low use of health services and poor health outcomes in those districts. Context factors such as hilly topography and bad road status are considered as limiting geographic access to maternal health services and this is more complicated in districts with high populations and health facilities not well distributed.

Incidence, characteristics and determinants of severe maternal outcome and newborn deaths

The severe maternal outcome (maternal death and near miss combined) incidence ratio in the four selected district hospitals was 38.4 per 1000 livebirths and the maternal near-miss incidence ratio 36 per 1000 livebirths. Lack of social support was found to be associated with the occurrence of severe maternal outcomes where more cases were seen among unmarried women (15% versus 5.6% in controls) and unemployed women (4.2% versus 0.2% in controls). In addition, lack of social support contributes to the occurrence of neonatal death where women who came unaccompanied to the health facility to deliver (aOR: 1.6) and death of both parents (aOR: 4.7) were more common among cases than in controls. Women aged less than 20 years (7.3 % vs 3.5% in controls) and more than 35 years (28.4% vs 12.6% in controls) were also found to be at risk of developing a severe maternal outcome: their vulnerability was greater in case of non-use of preventive services, as only 27.4% of women with severe maternal outcomes had attended any antenatal care visit.

Postpartum haemorrhage continues to be the top cause of both maternal mortality and severe morbidity, with 22.7% of all deaths in the 5 years retrospective study of maternal death audits and 23.4% of all severe maternal outcomes. The postpartum haemorrhage as a highly preventable cause of maternal death was associated with a high case fatality rate (8%), and the same was true for hypertensive disorders (10.5%). The prospective case-control of severe maternal outcomes at district hospitals resulted in a hospital-based maternal mortality ratio was 233 of per 100,000 live births (95% CI 110–360), with a mortality index (MI) of 6.1% (95% CI 2.9–9.3). This formed the basis to make recommendations for better management of similar cases, and reduce some of the top causes of maternal mortality. Despite the widespread use of life saving interventions, women continue to die and experience severe obstetric conditions that can be prevented. It indicates that even though the use of life saving interventions may be appropriate, it is not sufficient solely, as this thesis finds that 61% of contributing factors to maternal death are due to failure within the health system. The consequence of poor quality of care around delivery is also contributing to neonatal deaths where 11.3% were due to birth asphyxia because of substandard management of delivery and failure to observe infection control principles leading to neonatal sepsis (5.6%).

The implementation of recommendations made during the review of death audit should be prioritized and well monitored. Among them improvement of quality of care provided to mothers during antenatal care, delivery period and in postpartum period and adherence to protocols and standards for essentials obstetric and neonatal care. Improvement of referral practices and certain types of infrastructure, especially blood banks, would ensure truly

comprehensive emergency obstetric care and reduce the occurrence of severe maternal outcome.

This thesis reveals that the non-use of health facilities is still associated with newborn death due to some obstetrical conditions that are part of the emergency obstetric and neonatal care services provided at health facility level, like multiple gestation (aOR: 2.1), as well as the non-use of preventive services like family planning (aOR: 0.8). Respectful maternity care during labour and childbirth should be provided to all women for better experience of labour and childbirth to improve the perception of health services by clients.

Conclusion

Despite the performance realized in improving maternal health, Rwanda still experience high maternal and newborn mortality and further improvement is needed to achieve the sustainable development goals 3.1 and 3.2. This can be done by sustaining factors that have contributed to strengthening the health sector, such as the community health program and community-based health insurance, but also by addressing the quality of maternal and newborn across the continuum of care. Provision of respectful maternity care to improve the perception of health services by clients should also be prioritized.

The planning process for an equitable distribution of financial and infrastructural resources should consider regional particularities and be guided by geographic features and population data, as well as the actual use of health facilities and services.

Further analyses are needed on the factors beyond the health sectors that can be improved for better maternal health outcome. The current WHO health system framework with its model of six building blocks needs to consider setting context and factors beyond the health sector. Maternal deaths and near miss cases should be scrutinised whenever they occur in order to close the information gaps and inform remedial action.

SAMENVATTING

De vijfde Millenniumdoelstelling van de Verenigde Naties die de verbetering van de gezondheid van moeders nastreefde is niet gehaald. Tussen 1990 en 2015 is de maternale sterfte wereldwijd gedaald met 44%, van 385 gevallen per 100,000 levend geboren kinderen, tot 216. De regionale verschillen zijn alarmerend: lage- en midden-inkomenslanden nemen 99% van alle gevallen van maternale sterfte voor hun rekening, waarvan 66% in Afrika ten zuiden van de Sahara, gevolgd door de regio Zuid-Azië. De Agenda 2030 voor duurzame ontwikkeling bevat 17 ontwikkelingsdoelen (SDG). Eentje daarvan (SDG 3.1) betreft het terugdringen van de wereldwijde maternale sterfte ratio tot minder dan 70 gevallen per 100.000 levend geboren kinderen. Dit impliceert een reductie van gemiddeld 7,5% per jaar over een periode van 15 jaar (2016 – 2030). Dat is meer dan drie keer de gemiddelde jaarlijkse afname in de 25 jaar die er aan voorafgingen (1990 – 2015). Het bereiken van SDG 3.1 en het uiteindelijk beëindigen van vermijdbare maternale sterfte vergt dus een extra inspanning ten opzichte van wat er al is ondernomen na de millenniumverklaring in het jaar 2000.

De genocide die in 1994 plaatsvond, vooral gericht tegen de Tutsi bevolking, heeft het nationale gezondheidssysteem in Rwanda volledig ontwricht. Veel van de infrastructuur werd verwoest en een groot deel van het gezondheidspersoneel kwam om het leven. Nadat de vrede was hersteld is de Rwandese overheid begonnen met de wederopbouw van het gezondheidssysteem. In 1995 bracht de overheid een beleidsnotitie uit en in 2000 werd een begin gemaakt met een herstructurering en decentralisering van overheidstaken.

Sindsdien heeft Rwanda opmerkelijke resultaten geboekt. De maternale sterfte is in 15 jaar afgenomen van 1071 tot 210 gevallen per 100.000 levendgeborenen, zoals aangetoond in de *demographic and health surveys* uitgevoerd in 2010 en 2015. Een soortgelijke trend is waargenomen in het gebruik van zorg, met een stijging van het aandeel bevallingen in ziekenhuizen en klinieken van 68% in 2010 tot 91% in 2015. Dit heeft er mede toe bijgedragen dat Rwanda één van de weinige landen is geweest die juist wél de beoogde afname van 75% in maternale sterfte tussen 1990 en 2015 hebben bereikt. Onderzoekers hebben dit succes toegeschreven aan diverse initiatieven, zoals de invoering van een ziektekostenverzekering, het *community health* programma en prestatieafhankelijke beloning van personeel binnen de gezondheidszorg.

Aanleiding voor het onderzoek

Ondanks de successen in de moeder- en kindzorg gedurende de laatste 15 jaar is Rwanda nog steeds een van de landen met een hoge maternale sterfte. Sterfte gerelateerd aan zwangerschap en geboorte komt nog steeds veel voor en zou sneller teruggebracht moeten worden wil de wereldwijde SDG doelstelling in 2030 behaald worden. Een beter begrip van de factoren die bepalend zijn geweest voor de verbetering in de laatste 15 jaar en van de verdere mogelijkheden tot verbetering is belangrijk voor de toekomst – met name kennis van de factoren die leiden tot maternale sterfte en zogeheten *near-miss*, en van de huidige variatie in deze indicatoren tussen districten. De algehele doelstelling van deze dissertatie is om

gezondheidssysteemfactoren te identificeren en in hun context te plaatsen, teneinde de kwaliteit en het gebruik van dienstverlening rondom zwangerschap en bevallingen te verbeteren. Zoals in Hoofdstuk 1 belicht, was de algehele onderzoeksvraag: Wat zijn de gezondheidssysteem determinanten die bepalend zijn voor moeder- en zuigelingenzorg in Rwanda?

Om deze vraag te kunnen beantwoorden zijn er vijf studies ondernomen, daarbij gebruik makend van diverse methoden. Hoofdstuk 2 beschrijft de factoren die door middel van een internet enquête onder districtsdirecteuren gezondheidszorg als bepalend naar voren zijn gekomen voor Rwanda's gezondheidssuccessen. Hoofdstuk 3 verklaart de variatie tussen een viertal districten in gezondheidsuitkomsten onder moeders en zuigelingen door middel van een studie gebaseerd op individuele interviews en *focus group discussions*. Vervolgens komen drie empirische studies aan bod: de eerste betreft een *review* van vijf jaar maternale sterfte audits (Hoofdstuk 4); vervolgens een prospectieve *case-control* studie van ernstige maternale aandoeningen uitgevoerd in vier districtsziekenhuizen (Hoofdstuk 5); en tenslotte een *matched case-control* studie van sterfgevallen onder kinderen jonger dan vijf jaar in twee districten in het oosten van Rwanda (Hoofdstuk 6). Het afsluitende Hoofdstuk 7 bediscussieert de resultaten en trekt een aantal conclusies.

Verklaringen voor het verbeterde gezondheidssysteem

Het is niet één bepaalde maatregel, maar de veelomvattendheid en combinatie van verschillende interventies die bepalend zijn geweest voor de geconstateerde verbeteringen van het gezondheidssysteem in Rwanda. Factoren buiten de zorgsector blijken ook een bijdrage te hebben geleverd aan verbeterde maternale en perinatale gezondheid, zoals bijvoorbeeld de wijdverspreide toewijding van overheidspersoneel om hun prestaties te verbeteren. Deze toewijding is zichtbaar op verschillende niveaus en is zowel intrinsiek als extrinsiek gemotiveerd. Het grote aantal dorpsgezondheidsvrijwilligers, de introductie van een volksverzekering tegen ziektekosten en prestatieafhankelijke beloning van overheidsfunctionarissen blijken allemaal een belangrijke rol te spelen.

Als factoren die verbetering zouden behoeven worden genoemd: drinkwater- en sanitaire voorzieningen, algemene kennis van risicofactoren, geletterdheid (met name onder vrouwen), zwangerschapsspreiding en persoonlijke bescherming tegen gezondheidsrisico's.

Verschillen tussen districten

Het onderzoek wijst uit dat toegang tot zorg voor mensen die niet in staat zijn te betalen wordt vergroot door hen financieel te ondersteunen via lokale initiatieven waarbij nauw wordt samengewerkt tussen lokale leiders en gezondheidspersoneel. In districten waarin het lokaal bestuur burgerspaarsystemen ondersteunt blijkt de benuttingsgraad van gezondheidsdiensten hoger. Verder zijn er in de grensgebieden districten met relatief veel migranten (uit buurlanden) die minder vaak gebruik maken van ziekenhuizen en klinieken en zich ook minder vaak hebben ingeschreven voor een ziektekostenverzekering. In sommige districten blijken omgevingsfactoren, zoals een heuvelachtig terrein, de slechte staat van wegen en ongelijke spreiding van klinieken, toegang tot zorg ook in de weg te staan, en de slechtere gezondheidsuitkomsten – althans voor een deel – te verklaren.

Incidentie, karakteristieken en determinanten van ernstige maternale aandoeningen en neonatale sterfte

De incidentie van ernstige maternale aandoeningen (maternale sterfte en *near-miss* tezamen) in de vier geselecteerde districtsziekenhuizen was 38,4 per 1000 levend geboren kinderen, met een maternale *near-miss* incidentie van 36.0 per 1000 levendgeborenen. Gebrek aan sociale ondersteuning bleek geassocieerd met deze fenomenen, waarbij het percentage ongetrouwde moeders onder degenen met ernstige maternale aandoeningen relatief hoog was (15.0% tegenover 5,6% in de controle groep); hetzelfde gold voor het percentage vrouwen zonder betaald werk (4,2% tegenover 0,2% in de controle groep). Het ontbreken van sociale ondersteuning droeg ook bij aan neonatale sterfte, waarbij het risico groter was onder moeders die zonder begeleiding naar de kliniek kwamen om te bevallen (AOR 4,7) en onder moeders waarvan beide ouders waren overleden (aOR 4,7). Vrouwen jonger dan 20 jaar (7,3% tegenover 3,5% in de controle groep) en degenen ouder dan 35 (28,4% tegenover 12,6%) liepen ook een hoger risico op ernstige maternale aandoeningen. Hun kwetsbaarheid was groter onder degenen die geen gebruik hadden gemaakt van zwangerschapscontroles: slechts 27,4% van degenen met ernstige maternale aandoeningen had op enig moment deelgenomen aan een zwangerschapscontrole.

Overmatig bloedverlies na de bevalling is nog altijd de meest voorkomende oorzaak van zowel moedersterfte als ernstige maternale aandoeningen, verantwoordelijk voor respectievelijk 22,7% en 23,4% van alle geregistreerde gevallen van maternale sterfte geïncludeerd in de retrospectieve studie van 5 jaar maternale sterfte audits. Overmatig bloedverlies en hoge bloeddruk zijn vermijdbaar of kunnen in elk geval behandeld worden, maar desondanks waren zij sterk geassocieerd met maternale sterfte (8.0% en 10,5%, respectievelijk). De gevonden sterfte-index van 6.1 gaf aanleiding tot een aantal aanbevelingen voor verbeterde behandeling van dergelijke gevallen. Ondanks het wijdverspreide gebruik van levensreddende interventies tijdens de bevalling, lopen vrouwen in Rwanda nog steeds grote, doch vermijdbare risico's. Dit onderzoek constateert dat 61% van de factoren die bijdragen tot maternale sterfte te maken hebben met onvolkomenheden binnen het zorgsysteem. Het gevolg van de gebrekkige kwaliteit van zorg tijdens zwangerschappen en bevallingen draagt ook bij tot neonatale sterfte, waarbij 11,3% van de gevallen kan worden toegeschreven aan asfyxie en 5,6% aan neonatale sepsis.

Prioriteit dient verleend te worden aan uitvoering van de aanbevelingen die resulteerden van de review van maternale sterfte audits. De kwaliteit van zorg tijdens zwangerschapscontroles, de bevallingen en de postnatale periode dient te worden verbeterd, met meer aandacht voor het volgen van protocollen en werken conform de geijkte standaarden van essentiële obstetrische en neonatale zorg. Verbetering van doorverwijzingen en van bepaalde vormen van infrastructuur, met name bloedbanken, is cruciaal.

Dit proefschrift laat ook zien dat de onderbenutting van bestaande faciliteiten voor neonatale zorg dient te worden aangepakt, waarbij er sprake is van verhoogde risico's bij meervoudige zwangerschappen (aOR 2,1) en het niet deelnemen aan consultaties voor family planning (aOR 0,8). Meer aandacht voor respectvolle zorg rondom de bevalling en het geboorteproces

zou ten goede komen aan een hogere waardering onder de bevolking en daarmee een frequenter gebruik van de dienstverlening.

Conclusie

Ondanks de vele geconstateerde verbeteringen in maternale gezondheid zijn de maternale en neonatale sterftecijfers in Rwanda nog steeds te hoog. Verdere verbeteringen zijn nodig om de duurzame ontwikkelingsdoelen op dit terrein te halen (SDG 3.1**).** Dit is mogelijk door de reeds bestaande programma's verder te ondersteunen en uit te bouwen, zoals het systeem van dorpsgezondheidsvrijwilligers en de ziektekostenverzekering, alsmede door meer nadruk te leggen op verbetering van de kwaliteit van zorg rondom zwangerschap en geboorte. De verdeling van beschikbare middelen (geld, infrastructuur) dient meer te worden gebaseerd op regionale behoeften, lokale context en het feitelijk gebruik van diensten.

Verdere analyses zijn nodig om de invloed te bepalen van factoren buiten de zorgsector op maternale gezondheid. Het veelgebruikte analyseraamwerk van de WHO, gebaseerd op zes pijlers van nationale gezondheidssystemen, zou meer rekenschap moeten geven van omgevingsfactoren en invloeden van buiten de zorgsector. Maternale sterfte en *near-miss* gevallen dienen nauwlettend te worden onderzocht teneinde de oorzaken op te sporen en gepaste actie te ondernemen.

International Safe Motherhood & Reproductive Health ISM&RH

The Safe Motherhood Series

The "Safe Motherhood Series" is a collection of PhD thesis made in collaboration with members of the Working Party International Safe Motherhood and Reproductive Health (WPISM&RH).

The WPISM&RH aims to contribute to improvement of the reproductive health status of women around the globe, in particular by collaborating with health care workers in low income countries. The working party is part of the Dutch Society of Obstetrics and Gynaecology (NVOG) and the Dutch Society of Tropical Medicin and International Healthcare (NVTG).

The activitities undertaken by members of the WPISM&RH can be grouped into four pillars: education, patient care, research and advocacy. Research activitities are done by (medical) students, medical doctors and many others. Some of these develop into PhD thesis. If a PhD topic meets the objectives of the WPISM&RH, concerns Safe Motherhood and Reproductive Health issues, is mainly performed in low & middle income settings and one member of the WPISM&RH is involved in the project as promotor or co-writer (co promotor), the PhD thesis can be part of the Safe Motherhood series. Dr J van Dillen is board member of WPISM&RH.

The "Safe Motherhood Series" was started in 1995 by Prof Jos JM van Roosmalen and now contains more than 30 thesis. (www.safemotherhood.nl/publicaties-safe-motherhood-serie/).

ACKNOWLEDGEMENTS

I would like to thank the Netherlands Organisation for Scientific Research (NWO/WOTRO), which funded the Maternal Health and Health Systems in South Africa and Rwanda research project (MHSAR) as part of a larger research programme entitled "Global Health Policy and Health Systems" for having funded this research.

Special thanks to Radboud University UMC for giving me the opportunity to pursue my PhD and benefit from remarkable training.

A special thanks to the Rwanda Ministry of Health and Rwanda Biomedical Center for allowing me to pursue my PhD and tolerate my long absence from work for academic reasons and this spite the huge volume of work that was expected from me to fulfil.

I would like to thank my promotor Prof.dr. Koos van der Velden for shaping the direction of my thesis. Thank you for your detailed reviews, suggestions and valuable scientific guidance which were critical for the quality and the success of this thesis. Thank you for your patience, encouragement and the final push for completing the thesis. You have been a great inspiration and wonderful teacher.

To my esteemed co-promotors: Dr. Jeroen van Dillen, thank you for your motivating discussions, and your technical as well as clinical comments to enrich the thesis. Your experience in working in low-income countries in the area of maternal health has been critical to complete my thesis. To Dr. Leon Bijlmakers, you provided me with the tools that I needed to choose the right direction to complete my thesis. I will always be grateful for your support and linkage with other supervisors, including the interactions with Witwatersrand University colleagues working on a similar project. Thank you for your valuable time spent in Rwanda, preparing and supervising my research project.

To my promotor and co-promotors, thank you for making memorable my time spent in Nijmegen in terms of scientific learning and improving my writing skills. My PhD colleagues in Nijmegen: I thank you for the support, encouragement and friendship; you made my stay in Nijmegen enjoyable.

I would like to thank all my co-authors with whom I worked in different articles published or in process of publication for their support, trust and the valuable scientific insights they provided. In particular, I would to thank Dr. Fidele Ngabo, for the coaching you provided at the early stage of my PhD trajectory. Thank you for your support and encouragement to never give up.

To all my colleagues at Rwanda Biomedical Center / Maternal, child and community health division: thank you for your support, especially for standing in for me when I was absent from work for academic reasons.

I also acknowledge with a deep sense of reverence my gratitude towards my brothers and sisters and friends who have always supported me morally. I would like to thank my parents who passed away at the beginning of my PhD trajectory for their love and inspiration to always achieve my educational goal.

Many thanks to my son **Gisa Cyusa** who has been a great source of joy and to my wife Donata for her love, encouragement and patience that kept me believing over years and never give up.

I end my acknowledgement by thanking God for carrying me through this project. I would not have been able to complete it without Him and the prayers of my family members and friends.

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Name PhD candidate: Felix Sayinzoga	**PhD period: May 2013 – *June 2019***
Department: ELG	***Promotor(s): Prof. J. van der Velden***
Graduate School: Radboud Institute for Health Sciences	***Co-promotors: Dr. L. Bijlmakers, Dr J. van Dillen.***

	Year(s)	ECTS
TRAINING ACTIVITIES		
a) Courses & Workshops		
1. Literature searches (Radboud University Nijmegen Medical Library) Introduction to PUBMED	2013	0.1
2. Endnote Workshop (Radboud University Nijmegen)	2013	0.1
3. Mendeley workshop (Radboud University Nijmegen)	2013 2014	0.1 1.0
4. Erasmus Summer Programme, NIHES: Introduction to Data analysis	2014	3.0
5. Summer school- Utrecht: Applied multivariate analysis	2017 2017	0.2 1.75
6. Scientific integrity (Radboud Universiteit Nijmegen)		
7. Writing workshop on MHSAR researchers from South Africa (Witwatersrand University and University of the Western Cape) at Radboud UMC, June 2017	2018	1.75
8. Expanded Program on Immunization Leadership and Management Programme (EPI LAMP)/Yale University: Online mixed with face-to-face sessions course.		
b)Seminars & lectures^		
1. MHSAR consortium meeting in Kigali	2014	0.5
c)Symposia & congresses^		
1. COUNTDOWN TO 2015: Health Systems and Policy and Finance Workshop Windsor Hotel, Nairobi, Kenya, 25-28 February, 2014	2014	1.75
2. 47th session of the commission on population and development/ New York	2014	1.75
3. 5th Annual East African Health and Scientific Conference and Exhibition Concludes in Kampala, Uganda ^	2015 2015	2.25 2.25
4. Global Maternal Newborn Health Conference Mexico City, Mexico^	2015	2.25
5. Rwanda Society of Obstetricians and Gynecologists conference at Lemigo Hotel/ Kigali^	2016	2.25
6. International conference on Family Planning, Nusa Dua, Indonesia ^	2016	1.75
7. FP2020 Anglophone Africa Focal Point Workshop in Kampala, Uganda.	2017	0.25
8. Acting on the call summit in Addis Ababa, Ethiopia	2017	1.75
9. FP2020 Anglophone Africa Focal Point Workshop in	2018	2.25

Lilongwe, Malawi 10. 2017 Pre term birth initiative symposium in San Francisco, California, USA^ 11. SDGC/A Health Conference in Kigali/Rwanda 12. FIGO 2018 - Regional Congress of Middle East & Africa, in Dubai, UAE^ 13. 2018 Preterm Birth Initiative Annual Symposium, in Kigali, Rwanda^ 14. 5th International Conference on Family Planning, in Kigali, Rwanda^	 2018 2018 2018 2018	 0.25 2.25 2.25 4.25
d) Other - ***e.g. journal club*** - ***...*** - ***...*** - ***etc***		
TEACHING ACTIVITIES		
e) Lecturing - ***...*** - ***...*** - ***...*** - ***etc***		
f) Supervision of internships / other • Maartje Kletter, student BioMedical Sciences, Radboud UMC • Richard Supheert, Medical student, Radboud UMC	 11th May to 24th September2015 17th October 2015 to 12th January 2016	 1 1
TOTAL		**39**

^Indicate oral or poster presentation