Antenatal Care: Predictors of Delays and Effectiveness of Targeted Mentorship and Quality Improvement Intervention at Rural Health Centers in Rwanda

by

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A thesis submitted in full fulfilment to the University of Rwanda in accordance with the requirements

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by

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ABSTRACT

Background

Although 98% of women receive antenatal care (ANC) from a skilled provider in Rwanda, only 38% of them have an ANC visit in their first three months of pregnancy. Further, inadequate ANC delivery leads to missed diagnosis of danger signs which often results in poor pregnancy outcomes. This thesis provides evidence on predictors of delayed ANC in Rwanda. We also measured the effect and cost-effectiveness of the Mentorship, Enhanced Supervision and Quality Improvement (MESH-QI), an intervention to improve the quality of ANC at health centers in rural Rwanda.

Methods

We used a multivariate logistic regression model to assess factors associated with delayed ANC. This study included 6,325 women age 15-49. The second study used mixed-effects linear regression model to measure the effect of the MESH-QI on the danger sign assessment score. This study included 330 observation checklists completed at baseline and 292 completed during the MESH-QI intervention. An economic evaluation estimated the cost-effectiveness of the MESH-QI intervention.

Results

Having many children, feeling that distance to health facility is a problem, and unwanted pregnancy were significantly associated with delayed ANC. The second study found that MESH-QI led to significant improvements in danger sign assessments. The incremental cost per ANC visit attributable to MESH-QI with all assessment items completed was 0.70 USD for danger signs and 1.10 USD for vital signs.

Conclusions

Long distance to health facility, unwanted pregnancies, and having many children constitute the major predictors of delayed ANC. This reflects the need to decentralize ANC and birth control services. In the efforts to improve access to essential health services, the government of Rwanda launched a campaign to build community health posts. Future studies should to assess the impact of decentralized services on access and quality of ANC in Rwanda.

DECLARATION

This is to certify that this Thesis has passed through the antiplagiarism system and found compliant and this is the approved final version of the Thesis:

Antenatal care: Predictors of delays and Effectiveness of Targeted Mentorship and Quality Improvement Intervention at Rural Health Centers in Rwanda.

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DEDICATION

A special feeling of gratitude to my loving mother Angele Bagirinka, my beloved wife Delphine Mutesi, and my children; Shawn-Smith Manzi, Julia Manzi, and Joseph-Craig Manzi. Their words of encouragement, prayers, and push for tenacity ring in my ears. This work is also dedicated to my late father Simon Kagano who believed in education as a liberation and best provision for old age.

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My greatest achievement is not the final version of my thesis. It is rather having applied my findings to improve care delivery systems and patient outcomes in Rwanda, Malawi, Haiti, Lesotho, and Liberia. I want to express my appreciation to Dr. Paul Farmer, Dr. Joia Mukherjee, Dr. Sheila Davis, Dr. Peter Drobac, Dr. Evrard Nahimana, and Ms. Cory McMahon for their inspiration and support throughout the implementation of this work.

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LIST OF PAPERS

This thesis is based on the following studies referred to in the text by their Roman numerals.

I. Manzi A, Munyaneza F, Mujawase F, Banamwana L, Sayinzoga F, Thomson DR, Ntaganira J, Hedt-Gauthier B. Assessing predictors of delayed antenatal care visits in Rwanda: A secondary analysis of Rwanda demographic and health survey 2010. BMC Pregnancy Childbirth. 2014;14. doi:10.1186/1471-2393-14-290

II. Manzi A, Nyirazinyoye L, Ntaganira J, Magge H, Bigirimana E, Mukanzabikeshimana L, Hirschhorn RL, Hedt-Gauthier B. Beyond coverage: improving the quality of antenatal care delivery through integrated mentorship and quality improvement at health centers in rural Rwanda. BMC Health Services Research BioMedical Central; 2018;18: 136. doi:10.1186/s12913-018-2939-7

III. Manzi A, Mugunga JC, Nyirazinyoye L, Iyer H, Hedt-Gauthier B, Hirshhorn L, Ntaganira J. Cost-effectiveness of a mentorship and quality improvement intervention to enhance the quality of antenatal care at rural health centers in Rwanda. Accepted for Publication at International Journal for Quality in Health Care. INTQHC-2017-11-0697.

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LIST OF SYMBOLS AND ACRONYMS

ANC	Antenatal care
CI	Confidence interval
DH	District hospital
FANC	Focused antenatal care
HC	Health center
IMAI	Integrated Management of Adolescent and Adulthood Illness
IMCI	Integrated Management of Childhood Illness
ICER	Incremental cost-effectiveness ratio
MDGs	Millennium development goals
MESH-QI	Mentorship, enhanced supervision for healthcare and quality improvement
MoH	Ministry of Health
OR	Odd ratio
PIH	Partners In Health
RDHS	Rwanda Demographic and Health Survey
WHO	World Health Organization

LIST OF FIGURES AND TABLES

GLOSSARY OF TERMS*

Antenatal care coverage (at least one visit): Percentage of women aged 15–49 with a live birth in a given time period that received antenatal care provided by skilled health personnel at least once during their pregnancy (United Nations 2015)

Access to health services (1): The perceptions and experiences of people as to their ease in reaching health services or health facilities in terms of location, time, and ease of approach (Starfield 2001).

(2): Access to health services is a measure of the proportion of a population that reaches appropriate health services. This concept is used to detect inequity in the use of services between different populations defined geographically, socially or in terms of their clinical condition. The measure may also define the level of ease with which access is obtained: for example, the proportion that reaches local health services by the local means of transport in no more than one hour. A distinction has been made between access in the sense of accessibility and actual utilization. In this case access is defined as the cost to the consumer of using health services whether the consumer uses those services or not (World Health Organization 2014).

Universal coverage: Universal access to health services with social health protection (World Health Organization 2013).

Intervention: An activity or set of activities aimed at modifying a process, course of action or sequence of events, in order to change one or several of their characteristics such as performance or expected outcome (World Health Organization 2011).

Outcome: Those aspects of health that result from the interventions provided by the health system, the facilities and personnel that recommend them and the actions of those who are the targets of the interventions (Starfield 2001).

Effectiveness: The extent to which a specific intervention, procedure, regimen or service, when deployed in the field in routine circumstances, does what it is intended to do for a specified population (World Health Organization 2014).

* Adapted from the World Health Organization's Health Systems Strengthening Glossary

Evaluation: The systematic and objective assessment of the relevance, adequacy, progress, efficiency, effectiveness and impact of a course of actions, in relation to objectives and taking into account the resources and facilities that have been deployed (World Health Organization 2014).

Health system: A formal structure for a defined population, whose finance, management, scope and content is defined by law and regulations. It provides for services to be delivered to people to contribute to their health and health care, delivered in defined settings such as homes, educational institutions, workplaces, public places, communities, hospitals and clinics, and may affect the physical and psychosocial environment. A health system is usually organized at various levels, starting at the most peripheral to the state government, known as the community or primary level.

Clinical mentor: Clinical mentor is an experienced clinician-trainer who provides onsite training and consultation on complex cases; supports and enhances high level problem solving, diagnostic, and decision-making skills; leads case discussions; and addresses issues of quality assurance and continuing education. These mentoring activities take place in the context of an ongoing, two-way relationship between the mentor and the clinicians working at the site (I-TECH 2015).

Quality improvement project: A time-limited effort to improve an existing process regarding a specific quantitatively defined problem such as error frequency, cycle-time, etc. A quality improvement project typically hands-off to operations for the control and on-going improvement of the process in question (Tacoma Pierce County 2012).

Continuous quality improvement: An ongoing effort to increase an agency's approach to manage performance, motivate improvement, and capture lessons learned in areas throughout the agency. It is an ongoing effort to improve the efficiency, effectiveness, quality, or performance of services, processes, capacities, outcomes.

1. INTRODUCTION

1.1. Background

Despite remarkable efforts to improve population health outcomes, maternal death remains at the epicenter of global mortality. Approximately 830 women still die every day due to preventable or treatable causes (World Health Organization 2016a). In 2015, the World Health Organization estimated that 303,000 women died from pregnancy-related causes (World Health Organization 2016b). These unacceptable death rates reflect threefold delays, including delays in seeking care, delays in accessing health facilities, and delays receiving appropriate care (Thaddeus & Maine 1994; Calvello et al. 2015). In Africa, the leading causes of maternal deaths include hemorrhage (33.9%), sepsis (9.7%), hypertensive disorders (9.1%), HIV/AIDS (6.2%), and abortion (3.9%) (Say et al. 2014).

Antenatal care (ANC) constitutes an effective strategy to detect and prevent pregnancy complications and perinatal mortality (Hofmeyr & Hodnett 2013). ANC delivery aims at ensuring a healthy mother and healthy baby by monitoring the well-being of both the woman and the fetus during pregnancy, and helping them to make a smooth transition to labor and delivery (Lincetto et al. 2010). However, the ANC package is often limited to tracking the number of visits and basic measurements rather than an opportunity for a comprehensive and individualized assessment of danger signs and prenatal care (Fagbamigbe & Idemudia 2015; Sipsma et al. 2012). In many developing countries, including Rwanda, poor perceptions of ANC quality exacerbate the lack or limited use of ANC services (Hagey et al. 2013; Brighton et al. 2013; Påfs et al. 2015; FA Akanbiemu 2013).

Over the past three decades, an emphasis has been put on interventions to improve ANC coverage, an important indicator widely used by countries to track progress towards Universal Health Coverage (World Health Organization 2017). Despite investments by sub-Saharan countries in ANC services, the proportion of women who attend four or more ANC visits remains stagnant (47%) in 1990, (47%) in 2000, and (49%) in 2014. This slow progress suggests a need for further studies to understand factors that hinder the coverage and quality of ANC services.

Historically, ANC service model was developed in the early 1900s (Drife 2002). The traditional model ANC assumes that frequent visits and classifying pregnant women into low and high risk by predicting the complications ahead of time, as the best way to care for the mother and the fetus. This traditional approach was replaced by focused antenatal care (FANC) — a goal-oriented antenatal care approach, which was recommended by researchers in 2001 and adopted by the World Health Organization (WHO) in 2002. The differences between traditional ANC approach and FANC are outlined below (table 1.1.1).

Table 1.1.1. Basic differences between traditional and focused antenatal care.

Characteristics	Traditional antenatal care	Focused antenatal care
Number of visits	16–18 regardless of risk status	Four for women categorized in the *basic component*s
Approach	*Vertical*: only pregnancy issues are addressed by health providers	*Integrated* with PMTCT of HIV, counselling on danger symptoms, risk of substance use, HIV testing, malaria prevention, nutrition, vaccination, etc.
Assumption	*More frequent* visits for all and categorizing into high/low risk helps to detect problems. Assumes that the more the number of visits, the better the outcomes	Assumes all pregnancies are potentially 'at risk'. *Targeted and individualized* visits help to detect problems
Use of risk indicators	Relies on routine risk indicators, such as maternal height <150 cm, weight <50 kg, leg oedema, malpresentations before 36 weeks, etc.	Does not rely on routine risk indicators. Assumes that risks to the mother and fetus will be identified in due course
Prepares the family	To be solely dependent on health service providers	Shared responsibility for complication readiness and birth preparedness
Communication	*One-way communication* (health education) with pregnant women only	*Two-way communication* (counselling) with pregnant women and their husbands
Cost and time	Incurs much cost and time to the pregnant women and health service providers, because this approach is not selective	Less costly and more time efficient. Since majority of pregnancies progress smoothly, very few need frequent visits and referral

Implication	Opens room for ignorance by the health service provider and by the family in those not labelled 'at risk', and makes the family unaware and reluctant when complications occur	Alerts health service providers and family in all pregnancies for potential complications which may occur at any time

Adapted from reference (The Open University 2017)

1.2. Rwanda's demographics and population health

Rwanda is located in east central Africa. At 26,338 square kilometers (10,169 sq. mi), Rwanda is the world's 149th-largest country (Central Intelligence Agency (CIA) 2017). Rwanda is known as "The Land of a Thousand Hills", it has five volcanoes, 23 lakes and numerous rivers, some forming the source of the River Nile. The country lies 75 miles south of the equator in the Tropic of Capricorn, 880 miles 'as the crow flies' west of the Indian Ocean and 1,250 miles east of the Atlantic Ocean - in the heart of Africa. Rwanda is bordered by Uganda to the north, Tanzania to the east, Burundi to the south and the Democratic Republic of Congo to the west.

The Fourth Rwanda Population and Housing Census reported that the population of Rwanda was 10,515,973 residents, of which 52% were women and 48% men. While 43.3% of the population were aged 15 and under, 53.4% were between 16 and 64. The population density has increased steadily over the years, from 183 inhabitants per square kilometer in 1978 to 272 in 1991, 321 in 2002, and 415 in 2012 (National Institute of Statistics of Rwanda (NISR) [Rwanda] & Ministry of Finance and Economic Planning (MINECOFIN) 2012). Over 85% of the population live in rural areas (National Institute of Statistics of Rwanda - Ministry of Finance and Economic Planning 2012).

To improve population health and wellbeing, the post-1994 genocide against Tutsis era was marked by the implementation of the District Health Strengthening Strategy (MoH 2012).The Rwandan government increased its investment in rebuilding strong health systems as a strategy accelerate its progress towards the universal health coverage.

1.2.1. Overview of the health system

The Rwandan public health is composed of 5 referral hospitals, 42 district hospitals, 465 health centers, and 252 health posts (Republic of Rwanda 2013). Over 90% of the burden of disease is

managed at first level facilities including health centers and health posts (Selvarajah 2013). At community level, community health workers (generally three per village), oversee health promotion and prevention related activities. In some areas, community health workers offer curative services such as basic malaria case management. CHWs are supported by local health centers, which serve approximately 20,000 people and are staffed by nurses, most of whom have a secondary school education level. Health centers provide vaccinations, reproductive and child health services, acute care, and diagnosis and treatment of HIV, tuberculosis, and malaria. District hospitals provide more advanced care, including basic surgical services, such as caesarean sections. District pharmacies procure essential medicines and consumables from a central agency and distribute them to all health facilities within the district (Republic of Rwanda 2011).

1.2.2. Maternal health care in Rwanda

Rwanda has made significant progress in the reduction of maternal mortality. A comparison of the maternal mortality ratios from the 2000, 2005, 2010, and 2014-15, Rwandan Demographic and Health surveys (DHS) demonstrated a steady decline in maternal mortality over the past 15 years (1071, 750, 476 and 210 deaths per 100,000 live births, respectively) (National Institute of Statistics of Rwanda (NISR) [Rwanda] et al. 2015). Such a remarkable decline in maternal mortality qualified Rwanda as one of few sub-Saharan African countries to achieve the 5th Millennium Development Goal. However, there is still a need to cut down the actual maternal deaths which still account for 15% of all deaths of women aged 15-49 (National Institute of Statistics of Rwanda (NISR) [Rwanda] et al. 2015).

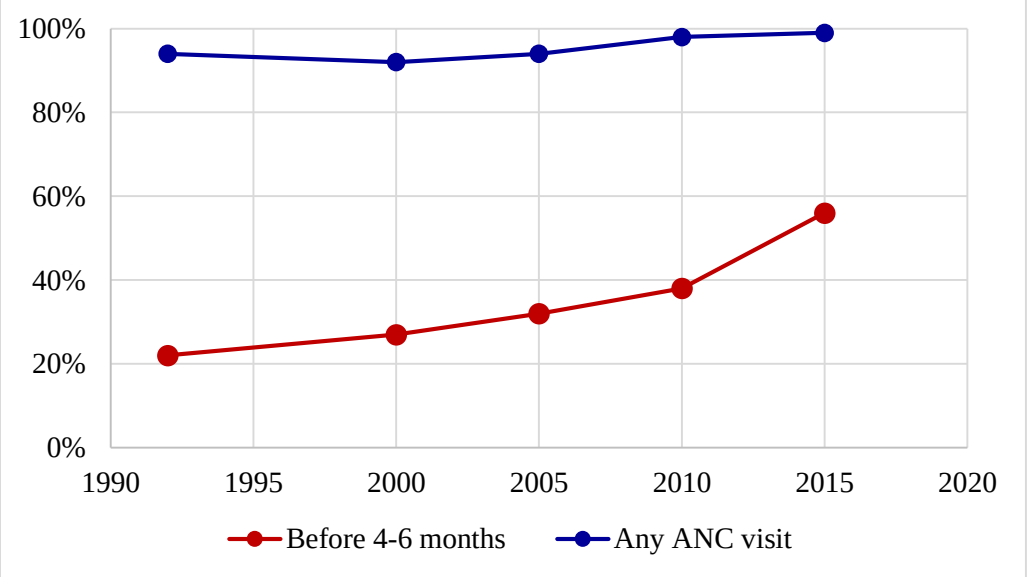
A number of maternal health indicators have been impacted by the national efforts to improve maternal health care delivery. For example, the 2015 DHS reported that more than half of married women were using a contraceptive method (53%), with most women using modern methods (48%). Furthermore, DHS reported substantial increases in the percent of deliveries assisted by a skilled health provider from 69% in 2010 to 91% in 2015.

1.3. Antenatal care: Overview and problem statement

1.3.1. Coverage and quality of antenatal care in Rwanda

Although 99% of women receive at least one antenatal care consult from a skilled health provider, there have been persistent delays in seeking antenatal care (ANC). For example, the DHS 2010 reported that only 38% of women made their first visit before the fourth month of pregnancy with slight improvement to 56% in 2015 (National Institute of Statistics of Rwanda (NISR) [Rwanda] et al. 2015; National Institute of Statistics of Rwanda (NISR) et al. 2010). Figure 1.3.1 illustrates the percent of women with delayed ANC consultation compare to those performing at least one ANC visit over the past fifteen years. In addition to delayed ANC service utilization, previous assessments identified a number of gaps in quality of ANC delivery—from poor assessments of vital signs to inconsistent detection of danger signs and management of pregnancy complications (Sipsma et al.2012).

Figure 1.3.1. Antenatal care visits before first 4-6 months versus any antenatal care visit in Rwanda, 1992-2015



Source: Rwanda DHS 1992-2015

In 2003, Rwanda adopted FANC as a strategy to strengthen the quality of ANC. Unlike traditional ANC, FANC prioritizes the identification of pre-existing health conditions, detection of pregnancy

complications, and promotes birth preparedness and complication readiness planning (table 1.3.1). However, persistent gaps in quality of ANC reflect a need for innovative interventions targeting both ANC providers and care delivery systems.

Table 1.3.1. Essential package of antenatal care at health facility level

- Identification and surveillance of the pregnant woman and her expected child
- Recognition and management of pregnancy-related complications, particularly pre-eclampsia
- Recognition and treatment of underlying or concurrent illness
- Screening for conditions and diseases such as anemia, STIs (particularly syphilis), HIV infection, mental health problems, and/or symptoms of stress or domestic violence
- Preventive measures, including tetanus toxoid immunization, de-worming, iron and folic acid, intermittent preventive treatment of malaria in pregnancy (IPTp), insecticide treated bednets (ITN)
- Advice and support to the woman and her family for developing healthy home behaviors and a birth and emergency preparedness plan to:
    - Increase awareness of maternal and newborn health needs and self-care during pregnancy and the postnatal period, including the need for social support during and after pregnancy
    - Promote healthy behaviors in the home, including healthy lifestyles and diet, safety and injury prevention, and support and care in the home, such as advice and adherence support for preventive interventions like iron supplementation, condom use, and use of ITN
    - Support care seeking behavior, including recognition of danger signs for the woman and the newborn as well as transport and funding plans in case of emergencies
    - Help the pregnant woman and her partner prepare emotionally and physically for birth and care of their baby, particularly preparing for early and exclusive breastfeeding and essential newborn care and considering the role of a supportive companion at birth
    - Promote postnatal family planning/birth spacing

Adapted from reference (Lincetto et al. 2010)

1.3.2. Training and supervision

Globally, didactic classroom trainings remain the common methodology used to training health care professionals. However, evidence from recent evaluations demonstrated that this traditional technique relies on passive instructions, such as reading or lecture known to have little impact of learning outcomes (Bluestone et al. 2013). In Rwanda, most of FANC trainings take place in capital cities, away from health facilities. Apart from being costly, it is challenging for participants to translate such theoretical knowledge into practice. The paucity of learning outcomes is often exacerbated by the lack or poor post-training supervision. For example, Kirehe and Southern

Kayonza district catchment area, two maternal health nurses were assigned to ensure the standard ANC supervision. This included conducting at least one monthly supervisory visit per health center. However, their visits were primarily focused on data collection and reporting, with minimal real-time feedback. Evidence from other settings demonstrated that such traditional supervisions are not sufficient to meaningfully improve the quality of care (Clements et al. 2007; H. H. Leslie et al. 2016).

To strengthen the quality of FANC, an integrated clinical Mentorship, Enhanced Supervision and Quality Improvement (MESH-QI) program was implemented in twenty one health centers served by Kirehe and Rwinkwavu District hospital catchment areas.

1.4. MESH-QI Intervention

The MESH-QI intervention had two main components including 1) provision of intensive, responsive, mentorship and real-time feedback, and 2) using data for continuous quality improvement at health center level with the ultimate goal to improve the quality of care and patient outcomes.

Intensive mentorship at health facility level

Locally trained expert nurses were used as mentors. Mentors conducted HC facility assessments and ensured the presence of necessary equipment, medications, and trained staff. They used clinical observation checklists to assess nurses' knowledge and skills and provide real-time feedback on individual and systems performance.

Data use for continuous systems improvement

MESH-QI mentors were trained in systems gap analysis, prioritization, and development of quality improvement projects. Mentors used data from different sources, including the national health management information system (HMIS) and clinical observation checklists to guide their priority interventions. With mentors' support, data were synthesized, analyzed, and reviewed by facility teams. Mentors facilitated the design and implementation of quality improvement projects using Plan-Do-Study-Act (PDSA) methodology (Manzi et al. 2012; Manzi 2016). Aggregated program data were also analyzed routinely across HCs and districts to monitor changes in quality and

nursing practices, inform future mentoring activities, guide data-driven QI projects, and identify high- or low-performing HCs for changes in support (Anatole et al. 2013). District-wide findings are shared with key HC, district-level, and MESH staff during monthly district reporting and supervision meetings in order to develop joint action plans to address priority issues.

2. AIM

A number of questions remain to address in regards to poor quality and delays in ANC service utilization. What are the predictors of delayed ANC visits in Rwanda? Is MESH-QI a cost-effective intervention to improve the quality of ANC at rural health centers in Rwanda?

The aim of this work is to assess the predictors of delayed ANC and measure the cost-effectiveness of the MESH-QI intervention in rural Rwanda. Specifically, the research seeks to:

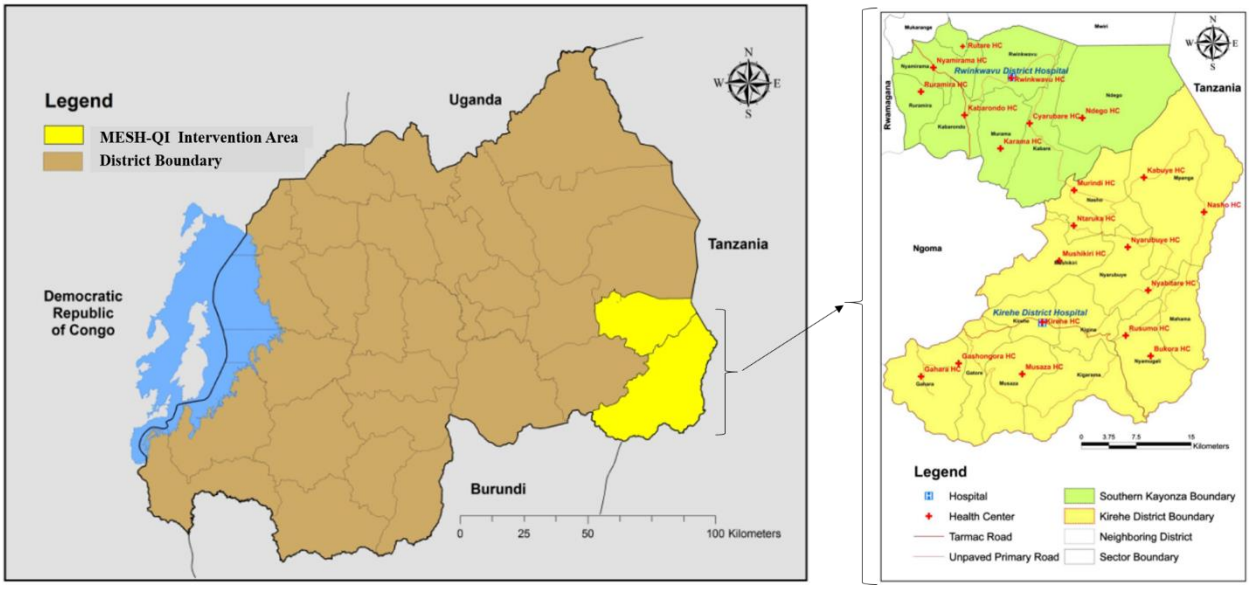
- Identify predictors of delayed ANC, defined as having no ANC visit or having the first ANC visit during the second or third trimester of pregnancy;
- Measure the effect of MESH-QI intervention on the quality of ANC delivery at health centers in Rwanda; and
- Estimate the cost-effectiveness of MESH-QI compared to standard district supervision practices in rural Rwanda.

3. Methodology

3.1. Study setting

While the first study reflects a national representation using RDHS 2010, the second and third studies measuring the effect and cost-effectiveness of the MESH-QI intervention covered 21 rural health centers from Kirehe and Southen Kayonza Districts in Rwanda. Each health center covers a population varying between about 20,000 (Southern Kayonza district) and 24,900 (Kirehe district) and encompasses an average area of 48 km2 in both districts. There are eight HCs in Southern Kayonza District and 13 in Kirehe District (Figure 3.1.1). The mean distance between the district hospital and HCs in Southern Kayonza is 22 km (median 21 km), with similar distances in Kirehe District (mean 26 km and median 23 km).

Figure 3.1.1. Geographic distribution of MESH-QI intervention: HCs and district hospitals in Southern Kayonza and Kirehe districts



Source: Geographic information systems, Partners In Health, 2012.

3.2. Study design

We used cross-sectional and analytical study design to assess the predictors of delayed ANC and measure the effectiveness of the MESH-QI. An economic analysis from the provider perspective was performed to estimate cost-effectiveness of the intervention.

3.3. Study population

The first study included 6,325 women ages 15-49 years who had a pregnancy five years prior to the Demographic and Health Survey (RDHS 2010). The second study included 622 mentor observation checklists; 330 completed at baseline and 292 completed 12-15 months after the start of the MESH-QI intervention.

3.4. Data source

For the first study, social demographic and health data were obtained from the RDHS 2010 dataset. In the second study, quality of care data were extracted from mentor observation checklists which were adapted from Rwandan national ANC screening tool. This form contained the essential ANC assessment items including medical history, screening for seven danger signs (headache, blurry vision, facial swelling, convulsions, bleeding, loss of fluid, and painful contractions), measurement

of vital signs, assessment of fetal well-being, and communication or counseling. Program expenditure reports and budgets were used to estimate the cost-effectiveness of the MESH-QI intervention.

3.5. Sample size

A representative sample of 12,972 households was selected for the 2010 RDHS. The sample was selected in two stages. In the first stage, 492 primary sampling units (PSUs) were selected with probability proportional to the village size. The village size is the number of households residing in the village. A complete mapping and listing of all households existing in the selected villages was conducted. The resulting lists of households served as the sampling frame for the second stage of sample selection. Households were systematically selected from those lists for participation in the survey. All women age 15-49 who were either permanent residents of the households or visitors present in the household on the night before the survey were eligible to be interviewed (National Institute of Statistics of Rwanda (NISR) et al. 2010). This study included 6,325 women who had reported a pregnancy within the last five years prior to the survey.

The second study included all 330 observation checklists completed before the implementation of MESH-QI and 292 completed between February 2012 and November 2012, roughly twelve months after the start of the MESH-QI intervention. All checklists contained the details for essential ANC assessment including vital signs and danger signs.

3.6. Statistical analysis

Delayed ANC was the outcome of first study. This was defined as having no ANC visit or having the first ANC visit during the second or third trimester of pregnancy. Potential predictors were identified based on the conceptual framework. The model building included only variables that were differentially distributed among women who did and did not have delayed ANC ($p<0.05$ in the design-adjusted Chi-squared). A manual backward stepwise regression was used to develop a multivariable logistic regression model of predictors of delayed ANC in Rwanda. Only factors significant at the $\alpha=0.05$ level were retained in the final model except age and place of residence which were considered by the study team as potential confounders. Analysis was completed in Stata v12, with svyset commands to apply inverse probability weights that account for

oversampling of urban PSUs, and to adjust for clustering of observations within PSUs and stratification by district. Odds ratios (ORs) and 95% confidence intervals were reported.

Danger sign assessment score was the outcome of the second study. This calculated based on equal weighting of the completion of each of the seven key danger sign assessments (0 indicating no danger sign was assessed and 7 indicating that all seven danger signs were assessed). Interaction terms were used to determine whether the intervention district, completion of FANC training, level of nurse-mentee's education, or type ANC visit (first or non-first ANC visit) modified the effect of the MESH-QI intervention. The interaction term was included in the final model if the interaction term variable was significant at the α=0.05 level in bivariate analyses. A mixed-effects linear regression analysis was performed to assess the effect of MESH-QI on the danger sign assessment score, controlling for the following potential confounders. Data were analyzed using Stata v12 (College Station, TX: StataCorp LP).

Finally, the third study estimated the incremental cost per ANC visit with complete danger sign and vital sign assessments. The effectiveness measure was completion of seven danger signs and four vital signs assessment items during ANC visits at baseline and after MESH-QI intervention as reported by the second study. The Costs to train mentors, salaries and benefits, transport and equipment were estimated in 2011USD from the provider perspective using both top-down and bottom-up approaches. The annual implementation costs and the incremental cost-effectiveness ratio (ICER) were estimated.

Equation 1: ICER = (Cb - Cf) / (Qb - Qf); where: C_b is the cost per ANC targeted mentorship assuming standard supervision; C_f is the cost per ANC targeted mentorship reflecting MESH-QI; Q_b is the % of ANC visits during the standard supervision period with complete danger signs or complete vital signs assessments and Q_f is the % of ANC under MESH-QI with complete danger signs or vital signs assessments.

To account for uncertainty in the patient volume, we performed a sensitivity analysis and modeled the ICER while varying number of ANC cases consulted. We considered two extreme scenarios including 100% decrease of ANC visits from the actual scenario with 0% ANC coverage and 100% increase of ANC visits from the actual scenario with almost 100% coverage to provide sensitivity bounds for our results.

3.7. Ethical Consideration

This study is covered through Population Health Implementation and Training Partnership research protocol approved by the Rwanda National Ethics Committee (RNEC 032/RNEC/2012) and Partners Institutional Review Board in Boston, MA (2009-P-001941/11; BWH). Names and other personal identifiers were excluded from datasets extracted for the analyses.

4. RESULTS

This section summarizes main findings of the above described studies including: 1) predictors of delayed antenatal care in Rwanda, 2) the effect of the MESH-QI on the quality of antenatal care, and 3) cost-effectiveness of the MESH-QI to improve ANC at health centers in rural Rwanda.

4.1. Predictors of delayed antenatal care in Rwanda (Paper I)

Of the 6,325 women that had reported being pregnant the last 5 years, 6,211 attended a health facility for their first ANC during the last pregnancy. Among them 3,797 women (61.1%, 95% CI: 59.3%, 62.7%) had a delayed first visit.

4.1.1. Relationships between demographic characteristics and delayed antenatal care

A bivariate analysis reported the following factors, significantly associated with delayed ANC: number of children ($p<0.001$), area of residence ($p=0.018$), place of ANC ($p<0.001$), marital status ($p=0.012$), type of health insurance ($p<0.001$), problem with distance to health facility ($p=0.002$), unwanted pregnancy ($p<0.001$), age ($p<0.001$), wealth status ($p<0.001$), woman's education level ($p<0.001$), partner's education level ($p<0.001$), woman's employment status ($p<0.001$), partner's employment status ($p<0.001$), and access to TV or radio at least once a week ($p=0.003$). Also, combining marital, education and employment status, we found that having an employed partner with at least secondary education was associated with delayed ANC. Table 4.1.1 describes bivariate relationships between demographic characteristics and delayed ANC in Rwanda.

Table 4.1.1 Relationships between Demographic Characteristics and Delayed ANC

Characteristic	N	%[95% CI]		P-value
Age group				<0.001
15-24	1,251	56.8	[53.6,60.1]	
25-34	3,235	60.3	[58.2,62.4]	
35-44	1,526	65.2	[62.5,67.8]	
45+	269	65.6	[59.7,71.2]	
Residence				0.018
Urban	806	55.9	[51.4,60.4]	
Rural	5475	61.8	[60.0,63.6]	
Number of children				<0.001
1-3	3,571	56.6	[54.5,58.6]	
4-6	1,850	66.0	[63.4,68.5]	
7+	860	68.9	[65.4,72.2]	

Table 4.1.1 Demographic Characteristics and Delayed ANC in Rwanda (continued)

Characteristic	N	%[95% CI]		P-value
Place of antenatal care				<0.001
Health center	5,799	61.6	[59.9,63.3]	
Home or other	20	67.0	[49.3,80.9]	
Dispensary/Health post	103	69.9	[58.6,79.2]	
District Hospital	239	56.3	[48.2,64.1]	
Private hospitals/clinics	56	19.8	[10.7,33.5]	
Referral hospitals	53	40.4	[28.6,53.3]	
Married				0.012
No	2682	63.0	[60.7,65.3]	
Yes	3599	59.5	[57.5,61.5]	
Type of health insurance				<0.001
No	1,657	66.6	[63.9,69.2]	
Mutuelle	4402	60.2	[58.4,62.0]	
RAMA_MMI and Others	194	31.2	[24.3,39.1]	
Problem with distance				0.002
No	4577	59.6	[57.8,61.5]	
Yes	1702	64.8	[61.9,67.6]	
Pregnancy				<0.001
Wanted	3600	56.8	[54.7,58.9]	
Unwanted	2679	66.8	[64.7,68.8]	
Wealth index				<0.001
Poorest	1427	64.2	[61.2,67.1]	
Poorer	1335	62.7	[59.9,65.5]	
Middle	1230	62.1	[58.8,65.4]	
Richer	1177	62.0	[58.9,64.9]	
Richest	1112	52.7	[49.3,56.1]	
Women education secondary or higher				<0.001
No	5665	62.3	[60.6,64.0]	
Yes	616	49.4	[45.3,53.5]	
Husband with secondary or higher education				<0.001
No	5,150	62.4	[60.6,64.1]	
Yes	672	49.5	[45.3,53.7]	
Not married	457	62.9	[57.8,67.9]	
Women's employment status				<0.001
Informal sector / Not working	5,668	62.3	[60.5,64.0]	
Formal sector	605	50.0	[45.4,54.6]	
Partner's employment status				<0.001
Informal sector / Not working	4,496	62.4	[60.5,64.3]	
Formal sector	1,316	55.5	[52.4,58.6]	
Not married	457	62.9	[57.8,67.9]	

Table 4.1.1. Demographic Characteristics and Delayed ANC in Rwanda (continued)

Characteristic	N	%[95% CI]		P-value
Current marital status				0.277
Never in union	457	62.9	[57.8,67.9]	
Married/living with partner	5,234	60.6	[58.8,62.4]	
Widowed and/or separated	590	63.7	[59.7,67.5]	
Husband's education and employment status				
Not Married	457	62.9	[57.8,67.9]	0.003
Employed partner with secondary education	413	45.3	[40.0,50.6]	
Employed partner without secondary education	903	60.2	[56.8,63.5]	
Unemployed partner with secondary education	257	56.1	[49.5,62.5]	
Unemployed partner without secondary education	4,239	62.8	[60.9,64.7]	
Knowledge of ovulatory cycle				0.072
Yes	768	57.8	[53.8,61.7]	
No	5,510	61.5	[59.7,63.2]	
TV or Radio at least once a week				0.003
No	2,114	63.8	[61.4,66.1]	
Yes	4,161	59.7	[57.7,61.6]	

4.1.2. Factors associated with women's delay to the first antenatal care visits in Rwanda

A reduced model of the multivariate logistic regression reported several factors associated with delayed ANC including having 4-6 children (OR=1.42, 95% CI: 1.22, 1.65) or more than 6 children (OR=1.57, 95% CI: 1.24, 1.99) versus 1-3 children; feeling that distance to health facility is a problem (OR=1.20, 95% CI: 1.04, 1.38); and having an unwanted pregnancy (OR=1.41, 95% CI: 1.26, 1.58). Different factors were associated with receiving ANC during the first trimester: having an ANC at a private hospital or clinic (OR=0.29, 95% CI: 0.15, 0.56) versus a public health center; being married (OR=0.85, 95% CI: 0.75, 0.96), and having public mutuelle health insurance (OR=0.81, 95% CI: 0.71, 0.92) or another type of insurance (OR=0.33, 95% CI: 0.23, 0.46) versus no insurance (table 4.1.2).

Table 4.1.2. Multivariate Logistic Regression Model With Odds Ratios, P-value and Confidence Intervals for Women's Delay to the First Antenatal Care Visits in Rwanda

	FULL				REDUCED			
Characteristics	**OR**	***P***	**95% CI**		**OR**	***P***	**95% CI**	
Age group								
15-24	1.00				1.00			
25-34	1.14	0.107	[0.97	1.34]	1.13	0.120	[0.97	1.33]
35-44	1.08	0.462	[0.87	1.34]	1.08	0.486	[0.87	1.33]
45+	0.94	0.741	[0.67	1.33]	0.94	0.732	[0.67	1.33]
Place of residence								
Urban	1.00				1.00			
Rural	0.87	0.245	[0.68	1.10]	1.03	0.760	[0.84	1.26]
Number of children								
1-3	1.00				1.00			
4-6	1.41	<0.001	[1.22	1.65]	1.42	<0.001	[1.22	1.65]
7+	1.55	<0.001	[1.22	1.97]	1.57	<0.001	[1.24	1.99]
Place of antenatal care								
Health center	1.00				1.00			
Home or other	2.10	0.137	[0.79	5.57]	1.63	0.200	[0.77	3.47]
Dispensary/Health post	1.50	0.118	[0.90	2.48]	1.47	0.130	[0.89	2.43]
District Hospital	0.96	0.808	[0.69	1.33]	0.94	0.734	[0.68	1.32]
Private hospitals/clinics	0.33	0.001	[0.17	0.65]	0.29	<0.001	[0.15	0.56]
Referral hospitals	0.72	0.200	[0.43	1.19]	0.65	0.093	[0.40	1.07]
Married								
No	1.00				1.00			
Yes	0.86	0.028	[0.76	0.98]	0.85	0.012	[0.75	0.96]
Type of health insurance								
No	1.00				1.00			
Mutuelle	0.81	0.003	[0.71	0.93]	0.81	0.002	[0.71	0.92]
RAMA, MMI, and Others **	0.43	<0.001	[0.29	0.64]	0.33	<0.001	[0.23	0.46]
Distance to health facility								
No	1.00				1.00			
Yes	1.19	0.017	[1.03	1.37]	1.20	0.012	[1.04	1.38]
Pregnancy								
Wanted	1.00				1.00			
Unwanted	1.41	<0.001	[1.25	1.58]	1.41	<0.001	[1.26	1.58]
Wealth index								
Poorest	1.00							
Poorer	0.97	0.707	[0.82	1.14]				
Middle	0.99	0.951	[0.82	1.20]				
Richer	0.99	0.900	[0.81	1.21]				
Richest	0.86	0.254	[0.67	1.11]				

Table 4.1.2. Multivariate Logistic Regression Model With Odds Ratios, P-value and Confidence Intervals (continued)

	FULL				REDUCED			
Characteristics	**OR**	***P***	**95% CI**		**OR**	***P***	**95% CI**	
Women with secondary school education or higher								
No	1.00							
Yes	0.94	0.565	[0.75	1.17]				
Women's employment status								
Informal sector / Not working	1.00							
Formal sector	0.84	0.100	[0.68	1.03]				
Partners' Education employment status								
Not Married	1.00							
Employed partner with secondary education	0.76	0.156	[0.53	1.11]				
Employed partner without secondary education	0.98	0.889	[0.74	1.30]				
Unemployed partner with secondary education	0.91	0.593	[0.63	1.30]				
Unemployed partner without secondary education	0.97	0.814	[0.76	1.25]				
Knowledge of ovulatory cycle								
Yes	1.00							
No	1.00	0.957	[0.84	1.20]				
TV or Radio once a week								
No	1.00							
Yes	0.98	0.720	[0.86	1.11]				

1.5. 4.2. Effect of MESH-QI on quality of antenatal care in Rwanda (Paper II)

4.2.1. Demographics and case-observation characteristics

A total of 330 baseline visits performed by 45 different nurses were observed. Follow up observations included 292 visits conducted by 35 different nurses. The number of nurses who had received FANC training varied over time; at baseline, 20 (44%) out of the 45 nurses had been trained in FANC compared to 21 (60%) out of 35 during follow-up period. Forty-three nurses (96%) at baseline had an A2 (high school) education compared to 32 (91%) during follow-up period. The remaining nurses had A1 (two to three years of post-secondary education as defined by the Rwanda Education Council) education.

4.2.2. Completeness of antenatal care assessments before and after MESH-QI intervention

We found significant improvement in completion each of the seven danger sign assessment items (headache, blurry vision, facial swelling, convulsions, bleeding, loss of fluid and painful contractions) at follow-up compared to baseline (p<0.001). The improvement in women with all danger signs assessed significantly improved from 2.1% at baseline to 84.0% at follow-up (p<0.001). Significant improvements were also found across other ANC assessment items (table 4.2.1). Observed ANC visits where nurses checked all vital signs and fetal wellbeing assessment items (fundal height, heart rate, movement, and position) improved significantly (1% to 55%, 37% to 89%, respectively, p<0.001). Completeness of counseling improved significantly as well (2.2% to 51.0%, p<0.001). Medical history assessment including previous surgeries, current medications, use of traditional medications, tobacco, and alcohol, domestic violence, and checking and documenting HIV status had less improvement, although the change was significant (2.1% to 14.0%, p<0.001). No significant improvement was seen in proportion of observed cases assessed for previous surgery (28% to 29%, p=0.796). The assessment of fetal heart rate remained high at both baseline and follow-up period (98% to 97%, p=0.914).

Table 4.2.1. Completeness of ANC assessments before and after MESH-QI intervention

	Baseline		Follow-up		P-value
	n	%	n	%	
Danger signs					
Headache	79	24.0	278	95.2	< 0.001
Blurry vision	77	23.3	278	95.2	< 0.001
Facial swelling	184	56.0	290	99.3	< 0.001
Convulsions	57	17.3	275	94.1	< 0.001
Bleeding	134	41.0	285	98.0	< 0.001
Loss of fluid	76	23.0	267	91.4	< 0.001
Painful contractions	91	28.0	264	90.4	< 0.001
Composite	7	2.1	246	84.2	< 0.001
Medical history					
Previous surgeries	92	28.0	85	29.0	0.734
Current medications	11	3.3	41	14.0	< 0.001
Traditional medications/herbs	7	2.1	41	14.0	< 0.001
Tobacco use	8	2.4	38	13.1	< 0.001
Alcohol	10	3.0	39	13.5	< 0.001
Domestic violence	17	5.2	36	12.5	0.001
HIV status checked and documented	66	42.0	80	86.0	< 0.001
Composite	7	2.1	40	14.0	< 0.001

Table 4.2.1. Completeness of ANC assessments before and after MESH-QI (continued)

	Baseline		Follow-up		P-value
	n	%	n	%	
Vital signs					
Temperature	85	26.0	213	74.0	< 0.001
Blood pressure	289	88.0	288	99.0	< 0.001
Pulse	111	34.0	273	93.5	< 0.001
Respirations	13	4.0	172	60.0	< 0.001
Composite	3	1.0	160	55.0	< 0.001
Fetal well being					
Fundal height†	167	98.0	199	100.0	0.030
Heart rate (BCF)†	167	98.0	194	97.5	0.914
Movement (after 20 weeks)†	80	47.0	197	99.0	< 0.001
Position (after 36 weeks)‡	82	95.4	89	98.0	0.367
Composite	121	37.0	259	89.0	< 0.001
Counseling					
Needed supplies are available	224	68.0	215	75.0	0.050
Counseling occurs in private room	304	92.1	288	99.0	< 0.001
Makes eye contact with woman	291	88.1	287	98.2	< 0.001
Speaks to woman in respectful manner	316	96.0	289	99.0	0.014
Uses words that woman can understand	294	89.0	285	98.0	< 0.001
Concrete response provided	78	24.0	199	68.0	< 0.001
Explains all medical procedures	44	13.3	269	93.4	< 0.001
Composite	7	2.2	149	51.0	< 0.001

4.2.3. Relationship between demographic characteristics and danger sign assessment score and mentoring period, stratified by demographics characteristics

Although we found significant improvement across intervention districts, the effect of MESH-QI on the danger sign assessment score was modified by district and type of ANC visit (p-value for interaction<0.001). No significant interaction was found between the effect of MESH-QI and FANC training (p=0.436) and level of mentee's education (p=0.101). Table 4.2.2 reports relationships between demographic characteristics and danger sign assessment score.

Table 4.2.2. Relationship between demographic characteristics and danger sign assessment score and mentoring period, stratified by demographics characteristics

Predictors	Bivariate analysis		P-value for interaction term
	Changes in ANC Assessment Score	95 % CI	
District			<0.001
Southern Kayonza			
Baseline	Ref.		
Post-MESH-QI	6.06	[5.43, 6.69]	
Kirehe			
Baseline			
Post-MESH-QI	3.88	[3.46, 4.30]	
FANC Training			0.436
Received FANC Training			
Baseline	Ref.		
Post-MESH-QI	4.75	[4.15, 5.35]	
Did not receive FANC training			
Baseline	Ref.		
Post-MESH-QI	4.47	[4.03, 4.91]	
Level of education			0.101
High education			
Baseline	Ref.		
Post-MESH-QI	5.90	[4.27, 7.54]	
Secondary education			
Baseline	Ref.		
Post-MESH-QI	4.50	[4.13, 4.87]	
ANC visit			<0.001
First ANC visits			
Baseline	Ref.		
Post-MESH-QI	5.05	[4.53, 5.57]	
Other ANC visits			
Baseline	Ref.		
Post-MESH-QI	3.84	[3.38, 4.30]	

4.2.4. Changes in danger sign assessment score post-MESH-QI intervention

After controlling for level of mentee's education and FANC training and clustering at nurse level, the MESH-QI intervention remained associated with significant improvement in the danger sign assessment score. However, the effect of the MESH-QI on the danger sign assessment score was different for each district and type of ANC visit: For Southern Kayonza District, the predicted increase in danger sign assessment score under MESH-QI was 6.28 (95% CI: 5.59, 6.98; p<0.001) for non-first ANC visits, and 5.39 (4.62, 6.15; p<0.001) for first ANC visits. For Kirehe District, the predicted increase in danger sign assessment score was 4.20 (95% CI: 3.59, 4.80; p<0.001) for non-first ANC and 3.30 (95% CI: 2.80, 3.81; p<0.001) for first ANC visits. Table 4.2.3 reports results the effect of the MESH-QI intervention on danger signs assessment score by intervention district and type of ANC visit.

Table 4.2.3. Changes in danger sign assessment score post-MESH-QI intervention*

	Changes in assessment score	95% CI
The effect of MESH-QI, Kirehe, non-first ANC	4.20	[3.59, 4.80]
The effect of MESH-QI, Kayonza, non-first ANC	6.28	[5.59, 6.98]
The effect of MESH-QI, Kirehe, first ANC	3.30	[2.80, 3.81]
The effect of MESH-QI, Kayonza, first ANC	5.39	[4.62, 6.15]

* Controlling for FANC training and level of mentee's education.

4.3. Cost-effectiveness of the MESH-QI intervention (Paper III)

4.3.1. Annual implementation costs for ANC supervision and MESH-QI program

We found that total annual costs of standard ANC supervision alone was 10,777.21 USD at the baseline, whereas the total costs of MESH-QI for ANC was 19,656.53 USD over one year. MESH-QI team salary and benefits and transportation constituted the major cost category, accounting for 48.3% and 15.3% of the total program expenses. Trainings for mentors, data management, and equipment costs were the other considerable cost drivers at 12.9%, 6.5%, and 6.5%, respectively. The rest of program costs included M&E, feedback meetings and organizational costs. Table 4.3.1 gives a breakdown of the annual programmatic costs at baseline and intervention period.

Table 4.3.1. Annual Implementation Costs for ANC supervision and MESH-QI program

Input category	Amount at baseline	%	Amount with MESH-QI	%
Salary and benefits for the manager and mentors	$ 5,352.09	49.7%	$ 9,495.49	48.3%
Trainings (onboarding, refresher)	$ -	0.0%	$ 2,541.61	12.9%
Meetings (debriefing and data sharing)	$ 625.00	5.8%	$ 1,030.35	5.2%
Data management	$ 960.15	8.9%	$ 1,280.20	6.5%
IT equipment	$ 672.54	6.2%	$ 1,273.28	6.5%
Transport costs	$ 2,411.64	22.4%	$ 3,016.00	15.3%
Organizational costs (Overhead)	$ 755.79	7.0%	$ 1,019.60	5.2%
Total	**$ 10,777.21**		**$ 19,656.53**	
Incremental costs			$ **8,879.32**	

4.3.2. Costs of MESH-QI for antenatal care and incremental cost-effectiveness ratio

The cost of MESH-QI per ANC visit was 1.67 USD. The ICER per ANC visit with complete assessment was 0.92 USD for danger signs and 1.40 USD for vital signs. Table 4.3.2 reports the incremental costs of MESH-QI for the provision of ANC services during the costing period.

Table 4.3.2. Costs of MESH-QI in relation to Antenatal care and ICER

	Baseline	Follow-up	Difference
ANC mentoring visit	$0.92	$1.67	$0.76
N (total ANC visits during the 1-year costing period)	11,760	11,760	
Costs for the 1-year ANC patient cohort	$10,777.21	$19,656.53	$8.879.32
Danger signs:			
Complete assessment (%)	2.1%	84.2%	
Modeled-completely assessed	247	9902	9655
Incremental cost-effectiveness ratio			$0.92
Vital signs:			
Complete assessment (%)	1.0%	55.0%	
Modeled-completely assessed	118	6468	6350
Incremental cost-effectiveness ratio			$1.40

4.3.3. Sensitivity analysis

A sensitivity analysis found that ICER fell as annual number of ANC visits increased. A tripling of annual ANC visits led to over a 50% reduction in ICER for complete danger signs and vital

signs assessments, respectively from 0.92 USD to 0.46 USD and 1.40 USD to 0.70 USD. The scenario with 50% decline in the annual ANC visits increased the ICER for danger signs from 0.92 USD to1.84 USD and vital signs assessment from 1.40 USD to 2.80 USD.

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RESEARCH ARTICLE Open Access

Assessing predictors of delayed antenatal care visits in Rwanda: a secondary analysis of Rwanda demographic and health survey 2010

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Abstract

Background: Early initiation of antenatal care (ANC) can reduce common maternal complications and maternal and perinatal mortality. Though Rwanda demonstrated a remarkable decline in maternal mortality and 98% of Rwandan women receive antenatal care from a skilled provider, only 38% of women have an ANC visit in their first three months of pregnancy. This study assessed factors associated with delayed ANC in Rwanda.

Methods: This is a cross-sectional study using data collected during the 2010 Rwanda DHS from 6,325 women age 15–49 that had at least one birth in the last five years. Factors associated with delayed ANC were identified using a multivariable logistic regression model using manual backward stepwise regression. Analysis was conducted in Stata v12 applying survey commands to account for the complex sample design.

Results: Several factors were significantly associated with delayed ANC including having many children (4–6 children, OR = 1.42, 95% CI: 1.22, 1.65; or more than six children, OR = 1.57, 95% CI: 1.24, 1.99); feeling that distance to health facility is a problem (OR = 1.20, 95% CI: 1.04, 1.38); and unwanted pregnancy (OR = 1.41, 95% CI: 1.26, 1.58). The following were protective against delayed ANC: having an ANC at a private hospital or clinic (OR = 0.29, 95% CI: 0.15, 0.56); being married (OR = 0.85, 95% CI: 0.75, 0.96), and having public mutuelle health insurance (OR = 0.81, 95% CI: 0.71, 0.92) or another type of insurance (OR = 0.33, 95% CI: 0.23, 0.46).

Conclusion: This analysis revealed potential barriers to ANC service utilization. Distance to health facility remains a major constraint which suggests a great need of infrastructure and decentralization of maternal ANC to health posts and dispensaries. Interventions such as universal health insurance coverage, family planning, and community maternal health system are underway and could be part of effective strategies to address delays in ANC.

Keywords: Antenatal care, Delayed, Demographic survey, Rwanda, Predictors

Background

In most developing countries, limited progress towards Millennium Development Goal 5 (75% reduction in the maternal mortality ratio between 1990 and 2015) reflects poor quality health services and socioeconomic challenges which limit access to health care [1]. According to the WHO, 358,000 women died in 2008 and the majority (87%) of deaths occurred in sub-Saharan Africa [2]. Leading causes of maternal deaths, including hemorrhaging, anemia, and hypertension during pregnancy [3], could be averted if detected early.

Utilization of maternal health services is associated with improved pregnancy outcomes [4], including reduced maternal and perinatal mortality [5-8]. When mothers receive prenatal care during the first trimester, early signs of pregnancy complications such as anemia, hypertension, hyperemesis gravidarum, polyhydramnios, ante-partum hemorrhage, gestational diabetes, and urinary tract infections can be detected [9,10]. However, utilization of antenatal care (ANC) services are often limited or delayed in developing countries due to

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demographic, education, culture, and economic factors and geographic barriers [11-13].

Rwanda has achieved a remarkable decline in maternal mortality from 750 to 476 deaths per 100,000 within only five years (2005–2010) [14]. This success is credited to improved health system strengthening through cross-sector collaborations, community-based care, evidence-based policy making, strong partnership with local and central governments and a high level political commitment [15]. As a result, 98% of pregnant women received at least one ANC from a skilled provider in 2010 [14]. Although this is a great success, Rwanda's maternal mortality rate remains in the highest 20% worldwide [16] and only 38% of women have their first ANC visit in the first three months of pregnancy [14]. In the context of progressive health systems strengthening and economic improvement, barriers still remain for timely uptake of ANC care. The goal of this research is to understand factors associated with delayed ANC in Rwanda to better understand limited improvement in this domain.

Methods

The 2010 RDHS is a nationally representative two-stage cluster sample that included 492 primary sampling units (PSUs) and 12,540 households. Data collection occurred between September 26, 2010 and March 10, 2011. Respondents answered detailed questions about their reproductive health histories, reproductive health practices, recent pregnancy experiences, household assets, and access to health services [17]. This study only includes the 6,325 women ages 15–49 years who had a pregnancy in the last five years [14]. If there was more than one pregnancy in the last five years, the outcomes and predictors were based on their last pregnancy.

The primary outcome for this study is delayed ANC, defined as having no ANC visit or having the first ANC visit during the second or third trimester of pregnancy. Based on a conceptual framework (Figure 1), 16 potential predictors of delayed ANC collected in the 2010 DHS were identified: number of children, place of residence, place of ANC, marital status, having health insurance, problem with distance to clinic, unwanted pregnancy, woman's age, wealth status, woman's education, partner's education, woman's employment status, partner's employment status, knowledge of ovulatory cycle, and access to TV or radio at least once a week. Due to collinearity, partner's education and working status were combined into a single variable.

Variables that were differentially distributed among women who did and did not have delayed ANC ($p < 0.05$ in the design-adjusted Chi-squared) were retained for model building. Collinearity was assessed, and for covariates that were identified to be strongly collinear ($r >= 0.8$, using Pearson's correlation test) the variable more strongly correlated with delayed ANC was retained. Manual backward stepwise regression was used to develop a multivariable logistic regression model of predictors of delayed ANC in Rwanda. Only factors significant at the $\alpha = 0.05$ level were retained in the final model except age and place of residence which were considered by the study team as potential confounders. Analysis was completed in Stata v12, with svyset commands to apply inverse probability weights that account for oversampling of urban PSUs, and to adjust for clustering of observations within PSUs and stratification by district. Odds ratios (ORs) and 95% confidence intervals are reported.

Ethical statement

This study is a secondary analysis of the 2010 Rwanda Demographic Health Survey and as such, no ethical approval was required. We registered and requested for access to data from DHS on-line archive and received an approval to access and download de-identified DHS data files. All guidelines, including treating data as confidential and not making effort to identify individual respondents, were respected.

Results

Of the 6,325 women that had a pregnancy in the last 5 years, 6,211 attended a health facility for their first ANC during the last pregnancy. Among the 6,211 women who presented to ANC clinics, 3,797 women (61.1%, 95% CI: 59.3%, 62.7%) had a delayed first visit (Table 1). In bivariate analysis, the following factors were significantly associated with delayed ANC: number of children ($p < 0.001$), area of residence ($p = 0.018$), place of ANC ($p < 0.001$), marital status ($p = 0.012$), type of health insurance ($p < 0.001$), expressed problem with distance to health facility ($p = 0.002$), unwanted pregnancy ($p < 0.001$), age ($p < 0.001$), wealth status ($p < 0.001$), woman's education level ($p < 0.001$), partner's education level ($p < 0.001$), woman's employment status ($p < 0.001$), partner's employment status ($p < 0.001$), and access to TV or radio at least once a week ($p = 0.003$). Also, combining marital, education and employment status, we found that having an employed partner with at least secondary education was associated with delayed ANC.

Table 2 contains results of the full and reduced (only including factors identified as significant using the backwards stepwise regression) models. In the reduced model, several factors were associated with delayed ANC: having 4–6 children (OR = 1.42, 95% CI: 1.22, 1.65) or more than 6 children (OR = 1.57, 95% CI: 1.24, 1.99) versus 1–3 children; feeling that distance to health facility is a problem (OR = 1.20, 95% CI: 1.04, 1.38); and having an unwanted pregnancy (OR = 1.41, 95% CI: 1.26, 1.58). Different factors were associated with receiving ANC during the first trimester: having an ANC at a private hospital or clinic

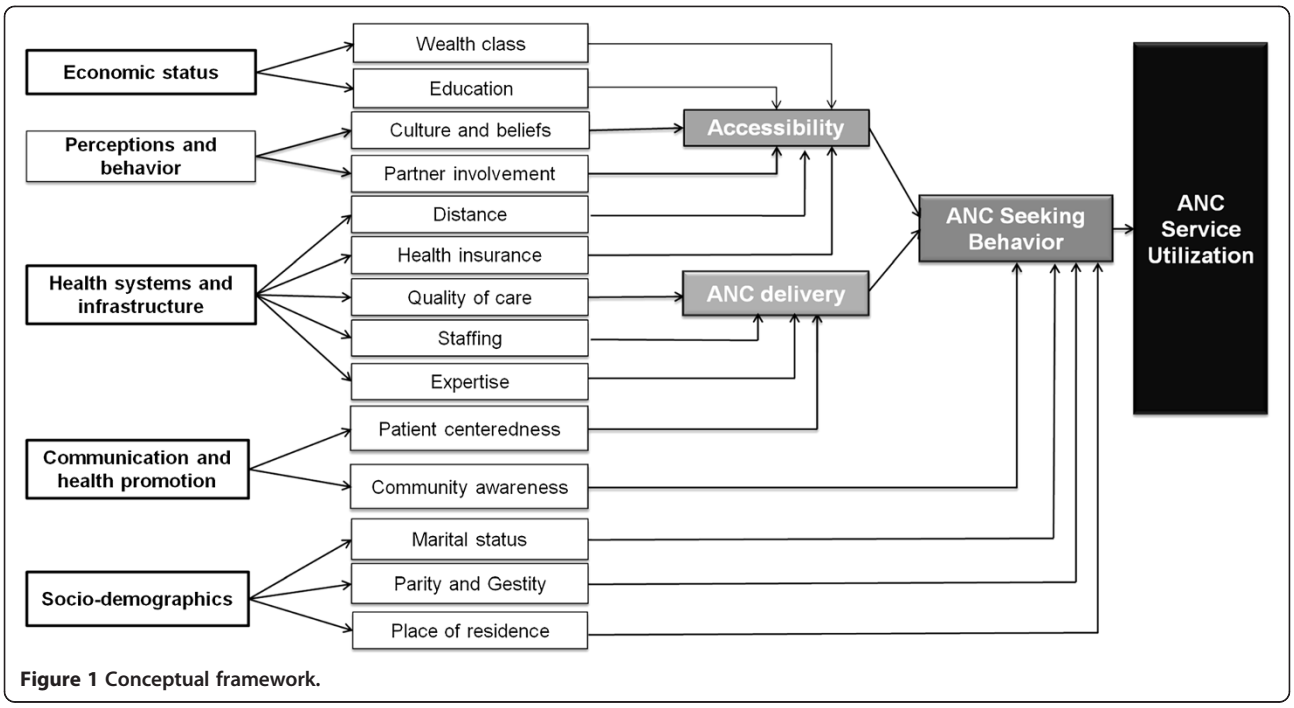

Figure 1 Conceptual framework.

(OR = 0.29, 95% CI: 0.15,0.56) versus a public health center; being married (OR = 0.85, 95% CI: 0.75, 0.96), and having public mutuelle health insurance (OR = 0.81, 95% CI: 0.71, 0.92) or another type of insurance (OR = 0.33, 95% CI: 0.23, 0.46) versus no insurance.

Discussion

In this secondary analysis of the 2010 RDHS, we found that more than three-fifths of pregnant women presented late for their first ANC visit. Having many children, poor geographic access to health facility and unwanted pregnancy were associated with the probability of a woman to not have an ANC visit in the first trimester. Significant delays for the first ANC visit have been observed in other countries in the region, including Ethiopia (more than half of women had a delayed ANC in 2012) [13]. In other studies, age at delivery, family income, media exposure, attitude towards pregnancy, knowledge about the danger signs of pregnancy, husband's approval of ANC, and distance to health facility were associated with ANC service utilization at any point during pregnancy [13,18]. In 2011, Hagey and colleagues explored social and behavioral factors that affect timely initiation of ANC from the perspective of health care providers in Kigali city. They found that women's knowledge gaps; having previous births; limited involvement of male partners; problems with health insurance; and ANC culture were the main barriers to first ANC initiation [19].

For this study, some variables such as quality of antenatal care provided, and women's perceptions of the ANC were not available for consideration in the existing RDHS data, but are likely important factors in determining timing of ANC. Of the available data, some factors did not appear significant in our analyses, most notably income. Other studies have found that women's poverty limits access to maternal health services, including ANC [12,20-24]; however, in Rwanda, the availability and uptake of health insurance may offset the impact of income on delays in care seeking behavior. In our study, almost all women (91.2%) had health insurance, and women with no health insurance were more likely to delay their first antenatal care visit than women with insurance.

In our analysis, having more than four children was significantly associated with delayed ANC [14]. Promotion of accessible family planning methods at the community level could help couples to achieve their desired number of children, educate them about the benefits of birth spacing, and promote better health seeking behavior during pregnancy, all of which are associated with improved child survival and reduced total number of pregnancies [25]. The majority of women in this study (61%) did not know about their menstrual cycle which suggests a lack of information about reproductive health broadly including information about the benefits of timely ANC, a finding that is consist with other studies [26]. Raising awareness about reproductive health is demonstrated to improve maternal health service utilization [3,27].

Surprisingly, our multivariable analysis did not include age as a risk factor for delayed ANC. This differs from recent studies that reported a significant association between delayed or lack of maternal health service utilization and

Table 1 Bivariate relationships between demographic characteristics and delayed antenatal care in Rwanda

Characteristic	N	% [95% CI]		P-value
Age group				**<0.001**
15-24	1,251	56.8	[53.6,60.1]	
25-34	3,235	60.3	[58.2,62.4]	
35-44	1,526	65.2	[62.5,67.8]	
45+	269	65.6	[59.7,71.2]	
Residence				0.018
Urban	806	55.9	[51.4,60.4]	
Rural	5475	61.8	[60.0,63.6]	
Number of children				<0.001
1-3	3,571	56.6	[54.5,58.6]	
4-6	1,850	66.0	[63.4,68.5]	
7+	860	68.9	[65.4,72.2]	
Place of antenatal care				<0.001
Health center	5,799	61.6	[59.9,63.3]	
Home or other	20	67.0	[49.3,80.9]	
Dispensary/health post	103	69.9	[58.6,79.2]	
District hospital	239	56.3	[48.2,64.1]	
Private hospitals/clinics	56	19.8	[10.7,33.5]	
Referral hospitals	53	40.4	[28.6,53.3]	
Married				0.012
No	2682	63.0	[60.7,65.3]	
Yes	3599	59.5	[57.5,61.5]	
Type of health insurance				<0.001
No	1,657	66.6	[63.9,69.2]	
Mutuelle	4402	60.2	[58.4,62.0]	
RAMA_MMI and others	194	31.2	[24.3,39.1]	
Problem with distance				0.002
No	4577	59.6	[57.8,61.5]	
Yes	1702	64.8	[61.9,67.6]	
Pregnancy				<0.001
Wanted	3600	56.8	[54.7,58.9]	
Unwanted	2679	66.8	[64.7,68.8]	
Wealth index				<0.001
Poorest	1427	64.2	[61.2,67.1]	
Poorer	1335	62.7	[59.9,65.5]	
Middle	1230	62.1	[58.8,65.4]	
Richer	1177	62.0	[58.9,64.9]	
Richest	1112	52.7	[49.3,56.1]	
Women education secondary or higher				<0.001
No	5665	62.3	[60.6,64.0]	
Yes	616	49.4	[45.3,53.5]	
Husband with secondary or higher education				<0.001
No	5,150	62.4	[60.6,64.1]	
Yes	672	49.5	[45.3,53.7]	
Not married	457	62.9	[57.8,67.9]	
Women's employment status				<0.001
Informal sector/not working	5,668	62.3	[60.5,64.0]	
Formal sector	605	50.0	[45.4,54.6]	
Partner's employment status				<0.001
Informal sector/not working	4,496	62.4	[60.5,64.3]	
Formal sector	1,316	55.5	[52.4,58.6]	
Not married	457	62.9	[57.8,67.9]	
Current marital status				0.277
Never in union	457	62.9	[57.8,67.9]	
Married/living with partner	5,234	60.6	[58.8,62.4]	
Widowed and/or separated	590	63.7	[59.7,67.5]	
Husband's education and employment status				0.003
Not married	457	62.9	[57.8,67.9]	
Employed partner with secondary education	413	45.3	[40.0,50.6]	
Employed partner without secondary education	903	60.2	[56.8,63.5]	
Unemployed partner with secondary education	257	56.1	[49.5,62.5]	
Unemployed partner without secondary education	4,239	62.8	[60.9,64.7]	
Knowledge of menstrual cycle				0.072
Yes	768	57.8	[53.8,61.7]	
No	5,510	61.5	[59.7,63.2]	
TV or radio at least once a week				0.003
No	2,114	63.8	[61.4,66.1]	
Yes	4,161	59.7	[57.7,61.6]	

older age of women [13,28,29]. More detailed studies are needed to better understand the factors that mitigate the effect of age on uptake of services in Rwanda.

We anticipated that delayed ANC would be lower among women seeking care from health posts because in Rwanda, health posts are more geographically accessible by pregnant women than other types of health facilities. One potential reason that health posts are not associated with timely ANC is that they are not yet accredited and equipped to deliver formal ANC. In this context, health post nurses do not vest much effort in monitoring of pregnant women. We also found that women who noted distance as a barrier to care were significantly more likely to have delayed ANC. Formally

Table 2 Multivariate logistic regression model with odds rations, P-value and confidence intervals for Women's delay to the first antenatal care visits in Rwanda

	Full				Reduced			
Characteristics	**OR**	***P***	**95% CI**		**OR**	***P***	**95% CI**	
Age group								
15-24	1.00				1.00			
25-34	1.14	0.107	0.97	1.34	1.13	0.120	0.97	1.33
35-44	1.08	0.462	0.87	1.34	1.08	0.486	0.87	1.33
45+	0.94	0.741	0.67	1.33	0.94	0.732	0.67	1.33
Place of residence								
Urban	1.00				1.00			
Rural	0.87	0.245	0.68	1.10	1.03	0.760	0.84	1.26
Number of children								
1-3	1.00				1.00			
4-6	1.41	<0.001	1.22	1.65	1.42	<0.001	1.22	1.65
7+	1.55	<0.001	1.22	1.97	1.57	<0.001	1.24	1.99
Place of antenatal care								
Health center	1.00				1.00			
Home or other	2.10	0.137	0.79	5.57	1.63	0.200	0.77	3.47
Dispensary/health post	1.50	0.118	0.90	2.48	1.47	0.130	0.89	2.43
District hospital	0.96	0.808	0.69	1.33	0.94	0.734	0.68	1.32
Private hospitals/clinics	0.33	0.001	0.17	0.65	0.29	<0.001	0.15	0.56
Referral hospitals	0.72	0.200	0.43	1.19	0.65	0.093	0.40	1.07
Married								
No	1.00				1.00			
Yes	0.86	0.028	0.76	0.98	0.85	0.012	0.75	0.96
Type of health insurance								
No	1.00				1.00			
Mutuelle[†]	0.81	0.003	0.71	0.93	0.81	0.002	0.71	0.92
RAMA, MMI, and others[‡]	0.43	<0.001	0.29	0.64	0.33	<0.001	0.23	0.46
Problem with distance to health facility								
No	1.00				1.00			
Yes	1.19	0.017	1.03	1.37	1.20	0.012	1.04	1.38
Pregnancy								
Wanted	1.00				1.00			
Unwanted	1.41	<0.001	1.25	1.58	1.41	<0.001	1.26	1.58
Wealth index								
Poorest	1.00							
Poorer	0.97	0.707	0.82	1.14				
Middle	0.99	0.951	0.82	1.20				
Richer	0.99	0.900	0.81	1.21				
Richest	0.86	0.254	0.67	1.11				
Women's education secondary or higher								
No	1.00							
Yes	0.94	0.565	0.75	1.17				

Table 2 Multivariate logistic regression model with odds rations, P-value and confidence intervals for Women's delay to the first antenatal care visits in Rwanda *(Continued)*

Women's employment status				
Informal sector/not working	1.00			
Formal sector	0.84	0.100	0.68	1.03
Partners' education employment status				
Not married	1.00			
Employed partner with secondary education	0.76	0.156	0.53	1.11
Employed partner without secondary education	0.98	0.889	0.74	1.30
Unemployed partner with secondary education	0.91	0.593	0.63	1.30
Unemployed partner without secondary education	0.97	0.814	0.76	1.25
Knowledge of menstrual cycle				
Yes	1.00			
No	1.00	0.957	0.84	1.20
TV or radio at least once a week				
No	1.00			
Yes	0.98	0.720	0.86	1.11

[†]Community based health insurance scheme, [‡]Alternative or private health insurance schemes.

decentralizing ANC services to health posts could improve early uptake of ANC; this proposal is supported by results from other studies [30]. Decentralization of ANC to community health posts and capacitating health posts and dispensaries to provide prenatal and postnatal services would decrease the distances that women must travel to get ANC services. However, measures such as clinical mentorship programs or supervision would be needed to ensure high quality of care at decentralized sites.

Rwanda is one of the sub-Saharan African countries that promote male involvement in antenatal care, preventing mother-to-child transmission of HIV and other maternal and child health services. With this policy, pregnant women are more likely than other settings to be accompanied by a partner for ANC. This might have caused some delays in ANC service utilization. Further studies are needed to understand the effects of this policy to the timing of ANC on married women, as well as among unmarried, separated or pregnant women living far from their male partners.

There are several limitations to this study. First, since this was a secondary analysis of the 2010 RDHS, we did not have all the variables proposed in our conceptual framework. We could not explore associations between the quality of care at the nearest health facility on delayed ANC. In addition, recall bias, particularly about older pregnancies, may have affected our secondary analysis. Moreover, the analysis included the primary predictors of the study outcome. Therefore, future researchers in this domain should explore whether or not the effect of these risk factors varies by different population strata.

Recent studies have shown that poor quality of care, and insufficient medical equipment and infrastructure for maternal health services contribute to limited maternal and child health services utilization [31-33]. This study measured predictors of delaying the first antenatal care visit. Therefore, further studies should assess risk factors for delays in subsequent visits.

Furthermore, the RDHS has limited information on perception and acceptability of ANC services, which is an important area for further study. Finally, the RDHS did not include questions on travel time to the clinic, and the only variable that could be included was a question that measured the perceived burden of distance on access.

Conclusion

The study assessed predictors of delayed ANC (receipt of first ANC in the second or third trimester of pregnancy) in Rwanda. We found that several socio-demographic factors was associated with delayed ANC, so we propose specific interventions to reduce these barriers. Distance to health facility remains a major barrier to ANC services which suggests a potential for decentralization of maternal ANC to health posts and dispensaries. There is a need to study the effectiveness of the existing community outreach programs such as community-based family planning and immunization as well as the feasibility of ANC decentralization and integration within other community-based interventions.

Several countries including Rwanda have launched an automatic phone text message system (RapidSMS) to remind community health workers about women's appointment [34]. Rwanda has also initiated semiannual

maternal, child and adolescent health weeks with activities coordinated in communities by community health workers. We believe that these initiatives can promote better health seeking behavior and, combined with decentralized ANC, could increase access and minimize delays in ANC service utilization. However, further studies are required to measure effects of these synergetic interventions.

Current efforts to provide universal coverage of health insurance, access to family planning, and strengthened community maternal health systems are important strategies for linking women to ANC care early in their pregnancies. In addition to the existing programs, though, these findings suggest a need for more infrastructure enabling geographic access to services. Furthermore, health promotion campaigns in communities with an emphasis on maternal health would additionally ensure that most women gain access to basic reproductive health information. Formal or ad hoc trainings and workshops should be implemented in communities to explain basic knowledge about reproductive health and the importance of antenatal service utilization.

Abbreviations

ANC: Antenatal care; OR: Odd ratio; CI: Confidence interval; RDHS: Rwanda demographic and health survey; WHO: World Health Organization.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

AM conceived and coordinated the study. FH, LB and FM participated in the study design, statistical analysis and manuscript preparation. FS and JN provided technical inputs and participated in manuscript preparation, DRT and BLHG helped with study design, data analysis as well as manuscript preparation and developed/led the training on survey analyses that precipitated the paper. All authors provided critical revision of subsequent drafts and read and approved the final manuscript.

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References

1. Wang W, Alva S, Wang S, Fort A: *Levels and Trends in the Use of Maternal Health Services in Developing Countries. DHS Comparative Reports No. 26.* ICF Macro: Calverton, Maryland, USA; 2011.
2. WHO: *Reduction of Maternal Mortality.* Geneva: A Joint WHO/UNFPA/UNICEF/World Bank Statement; 1999.
3. Khumanthem PD, Chanam MS, Samjetshabam RD: **Maternal mortality and its causes in a tertiary center.** *J Obstet Gynaecol India* 2012, **62:**168–71.
4. Heaman MI, Newburn-Cook CV, Green CG, Elliott LJ, Helewa ME: **Inadequate prenatal care and its association with adverse pregnancy outcomes: a comparison of indices.** *BMC Pregnancy Childbirth* 2008, **8:**15.
5. Goldie SJ, Sweet S, Carvalho N, Natchu UCM, Hu D: **Alternative strategies to reduce maternal mortality in India: a cost-effectiveness analysis.** *PLoS Med* 2010, **7:**1.
6. Dowswell T, Carroli G, Duley L, Gates S, Am G, Ggp P: **Alternative versus standard packages of antenatal care for low-risk pregnancy.** *Cochrane Database Syst Rev* 2010, CD000934.
7. Doku D, Neupane S, Doku PN: **Factors associated with reproductive health care utilization among Ghanaian women.** *BMC Int Health Hum Rights* 2012, **12:**1.
8. Bloom SS, Lippeveld T, Wypij D: **Does antenatal care make a difference to safe delivery ?** *A study in urban Uttar Pradesh, India* 1999, **14:**38–48.
9. Gravett CA, Gravett MG, Martin ET, Bernson JD, Khan S, Boyle DS, Lannon SMR, Patterson J, Rubens CE, Steele MS: **Serious and life-threatening pregnancy-related infections: opportunities to reduce the global burden.** *PLoS Med* 2012, **9:**e1001324.
10. Satti H, Motsamai S, Chetane P, Marumo L, Barry DJ, Riley J, McLaughlin MM, Seung KJ, Mukherjee JS: **Comprehensive approach to improving maternal health and achieving MDG 5: report from the mountains of Lesotho.** *PLoS One* 2012, **7:**e42700.
11. Regassa N: **Antenatal and postnatal care service utilization in southern Ethiopia: a population-based study.** *Afr Health Sci* 2011, **11:**390–7.
12. Matthews SA, Gubhaju B: *Contextual Influences on the Use of Antenatal Care in Nepal. DHS Geographic Studies 2.* ORC Macro.: Calverton, Maryland USA; 2004.
13. Birmeta K, Dibaba Y, Woldeyohannes D: **Determinants of maternal health care utilization in Holeta town, central Ethiopia.** *BMC Health Serv Res* 2013, **13:**256.
14. National Institute of Statistics of Rwanda (NISR) [Rwanda] M of H (MOH) [Rwanda], ICF International: *Rwanda Demographic and Health Survey 2010.* Calverton, Maryland, USA: NISR, MOH, and ICF International; 2012.
15. Farmer PE, Nutt CT, Wagner CM, Sekabaraga C, Nuthulaganti T, Weigel JL, Farmer DB, Habinshuti A, Mugeni SD, Karasi J-C, Drobac PC: **Reduced premature mortality in Rwanda: lessons from success.** *BMJ* 2013, **346:**f65–f65.
16. **WHO Statistical Information System.** [http://www.who.int/whosis/en/]
17. Corsi DJ, Neuman M, Finlay JE, Subramanian SV: **Demographic and health surveys: a profile.** *Int J Epidemiol* 2012, **41:**1602–13.
18. Abor PA, Abekah-Nkrumah G, Sakyi K, Adjasi CKD, Abor J: **The socio-economic determinants of maternal health care utilization in Ghana.** *Int J Soc Econ* 2011, **38:**628–648.
19. Hagey J, Rulisa S, Pérez-Escamilla R: **Barriers and solutions for timely initiation of antenatal care in Kigali, Rwanda: Health facility professionals' perspective.** *Midwifery* 2013, **30:**96–102.
20. Nisar N, White F: **Factors affecting utilization of antenatal care among reproductive age group women (15–49 years) in an urban squatter settlement of Karachi.** *JPMA J Pakistan Med Assoc* 2003, **53:**47–53.
21. Simkhada BB, Van Teijlingen E, Porter M, Simkhada P, van Teijlingen ER: **Factors affecting the utilization of antenatal care in developing countries: systematic review of the literature.** *J Adv Nurs* 2008, **61:**244–60.
22. Prakash R, Kumar A: **Urban poverty and utilization of maternal and child health care services in India.** *J Biosoc Sci* 2013, **20:**1–17.
23. Titaley CR, Hunter CL, Heywood P, Dibley MJ: **Why don't some women attend antenatal and postnatal care services?: a qualitative study of community members' perspectives in Garut, Sukabumi and Ciamis districts of West Java Province.** *Indonesia BMC Pregnancy Childbirth* 2010, **10:**61.
24. Gage AJ, Guirlene Calixte M: **Effects of the physical accessibility of maternal health services on their use in rural Haiti.** *Popul Stud (NY)* 2006, **60:**271–288.
25. Omran AR: **The epidemiologic transition: a theory of the epidemiology of population change. 1971.** *Milbank Q* 2005, **83:**731–57.
26. Kisuule I, Kaye DK, Najjuka F, Ssematimba SK, Arinda A, Nakitende G, Otim L: **Timing and reasons for coming late for the first antenatal care visit by pregnant women at Mulago hospital.** *Kampala Uganda BMC Pregnancy Childbirth* 2013, **13:**121.
27. Gross S, Glass TR, Schellenberg JA, Obrist BKA: **Timing of antenatal care for adolescent and adult pregnant women in south-eastern Tanzania.** *BMC Pregnancy Childbirth* 2012, **12:**16.

28. Sharma SK, Sawangdee Y, Sirirassamee B: **Access to health: women's status and utilization of maternal health services in Nepal.** *J Biosoc Sci* 2007, **39:**671–692.
29. Fantahun M, Olwit G: **Factors related to antenatal clinic choice and reported activities of antenatal care clinics by pregnant women in Gulele district, Addis Abeba.** *Ethiop Med J* 1995, **33:**51–58.
30. Wagstaff A, Claeson M, Hecht RM, Gottret P: *Chapter 9 Millennium Development Goals for Health: What Will It Take to Accelerate Progress?* 2003:181–194.
31. Sipsma HL, Curry LA, Kakoma J-B, Linnander EL, Bradley EH: **Identifying characteristics associated with performing recommended practices in maternal and newborn care among health facilities in Rwanda: a cross-sectional study.** *Hum Resour Health* 2012, **10:**13.
32. Pearson L, Shoo R: **Availability and use of emergency obstetric services: Kenya, Rwanda, Southern Sudan, and Uganda.** *Int J Gynaecol Obstet Off organ Int Fed Gynaecol Obstet* 2005, **88:**208–215.
33. Couillet M, Serhier Z, Tachfouti N, Elrhazi K, Nejjari C, Perez F: **The use of antenatal services in health centres of Fès, Morocco.** *J Obstet Gynaecol* 2007, **27:**688–694.
34. Ngabo F, Nguimfack J, Nwaigwe F, Mugeni C, Muhoza D, Wilson DR, Kalach J, Gakuba R, Karema C, Binagwaho A: **Designing and Implementing an Innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda.** *Pan Afr Med J* 2012, **13:**31.

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Beyond coverage: improving the quality of antenatal care delivery through integrated mentorship and quality improvement at health centers in rural Rwanda

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Abstract

Background: Inadequate antenatal care (ANC) can lead to missed diagnosis of danger signs or delayed referral to emergency obstetrical care, contributing to maternal mortality. In developing countries, ANC quality is often limited by skill and knowledge gaps of the health workforce. In 2011, the Mentorship, Enhanced Supervision for Healthcare and Quality Improvement (MESH-QI) program was implemented to strengthen providers' ANC performance at 21 rural health centers in Rwanda. We evaluated the effect of MESH-QI on the completeness of danger sign assessments.

Methods: Completeness of danger sign assessments was measured by expert nurse mentors using standardized observation checklists. Checklists completed from October 2010 to May 2011 ($n = 330$) were used as baseline measurement and checklists completed between February and November 2012 (12–15 months after the start of MESH-QI implementation) were used for follow-up. We used a mixed-effects linear regression model to assess the effect of the MESH-QI intervention on the danger sign assessment score, controlling for potential confounders and the clustering of effect at the health center level.

Results: Complete assessment of all danger signs improved from 2.1% at baseline to 84.2% after MESH-QI ($p < 0.001$). Similar improvements were found for 20 of 23 other essential ANC screening items. After controlling for potential confounders, the improvement in danger sign assessment score was significant. However, the effect of the MESH-QI was different by intervention district and type of observed ANC visit. In Southern Kayonza District, the increase in the danger sign assessment score was 6.28 (95% CI: 5.59, 6.98) for non-first ANC visits and 5.39 (95% CI: 4.62, 6.15) for first ANC visits. In Kirehe District, the increase in danger sign assessment score was 4.20 (95% CI: 3.59, 4.80) for non-first ANC visits and 3.30 (95% CI: 2.80, 3.81) for first ANC visits.

Conclusion: Assessment of critical danger signs improved under MESH-QI, even when controlling for nurse-mentees' education level and previous training in focused ANC. MESH-QI offers an approach to enhance quality of care after traditional training and may be an approach to support newer providers who have not yet attended content-focused courses.

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Background

With the introduction of the millennium development goals (MDGs) in 2000, maternal death has been a focus of clinical and public health interventions globally [1–3]. Despite numerous clinical and public health interventions, the highest maternal mortality is still reported in sub-Saharan Africa [4], where poor quality healthcare contributed to failure to reach the MDG5 goal to reduce maternal and child mortality by three-quarters by 2015 [5–7]. This inadequate decline of maternal mortality in developing countries [8] calls for improved coverage and quality in health care for pregnant women.

Antenatal care (ANC) was initiated in the twentieth century as a strategy to prevent or ensure early treatment of pregnancy complications through systematic assessments, women's education on positive behaviors, gestational age assessment, screening for fetal development and early detection of mother and baby abnormalities [6, 9]. There is evidence that ANC has the potential to reduce maternal mortality especially in low resource settings [10–12]. However, the quality of ANC is often hindered by gaps in knowledge and skills of care providers [13–17]. A study comparing thirty-eight countries found gaps in the quality of antenatal care delivery, including limited danger sign assessment and poor provision of essential counseling messages [18].

In Rwanda and other developing countries, poor quality of care is often exacerbated by the lack of basic equipment and low performance of health care workers [19–21]. While over 80% of the burden of diseases is addressed by health center nurses [22], the Africa Health Workforce Observatory estimated that Rwanda has only 1 nurse per 1493 people [23]. Such a low density of skilled professionals affects the overall quality of care at health center level. Although more than half of maternal deaths could be averted by adequate assessments and management of danger signs during ANC visits [9, 24–26], innovative strategies are needed to improve core maternal health care delivery processes [27, 28].

Focused antenatal care training and supervision

In 2002, the World Health Organization adopted focused antenatal care (FANC) as a proactive strategy to detect and address critical needs for the mother and fetal well-being [29]. The goal of FANC is to identify opportunities for education and prevention or early management of problems that could affect pregnancy outcomes. In contrast to traditional ANC, FANC targets the individualized needs rather than relying solely on the frequency of ANC visits.

In 2003, Rwanda launched the implementation of FANC [30]. Health center providers attended classroom-based trainings that include a comprehensive review of ANC screenings so that these providers could develop an individualized child birth plan with each pregnant woman [31–33].

In Rwanda, in addition to FANC training, routine supervision visits were implemented as a strategy to facilitate the implementation of FANC. The Rwandan Ministry of Health recommended monthly supervision visits from district hospital (DH)'s maternal and child health supervisors to health center-based ANC providers. Despite FANC trainings and routine supervision visits in Rwanda, there remained inconsistent and incomplete danger sign assessments during ANC visits, as has been observed in other countries in the region [22, 34–40]. We hypothesized that ongoing mentorship could address this gap by converting ANC assessment and management knowledge and skills into practice.

Historically, Rwanda has three main education tracks for nurses and midwives including A2, A1, and A0. A2 level nurses and midwives are trained to the secondary school level and covers basic clinical subjects and specific area of nursing specialties [41]. Since 2006, the Ministry of Health stopped training and deploying A2 level nurses and midwives, deeming their skill sets not sufficient to deliver high quality care services. Therefore, the ongoing efforts to upgrade A2 to A1 or A0 level may take several years [42]. In the meantime, A2 level nurses remain the bulk of nursing care at health center, fulfilling three functions including health promotion, preventative services provision, and primary healthcare delivery [43, 44].

The MESH-QI intervention

Partners In Health (PIH) in collaboration with the Rwandan Ministry of Health (MoH) implemented a clinical Mentorship, Enhanced Supervision for Healthcare and Quality Improvement (MESH-QI) Program to improve the quality of care and systems in rural health centers in Rwanda [45]. During health center visits, MESH-QI mentors delivered provider-centered support including side-by-side mentorship, bedside teaching and clinical case review to improve knowledge, skills and effective communication techniques. All ANC providers, regardless of their training background, received mentorship visits every four to six weeks. In addition to mentorship, health center providers were coached on quality improvement, using Plan-Do-Study-Act cycle methodology, to help providers address facility issues that affected quality of maternal healthcare delivery [45]. The MESH-QI package is provided by expert nurse mentors with extensive experience as providers in specific clinical areas. These mentors are MoH employees who were trained in coaching and provided with ongoing support from an experienced gynecologist obstetrician, expert midwife and PIH's QI specialist.

Previous evaluations have demonstrated that the MESH-QI model improved assessments and diagnosis across a variety of clinical programs, including the Integrated

Management of Childhood Illness (IMCI), Prenatal Care and Integrated Management of Adolescent and Adulthood Illness (IMAI) and HIV [45, 46]. A qualitative study found positive perceptions and acceptability of the MESH-QI model from the perspective of the mentors, health care workers and district hospital managers, building health workers' confidence in clinical diagnosis and case management [47].

In this study, we assess the impact of the MESH-QI intervention on the completeness of ANC assessment items, with a focus on danger signs. To our knowledge, no studies have evaluated the effectiveness of provider and systems-focused mentoring interventions to improve the quality of ANC at health centers in rural, sub-Saharan Africa. Our study findings could inform policy makers, managers and ANC providers wishing to improve the quality of ANC through integration of mentorship-based interventions in similar settings.

Methods

Study design and setting

This cross-sectional, pre-post study assesses the effect of MESH-QI on the completeness of ANC assessment items in rural Rwanda. We include all 21 PIH-supported public health centers, 8 in Southern Kayonza District and 13 in Kirehe District, collectively serving over 500,000 people [48]. These health centers, which are managed by the Rwandan MoH, were generally staffed by A2-level nurses (education level equivalent to secondary/high school) [49, 50]. All nurses working in the ANC clinic were eligible for mentoring and observation.

Data collection

Baseline measurements were completed by the expert nurse mentors from October 2010 to May 2011 ($n = 330$) prior to any mentoring intervention to understand the pre-intervention clinical care activities. The follow-up measurement was completed by the mentors during support visits from February to November 2012 ($n = 292$), 12–15 months after the start of the MESH-QI intervention. The mentor observation checklists were adapted from the standards described in the Rwandan national ANC screening tool used at all health centers [51]. This tool listed the essential ANC assessment items including medical history, screening for seven danger signs (headache, blurry vision, facial swelling, convulsions, bleeding, loss of fluid, and painful contractions), measurement of vital signs, assessment of fetal well-being, communication and counseling [52].

Data analysis

Data were analyzed using Stata v12 (College Station, TX: StataCorp LP).We use frequencies and percents to describe the nurse-mentee and facility characteristics. For all assessment areas, we compared completeness of assessment at baseline and after MESH-QI using the Chi-squared test.

The unit of analysis was the clinical encounter. The outcome of this study was the danger sign assessment score calculated based on equal weighting of the completion of each of the seven key danger sign assessments (0 indicating no danger sign was assessed and 7 indicating that all seven danger signs were assessed). We used interaction terms to assess whether the intervention district, completion of FANC training, level of nurse-mentee's education, or type ANC visit (first or non-first ANC visit) modified the effect of the MESH-QI intervention. The interaction term was included in the final model if the interaction term variable was significant at the $\alpha = 0.05$ level in bivariate analyses. We performed a multivariable linear regression analysis to assess the effect of MESH-QI on the danger sign assessment score, controlling for the following potential confounders: district (Southern Kayonza/Kirehe), nurse-mentee's education level, nurse-mentee's FANC training and type of ANC visit under observation (first vs others). Because a nurse could lead multiple clinical encounters, we used a random effect to account for clustering among observed ANC consultations conducted by the same nurse.

Results

Observations were completed on 330 ANC visits conducted by 45 different nurses at baseline and 292 visits conducted by 35 different nurses during the follow-up period (Table 1). The number of nurses who had received FANC training varied over time; at baseline, 20 (44%) out of the 45 nurses had been trained in FANC compared to 21 (60%) out of 35 during follow-up period. Forty-three nurses (96%) at baseline had an A2 (high school) education compared to 32 (91%) during follow-up period. The remaining nurses had A1 (two to three years of post-secondary education as defined by the Rwanda Education Council) education.

For each of the seven danger sign assessment items, there was a significant improvement in completion at follow-up compared to baseline ($p < 0.001$) (Table 2). Overall the improvement in women with all danger signs assessed significantly improved, from 2.1% at baseline to 84.0% at follow-up ($p < 0.001$). Significant improvements were also found across other ANC assessment items. Observed ANC visits where nurses checked all vital signs and fetal wellbeing assessment items (fundal height, heart rate, movement, and position) improved significantly (1% to 55%, 37% to 89%, respectively, $p < 0.001$). Completeness of counseling improved significantly as well (2.2% to 51.0%, $p < 0.001$). Medical history assessment including previous surgeries, current medications, use of traditional medications, tobacco, and alcohol, domestic violence, and

Table 1 Demographics, study population, and case-observation characteristics

	Baseline		Follow-up	
	#	%	#	%
Demographics				
Number of health facilities	21		21	
Number of nurses observed	45		35	
Number of observations	330		292	
Nurse characteristics				
District				
Southern Kayonza	18	40	8	23
Kirehe	27	60	27	77
FANC trained	20	44	21	60
A2 level of education[a]	43	96	32	91
Case-observation characteristics				
Average number of observed cases per health center	16		14	
Antenatal care visit				
First	159	48	93	32
Others	171	52	199	68
Nurse providers trained in FANC[c]	164	50	166	57
Nurse's education level				
A2[a]	317	96	266	91
A1[b]	13	4	26	9

[a]A2 level is a high school (secondary) level as defined by Rwanda education council
[b]A1 is two to three years of post-secondary education as defined by Rwanda education council
[c]FANC: Focused antenatal care including a thorough individualized surveillance of the pregnant woman, systematic screening of conditions and diseases, detection and management of pregnancy-related complications, and provision of counseling, preventive measures and support plan essential for safe pregnancy and delivery

checking and documenting HIV status had less improvement, although the change was significant (2.1% to 14.0%, $p < 0.001$). No significant improvement was seen in proportion of observed cases assessed for previous surgery (28% to 29%, $p = 0.796$). The assessment of fetal heart rate remained high at both baseline and follow-up period (98% to 97%, $p = 0.914$).

The effect of MESH-QI on the danger sign assessment score was modified by district and type of ANC visit (p-value for interaction< 0.001, Table 3). No significant interaction was found between the effect of MESH-QI and FANC training ($p = 0.436$) and level of mentee's education ($p = 0.101$). After controlling for level of mentee's education and FANC training and clustering at nurse level, the MESH-QI intervention remained associated with significant improvement in the danger sign assessment score (Table 4). However, the effect of the MESH-QI intervention on the danger sign assessment score was different for each district and type of ANC visit: For Southern Kayonza District, the predicted increase in danger sign assessment score under MESH-QI was 6.28 (95% CI: 5.59, 6.98; $p < 0.001$) for non-first ANC visits, and 5.39 (4.62, 6.15; $p < 0.001$) for first ANC visits. For Kirehe District, the predicted increase in danger sign assessment score was 4.20 (95% CI: 3.59, 4.80; $p < 0.001$) for non-first ANC and 3.30 (95% CI: 2.80, 3.81; $p < 0.001$) for first ANC visits.

Discussion

Although ANC represents an important opportunity to detect danger signs during pregnancy [26] and ensure appropriate management of pregnancy risks [53], there is a need of attention to quality of ANC delivery in resource-limited settings. This study's findings demonstrate that MESH-QI model strengthens the quality of ANC as measured by improvement in the danger sign assessment score. The observed improvements persist even when controlling for FANC-training status and level of nurse-mentee's education, and were greater for non-first ANC visits, both of which had lower danger sign assessment scores at baseline. The findings suggest MESH-QI as a promising intervention to improve components of quality of care in resource-limited settings facing staffing challenges including low levels of training and education. These results are consistent with the growing evidence highlighting the need for enhanced and effective supervision after didactic trainings [19].

Although overall danger sign assessments and most other assessment items were more likely to be completed under MESH-QI, some screening areas did not improve. For fetal position and heart rate, the completeness was high at baseline and stayed persistently high. For history assessment, even though there was a significant improvement during the MESH-QI intervention period, the levels of completeness under MESH-QI remained poor. We have several hypotheses that could explain this result. First, mentors may have emphasized strengthening danger sign assessments assuming that the woman's history was already known from previous visits. Furthermore, nurse-mentees were residents of the health center catchment area, and it is possible that they had opportunities to interact with women outside of clinic and therefore deprioritized a systematic woman's history assessment during ANC visit. The lack of essential tools to guide clinical supervision may have led to notable inconsistencies prior to MESH-QI intervention. The use of standardized checklists as part of MESH-QI intervention helped to assess and improve nurse-mentee's competencies and address systems gaps.

This study has important limitations to consider in interpreting results. First, the pre-post design without a control means that we cannot make definitive conclusions about attribution. However, there were no other

Table 2 Completeness of antenatal care assessments before and after MESH-QI intervention

	Baseline		Follow-up		*P*-value
	n	%	n	%	
Danger signs					
Headache	79	24.0	278	95.2	< 0.001
Blurry vision	77	23.3	278	95.2	< 0.001
Facial swelling	184	56.0	290	99.3	< 0.001
Convulsions	57	17.3	275	94.1	< 0.001
Bleeding	134	41.0	285	98.0	< 0.001
Loss of fluid	76	23.0	267	91.4	< 0.001
Painful contractions	91	28.0	264	90.4	< 0.001
Composite	7	2.1	246	84.2	< 0.001
Medical history					
Previous surgeries	92	28.0	85	29.0	0.734
Current medications	11	3.3	41	14.0	< 0.001
Traditional medications/herbs	7	2.1	41	14.0	< 0.001
Tobacco use	8	2.4	38	13.1	< 0.001
Alcohol	10	3.0	39	13.5	< 0.001
Domestic violence	17	5.2	36	12.5	0.001
HIV status checked and documented	66	42.0	80	86.0	< 0.001
Composite	7	2.1	40	14.0	< 0.001
Vital signs					
Temperature	85	26.0	213	74.0	< 0.001
Blood pressure	289	88.0	288	99.0	< 0.001
Pulse	111	34.0	273	93.5	< 0.001
Respirations	13	4.0	172	60.0	< 0.001
Composite	3	1.0	160	55.0	< 0.001
Fetal well being					
Fundal height[†]	167	98.0	199	100.0	0.030
Heart rate (BCF)[†]	167	98.0	194	97.5	0.914
Movement (after 20 weeks)[†]	80	47.0	197	99.0	< 0.001
Position (after 36 weeks)[‡]	82	95.4	89	98.0	0.367
Composite	121	37.0	259	89.0	< 0.001
Counseling					
Needed supplies are available	224	68.0	215	75.0	0.050
Counseling occurs in private room	304	92.1	288	99.0	< 0.001
Makes eye contact with woman	291	88.1	287	98.2	< 0.001
Speaks to woman in respectful manner	316	96.0	289	99.0	0.014
Uses words that woman can understand	294	89.0	285	98.0	< 0.001
Concrete response provided	78	24.0	199	68.0	< 0.001
Explains all medical procedures	44	13.3	269	93.4	< 0.001
Composite	7	2.2	149	51.0	< 0.001

[†]*N*= 171 for baseline and *N*= 199 for follow-up
[‡]*N*= 86 for baseline and *N*=91 for follow-up

ANC-targeted quality improvement work in the two districts and no changes in national ANC strategy or other ANC-focused interventions during the study period other than periodic FANC training or increased nurse education, which we controlled for in the final analysis. Another limitation is that we relied on performance measurements

Table 3 Relationship between demographic characteristics and danger sign assessment score and mentoring period, stratified by demographics characteristics

Predictors	Bivariate analysis		*P*-value for interaction term
	Changes in ANC Assessment Score	95% CI	
District			< 0.001
Southern Kayonza			
Baseline	Ref.		
Post-MESH-QI	6.06	[5.43, 6.69]	
Kirehe			
Baseline			
Post-MESH-QI	3.88	[3.46, 4.30]	
FANC Training			0.436
Received FANC Training			
Baseline	Ref.		
Post-MESH-QI	4.75	[4.15, 5.35]	
Did not receive FANC training			
Baseline	Ref.		
Post-MESH-QI	4.47	[4.03, 4.91]	
Level of education			0.101
High education			
Baseline	Ref.		
Post-MESH-QI	5.90	[4.27, 7.54]	
Secondary education			
Baseline	Ref.		
Post-MESH-QI	4.50	[4.13, 4.87]	
ANC visit			< 0.001
First ANC visits			
Baseline	Ref.		
Post-MESH-QI	5.05	[4.53, 5.57]	
Other ANC visits			
Baseline	Ref.		
Post-MESH-QI	3.84	[3.38, 4.30]	

Table 4 Changes in danger sign assessment score post-MESH-QI intervention[a]

	Changes in assessment score	95% CI
The effect of MESH-QI, Kirehe, non-first ANC	4.20	[3.59, 4.80]
The effect of MESH-QI, Kayonza, non-first ANC	6.28	[5.59, 6.98]
The effect of MESH-QI, Kirehe, first ANC	3.30	[2.80, 3.81]
The effect of MESH-QI, Kayonza, first ANC	5.39	[4.62, 6.15]

[a]Controlling for FANC training and level of mentee's education

collected during routine mentoring visits by mentors themselves, who may introduce bias in their observation of ANC assessments. Furthermore, a Hawthorne effect may have caused ANC nurses to perform better as a result of being observed resulting in overestimates of the overall effect of the MESH-QI intervention. However, mentors were trained in relationship building and other techniques as part of their orientation. We believe this reassured nurse-mentees so that they were able to provide their usual care without fear of judgment.

In the efforts to promote the universal health coverage, Rwanda successfully launched a community-based health insurance scheme, "Mutuelle" [54]. Local district officials incorporated *mutuelle* on the list of targets for district performance contracts locally known as "Imihigo" [55]. This study's baseline data were collected during the evaluation of the district performance [56], a period marked by intensive efforts deployed by districts to accelerate the pace toward performance goals. This efforts may have increased *mutuelle* enrollments, leading to increased utilization of health center services. Furthermore, an increased workload may have caused an intra-clinic pressure with indirect effect on baseline findings. As such, nurses may have rushed to complete consultations with limited time to focus on recommended ANC practices.

Finally, we sought to assess the effect of the MESH-QI model on danger sign assessments and other ANC screenings. We assume that improving key ANC assessments has improved case management. Further studies are needed to assess the effect of the MESH-QI intervention on pregnancy outcomes. Future studies should also assess the impact of the MESH-QI on other aspects of the nurse-mentees including satisfaction, retention and perceived impact on their clinical competencies. Future studies should also assess the impact of the MESH-QI on other aspects of nurse-mentees' experiences including satisfaction, retention and perceived impact on their clinical competencies. Moreover, we recommend exploring the experiences of pregnant women using ANC services and the impact of MESH-QI on these experiences. This information is crucial to understand their perceptions as well as improvements needed to better meet patient expectations.

While ANC is critical to strengthen maternal and newborn health outcomes, the failure of training and supervision to improve the quality of care suggests the need for evidence-based interventions to improve ANC quality in sub-Saharan Africa [57]. This study demonstrates the benefits of a mentorship intervention, MESH-QI, to improve the quality of ANC at rural health centers. As such, this constitutes an invaluable contribution to the WHO's goal to have a world where "every pregnant woman and newborn receives quality care throughout the pregnancy, childbirth and the postnatal period" [58] and is consistent with

their recommendation to promote health systems interventions that improve the utilization and quality of ANC [59].

Conclusion

In resource-constrained settings where the application of clinical skills constitutes a major challenge, MESH-QI could be an effective model to improve the quality of ANC and increase the opportunities to early detect and manage pregnancy complications.

This study highlights the importance of post-training mentoring and quality improvement rather than relying solely on didactic trainings and traditional supervision. Further, updated guidelines and observation checklists are key for mentors or supervisors to have a systematic view of ANC and provide feedback. In order to sustain these improvements, efforts are underway to integrate the MESH-QI checklists and quality of care indicators into routine district supervision and health management information system.

Abbreviations

DH: District hospital; FANC: Focused antenatal care; IMAI: Integrated Management of Adolescent and Adulthood Illness; IMCI: Integrated Management of Childhood Illness; MDGs: Millennium development goals; MESH-QI: Mentorship, enhanced supervision for healthcare and quality improvement; MoH: Ministry of Health; MoH: Ministry of Health; PIH: Partners In Health

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Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' contributions

AM conceived the study. EB and LM collected the data. AM, LRH, and BHG participated in the data analysis and interpretation. AM, LN, JN, and LRH participated in the study design and manuscript preparation. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study is covered through Population Health Implementation and Training Partnership research protocol approved by the Rwanda National Ethics Committee (RNEC 032/RNEC/2012) and Partners Institutional Review Board in Boston, MA (2009-P-001941/11; BWH). A verbal consent was obtained from each nurse-mentee. Names and other personal identifiers were excluded from datasets extracted for the analyses.

Consent for publication

Not Applicable.

Competing interests

The authors declare that they have no competing interests.

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References

1. WHO: Reduction of Maternal Mortality: A Joint WHO/UNFPA/UNICEF/World Bank Statement. Geneva; 1999.
2. Senanayake H, Dias T, Jayawardena A. Maternal mortality and morbidity: epidemiology of intensive care admissions in pregnancy. Best Pract Res Clin Obstet Gynaecol. 2013;27:811–20.
3. Wagstaff A, Claeson M, Hecht RM, Gottret P: Chapter 9 millennium development goals for health : what will it take to accelerate progress ? 2003.
4. WHO: Reported Information on Mortality Statistics. World Health Organization; 2014.
5. Alvarez JL, Gil R, Hernández V, Gil A. Factors associated with maternal mortality in sub-Saharan Africa: an ecological study. BMC Public Health. 2009;9:462.
6. Chopra M, Daviaud E, Pattinson R, Fonn S, Lawn JE. Saving the lives of South Africa's mothers, babies, and children: can the health system deliver? Lancet. 2009;374:835–46.
7. Patton GC, Coffey C, Sawyer SM, Viner RM, Haller DM, Bose K, Vos T, Ferguson J, Mathers CD. Global patterns of mortality in young people: a systematic analysis of population health data. Lancet. 2009; 374:881–92.
8. WHO: Maternal Mortality. WHO; 2014.
9. Lincetto O, Mothebesoane-anoh S, Gomez P, Munjanja S: Antenatal Care. 2010.
10. Carroli G, Rooney C, Villar J. How effective is antenatal care in preventing maternal mortality and serious morbidity? An overview of the evidence. Paediatr Perinat Epidemiol. 2001;15:1–42.
11. Ali AAA, Adam I. Lack of antenatal care, education, and high maternal mortality in Kassala hospital, eastern Sudan during 2005-2009. J Matern Fetal Neonatal Med. 2011;24:1077–8.
12. Dowswell T, Carroli G, Duley L, Gates S, Am G, Ggp P, Gülmezoglu AM, Khan-Neelofur D, Piaggio GG. Alternative versus standard packages of antenatal care for low-risk pregnancy. Cochrane Database Syst Rev. 2010;10:CD000934.
13. Gross K, Armstrong Schellenberg J, Kessy F, Pfeiffer C, Obrist B, Schellenberg JA. Antenatal care in practice: an exploratory study in antenatal care clinics in the Kilombero Valley, south-eastern Tanzania. BMC Pregnancy Childbirth. 2011;11:36.
14. Rani M, Bonu S, Harvey S. Differentials in the quality of antenatal care in India. Int J Qual Health Care. 2008;20:62–71.
15. Tetui M, et al. Quality of antenatal care services in eastern Uganda : implications for interventions. PanAfrican Med J. 2012;13:1–15.
16. Maestad O TG: Improving the Quality of Health Care When Health Workers Are in Short Supply. Volume 12; 2008.
17. Blank A, Prytherch H, Kaltschmidt J, Krings A, Sukums F, Mensah N, Zakane A, Loukanova S, Gustafsson LL, Sauerborn R, Haefeli WE. "Quality of prenatal and maternal care: bridging the know-do gap" (QUALMAT study): an electronic clinical decision support system for rural sub-Saharan Africa. BMC Med Inform Decis Mak. 2013;13:44.
18. Wang W, Alva S, Wang S, Fort A. Levels and trends in the use of maternal health Services in Developing Countries. DHS comparative reports no. 26. Calverton, Maryland: ICF Macro; 2011.
19. Rowe AK, de Savigny D, Lanata CF, Victora CG. How can we achieve and maintain high-quality performance of health workers in low-resource settings? Lancet. 2005;366:1026–35.
20. Ameh C, Msuya S, Hofman J, Raven J, Mathai M, van den Broek N. Status of emergency obstetric care in six developing countries five years before the MDG targets for maternal and newborn health. PLoS One. 2012;7:e49938.
21. Logie DE, Rowson M, Ndagije F. Innovations in Rwanda ' s health system : looking to the future. 2008;372(9634):256–61.

22. Finlayson K, Downe S. Why do women not use antenatal services in low- and middle-income countries? A meta-synthesis of qualitative studies. PLoS Med. 2013;10:e1001373.
23. AHWO: Human Resources for Health: Country Profile Rwanda. WHO 2009:17–24.
24. Say L, Chou D, Gemmill A, Tunçalp Ö, Moller A-B, Daniels J, Gülmezoglu AM, Temmerman M, Alkema L. Global causes of maternal death: a WHO systematic analysis. Lancet Glob Heal. 2014;2:e323–33.
25. Zanconato G, Msolomba R, Guarenti L, Franchi M. Antenatal care in developing countries: the need for a tailored model. Semin Fetal Neonatal Med. 2006;11:15–20.
26. Ps R, Verma S, Rai L, Kumar P, Pai MV, Shetty J. "' Near miss '" obstetric events and maternal deaths in a tertiary care hospital : an audit. J Pregnancy. 2013;2013:10–5.
27. Satti H, Motsamai S, Chetane P, Marumo L, Barry DJ, Riley J, McLaughlin MM, Seung KJ, Mukherjee JS. Comprehensive approach to improving maternal health and achieving MDG 5: report from the mountains of Lesotho. PLoS One. 2012;7:e42700.
28. Sipsma HL, Curry LA, Kakoma J-B, Linnander EL, Bradley EH. Identifying characteristics associated with performing recommended practices in maternal and newborn care among health facilities in Rwanda: a cross-sectional study. Hum Resour Health. 2012;10:13.
29. Villar J, Ba'Aqeel H, Piaggio G, Lumbiganon P, Miguel Belizán J, Farnot U, Al-Mazrou Y, Carroli G, Pinol A, Donner A, Langer A, Nigenda G, Mugford M, Fox-Rushby J, Hutton G, Bergsjø P, Bakketeig L, Berendes H, Garcia J, WHO antenatal care trial research group. WHO antenatal care randomised trial for the evaluation of a new model of routine antenatal care. Lancet (London, England). 2001;357:1551–64.
30. Republic of Rwanda: National Reproductive Health Policy. Kigali; 2003.
31. Ouma PO, van Eijk AM, Hamel MJ, Sikuku ES, Odhiambo FO, Munguti KM, Ayisi JG, Crawford SB, Kager PA, Slutsker L. Antenatal and delivery care in rural western Kenya: the effect of training health care workers to provide "focused antenatal care". Reprod Health. 2010;7:1.
32. ACCESS: Focused antenatal care: providing integrated, individualized care during pregnancy. 2007.
33. Vilar J BP: WHO Antenatal Care Randomized Trial. Manual for the Implementation of the New Model. World health Organization; 2003.
34. Fagbamigbe AF, Idemudia ES. Assessment of quality of antenatal care services in Nigeria: evidence from a population-based survey. Reprod Health 2015;12:88.
35. Ngabo F, Zoungrana J, Faye O, Rawlins B, Levine R, Sethi R, MacDowell J, Arscott-Mills S, Basinga P. Quality of Care for Prevention and Management of Common Maternal and Newborn Complications Findings from a National Health Facility Survey in Rwanda. Jhpiego; 2012.
36. Conrad P, Schmid G, Tientrebeogo J, Moses A, Kirenga S, Neuhann F, Müller O, Sarker M. Compliance with focused antenatal care services: do health workers in rural Burkina Faso, Uganda and Tanzania perform all ANC procedures? Trop Med Int Heal. 2012;17:300-7.
37. Anya SE, Hydara A, Jaiteh LE. Antenatal care in the Gambia: missed opportunity for information, education and communication. BMC Pregnancy Childbirth. 2008;8:9.
38. Mbalinda SN, Nakimuli A, Kakaire O, Osinde MO, Kakande N, Kaye DK. Does knowledge of danger signs of pregnancy predict birth preparedness? A critique of the evidence from women admitted with pregnancy complications. Health Res Policy Syst. 2014;12:60.
39. Pembe AB, Carlstedt A, Urassa DP, Lindmark G, Nyström L, Darj E. Quality of antenatal care in rural Tanzania: counselling on pregnancy danger signs. BMC Pregnancy Childbirth. 2010;10:35.
40. Majrooh MA, Hasnain S, Akram J, Siddiqui A, Memon ZA. Coverage and Quality of Antenatal Care Provided at Primary Health Care Facilities in the "Punjab" Province of "Pakistan." PLoS One 2014;9:e113390.
41. NUFFIC: The Rwandan education system described and compared with the Dutch system. 2015.
42. Binagwaho A, Kyamanywa P, Farmer PE, Nuthulaganti T, Umubyeyi B, Nyemazi JP, Mugeni SD, Asiimwe A, Ndagijimana U, Lamphere McPherson H, Ngirabega J de D, Sliney A, Uwayezu A, Rusanganwa V, Wagner CM, Nutt CT, Eldon-Edington M, Cancedda C, Magaziner IC, Goosby E. The human resources for health program in Rwanda — a new partnership. N Engl J Med. 2013;369:2054–9.
43. Government of Rwanda. Rwanda Human Resources for Health Program 2011-2019: Funding Proposal. Kigali; 2011.
44. Republic of Rwanda: Service Packages for Health Facilities at Different Levels of Service Delivery. Kigali; 2011.
45. Manzi A, Magge H, Redditt V, Karamaga A, Niyonzima S, Drobac P, Mukherjee JS, Ntaganira J, Nyirazinyoye L, Hirschhorn LR. Nurse mentorship to improve the quality of health care delivery in rural Rwanda. Nurs Outlook. 2012;61:137–44.
46. Magge H, Anatole M, Cyamatare FR, Mezzacappa C, Nkikabahizi F, Niyonzima S, Drobac PC, Ngabo F, Hirschhorn LR. Mentoring and quality improvement strengthen integrated management of childhood illness implementation in rural Rwanda. Arch Dis Child. 2014;100:565–70.
47. Manzi A, Magge H, Hedt-Gauthier BL, Michaelis AP, Cyamatare FR, Nyirazinyoye L, Hirschhorn LR, Ntaganira J. Clinical mentorship to improve pediatric quality of care at the health centers in rural Rwanda: a qualitative study of perceptions and acceptability of health care workers. BMC Health Serv Res. 2014;14:275.
48. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Finance and Economic Planning (MINECOFIN): Rwanda Fourth Population and Housing Census. Kigali, Rwanda; 2012.
49. Leuchowius K: Report on the health care sector and business opportunities in Rwanda. Sweden; 2014.
50. Goverment of Rwanda: Annual Report, July 2012–June 2013. Kigali; 2013.
51. National Collaborating Centre for Women's and Children's Health (UK): Antenatal Care: Routine Care for the Healthy Pregnant Woman. RCOG Press; 2008.
52. Vogel JP, Ndema HA, Souza JP, Gülmezoglu MA, Dowswell T, Carroli G, Baaqeel HS, Lumbiganon P, Piaggio G, Oladapo OT. Antenatal care packages with reduced visits and perinatal mortality: a secondary analysis of the WHO antenatal care trial. Reprod Health. 2013;10:19.
53. Bloom SS, Lippeveld T, Wypij D. Does antenatal care make a difference to safe delivery? A study in urban Uttar Pradesh, India. Health Policy Plan. 1999;14:38–48.
54. Makaka A, Breen S, Binagwaho A: Universal health coverage in Rwanda: a report of innovations to increase enrolment in community-based health insurance. Lancet 2012;380:S7.
55. African Development Bank: Performance Contracts and Social Service Delivery-Lessons from Rwanda. 2013.
56. Government of Rwanda: Districts Imihigo Evaluation Report. 2010.
57. Leslie HH, Gage A, Nsona H, Hirschhorn LR, Kruk ME. Training and supervision did not meaningfully improve quality of care for pregnant women or sick children in sub-Saharan Africa. Health Aff (Millwood). 2016;35:1716–24.
58. Tunçalp Ö, Pena-Rosas J, Lawrie T, Bucagu M, Oladapo O, Portela A, Metin Gülmezoglu A. WHO recommendations on antenatal care for a positive pregnancy experience-going beyond survival. BJOG An Int J Obstet Gynaecol. 2017;124:860–2.
59. WHO: WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience. Geneva, Switzerland: World Health Organization; 2017.

III

Cost-effectiveness of a mentorship and quality improvement intervention to enhance the quality of antenatal care at rural health centers in Rwanda

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ABSTRACT

Objective: To estimate cost-effectiveness of Mentorship, Enhanced Supervision for Healthcare and Quality Improvement (MESH-QI) intervention to strengthen antenatal care compared to standard district supervision practices in rural Rwanda.

Design: Cost-effectiveness analysis.

Setting: Kirehe and Rwinkwavu District Hospital catchment areas, Rwanda

Intervention: Mentorship, Enhanced Supervision for Healthcare and Quality Improvement.

Main outcome measures: Incremental cost per antenatal care visit with complete danger sign and vital sign assessments.

Results

The total annual costs of standard antenatal care supervision was 10,777.21 USD at the baseline, whereas the total costs of MESH-QI intervention was 19,656.53 USD. Human resources (salary and benefits) and transport drove the majority of program expenses, (44.8% and 40%, respectively). Other costs included training of mentors (12.9%), data management (6.5%) and equipment (6.5%). The incremental cost per ANC visit attributable to MESH-QI with all assessment items completed was 0.70 USD for danger signs and 1.10 USD for vital signs.

Conclusions

MESH-QI could be an affordable and effective intervention to improve the quality of antenatal care at health centers in low-resource settings. Cost savings would increase if MESH-QI mentors are integrated into the existing healthcare systems and deployed to sites with higher volume of antenatal care visits.

Background

The WHO recommends antenatal care (ANC) services in resource limited settings to facilitate health promotion, improve prevention, diagnosis and treatment practices, and reduce maternal newborn and child mortality (Lincetto et al. 2010; Bhutta et al. 2008; Carroli et al. 2001; Ali & Adam 2011; Dowswell et al. 2010). ANC prepares women for safe birth and parenthood, triages complicated cases, identifies pre-existing problems worsened during pregnancy, and promotes healthy lifestyles (Lincetto et al. 2010). Despite the beneficial impact of ANC on early detection and reduction of pregnancy complications (Chopra et al. 2009; Lincetto et al. 2010), the quality of ANC delivery is often hindered by the lack of basic ANC knowledge and skills among health workers. Focused antenatal care training was initiated and implemented as a strategy to respond to ANC skills gaps among healthcare workers (Ouma et al. 2010). Even though focused ANC training provides knowledge and skills to develop an individualized plan for each pregnant woman (ACCESS 2007; Vilar J 2003), the translation of knowledge into practice remains a major gap. In sub-Saharan Africa, challenges include the limited number of health personnel and the lack or insufficient skills and competencies among the workforce (Anyangwe & Mtonga 2007).

To improve quality of care and coverage in many developing countries, supportive supervision has been implemented to build capacity of health workforce, catalyze implementation of best practices in maternal health services (Hannah H Leslie et al. 2016; Sipsma et al. 2012; Gross et al. 2011; Rani et al. 2008; Moses Tetui et al 2012) and improve staff satisfaction and retention (McAuliffe et al. 2013). However, its effective use is often hindered by systems gaps and other competing priorities (Rowe et al. 2010; Bosch-Capblanch & Garner 2008). In Rwanda, district supervisors are supposed to visit health centers at least once a month, but supervision visits are often reduced or irregular due to competing responsibilities (Ngabo et al. 2012). When they occur, supervision visits focus mainly on collecting data or monitoring and evaluation (M&E) reports and auditing. Inconsistencies in supportive supervision were associated with gaps in quality of maternal and child health services (Ngabo et al. 2012).

In 2009, Partners In Health (PIH), an international non-profit organization collaborated with the Rwandan Ministry of Health to implement a comprehensive health systems strengthening initiative in two rural districts, Southern Kayonza and Kirehe situated in the Eastern Province of Rwanda

(Drobac et al. 2013). A Mentorship and Enhanced Supervision for Healthcare and Quality Improvement (MESH-QI) program was designed and implemented to strengthen the quality of ANC and other clinical domains through sustained, regular mentoring in clinical care and systems quality improvement projects at health facility level (Manzi et al. 2012; Ingabire et al. 2015). An evaluation reported significant improvements in complete danger signs assessments, from 2.1% at baseline to 84.2% after MESH-QI, and complete vital signs assessments, from 1% to 55% (Manzi 2016; Kirk et al. 2015). Similar studies highlighted MESH-QI as an effective approach to improve the quality of pediatric care and one which is largely accepted by health workers at the health centers (Manzi et al. 2014; Magge et al. 2014)

To our knowledge, no estimates exist of the cost-effectiveness of facility-based integrated clinical mentoring and quality improvement interventions to improve ANC in sub-Saharan Africa. We sought to estimate the cost-effectiveness of MESH-QI compared to standard district supervision practices in Rwanda by comparing the costs and quality of ANC resulting from each approach. We believe the study findings will inform policymakers and implementation specialists planning supportive supervision programs to improve ANC in other low-income settings.

METHODS

Study setting

Rwanda is a small landlocked country situated in central Africa. Over the last two decades, Rwanda has made remarkable progress in improving health, resulting in significant declines in maternal and child mortality, and substantial increase of life expectancy (WHO 2015; Farmer et al. 2013). Rwanda's public health strategy is guided by an emphasis on health systems strengthening and a commitment to health equity (Binagwaho et al. 2014). Interventions to improve the health system included implementation of a community-based health insurance scheme (Makaka et al. 2012; Lu et al. 2014), increasing the number of health facilities and skilled health workers (National Institute of Statistics of Rwanda 2015; Ministry of Health 2011), implementing performance-based financing for health service providers to increase service utilization (Basinga et al. 2011), and implementing national strategies to promote universal and effective health coverage (Government of Rwanda 2012). In 2010, the MESH-QI intervention covered 21 health centers located in Rwinkwavu and Kirehe District Hospitals' catchment areas,

serving a population of roughly 480,000 (National Institute of Statistics of Rwanda (NISR) [Rwanda] & Ministry of Finance and Economic Planning (MINECOFIN) 2012).

Intervention description

MESH-QI was implemented by the Government of Rwanda and Partners In Health, with financial support from the Doris Duke Charitable Foundation's African Health Initiative as a part of the Population Health Implementation and Training (PHIT) Partnership, an integrated health systems strengthening initiative (Drobac et al. 2013). Two nurses with advanced clinical training in maternal health care delivery were selected to mentor ANC providers in the two districts covered by the intervention. The MESH-QI program manager was tasked with planning and management of the program at district-level, aligning MESH-QI activities with clinical priorities across the district. Additionally, the monitoring and evaluation (M&E) officer coordinated quarterly data management and reporting. MESH-QI costs included MESH-QI staff salary and benefits, transportation, and the laptop computers provided for the program manager and mentors.

Prior to MESH-QI intervention, standard supervisory procedures existed for district-level ANC at health centers. Two maternal health nurses were assigned to ensure the standard ANC supervision including at least one supervisory visit per health center. The district hospital budget covered supervisors' salaries and benefits, transportation, IT equipment, and minimal data management through the national health management and information system (HMIS). This standard supervision was fully replaced by the MESH-QI intervention which focused on intensive, ongoing and responsive mentoring and systems targeted improvements (Manzi et al. 2012).

Intensive mentorship at health facility level

Clinical mentors attended a one-time intensive orientation training as well as quarterly workshops on both clinical mentoring and quality improvement techniques. After this training, mentors conducted 2-3 mentoring visits per health center every 4-6 weeks. Mentoring visits included direct observation, giving real-time feedback to ANC nurse mentees and coaching teams to use data for continuous systems improvement. Tools were developed and used by the MESH-QI mentors to assess the quality of ANC service delivery and included observation checklists.

Data use for continuous systems improvement

MESH-QI mentors trained and coached mentees in systems gap analysis, prioritization, and development of quality improvement projects using monitoring data. Data from the national health management information system (HMIS) and mentor observation checklists were synthesized, analyzed and reviewed by facility teams to develop quality improvement projects (Manzi et al. 2012; Manzi 2016).

Data analysis

We sought to estimate the incremental cost-effectiveness of the MESH-QI ANC intervention compared to standard district supervision. Our outcome was quality measured by completeness of all danger signs and vital signs assessment items described in more detail below. We obtained estimates of the difference in quality from a pre-post evaluation, which compared the quality of ANC during standard district supervision and after MESH-QI intervention.

Intervention costs

Cost data included actual expenses as well as in-kind resources used to train two mentors, salary and benefits for the staff including two full time mentors and a portion of two program managers' time), and laptop computers for the mentors and MESH-QI program staff. All of these costs were extracted from the program documents, budgets and other financial records (Lu et al. 2014), and were analyzed and reported in 2011 US dollars (USD) using a provider or implementer perspective. Overhead (administrative, logistics, and M&E) costs were estimated using PIH's annual expenditure reports for that study period and using estimates weighted by time spent on MESH-QI. We used the same approach to estimate the costs of a comparable ANC supervision program that existed at the baseline, prior to MESH-QI intervention. We applied a discount rate of 10% to estimate the cost of depreciating transportation equipment, including the cost of the vehicle, driver and fuel. Since there is a car sharing practice within the intervention districts, we narrowed down to cost only related to ANC MESH-QI using an average of six people who regularly shared the car with the two MESH-QI mentors throughout the intervention period. The M&E officer's salary was apportioned based on records of time spent on different tasks to estimate the cost of data management (data entry, analysis and reporting). Costs at baseline reflecting standard district supervision included salaries and benefits as well as transportation for two district supervisors who were responsible for maternal and child health related activities including ANC

across all 21 health centers.. The costs associated with provision of ANC care at health centers, including health facility infrastructure, staffing, equipment and supplies were not part of the MESH-QI intervention and so would remain constant regardless of whether standard supervision or MESH-QI were implemented. Therefore, only costs directly related to standard ANC supervision (baseline costs) and MESH-QI (intervention costs) were included in our analysis.

Intervention effect

Quality of care data were obtained from a prior evaluation conducted using observation checklist data. Baseline (standard district supervision) included checklist collected between October 2010 and May 2011, before implementation of the MESH-QI intervention. 12-month (MESH-QI) data included checklists collected between February 2012 and November 2012, roughly twelve months after the start of the MESH-QI intervention. Observation checklists contained information on essential ANC assessment items including vital signs and danger signs (Manzi et al. 2012).

Effectiveness measures were defined as completion of all seven danger signs and four vital signs assessment items, which were in the Rwanda ANC guidelines during ANC visits. The seven danger signs were headache, blurry vision, facial swelling, convulsions, bleeding, loss of fluid, and painful contractions and the four vital signs were temperature, blood pressure, pulse and respirations. Observation checklists completed by mentors were used to measure health care providers' adherence to ANC algorithms and diagnostic procedures at both baseline and during mentoring period. We used the difference in proportion of ANC visits with complete danger signs and vital signs assessments from the baseline (standard supervision) to 12-months (MESH-QI) to estimate effectiveness of the intervention.

Cost-effectiveness analysis

We adapted the six-steps approach proposed by Larson and Wambua to estimate the total annual costs of MESH-QI ANC program (Table 1) (Larson & Wambua 2011). Major cost categories included 1) salary and benefits including the two district hospital nurses assigned to monitor and supervise maternal health services prior to MESH-QI program and program management team and nurse mentors who were the main program staffs, 2) mentors' training in clinical mentoring techniques, 3) data management, 4) overhead, 5) transport, and 6) dissemination and regular debriefing.

The incremental cost-effectiveness ratio (ICER) was calculated as the difference in costs of MESH-QI compared to standard supervision divided by the difference in percentage change of quality of care, defined as complete assessment of 1) all seven danger signs and 2) all four vital signs assessments during ANC visit. Changes in ANC visits with complete assessments and additional cost per ANC visit with complete assessments were estimated.

Equation 1: $ICER = (C_b - C_f) / (Q_b - Q_f)$

Where: C_b is the cost per ANC targeted mentorship assuming standard supervision; C_f is the cost per ANC targeted mentorship reflecting MESH-QI; Q_b is the percentage of ANC visits during the standard supervision period with complete danger signs or complete vital signs assessments and Q_f is the percentage of ANC under MESH-QI with complete danger signs or vital signs assessments.

Sensitivity analysis

Our primary ICER estimates used 11,760, the actual number of ANC visits during the study period. To account for uncertainty in the patient volume, we performed a sensitivity analysis and modeled the ICER while varying number of ANC cases consulted. We considered two extreme scenarios including 100% decrease of ANC visits from the actual scenario with 0% ANC coverage and 100% increase of ANC visits from the actual scenario with almost 100% coverage to provide sensitivity bounds for our results.

Ethical consideration

This study is covered by the PHIT Partnership research protocol approved by the Rwanda National Ethics Committee and Partners Institutional Review Board in Boston, MA. No individual-level patient information were collected for this cost-effectiveness study.

RESULTS

The total annual costs of standard ANC supervision alone was 10,777.21 USD at the baseline (Table 2), whereas the total costs of MESH-QI for ANC was 19,656.53 USD over one year. MESH-QI team salary and benefits and transportation constituted the major cost category,

accounting for 48.3% and 15.3% of the total program expenses. Trainings for mentors, data management, and equipment costs were the other considerable cost drivers at 12.9%, 6.5%, and 6.5%, respectively. The rest of program costs included M&E, feedback meetings and organizational costs.

The cost of MESH-QI per ANC visit was 1.67 USD. The ICER per ANC visit with complete assessment was 0.92 USD for danger signs and 1.40 USD for vital signs. Table 3 reports the incremental costs of MESH-QI program for the provision of ANC services during the costing period. A sensitivity analysis found that ICER fell as annual number of ANC visits increased (Table 4). A tripling of annual ANC visits led to over a 50% reduction in ICER for complete danger signs and vital signs assessments, respectively from 0.92 USD to 0.46 USD and 1.40 USD to 0.70 USD. The scenario with 50% decline in the annual ANC visits increased the ICER for danger signs from 0.92 USD to1.84 USD and vital signs assessment from 1.40 USD to 2.80 USD.

Discussion

We found that the ICER for addition of MESH-QI to routine ANC associated with danger signs assessment (0.92 USD) and taking of complete vital signs (1.40 USD) represented a modest increase in cost compared to pre-intervention costs, demonstrating that a program can increase the quality of the ANC visit while incurring a cost that might be affordable in low-resource settings. Consistent with other cost-effectiveness studies of quality and systems improvement interventions, salaries and benefits account for the greatest proportion of program expenses (Shade et al. 2013). This finding was expected because even though MESH-QI was integrated with the existing Ministry of Health structure, additional staff including mentors and management team were recruited and paid as new hires. In settings where an effective supervisory team is in place that can be trained or are already doing effective supportive supervision, new hires would not have been required thus reducing this cost component. However, there is evidence that current supervision visits as delivered are not effective in ensuring quality of care in many settings (Hannah H Leslie et al. 2016) arguing that additional training for the supervisors and related cost would be required even if staff are already present.

The ICER to assess vital signs was greater than ICER for danger signs assessment. This could arise because mentoring resulted in much less improvement in vital signs assessment than danger sign assessments. Failure to completely assess vital signs, even after MESH-QI intervention, may reflect the limited availability of some tools specifically needed for these assessments, such as watches, scales, thermometers, and sphygmomanometers. Strengthening systems including supply chain is an important area for the district and national programs to focus on to ensure readiness to provide quality care, while MESH-QI focuses on helping providers use this equipment effectively.

Costs of M&E, including the time for data officer to enter and analyze data from observation checklists, increased program expenses. These costs may decrease in settings with an existing M&E team, or where mHealth technology such as tablet-based data collection in real time by mentors has been adopted.

These study findings demonstrated that MESH-QI could provide a cost-effective approach to transfer tacit knowledge and skills and gains in ANC training (Couillard 2006; Abiddin 2006) and strengthen competency areas that researchers agree are essential for good care (Eby et al. 2008; WHO 2006).

This study has a number of limitations. First, the effectiveness was defined as completion of all seven danger signs and four vital signs assessment items, as computed in a previous study (Manzi 2016) . Any limitations of the original study's results may have affected our cost-effectiveness estimates. Second, this study did not report lives saved, quality-adjusted life years (QALY) or disability-adjusted life year (DALY), commonly measured outcomes in cost-effectiveness studies that capture more of the impact of the intervention on the patient and population health. However previous studies demonstrated that quality ANC delivery improves maternal and neonatal outcomes (Lassi et al. 2014; Barros et al. 1996; Pinzón-Rondón et al. 2015). Future studies should include clinical outcome measures and the QALYS and DALYS in evaluations of implementation of MESH-QI intervention in similar settings to provide information about the impact the intervention has on patients. Our effectiveness measures also did not include patient-reported satisfaction and perceived impact of the MESH-QI model on experiential and technical quality

ANC, areas which have been associated with better adherence to care (Kruk & Freedman 2008); these should be included in future studies to capture benefits to patients.

This study was based a set of assumptions about our costs and patient volume that introduce a certain level of uncertainty (Jain et al. 2011). For example, we used the total number of ANC visits throughout the study period. This may have affected our cost estimates as patient volume is a major driver of overall ICER. Therefore, a sensitivity analysis was performed to test the impact of these assumptions on our results, which showed that costs in absolute terms did not increase by more than $2.50 per patient. The change in quality of danger sign and vital sign assessments used in this cost-effectiveness analysis might have been affected by changes in non-MESH-QI health center factors that were not included in our analysis such as the number of staff, infrastructure, ANC equipment and drugs. Further studies are needed to estimate the costs of ensuring comprehensive quality ANC in similar settings.

Conclusion

Clinical mentorship and quality improvement has been shown to serve as an effective means of improving the quality of ANC in rural Rwanda. Our analysis demonstrates that the additional costs to standard supervisory system are modest, and in concert with prior work showing the impact on quality improvement and job satisfaction, such costs may provide an affordable option for district health supervisors to improve quality of ANC in low-resource settings. Further studies of cost-effectiveness should incorporate benefits relating to satisfaction of providers and patients resulting from this program. This information could be beneficial to policy makers and program implementers from resource-limited settings seeking to improve ANC quality of care in their countries.

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References

Abiddin, N.Z., 2006. Mentoring and Coaching : The Roles and Practices. *Journal of Human resource and Adult Learning*, 2, pp.107–116.

ACCESS, 2007. *Focused Antenatal Care: Providing Integrated, Individualized Care during Pregnancy*, Available at: http://reprolineplus.org/resources/focused-antenatal-care-providing-integrated-individualized-care-during-pregnancy [Accessed April 6, 2015].

Ali, A.A.A. & Adam, I., 2011. Lack of antenatal care, education, and high maternal mortality in Kassala hospital, eastern Sudan during 2005-2009. *The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians*, 24(8), pp.1077–1078. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21231847.

Anatole, M. et al., 2013. Nurse mentorship to improve the quality of health care delivery in rural Rwanda. *Nursing Outlook*, 61(3), pp.137–144. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0029655412002916 [Accessed April 20, 2017].

Anyangwe, S.C.E. & Mtonga, C., 2007. Inequities in the Global Health Workforce: The Greatest Impediment to Health in Sub-Saharan Africa. *International Journal of Environmental Research and Public Health*, 4(2), pp.93–100. Available at: http://www.mdpi.com/1660-4601/4/2/93/htm [Accessed December 19, 2015].

Barros, H., Tavares, M. & Rodrigues, T., 1996. Role of prenatal care in preterm birth and low birthweight in Portugal. *Journal of Public Health*, 18(3), pp.321–328. Available at: http://jpubhealth.oxfordjournals.org/content/18/3/321.abstract [Accessed December 31, 2015].

Basinga, P. et al., 2011. Effect on maternal and child health services in Rwanda of payment to primary health-care providers for performance: an impact evaluation. *Lancet (London, England)*, 377(9775), pp.1421–8. Available at: http://www.thelancet.com/article/S0140673611601773/fulltext [Accessed December 29, 2015].

Bhutta, Z.A. et al., 2008. Alma-Ata: Rebirth and Revision 6 Interventions to address maternal, newborn, and child survival: what difference can integrated primary health care strategies make? *Lancet (London, England)*, 372(9642), pp.972–89. Available at:

http://www.thelancet.com/article/S0140673608614075/fulltext [Accessed November 27, 2015].

Binagwaho, A. et al., 2014. Rwanda 20 years on: investing in life. *The Lancet*, 384(9940), pp.371–375. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0140673614605742 [Accessed January 8, 2017].

Bluestone, J. et al., 2013. Effective in-service training design and delivery: evidence from an integrative literature review. *Human Resources for Health*, 11(1), p.51. Available at: http://human-resources-health.biomedcentral.com/articles/10.1186/1478-4491-11-51 [Accessed February 18, 2018].

Bosch-Capblanch, X. & Garner, P., 2008. Primary health care supervision in developing countries. *Tropical medicine & international health : TM & IH*, 13(3), pp.369–83. Available at: http://www.ncbi.nlm.nih.gov/pubmed/18397400 [Accessed January 7, 2016].

Brighton, A. et al., 2013. Perceptions of prenatal and obstetric care in Sub-Saharan Africa. *International Journal of Gynecology & Obstetrics*, 120(3), pp.224–227. Available at: http://doi.wiley.com/10.1016/j.ijgo.2012.09.017 [Accessed November 27, 2017].

Calvello, E.J. et al., 2015. Applying the lessons of maternal mortality reduction to global emergency health. *Bulletin of the World Health Organization*, 93(6), pp.417–423. Available at: http://www.who.int/entity/bulletin/volumes/93/6/14-146571.pdf [Accessed November 27, 2017].

Carroli, G., Rooney, C. & Villar, J., 2001. How effective is antenatal care in preventing maternal mortality and serious morbidity? An overview of the evidence. *Paediatric and perinatal epidemiology*, 15(s1), pp.1–42. Available at: http://doi.wiley.com/10.1046/j.1365-3016.2001.0150s1001.x [Accessed March 7, 2014].

Central Intelligence Agency (CIA), 2017. The World Factbook — Central Intelligence Agency-Rwanda. Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/rw.html [Accessed December 18, 2017].

Chopra, M. et al., 2009. Saving the lives of South Africa's mothers, babies, and children: can the health system deliver? *Lancet*, 374(9692), pp.835–46. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19709729 [Accessed July 23, 2011].

Clements, C.J., Streefland, P.H. & Malau, C., 2007. Supervision in primary health care--can it be carried out effectively in developing countries? *Current drug safety*, 2(1), pp.19–23.

Available at: http://www.ncbi.nlm.nih.gov/pubmed/18690946 [Accessed May 7, 2017].

Couillard, D., 2006. *Managing in a Sea of Uncertainty: Leadership, Learning, and Resources for the High Tech Firm*, Presses inter Polytechnique. Available at: https://books.google.com/books?id=kA8qa6DayC0C&pgis=1 [Accessed March 2, 2016].

Dowswell, T. et al., 2010. Alternative versus standard packages of antenatal care for low-risk pregnancy. *The Cochrane database of systematic reviews*, 10, p.CD000934. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20927721 [Accessed January 27, 2014].

Drife, J., 2002. The start of life: a history of obstetrics. *Postgraduate medical journal*, 78(919), pp.311–5. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12151591 [Accessed February 16, 2018].

Drobac, P. et al., 2013. Comprehensive and integrated district health systems strengthening: the Rwanda Population Health Implementation and Training (PHIT) Partnership. *BMC Health Services Research*, 13(2). Available at: http://dx.doi.org/10.1186/1472-6963-13-S2-S5. [Accessed March 27, 2017].

Eby, L.T. et al., 2008. Does Mentoring Matter? A Multidisciplinary Meta-Analysis Comparing Mentored and Non-Mentored Individuals. *Journal of vocational behavior*, 72(2), pp.254–267. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2352144&tool=pmcentrez&rendertype=abstract [Accessed November 11, 2015].

FA Akanbiemu, A.M.A.F.A.A., 2013. Effect of Perception and Free Maternal Health Services on Antenatal Care Facilities Utilization in Selected Rural and Semi-Urban Communities of Ondo State. *Nigeria.*, 3, pp.681–697.

Fagbamigbe, A.F. & Idemudia, E.S., 2015. Assessment of quality of antenatal care services in Nigeria: evidence from a population-based survey. *Reproductive Health*, 12(1), p.88. Available at: http://reproductive-health-journal.biomedcentral.com/articles/10.1186/s12978-015-0081-0 [Accessed November 27, 2017].

Farmer, P.E. et al., 2013. Reduced premature mortality in Rwanda: lessons from success. *BMJ (Clinical research ed.)*, 346(jan18_1), p.f65. Available at: http://www.bmj.com/content/346/bmj.f65 [Accessed November 14, 2015].

Government of Rwanda, 2012. Third health sector strategic plan 2012-2018. *MoH*, (July). Available at:

http://moh.gov.rw/fileadmin/templates/Docs/HSSP_III_FINAL_VERSION.pdf.

Gross, K. et al., 2011. Antenatal care in practice: an exploratory study in antenatal care clinics in the Kilombero Valley, south-eastern Tanzania. *BMC pregnancy and childbirth*, 11(1), p.36. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3123249&tool=pmcentrez&rendertype=abstract.

Hagey, J., Rulisa, S. & Pérez-Escamilla, R., 2013. Barriers and solutions for timely initiation of antenatal care in Kigali, Rwanda: Health facility professionals' perspective. *Midwifery*, 30(1), pp.96–102. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84875322700&partnerID=40&md5=2dd709e3a5894ba52e0d7140806dbbc9.

Hofmeyr, G.J. & Hodnett, E.D., 2013. Antenatal care packages with reduced visits and perinatal mortality : a secondary analysis of the WHO antenatal care trial - Comentary : routine antenatal visits for healthy pregnant women do make a difference. , 10, pp.0–3.

I-TECH, 2015. Clinical Mentoring. Available at: http://www.go2itech.org/what-we-do/health-workforce-development/clinical-mentoring/ [Accessed February 20, 2018].

Ingabire, W. et al., 2015. Roadmap to an effective quality improvement and patient safety program implementation in a rural hospital setting. *Healthcare*, 3(4), pp.277–282. Available at: http://www.sciencedirect.com/science/article/pii/S2213076415300476 [Accessed November 27, 2015].

Jain, R., Grabner, M. & Onukwugha, E., 2011. Sensitivity analysis in cost-effectiveness studies: from guidelines to practice. *PharmacoEconomics*, 29(4), pp.297–314. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21395350 [Accessed January 31, 2016].

Kirk, C. et al., 2015. *Mentorship and Enhanced Supervision for Health Care and Quality Improvement in Rwanda*, Available at: http://www.pih.org/library/pih-reports-volume-2-issue-1 [Accessed December 28, 2015].

Kruk, M.E. & Freedman, L.P., 2008. Assessing health system performance in developing countries: A review of the literature. *Health Policy*, 85(3), pp.263–276. Available at: http://www.sciencedirect.com/science/article/pii/S016885100700200X [Accessed March 30, 2017].

Larson, B.A. & Wambua, N., 2011. How to calculate the annual costs of NGO-implemented programmes to support orphans and vulnerable children: a six-step approach. *Journal of the*

International AIDS Society, 14, p.59. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3271988&tool=pmcentrez&rendertype=abstract [Accessed June 4, 2015].

Lassi, Z.S. et al., 2014. Essential pre-pregnancy and pregnancy interventions for improved maternal, newborn and child health. *Reproductive Health*, 11(Suppl 1), p.S2. Available at: http://www.ncbi.nlm.nih.gov/pubmed/25178042 [Accessed March 30, 2017].

Leslie, H.H. et al., 2016. Training And Supervision Did Not Meaningfully Improve Quality Of Care For Pregnant Women Or Sick Children In Sub-Saharan Africa. *Health affairs (Project Hope)*, 35(9), pp.1716–24. Available at: http://www.ncbi.nlm.nih.gov/pubmed/27605655 [Accessed April 9, 2017].

Leslie, H.H. et al., 2016. Training And Supervision Did Not Meaningfully Improve Quality Of Care For Pregnant Women Or Sick Children In Sub-Saharan Africa. *Health Affairs*, 35(9), pp.1716–1724. Available at: http://content.healthaffairs.org/cgi/doi/10.1377/hlthaff.2016.0261 [Accessed January 8, 2017].

Lincetto, O. et al., 2010. *Antenatal Care*, Available at: http://www.who.int/pmnch/media/publications/aonsectionIII_2.pdf.

Lu, C. et al., 2014. Tracking rural health facility financial data in resource-limited settings: a case study from Rwanda. *PLoS medicine*, 11(12), p.e1001763. Available at: http://dx.plos.org/10.1371/journal.pmed.1001763 [Accessed January 8, 2017].

Magge, H. et al., 2014. Mentoring and quality improvement strengthen integrated management of childhood illness implementation in rural Rwanda. *Archives of disease in childhood*, 100, pp.565–70. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24819369 [Accessed May 26, 2014].

Makaka, A., Breen, S. & Binagwaho, A., 2012. Universal health coverage in Rwanda: a report of innovations to increase enrolment in community-based health insurance. *The Lancet*, 380, p.S7. Available at: http://www.thelancet.com/journals/a/article/PIIS0140-6736%2813%2960293-7/fulltext [Accessed August 12, 2014].

Manzi, A., 2016. Boosting Quality Health Care Delivery and Systems Performance Through Clinical Mentorship and Quality Improvement Coaching: Lessons Learned From Rural Health Facilities in Rwanda. In *Global Health & Innovation Conference*. New Haven: Unite

for Sight. Available at: http://www.uniteforsight.org/conference/speaker-schedule-2016#posters [Accessed December 21, 2016].

Manzi, A. et al., 2014. Clinical mentorship to improve pediatric quality of care at the health centers in rural Rwanda: a qualitative study of perceptions and acceptability of health care workers. *BMC health services research*, 14, p.275. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24950878 [Accessed March 27, 2017].

Manzi, A. et al., 2012. Nurse mentorship to improve the quality of health care delivery in rural Rwanda. *Nursing Outlook*, 61(3), pp.137–44. Available at: http://www.ncbi.nlm.nih.gov/pubmed/23164530 [Accessed December 11, 2012].

McAuliffe, E. et al., 2013. The Critical Role of Supervision in Retaining Staff in Obstetric Services: A Three Country Study H. R. Baradaran, ed. *PLoS ONE*, 8(3), p.e58415. Available at: http://dx.plos.org/10.1371/journal.pone.0058415 [Accessed March 27, 2013].

Ministry of Health, 2011. *Human Resources for Health Strategic Plan*, Available at: http://www.brown.edu/academics/medical/bright/sites/brown.edu.academics.medical.bright/files/uploads/MOH Rwanda HRH Strategic Plan 2011 - 2016.pdf.

MoH, 2012. *Health Sector Strategic Plan II*,

Moses Tetui et al, 2012. Quality of Antenatal care services in eastern Uganda : implications for interventions. *PanAfrican Medical Journal*, 13, pp.1–15. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3527020.

National Institute of Statistics of Rwanda, 2015. *Statistical YearBook 2015*, Available at: http://statistics.gov.rw/publications/statistical-yearbook-2015 [Accessed December 28, 2015].

National Institute of Statistics of Rwanda - Ministry of Finance and Economic Planning, 2012. *Integrated Household Living Conditions Survey (EICV4)*, Available at: http://microdata.statistics.gov.rw/index.php/catalog/75 [Accessed November 27, 2017].

National Institute of Statistics of Rwanda (NISR) [Rwanda] & Ministry of Finance and Economic Planning (MINECOFIN), 2012. *Rwanda Fourth Population and Housing Census*, Kigali, Rwanda. Available at: http://www.statistics.gov.rw/publications/2012-population-andhousing-.

National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MoH) [Rwanda] & ICF International, 2015. *Demographic and Health Survey 2014-15*, Rockville,

Maryland, USA.

National Institute of Statistics of Rwanda (NISR), Ministry of Health (MOH) [Rwanda] & ICF International, 2010. *Rwanda Demographic and Health Survey*, Rockville, Maryland, USA.

Ngabo, F. et al., 2012. *Quality of Care for Prevention and Management of Common Maternal and Newborn Complications Findings from a National Health Facility Survey in Rwanda*, Available at: http://www.mchip.net/sites/default/files/Rwanda_QoC.PDF [Accessed March 24, 2017].

Ouma, P.O. et al., 2010. Antenatal and delivery care in rural western Kenya: the effect of training health care workers to provide "focused antenatal care." *Reproductive Health*, 7(1), p.1. Available at: http://reproductive-health-journal.biomedcentral.com/articles/10.1186/1742-4755-7-1 [Accessed March 24, 2017].

Påfs, J. et al., 2015. 'They would never receive you without a husband': Paradoxical barriers to antenatal care scale-up in Rwanda. *Midwifery*, 31(12), pp.1149–1156. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0266613815002569 [Accessed November 27, 2017].

Pinzón-Rondón, Á.M. et al., 2015. Low birth weight and prenatal care in Colombia: a cross-sectional study. *BMC pregnancy and childbirth*, 15, p.118. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4491421&tool=pmcentrez&rendertype=abstract [Accessed December 10, 2015].

Rani, M., Bonu, S. & Harvey, S., 2008. Differentials in the quality of antenatal care in India. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua*, 20(1), pp.62–71.

Republic of Rwanda, 2013. *Annual Health Statistical Booklet 2013*, Kigali. Available at: http://www.moh.gov.rw/fileadmin/templates/policies/Rwanda_Annual_Health_Statistics_Booklet_2013_signed.pdf.

Republic of Rwanda, 2011. *Service packages for health facilities at different levels of service delivery*,

Rowe, A.K. et al., 2010. The rise and fall of supervision in a project designed to strengthen supervision of Integrated Management of Childhood Illness in Benin. *Health policy and planning*, 25(2), pp.125–34. Available at: http://heapol.oxfordjournals.org/content/25/2/125.long [Accessed January 6, 2016].

Say, L. et al., 2014. Global causes of maternal death: a WHO systematic analysis. *The Lancet Global Health*, 2(6), pp.e323–e333. Available at: http://linkinghub.elsevier.com/retrieve/pii/S2214109X1470227X [Accessed July 17, 2017].

Selvarajah, S., 2013. Charity does not rhyme with sustainability. *UCL-Lancet Lecture*. Available at: https://blogs.ucl.ac.uk/events/tag/ucl-lancet-lecture/.

Shade, S.B. et al., 2013. Cost, cost-efficiency and cost-effectiveness of integrated family planning and HIV services. *AIDS (London, England)*, 27 Suppl 1, pp.S87-92. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24088688 [Accessed December 19, 2015].

Sipsma, H.L. et al., 2012. Identifying characteristics associated with performing recommended practices in maternal and newborn care among health facilities in Rwanda: a cross-sectional study. *Human Resources for Health*, 10(1), p.13. Available at: http://www.human-resources-health.com/content/10/1/13/.

Starfield, B., 2001. Basic concepts in population health and health care. *Journal of epidemiology and community health*, 55(7), pp.452–4. Available at: http://www.ncbi.nlm.nih.gov/pubmed/11413173 [Accessed February 19, 2018].

Tacoma Pierce County, 2012. Glossary of Key Quality & Performance Management Terms. *Health Department*. Available at: https://www.doh.wa.gov/portals/1/documents/1000/pmc-quality_performancemanagement-glossary.pdf [Accessed October 11, 2018].

Thaddeus, S. & Maine, D., 1994. Too far to walk: Maternal mortality in context. *Social Science & Medicine*, 38(8), pp.1091–1110. Available at: http://www.sciencedirect.com/science/article/pii/0277953694902267 [Accessed May 27, 2015].

The Open University, 2017. Antenatal Care. *OpenLearn Create*. Available at: http://www.open.edu/openlearncreate/mod/oucontent/view.php?id=44%253f [Accessed May 4, 2017].

United Nations, 2015. Antenatal care coverage (at least one visit and at least four visits) - ScrewTurn Wiki. Available at: http://mdgs.un.org/unsd/mi/wiki/5-5-Antenatal-care-coverage-at-least-one-visit-and-at-least-four-visits.ashx [Accessed February 20, 2018].

Vilar J, B.P., 2003. *WHO antenatal care randomized trial. Manual for the implementation of the new model*, World Health Organization. Available at: http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/RHR_01_30

/en/ [Accessed March 30, 2015].

WHO, 2006. *WHO recommendations for clinical mentoring to support scale-up of HIV care, antiretroviral therapy and prevention in resource-constrained settings*, World Health Organization. Available at: http://www.who.int/hiv/pub/meetingreports/clinicalmentoring/en/ [Accessed December 25, 2015].

WHO, 2015. *World Health Statistics 2015*, World Health Organization. Available at: http://www.who.int/gho/publications/world_health_statistics/2015/en/ [Accessed December 28, 2015].

World Health Organization, 2011. Health Systems Strengthening Glossary. *WHO*. Available at: http://www.who.int/healthsystems/hss_glossary/en/index6.html#6 [Accessed February 19, 2018].

World Health Organization, 2016a. *Maternal mortality*, Geneva: World Health Organization.

World Health Organization, 2016b. *Pregnant women must be able to access the right care at the right time*, Geneva: World Health Organization. Available at: http://www.who.int/mediacentre/news/releases/2016/antenatal-care-guidelines/en/ [Accessed February 16, 2018].

World Health Organization, 2013. *The World Health Report 2008 - primary Health Care (Now More Than Ever)*, World Health Organization. Available at: http://www.who.int/whr/2008/en/ [Accessed February 20, 2018].

World Health Organization, 2017. *Tracking Universal Health Coverage: 2017 Global Monitoring Report*, Geneva, Switzerland. Available at: http://www.who.int/healthinfo/universal_health_coverage/report/2017_global_monitoring_report.pdf?ua=1 [Accessed February 16, 2018].

World Health Organization, 2014. WHO/WPRO-Strategy on Health Care Financing for Countries of the Western Pacific and South-East Asia Regions (2006-2010). Available at: http://www2.wpro.who.int/rcm/en/archives/rc56/rc_resolutions/wpr_rc56_r06.htm [Accessed February 19, 2018].

Table 1. A summary of steps

Step 1.	Accessed financial reports (FY2011)
Step 2.	Extracted and kept only those expenses specific to MESH-QI program
Step 3.	Linked and grouped report activities (e.g: monthly payroll) into input cost categories (e.g: Salaries and benefits)
Step 4.	Estimated and included a small portion of the organizational costs (administration & finance) that are not attributed to any specific program: Overhead costs
Step 5.	Estimated and included M&E costs to account for activities related to MESH-QI ANC data entry (Data officer time to enter the checklists forms into the database)
Step 6.	Estimated only the total costs of ANC sphere as portion of the entire MESH-QI costs (5 clinical spheres); stratified by input cost category (e.g: Salaries and benefits)
Step 7.	Accessed patient care information (e.g: Number of ANC patients and their visits at the mentored health facilities)
Step 8.	Linked the cost of MESH-QI program (from step 6) to the number of ANC clients and visits at the health center during the period of analysis (from step 7.) and calculated the cost of MESH-QI per ANC visit (provider time + treatment + MESH-QI)
Step 9.	Accessed the findings on the effectiveness of MESH-QI as related to caring for ANC clients—The main measures of effectiveness were the number of ANC clients completely assessed for "danger signs" and "vital signs" (before and during MESH-QI implementation)
Step 10.	Linked the "cost" to "effectiveness" at both the baseline and the follow up period to calculate the cost-effectiveness ratio*

* Conducted a sensitivity analysis of the cost per ANC client to adjust for a cost increase or decrease that could result from a higher or lower number of ANC clients than observed in step 9.

Table 2: Annual Implementation Costs for ANC supervision and MESH-QI program:

Input category	Amount at baseline	%	Amount with MESH-QI	%
Salary and benefits for the manager and mentors	$ 5,352.09	49.7%	$ 9,495.49	48.3%
Trainings (onboarding, refresher)	$ -	0.0%	$ 2,541.61	12.9%
Meetings (debrief and data sharing)	$ 625.00	5.8%	$ 1,030.35	5.2%
Data management	$ 960.15	8.9%	$ 1,280.20	6.5%
IT equipment	$ 672.54	6.2%	$ 1,273.28	6.5%
Transport costs	$ 2,411.64	22.4%	$ 3,016.00	15.3%
Organizational costs (Overhead)	$ 755.79	7.0%	$ 1,019.60	5.2%
Total	**$ 10,777.21**		**$ 19,656.53**	
Incremental costs			$ **8,879.32**	

Table 3: Costs of MESH-QI in relation to Antenatal care and Incremental Cost-Effectiveness Ratio

	Baseline	Follow-up	Difference
ANC mentoring visit	$0.92	$1.67	$0.76
N (total ANC visits during the 1-year costing period)	11,760	11,760	
Costs for the 1-year ANC patient cohort	$10,777.21	$19,656.53	$8.879.32
Danger signs:			
Complete assessment (%)	2.1%	84.2%	
Modeled-completely assessed	247	9902	9655
Additional cost per additional patient correctly assessed (ICER)			$0.92
Vital signs:			
Complete assessment (%)	1.0%	55.0%	
Modeled-completely assessed	118	6468	6350
Additional cost per additional patient correctly assessed (ICER)			$1.40

Table 4: Sensitivity analysis assuming lower or higher number of ANC visits than reported in HMIS in the actual scenario

Scenario with % deviation from the actual	Number of ANC visits annually	Incremental cost of MESH-QI to each ANC visit	ICER per patient assessed for all danger signs	ICER per patient assessed for all vital signs
100 % decrease	0	-	-	-
50% decrease	5,880	$3.34	$1.84	$2.80
Actual	11,760	$1.67	0.92	1.40
% increase	17,640	$1.11	0.61	0.93
100% increase	23,520	$0.84	0.46	0.70

5. DISCUSSION

5.1. Main findings

The first study pinpointed distance as the main predictor of delayed ANC in Rwanda. Despite limited evidence on the effect of ANC on maternal mortality reduction, delayed ANC visits could be a proxy measure of the poor utilization of maternal and child health services. For example, if women delay their ANC visit due to their living along distance to the clinic, the same delays are likely to occur when they have a pregnancy or post-partum complications. Other maternal and child health needs including nutrition and immunization services may be affected. Having many children and unwanted pregnancy reflect the need for access to birth control services. To address these barriers, it is evident that efforts should be invested in mapping up geographic locations of all health facilities and their proximity to the population. This will inform an effective decentralization of ANC services and ensure an easier access to services. Further, an integration of ANC and birth control services would constitute a comprehensive solution to root causes reported by this study.

The second study reported poor quality of ANC delivery at health centers prior to the MESH-QI intervention. This was due in part to the inability of providers to translate FANC knowledge and skills into practice. Furthermore, the clinical supervision system was irregular, focusing mainly on data collection rather than teaching and mentoring ANC providers. Significant improvements in danger signs assessments and other ANC screenings after the intervention highlighted MESH-QI as an effective model to improve clinical competencies and quality of ANC at health centers. This model was adopted by the central Ministry of Health to improve the quality of maternal and newborn health care in Rwanda. Although MESH-QI led to significant improvements in quality of care, it is still unknown if this model impact the maternal and newborn mortality. Further studies should explore the effect of the MESH-QI on maternal and newborn outcomes. Moreover, none of these studies explored the level of satisfaction of patients. A qualitative assessment is needed to explore perceptions and satisfaction from the perspective of the patients.

The third study's results demonstrated MESH-QI as a cost-effective intervention. This information is critical to policy makers and program implementers in public health practice where evidence-based interventions are critical to inform decisions on resource allocation.

While the MESH-QI is a cost-effective intervention, our findings suggest a need for contextual adaptation. For example, in settings with an existing supervisory system, the use of the existing supervisors as mentors may make this intervention even more cost-effective. In contrast, settings without basic human resources will invest greater upfront costs which would affect the overall cost-effectiveness.

5.2. Our findings in relation to other studies

Our studies sought to understanding factors that limit or cause delays in ANC service utilization, measure the quality of ANC provided at health facilities, and estimate the cost-effectiveness of an integrated mentorship and quality improvement intervention to strengthen the quality of ANC. Findings from the first paper are consistent with a number of research studies that raised distance as a major barrier to ANC service utilization. Further, findings from the second paper are consistent with other several research findings that demonstrated gaps in the quality of antenatal care as well as the need to enhance the existing supervision system. To our knowledge, the third study was the first to estimate cost-effectiveness of an integrated mentorship and quality improvement in resource-limited settings. Results from this study will inform policy makers and implementers on feasibility and replicability of the MESH-QI model.

5.3. Methodological considerations

A methodological and statistical rigor was applied in both the design and implementation of these studies. In the first study, assessing collinearity helped to identify and retain variables more strongly correlated with the outcome of interest. Using manual backward stepwise regression to develop a multivariate regression model increased the rigor of the analysis and results.

The second study used interaction terms to determine MESH-QI intervention's effect modifiers and included them in the final model. These studies controlled for potential confounders.

The second and third studies demonstrated the feasibility of integrating quality measurements and cost-effectiveness analysis with routine evaluation of ANC delivery.

Although the results from these studies are compelling, it is important to note key implementation and evaluation limitations. First, the assessment of predictors of delayed antenatal care sorely included variables from DHS's database. Any missing variables may have affected our overall conceptual framework, analyses, and conclusions. For example, the DHS database did not have data on male partners' use of ANC services. It was impossible to assess if male's involvement reduces delays in seeking ANC. The second study used direct observation data to measure the effect of the MESH-QI. The presence of data collectors may have led to the Hawthorne effect. However, rigorous strategies were adopted to address these limitations. Finally, the incremental cost-effectiveness ratio was defined as the difference in costs of MESH-QI compared to standard supervision over the difference in percentage change in danger signs and vital signs. We assume that early detection of pregnancy danger signs saves life. Further studies are needed to assess disability-adjusted life years (DALY) averted by the MESH-QI intervention.

6. CONCLUSION

As antenatal care remains a unique opportunity to detect pregnancy danger signs, it is essential to understand factors that limit the use of ANC services. Cost-effective interventions like MESH-QI are needed to strengthen the adherence to national guidelines and improve the quality of ANC delivery.

The first study demonstrated that distance to health facility as the major predictor of delayed ANC visits. Decentralizing ANC services or increasing the number of facilities capable to provide basic ANC package constitutes a proactive strategy to promote timely ANC and increase the overall universal health coverage.

MESH-QI is an effective intervention to improve the quality of ANC at health centers. Findings from the second study highlight the need to enhance the national supervision system which often relies on traditional evaluative supervision techniques. Further, significant improvements in

danger signs and vital signs assessments suggest MESH-QI as a potential model to orient new or less experienced ANC providers.

Although the additional costs to standard supervisory system are modest. These findings are vital to program implementers and policy makers seeking to replicate the MESH-QI model in similar settings. For instance, while several low-income countries did not reach meet MDGs, improving the quality of maternal healthcare through cost-effective interventions like MESH-QI constitutes a strategy to strengthen their ANC delivery systems.

7. FUTURE PERSPECTIVES

7.1. Policy implications

This work led to a number of local and global research and policy implications. First, demonstrating distance as a predictor of delayed ANC highlighted the national health sector strategic priority needs to decentralize health services. To address this need, Rwanda increased the number of health posts from 45 in 2010 to 252 in 2013. Discussions are underway to decentralize basic components of preventative and curative care including ANC services. We believe that this will address distance and other systems gaps affecting the use of maternal health services.

The Rwandan Ministry of Health adopted mentorship as a strategy to strengthen maternal and newborn health and HIV care. A national mentorship technical working was created as a platform to ensure an effective adaptation and implementation. Expert clinicians were hired and oriented to serve as national mentors. In 2013, preliminary results were presented in the World Health Organization's technical consultation meeting that took place from Geneva. MESH-QI was highlighted by the panelists as a potential model to strengthen ANC and primary care in general.

Decentralizing ANC services and MESH-QI model should be combined to ensure both access and quality ANC delivery. MESH-QI model was already adopted by other countries with resource-limited settings including Haiti and Malawi. Further, MESH-QI was adopted as a strategy to strengthen post-Ebola Health Systems Strengthening in Liberia.

The results of the second and third studies highlight the importance of an integrated in-service mentorship and quality improvement. Further, integrating MESH-QI model into pre-service education would be a great strategy to train future change agents, ready to restore trust and

confidence among healthcare workers. Local and national policy makers should adopt this as a strategy to catalyze learning and strengthen the quality of maternal healthcare delivery at rural health centers.

7.2. Research implications

These research studies shed light on a number of areas. First, while several research studies focused on assessing ANC coverage, our first study sought to explore root causes of delayed ANC visits. This evidence constitutes an important contribution to the existing literature in maternal health arena. DHS dataset constitutes a clean and accessible source for future research seeking to address questions related to ANC service utilization.

While previous ANC evaluations reported patient level data, our second study assessed the quality of ANC (danger signs and vital signs assessments) before and after MESH-QI intervention. Results from this study support the importance of investing in care delivery processes as a strategy to improve maternal health outcomes.

Traditionally, cost-effectiveness analysis assessed disability-adjusted life years (DALY) averted by the specific interventions. In contrast, our third study reported the incremental cost-effectiveness ratio, defined as the difference in costs of MESH-QI compared to standard supervision over the difference in percentage change in danger signs and vital signs. This study suggests changes in quality of care as a possible outcomes for cost-effectiveness analyses.

8. REFERENCES

Anatole, M. et al., 2013. Nurse mentorship to improve the quality of health care delivery in rural Rwanda. *Nursing Outlook*, 61(3), pp.137–144. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0029655412002916 [Accessed April 20, 2017].

Bluestone, J. et al., 2013. Effective in-service training design and delivery: evidence from an integrative literature review. *Human Resources for Health*, 11(1), p.51. Available at: http://human-resources-health.biomedcentral.com/articles/10.1186/1478-4491-11-51 [Accessed February 18, 2018].

Brighton, A. et al., 2013. Perceptions of prenatal and obstetric care in Sub-Saharan Africa. *International Journal of Gynecology & Obstetrics*, 120(3), pp.224–227. Available at: http://doi.wiley.com/10.1016/j.ijgo.2012.09.017 [Accessed November 27, 2017].

Calvello, E.J. et al., 2015. Applying the lessons of maternal mortality reduction to global emergency health. *Bulletin of the World Health Organization*, 93(6), pp.417–423. Available at: http://www.who.int/entity/bulletin/volumes/93/6/14-146571.pdf [Accessed November 27, 2017].

Central Intelligence Agency (CIA), 2017. The World Factbook — Central Intelligence Agency-Rwanda. Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/rw.html [Accessed December 18, 2017].

Clements, C.J., Streefland, P.H. & Malau, C., 2007. Supervision in primary health care--can it be carried out effectively in developing countries? *Current drug safety*, 2(1), pp.19–23. Available at: http://www.ncbi.nlm.nih.gov/pubmed/18690946 [Accessed May 7, 2017].

Drife, J., 2002. The start of life: a history of obstetrics. *Postgraduate medical journal*, 78(919), pp.311–5. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12151591 [Accessed February 16, 2018].

FA Akanbiemu, A.M.A.F.A.A., 2013. Effect of Perception and Free Maternal Health Services on Antenatal Care Facilities Utilization in Selected Rural and Semi-Urban Communities of Ondo State. *Nigeria.*, 3, pp.681–697.

Fagbamigbe, A.F. & Idemudia, E.S., 2015. Assessment of quality of antenatal care services in Nigeria: evidence from a population-based survey. *Reproductive Health*, 12(1), p.88. Available at: http://reproductive-health-journal.biomedcentral.com/articles/10.1186/s12978-015-0081-0 [Accessed November 27, 2017].

Hagey, J., Rulisa, S. & Pérez-Escamilla, R., 2013. Barriers and solutions for timely initiation of antenatal care in Kigali, Rwanda: Health facility professionals' perspective. *Midwifery*, 30(1), pp.96–102. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84875322700&partnerID=40&md5=2dd709e3a5894ba52e0d7140806dbbc9.

Hofmeyr, G.J. & Hodnett, E.D., 2013. Antenatal care packages with reduced visits and perinatal mortality : a secondary analysis of the WHO antenatal care trial - Comentary : routine antenatal visits for healthy pregnant women do make a difference. , 10, pp.0–3.

I-TECH, 2015. Clinical Mentoring. Available at: http://www.go2itech.org/what-we-do/health-workforce-development/clinical-mentoring/ [Accessed February 20, 2018].

Leslie, H.H. et al., 2016. Training And Supervision Did Not Meaningfully Improve Quality Of Care For Pregnant Women Or Sick Children In Sub-Saharan Africa. *Health Affairs*, 35(9), pp.1716–1724. Available at: http://content.healthaffairs.org/cgi/doi/10.1377/hlthaff.2016.0261 [Accessed January 8, 2017].

Lincetto, O. et al., 2010. *Antenatal Care*, Available at: http://www.who.int/pmnch/media/publications/aonsectionIII_2.pdf.

Manzi, A., 2016. Boosting Quality Health Care Delivery and Systems Performance Through Clinical Mentorship and Quality Improvement Coaching: Lessons Learned From Rural Health Facilities in Rwanda. In *Global Health & Innovation Conference*. New Haven: Unite for Sight. Available at: http://www.uniteforsight.org/conference/speaker-schedule-2016#posters [Accessed December 21, 2016].

Manzi, A. et al., 2012. Nurse mentorship to improve the quality of health care delivery in rural Rwanda. *Nursing Outlook*, 61(3), pp.137–44. Available at: http://www.ncbi.nlm.nih.gov/pubmed/23164530 [Accessed December 11, 2012].

MoH, 2012. *Health Sector Strategic Plan II*,

National Institute of Statistics of Rwanda - Ministry of Finance and Economic Planning, 2012. *Integrated Household Living Conditions Survey (EICV4)*, Available at: http://microdata.statistics.gov.rw/index.php/catalog/75 [Accessed November 27, 2017].

National Institute of Statistics of Rwanda (NISR) [Rwanda] & Ministry of Finance and Economic Planning (MINECOFIN), 2012. *Rwanda Fourth Population and Housing Census*, Kigali, Rwanda. Available at: http://www.statistics.gov.rw/publications/2012-population-andhousing-.

National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MoH) [Rwanda] & ICF International, 2015. *Demographic and Health Survey 2014-15*, Rockville, Maryland, USA.

National Institute of Statistics of Rwanda (NISR), Ministry of Health (MOH) [Rwanda] & ICF International, 2010. *Rwanda Demographic and Health Survey*, Rockville, Maryland, USA.

Påfs, J. et al., 2015. 'They would never receive you without a husband': Paradoxical barriers to antenatal care scale-up in Rwanda. *Midwifery*, 31(12), pp.1149–1156. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0266613815002569 [Accessed November 27, 2017].

Republic of Rwanda, 2013. *Annual Health Statistical Booklet 2013*, Kigali. Available at: http://www.moh.gov.rw/fileadmin/templates/policies/Rwanda_Annual_Health_Statistics_Booklet_2013_signed.pdf.

Republic of Rwanda, 2011. *Service packages for health facilities at different levels of service*

delivery,

Say, L. et al., 2014. Global causes of maternal death: a WHO systematic analysis. *The Lancet Global Health*, 2(6), pp.e323–e333. Available at: http://linkinghub.elsevier.com/retrieve/pii/S2214109X1470227X [Accessed July 17, 2017].

Selvarajah, S., 2013. Charity does not rhyme with sustainability. *UCL-Lancet Lecture*. Available at: https://blogs.ucl.ac.uk/events/tag/ucl-lancet-lecture/.

Sipsma, H.L. et al., 2012. Identifying characteristics associated with performing recommended practices in maternal and newborn care among health facilities in Rwanda: a cross-sectional study. *Human Resources for Health*, 10(1), p.13. Available at: http://www.human-resources-health.com/content/10/1/13/.

Starfield, B., 2001. Basic concepts in population health and health care. *Journal of epidemiology and community health*, 55(7), pp.452–4. Available at: http://www.ncbi.nlm.nih.gov/pubmed/11413173 [Accessed February 19, 2018].

Tacoma Pierce County, 2012. Glossary of Key Quality & Performance Management Terms. *Health Department*. Available at: https://www.doh.wa.gov/portals/1/documents/1000/pmc-quality_performancemanagement-glossary.pdf [Accessed October 11, 2018].

Thaddeus, S. & Maine, D., 1994. Too far to walk: Maternal mortality in context. *Social Science & Medicine*, 38(8), pp.1091–1110. Available at: http://www.sciencedirect.com/science/article/pii/0277953694902267 [Accessed May 27, 2015].

The Open University, 2017. Antenatal Care. *OpenLearn Create*. Available at: http://www.open.edu/openlearncreate/mod/oucontent/view.php?id=44%253f [Accessed May 4, 2017].

United Nations, 2015. Antenatal care coverage (at least one visit and at least four visits) - ScrewTurn Wiki. Available at: http://mdgs.un.org/unsd/mi/wiki/5-5-Antenatal-care-coverage-at-least-one-visit-and-at-least-four-visits.ashx [Accessed February 20, 2018].

World Health Organization, 2011. Health Systems Strengthening Glossary. *WHO*. Available at: http://www.who.int/healthsystems/hss_glossary/en/index6.html#6 [Accessed February 19, 2018].

World Health Organization, 2016a. *Maternal mortality*, Geneva: World Health Organization.

World Health Organization, 2016b. *Pregnant women must be able to access the right care at the right time*, Geneva: World Health Organization. Available at: http://www.who.int/mediacentre/news/releases/2016/antenatal-care-guidelines/en/ [Accessed February 16, 2018].

World Health Organization, 2013. *The World Health Report 2008 - primary Health Care (Now More Than Ever)*, World Health Organization. Available at: http://www.who.int/whr/2008/en/ [Accessed February 20, 2018].

World Health Organization, 2017. *Tracking Universal Health Coverage: 2017 Global Monitoring Report*, Geneva, Switzerland. Available at: http://www.who.int/healthinfo/universal_health_coverage/report/2017_global_monitoring_report.pdf?ua=1 [Accessed February 16, 2018].

World Health Organization, 2014. WHO/WPRO-Strategy on Health Care Financing for Countries of the Western Pacific and South-East Asia Regions (2006-2010). Available at: http://www2.wpro.who.int/rcm/en/archives/rc56/rc_resolutions/wpr_rc56_r06.htm [Accessed February 19, 2018].

APPENDICES

9.1. Case observation checklist

Name of Mentor: _____ **Health Center:** _____

Date:_____/_____/_____ **Consultation Start Time:** _____

ANC Visit Number: ☐ 1st ☐ 2nd ☐ 3rd ☐ 4th ☐ Sick visit ☐ Other, specify: _____

Mentee Name: _____ **Is he/she a new mentee?** ☐ No ☐ Yes

Mentee trained in SONU/EmONC? ☐ Yes ☐ No **Education Level**: ☐ A2 ☐ A1 ☐ A0

Mentee's Sex: ☐ Male ☐ Female **Training**: ☐ Nurse ☐ Midwife ☐ Other

A. FIRST ANC VISIT CONSULTATION (SKIP TO SECTION C IF NOT FIRST ANC VISIT)				
Did the provider assess correctly and completely for…	**Yes Assessed**	**Not Assessed**	**Mentor Intervened**	**Results**
1. Gestational age	☐	☐	☐	weeks
2. Mother's age	☐	☐	☐	
3. Gravida	☐	☐	☐	
4. Para (live, stillbirths, abortions)	☐	☐	☐	☐ N/A
5. Previous C-sections	☐	☐	☐	☐ N/A
6. History of pregnancy complications (pre-term labor, pregnancy induced hypertension, pre-eclampsia/eclampsia, PPH, pro-longed labor, or gestational diabetes).	☐	☐	☐	☐ N/A, first pregnancy
7. History of anemia	☐	☐	☐	
8. HIV status	☐	☐	☐	
Did the provider ask if the woman…	**Yes Asked**	**Not Asked**	**Mentor Intervened**	**Results**
10. Has any underlying medical conditions	☐	☐	☐	
11. Has had previous surgeries	☐	☐	☐	
12. Is taking any medications	☐	☐	☐	

B. FIRST VISITS: LAB TESTS (SKIP TO SECTION C IF NOT FIRST ANC VISIT)				
Did the provider order the following labs...	**Yes Ordered**	**Not Ordered**	**Test Not Available**	**Mentor Intervened**
1. HIV	☐	☐	☐	☐
2. Syphilis (RPR)	☐	☐	☐	☐
3. Hemoglobin (taux d'hémoglobine)	☐	☐	☐	☐
4. Albumin (recherche d'albumine)	☐	☐	☐	☐

5. Blood type (groupe sanguin)	☐	☐	☐	☐

C. FOLLOW-UP ANC VISIT CONSULTATION					
Did the provider…	**Yes Assessed**	**Not Assessed**	**Mentor Intervened**	**No records available**	**Results**
1. Assess correctly gestational age	☐	☐	☐	☐	Wks
2. Review prior visit information (such as previous weight, patient history, etc.)	☐	☐	☐	☐	
3. Ask if there have been any changes since the last visit	☐	☐	☐		

D. ALL VISITS: DANGER SIGNS					
Did the provider check correctly and completely for...	**Yes Assessed**	**Not Assessed**	**Not Applicable**	**Mentor Intervened**	**Check if Present**
1. Headaches	☐	☐		☐	☐ Present
2. Blurry vision	☐	☐		☐	☐ Present
3. Facial swelling	☐	☐		☐	☐ Present
4. Convulsions	☐	☐		☐	☐ Present
5. Fever	☐	☐	☐ No equipment	☐	☐ Present
6. Bleeding	☐	☐		☐	☐ Present
7. Loss of fluid	☐	☐		☐	☐ Present
8. Painful contractions	☐	☐		☐	☐ Present
9. Decreased fetal movement (after 20 weeks gestation)	☐	☐	☐ GA <20wks	☐	☐ Present

E. ALL VISITS: ASSESSEMENT OF THE WOMAN					
Did the provider assess the mother correctly and completely for…	**Yes Assessed**	**Not Assessed**	**No Equipment**	**Mentor Intervened**	**Results**
1. Pulse	☐	☐	☐	☐	
2. Blood Pressure	☐	☐	☐	☐	
3. Weight	☐	☐	☐	☐	Kg
4. Weight gain (for 2nd, 3rd, and 4th ANC visits) reviewed by comparing today's weight to weight at prior visit	☐	☐	☐	☐	☐ N/A, 1st visit
5. MUAC	☐	☐	☐	☐	Mm
6. Anemia	☐	☐		☐	
7. Respirations/breaths per minute	☐	☐	☐	☐	
8. Tetanus vaccination is up to date and provides vaccine if needed	☐	☐	☐	☐	

F. ALL VISITS: ASSESSMENT OF THE FETUS (≥ 20 weeks)					
Did the provider assess the fetus correctly and completely for…	**Yes Assessed**	**Not Assessed**	**Not Applicable**	**No Equipment**	**Mentor Intervened**
1. Fundal height (≥20 weeks)	☐	☐	☐	☐	☐
2. Fetal heart rate (≥20 weeks)	☐	☐	☐	☐	☐
3. Fetal movement (≥20 weeks)	☐	☐	☐	☐	☐
4. Fetal position (≥20 weeks)	☐	☐	☐	☐	☐

G. ALL VISITS: BIRTH PLANNING			
Did the provider discuss with the woman…	**Yes Asked**	**Not Asked**	**Mentor Intervened**
1. If she has a birth plan and the details of the plan*	☐	☐	☐
2. Danger signs that require seeking care at the health center immediately**	☐	☐	☐
3. If she has a plan in the case of emergency complications	☐	☐	☐
4. If she has and is using a mosquito net	☐	☐	☐

***A birth plan includes:** (1) identifying a place for birth; (2) identifying a competent provider and knowing how to contact that provider; (3) A plan on how to get to the provider); (4) Identify a person to accompany the woman to the place of provider; (5) Determine who will care for the family while the woman is away; (6) Identify the person who will authorize the woman to go to the maternity; (7) set aside the money needed for delivery (and transport); (8) prepare necessary materials for delivery (soap, clean cloths, sheet, sanitary towels, etc.)

****Danger signs include:** vaginal bleeding, smelly vaginal discharge, vaginal fluid flow, painful urination, persistent vomiting, pelvic pain, visual disturbances or headaches, fainting/seizures, lethargy or tiredness, respiratory problems, night blindness, disappeared or decreased fetal movements, and anything else that may concern them

H. ALL VISITS: COUNSELING			
Type of Counseling	**Yes Provided**	**Not Provided**	**Mentor Intervened***
1. Individual counseling	☐	☐	☐
2. Group counseling	☐	☐	☐
If provided, the quality of counseling today was…	**1 (Poor)** ☐ Incorrect information or judgmental **2** ☐ **3** ☐ **4** ☐ **5 (Very good)** ☐ Correct and comprehensive counseling		

I. DIAGNOSIS AND TREATMENT PATIENT FOLLOW-UP		
	Mentee Decision	**Mentor Decision**
Diagnosis	☐ **None** ☐ Urinary tract infection ☐ Malaria ☐ Pneumonia ☐ Moderate or severe anemia ☐ Other, specify: _____	☐ **None** ☐ Urinary tract infection ☐ Malaria ☐ Pneumonia ☐ Moderate or severe anemia ☐ Other, specify: _____
	☐ **Mentor corrected diagnosis**	
Complications of Pregnancy	☐ **No complications** ☐ Amnionitis ☐ Septic abortion ☐ Threatened or incomplete abortion ☐ Ectopic pregnancy ☐ Placental abruption ☐ Placenta previa ☐ Uterine rupture ☐ Gestational hypertension ☐ Mild or severe pre-eclampsia ☐ Premature rupture of membranes (PROM) ☐ Preterm PROM (pPROM) ☐ Other, specify: _____	☐ **No complications** ☐ Amnionitis ☐ Septic abortion ☐ Threatened or incomplete abortion ☐ Ectopic pregnancy ☐ Placental abruption ☐ Placenta previa ☐ Uterine rupture ☐ Gestational hypertension ☐ Mild or severe pre-eclampsia ☐ Premature rupture of membranes (PROM) ☐ Preterm PROM (pPROM) ☐ Other, specify: _____
	☐ **Mentor corrected identification of complications**	

Treatment	☐ **None** ☐ IV antibiotics ☐ Oral antibiotics ☐ Anti-malarials ☐ IV fluids ☐ Diazepam ☐ Mebendazole ☐ Iron ☐ Tetanus vaccine ☐ Folic Acid	☐ **None** ☐ IV antibiotics ☐ Oral antibiotics ☐ Anti-malarials ☐ IV fluids ☐ Diazepam ☐ Mebendazole ☐ Iron ☐ Tetanus vaccine ☐ Folic Acid

J. PATIENT TRANSFERS AND FOLLOW-UP		
	Mentee Decision	**Mentor Decision**
Other Follow-Up or Transfers	☐ **None** ☐ Urgent transfer to district hospital ☐ Requires delivery at a hospital or higher level facility ☐ Admit to Health Center ☐ Requires more frequent follow-up ☐ Provide bed net ☐ Other, specify: _____	☐ **None** ☐ Urgent transfer to district hospital ☐ Requires delivery at a hospital or higher level facility ☐ Admit to Health Center ☐ Requires more frequent follow-up ☐ Provide bed net ☐ Other, specify: _____
	☐ **Mentor corrected other follow-up plan**	

K. WRAP-UP FOR ALL VISITS				
Did the provider…	**Yes**	**No**	**Not Applicable**	**Mentor Intervened**
1. Remind woman about rendezvous date?	☐	☐	☐	☐
2. Treat the woman with respect throughout the consultation.	☐	☐	☐	☐
3. Answer concretely all of the woman's questions.	☐	☐		☐
4. Use standard ANC form for documentation.	☐	☐		☐

Consultation End Time: _____

PARTNERS HEALTHCARE
FOUNDED BY BRIGHAM AND WOMEN'S HOSPITAL AND MASSACHUSETTS GENERAL HOSPITAL

Partners Human Research Committee
116 Huntington Avenue, Suite 1002
Boston, MA 02116
Tel: (617) 424-4100
Fax: (617) 424-4199

9.2 Ethical Consideration:

Continuing Review: Notification of IRB Approval/Activation
Protocol #: 2009P001941/BWH

Date: December 8, 2015

To: Peter C Drobac
BWH
Medicine / Global Health Equity

From: Partners Human Research Committee
116 Huntington Avenue, Suite 1002
Boston, MA 02116

Title of Protocol:	Monitoring and Evaluating an integrated Approach to Strengthening Primary Health Care Delivery in 2 districts in rural Rwanda
Version/Number:	DDCF
Version Date:	10/19/2011
Sponsor/Funding Support:	Proposal Title: Com-Based Int HCare Rw Name: Doris Duke Charitable Foundation Sponsor Number: 2009057

Study Population:	Adults
Consent/Authorization:	Required
Documentation of Consent:	Written Documentation Waived Written
Informed Consent From:	Adult Subject
Informed Consent By:	Other Study Staff (Trained Rwandan community health workers)

Study Population:	Pregnant Women/Fetuses
Consent/Authorization:	Required
Documentation of Consent:	Written Documentation Waived Written
Informed Consent From:	Adult Subject (Non-Pregnant) Pregnant Woman
Informed Consent By:	Other Study Staff
IRB Continuing Review #:	6
IRB Review Type:	Expedited
Expedited Category/ies:	(5), (7)
IRB Approval Date:	12/8/2015