Economic analysis of Results-based financing in Malawi

Strengthening the evidence base for alternative maternal and perinatal Healthcare funding

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In memory of my dear sister, Flocy Chinkhumba-Kamoto, who died due to childbirth complications.

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Table of contents

List of Tables

Table of Figures

Abbreviations

ANC Antenatal Care

BEmOC Basic Emergency Obstetric Care

CCT Conditional Cash Transfer

CEmOC Comprehensive Emergency Obstetric Care

EmOC Emergency Obstetric Care

FBD Facility-Based Delivery

HC Health Centre

ICER Incremental Cost Effectiveness Ratio

ICD International Classification of Diseases

MCH Maternal and Child Health

MDGs Millennium Development Goals

MNCH Maternal New-born and Child Health

PBF   Performance Based Financing

RBF Results Based Financing

SBA Skilled Birth Attendant

SES Socio-economic status

SSA Sub-Saharan Africa

TBA Traditional Birth Attendant

i

Definitions

Maternal death: The death of a woman while pregnant or within 42 days of termination of pregnancy from any cause related to the pregnancy or its management, but not from accidental or incidental causes (ICD-10).

Late maternal death: The death of a woman from direct or indirect obstetric causes, more than 42 days but less than one year after termination of a pregnancy.

Pregnancy-related death: Death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death.

Neonatal death: The death of a live new-born during the first 28 days of life.

Early neonatal death: The death of a live new-born during the first 7 days of life.

Perinatal death: Foetal deaths occurring after 28 completed weeks of gestation, during childbirth and deaths of live new-born occurring up to 7 days of life.

Results Based Financing: Any program that rewards the delivery of one or more outputs or outcomes by one or more incentives, financial or otherwise, upon verification that the agreed upon result has been delivered.

Abstract

The identification of policies and strategies that can increase coverage of pregnant women and the new-born with priority health interventions, especially for the poor, is one of the key challenges for global health. In the sub-Saharan Africa region, encouraging prospective mothers to deliver their babies in health facilities is one way of increasing coverage of skilled care at the time of delivery. In 2013, the Ministry of Health in Malawi embarked on an innovative initiative called Results-based financing for maternal and neonatal health (RBF4MNH) which provides conditional financial incentives to health workers to increase quality delivery care and to mothers for delivering in health facilities. Yet in the sub-Saharan region, the benefits of facility compared to home-based births; the impact of RBF initiatives on obstetric emergency care seeking and associated costs, and the evidence for RBF efficiencies are lacking.

In this thesis, I conducted three separate studies. First, I examined maternal and perinatal benefits of facility-based births relative to home births. I conducted a literature review of population-based cohort studies reporting on maternal and perinatal outcomes by place of delivery in sub-Saharan Africa. The studies were assessed for quality using the Newcastle-Ottawa scale. I used meta-analytic procedures to summarise and describe the risks of maternal and perinatal deaths by place of delivery in the region. I identified nine (9) population-based cohort studies: 6 reporting on perinatal and 3 on maternal mortality. The mean quality score for the studies was high, averaging 10 out of 15 points. A total of 36,772 pregnancy episodes were included in the analyses. Relative to facility births, perinatal mortality was higher among home births, but the difference was only significant when produced with a fixed effects model (OR 1.21, 95% CI: 1.02-1.46) and not when produced by a random effects model (OR 1.21, 95% CI: 0.79-1.84). At best, 14 perinatal deaths might be averted per 1000 births if women delivered at facilities instead of homes.

iii

There was increased risk of maternal mortality for facility-based relative to home deliveries (OR 2.29, 95% CI: 1.58-3.31).

Second, using a pre-and post-design with independent controls, I used generalised linear models to ascertain the impact receipt of RBF4MNH had on time to seek care for women experiencing pregnancy related complications and associated household costs. I used primary household survey data conducted in four districts in Malawi: at baseline in 2013 and repeated in 2014 (midline) and 2015 (endline), involving a total of 2, 219 women experiencing complications in their most recent pregnancy before the surveys. Receipt of RBF4MNH was associated with reduced expected mean time to presentation for facility care for women experiencing complications. The reduction in mean time till service was progressive: Relative to non-RBF4MNH areas, time to seek care in RBF4MNH areas decreased by 27.3% (95% CI: 28.4-25.9) at midline and 34.2% (95% CI: 37.8-30.4) at endline. Women with high education attainments, with more severe disease and high parity were more likely to present for care promptly. There was no demonstrable effect of RBF4MNH on overall (direct + indirect) household costs. However, women who received cash transfers as part of RBF4MNH had lower household costs, suggesting that receipt of cash may substitute informal carer's time sufficiently to lower productivity losses/indirect costs and, ultimately, overall household costs.

Thirdly, I used a decision tree model, populated with both primary service use and cost data from Malawi and complimented with secondary epidemiologic data from the international literature, to estimate expected RBF4MNH efficiency in terms of cost per deaths averted and life years gained. Relative to the status quo, RBF4MNH cost $42.83 per additional birth, averted 0.0015 death and gained 0.0410 life year. Thus, RBF4MNH had an incremental cost-effectiveness ratio per death averted and life year gained of $29,135 and $1,045, respectively. At a willingness to pay of $1,446 (3 times Malawi Gloss Domestic Product per capita), RBF4MNH had 60% probability of being cost-effective.

The cost-effectiveness results were sensitive to assumptions about coverage of facility-based births in RBF supported facilities and share of women accessing quality care in control facilities.

I conclude that policies that promote facility-based births can increase perinatal survival, but their benefits on material health would be contingent on concomitant quality improvement efforts given high risk of maternal deaths associated with facility deliveries in the SSA region. RBF encourages women with pregnancy related complication to present for facility care early which may lead to better outcomes if quality care is provided. RBF appears borderline cost-effective at high levels of willingness to pay and unlikely to be cost-effective at less than 3 times GDP per capita. Countries should carefully consider overall RBF merits, at health system level, before introducing it as one of the strategies for increasing coverage of facility quality care to reduce maternal and perinatal mortality.

Original papers

I. **Maternal and perinatal mortality by place of delivery in sub-Saharan Africa: a meta-analysis of population-based cohort studies**
Jobiba Chinkhumba, Manuela De Allegri, Adamson S Muula, Bjarne Robberstad
BMC Public Health 2014 14:1014

II. **Household costs and time to seek care for pregnancy related complications: The role of results-based financing**
Jobiba Chinkhumba, Manuela De Allegri, Jacob Mazalale, Stephan Brenner, Don Mathanga, Adamson S. Muula, Bjarne Robberstad
PLoS ONE 12(9) September 21, 2017

III. **Cost-effectiveness of Results-based financing in reducing maternal and perinatal mortality: Evidence from decision tree modeling.**
Jobiba Chinkhumba, Manuela De Allegri, Stephan Brenner, Jacob Mazalale, Don Mathanga, Adamson Muula, Bjarne Robberstad
Under review

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CHAPTER 1: Introduction

In this thesis, I present and discuss the findings of the economic analysis of a Results-based financing (RBF) initiative aimed at increasing service use and quality of maternal and perinatal healthcare at four districts in Malawi. I also present the implications of using RBF as an alternative option to fund maternal and perinatal healthcare in resource poor countries like Malawi. RBF is one of innovative health financing tools policy makers in developing countries are implementing to promote maternal and perinatal health by increasing the supply of and demand for quality facility-based care during childbirth. The evaluated RBF initiative is made of a supply side Performance based financing (PBF) and a demand side Conditional Cash Transfer (CCT) components. It was designed and is being implemented by the Reproductive Health Unit, Malawi Ministry of Health (MoH).

While there is mounting enthusiasm for RBF among policy makers in developing countries, there are strong debates among academics and development partners related to whether RBF is the best way to finance healthcare services and improve health system performance in resource poor settings. These debates are indicative of important policy and research evidence gaps surrounding RBF. Through this work, I hope to generate valuable additional data to inform these debates.

1.1 Background to the research

Coverage of pregnant women and new-borns with priority maternal and new-born interventions in low income countries is generally low, with important disparities existing between income groups (United Nations 2010). As a result, it is estimated that in the sub-Saharan Africa (SSA) region alone in 2015, 1 million babies were stillborn (Blencowe, Cousens et al. 2016), about 0.8 million new-borns died within 7 days of birth (UNICEF 2015, Lawn J, Mongi P et al. 2015) while 201,000 women died from pregnancy and delivery complications (WHO 2015). The majority of these deaths could have been prevented if more mothers were provided with adequate prenatal and obstetric care (Bhutta, Darmstadt et al. 2005, Filippi, Ronsmans et al. 2006).

Conventional mother and new-born health interventions that are effective, acceptable and feasible in resource poor settings exist (Bhutta, Darmstadt et al. 2005).

Although delivery of these interventions enabled several countries in the SSA region achieve Millennium Development Goals (MDGs) 4 (Child Mortality) and 5 (Maternal mortality) (UNDP 2015), maternal and perinatal mortality rates in the SSA region are still considered high, especially among populations most in need due to both constrained supply of quality care and sub optimal demand. To date, SSA has the highest maternal mortality ratio, 546 per 100,000 live births (WHO 2015) and perinatal mortality rate, 56 per 1,000 births (World Health Organization 2007). Weak healthcare systems, lack of a skilled, motivated work force and inadequate finances limit supply of care (Prata, Passano et al. 2010, Prata, Passano et al. 2011); while poor quality care, direct and indirect costs associated with care seeking dissuade pregnant women from effectively demanding needed services (Borghi, Ensor et al. 2006, McNamee, Ternent et al. 2009).

The traditional response by international agencies and donors to this state of affairs has been to significantly increase funding for maternal and new-born health (MNH) programs (Pitt, Greco et al. 2010). Referred to as input based aid, this support has largely focused on training of health workers, construction and upgrading of health facilities, purchases and distribution of new equipment and drug supplies (Hussein, Goodburn et al. 2001, Ameh, Msuya et al. 2012). Although some gains have been made, evidence shows that health systems in the sub-Saharan region continue to under provide effective MNH services, particularly for poor populations (Gauthier B 2006, Mbonye, Asimwe et al. 2007, Leigh, Mwale et al. 2008, Eichler, Agarwal et al. 2013).

Lately, there have been calls for novel strategies that can significantly increase the supply of and demand for MNH interventions (Meessen, Soucat et al. 2011). To this end, several low and middle-income countries (LMIC), with technical and financial assistance from development partners, are piloting new healthcare financing strategies. Unlike input based aid, these strategies focus on health service outputs and are collectively referred to as Results-based financing (Musgrove 2011).

Results-based financing (RBF) strategies are premised upon the assumption that individuals and organizations are motivated to perform better by incentives (Witter, Toonen et al. 2013). Within the context of MNH, RBF encompasses a range of mechanisms. On the supply side, PBFs are designed to motivate health workers with

financial rewards to encourage provision of quantity and quality care based upon attainment of pre-agreed targets. On the demand side, CCTs are designed to stimulate demand by lowering financial barriers to access care. This can be done by subsidizing transport and or stay in maternity waiting homes (Savedoff 2010, Morgan, Stanton et al. 2013). These financial incentives are also tied to autonomy, enhanced supervision and better data collection to allow for verification.

As nearly half of all births take place at home and are conducted by informal health workers in the developing countries (Montagu, Yamey et al. 2011), RBF in the SSA region has often specifically focused on incentivizing the supply of or demand for quality facility-based deliveries (Basinga, Gertler et al. 2011, Bonfrer, Van de Poel et al. 2014, Binyaruka, Patouillard et al. 2015), based on the recognition that mothers face the highest risk of death during birth (Orenstein, Orenstein et al. 2012).

1.2 Research gaps and justifications for the study

As mentioned above, the rationale for investing in RBF within the context of maternal care hinges on its putative link with increased institutional service use and quality of care for mothers and new-borns in marginalized communities. Evaluation studies on impact of RBF schemes have therefore focused on output measures that are relevant for maternal and perinatal health.

A number of reviews have summarized the current evidence base for RBF strategies (Fretheim, Witter et al. 2012, Eichler, Agarwal et al. 2013, Das, Gopalan et al. 2016, Turcotte-Tremblay, Spagnolo et al. 2016). Although individual RBF strategies are heterogeneous in terms of design and the rigor with which they are implemented, there is evidence that, under some favourable settings, RBF can increase coverage, quality and improve equity of access to MNH services (Morgan, Stanton et al. 2013, Das, Gopalan et al. 2016). However, most of these reviews highlight salient and important knowledge gaps some of which are the focus of this thesis.

First, the health benefits of facility delivery relative to home births in developing settings are implicit, as no experimental trial which would allow for making of inferences about causality has been done (Nove, Berrington et al. 2012). The evidence used to promote facility deliveries usually is the graphical presentation of the inverse association between maternal and/or perinatal mortality and the percentage of facility-

3

based deliveries. This evidence typically comes from ecological and/ or cross sectional studies (Scott and Ronsmans 2009, Moyer, Adanu et al. 2013, Godlonton and Okeke 2016). Yet the intrinsic inability of such study designs to make causal inferences is well known (Scott and Ronsmans 2009). Reliable evidence from stronger study designs, such as cohort studies, that demonstrate the benefits of facility-based deliveries compared with home deliveries is thus required to better support and inform policies that advocate for institutional births in low income countries.

Second, even though household costs and time to seek care are important dimensions of access to formal maternal care (Thaddeus and Maine 1994, Gabrysch and Campbell 2009)-with implications for maternal and perinatal health outcomes- few studies have described the impact of RBF on household costs (Soeters, Peerenboom et al. 2011) or on time till service use for obstetric emergency care in the SSA region. Dolan and Rudisill argue that context is important to understand health effects of any financial incentives (Dolan and Rudisill 2014). Therefore, evaluations of health outcomes would have greater explanatory value if they incorporate assessment of changes in other conditions that may modulate them i.e. through their actions on access (Thomson and Thomas 2015). Thus, understanding if and how RBF influences household costs and time to seek care might be helpful to explain changes in maternal and perinatal outcomes, or the lack of. Importantly, such understanding may also offer insight into potential policy and programmatic intervention points.

Third, given that governments and their development partners have limited resources, RBF schemes compete for scarce funds with alternative strategies within the healthcare sector. It is therefore worth assessing whether RBF provides value for money (Borghi, Little et al. 2015). Currently, little information exists on cost-effectiveness of RBF schemes in the SSA region (Alfonso, Bishai et al. 2013) even though assessment of comparative efficiency of RBF schemes has been identified as a priority research area (Eichler, Agarwal et al. 2013, Mangham-Jefferies, Pitt et al. 2014, Turcotte-Tremblay, Spagnolo et al. 2016). Cost-effectiveness information will add to regional evidence on RBF, thereby supporting policy makers prioritize health interventions and make informed resource allocation decisions (Turcotte-Tremblay, Spagnolo et al. 2016).

1.3 Research questions

Commensurate with the identified research gaps, the thesis sets to answer three questions:

o What are the risks of maternal and perinatal mortality for facility-based deliveries compared with home-based deliveries in sub-Saharan Africa?

o What effect does RBF have on household costs and time to seek facility care for women experiencing pregnancy related complications?

o What is the cost-effectiveness of obstetric care under RBF compared with status quo care?

1.4 Methodological approach

Answering all the three questions would not have been possible using a single method alone. A mix of non-empirical and empirical approaches was therefore used. This strategy allowed graded generation of data that informed design and conduct of subsequent approaches and ultimately allowing all the three questions to be answered.

A literature review and meta-analysis of population-based cohort studies in SSA allowed the quantification of the risk of maternal and perinatal mortality by place of delivery. Three waves of cross-sectional household data allowed the estimation of effects of RBF on household costs and time to seek care for women experiencing complications. In particular, this line of inquiry offered insight regarding the extent to which financial incentives may contribute to timely emergency care seeking and thus ultimately reduce maternal and perinatal mortality in beneficiary populations. A decision tree model enabled estimation of the expected mean costs and expected health benefits of RBF relative to status quo care. These assessments were supplemented with a review of Malawi RBF project documents and Health Information System data.

1.5 Situating the thesis

During the period of the thesis, I was based at the Centre for International Health, University of Bergen, Norway. However, this PhD -and several other related research projects-was situated within a community-based RBF for maternal and neonatal health (RBF4MNH) study in four districts- Balaka, Ntcheu, Mchinji and Dedza- in Malawi. The RBF4MNH study was evaluating the programmatic piloting RBF in Malawi. The specific objectives of the RBF4MNH study was to assess the impact of RBF4MNH on

uptake and quality of maternal and perinatal care at mainly public health facilities designated as capable of providing emergency obstetric care (EmOC) services by the Malawi MoH. All primary data collection for this PhD thesis was based on the four study districts in Malawi.

1.6 Organization of the thesis

The rest of the thesis is organized as follows. Chapter two provides the definitions, key concepts and terminologies around RBF. In addition, it provides a brief description of the principal agent theory whose constructs underpin analyses of task delegations and contracting within the healthcare system. Chapter three situates the thesis within the context of the broader published literature on RBF. Chapter four situates the thesis within the specific environment in Malawi. It highlights both the economic background and policy developments related to reproductive healthcare in the country with focus on maternal and new-born health. Chapter 5 outlines the thesis general and specific objectives. Chapter 6 describes the methods used to achieve the three thesis objectives. Chapters 7, 8 and 9 present the results of the three studies. Finally, Chapter 10 presents key findings, recommendations and conclusion.

CHAPTER 2: Theoretical frameworks

This chapter is divided into three sections. Section 2.1 provides an overview of key dimensions that are used to measure health intervention performance. Section 2.2 provides a brief introduction to RBF and defines its related key terminologies. Section 2.3 describes the theoretical basis underlying RBF and generates a conceptual framework illustrating how RBF implementation may lead to improved maternal and perinatal health outcomes. Section 2.4 provides an overview of costing approaches for healthcare programs. Finally, section 2.5 provides a general framework for cost-effectiveness analysis, illustrating how health outcomes and costs are linked and interpreted in economic evaluations.

2.1 How is the performance of a healthcare intervention measured?

Von Bertalanffy defines a system as an arrangement of parts and their interconnections that come together for a purpose (Von Bertalanffy 1968). Thus, by health systems is meant the total sum of all the organizations, institutions and resources-

including health providers, individual patients, their households and communities-whose primary purpose is to produce health (The World Health Report 2000).

Because a healthcare intervention is an integral part of a health system, the domains used to measure its performance are similar to those used for assessing health system performance, see for example: (Kessner, Kalk et al. 1973, WHO 2000, Handler A, Issel M et al. 2001).

The following sections describe concepts that specifically relate to measuring performance of a healthcare intervention (such as an RBF initiative), including effectiveness, quality, equity and efficiency. The three thesis objectives to varying degree align with these outlined concepts. For example, objective 2 is concerned with effectiveness (described in section 2.1.1) whereas objective 3 is concerned with efficiency (described in section 2.1.4).

2.1.1 Effectiveness

Several definitions for the term effectiveness exist. The one probably most pertinent to appraisal of healthcare interventions is that proposed by Wojtczak which states that effectiveness is a measure of 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 (Wojtczak 2012). In the public health field, effectiveness is often measured using intermediate indicators e.g. coverage, access and quality.

Coverage and access are themselves related concepts, though each has unique connotations. Among public health policy makers, there is some debate whether coverage is a means to an end or an end in itself (McManus J 2013). It can be argued that the World Health Organization-through the concept of universal coverage-treats coverage as an end; setting it as a goal that individuals obtain the interventions they need without risking financial hardship from unaffordable out-of-pocket payments (World Health Organization 2010). This goal recognizes coverage with health services as well as coverage with a form of financial risk protection.

Regarding access, different constructs exist. The construct used here is a more recent one proposed by McIntyre et al and is based on three interacting dimensions: availability, affordability and acceptability (McIntyre, Thiede et al. 2009). Availability

is understood as the presence of good health services within reasonable reach of those who need them and of opening hours, appointment systems and other aspects of service organization and delivery that allow people to obtain services as needed. Affordability relates to people's ability to pay for services without financial hardship. It considers not only the price of the health services, but also direct and indirect costs associated with obtaining the care. As such, affordability is influenced by the wider health financing system and by household income. Acceptability relates to people's willingness to seek services. It is influenced by social and cultural factors as well as perceptions of service effectiveness and quality (Evans, Hsu et al. 2013).

2.1.2 Quality

Quality is inextricably linked to effectiveness and has various but related definitions. An earlier definition by the American Institute of Medicine describes quality as the "degree to which health services for individuals and populations increase the likelihood of attaining desired health outcomes and are consistent with current professional knowledge" (Lohr K 1990) whereas the World Health Organization defines quality as "the process of meeting the needs and expectations of patients and health service staff." Donabedian, the father of healthcare quality, suggested a broader definition of quality care with three key dimensions: structural, process and outcomes (Donabedian 1966). The structural dimension is contextual and relates to such things as range of services provided, staff cadres and other means of health production e.g. drugs and supplies. The process dimension refers to how care is delivered and covers all the actions that encompass healthcare delivery. The outcome dimension relates to the effects and results of the care delivered. Like effectiveness, it refers to changes in health status because of treatment or intervention.

2.1.3 Equity

Equity in health is a normative concept and could denote all types of differences between individuals and groups. Commonly, equity is considered as denoting the absence of avoidable or remediable differences among groups of people (Whitehead M 1992). Health inequalities are thus considered unfair and inequitable because they do not occur randomly or by chance but are socially determined by circumstances largely

beyond an individual's control. Health inequalities that are rooted in political and social decisions (in contrast to biological or genetic differences) are also considered avoidable. This notion is consistent with the operational proposition by Braveman that a health inequality is a particular type of difference in health or in the determinants of health that could potentially be shaped by policies i.e. a difference in which disadvantaged social groups-such as the poor or less educated-systematically experience worse health or greater health risks than more advantaged social groups (Braveman 2006). Social economic status (SES) or groups are often classified according to individuals wealth index, based on housing characteristics and assets ownerships (Vyas and Kumaranayake 2006). Although equal treatment for equal need is a principle often proclaimed in health policy, the bulk of studies report consistent variations in both treatment and outcomes by SES (Wilder-Smith 2003, Ahmed, Creanga et al. 2010).

2.1.4 Efficiency

Efficiency is an economic term and considers resource use when measuring intervention's performance. Technical efficiency is achieved when allocation is organized to minimize the inputs required to produce a given output; and allocative efficiency is achieved when allocation is organized in a way that the prices of each good produced are proportional to the utilities consumers derive from them (McPake B and Normand C 2008, page 28).

2.2 Results-based financing

Achieving best results from a health system depends on choosing an optimal mix of health system components that offer the best value, and making sure they are implemented in the most efficient way (Drummond MF, Sculpher MJ et al. 2005, page 7). In practice, Eichler et al. point out that conflicting mandates and sometimes perverse incentives can stand between how a component of a health system e.g. treatment program is implemented by healthcare providers and results obtained by consumers of the healthcare. For example, a health program design may not contain explicit incentives for efficiency or offer few incentives for effectiveness. To optimize intervention performance (however it is measured), there is need to ensure congruity between intervention objectives with those of providers and users. It has been argued

that one approach that can be used to align disparate objectives in the healthcare sector in order to get better results (or health) is Results-based financing (Preker, Harding et al. 2000, Vujicic M 2009).

2.2.1 What is results-based financing?

Programs that link rewards (financial or material) conditional on performance are collectively called results based (Musgrove 2011). The term RBF encompasses a range of mechanisms and a spectrum of design, implementation and financing options (Oxman and Fretheim 2009). In the healthcare sector, RBF programs are not new. Developed countries such as the United Kingdom and the United States have all provided financial rewards to hospitals, healthcare providers and insurers for meeting volume and quality targets (Campbell, Reeves et al. 2007). The economic downturn in high-income economies has led to a period of stagnating, reduced aid to developing countries and subsequent falling budgets for global health (Fan, Duran et al. 2013). Consequently, international efforts to improve health in developing countries are also increasingly exploring initiatives such as RBF to increase volume and quality of healthcare (Meessen, Soucat et al. 2011).

2.2.2 Results-based financing related key concepts

RBF is an umbrella term and is often used interchangeably with related concepts such as performance-based financing (PBF), Performance based contracting (PBC), contracting out or purchasing health services. Although the growing attention and experimentation with RBF has led to increasing clarity about its main features regarding designs and implementation options (Savedoff 2010), some confusion about the terms still exists. The World Bank has created a glossary of terms to help make clear the subtle distinctions among RBF related concepts (Musgrove 2011) as shown in **Table 1**.

Table 1: Results-based financing related concepts, activities, targets and example

Concept	Activities	Target	Examples
Performance based Financing (PBF)	Financial rewards given to health workers providing a list of services, conditional on pre–agreed targets.	Typically, the public health sector at health facility or health worker/ management team level.	Basinga et al. 2011; Binyaruka et al. 2015;
Results based budgeting (RBB)	Budget payments based on desired outputs	Sub-national administrations, zones or public-sector organizations	Brenzel et al 2009 Brenzel et al 2015;
Conditional cash transfers (CCT)	Financial rewards given to consumers upon use of a social service.	Geographical area, vulnerable groups such as children or mothers and other users of services	Lim et al 2010; Powel-Jackson et al. 2012;
Performance based contracting (PBC)	Payment for a set of social services purchased from or contracted out to non-governmental organization (NGO) or contracted in, in the form of technical support, to public facilities.	Depending on context, targets can be individual health facilities, districts or provinces	Loevinsohn 2009
Health Equity funds (HEF)	Payment for priority health services for the poor	The poor and vulnerable individuals so they are cushioned from catastrophic health expenditures	Ir et al. 2010;
Cash on delivery aid (COD aid)	Payment is for achieving pre-determined results.	Government	Birdsall et al. 2010;
Output based aid (OBA)	Developmental aid based on output not input.	Diverse social or utility service providers such as education and energy	Mumssen et al. 2010;
Vouchers	Payment to providers and or consumer of healthcare	Providers and specific clients or individual to reduce\remove cost at point of use	Ahmed et al. 2011; Nguyen et al. 2012; Alfonso et al. 2014;

Source: Adapted from Musgrove, 2011

2.2.3 Results-based financing main categories

Pearson posits that the purpose of RBF is to transfer purchasing power to specified groups for the purchase of defined goods or services (Pearson M 2001). In this regard, RBF schemes can further be categorized into supply–side and demand-side, depending on where the financial transfers are primarily applied. Although in practice this categorization is not clear as cut, **Figure 1**, it still is useful in understanding the design of individual RBF schemes, the potential beneficiaries they aim to target and importantly, how they are anticipated to influence outcomes.
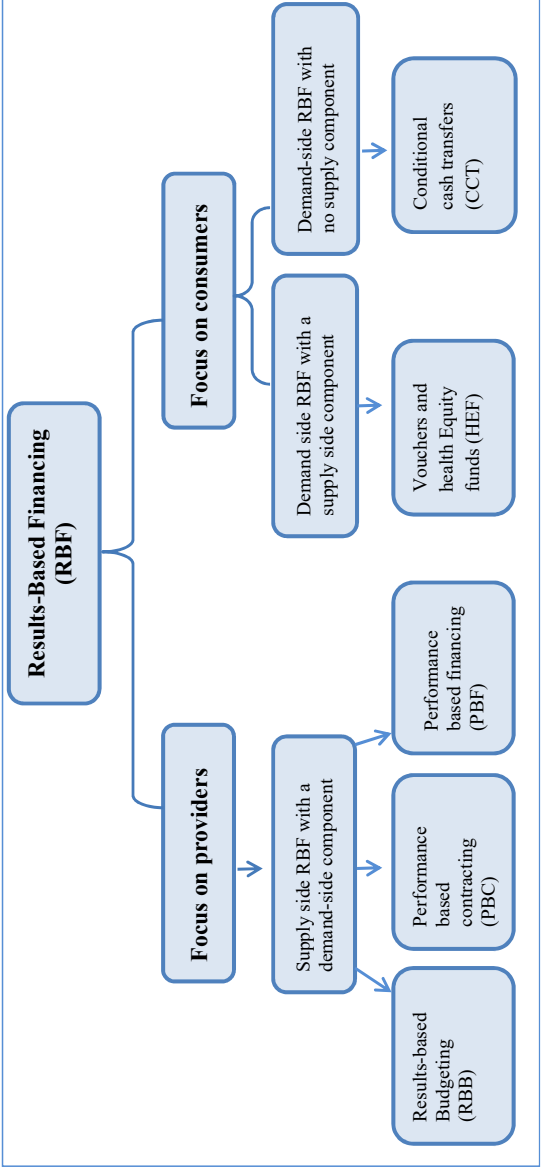
Figure 1: Categories of Results-based financing schemes depending on the focus of purchasing power application.

Source: Adapted from Goertal et al, 2013

2.3 Theoretical foundations for Results based financing

To understand how RBF, in particular supply side PBF schemes, may lead to better health, it is first important to understand what governs contractual relationships. Below, the theoretical basis underpinning PBF is outlined.

2.3.1 Principal Agent Theory

Conrad argues that the principal agent theory is suited to explain contractual and other economic relationship where one individual (principal) delegates or contracts tasks to another individual (agent) (Conrad 2015). In this relationship, the principal has objectives she wants to attain but may not have the capacity in terms of skills to achieve them. Information asymmetry between the two often entails that the principal cannot directly observe or may not know the level of technical skills expended by the agent doing the contracted work (Ross 1973, Witter, Fretheim et al. 2012). When the principal is not certain about the production process or when the transactional costs of monitoring the agent are higher than the costs of monitoring outputs, it may be better to pay the agent on the basis of pre-specified performance and targets (Savedoff 2010).

Pertaining to healthcare, the principal serves as a purchaser, providing both financing and oversight, with an objective of increasing health system performance-such as effectiveness, efficiency and equity. The function of the agent in this relationship is to provide healthcare according to standards stipulated in the contract (Liu, Hotchkiss et al. 2007). In the specific context of RBF4MNH, this means the Ministry of health (the principal) paying providers of healthcare (the agents) for delivering women in a health facility or the Ministry of health paying mothers (agents) for delivering in health facilities.

According to Conrad, the principal seeks to design payment structures that induce the agent to deliver the quantity and quality of service that will provide value for money (Conrad 2015). In practice, both the principal and agents may manifest opportunistic behaviours (Preker, Harding et al. 2000); contractual obligations may thus have both intended and unintended effects. The principal-agent model is robust enough to provide insight into potential adverse consequences or opportunistic behaviours that may arise, for example, due to fraud or gaming. This may occur, for example, when agents (health providers) provide unneeded care simply to increase their earnings or

put their focus on incentivized services to the detriment of other (but equally important) un-incentivized services, or select simple to manage, less costly patients (Shen 2003, Savedoff 2010).

2.3.2 How do financial incentives work?

An important aspect of the study of any financial incentives is the understanding of the mechanism or pathways through which they may effect change(s). Uri et al, suggest that financial incentives act in two ways, though the standard direct price effect by making the incentivized behaviour more attractive and indirectly through psychological effect (Uri Gneezy, Stephan Meier et al. 2011). The subsections below describe how these theoretical perspectives are applied in the healthcare sector through both the demand and supply components of RBF to increase service use and quality of care, respectively.

2.3.2.1 How demand side financial incentives may effect change in service use

Recognising the importance social-economic constraints place on poor families in accessing and utilizing healthcare, financial rewards are designed to encourage poor families to invest in their health. Financial incentives, if large or frequent enough, can increase incomes. It is assumed that more income would enable poor families to overcome economic barriers that constrain their access to healthcare, leading to increased expenditures on (or consumption of) normal goods such as healthcare for pregnant mothers or new-born infants. In this regard, the financial incentives are anticipated to change behaviour through income effect as predicted by economic theory (De Walque, Dow et al. 2012).

Conditional incentives can also be used to increase demand through price effect. While standard economic theory postulates that fully informed individuals make rational decisions after weighing the advantages and disadvantages of different choices, in reality, inconsistencies exist between economic models and human rationality (Higgins 2010, Heise, Lutz et al. 2013). For example, individuals or households may overestimate the price of effective preventive interventions for addressing health problems such as antenatal screening, leading to sub-optimal utilization, with potential negative externalities as this can lead to illness not just for the mother but can also put

the unborn child at risk. Alternatively, private investment in new-born's human capital can be too low due to parents incorrectly believing that future earnings respond to health investments less elastically than is actually the case (Ariel Fiszbein, Norbert Schady et al. 2009). By conditioning financial rewards on healthcare utilization, the financial rewards can be used to stimulate households to act towards appropriate health seeking behaviours such as antenatal care screening or facility deliveries.

2.3.2.2 How supply side financial incentives may effect change in quantity of care

The same reasoning as outlined above is applicable to providers of healthcare. According to Prendergast, providers obtain utility from net income and disutility from efforts exerted on behalf of the principal (Prendargast C 1999). Therefore, by making financial incentives contingent on volume of units of services provided, the financial rewards can be used to shape provider behaviour leading to increased quantity of provided health services. In these aspects, conditioning acts through the price effect mechanism: a "price" is incurred (loss of a financial reward) if a particular behaviour or task is not performed (De Walque, Dow et al. 2012).

2.4 Conceptual framework for evaluating impact of results-based financing on maternal and perinatal health outcomes.

Based on the above discussions and drawing on the ideas by Glassman et al (Glassman, Duran et al. 2013) together with works by Witter et al (Witter, Toonen et al. 2013) and Brenner et al (Brenner, Muula et al. 2014) this section presents an intuitive conceptual framework within which to evaluate the impact of RBF on maternal and perinatal mortality as shown in **Figure 2**.

I assume that offering health providers conditional financial incentives, linked to quality facility based care for pregnant mothers, can motivate them to increase the supply of priority maternal services (Diamond and Kaul 2009) or to stimulate a change in their behaviour so that they comply more with clinical guidelines with respect to preventive, diagnostic and treatment decisions (Epstein, Lee et al. 2004); then, I can anticipate that the mothers and infants they treat should (by definition) receive quality care (Campbell, Roland et al. 2000). I also anticipate that the conditional financial incentives provided to pregnant mothers would shape their behaviour, leading to

increased demand for facility-based deliveries. Or, alternatively, that the financial incentives would increase poor mothers' income, enabling them to overcome economic barriers to accessing pregnancy related care and thus reducing inequality in access. The combination of increased supply of quality care by providers and increased use of quality care by vulnerable mothers and their new-born infants should lead to reduced frequency or severity of maternal and new-born illnesses. These improvements in health outputs should be reflected by a corresponding reduction in maternal and perinatal mortality, respectively, at population level. In making this postulation, I am cognizant of the fact that demographic factors (e.g. age and number of previous pregnancies) and social economic factors (e.g. wealth and education status) can also positively or negative affect maternal and perinatal mortality at community level.
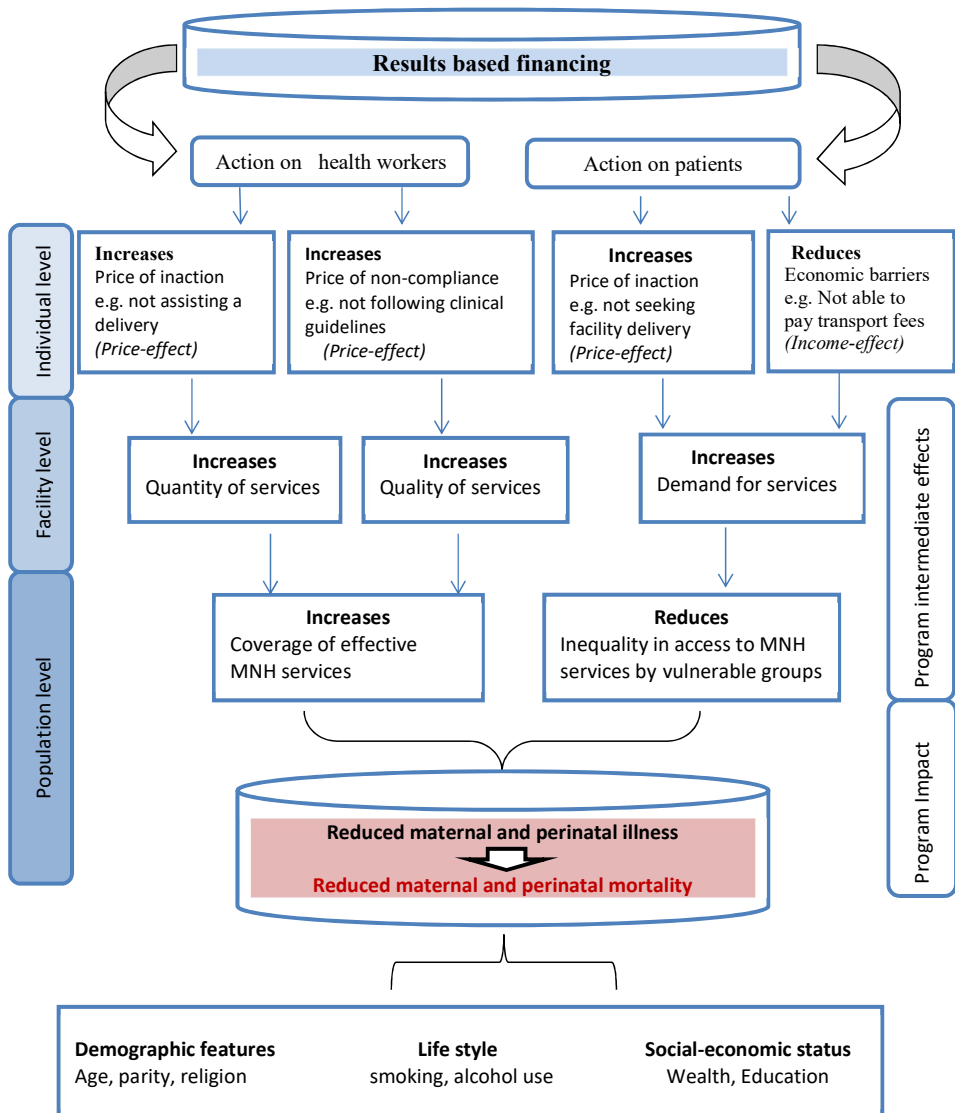
Figure 2 : Proposed conceptual framework for assessing the impact of Results-based financing on maternal and perinatal mortality.

This figure assumes that demand and supply measures are applied jointly, which is consistent with the RBF configuration in Malawi. However, this is not always the case.

2.5 Costing of healthcare interventions

2.5.1 Costs

Costs are values of resources needed to provide a service. Healthcare costs are thus estimated by identifying and quantifying resources that are consumed during the course of providing care and then assigning monitory values or prices to each resource (WHO 2003). Different ways have been proposed to categorize costs. Drummond et al categorize costs into two: a) Direct costs such costs of medical care (including the intervention itself and follow-up care) and the cost of traveling to and from a health facility b) Indirect costs such as the value of time that family and informal carers' spend seeking care and caring for patients, and the value of the patients' time in treatment (Drummond MF, Sculpher MJ et al. 2005, page 24). Costs in addition can be categorized into fixed and variable costs (Shepard, Zeng et al. 2015). Fixed costs are those that do not change as volume of care increases. Examples include office rentals and insurance. Variable costs are those that change with volume of care, they include drugs and other consumables. A third way to categorize costs is into financial and economic costs. Financial costs focus on direct expenditures (Creese A and Parker D 1994). Unlike financial costs, economic costs reflect on what is forgone (opportunity costs) in terms of benefits elsewhere, because funds are tied up to provide the intervention being evaluated (Drummond, O'Brien et al. 1997, page 54, WHO 2003)

2.5.2 Approaches to costing

Two approaches are often used to collect and measure cost information (Shepard, Zeng et al. 2015). The macro-costing approach uses summary expenditure data e.g. based on administrative records and allocate them to a health program based on proxy allocation factors such as percentage of space use or share of consultations. Though not as precise, this approach is time saving (Drummond MF, Sculpher MJ et al. 2005, page 78). Micro-costing on the other hand uses detailed information based on types and quantity of inputs e.g. from surveys and inventory records. Micro-costing requires more time, relative to macro costing, but provides more detailed cost information about program activities. Often both approaches are used in costing.

2.5.3 Perspectives.

The costs that are most appropriate for inclusion in an analysis depend on its "perspective." The term "perspective," when used in economic analyses, refers to whose costs are counted and, thus, to what is quantified. Providers (health systems) and patients (household) perspectives are commonly used. The most comprehensive perspective is that of society, which includes all costs but not necessarily all financial transactions, on all levels attributable to an illness's impact and treatment (Polsky, Doshi et al. 2006). Taking into consideration the different perspectives is helpful not just in providing as much detail as possible, but also in allowing for the presentation of results to different audiences.

2.5.4 Time horizon

Economic analyses ideally should be long enough to capture all the differences in health outcome and cost between alternative interventions that are likely to have an impact on the results (Gray, Clarke et al. 2011, page 73). Glassman et al argue that this is especially pertinent to incentive based interventions, as providers and clients may adapt to incentive structures, leading to time varying outcomes and costs (Glassman, Duran et al. 2013).

2.5.5 Discounting

Individuals and society prefer to have dollars or resources now as opposed to later because they can benefit from them in the interim (Hauck, Smith et al. 2004). To allow for this time preference, it is recommended that future costs should be discounted so that an amount paid in future is assigned a lower value than the same amount paid in the present. Future costs are first expressed in constant prices or present value of the year in which the program started and then discounted. An overall indicator of inflation, the Gross Domestic Product (GDP) deflator is often chosen to convert future costs into constant costs (Shepard, Zeng et al. 2015). A common discount rate of 3% (WHO 2003) is then applied to costs incurred during different years.

While there is consensus on discounting of costs, discounting of health benefits/ outcomes is one of the most controversial issues within health economics practice with vast literature submitting to both views: to discount or not (Drummond MF, Sculpher

MJ et al. 2005, page 109). In keeping with WHO recommendation, a discount rate of 3 % will be used to discount outcomes in this study (WHO 2003).

2.6 Economic evaluations: Normative basis

Tsuchiya and Williams argue that economic evaluations are built upon classical welfare and extra welfare economics frameworks (Tsuchiya and Williams 2001). The classical welfare framework focuses on individual utility or preferences. A situation in which the sum of utilities is maximized is judged to be optimal. This necessitates that utilities are measured in a cardinal scale to allow for comparison of absolute utility levels obtained by different individuals. As indicated by Hauck et al attaining such utility properties historically was considered unattainable, leading to replacement of utility maximization criterion by the concept of Pareto optimality (Hauck, Smith et al. 2004). A situation is judged Pareto optimal when a utility distribution strategy or social policy exists where one party's situation cannot be improved without making another party's situation worse. Although considered both technically and allocatively efficient (Kaldor 1939) and (Hicks 1939) argue that in practice, it is almost impossible to take any social action without making at least one person worse off. To overcome this, they proposed the concept of Pareto improvement, this entails that individuals that are made better off following a social policy can compensate those that are made worse off and remain in preferred position compared with the situation before the policy change (the Kaldor-Hicks criterion).

It has been argued that extra-welfarism was developed to adapt the classical welfare economic framework to the particular characteristics of priority setting for health (Sen A 1995, Hauck, Smith et al. 2004); that is, this non-welfarist perspective takes an exogenously defined societal objective and budget constraint for healthcare (Briggs A, Claxton K et al. 2006, page 3). This position is relevant to this study, as the focus of the RBF4MNH intervention is on maximizing maternal and perinatal health outcomes within a fixed budget.

2.6.1 Types of economic evaluations

According to Drummond et al there are four main types of full economic evaluations: a) cost benefit analysis, b) cost effectiveness analysis, c) cost utility

analysis and d) cost minimization analysis (Drummond MF, Sculpher MJ et al. 2005, page 11). The different types of evaluation methods serve different purposes. The objective of cost-benefit analysis is to maximize net benefits, while the objective of cost effectiveness analysis is to rank order the preferred alternatives for maximizing achievement of health. Cost-utility analysis (CUA) allows more complex measures of consequences, which can be compared over different types of interventions. The selection of the appropriate analytic method depends on many factors, including the target audience for the study, the study question, and the availability of data. This thesis aims to inform policy about how RBF compares with current practices for increasing social welfare through maternal and perinatal health promotion, and a CUA would have been appropriate for the purpose. Due lack of data to inform calculations of Quality Adjusted Life Years (QALYs), however, I rather conducted a cost-effeteness analysis (CEA) based on mortality data and calculations of life years gained.

2.6.2 Cost effectiveness analysis

CEA compares interventions in terms of both health outcomes and costs. The intervention under study can be compared, for example, to the option of "doing nothing," to "minimum care," to "usual care," or the highest valued alternative intervention. Although a randomized trial data under routine setting is the best source of evidence for a program effectiveness, information on program intermediate indicators such as coverage and quality can also be used to estimate program effects as long as such indicators have clinical utility (Drummond MF, Sculpher MJ et al. 2005, page 108).

2.6.3 The incremental cost effectiveness ratio

The central measure in CEA is the incremental cost-effectiveness ratio (ICER) (Gold et al. 1996b). The ICER is the difference in costs between two interventions divided by the difference in their effects, and is interpreted as the incremental price of a unit health effect from the intervention under study, relative to the other (Hauck, Smith et al. 2004). Mathematically the ICER is expressed as:

$$ICER = \frac{\text{Cost}_B - \text{Cos}_A}{\text{Effect}_B - \text{Effect}_A} = \frac{\Delta C}{\Delta E}$$

A represents old intervention, B represents new intervention while ΔC and ΔE represent the difference between costs and effects of the two interventions, respectively.

Figure 3 illustrates that to inform decisions, CEA results should enable policy makers identify interventions that are less costly than the comparator and have better health outcomes, called dominant, and preclude those that are costlier and less effective, termed dominated. Interventions that are less costly and less effective relative to comparators or interventions that are more costly and more effective compared with comparators are selected if they are considered good value for money (Drummond, O'Brien et al. 1997, page 40) .
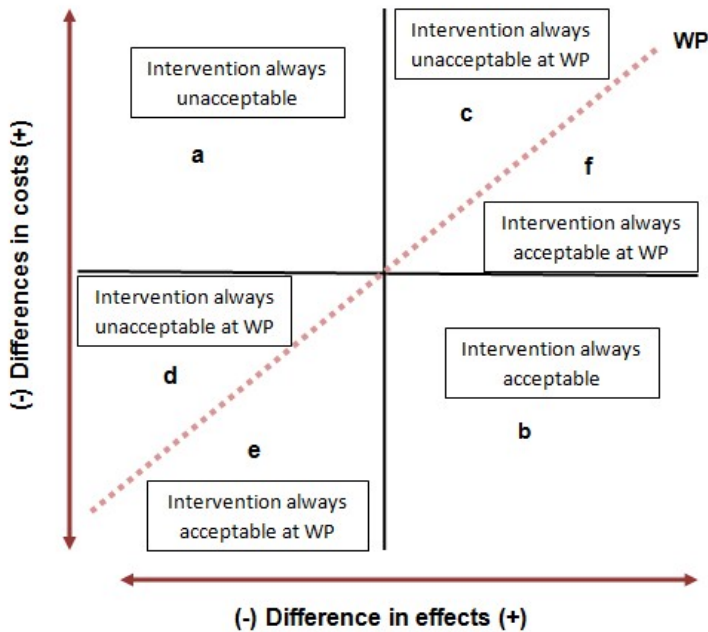
Figure 3 : Schema for interpretation of cost-effectiveness analysis results.

The dotted line shows a given willingness to pay (WP) threshold. If an intervention's ICER lies above the line, it is not acceptable on cost-effectiveness grounds. Either it is dominated by the alternative, whatever the WP threshold, as in point *a*; or its ICER does not satisfy the WP, as in points *c* and *d*. In the north-east quadrant, this means that the ICER is above the WP level, as in point *c*; the higher benefits are outweighed by the higher costs. In the south-west quadrant, as in point *d*; the cost saving does not justify the lower effectiveness. Below the WP threshold the intervention is acceptable. This is because either it dominates the alternative, as in point *b*, or its ICER satisfies the WP level, as in points *e* and *f*. If the ICER is below the WP line in the north-east quadrant, as in point *f*, the higher costs are justified by the increased benefits. If it is below in the south-west quadrant, as in point *e*, the cost savings outweigh the lower benefits.
Adapted from: www.healthknowledge.org.uk

2.6.4 Cost-effectiveness thresholds

Which value is low enough for the intervention to be chosen is a subjective decision, depending ultimately on the value society places on a unit of health effect. When DALYs are used as health outcomes, the GDP per capita has been suggested as a threshold to determine if an intervention being evaluated is cost-effective or not, relative to a comparator. An intervention is considered highly cost-effective if its ICER is less than GDP per capita; cost-effective if the ICER is between one and three times GDP per capita; and not cost-effective if the ICER is more than three times GDP per capita (WHO 2001). Although Malawi has no official policy on what threshold to use, local documents cite cost-effectives as defined above as one criteria for selecting priority interventions and services (Bowie and Mwase 2011, MoH 2011). The use of the WHO proposed threshold can thus be considered pertinent in this thesis. Additionally, this would be in keeping with international economic studies on RBF (Alfonso, Bishai et al. 2013) allowing for comparison of this thesis results with published data.

However, others have criticized this decision rule (Revill, Walker et al. 2014, Marseille, Larson et al. 2015). Using GDP per capita as a threshold does not necessarily ensure that a new intervention is affordable. Importantly, Marseille et al argue that using GDP per capita as the threshold is premised on an assumption that the country is willing to pay up to that threshold for the health benefit (Marseille, Larson et al. 2015). Often concrete evidence of that willingness to pay is not available. Revill et al further argue that, especially for developing countries where coverage gaps remain for other important health interventions, implementing any new costly intervention according to this criterion can only occur at the expense of other interventions being replaced (Revill, Walker et al. 2014). If the intervention being pushed out has higher benefits, this may lead to overall health loss at a health systems level and may risk causing inequalities.

2.6.5 Uncertainty analysis

It is recognized that outcomes from trials suffer from sampling errors and there are uncertainties related to selection of trials to inform parameter estimates in CEA. In addition, when CEA is based on modeling, some uncertainties are structural, meaning they are imposed by the framework used to create the model (Briggs A, Claxton K et

al. 2006, page 83). It is thus recommended to systematically document these uncertainties by conducting sensitivity analyses (Briggs and Gray 1999). Two approaches are often used when performing sensitivity analyses to characterize these uncertainties.

2.6.5.1 Deterministic sensitivity analysis

In deterministic sensitivity analysis, single-point parameter estimates are used (Briggs, Sculpher et al. 1994). The estimates are chosen to reflect values for discreet scenarios such as worst case, best case and most likely case. Because it considers one or two parameters at a time, deterministic sensitivity analysis faces criticism that it is over simplistic. Examples of deterministic sensitivity analysis include one way, threshold and scenario analyses.

2.6.5.2 Stochastic sensitivity analysis

In stochastic sensitivity analysis, parameter uncertainty is incorporated by using ranges of probable values or probability distributions (Briggs, Sculpher et al. 1994). Using probability distributions instead of single point parameter estimate is considered a more realistic way of describing uncertainties, since the method enables simultaneous consideration of uncertainty in many parameters. Stochastic sensitivity analysis, also called probabilistic sensitivity analysis (PSA) are commonly done through bootstrapping and the results presented as cost–effectiveness acceptability curves, scatter plots and expected value of perfect information results (Gray, Clarke et al. 2011, page 279).

Cost effectiveness acceptability curves represent uncertainties for an intervention over a range of thresholds for cost-effectiveness (Briggs A, Claxton K et al. 2006, page 167). Thus, for any given value of willingness to pay for a health outcome, acceptability curves show the probability of an intervention being cost-effective relative to its comparator. Cost effectiveness scatter plots on the other hand plots the uncertainty in the costs and effects associated with an intervention as simulated incremental cost and effect pairs in a cost-effectiveness plane. Finally, expected value of perfect information are premised on the fact that there is a chance a wrong decision can be made based on existing information given that parameter estimates are inevitably

associated with some degree of uncertainty. The expected cost of this uncertainty can be estimated by calculating the joint probability of making a wrong decision and the expected costs of making that decision (Briggs A, Claxton K et al. 2006, page 170).

2.7 Summary

Dimensions for measuring health intervention performance have been described in this chapter. RBF schemes and related concepts have also been explained. This information is useful for understanding evaluation studies of RBF schemes reviewed in the following Chapter. This chapter also presented a framework depicting how RBF may lead to better health outcomes and another guiding the conduct of an RBF cost-effectiveness analysis, both are relevant for understanding results of studies II and III presented in chapters 8 and 9, respectively.

CHAPTER 3: Literature review

This Chapter reviews evidence from the published literature related to RBF schemes' effects. To obtain the information, Medline database was searched using the terms "results-based financing", results based financing and "rbf" combined with "impact" or "effects". The search inclusion criteria was broad enough to include studies done in countries classified as low and middle income countries (The World Bank) irrespective of year of publication but limited to publications in the English language. Additional studies, including the grey literature, were identified through searches of reference lists. The search was repeated with one additional restriction "sub-Saharan Africa" to ensure that studies from the region in which Malawi is located were not missed. This Chapter highlights gaps in the current available evidence base to illustrate the relevance of the thesis objectives outlined in chapter 5 and put into context the thesis findings presented in chapters 7, 8, 9 and key recommendations presented in chapter 10.

3.0 What is the current evidence base for Results-based financing?

Witter et al note that the wide diversity of RBF design options, contexts in which they are applied, multiple objectives and range of possible effects–both intended and unintended-present a particular challenge identifying and summarising the best available RBF evidence (Witter, Fretheim et al. 2012). This view is reinforced by the

observation that most of the evidence comes from evaluation of individual RBF schemes in which the focus was primarily on the specific objective(s) of the scheme in question. Nonetheless, efforts to summarize RBF results have been attempted (Oxman and Fretheim 2009, Witter, Fretheim et al. 2012, Glassman, Duran et al. 2013, Gorter, Ir et al. 2013, Das, Gopalan et al. 2016, Turcotte-Tremblay, Spagnolo et al. 2016). Parallel to dimensions used to measure a health intervention performance previously outlined in section 2.1 and based on existing literature (Gorter, Ir et al. 2013, Das, Gopalan et al. 2016, Turcotte-Tremblay, Spagnolo et al. 2016) there are five mutually exclusive dimensions into which RBF effects can be categorized **Box 1.** The reported RBF effects are presented along these dimensions, separating findings from outside the SSA region from those in the SSA region. Two reasons justify this division. First, most RBF results from outside the SSA region are demand-side while those from the SSA are predominantly supply-side. Second, this demarcation highlights other salient features, such as dynamic health policy environments and generally weak healthcare systems, which are frequent in the SSA context (Turcotte-Tremblay, Spagnolo et al. 2016).

Box 1 : Five dimensions for presenting evidence for RBF effects, with example indicators.

1) Coverage with maternal and perinatal healthcare
   o *Increase in provision of facility-based deliveries*
   o *Increase in access for facility-based deliveries*
2) Quality of maternal and perinatal healthcare
   o *Increase in adherence to clinical guidelines*
   o *Increase in content of maternal and perinatal care*
3) Equity in utilization of maternal and perinatal healthcare
   o *Narrow gap in access for poor compared to least poor*
   o *Increased share of poor benefiting from maternal and perinatal care*
4) Efficiency of results- based financing schemes
   o *Cost per capita relative to funding options*
   o *Cost per death averted and or life year gained*
5) Impact on maternal and perinatal health
   o *Reduced maternal and perinatal morbidity*
   o *Reduced maternal and perinatal mortality*

3.1 Effects of RBF schemes on coverage with maternal and perinatal healthcare

Two recent reviews relevant for the assessment of evidence for RBF schemes on selected maternal and perinatal health indicators were identified. The first focuses on supply-side PBF (Fretheim, Witter et al. 2012) while the second focuses on demand side schemes such as CCT and Vouchers, some of which were implemented with supply side elements e.g. incentives for community health workers (Glassman, Duran et al. 2013). The majority of studies are on demand side schemes e.g. (Lim, Dandona et al. 2010, Nguyen, Hatt et al. 2012, Bellows, Kyobutungi et al. 2013).

Because of its pivotal role in maternal and perinatal health (Filippi, Ronsmans et al. 2006, Darmstadt, Yakoob et al. 2009), facility-based delivery is the most commonly evaluated indicator for coverage of pregnant women and the new-born with maternal and perinatal healthcare (Fretheim, Witter et al. 2012, Bellows, Conlon et al. 2013). Although there are other relevant indicators that are also used to measure MNH coverage **Table 2**, the review is limited to using facility-based delivery as the *proxy* indicator of MNH service coverage. It is beyond the scope of this thesis to provide detailed evidence on all indicators of MNH coverage. Facility/ institutional based delivery denotes births that take place in a health facility.

Table 2: Indicators of maternal and perinatal healthcare coverage according to stage of pregnancy.

Antenatal period	Delivery period	Postnatal period
o Antenatal attendances o First trimester attendance o Maternal vaccinations o HIV testing for mothers o Mothers initiated on ART o Diagnosis and treatment for sexually transmitted diseases e.g. Syphilis o ITN distribution	o Facility delivery rate o Skilled birth attendance rate o Caesarean section rate o Administration of Nevirapine to HIV exposed new born o Complications referral rate o Treatment of complications	o Posta natal care visits o Maternal check-ups o Neonatal check-ups o Modern family planning uptake o Infant vaccinations

ART=Anti-retroviral therapy, ITN= Insecticide treated nets, HIV=Human Immunodefieciency Virus
Source of data: Soeters et al 2008, Basinga et al 2011 & Bonfrer et al 2014.

Given that researchers use different study designs and analytical approaches, there are variations in analytical rigour and the ways changes in facility-based delivery coverage are presented, which make comparisons between publications challenging. However, a reasonably consistent picture of positive effects of different RBF schemes on facility delivery coverage exists. In the following sections, specific RBF scheme names rather than RBF, the umbrella term, are used to focus on the evaluated RBF schemes.

3.1.1 Evidence from outside sub-Saharan Africa

Lim et al evaluated one of the world's largest CCT program, India's *Janani Suraksha Yojana*, employing three analytic approaches (exact matching with logistic regression, with versus without, and district level difference-in-differences) to estimate the effects of maternal receipt of CCT on several maternal and child health indicators including coverage for institutional delivery. All three analytical approaches consistently showed that CCT increased institutional-based deliveries (Lim, Dandona et al. 2010). In Nepal, Powell-Jackson et al used propensity score matching methods to assess another CCT program. They reported that women who had heard of the program before childbirth were more likely to deliver in a health facility (Powell-Jackson and Hanson 2012). Similarly, positive results are found for voucher and health equity fund schemes. For example, Ir et al analysed both a voucher scheme and Health Equity funds in Cambodia (Ir, Horemans et al. 2010). They noted that facility-based deliveries increased sharply after the introduction of the voucher and health equity funds schemes. In Bangladeshi, both Ahmed et al (Ahmed and Khan 2011) and Nguyen et al (Nguyen, Hatt et al. 2012) also reported that voucher program participants were more likely than non-participants to deliver babies in a health facility. An exception to these results is a recent cluster randomized study of a PBF scheme in Afghanistan that failed to demonstrate any effect of the PBF scheme on facility births (Engineer, Dale et al. 2016).

3.1.2 Evidence from sub-Saharan Africa

With the exception of one of the earliest studies conducted in the democratic republic of Congo (DRC) which demonstrated more coverage of facility-based births in non-PBF than PBF areas (Soeters, Peerenboom et al. 2011) and a recent CCT study

in Uganda which failed to demonstrate positive impact of CCT on facility births (Kahn, Iraguha et al. 2015), results from SSA are consistent with the majority of findings from outside the region in that they are generally positive. For instance, in Kenya, Bellows et al found that women who benefited from a voucher scheme were more likely to deliver in a facility compared to the time before the scheme launch (Bellows, Kyobutungi et al. 2013). Similarly, another voucher study in Kenya by Obare et al also reported an increased likelihood for facility-based delivery in intervention areas compared to non- intervention areas (Obare, Warren et al. 2013).

Arguably, the strongest evidence for impact of RBF schemes on facility-based delivery coverage in SSA comes from studies that have used more robust econometrics methods, specifically difference-in-differences approaches based on before-after studies with controls. A cluster randomized study by Basinga et al in Rwanda is one of the earliest (Basinga, Gertler et al. 2011). They reported an 8.1 percentage point increase in facility-based deliveries in PBF areas. Priedman-Skiles reported similar results, again from Rwanda (Priedeman Skiles, Curtis et al. 2012). In Burundi, Bonfrer et al reported that compared to control sites, PBF increased the likelihood of women delivering in an institution by 5 percentage points (Bonfrer, Soeters et al. 2013) while in Tanzania, Binyaruka et al have reported an 8.2 percentage point increase in facility-based delivery for PBF relative to non-PBF areas (Binyaruka, Patouillard et al. 2015). In Uganda, Alfonso et al indicated that a voucher scheme increased the share of women delivering in an institution by 9.4 percentage points (Alfonso, Bishai et al. 2013). **Figure 4** summarizes results of these RBF schemes effects related to facility-based births in SSA under different baseline settings. The observed percentage point increases range from 5 to 10 and appear to be higher when baseline facility-birth coverages are low and decreasing with increasing baseline coverages.
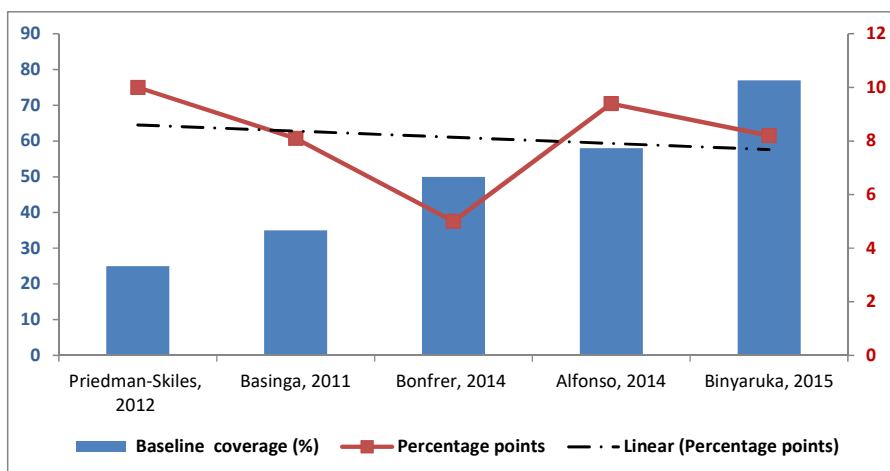
Figure 4: Plot of baseline facility-based births coverage (first Y axis) versus percentage point increase in facility deliveries following RBF implementation (second Y axis).

Illustrating the relation between the share of facility-based deliveries attributable to RBF schemes (in percentage points) and baseline facility births for selected studies in sub Saharan Africa. The dotted line is a fitted percentage points line, estimated by ordinary least squares approach. Note: Care should be taken in interpreting the figure as no attempt was made to control for other factors including the level of confidence for the point estimates.   Source: Author calculations

3.2 Effects of RBF schemes on quality of maternal and perinatal healthcare

The multi-faceted nature of quality is reflected in the many variable indicators used to measure it. They range from assessments of content of care i.e. antenatal services provided (Rahman M, Ubaidur R et al. 2009, Basinga, Gertler et al. 2011) ; fraction of health workers with appropriate training in a service of interest (Meuwissen, Gorter et al. 2006); the mean score for health workers knowledge in a particular clinical area (Meuwissen, Gorter et al. 2006); perceived improvements in quality of care for selected health services (Meuwissen, Gorter et al. 2006, Soeters, Peerenboom et al. 2011) and structured observations of content of clinical care conducted using a checklist and summarized into composite quality score (Basinga, Gertler et al. 2011, Bonfrer, Soeters et al. 2014). Others have assessed quality in terms of quantity and stock-outs of equipment and supplies for maternal and perinatal care (Das, Gopalan et al. 2016,

Binyaruka and Borghi 2017, Brenner, Wilhelm et al. 2017). Mixed evidence of RBF effects on quality was found.

3.2.1 Evidence from outside sub-Saharan Africa

In Nicaragua, Meuwissen et al assessed satisfaction with care among voucher users compared with non-users (Meuwissen, Gorter et al. 2006). They reported high satisfaction with care among users, especially related to clinic reception and clarity of doctors' explanations. In a related study, the same authors assessed provider's knowledge, practice and attitudes before and after a voucher scheme. They found a general improvement in health provider's knowledge, attitude and practices after the voucher scheme (Meuwissen, Gorter et al. 2006).

In Mexico, Barger et al measured quality in terms of received procedures that corresponded with clinical guidelines for history taking, diagnostics, physical examination and prevention. They indicated that births among women beneficiaries of a CCT program (Oportunidades) received more prenatal procedures compared with non-beneficiaries (Barber and Gertler 2009).

3.2.2 Evidence from sub-Saharan Africa

In Rwanda, Basinga et al assessed quality in terms of compliance with Rwandan prenatal care clinical practice guidelines (Basinga, Gertler et al. 2011). They reported an increase in prenatal quality among PBF recipients. In neighbouring Burundi, Bonfrer et al reported that overall quality scores for health care facilities improved during PBF intervention period, but noted that PBF had no effects on the quality of care as reported by mothers (Bonfrer, Soeters et al. 2014). The latter results are consistent with those reported by Binyaruka et al in Tanzania, who reported no effect of P4P on patient experience of care for targeted services, including facility births (Binyaruka, Patouillard et al. 2015).

Finally, related to PBF impact on quantity and quality of equipment used for deliveries, Rudasingwa et al report that PBF improved quality of care in supported facilities in Burundi (Rudasingwa, Soeters et al. 2015). But recent more in-depth studies have shown mixed results. While Binyaruka et al found that PBF had no effect on availability of functional equipment in Tanzania (Binyaruka and Borghi 2017), Brenner

31

et al in contrast reported that a PBF scheme in Malawi had positive effect on availability of functional equipment (Brenner, Wilhelm et al. 2017).

3.3 Effects of RBF schemes on equity of maternal and perinatal healthcare

With respect to facility-based deliveries, equity is usually measured in terms of rates of facility-based deliveries across women's social economic status or areas of residence. Somewhat mixed evidence on equity, especially from the SSA region, was found.

3.3.1 Evidence from outside sub-Saharan Africa

In Pakistan and Bangladesh, Agha (Agha 2011) and Ahmed et al (Ahmed and Khan 2011) both report that poor voucher recipients were more likely to deliver in a health facility than the non-poor recipients, implying that voucher schemes had more effect in terms of increasing demand for facility delivery on the poor.

3.3.2 Evidence from sub-Saharan Africa

In Rwanda, Priedman-Skiles et al studied whether PBF reached the poorest of the population and helped to close the gap in service use between the least poor and poorest women (Priedeman Skiles, Curtis et al. 2012). They found no evidence that PBF is pro-poor (and neither did they found it pro-rich). While Bonfrer et al found PBF pro-rich results in Burundi (Bonfrer, Soeters et al. 2014), in contrast, Binyaruka et al found pro-poor results for facility-based delivery in Tanzania. In particular, they found an increase in institutional-based deliveries among the middle tercile relative to the least poor tercile, and among the poorest tercile relative to the least poor tercile (Binyaruka, Patouillard et al. 2015). In view of these findings, Priedman-Skiles et al argue that supply side schemes e.g. PBF as a policy tool is not adequate, in and of itself, to overcome demand side barriers and reduce inequality in facility use (Priedeman-Skiles, Curtis et al. 2015). The consistently pro poor results based on demand side schemes such as CCTs (Ahmed, Creanga et al. 2010, Agha 2011) in part supports this argument.

3.4 Efficiency of RBF schemes

Cost information on RBF schemes including data on program start-up costs is very limited to date thus there are few studies investigating efficiencies of RBF schemes

(Liu, Hotchkiss et al. 2008, Borghi, Little et al. 2015, Turcotte-Tremblay, Spagnolo et al. 2016).

3.4.1 Evidence from outside sub-Saharan Africa

In Cambodia, Bhushan et al found that PBF increased the public cost per capita against the comparison mean, $2.93 vs $1.59, (Bhushan I, Keller S et al. 2002). But private out of pocket expenditure among PBF recipients reduced significantly so that total costs (from a societal perspective) reduced or remained constant. Because the PBF scheme brought about better results–in terms of financial risk protection-than conventional funding approaches, they argued this is suggestive evidence that PBF is more efficient. Similar results were found by Cercerone et al in Costa Rica (Cercerone, Briceno et al. 2005). Private per capita expenditures were 30% lower in clients attending contracted PBF clinics, but there were no demonstrable improvements/differences in health outcomes between contracted and un-contracted clinics. This implies that, at least from the patient perspective, the same outcomes were achieved at lower costs.

3.4.2 Evidence from sub-Saharan Africa

In DRC, Soeters et al reported that although per capita expenditure were lower in PBF than non-PBF areas ($2.4 vs $9.0), results were comparable and sometimes better in PBF areas, which they interpreted as indicative evidence for PBF efficiency (Soeters, Peerenboom et al. 2011).

Only one CEA study in the SSA region based on a voucher scheme in Uganda was found (Alfonso, Bishai et al. 2013). Relative to status quo care, Alfonso et al reported an incremental cost-effective ratio of $20,756 and $302 per maternal death and per DALY averted, respectively. Since the $302 per DALY averted is lower that Uganda gross domestic product (GDP) per capita, they argued that the voucher scheme was cost-effective.

Regarding specific costs related to a facility-based delivery, wide variations in costs are reported. While Alfonso and Mayora found low cost per delivery for a voucher scheme in Uganda of $20 and $24, respectively (Alfonso, Bishai et al. 2013, Mayora, Ekirapa-Kiracho et al. 2014), Borghi et al found much higher cost per additional facility-based birth ranging from $540 to $907 under PBF pilot settings, and from $94

to $261 for a national program (Borghi, Little et al. 2015). Care needs to be taken when making head to head comparison of unit costs across RBF schemes given differences in design and implementation. For instance, unlike voucher schemes, PBF schemes may require substantial infrastructural and equipment upgrades (Shepard, Zeng et al. 2015) which have implications for unit cost estimates.

The relatively lower unit costs under scaled up national program settings as reported by Borghi et al indicates that the efficiency of PBF may depend on economies of scale (Borghi, Little et al. 2015), as previously suggested by Soeters et al (Soeters, Habineza et al. 2006). Thus these costs variations can also be explained in part by the scale of implementation and probably the costing methodology used (Mayora, Ekirapa-Kiracho et al. 2014).

3.5 Impact of RBF schemes on maternal and perinatal health outcomes

The aim of RBF schemes as applied to MNH is to improve maternal and perinatal health outcomes. For these outcomes, evidence is scarce and largely points towards lack of evidence for RBF impact on health outcomes (Gopalan, Mutasa et al. 2014, Das, Gopalan et al. 2016).

3.5.1   Evidence from outside sub-Saharan Africa

Earlier studies on India's *Janani Suraksha Yojana* CCT program by Lim et al found positive effects of CCT receipt on perinatal outcomes, and the program was estimated to reduce perinatal deaths by 4.1 per 1,000 births (Lim, Dandona et al. 2010). In contrast, a recent study found no effect of CCT on perinatal outcomes or maternal complications (Mohanan, Bauhoff et al. 2014). Other recent evaluations are consistent with these results, finding no improvement on neonatal mortality, even in districts with relatively high quality care (Powell-Jackson, Mazumdar et al. 2015). Similarly, in Cambodia, Van de Poel et al found no impact on neonatal mortality for a voucher scheme, despite demonstrable increase in institutional deliveries (Van de Poel, Flores et al. 2016).

3.5.2 Evidence from sub-Saharan Africa

No study reporting impact of RBF on maternal mortality was found while only one study reporting on neonatal health outcomes was available from the SSA region. In Rwanda, Chari et al reported no RBF effect on neonatal mortality (Chari and Okeke 2014).

It is worth noting that the studies evaluating RBF schemes impact on health outcomes did not explicitly take quality of care into account. A recent study from Malawi evaluating the effects a ban of traditional birth attendants had on institutional-based births has demonstrated that neonatal outcomes are better among births in better quality facilities compared with births in poor quality facilities (Godlonton and Okeke 2016). Although not done within the context of an RBF, these findings are instructive, as they suggest the reported lack of RBF effects on health outcomes maybe explained in part by lack of quality of care in the evaluated health facilities.

3.6 Gaps in RBF evidence base.

Limited evidence for RBF schemes in all five thematic dimensions as illustrated in **Box 1** was found. Additionally, the strength of this evidence appears low due to multiple constraints. Limitations of the evidence have been highlighted by others (Liu, Hotchkiss et al. 2008, Fretheim, Witter et al. 2012) so only key points are hereby summarized. First, some of the studies were done while the local health policy environment was changing as well. For example, Rwanda introduced PBF within a system of community-based health insurance (Basinga, Gertler et al. 2011) while in Burundi user fees for facility deliveries and care for under-fives were removed at the same time it adopted the performance-based approach (Bonfrer, Soeters et al. 2014). These policy actions may have fostered the use of maternal and perinatal healthcare services by individuals and households, making it difficult to disentangle the effects of the performance-based payments. Second, given the usual lag between intervention and impact, most of the studies were evaluated within a time period that can be considered too short for the programs to have matured enough to show full effects let alone to observe longer-term trends (Glassman, Duran et al. 2013, Bonfrer, Soeters et al. 2014). Third, some studies e.g. (Lim, Dandona et al. 2010, Bellows, Kyobutungi et al. 2013) were done without a proper comparison group to control for factors such as financial

and technical input, which may have also contributed to the observed effects. Forth, especially relevant for the conflicting results from India, Mohanan et al point out study limitation to internal validity such as i) failure to adequately address self-selection of women into institutional delivery ii) inability to correct reporting of inaccuracies by hospitals and iii) inability to account for any increases in institutional deliveries over time that is unrelated to RBF (Mohanan, Bauhoff et al. 2014).

3.7 Summary of RBF evidence.

In summary, the evidence base for RBF is mixed. Variations in RBF performance exist within and across the five performance dimensions, driven by context, scheme design, quality of implementation and analytical approaches. Nonetheless, the existing knowledge base appears suggestively positive in relation to intermediate and direct program effects (e.g. facility coverage and quality of care) highlighting the need for research related to distal and indirect population level health impacts (e.g. morbidity and mortality outcomes). Specifically, for the SSA region, less research on health outcomes and even lesser research on RBF cost-effectiveness exists. Lack of this information has important implications for both RBF related policy formulations and programming.

CHAPTER 4: Malawi

This section situates the research within the Malawi context by providing a brief overview of the economic setting, the health system structure, the current maternal and perinatal health situation, and background to key maternal and new-born health policies, strategies and programs in the country.

4.1 Economic background

Malawi is a narrow and landlocked country that shares boundaries with Zambia in the west, Mozambique in the east, south and southwest, and Tanzania in the north (MoH 2011). It has an estimated population of about 17 million people, 52 % of which are females (NSO 2008). For administrative purposes, the country is divided into three regions. The southern region is home to 50% of the population and Blantyre, the largest commercial city in the country; the central region is home to 40% of the population and the capital city, Lilongwe; the Northern region, home to 10% of the population has

Mzuzu as its main commercial city. The three regions are further sub-divided into 28 districts **Figure 5**.

Figure 5: Top right -map of Africa showing the location of Malawi. Middle- map of Malawi showing the three administrative regions and their respective districts.

Source: Maps of the World

Malawi has a gross domestic product (GDP) of 4.2 billion US$ and a per capita income of US$ 482 (Trading Economics). Agriculture is the most important sector, accounting for 35 percent of the GDP. The country's major exports are tobacco, tea and sugar. Combined, these produce account for approximately 85 percent of domestic exports (World Bank 2010). Most of the population (80%) especially in rural areas are engaged in small-scale subsistence farming.

The World Bank classifies Malawi as a low income country based on per capita income level (World Bank). According to the 2012 integrated household survey (IHS), 50.7 percent of the population are classified as poor; while 24.5% are considered ultra-poor (National Statistics Office and Republic of Malawi 2012). IHS uses relative poverty lines to classify an individual. An individual is poor if her consumption is less than the sum of the cost of a food bundle required to provide the necessary energy needs

per person per day plus the cost of basic non-food daily needs. An individuals whose consumption falls below the cost of the food bundle alone is classified as ultra-poor (National Statistics Office and Republic of Malawi 2012).

4.2. Level and distribution of general health status

Over the past two decades, Malawi has made some improvements in overall population health including life expectancy and some key health indicators. For instance, following its reduction during the 1990s as a results of the HIV epidemic, life expectancy increased from 37 years in 2003 to 40 years in 2005 (Matchaya 2007); by 2010, it was 49 years, higher that it was in 1990 (DHS 2010), suggesting significant offsetting of the HIV impact. This improvement is also reflected in other health indicators – such as under five mortality (64 per 1000 live births) and facility based deliveries (96%) (DHS 2016). Yet, several other health indicators are below targets, **Box 2**. Importantly, the country still experiences a high burden of disease. HIV/AIDS, respiratory tract infections, malaria, diarrhoea and ischemic heart disease are the leading causes of death (IHME 2015).

4.3 Level and distribution of maternal and perinatal health status

Malawi is one of few countries in the SSA region which managed to reduce child mortality rates in line with the formally Millennium Development Goals (MDGs) 4 (child mortality) (Kanyuka, Ndawala et al. 2016) and the country has made some progress, though slow, in relation to MDG 5 (maternal mortality). Even so, the current rates of both maternal and perinatal mortality remain relatively high.

From 1990 to 2000, the maternal mortality ratio (MMR) in Malawi declined from 1,100 to 750 deaths per 100, 000 live births, a decrease of 32% (WHO, UNICEF et al. 2014). The major causes of maternal deaths were haemorrhage, sepsis, pregnancy induced hypertension, obstructed labour and abortions (Malata A 2010). Between 2005 and 2010, the MMR further dropped from 570 to 510 per 100,000 live births (WHO, UNICEF et al. 2014). Estimates for the year 2015 put the MMR at 574 per 100,000 live births (DHS 2016). On the other hand, between 2000 and 2010, perinatal mortality rate (PMR) fluctuated from 41 per 1,000 births in 2000 to 34 per 1,000 births before rising to 40 per 1,000 births in 2010 (DHS 2010) as shown **Figure 6.**
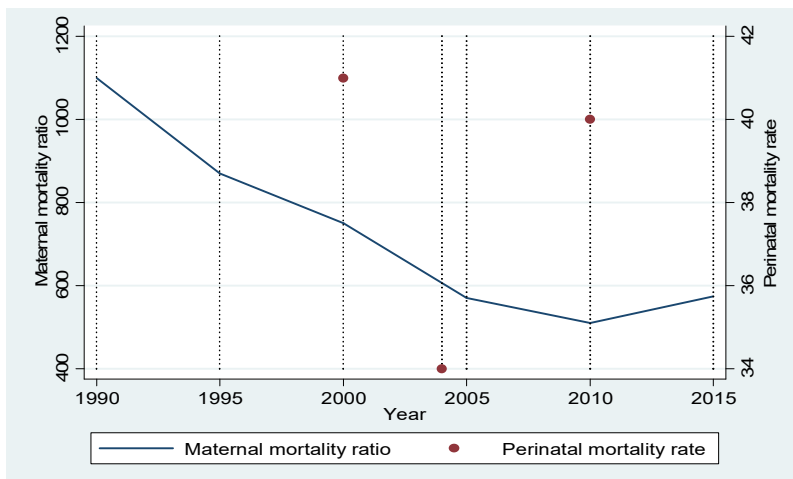
Figure 6: Trends in maternal mortality (1990 to 2015) and perinatal mortality (2000 to 2010).

Source: Author calculations.

Box 2: A summary of socio-demographic features and selected health indicators for Malawi.

Population: 17,377,468[a]
% Females of reproductive age: 25[b]
GDP per capita:482[c]
Health expenditure per capita:US$28[d]
% Poor: 50.7[e]
Life expectancy at birth:
  For females:62[f]
  For males: 58[f]
Maternal mortality ratio: 574[g]
Perinatal mortality rate: 40[b]
Facility delivery rate: 96%[g]
Total fertility: 4.4[g]
Women with at least one antenatal clinic visit: 96%[g]
Women with at least four antenatal clinic visits: 45%[g]
HIV prevalence: 10.6[b]
Number of doctors per 100,000 Population: 1.9[i]
Number of nurses per 100,000 Population: 283[i]

Sources: Malawi 2008 Population and housing census report[a], Malawi DHS 2010[b], Trading Economics, 2016[c] O'Hare and Curtis 2014[d]. Integrated Household Survey 2012[e], Malawi MDG Endline Survey 2014[g], Malawi DHS 2015-16, [i]World Health Organization, 2014

4.4 Health system structure

Malawi is a former British colony and as such, inherited or adopted a universal model of healthcare system, characterized by a large share of health facilities being public, large proportion of public health financing and central management. Despite ongoing efforts over the past decade towards decentralization, the health system in Malawi remains very centralized and vertically managed (Government of Malawi, 2002).

4.4.1 Health financing

The Malawi general government health expenditure as share of general government expenditure in 2014 was 11.4 % (WHO 2014), less that the 15% target set by heads of African Union countries in Abuja (African Union 2001). Malawi's health care financing relies on general tax revenue on personal income and company profits, trade taxes and grants from donors (Government of Malawi and Ministry of Health 2011).

The government's annual budget allocation to health and projected allocations are shown in **Figure 7** for the years 2011 to 2016. Total health care expenditure has shrunk in absolute terms over the 5 years largely due to reduced government of Malawi contributions to the health budget. Donors contribute significantly to health financing and the level of their contributions have largely remained unchanged. Others have argued that this high dependence on external funding not only threatens long term sustainability of national health budgets but may also make health system financing unable to support national health policies and plans (Bayarsaikhan D and Musango L 2016).
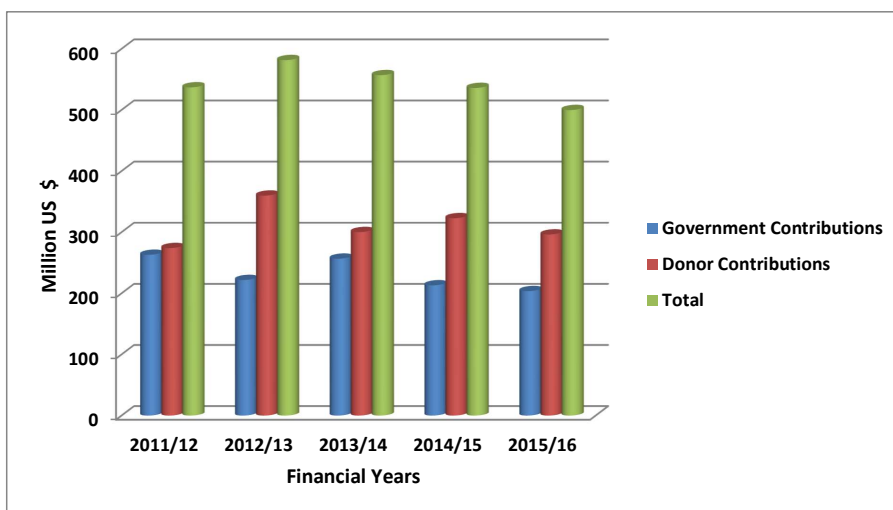
Figure 7: Malawi Health care budget in million US$ (2010 US$) for years 2011 to 2016.

Data for financial years 2014/15 and 2015/16 are projections. Adapted from O'hare and Curtis, 2014.

4.4.2 Per capita expenditures on health

Healthcare spending has steadily increased from US$5.3 per capita in 2004/5, to US$16.3 per capita in 2008/09 and declined slightly to an estimated US$14.5 per capita in 2009/10 (Ministry of Health 2011). Per capital healthcare spending estimate in 2012/13 was US$28. It's worth noting that these per capita spending figures do not include private spending on health. In 2014, the estimated out-of-pocket payment as % of total health expenditure in the country was 12%, amongst the lowest in the region (Bayarsaikhan D and Musango L 2016).

Pertaining to reproductive health (RH), estimates show that the expenditure rose from US$50.1 million in 2009/10 to US$74.3 million in 2010/2011, and then declined to US$63.6 million in 2011/12 (Ministry of Health 2014). On average, US$9.9 per annum was spent on RH over the same period on each woman of reproductive age 15–49 years, (MoH 2014)

4.4.3 General health services

The health system is three tired (MoH 2011) and aims to provide an essential healthcare package (EHP) targeting priority diseases free at point of use. Health centres and out-reach clinics (primary level), with catchment areas ranging from 20,000-50,000

individuals, are at the centre of EHP delivery, providing both preventive and curative healthcare for the general population. They play a key role in providing communities with a broad spectrum of services such as behaviour change and health education (e.g. promotion of antenatal care and use of mosquito nets), vaccinations, growth monitoring and screening, and treatment of common infectious illnesses such as malaria and respiratory tract infections. Health centres and clinics refer patients for further management to district hospitals (secondary level). There is at least one public district hospital in each district catering for approximately 400,000 to 600,000 individuals. District hospitals are staffed and equipped to manage most patients with complications or severe diseases and offer comprehensive curative services including intensive inpatient care. When appropriate, district hospitals refer cases for additional and specialized care to referral hospitals (tertiary level). One public referral hospital is in each of the regional main cities; Blantyre, Lilongwe and Mzuzu.

Public health facilities provide the majority (60%) of health services in the country. Private non-profit making Christian Health Association Mission (CHAM) hospitals and health centres, which charge subsidized user fees, provide about 37% of health services (CHAM 2016). The rest of healthcare is provided by private for-profit clinics, mainly in urban areas.

4.4.4 Challenges facing general health services provision.

The provision of quality health services in Malawi is facing challenges, such as shortage of drugs and equipment, long distance to facilities and poor attitudes of health workers. Malawi also has a serious shortage of health workers. For example, only 2 doctors and 283 nurses are available for every 100,000 people (WHO 2014), **Box 2**. In addition, healthcare resources (staff and facilities) are not evenly distributed as they are more concentrated in urban areas, meaning that the shortfalls are even larger in rural areas (Abiiro, Mbera et al. 2014).

4.4.5 Specific maternal and perinatal health services.

Maternal and new-born care (MNC) in Malawi is provided as a package within the context of EHP. The overall MNC package includes focused antenatal care, delivery and post-natal care services. Public health sector provides most of the MNH care in the

country. MNH care is mostly free of charge at point of use both for public facilities and for CHAM facilities that have signed Service Level Agreements with the MoH.

MNC is supposed to be provided by health facilities capable of providing emergency obstetric care (EmOC). Malawi subscribes to international guidelines (UN 2009), thus EmOC facilities in the country are expected to provide a set of seven key interventions also known as "signal functions" for health facilities providing basic EmOC (BEmOC) while health facilities providing more sophisticated care through Comprehensive EmOC (CEmOC) are expected to provide an additional two more advanced key interventions.

UN guidelines recommend at least 5 EmOC facilities, one of which should provide CEmOC services, for every 500,000 population (UN 2009). Studies in Malawi have consistently shown that while there is adequate coverage for CEmOC facilities, there is a deficit of BEmOC facilities, underscoring the need to improve EmOC services in peripheral communities (MoH 2015). Ideally, health centres providing BEmOC are expected to manage simple obstetric complications (such as removal of a retained placenta) and to only refer emergency cases requiring more comprehensive care (e.g. blood transfusions and surgical interventions) to respective district hospitals equipped to provide such CEmOC services.

4.4.6 Challenges facing maternal and perinatal health service provision

There are several concerns and challenges facing provision of maternal and perinatal care, which are like general health care limitations. Unique ones relate to the lack of knowledge and skills among healthcare providers, resulting in failure to recognise obstetric complications and manage them appropriately (Grady, Ameh et al. 2011), leading to conditions being referred that are otherwise anticipated to be managed at health centre level. Especially for rural health facilities, quality of care issues encompasses lack of access to emergency obstetric care, inadequate transport systems for referrals and inadequate drugs and staff with midwifery skills (MoH 2010, MoH 2015).

4.5 Maternal and child health policy environment and programs in Malawi.

Public health sector policies, alone or in conjunction with those from other sectors such as education, have huge potential for securing health of communities in a country (Don de Savigny and Taghreed Adam (Eds) 2009). The public health care act of 1948 and the constitution of the republic of Malawi mandates the MoH in the country to formulate health policies aimed at promoting the health of the nation through provision of oversight for implementations of both preventive and curative health services (GoM 1948). Within this legal framework, the MoH has over the years produced key policy and strategy documents, program and treatment guidelines including initiating specific reforms to facilitate maternal and child health promotion.

The most important health policies addressing maternal and child health were enacted in the post independent era in the 70s. The first to be launched was the maternal and child health program (MCH) in 1973 (Chirambo 1987). The aim of the program was to promote maternal and child health outcomes through increasing coverage of preventive services such as antenatal screening for mothers, provision of vaccinations and growth monitoring for children ≤ 5 years of age. To ensure adequate service delivery at primary level health facilities and access to these services in rural areas, the program was accompanied by initiatives to train lower cadre health workers and involvement of community health volunteers. This was followed by the launch of Expanded Program of Immunisation (EPI) in 1976 (Minetti, Kagoli et al. 2013). EPI aims to increase vaccination coverage for immunizable diseases and reduce mortality in children ≤ 5 years of age. These two programs were successful in increasing service delivery in rural areas and increasing overall national service delivery coverage.

The global economic crisis of the 80s reduced economic growth in developed countries (Fan, Duran et al. 2013). As a result, the amount of donor aid to poor countries was reduced. In response, structural adjustment programs were recommended in developing countries as a means to reduce government expenditures- including expenditures on healthcare (Loewenson 1993). To maximise health from dwindling resources, developing countries including Malawi formulated a minimum package of health services termed essential healthcare package. First implemented in 2004, EHP

prioritized provision of selected affordable and cost-effective interventions at primary level for illnesses of public health importance (MoH 2002). It is worth noting that services related to maternal and child health constitutes an important component of the EHP.

In 2005, a group of industrialized nations (G8) decided to provide debt relief to highly indebted countries like Malawi (Mutume 2005). To accelerate attainment of the MDGs 4 and 5, the Malawi MoH took advantage of the extra resources and invested them to improve social service delivery including health. The extra funding was aligned to respond to both high maternal mortality in the country and to global and regional calls for each country to develop a country-specific road map, to accelerate reduction of maternal, new-born and child deaths (Republic of Malawi and Ministry of Health 2005). Malawi prepared and launched the national road map strategic plan in 2005. The purpose of the road map is to ensure improved coordination of interventions and delivery of services for the MNCH subsector and to guide implementation across operational levels of the health system and standardize monitoring and evaluation.

Other strategies with bearing on MNCH have since been rolled-out, the latest being the launch of Results based financing for MNH (RBF4MNH) in 2012 (Brenner, Muula et al. 2014). The Malawi RBF4MNH initiative is a response to findings of an EmOC needs assessment in the country which reported that most facilities meant to provide basic EmOC could not meet United Nations (UN) criteria, and that 70% of pregnant women with complications had unmet need for EmOC (Ameh, Msuya et al. 2012).

4.6 The Malawi RBF4MNH initiative

The RBF4MNH initiative in Malawi is designed to improve service quality at MoH designated EmOC facilities by approaching both the supply and demand sides. From the supply side, PBF is provided to health providers in intervention or RBF4MNH supported health facilities (hence forth called RBF) based on achievements of pre-defined targets. The targets include such items as institutional deliveries and compliance to active management of third stage of labour. The PBF payments are made retrospectively approximately every quarter: 70% is divided as top-up among health providers of (MCH) services while 30% is to be invested in

improving facility infrastructure and supplies. Hospitals receive 60% for top-up and 40% for investments. From the demand side, the initiative uses CCTs to change health seeking behaviour of pregnant women residing in the catchment areas of RBF facilities to deliver at MoH designated EmOC facilities instead of at home. The CCTs, averaging US$ 10.50 per client (Brenner S and De Allegri M 2015) are therefore conditioned on deliveries in RBF supported facilities. The RBF implementation was preceded by a one-off investment in infrastructural upgrades and equipment supplies. This was to ensure that the providers/health facilities had the required capacity to provide quality MNH care (Brenner, De Allegri et al. 2015) **Table 3** provides a summary of key maternal and child health strategies and programs in Malawi.

Table 3: A Summary of key maternal and child health strategies and programs in Malawi

Year	Program/ Strategy	Purpose
1973	Maternal and Child Health program	Improve and expand MCH services
1979	Expanded program of Immunization (EPI)	Improve coverage of immunizations in children ≤ 5
1980	National Malaria Control program (NMCP)	Guide national malaria prevention and control
1982	Family Planning (FP) adopted nationally	Reduced fertility and promote MCH outcomes
1993	First country to adopt SP for malaria treatment	Reduce malaria related deaths and morbidity
1995	National strategic plan for safe motherhood launched	Promote reproductive health, promote MCH outcomes
1996	Safe Motherhood Program initiated	Reduce maternal and neonatal mortality
1999	National reproductive health strategy Integrated Management of Childhood illness (IMCI) enacted	Promote reproductive health. Improve child survival by increasing access to common infections (malaria, respiratory tract infections and diarrhoea)
2000	Child Lung Health Program	Reduce respiratory morbidity and mortality
2002	Service level agreements (SLA) with mission hospitals	To address maternal and child services gaps and increase coverage.
2003	National HIV policy launched	Reduce HIV infections and mortality
2004	Essential health care package	Provide minimum essential care at primary level
2004	Post abortion care strategy	Reduce abortion related mortality and morbidity
2005	National Road Map for Accelerating the reduction of maternal and neonatal mortality and morbidity	Strategic guidance to key maternal and child health problems from policy to implementations
2006	Child Health Days	To increase coverage of child survival interventions such as vaccinations
2010	Option B+ for PMTCT	To reduce mother to child transmission of HIV
2012	Result based financing strategy for maternal and neonatal health	Reduce maternal and neonatal mortality through Increase of quality institutional care.

Source: Adapted from Cortez r, Sarker I. et al 2014

4.7 Summary

The lack of evidence on RBF effectiveness in reducing maternal / perinatal mortality and on its efficiency as documented during the literature review (Chapter 3), combined with the challenges associated with providing quality MCH care in Malawi, as documented in this chapter, in combination logically set the grounds for the objectives for this PhD project as outline in the following Chapter.

CHAPTER 5: Aims and objectives

5.0 Aim

The overall aim of the thesis is to contribute towards strengthening the economic evidence base, in Malawi and the rest of the sub-Saharan African region, related to results-based financing as a mechanism to strengthen healthcare systems and increase facility based-provision and utilization of priority and quality maternal and perinatal healthcare.

5.1 Specific objectives

The thesis has three specific objectives:

1) To estimate from secondary data maternal and perinatal mortality risks for facility-based deliveries compared with home deliveries in sub-Saharan Africa;

2) To estimate the effects that RBF has on household costs and time to seek facility care for women experiencing pregnancy related complications;

3) To estimate the cost-effectiveness of obstetric care provided under RBF as compared to status quo obstetric care.

Each objective was selected based on its suitability to investigate and provide information on each of the three thesis questions outlined in Chapter 1, section 1.3. Literature review and meta-analytic methods were used to provide estimates of maternal and perinatal mortality risks and to highlight gaps in epidemiological data. The results of the literature review, in particular the identified information gaps, informed the design of service use for pregnancy related complications and associated cost analyses. Finally, the combination of meta-analytic, service use and costing analyses allowed modeling of cost effectiveness of RBF that would not have been possible using a single method alone, as shown in **Figure 8.**
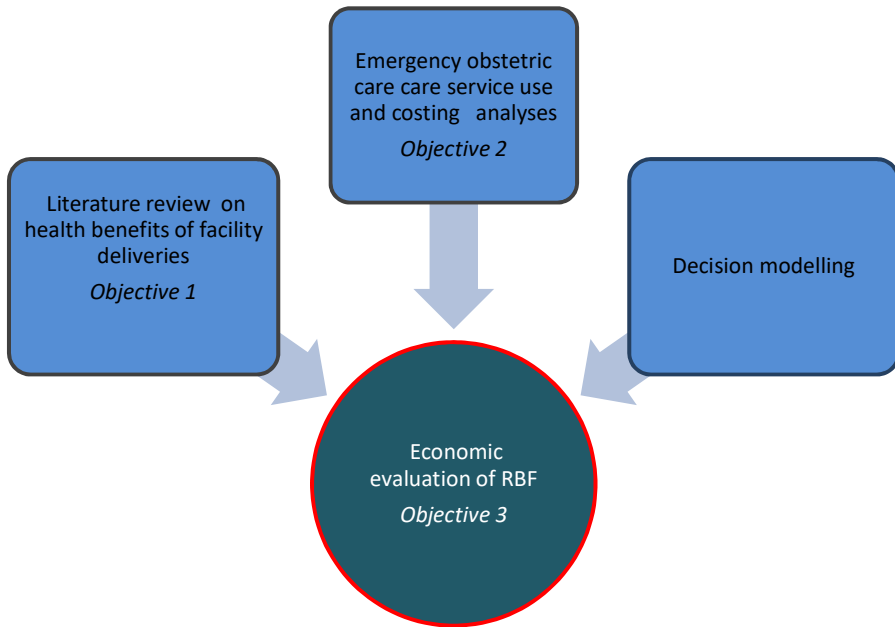
Figure 8: Illustrates the relationship between the three thesis objectives.

CHAPTER 6: Methods

This thesis draws on a mix of methodologies to answer the three thesis objectives. Correspondingly, section 6.1, section 6.2 and section 6.3 describe the methods used for studies I), II) and III). Finally, section 6.4 describes the process followed during the studies to ensure that study procedures conformed to ethical guidelines and standards. Summary descriptions of the study designs and methods used are outlined in **Table 4.**

Table 4: Overview of study designs, analytical approaches and data sources

Study	design	Analytical approach and data sources
Study I	Literature review and meta-analysis of population-based cohort studies	A structured and systematic search of databases, with primary focus on PubMed, using pre-agreed eligibility and exclusion criteria. Eligible studies were assessed for quality using a modified Newcastle-Ottawa scale for cohort studies. Extracted information was pooled using both fixed effects and random effects models in meta-analyses to estimate the risk of maternal and perinatal mortality by place of delivery in sub-Saharan Africa.
Study II	Cross-sectional surveys	Primary household costs and time till service use data were collected at community level in four districts in Malawi. Data were collected at baseline in 2013, midline in 2014 and endline in 2015. Using a before and after approach with controls, generalized linear models were used to estimate effects receipt of RBF (PBF+CCT) had on household costs and expected mean time to seek care for women experiencing pregnancy related complications.
Study III	Cost- effectiveness analysis	This study used primary cost data collected from 4 randomly sampled health facilities in Malawi, project document reviews and household costs collected as part of study II. Effectiveness data (percentage change in service use) were obtained from RBF4MNH impact evaluations. Additional secondary information was obtained from review of published articles in sub-Saharan Africa. Adopting a societal perspective, costs and health benefits were estimated over a one-year time horizon, using a decision tree model programmed in TreeAge software ©2016. Incremental cost-effective ratios were estimated in terms of deaths averted and life years gained.

6.1 Study I

Pursuant to specific object 1 (*To estimate from secondary data maternal and perinatal mortality risks for facility-based deliveries compared with home deliveries in sub-Saharan Africa*): A systematic search of peer reviewed population-based studies involving pregnant women and reporting on risk of maternal and or perinatal mortality at the individual level by place of delivery in the sub-Saharan region was conducted.

6.1.1 Search strategy

The search was conducted between January and August 2013 and followed guidelines for meta-analysis of observational studies in Epidemiology (MOOSE) and preferred reporting items for systematic reviews and meta-analysis (PRISMA) (Stroup, Berlin et al. 2000). Medical and social science databases and journal libraries searched included, but were not limited to, PubMed, EBSCO Host, Web of Science, ScienceDirect, Wiley, Cochran library and Google Scholar. The following key words were used in various combinations "Maternal mortality", "Maternal deaths", "Perinatal mortality", "Perinatal deaths", risk, "Place of birth/delivery", study, Africa and "sub-Saharan Africa". To facilitate comparison of findings with other publications, the

following definitions applicable to the SSA region were used. Maternal deaths were defined as all direct and indirect obstetric deaths during pregnancy, delivery, and the first 42 days after birth (Abouzahr 2011). Perinatal deaths were defined as pregnancy losses occurring after seven completed months of gestation, or deaths within the first seven days of delivery of a live born child (early neonatal deaths) weighing 1000 grams or more (ICD-10). Place of delivery was denoted facility-based (births or delivery in a formal health facility whether or not attended by a skilled medical attendant) or home (births or delivery outside of a formal health facility whether or not attended by a skilled traditional birth attendant).

6.1.2 Study selection

A multi-stage procedure was used to select studies of interest. In the first stage, titles and abstracts of publications retrieved during database searches were screened. In the second stage, full articles of abstracts and titles that appeared concordant with the inclusion and exclusion criteria were retrieved. In the third stage, full articles that did not meet the study inclusion criteria were excluded.

6.1.3 Inclusion criteria

- o Cohort and or demographic surveillance studies.
- o Studies reporting on pregnancy outcomes from 7 complete months until 7 days after birth.
- o Studies reporting on maternal deaths as soon as pregnancy was identified until 42 days after birth.
- o Studies written in the English language.
- o Studies published between 1990 and 2013.
- o Studies conducted in the sub-Saharan African region.

6.1.4 Exclusion criteria
- o Study design other than cohort or demographic surveillance e.g. surveys.
- o Studies which under reported outcomes i.e. with <25% assignment of outcomes of interest by place of delivery.

- Studies where reported data could not completely fill a 2 × 2 table illustrating maternal/perinatal outcomes (live or dead) by place of delivery.
- Studies reporting only on risk of an exposure (e.g. HIV infection or severe anemia in pregnancy) or an intervention (e.g. Prevention of mother to child transmission of HIV) on perinatal or maternal mortality.

6.1.5 Study quality

Each retrieved study was subjected to a quality review using a modified Newcastle-Ottawa scale for cohort studies (Wells, Shea et al.). The key information related to study quality assessed included representativeness of the study population, population characteristics such as gestation age at enrolment and duration of pregnancy follow up, information about study design (population-based cohort vs. demographic and health surveillance), ascertainment of exposure, proportion of home deliveries, and use of standard definitions for main outcome measures and denominators (e.g. births, live births). In addition, information that may have affected estimates of the primary outcomes including frequency of data collection, proportion of refusals, loss to follow up and sample sizes was also extracted.

6.1.6 Data extraction

From each study, general study information (e.g. year of study publication and names of authors) and the primary health outcomes for the study (e.g. maternal and perinatal mortality ratio by place of delivery) was obtained. As the outcomes of interest are ratios, information on relevant numerators and denominators to enable independent calculations of these ratios was also extracted. This information was used to estimate denominators by simple proportion in instances where an appropriate denominator (e.g. number of live births at home) was not provided while the numerator and corresponding appropriate ratio was given.

6.1.7 Study outcomes

Study 1 had two main outcomes.

- Odds ratio of maternal mortality for facility births relative to home births
- Odds ratio of perinatal mortality for home births relative to facility births

The odds of maternal mortality among facility births was defined as the number of maternal deaths among facility-based births divided by the number women who did not experience deaths/ lived (among facility births). Odds of maternal deaths among home births were similarly defined. The odds ratio (OR) of maternal mortality for facility births relative to home births was calculated as odds of maternal mortality among facility births divided by odds of maternal mortality among home births (Bland and Altman 2000). The same definitions and calculations were used for estimating the OR for the perinatal mortality for home births relative to facility births.

6.1.8 Statistical analysis

Quality scores for each study were categorized in two: high if more than 60% of the quality items were reported and low otherwise. The crude OR by place of delivery in each study was estimated. The individual study crude ORs were then used to calculate the weighted average of the OR across the studies using meta-analytic procedures (Kirkwood and Sterne 2003). The OR can be combined using two approaches. Fixed effects models weight studies according to the amount of information they contain while random-effects models incorporate an estimate of between-study variation in the weighting (Harris, Bradburn et al. 2008, Haidich 2010). Study heterogeneity was assessed using I^2 statistic, which measures the percentage of variation in OR attributable to heterogeneity between studies. As recommended (Higgins, Thompson et al. 2003), the fixed effects model was used when I^2 was low < 50%, otherwise the random-effects model was used to calculate individual study OR, corresponding 95% confidence intervals (95% CI) and to pool the results across the studies.

6.1.9 Estimates of effects

The potential effect of place of delivery on maternal and perinatal mortality was estimated in terms of attributable risk percentage reduction, defined as the portion of the incidence of an outcome in the exposed that is due to the exposure:

$$[(I_{exp} - I_{un})/I_{exp}] * 100$$

Where I_{exp} and I_{un} are incidences in the exposed and unexposed groups, respectively (Daly and Geoffrey 2007). In this analysis, this represented the incidence of mortality in the exposed (home delivery group) that would be prevented if the exposure (home

deliveries) were eliminated. A Poisson method was used to calculate mortality ratios and their associated 95% CIs as this method approximates distribution of these ratios better (Bouvier-Colle, Ouedraogo et al. 2001). STATA version 12.0 (Stata Corp, College Station, Texas) was used for the analysis.

6.2 Study II

Pursuant to objective 2 *(To estimate the effects that RBF has on household costs and time to seek facility care for women experiencing pregnancy related complications):* This study used quantitative methods to evaluate impact of RBF on healthcare use by women experiencing pregnancy and delivery related complications, and the associated household economic costs. The utilization and economic cost data were gathered through household surveys. Surveys are considered best approaches for collecting standardized responses on individuals' behaviours across a large sample of subjects (Patton, 1990). Importantly and pertinent to this study, when survey data are collected at more than one point in time, they allow for assessing direction of observed associations using analytical statistical techniques (Kelley, Clark et al. 2003).

The sections below describe the intervention (RBF4MNH), study sites, populations and data collection methods that were used to evaluate the Malawi RBF4MNH initiative. Because study II was nested within the RBF4MNH impact evaluation, the methods used for both studies were essentially similar.

6.2.1 The intervention

The RBF intervention, designed to work with incentives to promote quality and encourage services use, is as described previously in section 4.6.

6.2.2 The comparator

The comparator or status quo MNH care is as detailed previously in section 4.4.5. In contrast to the RBF facilities, non-RBF facilities (comparators) did not receive explicit infrastructural upgrades nor any other interventions.

6.2.3 Study sites

The RBF study was conducted in four out of the 28 districts in Malawi. The districts were purposefully selected so that they were relatively representative of the rest of the districts in the country in terms of maternal/childhood illness patterns and administrative arrangements. The selected districts were Mchinji, Dedza and Ntcheu in the central region and Balaka in the southern region, **Figure 10**. These districts have an approximate population of 2 million, about 12% of the national population. Women of reproductive age constitute 25% (500,000) of the study districts population.

The four districts have a total of 33 health facilities designated by the Malawi Ministry of health as capable of providing BEmOC or CEmOC services. The RBF initiative focused on women of reproductive age living within the catchment areas of these 33 health facilities.
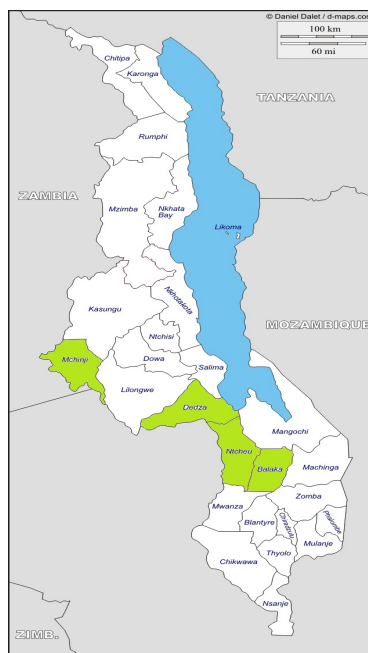
Figure 9: Map of Malawi showing the four study districts.

Source: Adapted from Maps of the World.

6.2.4 Study design

In 2013, the MoH selected 17 health facilities out of the 33 EmOC health facilities (4 district hospitals/CEmOCs and 13 BEmOCs) to be recipients of the RBF4MNH initiative. One year later, the initiative was expanded to include a total of 28 health facilities (5 CEmOC and 23 BEmOCs) with the remaining health facilities serving as controls. Selection of facilities by MoH was non-random. Facility catchment population size, geographical EmOC coverage, facility's performance of emergency obstetric care signal functions and functionality of referral structures were the criteria used for selection.

The supply-side component was rolled out at the selected CEmOC and BEmOC facilities soon after the official launch of the program in April 2013. However, due to

implementation challenges, the demand-side component was rolled out progressively across the RBF4MNH facilities and only became fully functional one year later (2014) as illustrated in **Figure 10**

6.2.5 Enumeration areas and household selections

A three-stage cluster sampling procedure was used to select study areas. In the first stage, catchment areas of the 33 health facilities capable of providing EmOC services were designated as clusters. Depending on size, each cluster contained 11-45 Enumeration areas (EAs). EAs are administrative data collection units, demarcated by the National Statistics office (National Statistical Office 2010) and contain about 500 households with a mean of 1,500 people (National Statistical Office 2008). In the second stage, EAs were randomly sampled within each cluster: two EAs for health centres (BEmOCs) and four for district hospital catchment areas (CEmOCs), to allow for larger populations and rural-urban differences in the district hospital areas. In the third stage, at least 26 eligible women were randomly selected from each EA.

To identify the women, fieldworkers started by finding a central point in the EA, spin a bottle and then walked in the direction the bottle pointed while visiting all households between the central point and the EA border. Household were included if they met eligibility criteria, detailed in section 6.2.12 below. If not, fieldworkers moved on to the next household. Once the EA border was reached, fieldworkers then moved about 100 meters either side of the border before starting moving towards the central point again. This was done to ensure that selected households did not cluster around the EA central point but were spread throughout the EA so that the sampled women were representative of the EA. It was emphasized to the fieldworkers during training to adhere to this procedure. The fieldworkers worked in pairs in the selected EA, visiting alternate houses and consulting with one another or their supervisors in case of uncertainty.

6.2.7 Data collection

Data was collected through three repeated cross-sectional household surveys. The first survey was conducted at baseline (April-May 2013), the second was conducted at midline (June-July 2014) and the third survey took place at endline (June-July 2015).

During each survey, questions were asked spanning 12 months period preceding the survey as shown in **Figure 11.**
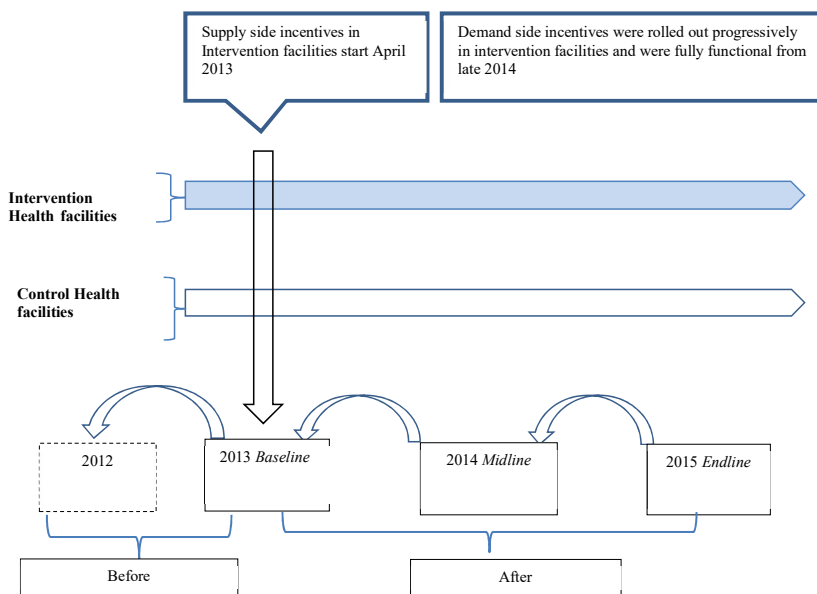
Figure 10: Provides information on incentives and data collection periods for evaluation of the Malawi RBF4MHH initiative

The vertical arrow indicates when supply-side incentives to health workers were applied to Intervention facilities. The intervention facilities in addition received gradual demand-side incentives for women from 2014. Blue horizontal arrow represents intervention facilities. White horizontal arrow represents control facilities. Horizontal axis shows the before and after periods and

6.2.8 Survey interviewers

Trained interviewers collected data from the eligible women using a structured questionnaire, programmed digitally using Open Data Kit (ODK) software and administered using Samsung Galaxy-Tab-2.0 tablet computers. The use of tablet computers was motivated by the known advantages of electronic data capture compared to paper based questionnaires (Fanning and McAuley 2014). For example, use of tablet computers precludes the need for manual data entry, which in turn eliminates data entry

errors and shortens the time between data collection and data availability for systematic exploration/inspections and analysis. In addition, checks and skips were programmed into the questionnaire, preventing fieldworkers from accidentally skipping questions and alerting fieldworkers if invalid entries were made. This improved both data quantity and quality. Loops ensured that only appropriate questions were asked depending on respondent's unique situation. For example, if a woman did not experience any complication during previous pregnancy, then complications related questions were automatically not asked.

It's worth noting that this electronic approach has disadvantages too, particularly when used in resource poor settings. Sufficient time is needed to train field workers, so they can build competence in using tablet computers, competent information technology (IT) support is required for programming and troubleshooting, reliable internet and regular power are needed to send the information from tablets to a central server according to laid down schedules. While hiring of enumerators with experience in use of tablet computers and regular IT support from both Universities of Malawi and Heidelberg, Germany, allowed for a less challenging enumerator training, in the field, the following challenges were experienced. Poor internet coverage prevented regular uploading of data to the central server, risking loss of data if a tablet was stolen or damaged. Most evenings, supervisors had to search for areas with strong network signals, incurring extra fuel costs and distracting from working on other tasks such as getting timely/ adequate feedback from the fieldworkers or preparing for next day activities. Frequent blackouts always threaten tablet power. This threat was minimized by having spare tablets (additional survey costs) and using car battery power to charge the tablets.

6.2.9 Pre-survey training and piloting

About 18 enumerators took part in gathering each wave of household survey data. The enumerators were mainly non-health workers. Given that some of the household data was intended to be used in study II, I was very involved in the training of these enumerators. Their training, which included piloting of the questionnaire, was carried out over an average five-days period before each of the surveys. The training followed a similar format for each of the three survey rounds.

A paper version of the questionnaire with English and Chichewa translations was used to train the enumerators during the initial phase (first two days) of the training. This was done to ensure the enumerators had good understanding of the questions, how they were related and to verify that the Chichewa versions were true reflections of their English counterparts. Following this, three days were committed to the use of tablet computers with only the Chichewa version of the questionnaire. The fieldworkers practiced using the questionnaire as a group and then in pairs; interviewing each other, taking turns to act as interviewer and respondent.

Important and challenging parts of questionnaire development relate to ensuring that all important questions are included, are asked appropriately, that the flow of the questions is logical, and that checks and skips are working properly or as intended. I therefore took part in systematically testing the questionnaires individually and in groups during training, taking notes of important observations that required changes to the questionnaire or program. After this class work, the questionnaires/ tablets were piloted in rural villages in Blantyre on volunteer women who had ever given birth. After piloting, more modifications were made to the questionnaires to improve question readability and clarity. These changes mainly related to modifications to the questionnaire wording to make them more generic and context appropriate and simplifications of questions or adding lead in questions in cases where there were evidence respondents had difficulties understanding questions as initially phrased. All interviewers were Malawians and fluently spoke Chichewa, the common local language. The questionnaire **(Appendix 1: Questionnaire)** was administered in Chichewa.

6.2.10 Data Collection

Information collected included details on the women's social demographic features e.g. age, education and marital status, reported complications and hospital admissions due to complications related to the most recent pregnancy (**Appendix 1: Questionnaire)**. The information on self-reported complications was collected in the form of lay person descriptions of a combination of symptoms and signs suggestive of common obstetric complications (Nahar, Banu et al. 2011). This information was validated using formal diagnosis recorded in the women's health passports or health

facility discharge slips, where possible. For each reported complication, information about relevant out-of-pocket expenditures on medical costs (consultations, drugs and laboratory fees) transport costs, food and accommodation were recorded. Time use for seeking and obtaining care for both patient and their guardians was also recorded. All women reporting a complication were asked if they sought care. If the response was yes, the women were then asked to report how quickly after symptoms onset they had decided to seek care, and how many days elapsed before they presented to a facility once decision to seek care was made.

6.2.11 Data management

At the end of each field day, electronic data collection forms were checked for completeness and accuracy of recordings before being sent to a central saver. During data collection, the database (in the central saver) was regularly reviewed for completeness. Information in the database was crosschecked with information from field reports regarding number of interviews, EA locations and dates the interviews were conducted. Any disparities, duplicates or missing records were corrected by referencing the appropriate tablet computers. During the study, access to electronic records was restricted only to study staff or enumerators using passwords.

6.2.12 Inclusion and exclusion criteria

As mentioned above, section 6.2, study II was a sub-study of the household surveys, conducted as part of RBF4MNH impact evaluation. As such, data used in the analyses for study II are from a truncated sample of the respondents for household surveys.

Respondents data were used in study II if

- o Respondents were aged ≥ 15 years old
- o Respondents had completed a pregnancy (either through miscarriage, abortion, stillbirth or delivery of a live baby) during the 12 months before day of survey
- o Respondents had experienced a pregnancy or delivery related complication at any point during their pregnancy
- o Respondents provided fully informed voluntary consent and the relevant consent forms were signed or thumb printed **(Appendix 2: Consent form)**.

Respondents data were excluded if

- o Respondents were <15 years old

6.2.13 Study main outcomes

Study II had two main outcomes

- o Total costs and
- o Time to seek care.

Total costs: Total costs were defined as the sum of both direct costs (e.g. medical and transport fees) and productivity losses associated with each reported complication. Costs of time taken to seek care and actually spent at health facilities were estimated using the human capital approach (Jo 2014). Lost patient and informal guardian's time in days for each reported complication were quantified and added up. Given the high level of self- or informal employment in the sample (>80%) and the lack of job specific mean wage information for those in formal employment, minimum wages were used to value lost productivity for both the formally and informally employed. Productivity losses (opportunity cost) were estimated as the product of the time lost and daily minimum wage pertaining to the survey year. Reported minimum wages per day in Malawi Kwacha (MK) were 317, 551, 687 for years 2013, 2014 and 2015 respectively (Malawi Labour Market Profile 2014). To compare the costs reported over the years, the annual Consumer Price Index (CPI) increases from 2013 to 2014, 2014 to 2015 and 2014 to 2015 respectively was used to adjust the 2013 (baseline) and 2014 (midline) costs to 2015 (endline) values (1US$=550MK). Hereafter, total household costs are simply referred to as costs, unless stated otherwise.

Time to seek care: To estimate time taken till service use, women were prompted to recall when key symptom(s) for reported complication started. Time to seek care was defined as duration in days a woman with a reported complication took to present for care at a health facility after symptoms onset. Hereafter, time taken to seek care is simply referred to as time to care.

6.2.14 Study Independent variables

The main exposure was receipt of RBF4MNH, composed of PBF and CCT, for women in designated health facility areas. To control for confounding in the estimation

of the effect, independent variables identified as important determinants of care seeking (Gabrysch and Campbell 2009) and that have local context and cultural relevance within the framework of understanding obstetric complications care seeking (Kambala, Morse et al. 2011, Combs Thorsen, Sundby et al. 2012) were included. The variables **Table 5** include age, parity, education, socio-economic status (SES), area of residence, facility type and distance to facility. In addition, in view of the gradual roll out of CCT as previously explained section 6.2.4, three more variables were included. The first indicated if women were registered to receive CCT. The second related to those who sought care and indicated whether they were treated as in-patients (a proxy for disease severity). The third indicated the days spent in facility for women treated as in-patients. These three variables were included on the assumption that they would have bearing on costs. Following standard approaches, a wealth index based on household assets ownership was generated using principal component analysis (Vyas and Kumaranayake 2006). The wealth index was used to rank the women into three SES terciles.

Table 5: Independent variables and their coding

Independent variable	Definition, measurement and coding
Age	Continuous variable, measured in years
Parity	Number of term deliveries, categorized as 0 if < 2 term deliveries and 1 if $\geq$ 2 deliveries
Married	Marital status, categorized as 0 if woman not married and 1 if woman married
Head Household	Household head status, categorized as 0 if woman did not head household and 1 if woman headed household
Educated	Primary education attainment, equivalent to 8 years of schooling, categorized as 0 if woman had no primary school leaving certificate and 1 if woman had primary school leaving certificate or above
Residence	Place of residence, coded as 1 if woman stayed in an urban area and 0 otherwise.
Distance	Continuous variable measured in kilometres to the nearest formal health facility
Facility	Type of health facility, coded as 1 if a facility provided CEmOC and 0 if BEmOC.
Registered	Denotes enrolment to receive demand side incentives, coded 1 if woman enrolled and 0 otherwise
In-patient	Coded as 1 if woman with self-reported complication was admitted for in-patient care and 0 otherwise
Days	Continuous variable, measure as number of nights spent in facility
Social economic status	Coded as 0 if poor, 1 if middle and 2 if least poor

6.2.15 Data analysis

To compare and describe social-demographic characteristics of the women with a self-reported complication in the RBF and non-RBF groups, I used summary statistics (means, proportions and corresponding 95% confidence intervals). T-tests and chi-

square tests were used to assess differences in means and proportions, respectively, between the two groups.

I first explored the data using ordinary least squares regression. Standard diagnostics showed that the main outcomes (household costs and time) were positively skewed and heteroskedastic **Figure 11** making it problematic to use parametric analytic approaches (Mihaylova, Briggs et al. 2011). To estimate populations means, $E(y|x)$, while considering the non-normal distribution of health care data, I therefore applied generalized linear models (GLMs). GLMs allow for making direct inference about expected population means without recourse to complex transformations or re-transformations (Barber and Thompson 2004). Total costs had trivial amounts of zeros (< 3%). Therefore a two part model, an approach often used in modeling cost data, was deemed likely to have little effect on the overall predicted mean costs (Blough and Ramsey 2000). Thus, the cost analysis was limited into a single part prediction model.
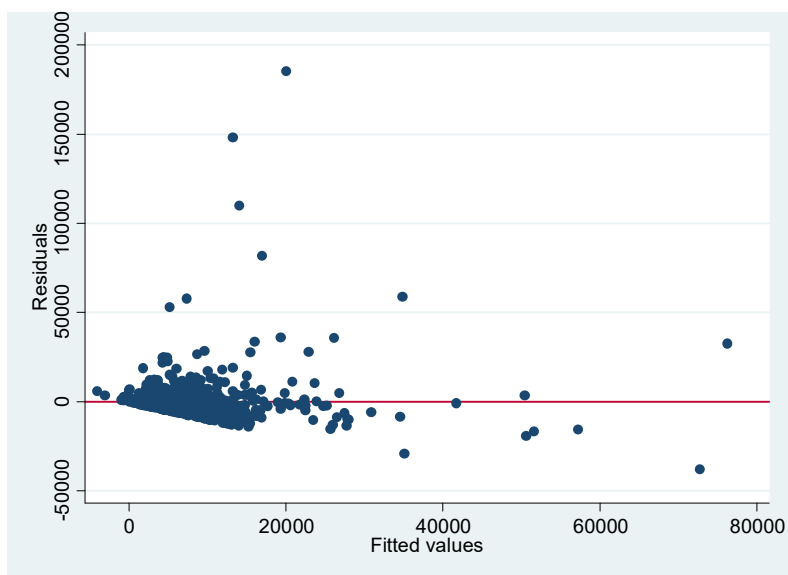
Figure 11: Regression diagnostics for the ordinary least squares on household costs.

Plot of residuals versus fitted values illustrating non-constant variance of residual as costs increase, suggestive of heteroskedasticity.

GLMs require explicit specification of the distribution (F) of the dependent variable and the link function (g) describing how independent variables are functionally related to the dependent variable (Blough and Ramsey 2000). A modified Parks test was used to select appropriate distribution and link functions for the study outcomes (Manning and Norton 2013). Through this test, it was found that a log link with Gamma and Poisson families respectively provided best fits for the costs and time data. The empirical GLMs took the form:

$$g(\mu_i) = \beta_0 + \beta_1 Year_i + \beta_2 RBF_i + \beta_3 RBF_i * Year_i + \beta_4 X_I, \qquad y_i \sim F$$

Where μ_i denotes the study outcome of interest (costs/time) for every unit (pregnant woman seeking care for a reported complication), $Year_i$ is a categorical variable indicating the time point taking value 0 at baseline, 1 at midline and 2 at endline, RBF_i, is an indicator variable coded 1 if the unit is in the RBF group, 0 if in the non-RBF group, X_i is a vector of independent factors known to influence the dependent variables as outlined above. The estimable quantities of interest are thus: β_0 a common constant for all observations, β_1 effect of time on each unit, β_3 the effect of treatment (and the main target of inference) and β_4 representing a vector of coefficients for X **Table 5**. Because the decision to admit women with reported complications for in-patient care was based on clinical assessments, women admitted for care were considered a distinct subgroup. Therefore, two separate models for each of the primary study outcomes were ran: the first model included all women with a self-reported complication who sought care (full model), while the second was restricted to the women who were admitted (restricted model). As the models have a log link, the exponential of coefficients should be interpreted as the ratio of arithmetic means (Barber and Thompson 2004). The analysis generated robust standard errors and used the cluster command to allow for clustering of women at health facility levels. StataIC/14 (Stata-corp LP, Texas, USA) was used for the analysis.

6.3 Study III

Pursuant to objective 3 (*To estimate the cost-effectiveness of RBF compared with status quo obstetric care*): This study evaluated the cost-effectiveness of *RBF* compared to status quo obstetric care in Malawi, using a decision tree model.

6.3.1 The intervention and comparator

The intervention is as described in section 4.6. The comparator is as described in section 4.4.5.

6.3.2 The decision model

A decision tree model was used to calculate the expected health effects and expected costs of the RBF initiative from a societal perspective. The choice for using a decision tree was programmatic, influenced by data availability. Reflecting the financing options Malawi decision makers face, the decision model included two arms: RBF and non-RBF. Policy makers decide which facilities should receive RBF while mothers' face different probabilities, within each arm, of delivering in an RBF health facility, non-RBF facility or at home. In the model, place of delivery probabilities are based on primary trial data. Mothers who delivered in RBF facilities benefited from the intervention (PBF + CCT) while those who delivered in non-RBF facilities did not.

The model included information on population coverage with facility-based delivery (FD), the incidence of maternal complications, cause-specific maternal case fatality rates (CFRs), stillbirth and early neonatal mortality risks, time to seek care for complications and improvements in quality of obstetric care. The cost information included care seeking and associated treatments costs, including RBF costs for the intervention arm. The costs are presented in 2013 USD, which is the year the RBF program started.

For each arm, the model tracked maternal and perinatal outcomes from 28 weeks gestation until 7 days after delivery. This cut-off is consistent with the definition of perinatal outcomes in developing settings (Lawn, Cousens et al. 2005, Froen, Cacciatore et al. 2011). Importantly, it focuses on capturing maternal deaths during the third trimester and the first week after birth, when the majority of deaths occur (Vogel, Souza et al. 2014). By comparing with the status quo, the model estimated incremental deaths averted and years of life gained (YLG) from perinatal and maternal mortality averted by the intervention as well as the additional (incremental) costs incurred by the RBF initiative.

Figures 12 and **13** show the schema of the decision model. The full model was constructed using TreeAgePro© 2016 software.
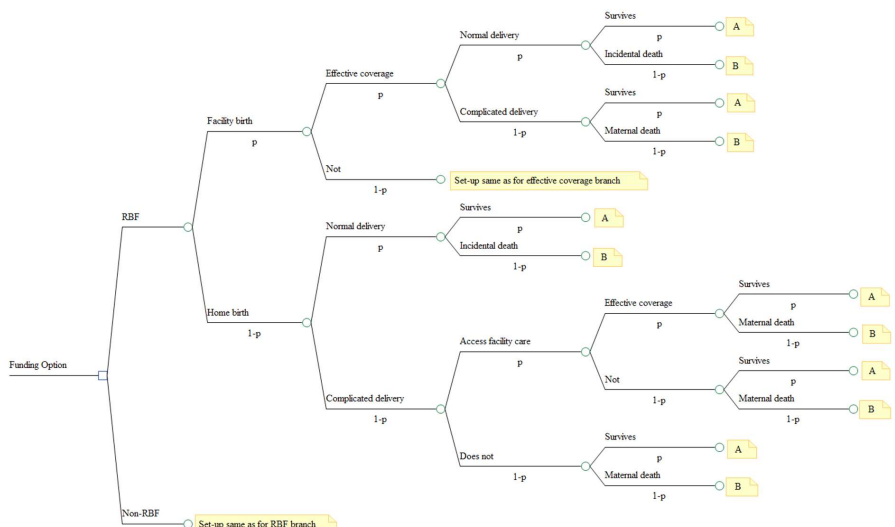
Figure 12: Pathways of maternal events, demonstrating maternal status after delivery.

A is linked to perinatal outcomes for live mothers. B is linked to perinatal outcomes for dead mothers as shown in **Figure 13**. RBF-Results based financing. EmOC-Emergency obstetric care.
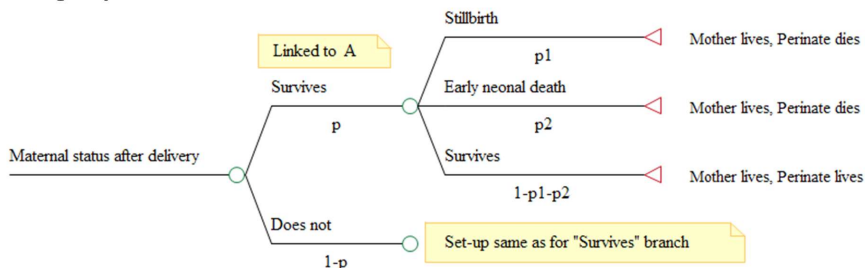
Figure 13: Pathways of perinatal events demonstrating conditional relationships between perinatal outcomes and maternal status after a delivery event.

6.3.3 RBF effects on service use, quality and subsequent mortality reductions

At population level, maternal/perinatal survival depends on coverage of pregnant women with facility-based delivery services of high quality, also known as effective coverage. The impact evaluation of the RBF in Malawi demonstrated significant differences in effective coverage of pregnant women with obstetric services between

RBF and non-RBF facilities: RBF significantly increased effective coverage in facilities by 10.5%-points (95%CI: 8.9−12.1%-points, p=<0.01) (Brenner, Wilhelm et al. 2017). In addition, receipt of RBF was associated with significantly reduced mean time to seek care for women experiencing complications (Study II), which may translate into better survival (Chinkhumba, De Allegri et al. 2017).

Similar efforts to improve the quality of obstetric care were associated with 25 to 30% reductions in CFRs and 19 to 20% reductions in stillbirth rates in Zambia and Uganda (CDC 2014). Assuming same effects in Malawi, the mean figures of 27.5% and 19.5% reductions in CFRs and stillbirth rates, respectively, were adopted to estimate CFR and stillbirth rate reductions in RBF supported facility deliveries. Consistent with the Zambia and Uganda studies, it was assumed that RBF had no significant effect on early neonatal mortality. The mean estimates were used as baseline scenario and varied ± 20% in sensitivity analysis **Table 6.**

6.3.4 Epidemiological data

Estimates of other key epidemiological parameters were obtained from the published literature as outlined below.

6.3.4.1 Perinatal mortality

Because some maternal complications can negatively affect perinatal outcomes, perinatal survival is linked to maternal survival (Saleem, McClure et al. 2014, Vogel, Souza et al. 2014). After a delivery event, the model therefore considered perinatal outcomes based on mothers' status, i.e. whether the mother was alive or dead. The status of the new-born (stillbirth, early neonatal death, alive) was then assigned conditional on the status of their mothers **Figure 13**. Therefore, perinatal deaths were calculated by combining the risk of stillbirth and early neonatal mortality with information about the status (live or dead) of the mother after delivery.

The estimates for stillbirth and early neonatal mortality rates are 28.4/1,000 births and 19.3/1,000 live births, respectively, among a population-based cohort of mothers that survive births. For mothers that die soon after births, the estimated stillbirth and neonatal mortality rates are 318.8/1,000 births and at 89.9/1,000 live births, respectively (Saleem, McClure et al. 2014). As perinatal mortality risks following

incidental maternal deaths are not linked to maternal complications, it was assumed that they are the same as for normal deliveries. These rates were transformed into corresponding probabilities following recommended approaches (Fleurence and Hollenbeak 2007) **Table 6**.

6.3.4.2 Adjusting perinatal risks by place of delivery

Individual studies in SSA report mixed results on risk of perinatal mortality by place of delivery; some find that the risk is lower for facility-based deliveries (Walraven, Mkanje et al. 1995, McDermott, Steketee et al. 1996, Nankabirwa, Tumwine et al. 2011) while others report lower risk for non-facility based deliveries (Matendo, Engmann et al. 2011, Schmiegelow, Minja et al. 2012). Perinatal risk adjustment was based on a meta-analysis (Study I) that pooled results from population-based cohort studies in SSA (Chinkhumba, De Allegri et al. 2014). The study reported a relative risk of 1.25 for perinatal death among home based births compared to facility-based births.

6.3.4.3 Incidence of maternal complications

Information on incidence of maternal complications and respective case fatality rates is needed to calculate maternal deaths. To track maternal complications in the model, each delivery was defined as normal (not associated with a maternal complication) or complicated (associated with a maternal complication). Mothers experiencing maternal complications could experience a direct obstetric complication, such as haemorrhage, sepsis, obstruction and eclampsia or other/ indirect causes. Each complication could lead to a maternal death or recovery. The model allowed for the fact that mothers experiencing normal deliveries may die from incidental causes. There is wide variations in reported incidences of maternal complications even though countries by principle adhere to the same version of the International Classification of Diseases (World Health Organization 1992). A World Health Organization multi-country survey estimate of 7.3% maternal complications prevalence associated with facility-based deliveries in developing countries was adopted (Souza, Gulmezoglu et al. 2013). Given the survey methodology rigor and inclusion of countries from SSA region, this is probably the most representative estimate, thus it was used as the baseline scenario. For home births, it was assumed that the percentage of complicated deliveries was 80%

lower, based on the fact that majority of women with complications normally self-select themselves into care (McClure, Goldenburg et al. 2007).

There is lack of reliable data on case-specific incidences for sepsis, haemorrhage, eclampsia and obstruction (Leigh, Mwale et al. 2008, Kaye, Kakaire et al. 2011). However, data on relative frequencies of these conditions among women with complications exist. In Malawi rural facilities, sepsis, haemorrhage, eclampsia and obstruction have been showed to account for 32%, 32%, 20% and 11% respectively of obstetric complications, with other direct/indirect causes accounting for the remaining 5% (MoH 2000). Cause-specific incidences were thus estimated indirectly, by multiplying the relative frequency of each condition with the overall incidence of maternal complications.

6.3.4.4 Maternal case fatality rates

Regarding maternal case fatality rates (CFRs), wide variations exist in data for the SSA region. A review of recent estimates (year 2000 onwards)(Kaye, Kakaire et al. 2011) reported that facility based CRFs range from 3.6-18.0% for sepsis (Prual, Bouvier-Colle et al. 2000, Kaye, Mirembe et al. 2003); 2.8 to 12.3% for haemorrhage (Prual, Bouvier-Colle et al. 2000, Oladapo, Sule-Odu et al. 2005); 3.4-18.0% for eclampsia (Prual, Bouvier-Colle et al. 2000, Kaye, Mirembe et al. 2003) and 2.0-12.7% for obstruction (De Bernis, Dumont et al. 2000, Kaye, Mirembe et al. 2003). For each CFR, the mean estimates were used as baseline scenario while the whole ranges were tested in sensitivity analyses to reflect this diversity of CFRs across SSA settings. As no corresponding data exists for women experiencing indirect complications and among home births, the mean CFR (0.09%) was adopted to identify deaths due to complications from other/indirect causes and during home births **Table 6.** For home births, this rate is likely to be on the lower side but may be justified in light of reports that sometimes, the quality of care provided by the formal sector providers may not be much better than that provided by informal providers (Godlonton and Okeke 2016).

6.3.4.5 Maternal mortality risks

Though rare, a woman can have co-morbidities or experience more than one complication, raising the problem of competing mortality risks (Pintilie M 2006). The model applied cause-specific incidences concurrently, based on the simplifying

assumption that the risk of each maternal complication is independent from the risk of other complications.

Mortality risk for incidental causes was thus approximated by subtracting annualized life time risk for maternal death (1 in 34) for women of reproductive age,15 to 49 years (WB 2015) from annualized all-cause mortality risk (0.0242) for women aged 25-29 years (World Health Organization).

6.3.4.6 Estimation of years of life gained.

Malawi life expectancies at birth and at the mean age of women of reproductive age were used to calculate YLG (World Health Organization) for each perinatal and maternal death averted, respectively. Future YLG were discounted at 3% in the baseline scenario (Shepard, Zeng et al. 2015), while the influence of no discounting of future health was explored in sensitivity analysis. Details of parameters used in the model and their sources are shown in **Table 6**

Table 6: List of parameters used in Results based financing compared to non-Results based financing decision tree model.

Parameter	Baseline estimates	[a]PSA distributions	Sources
Life years gained (discounted)			
Maternal years	25.02 ± 20%		(World Health Organization)
Perinatal years	27.84 ± 20%	Normal	(World Health Organization)
Outcome probabilities			
Stillbirth if mother is alive	0.028 ± 20%	Beta	(Saleem, McClure et al. 2014)
Stillbirth if mother is dead	0.273 ± 20%		(Saleem, McClure et al. 2014)
Early neonatal death if mother is alive	0.019 ± 20%		(Saleem, McClure et al. 2014)
Early neonatal death if mother is dead	0.086 ± 20%		(Saleem, McClure et al. 2014)
Maternal death from incidental causes	0.004 ± 20%		(World Health Organization , WB 2015)
Maternal complications (%)			
Facility births	7.3 ± 20%		(Souza, Gulmezoglu et al. 2013)
Home births	3.6 ± 20%		Assumption
Maternal case fatality rates (%)			
Sepsis	10.8 (3,6-18,0)		(Prual, Bouvier-Colle et al. 2000, Kanya, Obare et al. 2014)
Haemorrhage	7.6 (2,8-12,3)		(Prual, Bouvier-Colle et al. 2000, Oladapo, Sule-Odu et al. 2005)
Obstruction	7.4 (2.0-12,7)		(De Bernis, Dumont et al. 2000, Kanya, Obare et al. 2014)
Eclampsia	10.7 (3,4-18,0)		(Prual, Bouvier-Colle et al. 2000, Kanya, Obare et al. 2014)
Other/ complicated home births	9.1 ± 20%		Assumption
Share of complications (%)			
Sepsis	32 ± 20%		(MoH 2000)
Haemorrhage	32 ± 20%		(MoH 2000)
Obstruction	11 ± 20%		(MoH 2000)
Eclampsia	20 ± 20%		(MoH 2000)
Others	5 ± 20%		(MoH 2000)
Service use (%)			
RBF births	89.2± 20%	Beta	(Brenner, Wilhelm et al. 2017)
RBF Effective coverage	77± 20%	Beta	(Brenner, Wilhelm et al. 2017)
Non-RBF births	82.7± 20%	Beta	(Brenner, Wilhelm et al. 2017)
Non-RBF Effective coverage	69.5± 20%	Beta	(Brenner, Wilhelm et al. 2017)
RBF complication care seeking	78 ± 20%		(Chinkhumba, De Allegri et al. 2017)
Non-RBF complication care seeking	75 ± 20%		(Chinkhumba, De Allegri et al. 2017)
Quality effects in RBF facilities (%)			
Reduction in maternal CFRs	27.5 ± 20%	Beta	(CDC 2014)
Reduction in stillbirth rate	19.5 ± 20%		(CDC 2014)
Reduction in early neonatal death rate	0		(CDC 2014)
Relative risks			
Stillbirth, RBF vs Non-RBF facility	0.829 ± 20%	Log Normal	(CDC 2014, Saleem, McClure et al. 2014)
Perinatal death, Home vs facility births	1.258 ± 20%	Log Normal	(Chinkhumba, De Allegri et al. 2014)
Patient costs ($)			
Normal birth RBF facility	5 ± 20%		(Brenner S and De Allegri M 2015)
Normal birth, Non-RBF facility	5 ± 20%		(Brenner S and De Allegri M 2015)
Complicated birth Non-RBF facility	13.68 ± 20%		(Chinkhumba, De Allegri et al. 2017)
Complicated birth, RBF facility	15.15 ± 20%		(Chinkhumba, De Allegri et al. 2017)
Home delivery	2 ± 20%		Assumption

*PSA probabilistic sensitivity analysis

6.3.5 Cost data

Health systems and RBF program costs were collected from four health centres. Two districts were randomly selected and within each district, an intervention and a comparison health centre were also randomly selected. Data were retrospectively collected twice, spanning fiscal years 2013/14 and 2014/15, in June-July of 2014 and 2015 respectively. Given some differences in actual timing of RBF implementation between intervention health centres, the periods of data collection were not identical.

The World Bank RBF toolkit was used to guide cost data collection (Shepard, Zeng et al. 2015). Costs were defined as variable costs (those that change with service volume) or fixed costs (those that do not change with service volume). For variable costs, an ingredient approach was used to estimate unit costs (Drummond, O'Brien et al. 1997, page 67). At the health facilities, quantities of resources used for maternal and new-born care were identified and recorded. Pharmacy and inventory records were used to quantify drugs and other supplies. Unit prices were obtained from Malawi Central Medical Stores (CMS) catalogue or local retailers as appropriate (MoH 2013). Information on utilities and building maintenance were either collected at the health facilities or respective district offices, depending on where complete records were available. RBF data including on incentives, training, information and communication (IEC) materials, equipment supplies, and supervision were collected from both RBF desk officers at the health facility and/or the main office at the MoH reproductive health unit. The consumer price index was used to convert prices into 2013 constant prices while future costs were discounted at 3% (Shepard, Zeng et al. 2015).

For fixed costs (building and equipment) information on useful life years and replacements costs was obtained from MoH Planning and Policy Directorate and from national health accounts (MoH 2014). Fixed costs were annualized and discounted at 3% rate. A top-down approach was used to allocate joint or shared costs using allocation proxies (Drummond, O'Brien et al. 1997, page 64) . The proportion of maternity unit area relative to the area of all hospital units was used to allocate building costs to the maternity

unit. The share of maternity unit clients among all visits was used to apportion health worker salaries. An implicit assumption is that the resource requirements of the maternity unit are equal to the average resource requirement of all facility activities.

Information on number of deliveries staffing levels and cadres were taken from facility registers and other office documents e.g. human resource records. Costs related to administrative support from the district offices were not collected, on the assumption that they would not substantially differ between health centres. RBF personnel costs, office rentals and other overhead costs from the central office were captured by inflating all RBF costs by 38.8% so that overall RBF administrative costs would account for 28%, a figure reported as share of administrative costs for a pay for performance program in Tanzania (Borghi, Little et al. 2015). Household costs, including direct and indirect costs, associated with care seeking were based on earlier analyses (Study II). Local currency values were converted to US$ equivalents using 2013 midyear exchange rate (US$1=MK 330).

6.3.6 Outcome measures

Study III had two related outcomes: deaths averted and LYG. Thus, to assess which arm (RBF vs non-RBF) provided good value for money, incremental cost-effectiveness ratios (ICERs) were calculated in terms of cost per death averted and cost per LYG.

6.3.7 Sensitivity analyses and parameter uncertainty

The impact of each model parameter on ICERs was first explored through one-way sensitivity analyses. The mean of each parameter was varied over appropriate ranges, or in the absence of empirical estimates they were varied ± 20%, **Table 6.** The ten parameters that influenced the ICERs most were further assessed through probabilistic sensitivity analysis, after assigning them appropriate distributions. Gamma distributions were specified for costs, normal distribution for LYG, logNormal distributions for relative risks and Beta distribution for probabilities (Gray, Clarke et al. 2011, page 261). Bounds for the parameters were derived using methods of moments (Gray, Clarke et al. 2011, page 263). Parametric bootstrapping based on 5,000 iterations was conducted to propagate parameter uncertainty through the model and the results were presented as cost–effectiveness scatter

plot and acceptability curves. At any given value of willingness to pay, acceptability curves show the probability of an intervention being cost-effective relative to the comparator.

6.3.8 Model validation

The model was validated by comparing estimated baseline perinatal mortality rates with estimates from the published literature (internal validity) and by inspecting that all parameters influenced the model according to expectations (face validity).

6.4. Ethical approvals

The overall RBF4MNH impact evaluation was approved by the Ethics committee at University Heidelberg, protocol number S-256/2012. In addition, except for Study I where secondary data were used, ethical approval was sought for Studies II and III from University of Malawi, College of Medicine Research and Ethics Committee (COMREC) protocol number P.02/13/1353. Finally, verbal permission to conduct the studies was also sought from district and village authorities.

6.4.1 Informed consent

For study II, fully informed voluntary written consent was obtained from all mothers in the local language before administration of the household questionnaire. (**Appendix 2: Consent form**). The information provided related to the study objectives, procedures, potential risks and benefits. The voluntary nature of the enrolment and the right to refuse or withdraw at any time was emphasized.

The women were encouraged and given ample time to ask questions. Only after this process was completed were the women asked for written consent. In cases where the women were not able to read or write, the information was explained in the presence of a literate guardian not connected to the survey. Consent was then provided in the form of thump print.

Two copies of the signed or thumb printed consent forms were made. One was given to the participant and the other was kept in lockable cabinets by the study manager at the Malawi College of Medicine, Blantyre.

For study III, only verbal permission was sought from MoH managers given that secondary cost data was used, extracted from accounts records and inventories, and did not contain personal identifiers.

6.4.2 Ethical implications

The ethical implications of the studies mainly related to interviews of mothers (Study II). Is it fair to ask for an interview while mothers had other important chores to do like taking care of their children or preparing their crop fields? Would participating in an interview negatively affect their other work? Are their harms in asking mothers to recall previous painful experiences such as losing a child during child births? Careful considerations were given for these risks. Important steps taken to minimize these risks included training interviewers to be aware of these risks and allowing the women to stop interviews any time they felt uncomfortable. Women were also allowed to suspend interviews while attending to urgent household chores such nursing their children.

CHAPTER 7: What are the benefits of institutional deliveries when compared to home deliveries in sub-Saharan Africa?

This chapter draws on findings from study I described in section 6.1. It explores the evidence in support of institutional based-deliveries in terms of maternal and perinatal mortality risks risk reduction. Challenges in estimating benefits of institutional deliveries are discussed.

7.1 Systematic search results

A total of 1,247 study citations were identified. Of these, 615 studies were discarded after appraising their titles as they contained irrelevant information. Abstracts for the remaining 632 studies were then screened, leading to the exclusion of 617 further studies. Excluded were studies that were not population based or did not report outcomes by place of delivery (n=594), assessed risk of an exposure or focused on impact evaluation of an intervention (n=19) or were duplicate publications (n=4). Thus, only 15 studies were retrieved in full, out of which 6 studies were further removed. Five (5) prospective cohorts and one (1) retrospective cohort as the reported data for 5 studies were not sufficient to

completely fill a 2 X 2 table illustrating outcomes (death/alive) by pace of delivery (Aisien AO, Lawson JO et al. 2000, Teija Kulmala, Merimaaria Vaahtera et al. 2000, Chalumeau M, Salanave B et al. 2000 , T. O. Lawoyin, M. O. Onadeko et al. 2010, Paul Welaga, Cheryl A. Moyer et al. 2013) while 1 study (Cyril Engmann, Paul Walega et al. 2012) did not have adequate data related to place of delivery **Figure 14**.

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┌─────────────────────────────┐     ┌─────────────────────────────┐
│ 1224 Articles identified    │     │ 23 Additional articles      │
│ through electronic database │     │ identified through other    │
│ search e.g. PubMed          │     │ sources e.g. conference     │
│                             │     │ proceedings                 │
└─────────────────────────────┘     └─────────────────────────────┘
              │                                    │
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                             ▼
              ┌─────────────────────────────┐
              │ 1247 Article titles screened │        ┌──────────────────────────┐
              │ in total                    │───────▶│ 615 Articles excluded    │
              └─────────────────────────────┘        │ as titles contain        │
                             │                        │ irrelevant information   │
                             ▼                        └──────────────────────────┘
              ┌─────────────────────────────┐
              │ 632 Abstracts down          │        ┌──────────────────────────┐
              │ loaded and screened         │        │ 617 Abstracts excluded   │
              └─────────────────────────────┘───────▶│ 594 are not population-  │
                             │                        │ based studies            │
                             │                        │ 19 evaluated other       │
                             │                        │ exposure or intervention │
                             │                        │ 4 are duplicate studies  │
                             ▼                        └──────────────────────────┘
              ┌─────────────────────────────┐
              │ 15 Full-text articles       │
              │ down loaded and             │        ┌──────────────────────────┐
              │ assessed for eligibility    │        │ 6 Full-text articles     │
              └─────────────────────────────┘───────▶│ further excluded         │
                             │                        │ 5 do not have complete   │
                             │                        │ information to fill 2 X 2 │
                             ▼                        │ Table                    │
              ┌─────────────────────────────┐        │ 1 does not have adequate │
              │ 9 Articles are included in  │        │ information on place of  │
              │ meta-analysis               │        │ delivery                 │
              │ 6 report on perinatal       │        └──────────────────────────┘
              │ mortality                   │
              │ 3 report on maternal        │
              │ mortality                   │
              └─────────────────────────────┘
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Thus a total of 9 studies that met the inclusion criteria were obtained for the analysis: six (6) studies (Walraven, Mkanje et al. 1995, J. McDermott, V R. Steketee et al. 1996, Diallo AH, Meda N et al. 2010, Matendo, Engmann et al. 2011, Nankabirwa, Tumwine et al. 2011, Schmiegelow, Minja et al. 2012) reported on perinatal mortality, and the other three (3) studies (De Bernis, Dumont et al. 2000, Bouvier-Colle, Ouedraogo et al. 2001, Høj L, da Silva D et al. 2002) reported on maternal mortality. All were population based prospective cohort studies.

7.2 Quality of selected studies

Table 7 shows that the mean study quality scores (Wells, Shea et al.) for the selected studies were 10 out of 15 possible points. The most common limitations identified were the lack of randomization in group allocation and the lack of independent blind assessment of study outcomes. The nine (9) retained studies contained information on 36,772 pregnancy episodes in total. Of these 9,362 (25.5%) had information on the perinatal outcome alone. Further details on the characteristics of the studies included in the meta-analysis are provided in **Table 8.**

Table 7: Assessment of studies used in analysis of maternal and perinatal mortality against elements of good quality cohort design

Quality Items	Author Score#	Perinatal studies							Maternal studies	
		Walraven et al [245]	McDermott et al [147]	Diallo et al [69]	Nankabirwa et al [176]	Matendo et al [141]	Schmiegelow et al [213]	De Bernis et al [63]	Bouvier-Colle et al [34]	Høj et al [107]
Exposed cohort representative of community	1	Yes	Partly	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Non-exposed cohort from same community	1	Yes	Partly	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Random allocation of exposure	2	No	No	No	No	No	No	No	No	No
Exclusion of outcome of interest at start of study	1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size calculations	2	No	No	No	No	No	No	No	No	No
Adequate sample size	1	Partly	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjustment for confounding	2	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Objective outcome	2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rigour of outcome assessment	1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adequate follow up for outcomes to occur	1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Low loss to follow up of cohort	1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear
Total quality score	15	10	9	11	11	11	11	10	10	9

#: Maximum score for each quality item.

Table 8: Characteristics of studies included in the analysis of perinatal and maternal mortality by place of delivery in sub-Saharan Africa

Author (s)	Year of publication	Study Country	Study Setting	Study design	Home births (%)	Refusals (%)	Lost follow ups (%)	Sample Size	Deaths/Births (n/N) Facility	Deaths/Births (n/N) Home
Perinatal studies										
Walraven et al	1995	Tanzania	Rural	Prospective cohort	52.7	NP	3.8	447	7/202	22/225
McDermott et al	1996	Malawi	Rural	Prospective cohort	41.6	NP	4.3	4,052	131/2257	133/1609
Diallo et al	2010	Burkina Faso	Rural	Prospective cohort	64.4	1.8	<0.1	900	26/326	46/589
Nankabirwa et al	2011	Uganda	Rural	Prospective cohort	41.5	1.0	3.0	835	13/490	21/347
Matendo et al	2011	DRC*	Rural	Prospective cohort	78.3	1.0	<0.1	1,886	34/411	82/1481
Schmiegelow et al	2012	Tanzania	Rural	Prospective cohort	16.7	1.1	3.9	995	41/726	5/146
Maternal studies										
De Bernis et al	2000	Senegal	Urban	Prospective cohort	57.4	<0.1	<0.1	3,777	12/2160	4/1316
Bouvier-Colle et al	2001	West Africa**	Rural/ Urban	Prospective cohort	26.4	NP	<0.1	20,326	50/10058	5/3621
Høj et al	2002	Guinea-Bissau	Rural	Prospective cohort	75.4	NP	NP	14,257	35/2489	50/7610

*Democratic republic of Congo. **Countries included: Ivory Cost, Mala, Niger, Mauritania, Burkina Faso and Senegal. NP

7.3 The odds of perinatal mortality for home relative to facility births

The odds of perinatal mortality by place of delivery was calculated to estimate the protective effect of place of delivery. A fixed effects model showed that the pooled crude odds of perinatal mortality was significantly higher for home compared to facility delivery (OR 1.21, 95%CI: 1.02-1.46) **Figure 15**. Due to a high between-study heterogeneity I^2=73.7, the pooled effect was also estimated with a random effects model (DerSimonian R and Laird N 1986). The estimate from the more conservative random effects model gave the same mean result, but was no longer significant (OR 1.21, 95% CI: 0.79-1.84) **Figure 15**.
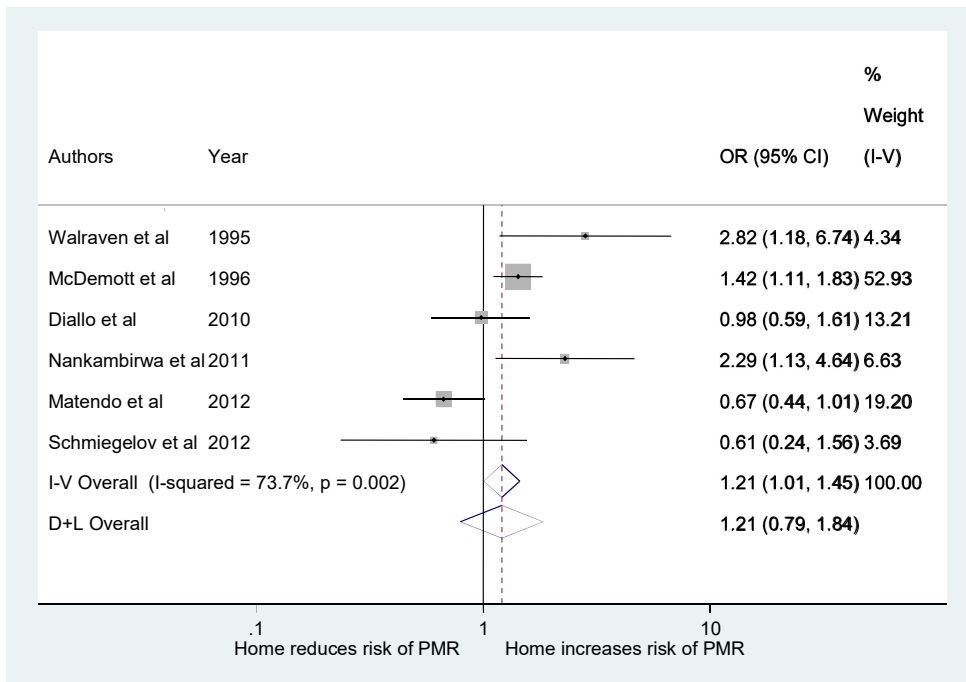

Figure 15: Pooled analysis of perinatal mortality by place of delivery in sub-Saharan Africa.

The results of the individual studies were mixed. While two studies were in favour of home delivery (Matendo, Engmann et al. 2011, Schmiegelow, Minja et al. 2012), one was neutral (Diallo AH, Meda N et al. 2010) and the remaining three were in favour of facility-based delivery (Walraven, Mkanje et al. 1995, J. McDermott, V R. Steketee et al. 1996, Nankabirwa, Tumwine et al. 2011).

Next, the actual perinatal mortality ratio (PMR) by place of delivery was estimated. **Table 9** shows that the overall weighted PMR was 63 (95% CI:54-73) per 1000 births. The PMR was 70 (95% CI: 57-86) and 56 (95% CI: 44-69) per 1000 births for home and facility-based deliveries, respectively. The attributable risk percentage reduction was 21% (95% CI:-6,40).

Table 9: Weighted perinatal and maternal mortality ratios by place of delivery in sub-Saharan Africa.

Outcomes/ place of birth	Dead	Alive	Mortality ratio (95%CI)*	Attributable Risk % (95%CI)*
Perinatal mortality			*Deaths/1000*	
Home deliveries	95	1,258	70 (57-86)	21 (-6,40)
Facility deliveries	82	1,387	56 (44-69)	
Total	**177**	**2,645**	**63 (54-73)**	
Maternal mortality			*Deaths/ 100,000*	
Home deliveries	38	6,302	599 (424-823)	N/A
Facility deliveries	35	3,668	945 (658-1315)	
Total	**73**	**9,970**	**726 (570-913)**	

7.4 The odds of maternal mortality for facility relative to home births

Figure 16 shows that the estimated pooled crude odds ratio for maternal mortality at facility compared to home settings was 2.29 (95% CI: 1.58-3.31). There was no variation in OR attributable to heterogeneity, I-squared = 0%. The increased odds for maternal mortality at facility were consistently high across all the three individual maternal studies and stable across both fixed and random effect models.
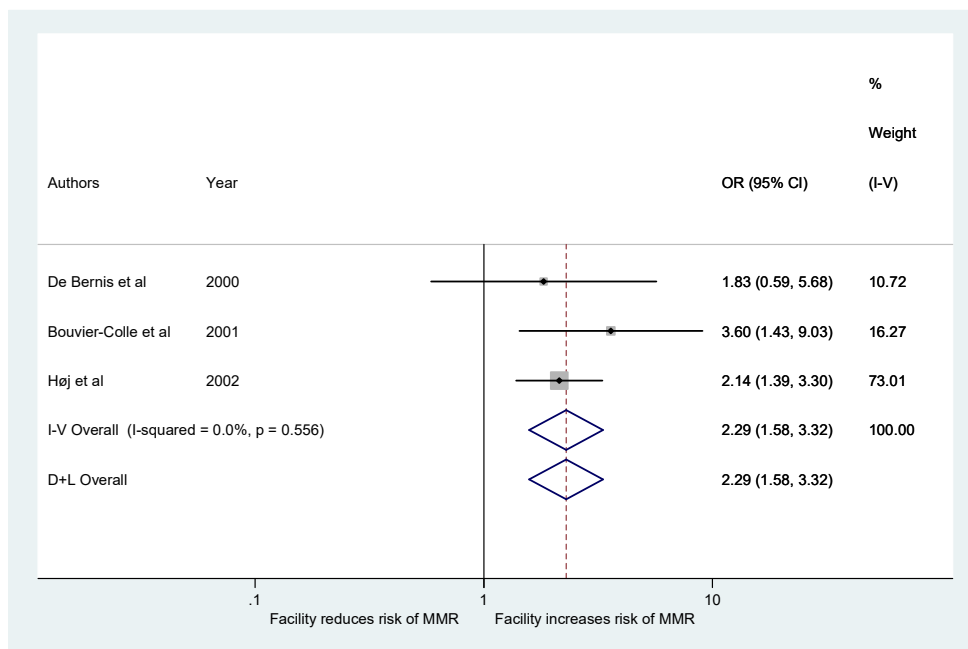
Figure 16: Pooled analysis of maternal mortality by place of delivery in sub-Saharan Africa.

The overall weighted maternal mortality ratio (MMR) was 726 (95% CI: 570-913) deaths per 100, 000 live births. The MMR was 599 (95% CI: 424-823) and 945 (95% CI: 658-1315) per 100,000 live births for home and facility deliveries, respectively **Table 9**. The high maternal mortality at facilities relative to home birth precluded estimation of attributable risk percentage reductions.

7.5 Discussion

7.5.1 Study strengths

    The strengths of study 1 are related to the deliberate decision to include studies with a homogenous design, that used standard definitions for study outcomes (perinatal and maternal mortality ratios) and that largely collected data prospectively and at regular intervals thereby minimizing recall bias and increasing validity of the outcome measures. This is in contrasts with common approaches used to estimate perinatal and maternal mortality in African countries which are based on complex statistical modeling techniques

(Stanton C, Lawn JE et al. 2006) or derived from nationally representative demographic and health surveys that use sisterhood approach methods (Lawn, Cousens et al. 2005). It has been reported that poor quality data, recall bias and selective under reporting tend to affect such estimates (Otia SO and Odimegwu C 2011).

7.5.2 Study limitations

Nonetheless, Study 1 suffers from some limitations. Because population-based cohort studies are costly, only a few have been conducted in the SSA region. Thus, despite the high quality of individual eligible studies, the pooled analysis is based on a limited number of studies. Also, subtle operational variations appeared in how the exposures were defined among the studies. For example, while home delivery in some settings meant delivery by non-trained traditional birth attendants (TBAs) (Walraven, Mkanje et al. 1995) in other settings it denoted delivery by trained TBAs (Matendo, Engmann et al. 2011). Despite the uniform study design used, such conceptual differences can lead to clinical variations and heterogeneity (Haidich 2010).

Differences in geographical, temporal, health systems and individual patient risk profiles can also affect maternal and perinatal outcomes (Scott and Ronsmans 2009) and thus confound interpretation of health outcomes by place of delivery. It is known for instance that rural areas tend to have worse perinatal and maternal health outcomes than urban areas (Ronsmans C and Graham WJ 2006). Within the SSA region, important variations in the risk of mortality exist between sub-regions (Moyer CA, Dako-Gyeke P et al. 2013). At an individual level, age, parity and existence of other co-morbidities such as hypertension can influence both maternal and perinatal outcomes (Høj L, da Silva D et al. 2002, Schmiegelow, Minja et al. 2012). The implication is that these factors need to be controlled for before making statements about the relative effectiveness of one place of delivery compared to another (Lohela TJ, Campbell OMR et al. 2012). Although this was recognized, inadequate number of studies and particularly the lack of patient level information from the available studies precluded the possibility of such adjustments through meta-regression in this review.

7.5.3 Perinatal mortality

The study found evidence for increased chance of perinatal losses following home compared to facility-based deliveries at an individual level. However, opposite conclusions can statistically be reached, significant versus non-significant results, depending on whether fixed model or random effect model assumptions are made. In a scenario where findings are statistically significant with the latter but not with the former model, it has been suggested the results should be viewed with caution (DerSimonian R and Laird N 1986, Amit X. Garg, Dan Hackam et al. 2008).

The overall weighted perinatal mortality ratio in SSA was estimated to be 63 (95% CI: 54-73) deaths per 1000 births. This figure compares well with current WHO estimates of PMR (56 per 1000 births) in the region (WHO 2007). The results imply that at best, an expected 14 perinatal deaths could be averted per 1000 births if women delivered at facility instead of home. This would represent a 21% (95% CI:-6,40) reduction in perinatal mortality risk for the home delivery group. To put this into perspective, it's worth noting that in 2012, 36.8 million births were estimated to have taken place in SSA of which 18.0 million (49%) were home deliveries (Singh S, Darroch JE et al. 2013). It can be argued that a 21% reduction in perinatal mortality risk might produce important public health improvements-in view of the high number of home deliveries in the SSA region- if a significant portion of the women who currently give birth at home could instead be motivated to deliver in health facilities.

Regional practice and policy is needed to further put these results into context. The current practice in the region encourages active or self-referral of pregnant women, especially those with high risk factors (e.g. twin pregnancy, pregnancy induced hypertension) to deliver at health facilities through health worker trainings and WHO policy (WHO 2005), This practice is reflected in some of the studies included in the analysis where special arrangements for facility referral of at risk pregnancies were made (Walraven, Mkanje et al. 1995, Schmiegelow, Minja et al. 2012). This practice introduces selection bias making the facility and home delivery groups different with respect to perinatal risk factors, the latter being on average less at risk than the former. Therefore, the

study results might represent an underestimation of PMR in the home delivery group and an overestimation for facility deliveries. The observation that perinatal mortality is on average high in the home delivery group, despite its relative low risk profile, should thus be of concern to policy makers, program implementers and health care providers in SSA.

7.5.5 Maternal mortality

Pregnant mothers delivering in facilities have a significantly higher risk of experiencing a maternal death than women delivering at home. Possible reasons that may account for this surprising result are as follows. First, in settings where access to facility-based delivery is low (<40%), women seeking care at facilities tend to be complicated cases with higher risk of mortality (McClure, Goldenburg et al. 2007, Lohela TJ, Campbell OMR et al. 2012). Given the high risk selection, high maternal deaths would be expected as already reported in the literature (Ronsmans C, Chowdhury ME et al. 2010). Only one out of the three studies reporting on maternal mortality had a low facility delivery rate (Bouvier-Colle, Ouedraogo et al. 2001). However, precluding this study from the analysis did not significantly change the results, suggesting that in this study, low facility delivery rate alone does not appear to explain the relatively high risk of mortality observed for facility-based deliveries.

Second, and related to the risk selection, the study by Høj et al shows a progressive increase in risk of maternal mortality from health centre to hospital compared to home: (OR 1.49,95% CI: 0.73-2.76) and (OR 2.72, 95% CI:1.64-4.38), respectively (Høj L, da Silva D et al. 2002). This suggests the existence of a differential in terms of the complexity of case mix by level of care. Bouvier-Colle and others argue that such a differential can be interpreted as an indication that referral for facility-based delivery is actually working with secondary or tertiary referral facilities treating women with more complex conditions (Bouvier-Colle, Ouedraogo et al. 2001), although probably the timeliness of care is not optimal to make a difference (Scott and Ronsmans 2009).

Thirdly, it's worth noting that facility-based delivery as a strategy to reduce maternal mortality does not simply entail delivery at a health facility, but also having access

to an enabling environment including availability of health workers with midwifery training, diagnostic tools, appropriate drug supplies and access to blood bank for effective care. In this regard, high risk of maternal mortality at facility may therefore reflect lack of requisite capacity for facilities to offer quality care to high-risk women (Blum LS, Sharmin T et al. 2006). There is empirical evidence supporting the premise that poor quality of care at health facilities is likely to explain a significant portion of the observed high risk of facility-based maternal deaths. A large study in the region has shown that most maternal deaths occurring at facilities are among women who receive substandard care (Bouvier-Colle, Ouedraogo et al. 2001) while another has reported that not all facilities-based deliveries are attended by health workers with midwifery training due to unfilled vacancies and staff absenteeism (Mueller DH, Lungu D et al. 2011). Fourthly, the possibility that mothers might be harmed at facilities due for example to poor infection control or other human errors cannot be ruled out (Lohela TJ, Campbell OMR et al. 2012), although hard evidence is lacking.

7.6 Conclusions

Maternal deaths are relatively rare events posing challenges when estimating a maternal mortality ratio (Graham WJ, Filippi VGA et al. 1996). The observed high risk of maternal death at facilities makes it problematic to use this outcome measure to assess the potential impact of interventions that promote facility-based deliveries. Approaches that assess impact of interventions aimed at increasing facility-based deliveries in relation to reductions in morbidity, not just mortality, would be more appropriate. Studies of maternal illness such as severe maternal complications, which occur in far greater numbers than maternal deaths, may instead allow for robust quantification and evaluation of interventions that promote facility-based deliveries and have been suggested as alternatives to assessment of maternal mortality (Adeoye, Onayade et al. 2013).

Put together, our results appear to suggest that as a strategy to reduce maternal and perinatal mortality, facility-based delivery is more likely to reduce perinatal than maternal mortality. Current evidence of poor quality of care and high risk of maternal mortality at

facilities emphasis the need for quality improvement efforts to precede activities aimed at increasing demand for facility-based deliveries in the SSA region (Maine D and Rosenfield A 1999).

Evaluating the impact of facility-based delivery strategy on maternal and perinatal mortality using population-based studies is complicated by selection bias in favour of women that deliver at facilities and poor control of confounders. Studies that pool data at an individual level may allow for better control of confounding/risk modifying factors and provide better estimates of relative safety of places of delivery in the region. Future studies should focus on assessing the relative contribution of poor quality and delayed care seeking on facility based maternal and perinatal deaths to better prioritize resources and align interventions efforts.

CHAPTER 8: What are the effects of RBF on time to seek care for pregnancy related complications and household costs associated with such care seeking?

This chapter draws on findings from study II described in section 6.2. The chapter describes the effects RBF has on expected time to seek care for women experiencing pregnancy related complications and the associated household costs. Other factors that may independently influence time to seek care and household costs are also discussed.

8.1 Social-demographic features of household surveys participants

A total of 5,622 women were surveyed across the three time points: baseline (2013), midline (2014) and endline (2015). **Table 10** illustrates the social-demographic features and care seeking patterns for the 2,219 (39.4%) women who reported a complication stratified by the year of survey and group (RBF or non-RBF). Of these, 1,716 (30.5%) sought care, out of which 691(12.2%) were treated as in-patients. Across the sample, the mean age ranged from 24.8 to 26.0, most of the women (66.7-75.0%) had given birth more than twice and most (55.5-66.4%) had completed primary school education.

Compared to the RBF group at endline, there were significantly fewer married women (82.3 vs 89.1%) but more women heading households (13.6 vs 6.2%) in the non-RBF group. Although there was suggestive evidence that care seeking for reported complications was low among women in non-RBF group at baseline and midline, these differences were not statistically significant. In both RBF and non-RBF facilities, care seeking decreased substantially between baseline and endline.

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Table 10: Socio-demographic characteristics and care seeking for women with self-reported complications, by group and survey year

	Baseline, 2013			Midline, 2014			Endline, 2015		
	Non-RBF N=290	RBF N=444	P value	Non-RBF N=298	RBF N=351	P value	Non-RBF N=198	RBF N=638	P value
Age (mean)	25.6(24.9-26.4)	26.0(25.4-26.7)	0.4	25.0(24.3-25.7)	25.3(24.6-25.9)	0.606	25.1(24.2-25.9)	24.8(24.3-25.3)	0.591
Parity≥2 (%)	75.5(70.2-80.1)	74.0(69.8-77.9)	0.666	68.4(62.9-73.5)	68.3(63.2-73.0)	0.983	68.6(61.8-74.8)	66.7(63.0-70.3)	0.616
Married (%)	86.2(81.7-89.7)	85.1(81.4-88.1)	0.686	87.9(83.6-91.1)	86.3(82.2-89.5)	0.546	82.3(76.3-87.0)	89.1(86.5-91.3)	0.011
H.Household[a](%)	07.5(5.03-11.2)	05.8(04.0-08.4)	0.354	10.4(07.3-14.4)	09.6(06.9-13.2)	0.762	13.6(09.4-19.2)	06.2(04.6-08.4)	0.001
Educated (%)	55.8(50.0-61.5)	56.7(52.0-61.3)	0.811	66.4(60.8-71.6)	60.9(55.7-65.9)	0.149	60.1(53.0-66.7)	66.4(62.6-70.0)	0.101
Residence (%)	0.3(0-2.4)	23.6(19.9-27.4)	0	0(0)	16.8(13.2-21.1)	0	0(0)	23.9(20.8-27.4)	0
Distance (mean)	05.2(04.8-05.5)	05.6(05.3-06.0)	0.072	05.5(05.2-05.9)	05.5(05.1-05.9)	0.9	05.1(04.7-05.5)	05.3(05.0-05.6)	0.507
SES[b,c](%)									
Poor	34.8(29.5-40.5)	31.5(23.7-36.0)		37.9(32.5-43.5)	29.9(25.3-34.9)		40.4(33.7-47.4)	29.1(25.7-32.8)	
Middle	34.1(28.8-39.8)	30.1(26.0-34.6)		32.8(27.7-38.4)	35.3(30.4-40.4)		29.7(23.7-36.5)	32.9(29.3-36.6)	
Least poor	31.0(25.9-36.6)	38.2(33.8-42.9)	0.132	29.1(24.2-34.6)	34.7(29.9-39.9)	0.086	29.7(23.7-36.5)	37.9(34.2-41.7)	0.01
Sought care (%)	78.2(73.1-82.6)	83.7(80.0-86.9)	0.06	80.2(75.2-84.3)	85.4(81.3-88.7)	0.075	67.1(60.2-73.4)	69.7(66.0-73.1)	0.493
Admitted (%)	44.1(38.4-49.9)	43.4(38.9-48.1)	0.858	24.4(19.9-29.7)	29.9(25.3-34.9)	0.123	21.2(16.0-27.5)	23.5(20.3-26.9)	0.502

[a]H.Household=Heads Household
[b]Social Economic Status
[c]Figures may not add up 100 due to rounding

8.2 Household costs associated with pregnancy related complications care

Table 11 shows that women reporting a complication incurred similar mean costs at baseline and midline. Mann-Whitney test showed that the median costs were not significantly different between the women in RBF and non-RBF groups across the surveys, although the mean costs were high for the women in the RBF group at endline. The total costs incurred by women who received in-patient care across the surveys are shown in Table 12, stratified by facility type within each group as resource use may differ by level of health facility. Women admitted for in-patient care at BEmOC facilities had higher mean costs than women admitted for care at CEmOC health facilities. There was no significant difference in the median costs incurred by the women between the two groups. As a percentage of total costs, transport/other costs (i.e. food and accommodation) and productivity losses separately accounted for nearly 50% of all costs for both RBF and non-RBF groups, while medical costs accounted for a much smaller percentage.

Table 11: Summary of costs (USD)[a] of care in women with self-reported complication, by group and survey year.

	Baseline 2013			Midline 2014			Endline 2015		
	Non-RBF	RBF	P value[b]	Non-RBF	RBF	P value[b]	Non-RBF	RBF	P value[b]
	N=227	N=372		N=239	N=300		N=133	N=445	
Mean	6.69	6.19		5.22	5.59		6.34	7.51	
SD[c]	12.01	12.62		25.15	15.31		18.71	22.99	
Median	1.76	1.02	0.382	0.73	0.73	0.544	0.46	1.05	0.429

[a]Exchange rate mid-year 2015, 1 US$=550 Malawi Kwacha (MK)
[b]P values estimated using Mann-Whitney test.
[c]SD Standard deviation

90

Table 12: Summary of household costs for women admitted for complication care, by cost-categories and group

	Non-RBF				RBF			
	BEmOC N=222	CEmOC N=21	Overall N=243	%	BEmOC N=247	CEmOC N=201	Overall N=448	%
Medical costs (US$)[a]				*6.9*				*2.5*
Mean	0.91	1.34	0.95		0.58	0.15	0.38	
SD[b]	3.09	5.21	3.32		2.42	1.5	2.06	
Median	0	0	0		0	0	0	
Transport & other[c](US$)[a]				*48.7*				*49.7*
Mean	7.16	1.48	6.67		7.09	8.07	7.53	
SD[b]	23.2	1.93	22.23		13.49	26.05	20.1	
Median	1.82	0.97	1.82		2.37	1.54	2.21	
Productivity costs(US$)[a]				*44.2*				*47.7*
Mean	5.81	8.65	6.05		7.97	6.34	7.24	
SD[b]	10.44	10.49	10.46		16.11	11.19	14.13	
Median	3.1	4.63	3.19		3.81	2.61	3.04	
Total costs(US$)[a,d]	3,083.23	240.97	3,324.20	*100*	3,861.11	2,927.27	6,788.39	*100*
Mean	**13.89**	**11.47**	**13.68**		**15.63**	**14.56**	**15.15**	
SD[b]	**30.29**	**11.85**	**29.15**		**21.29**	**31.44**	**26.31**	
Median	**7.73**	**7.44**	**7.71**		**8.50**	**6.40**	**7.34**	

[a]*Exchange rate mid-year 2015,1 US$=550 Malawi Kwacha (MK)*
[b]*SD Standard deviation*
[c]*Includes food and accommodation*
[d]*No statistical differences in medians for total costs between intervention and control groups, P= 0.729. Mann-Whitney te*

8.3 Effects of RBF on household costs associated with pregnancy related complications care.

Regression analysis showed that the expected mean costs for obstetric complications were not significantly different between women who received RBF and those who did not, at both midline (1 year after RBF implement nation) and endline (2 years after RBF implementation). This was the case both for all women seeking complication care (the full model) and when only women who ended up admitted for in-patient care were included (restricted model) **Table 13**. The full model showed significant negative associations between costs and parity, women heading households, registration for CCTs and being middle poor. It also showed significant evidence of positive association between cost and increasing number of in facility days and between costs and in-patient care, the proxy for complication severity. The expected mean costs increased by 7.8% (95% CI:6.1-9.6) for each additional day in a facility and was 945.4% (95%CI: 843.7-1,058.8) greater for women who received in-patient care compared to those who did not. In the restricted model associations were similar, except that heading household and being middle poor status were no longer significantly negatively associated with costs, while residence in urban areas was.

Table 13: Effects of RBF on household costs, adjusted for covariates

	Full costs model: N =1,716			Restricted costs model: N=691		
	Coef[a]	*95% CI*[b]		Coef[a]	*95% CI*[b]	
Year1*RBF	-.047	-.414	.319	-.018	-.718	.680
Year2* RBF	.270	-.221	.762	.431	-.358	1.221
Age	.001	-.004	.007	.014	-.008	.036
Parity	-.073	-.127	-.019	-.206	-.218	-.194
Married	-.085	-.312	.140	-.129	-.314	.055
Heads Household	-.106	-.172	-.041	-.327	-.672	.017
Educated	.049	-.129	.227	.181	-.071	.434
Residence	-.263	-.583	.056	-.467	-.882	-.051
Distance	-.001	-.017	.013	-.003	-.010	.002
Facility	.066	-.152	.286	.018	-.119	.156
Registered	-.203	-.318	-.087	-.501	-.818	-.183
Days	.075	.059	.092	.069	.061	.078
In-patient	2.34	2.244	2.450			
SES						
Middle	-.063	-.112	-.015	-.220	-.590	.148
Least poor	-.006	-.194	.182	-.109	-.815	.596
Constant	6.220	5.805	6.635	8.178	7.708	8.648

[a]Coefficient[b]95% Confidence interval

8.4 Time to seek care for pregnancy related complications

Table 14 illustrates that at baseline and midline, the median duration to seek care was not statistically different for women with self-reported complications between the RBF and non-RBF group. However, women in the RBF group took significantly less median duration (2 vs 5 days, p=0.025) presenting for care at endline.

Table 14: Time to seek care in days among women with reported obstetric complications, by group and survey year

| | Baseline, 2013 | | | Midline, 2014 | | | Endline, 2015 | | |
	Control N=227	Intervention N=372	P value	Control N=239	Intervention N=300	P value	Control N=133	Intervention N=445	P value
Mean	2.2	3.1		4.5	4.6		5.9	5.5	
SD	5.3	9.1		9.0	7.5		6.1	8.4	
Median	0	0	0.294	1.0	1.9	0.122	5.0	2.0	0.025

*P values estimated using Mann-Whitney test.

8.5 Effect of RBF on time to seek pregnancy related complications care.

Regression analysis showed that the expected mean time taken to seek complications care was significantly lower for women who benefited from RBF compared to women who did not. This was the case both for all women seeking care for reported complications (the full model) and when only women admitted for care were included (restricted model). In both models, the estimated effects were much stronger in the second year of program implementation **Table 15**. In the full model, women in the RBF group in year 1 took 27.3% (95% CI:28.4-25.9) less while in Year 2 they took 34.2% (95%CI: 37.8-30.4) less time to seek care compared to women in non-RBF group. In the full model, time was significantly positively associated with increasing age, being married and registration for CCT whereas parity, education and in-patient care (disease severity) were significantly negatively associated with time. Women who ended up admitted for in-patient care took significantly less time to present for care,63.7%(95%CI: 73.9-49.5), than women with reported complications but who were not admitted for care. The decision to admit women was based on clinical assessments and largely based on complication severity. This finding therefore means that women who experienced severe complications in the intervention group on average took much less time to present for care.

In the restricted time model, being married was the only attribute significantly positively associated with time, while age, education, distance and middle poor were significantly negatively associated with time.

Table 15: Effects of RBF on time to care (days) for obstetric complications, adjusted for covariates

	Full Time Model: N=1, 716			Restricted Time Model: N=691		
	Coef.[a]	95% CI[b]		Coef.[a]	95% CI[b]	
Year1* RBF	-.318	-.335	-.300	-.458	-.568	-.348
Year2* RBF	-.419	-.476	-.363	-.835	-1.084	-.585
Age	.010	.004	.015	-.016	-.024	-.009
Parity	-.083	-.102	-.064	-.293	-.341	-.245
Married	.135	.038	.233	.697	.468	.926
Heads Household	.101	-.057	.260	.325	-.196	.848
Educated	-.200	-.295	-.104	-.602	-.829	-.374
Residence	.170	-.030	.370	-.392	-.886	.102
Distance	.013	-.014	.040	-.016	-.028	-.005
Facility	-.057	-.224	.109	.391	-.150	.933
Registered	.166	.101	.231	.397	-.136	.931
In.patient	-1.014	-1.344	-.684			
SES						
Middle	.044	-.142	.231	-.289	-.457	-.121
Least poor	.065	-.004	.136	-.140	-.497	.215
Constant	.906	.770	1.041	.135	.020	.250

[a]Coefficient
[b]95% Confidence interval

8.6 Study limitation

This study has several limitations which merit discussions as they may affect how the results are interpreted. The limitations mainly relate to study design, outcome measurements and intervention implementation.

8.6.1 Study design limitations

Randomized controlled trials (RCT) are the 'gold standard' when the purpose of a study is to generate convincing evidence on the effect of an intervention (Rychetnik, Frommer et al. 2002). However, for practical reasons, public health interventions like RBF can rarely be studied using RCT designs. In this case, a pre-post design with controls was used. While this design has the advantage of temporally being able to suggest that the

outcome of interest is influenced by the intervention, this design does not have control over unobservable or omitted variables that may also be changing at the same time the intervention is implemented (Thiese 2014), making it challenging to fully attribute observed changes in outcomes to the intervention. In this study, selection of variables to include in the models was based on the literature and to control for omitted variables, as many covariates as were available from the datasets were included. Still, it is plausible that other potential covariates were not included, which may have biased the results.

A key identifying assumption in econometric analysis aimed at assessing intervention effects is that of parallel trends. That is, the average change in the control groups represents the counterfactual or change in intervention groups in the absence of treatment. While the difference-in-differences method appears preferred for analysis of RBF impact (see for example (Bonfrer, Soeters et al. 2013, Binyaruka, Patouillard et al. 2015)), it was deemed not suitable in this study because the dependent variables were very skewed. If more than one data points were available before the intervention, it would have been possible to verify this assumption empirically. In the absence of such data points, the estimating specification for both dependent variables (time and costs) included time trend differentials (year dummy variables) between the control and intervention groups at least to control for yearly trends.

8.6.2 Outcomes measurement limitations

Pregnancy complications were self-reported. Although attempts were made to verify the diagnosis by checking formal diagnosis in the health passports or discharge slips, this was not possible for the majority of women (about 60%). If these women had minor ailments, that would bias the cost estimates downwards and the time estimates upwards, on the assumption that household may not seek care early if they perceive a condition minor or not urgent.

Not all women sought care for their self-reported complications. The women who did not seek care could thus bias the results, if the selection into care was different in areas with and without RBF. Since the intervention did not produce significant effects on overall

service use between the RBF and non-RBF across the survey years, a large selection bias should not be anticipated.

Because the information from the study participants was collected retrospectively, recall bias resulting in time-varying deferential reporting of study outcomes may have affected the results. Although this could have affected any of the variables e.g. complications service use or type, this would especially be relevant for the dependent variable, cost, given reported problems for respondents to remember expenditures and incomes when the reference period is too long (up to 12 months in this case) or if the expenditures are not disaggregated enough. Less disaggregated expenditures tend to underestimate expenditures(Beegle, De Weerdt et al. 2010). As a four-week recall is often used in cost studies (Deaton and Kozel 2005), we compared costs/ time estimates reported within 4 weeks of termination of pregnancy with those reported after 4 weeks as validation checks and to assess size of bias, if any. We made these comparisons between the two groups, before and after the implementation of RBF. The results (not shown) demonstrated no influence of recall bias on time estimates (the null hypothesis that time estimates between the two time periods were not different could not be rejected) but suggested recall bias may have affected cost estimates in the post RBF period (costs estimates tended to be higher within 4 weeks period for both RBF and non-RBF group when compared to the period after 4 weeks).

Finally, the study may have suffered from social disability bias (Grimm 2010). The women in study areas for example may have over reported expenditures hoping the program would offer higher financial rewards.

8.6.3 Intervention implementation

In the dicussions above, fidelity of the evaluation process to detect the success or failure of the RBF intervenion to effect changes in outomes of interest was considered. In this section, the intervention itself is considred, based on the premise that the success or failure of the intervention implimentation can also have impact on outcomes of interest.

The operation definition of exposure in the study was receipt of PBF and CCT. As noted in section 4.6, programtic challenges entailed that the two components were staggered, wth the CCT component only becoming fully functional towards the end of 2014. The implication is that there was heterogeneity in exposure for the women in intevention areas. In an attempt to ascertain the separate effects of CCT, a dummy variable equal to 1 if women were registered for CCT and 0 otherwise was created and included in the GLM regressions. Because the CCT group was a subset of the intervention group, there was concern this may have induced collinearity problems. Routine diagnostics however showed collinearity not to be a severe problem.

8.7 Discussion

This study increases our knowledge on RBF since it is the first to describe costs and time to seek care for reported obstetric complications within the context of RBF. RBF substantially reduced time to seek care for women experiencing a pregnancy related complication, while RBF did not produce any substantial effect on related household costs.

8.7.1 Costs of obstetric complications care

RBF did not have any substantial effect on household costs among women with reported pregnancy related complications. In settings like Malawi where MNH services are free, it may be difficult for RBF to produce a significant effect on household costs related to seeking care when both direct and indirect costs are considered together. The finding that indirect costs were significantly lower for households that benefitted from CCT indicates that RBF has potential to reduce overall economic burden on the households,

Overall, relative percentages for different cost sub-categories were similar between women in RBF- and non-RBF areas. The results are consistent with findings by McIntyre et al (McIntyre, Thiede et al. 2006), showing that other direct costs (e.g. transports, food) and indirect costs are substantially higher than medical costs alone, which is not surprising given that Malawi does not impose formal user fees. The finding on reduced expected mean costs and substantially reduced informal caregiver engagement (results not shown) among women receiving CCT are suggestive of the potential for cash receipts to substitute for

informal caregivers' time or support. The few informal caregivers per case among beneficiary households allow them to minimise productivity losses sufficiently to lower overall household costs.

8.7.2 Time to seek obstetric complication care

The mean time to seek care for obstetric complications was significantly lower for women exposed to RBF intervention. This effect was stronger in the longer rather than shorter term. This finding is similar to that published by Nahar et al (Nahar, Banu et al. 2011) in Bangladesh showing that financial reimbursements were associated with reduced delays in seeking emergency obstetric care, though this work was not done within a formal RBF context.

Several possible explanations may underlie the observed reduction in time to seek care in the study setting. Supply side improvements in quality of care may have occurred in RBF facilities, inclining household decision making towards early care seeking. The promise of transport refunds may have emboldened beneficiaries to increase fiscal expenditure thresholds, allowing them to use relatively expensive, but quick modes of transport, to get to facilities. Alternatively, the prompt care seeking noted in RBF areas could have been part of a response to broader health education/promotion efforts in the areas informing women about obstetric dangers signs and encouraging them to seek formal care early, or a more functional referral system may have existed in intervention areas. Below, each of these plausible explanations is examined in turn.

First, there is consensus that quality health services attract women to formal care (Andaleeb 2001, Brighton, D'Arcy et al. 2013, Srivastava, Avan et al. 2015). Parallel project evaluations provided evidence of attendant improvements in structural quality for RBF facilities as a result of equipment and other supplies provided as part of RBF4MNH to strengthen facility capacities (Brenner, Wilhelm et al. 2017). Because the majority of women in the RBF areas at least attend one antenatal care visit (Mazalale, Kambala et al. 2015), it is probable that engagement with better antenatal care services during preceding visit(s) may have "primed" the women's perceptions regarding improved quality of care

at intervention facilities, leading to subsequent prompt care seeking in times of potential obstetric emergencies.

Second, guarantees of transport refunds could have empowered potential beneficiaries to use their fiscal resources to pay for motorized modes of transport. Alternatively, guarantees of cash refunds could have reduced perceived financial constraints allowing household to take immediate decisions to seek emergency obstetric care. Regarding the former, study data does not support this assertion as the percentage of households that used any motorized form of transport (e.g. cars) did not significantly differ between RBF and non-RBF areas (results not shown). Women registered for CCT had significantly higher expected mean time to seek care, which does not support our premise that perceptions of fiscal empowerment may have promoted prompt decision making.

Third, health education is an integral part of RH services provided to antenatal women. Centrally planned and coordinated, standardized reproductive health education is evenly provided across all facilities in a district. Although local non-governmental organizations are increasingly taking part and supporting DHMT in health promotion activities in the study districts, there is no evidence that intervention areas received any special intensive health promotion activities. In fact, the data shows that care seeking patterns were not different between RBF and non-RBF groups **Table 10**. Fourth, even though referral systems were not explicitly incentivised, there is a possibility that (presumably) motivated health providers in intervention BEmOC facilities could have coordinated better with CEmOC facilities to arrange transport for the women with complications, for those referred from BEmOC to CEmOC facilities. There is evidence that differential transport arrangements existed between intervention and control facilities, but this was in favour of referrals from control BEmOC (Brenner S and De Allegri M 2015).

Ruling out these alternatives, I conclude that the significantly reduced time to seek care observed in intervention areas most likely resulted from prompt decision making at household level due to perceptions of facility quality improvement, while community level delays appear to be less important.

From a policy perspective, it is important that women with higher risk profiles for obstetric complications (e.g. high parity or the poor) present for curative care early. It is therefore worth exploring how responsive women with different risk attributes were to RBF. I found that high parity, education, increasing distance and medium poor status were associated with significantly lesser expected mean time to seek care. The experience that comes with more births (high parity) and information associated with high education allows women to make better decisions as might be expected. That the medium poor respond faster than the poor reiterates the usual disadvantage faced by the poor while underscoring the need to formulate interventions that explicitly target the poor

It is a fair question to ask what influence different components of RBF4MNH had on primary study outcomes. The observed short-term effects give an estimate of what to expect if only supply-side incentives were in place; a significantly reduced mean time to care but no substantial change in overall household costs. Unfortunately, estimating with certainty any additional effects accruing from a combination of supply and demand-side incentives is not possible in our study given the low coverage (25%) for demand-side incentives. Because this would be valuable information for policy makers, studies based on optimally designed and implemented RBF programs that allow for such detailed evaluations are needed. Information on relative effectiveness of RBF components will provide more policy options: enabling better configuration of financial incentive structures to align with local health priorities and health systems capacities.

8.8 Conclusion

The most important finding of this study is the significant reduction in the expected mean time taken before presenting for obstetric complication care by recipients of RBF. This occurred despite the lack of a substantial change in overall household costs. This result is probably a manifestation of the RBF induced quality improvements which encourage women to seek early care for pregnancy related complications. These results provide insight regarding possible mechanisms through which RBF may contribute to prompt

emergency care seeking and thus ultimately reduce maternal morbidity and mortality in beneficiary populations.

CHAPTER 9: What is the cost-effectiveness of RBF?

This chapter draws on findings from study III described in section 6.3. The chapter provides cost-effectiveness estimates for the Malawi RBF (PBF+CCT) initiative in terms of cost per death averted and life years gained when compared to input based funded maternal care. Key factors influencing RBF cost-effectiveness estimates are also described.

9.1 Costs of RBF

The estimated annual operational cost for an RBF facility was $53,774, about four times the costs for a non-RBF facility. The extra costs were largely RBF related, driven by new medical equipment investments, financial rewards and program monitoring. But, RBF facilities were also large in terms of catchment areas size and staffing levels. RBF facilities also had higher non-RBF related budget lines e.g. salaries **Table 16**. A health worker in RBF facility received $420 annually as rewards, an amount that varied by health worker cadre. The professionals, e.g. nurse-midwives received almost three times as much rewards compared to non-professionals such as community health workers. Eligible mothers received $6 on average, over 50% of which was for reimbursing costs directly linked to institutional delivery **Table 17**.

Table 16: Facility characteristics and provider economic costs (US$)

	RBF	non-RBF
Number of sampled Facilities	2	2
Catchment area population/ facility	23 494	41 124
Number of deliveries/ facility/ year	1 212	1 506
Number of Health workers per facility	30	26
Professionals e.g. Nurses per facility	5	4
Fixed costs per year/facility		
Building rentals	2 861	2 700
Office furniture	240	232
Salaries	9 339	6 281
MoH[a] Medical Equipment	1 977	1 367
RBF renovations/maternal shelters	8 894	
RBF Medical equipment	2 306	
RBF Training & Capacity building	2 454	
Subtotal fixed costs	*28 071*	*10 579*
Variable costs per year/ facility		
Supplies	1 027	579
Drugs	1 914	1 571
Utilities & maintenance	1 436	675
Transport	474	687
RBF IEC[b]	266	
RBF Supervision	2 829	
RBF Health worker incentives	12 577	
RBF Mother incentives	5 181	
Subtotal variable costs	*25 703*	*3 511*
Grand total	**53 774**	**14 090**

[a]MoH-Ministry of Health   [b]IEC-Information, education and communication.

Source: Author calculations

Table 17: RBF related incentives (US$)

RBF Incentive per HW/ year	**420.99**
For professionals, e.g. nurse/ year	576,07
Others e.g. Community health worker/ year	197,9
RBF incentive per eligible woman	**5,77**
Transport	0,55
Delivery	3,00
48 Hour stay	2,21

RBF- Results-based financing.   HW: Health worker
Source: Author calculations

9.2 Cost-effectiveness of RBF relative to non-RBF

The model estimated that compared to non-RBF, each additional birth costs $42.83. Taking both maternal and perinatal deaths into account, RBF would avert one additional death and gain one additional life year at an incremental cost of $29,135 and $1,045 respectively, **Table 18.**

Table 18: Incremental cost effectiveness ratios of RBF compared to non-RBF, by outcomes

	RBF		non-RBF				
	Mean		Mean		Incremental		
Outcome	Costs ($)	Effects	Costs ($)	Effects	Costs ($)	Effects	ICER ($)[a]
Deaths	55.55	0.055	12.72	0.057	42.83	0.0015	**29,135**
LYG[b]	55.55	51.343	12.72	51.302	42.83	0.0410	**1,045**

[a] Incremental cost effectiveness ratio, estimates by TreaAge software, [b] Life years gained (discounted).

9.2.1 One-way sensitivity analysis

The ICERs for any life year gained were sensitive to changes in coverage of RBF facility-based births and the share of women accessing quality care (effective coverage) in non-RBF facilities **Figure 17**. For example, a 10% change in RBF facility births or births in non-RBF facilities with quality care would lead to a 25% and 30% change in ICER, respectively. The ICERs were not sensitive to any other parameters. The ten parameters

with most relative influence on RBF cost-effectiveness are shown in **Figure 17**.
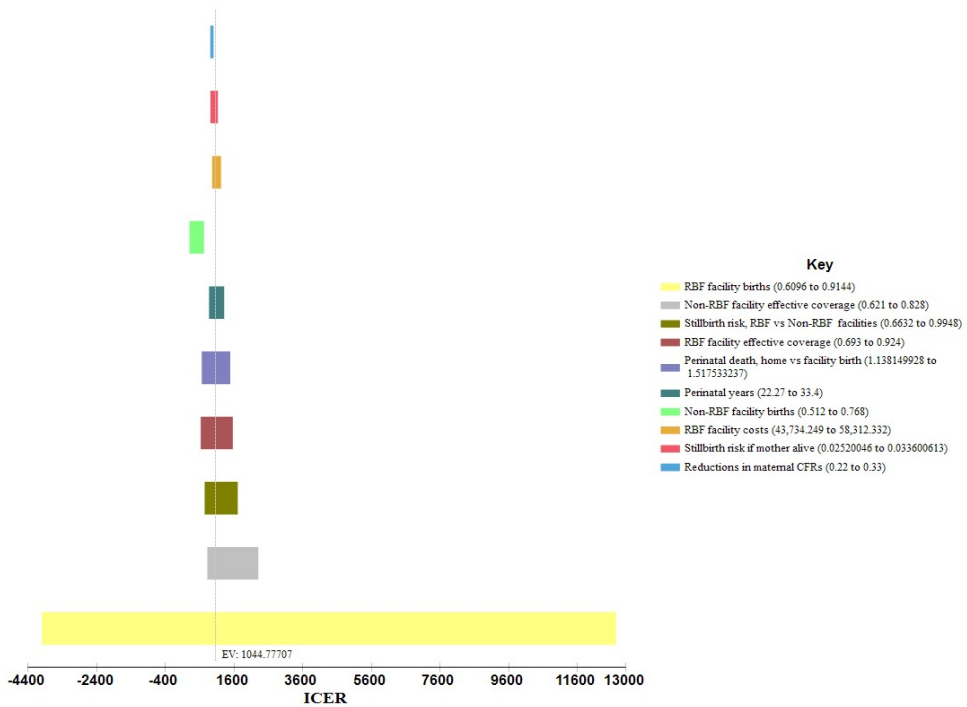

Figure 17: One-way sensitivity analysis showing variations in incremental cost-effectiveness ratios per life year gained.

RBF-Results based financing. EmOC-Emergency obstetric care. CFRs-Case fatality rates.

9.2.2 Probabilistic sensitivity analyses

The ICER scatter plot illustrates that all iterations of LYG in the RBF relative to non-RBF arm consistently have positive costs, reflecting higher relative RBF costs with certainty. However, some iterations have less (negative) LYG relative to non-RBF, suggesting that the probability of overall lower health effects in the RBF arm relative to non-RBF cannot be completely ruled out **Figure 18.**
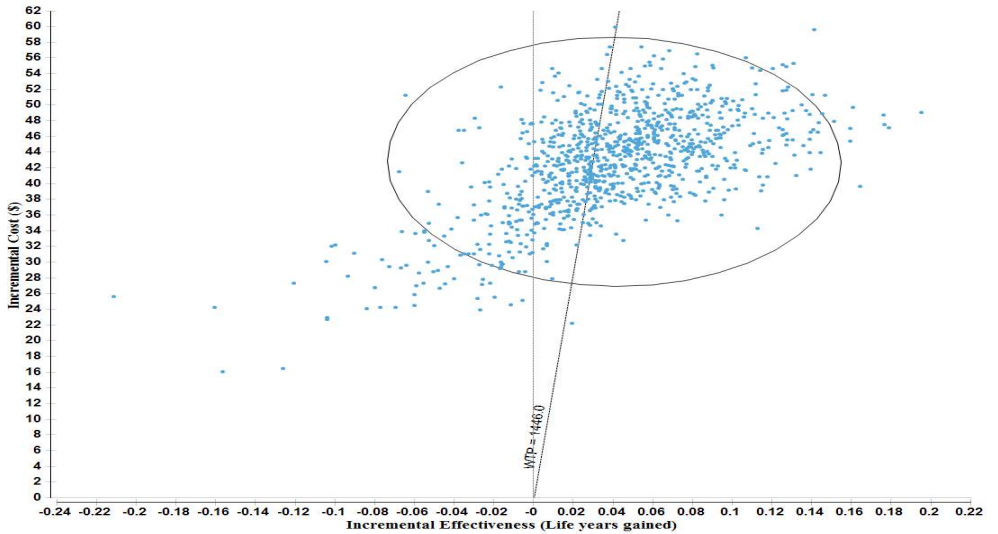
Figure 18: Incremental cost-effectiveness scatter plot for RBF relative to non-RBF

The probabilities that RBF is cost-effective compared to non-RBF at different levels of willingness to pay are shown in **Figure 19**. At a willingness to pay of $1000 per life year gained, RBF and non-RBF have equal probabilities of being cost-effective. With lower willingness to pay for health, non-RBF is most likely to be optimal, while for higher levels of willingness to pay RBF represents the policy most likely to be optimal. At willingness to pay of $1,146, RBF has a 60% probability of being the most cost-effective alternative.
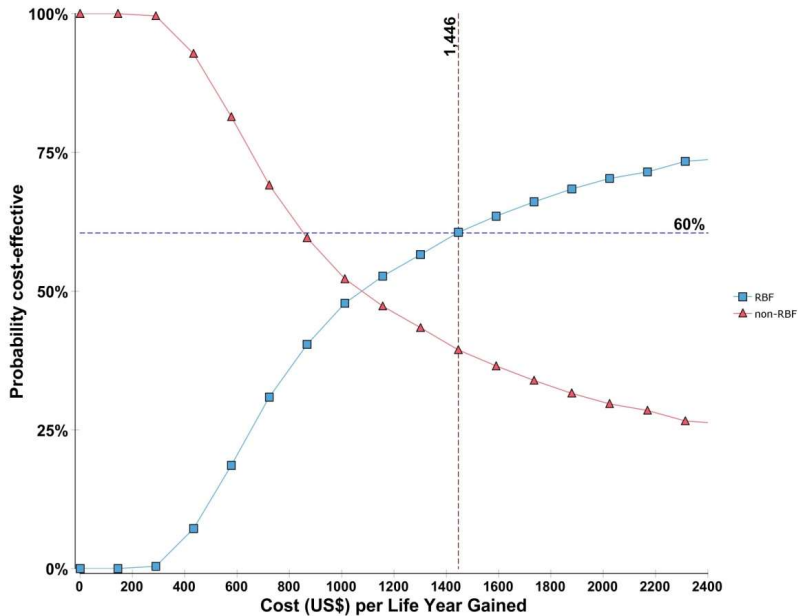
Figure 19: Cost-effectiveness acceptability curves for RBF compared to non-RBF funding option

9.3 Model validation

MacCabe and Dixon have proposed four dimensions for assessing validity of cost-effectiveness models: (i) the structure of the model (ii) the inputs of the model (iii) the results of the model and (iv) the value of the model to the decision maker (McCabe and Dixon 2000). They raise doubt if a set of objective tests of validity will ever be produced. The model was validated based on its results, which arguably is objective. The model estimates a perinatal mortality rate of 49/1,000 births in the baseline scenario, which is very comparable to 56/1,000 births reported for the SSA region and the 40/1,000 births estimate for Malawi (National Statistical Office 2010).

Model structure and key inputs to the model are discussed below under limitations while the value of the model to decision makers is discussed under section 9.5.

9.4 Study limitations.

This study has several limitations. They include model input parameters, data collection and methodology or frameworks used.

9.4.1 Input for effectiveness

The parameter estimates of RBF "effects" on stillbirth and maternal case fatality rates were based on program evaluations results from Zambia and Uganda due to lack of randomized trial data. Pre-post program evaluations do not have the rigor of clinic trials about bias control or minimization. The implication is that one cannot be fully certain of how biased the "effects" estimates used for the study are or, ultimately, the actual impact RBF has on perinatal and maternal mortality. It's worth noting that new program like the one in Zambia and Uganda tend to be closely supervised. Thus, intense monitoring and supervision under program settings may have improved program effectiveness, biasing the effect estimates downwards. An attempt to minimize this was made by using mean effectiveness estimates in the baseline scenario. Moreover, to characterize these uncertainties, wide ranges (±20%) in probability sensitivity analysis were used and the main results were found to be stable across the ranges.

9.4.2 Data collection limitations

It was not possible to account for maternal deaths that occurred before 28 weeks gestation due to lack of data. Because the share of maternal deaths before 28 weeks is small and as early maternal deaths are not explicitly targeted by RBF, they may be assumed to be a constant that does not affect study estimations. Thus, this omission is less likely to substantially bias the effectiveness estimates.

Even though the initial hope was to estimate costs from societal perspective, which entails inclusion of all costs and benefits associated with an intervention, not all costs were captured. In particular, it was not possible to reconstruct start-up costs incurred during RBF program planning/design at central levels. This might have led to underestimating RBF costs, especially if only looked at from the provider perspective.

9.4.3 Limitations related to methodology or frameworks

The remaining three limitations relate to methodology or frameworks used in the study. Although decision-analytical models are increasingly being used to evaluate health polices to guide resource allocations, they have limitations. Relevant to this study is their limited ability to account for long term health outcomes such as chronic sequelae of preganancy related complications. Although in theory it is possible to add branches to a decision tree to allow for this, the results may be a more complex model possing more challenges finding reliable input data. Also, decision tree models are not good at modeling repeated events (and for individual women, pregnancy episodes are). Other modelling approaches, such as Markov models, would have been more suitable to handle such scenarios. While it was initially hoped to use Markov models to overcome some of these limitations, in practice, lack of quality data to parametrize the models compelled us to settle for decision tree models.

A narrow RBF framework, which emphasizes payments based on outputs verified for quality, provided a good basis to study costs and effects of RBF as considered within this thesis. However, others have question whether this narrow definition corresponds to reality (Renmans, Holvoet et al. 2017), given that in developing country settings the implementation of financial incentives based on performance often is not a standalone intervention. It involves a broader set of reforms geared towards strengthening the health systems including providing more autonomy and enhancing health information management (Witter, Toonen et al. 2013). In using this narrow RBF framework, an implicit simplifying assumption was that all RBF effects can be measured as health outcomes.

Finally, there are limitations of CEA framework which may have affected the results. This primarily relates to the lack of CEA to capture more dimensions of health status, pertinent for a complex intervention like RBF initiative in Malawi (acting at different levels through the continuum of pregnancy related care). As already alluded to previously, cost utility analysis would have been a better option. Using cost utility analysis would have at least allowed incorporation of qualitative health outcomes and might have estimated better RBF health outcomes.

9.5 Discussion

This study demonstrates that an RBF intervention (PBF +CCT) with a strong quality improvement component is probably cost-effective compared with input based financed maternal and perinatal care. These results were achieved in a situation of high levels of facility-based delivery and in the absence of significant changes in service use, underscoring the potential gains for maternal and new-born survival due to RBF induced quality improvements.

To the best of my knowledge, this is the first full economic evaluation of a RBF (PBF+ CCT) intervention to address MNH in a low-income country. Thus, there are no obvious previous studies against which these results may be compared. For a voucher program aimed at increasing facility births in Uganda, Alfonso et al have reported an ICER per maternal death averted of $20,756 (Alfonso, Bishai et al. 2013). This estimate however ignores the benefits in terms of perinatal health, as they were not included in the benefits estimations. Hounton et al assessing a health worker surgery training aimed at increasing access to EmOC in Burkina Faso have reported an ICER per perinatal death averted of $11,757 (Hounton, Newlands et al. 2009). But this estimate ignores maternal health benefits which were not included in the calculations of the health benefits. We find higher ICERs than the two above mentioned studies, even though we included both maternal and perinatal health benefits in our estimations. This may in part be explained by higher investments costs associated with PBF schemes (Borghi, Little et al. 2015), a key component of the Malawi RBF intervention. In addition, the study RBF facilities tended to have higher catchment areas and staff sizes (study II), the possibility that high operational costs in Malawi RBF facilities may in part underlie the observed high ICERs can therefore not be excluded.

Because the RBF intervention appears more effective, but also more costly than providing emergency obstetric care under status quo conditions, decisions to adopt it would depend on policy makers' willingness to pay. At a willingness to pay of $1,146 per LYG, (3 times Malawi GDP per capita) policy makers can be 60% certain that RBF is cost-effective compared with status quo care. This can arguably be considered borderline cost-

effectiveness. As others have noted, the choice of a new intervention is not only based on cost effectiveness analysis (CEA) results alone, but also on the capacity of resource-constrained governments to sustain its routine use (Marseille, Larson et al. 2015). A pertinent question to ask is whether the health system in Malawi will sustain the RBF program and sustain its operations when external financial assistance ceases. While this thesis did not focus on this area, moving forward, an important line of inquiry would be to conduct budget impact analysis of RBF. Such inquiry will provide information on RBF affordability and the potential for the government of Malawi to finance RBF using domestic sources.

A key challenge facing health systems in SSA is the persistence of coverage gaps in other vital MNH interventions. The implications for low income SSA countries like Malawi of implementing new costly interventions based on the WHO threshold should therefore be carefully considered. Within the framework of opportunity cost or budget constraint, introduction of a new program can only occur at the expense of pushing other interventions out. If the interventions being replaced have more returns at the margin, this would risk lowering overall population health attainment and increasing health inequalities (Revill, Walker et al. 2014). Again, this underscores the need for additional analysis beyond economic evaluations: they may also offer needed insight regarding broader impact of RBF on health systems or other interventions.

The model is sensitive to estimates of coverage of RBF facility births and the proportion of births in non-RBF facility with good quality care. Quality of care is important in healthcare including RBF programs and there are ongoing efforts to improve its measurement and reporting (Brenner, De Allegri et al. 2015). The observed sensitivity underscores the importance of quality as it relates to health outcomes and that better data are needed to improve our model accuracy. Though the model is sensitive to the share of births in RBF facilities, it is not sensitive to the percentage of complications among facility deliveries (FD). The share of complications among FD depends on coverage of facility based deliveries since women with complication self-select into care, especially when FD rates are less than 40% (McClure, Goldenburg et al. 2007). As FD rates are variable in

SSA, ranging from as low as 12% in Ethiopia (Yesuf, Kerie et al. 2014) to as high as 91% in Malawi (Mazalale, Kambala et al. 2015), we postulate that cost-effectiveness of RBF may be strongly influenced by the share of obstetric complications at much lower FD rates than those obtained in Malawi. In this regard, CEA studies in different setting are required to contextualize findings. The lack of demonstrable sensitivity of ICERs to RBF costs is surprising, given the financial outlays associated with RBF (Mayora, Ekirapa-Kiracho et al. 2014).

This study did not consider benefits from potential reductions in maternal and perinatal morbidity due to lack of quality data. Studies on MNH report a heavier morbidity burden due to disabilities than to mortality per se (Adeoye, Onayade et al. 2013). Inclusion of averted morbidity would thus increase effectiveness and improve cost-effectiveness of RBF. Future CEA studies should account for the potential of RBF to reduce disabilities (Mangham-Jefferies, Pitt et al. 2014).

Large differences in rewards based on cadre were observed. The size of financial rewards is assumed to positively influence performance (Franco, Bennett et al. 2002) while perceived unfairness in distribution of rewards may de-motivate staff, undermining RBF objectives. Assessment of adequacy of rewards, perceived fairness in how rewards are shared and their impact on health system performance should inform future lines of inquiries.

9.6 Conclusion:

At high levels of willingness to pay (3 times Malawi GDP per capita), RBF appears a cost-effective way to fund health facilities to improve quality of maternal and perinatal health, and to fund pregnant women in order to increase access to emergency obstetric care, compared to the current non-RBF based funding. At this level, RBF cost-effectiveness is also comparable to other RBF interventions currently implemented for maternal and perinatal survival in the SSA region. However, at less than 3 times Malawi GDP per capita, RBF is less likely to be cost-effective, implying that RBF implementation at this threshold is likely to displace health gains from alternative healthcare interventions and lower health

benefits at health system level. These considerations underscore the need for countries to carefully consider broader health systems RBF benefits before its implementation. Although economic costs of running RBF-supported facilities are about 4 times as expensive compared to costs at facilities without RBF, the intervention averts 3.5% deaths occurring in the status quo MNH care in Malawi. The cost of $1,046 per life year gained is lower than three times Malawi's GDP per capita, which is commonly suggested as a decision rule for implementation.

This is the first cost-effectiveness study of an RBF (PBF+CCT) intervention in Africa south of the Sahara and many unresolved issues remain. More RBF CEAs are merited to explore cost-effectiveness of different intervention types, different health systems settings and health services, and to reduce uncertainties around RBF CEA estimates related to modeling. Researchers in SSA should take advantage of the numerous RBF studies being implemented in the region to generate needed economic information to support policy decisions. RBF studies should prioritize generating better health outcomes data. Future economic evaluations should focus on identifying optimal RBF designs and implementation models that have lower transactional costs. They should also assess adequacy of different reward options and fairness of allocation mechanism that maximize individual health worker and team efforts.

CHAPTER 10: Summery of main findings and recommendations

10.1 Key findings

The first objective of this thesis was to assess the benefits of institutional-based births compared to home deliveries in terms of reducing the risk of maternal and perinatal mortality among pregnant women in the SSA region. This study found that the risk of perinatal deaths is lower for institutional births relative to home births while the risk of maternal mortality is high among institutional births relative to home births, possibly driven by selection bias and poor quality of care in health facilities.

The second objective was to assess the effects of RBF on time to seek care for pregnancy related complications and associated costs households incur during obstetric emergency care seeking. This study found that among pregnant women, receipt of RBF was associated with substantially reduced expected mean time to seek emergency obstetric care. This effect was greater in the longer than shorter term. Time to seek care was positively associated with increasing age, being married and registration for CCT while parity, education and disease severity were negatively associated with time to seek care.

No substantial change in overall household costs was found between households in RBF compared to households in non-RBF areas. Household costs were significantly positively associated with increasing number of days spent in a facility and with in-patient care treatment, the proxy for complication severity. Household costs were significantly negatively associated with parity, women heading households, registration for CCT and being middle poor. Women who registered for CCT had substantially less engagement with informal caregivers during illness episodes, leading to significantly lower expected mean costs among the women's overall households' costs.

The third objective was to assess the cost-effectiveness of RBF compared to the status quo. This study found that RBF is probably cost effective at a conventional although ambitious threshold for willingness to pay. Importantly, RBF cost-effectiveness is comparable to contemporary interventions used to promote maternal and neonatal care in the region.

10.2 Public health implications and recommendations

The thesis findings provide information which answers important public health questions.

- The results suggest that institutional based deliveries are beneficial in reducing perinatal mortality in the sub-Saharan Africa relative to home births. Women, especially the poor, should therefore be encouraged and supported to give birth in health facilities.
- The data shows that there is increased risk of maternal mortality in health facilities relative to home births, underscoring the need to improve quality of care in health

institutions in the SSA region to drive down the high maternal mortality rates currently observed. Importantly, quality improvement efforts should precede and be prioritized over efforts to increase institutional based births, especially in settings like Malawi where facility births are already high.

- The finding that RBF is associated with reduced expected mean time to seek care has the potential to lead to improved promptness of health facility attendance for women with pregnancy related complications, which may result in better outcomes (if quality care is provided) and reduced obstetric emergency related care costs on households.

- Households of women with pregnancy related complications face high indirect costs relative to medical costs even when provided with financial support. Alternative interventions that lower such indirect costs are therefore needed as they may reduce the economic burden of treatment and make households resilient to health financial shocks due to maternal or perinatal complications.

- RBF (PBF+ CCT) is probably cost-effective at high thresholds of willingness to pay. Countries in the SSA region should carefully consider broader health systems benefits when deciding to implement RBF as one of the tools to improve quality of care and reduce maternal and perinatal mortality in health facilities.

10.3 Research implications

The studies presented within this thesis expanded our understanding and knowledge of benefits of facility-based births in the SSA region, the effects of RBF on timeliness to seek care for pregnancy related complications and associated household costs. Additional knowledge related to cost-effectiveness of RBF and its key drivers in the region was also provided. However, further research is suggested as many questions remain unanswered.

The first relates to measures of maternal and perinatal intervention effectiveness in terms of morbidity and mortality reductions. Such measures should be prioritized instead of the commonly used intermediate indicators, for instance, facility-based delivery rate. To that end, low cost but accurate approaches designed to collect morbidity and mortality data

in developing country settings will be important. This will enable better tracking of intervention impact and directly support complimentary studies such as cost-effectives analyses and quality improvement assessments.

Time to seek emergency obstetric care is influenced by multiple factors, including gender and power dynamics in the home. Qualitative studies are therefore needed to explore how RBF empowers women or affects decision making in the homes, particularly in developing countries where key health choices are made by men.

Since RBF in Malawi and most countries in SSA is largely development partner's supported, research is needed to assess the affordability and sustainability of RBF in the region. RBF continuity can only be guaranteed if domestic financial resources are adequate to finance recurrent operational costs beyond donor support.

More RBF cost-effectiveness studies are needed in the SSA comparing efficiencies of different RBF designs and to reduce uncertainties surrounding current RBF cost-effective analysis estimates.

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Appendix 1: Household Survey questionnaire RBF4MNH
Instructions:
This survey is designed to capture information from consenting and eligible women living as permanent residents in the selected enumeration areas. It is supposed to take no more than one hour. Please ensure the woman is comfortable and that there is adequate privacy.
Section A: General Information
This section should be fully completed before interview starts. Please return to this section after completion of the entire survey and enter missing data.

0.01	Name of district	☐Balaka ☐Dedza ☐Mchinji ☐Ntcheu
0.02	Enumeration area code	*Enter the code here:* |_|_|_|
0.03	Health facility catchment area	☐ Balaka District Hospital (Balaka) ☐ Kalembo Health Center (Balaka) ☐ Kankao Health Center (Balaka) ☐ Kwitanda Dispensary (Balaka)

		☐ Mbera Health Center (Balaka)
		☐ Nandumbo Health Center (Balaka)
		☐ Phalula Health Center (Balaka)
		☐ Phimbi Health Center (Balaka)
		☐ Chitowo Health Center (Dedza)
		☐ Dedza District Hospital (Dedza)
		☐ Golomoti Health Center (Dedza)
		☐ Kaphuka Health Center (Dedza)
		☐ Kasina Health Center (Dedza)
		☐ Lobi Health Center (Dedza)
		☐ Mayani Health Center (Dedza)
		☐ Mua Mission Hospital (Dedza)
		☐ Chipumi Health Center (Mchinji)
		☐ Kaigwazanga Health Center (Mchinji)
		☐ Kapiri Health Center (Mchinji)
		☐ Kochilira Health Center (Mchinji)
		☐ Mchinji District Hospital (Mchinji)
		☐ Mikundi Health Center (Mchinji)
		☐ Mkanda Health Center (Mchinji)
		☐ Nkhwazi Health Center (Mchinji)
		☐ Bilila Health Center (Ntcheu)
		☐ Biriwiri Health Center (Ntcheu)
		☐ Kandeu Health Center (Ntcheu)
		☐ Kapeni Health Center (Ntcheu)
		☐ Kasinje Health Center (Ntcheu)
		☐ Katsekera Health Center (Ntcheu)
		☐ Lizulu Health Center (Ntcheu)
		☐ Ntcheu District Hospital (Ntcheu)
		☐ Ganya Health Center (Ntcheu)
0.04	Date of Interview	|_|_| - |_|_|_| - |_|_|_| DD-MMM-YYYY
0.05	Village Name	*Write name here:* ……………………………………………..
0.06	Village setting	☐ Urban ☐Rural
0.07	Interviewer Code	*Enter your interviewer code here:* |_|_|_|
	Administer consent. Read consent form and allow patient to ask questions	
0.08	Consent given	☐ Yes ☐ No
	Start interview only if consent given and consent form signed	
0.09	How old are you (in years)?	Enter number here: |_|_|_|
0.10	Are you married?	☐ Yes ☐ No ☐ Does not wish to disclose

0.11	What is your religion?	☐ Christian ☐ Muslim ☐ Traditional ☐ Other	
0.12	What is the highest education level that you ever attained?	☐ None ☐ Primary school leaving certificate ☐ Secondary school ☐ University ☐ Other	
0.13	Are you able to read and write?	☐ YES	☐ NO
0.14	Are you employed?	☐ YES	☐ NO
0.15	What is your occupation?	☐ Working in a farm) Working in business) Day laborer / casual laborer / odd job) Civil servant) Other public service) Non-governmental organization) Cooperative) Church) Domestic work / housewife) Student ☐ Retired) Unemployed) Other	
	Now I would like to ask some information about your household		
0.16	How many people (adults and children) live in this household?	Enter number here: ⎵⎵	
0.17	How many women of child bearing age, including you, live in the household?	Enter number here: ⎵⎵	
	Now I would like to know the items that are owned or used by your household		
0.18	Who owns the house you are currently living in?	☐ Owned by household ☐ Owned by another family member ☐ Rented ☐ Does not wish to disclose ☐ Does not know ☐ Other	

0.19	How many bedrooms in the house are occupied by your household members?	Enter number here: |_|_|
0.20	What material is the outer wall of the house predominantly made of?	☐ Grass ☐ Mud (Yomata) ☐ Compacted Earth (Yamdindo) ☐ Mud Brick (unfired) ☐ Burnt Bricks ☐ Concrete ☐ Wood ☐ Iron Sheets ☐ Does not wish to disclose ☐ Does not know ☐ Other
0.21	What material is the roof of the house predominantly made of	☐ Grass ☐ Iron sheets ☐ Clay ☐ Tiles ☐ Concrete ☐ Plastic sheeting ☐ Does not wish to disclose ☐ Does not know ☐ Other
0.22	What material is the floor of the house predominantly made of?	☐ Sand ☐ Smoother Mud ☐ Smooth cement ☐ Wood ☐ Tile ☐ Does not wish to disclose ☐ Does not know ☐ Other
0.23	What is the main source of light in your house?	☐ ESCOM ☐ Solar ☐ Generator ☐ Biogas/biofuels ☐ Candles ☐ Kerosine lamps ☐ Electric Torches ☐ None ☐ Does not wish to disclose

		☐ Does not know ☐ Other
0.24	What is the main source of drinking water for your house during this time of year?	☐ Piped in dwelling ☐ Communal stand piped ☐ Hand pump/ borehole ☐ Tanker service ☐ Private well ☐ Public well ☐ Spring ☐ River/stream ☐ Pond/dam/lake ☐ Rain water
0.25	What kind of toilet facility does the household have?	☐ Flush toilet ☐ VIP Latrine ☐ Dug-out pit with roof ☐ Dug-out pit without roof ☐ None ☐ Does not wish to disclose ☐ Other
0.26	Doe the household own a functioning telephone?	☐ YES ☐ NO
0.27	Do you have other houses apart from the one you are living in?	☐ YES ☐ NO
0.28	Does your household own permanent land that you use for farming?	☐ YES ☐ NO
	Now I would like to know the number of birds and animals owned by the household	
0.28	Pigs	Enter number here: |||
0.29	Goats	Enter number here: |||
0.30	Chickens, Turkeys, ducks and pigeons	Enter number here: |||
	Indicate the number of each of the following means of transportation that are owned by members of the household?	
0.31	Bicycle	
0.32	Car	
	Now I would like to know the number of agricultural implements that are owned by all members of the household?	

0.33	Panga Knife	Enter number here: |||
0.34	Sickle	Enter number here: |||
0.35	Pick axe	Enter number here: |||
0.36	Axe	Enter number here: |||
0.37	Wheel barrow	Enter number here: |||
0.38	Shovel	Enter number here: |||
0.39	Hammer	Enter number here: |||
	Now I would like to know the number of the following items owned by the household	
0.40	Radio	Enter number here: |||
0.41	Stove	Enter number here: |||
	Now I would like to ask you questions regarding the LAST pregnancy and other previous pregnancies if any	
0.42	When did your LAST pregnancy end?	☐ More than 8 weeks ago ☐ 8 weeks ago ☐ 7 weeks ago ☐ 6 weeks ago ☐ 5 weeks ago ☐ 4 weeks ago ☐ 3 weeks ago ☐ 2 week ago ☐ 1 week ago ☐ Less than 1 week ☐ Does not wish to disclose ☐ Does not know
0.43	What was the outcome?	☐ Live new-born at term ☐ Live new-born before term (premature birth) ☐ Dead new-born at term (stillbirth) ☐ Dead new-born before term (miscarriage) ☐ Does not wish to disclose
0.44	If baby born alive, how is the baby?	☐ Alive ☐ Survived the first 48 hrs after birth, but died later on ☐ Died within first 48 hours after birth ☐ Does not wish to disclose
0.45	If baby died, where did the death take place?	☐ At facility. ☐ At home or at other private house. ☐ On the way to a health facility. ☐ On the way from a facility home. ☐ Does not wish to disclose ☐ Does not know ☐ Other

0.45	How many pregnancies, including the past one, have you ever had?	Enter number here: |_|_|
0.46	How many times have you given birth, including the most recent?	Enter number here: |_|_|

Section B: Antenatal complications

0.01	DURING the months of your pregnancy, but BEFORE the day your child was supposed to be born, did you or your unborn child encounter any complications?	☐ YES	☐ NO
0.02	Was this complication during your pregnancy due to the fact that you were found to have high blood pressure readings and/or severe swelling of your feet? (also called pre-eclampsia)	☐ YES	☐ NO
0.03	Was this complication during your pregnancy due to the fact that you experienced convulsions because of high blood pressure (eclampsia)	☐ YES	☐ NO
0.04	Was this complication during your pregnancy due to the fact that you were losing blood through the birth passage?	☐ YES	☐ NO
0.05	Was this complication during your pregnancy due to the fact that you were vomiting a lot, to merit hospital admission?	☐ YES	☐ NO
0.06	Was this complication during your pregnancy due to the fact that you were draining liquor?	☐ YES	☐ NO
0.07	Was this complication during your pregnancy due to the fact that you did not have enough blood, called anemia?	☐ YES	☐ NO
0.08	Was this complication during your pregnancy due to your baby born before due data (also called premature birth)?	☐ YES	☐ NO
0.09	Was this complication during your pregnancy due to the fact that your baby was not adequately growing in size?	☐ YES	☐ NO
0.10	Was this complication during your pregnancy due to the fact that your baby was not adequately moving in the womb?	☐ YES	☐ NO
0.11	Did you seek treatment for this complication?	☐ No ☐ Yes	

141

		☐ Does not wish to disclose ☐ Does not remember
0.12	At what point during this complication did you decide to seek treatment from a care provider?	☐ Immediately ☐ Waited to see whether illness improves ☐ When it started affecting my day-to-day activities ☐ When it started severely incapacitating me ☐ Does not wish to disclose ☐ Does not remember ☐ Other
0.13	How many days after the complication occurred did you seek treatment? (DAYS)	Enter number here: |_|_|
0.14	Were you hospitalized for the complications just mentioned?	☐ YES ☐ NO
0.15	How long did you have to wait before you were attended by the health worker? (MINUTES)	Enter number here: |_|_|_|
0.16	How many nights did you sleep in the facility?	Enter number here: |_|_|
0.17	In which district is the facility where you were hospitalized located?	☐ Balaka ☐ Dedza ☐ Mchinji ☐ Ntcheu ☐ Does not wish to disclose ☐ Does not know / remember ☐ Other
0.18	What is the name of the facility that you were hospitalized in?	☐ Balaka District Hospital (Balaka) ☐ Banja la Mtsogolo (Balaka), PVT ☐ Chiendausiku Dispensary (Balaka) ☐ Chifundo Maternity (Balaka), PVT ☐ Chizeni Clinic (Balaka), PVT ☐ Dream Confort Health Center (Balaka), CHAM ☐ Ipyana Maternity

		(Balaka), PVT ☐ Kalembo Health Center (Balaka) ☐ Kankao Health Center (Balaka), CHAM ☐ Kwitanda Dispensary (Balaka) ☐ Mbera Health Center (Balaka) ☐ Namanolo Dispensary (Balaka) ☐ Nandumbo Health Center (Balaka) ☐ Phalula Health Center (Balaka), CHAM ☐ Phimbi Health Center (Balaka) ☐ Pilirani Clinic (Balaka), PVT ☐ Ulongwe Health Center (Balaka), CHAM ☐ Utale 1 Health Center (Balaka), CHAM ☐ Utale 2 Health Center (Balaka), CHAM ☐ Does not wish to disclose ☐ Does not remember ☐ Other
0.19	How did you get to the facility?	☐ Walking ☐ Bus/Minibus/Matola ☐ Cart ☐ Bicycle ☐ Motorbike ☐ Car ☐ Bicycle ambulance ☐ Motorized ambulance ☐ Does not wish to disclose ☐ Does not remember ☐ Other
0.20	How much did you pay for transport? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.21	How long did it take you to get to the facility? (HOURS)	|_|_|_|.|_|_| Hours

0.22	How many adults accompanied you to the facility?	Enter number here: |_|_|_|
0.23	What is the main occupation of the first person who accompanied you?	☐ Working in a farm ☐ Working in business ☐ Day laborer / (farm/non-farm) ☐ Civil servant ☐ Other public service ☐ NGO ☐ Cooperative ☐ Church ☐ Domestic work / housewife ☐ Student ☐ Retired ☐ Unemployed ☐ Other
0.24	How many times did this person visit you while you were admitted at the facility?	Enter number here: |_|_|_|
0.25	How much would you estimate the person spent on transport to and from the facility each trip? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.26	Did you have to pay the person who took care of you during hospitalization?	☐ YES ☐ NO
0.27	How much did you pay the person to take care of you? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.28	Did you buy any food or drinks for yourself and companions during your stay at the facility?	☐ YES ☐ NO
0.29	How much money in total did you spend on meals and drinks for you and your companions? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.30	Did you have to pay anything for any of the medical care associated with the pregnancy-related complication(s)?	☐ YES ☐ NO
0.31	How much in total did you pay for the care associated with this complication? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK

Section C: Delivery complications

144

0.01	ON THE DAY your child was supposed to be born or IMMEDIATELY after the delivery, did you or your child encounter any complications?	☐ YES	☐ NO
0.02	Was this complication during or immediately after the delivery due to the fact that your baby was too big or positioned in a way inside your womb that made it difficult to give birth the natural way (also called Obstructed / Prolonged labor)?	☐ YES	☐ NO
0.03	Was this complication during and immediately after the delivery due to severe bleeding (also called Postpartum hemorrhage)?	☐ YES	☐ NO
0.04	Was this complication during delivery due to tearing of your womb (also called uterine rupture)?	☐ YES	☐ NO
0.05	Was this complication during or immediately after the delivery due to a severe infection of your womb (also called Peuperal Sepsis)?	☐ YES	☐ NO
0.06	Was this complication during or immediately after the delivery due to your baby not breathing or crying well (also called Neonatal asphyxia)?	☐ YES	☐ NO
0.07	Was this complication immediately after the delivery due to your baby having a severe infection (also called neonatal sepsis)?	☐ YES	☐ NO
0.08	Was this complication during or immediately after the delivery due to your child being born too early or too small than expected (also called Prematurity or Pre-term)?	☐ YES	☐ NO
0.10	Was this complication during or immediately after the delivery due to your child being born with deformities?	☐ YES	☐ NO
0.11	Did this complication take place at Home	☐ YES	☐ NO
0.12	At what point during this complication did you receive treatment from a care provider?	☐ Immediately ☐ Waited to see whether illness improves ☐ When it started affecting my day-to-day activities ☐ When it started severely incapacitating me ☐ Does not wish to disclose	

		☐ Does not remember ☐ Other
0.13	How many days after the complication occurred did you seek treatment? (DAYS)	Enter number here: ⎵⎵
0.14	Were you hospitalized for the complications just mentioned?	☐ YES ☐ NO
0.15	How long did you have to wait before you were attended by the health worker? (MINUTES)	Enter number here: ⎵⎵⎵
0.16	How many nights did you sleep in the facility?	
0.17	In which district is the facility where you were hospitalized located?	☐ Balaka ☐ Dedza ☐ Mchinji ☐ Ntcheu ☐ Does not wish to disclose ☐ Does not know / remember ☐ Other
0.18	What is the name of the facility that you were hospitalized in?	☐ Balaka District Hospital (Balaka) ☐ Banja la Mtsogolo (Balaka), PVT ☐ Chiendausiku Dispensary (Balaka) ☐ Chifundo Maternity (Balaka), PVT ☐ Chizeni Clinic (Balaka), PVT ☐ Dream Confort Health Center (Balaka), CHAM ☐ Ipyana Maternity (Balaka), PVT ☐ Kalembo Health Center (Balaka) ☐ Kankao Health Center (Balaka), CHAM ☐ Kwitanda Dispensary (Balaka) ☐ Mbera Health Center (Balaka)

		☐ Namanolo Dispensary (Balaka) ☐ Nandumbo Health Center (Balaka) ☐ Phalula Health Center (Balaka), CHAM ☐ Phimbi Health Center (Balaka) ☐ Pilirani Clinic (Balaka), PVT ☐ Ulongwe Health Center (Balaka), CHAM ☐ Utale 1 Health Center (Balaka), CHAM ☐ Utale 2 Health Center (Balaka), CHAM ☐ Does not wish to disclose ☐ Does not remember ☐ Other
0.19	How did you get to the facility?	☐ Walking ☐ Bus/Minibus/Matola ☐ Cart ☐ Bicycle ☐ Motorbike ☐ Car ☐ Bicycle ambulance ☐ Motorized ambulance ☐ Does not wish to disclose ☐ Does not remember ☐ Other
0.20	How much did you pay for transport? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.21	How long did it take you to get to the facility? (HOURS)	|_|_|_|.|_|_| Hours
0.22	How many adults accompanied you to the facility?	Enter number here: |_|_|_|
0.23	What is the main occupation of the first person who accompanied you?	☐ Working in a farm ☐ Working in business ☐ Day labourer / (farm/non-farm) ☐ Civil servant ☐ Other public service ☐ NGO

		☐ Cooperative ☐ Church ☐ Domestic work / housewife ☐ Student ☐ Retired ☐ Unemployed ☐ Other
0.24	How many times did this person visit you while you were admitted at the facility?	Enter number here: |_|_|_|
0.25	How much would you estimate the person spent on transport to and from the facility each trip? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.26	Did you have to pay the person who took care of you during hospitalization?	☐ YES ☐ NO
0.27	How much did you pay the person to take care of you? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.28	Did you buy any food or drinks for yourself and companions during your stay at the facility?	☐ YES ☐ NO
0.29	How much money in total did you spend on meals and drinks for you and your companions? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK
0.30	Did you have to pay anything for any of the services associated with the pregnancy-related complication(s)?	☐ YES ☐ NO
0.31	How much in total did you pay for the care associated with this complication? (KWACHA)	|_|_|_|_|_|_|.|_|_| MK

Appendix 2: Informed consent form: Results based financing for maternal and neonatal health (RBF4MNH)

UNIVERSITY OF HEIDELBERG   UNIVERSITY OF MALAWI   UNIVERSITY OF BERGEN

<u>Who is conducting the study</u>
This research study is being conducted by University of Malawi, College of Medicine, Malawi; University of Heidelberg, Germany and University of Bergen, Norway. It is being led by Professor Adamson Muula of College of Medicine, University of Malawi.

<u>What is the aim of the study</u>
In this study, we are looking at how well Results based financing (RBF) works. RBF is provided by the Ministry of Health in the following districts: Mchinji, Dedza, Ntcheu and Balaka. As part of RBF intervention, money is given to hospital staff if they provide selected services to pregnant mothers and the new-born according to agreed standards. Money is also provided to pregnant women who have given birth at health facilities and/ or have stayed in the facility for 48 hours after birth. In this study we would like to find out if the procedure of handing out cash to hospital staff and mothers who have recently given birth encourages or improves utilization of maternal health services by pregnant women in Malawi. Results from the study will help us give proper recommendations to the Ministry of Health on ways to improve service use and quality of maternal health services in Malawi.

<u>What are the study procedures?</u>
This study component looks at how RBF affects those who receive maternal and new-born health services. The Household survey interviews will be conducted with the mothers who have terminated a pregnancy in the past 12 months before the date of the interview. The questionnaire will be asked to both mothers who have benefited from RBF or not. The questionnaire will collect basic demographic information such as age, area of residence, marital status, ethnicity and religion. Information related to obstetric history will also be collection. This information will include but will not be limited to number of pregnancies, outcomes of pregnancies and place of birth. Questions specifically related to the last pregnancy will include use of antenatal services, place of delivery, experienced illnesses during the pregnancy, care seeking for any reported illnesses and costs associated with the care seeking. This questionnaire will take 45 to 60 minutes to complete.

<u>Risks associated with the study</u>

We do not anticipate that any harm will come to people through their participation in the research.

Please note that your participation in the research is entirely voluntary in all phases. If you don't want to take part, you can refuse without any penalty or loss of benefits to you. If you do agree to participate and then change your mind, please tell the researchers and they will end your participation immediately, without any penalty or loss of benefits to you. You can do this at any point during this study.

Cost or compensation to you for participation
There are no costs or compensation to take part in this study.

Confidentiality

As a participant in the research you can expect that all the information you provide will be treated in confidence. This means that your name will not be used when we write our reports about the research. It also means that no one outside the research team will know how you as an individual answered the questions. We will not tell anyone at the College of Medicine or Ministry of Health about your responses. No quotes or other results arising from your participation in this study will be included in any reports, even anonymously, without your agreement.

Who approved this research:
Ethical Committee of the Faculty of Medicine of the University of Heidelberg S-256/2012 and the College of Medicine Research Ethics Committee (COMREC) (application number P.08/13/1438).

Agreeing to take part in this research
I have read the study information sheet and I understand what will be required of me and what will happen to me if I take part in it
I understand that the information I will give will be treated in the strictest confidence.
I understand that at any time I may withdraw from this study without giving a reason and that I will not be affected negatively in any way if I do not want to participate
My questions concerning this study have been answered by _____
I voluntarily agree to take part in this study
Participant's name (please print): _____ **Date:**_____

Participant's signature: _____

Or
Participant's thump print : _____ **Date:**_____
Witness Name (please print): _____**Date:**_____
Witness signature: _____
Re-searcher's name (please print): _____ **Date:**_____

Re-searcher's signature: _____
More information
For further questions about this research, your rights as a subject, or any adverse effects related to the research, please contact:

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