COST EFFECTIVENESS AND SCALABILITY OF AN mHEALTH INTERVENTION TO IMPROVE PREGNANCY SURVEILLANCE AND CARE SEEKING IN RURAL BANGLADESH

by

Youngji Jo

A dissertation submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy

Baltimore, Maryland

March 2017

ABSTRACT

Background: Proven health interventions, when implemented with high fidelity and adequate coverage, could save millions of maternal and newborn lives. In many low and middle-income countries, however, coverage levels of these interventions are still low. The mCARE program, implemented from 2011 to 2015 in Gaibandha district in Bangladesh, was implemented with the aim of developing and testing a mobile phone-based system to improve healthcare-seeking behaviors of pregnant women during and after their pregnancy through health worker-delivered automated and personally scheduled Short Message Service (SMS) and home visit reminders. Despite the growing recognition of the potential benefits of mobile health (mHealth) in improving knowledge, care seeking, and treatment adherence, little evidence exists on the value of mHealth for money or affordability in developing countries.

Methods: Following established guidelines (e.g. CHEERS, ISPOR), we present analyses of the costs, consequences and affordability of the study drawn from a wide spectrum of datasets from the mCARE project including system-generated data on utilization, financial records from implementation and technical organizations, interviews with local experts and stakeholders, observations of service provision and exit interviews with 100 pregnant women in rural Bangladesh. Secondary data were also drawn from the literature and published national surveys. We used an ingredients-based approach to measure program costs by activity, and developed an Excel-based spreadsheet model to forecast program, provider and user costs and consequences for various alternatives and service delivery scenarios. The Lives Saved Tool (LiST) was used to model the number of lives

saved and disability adjusted life years (DALYs) averted stemming from increases in coverage over time. We tested the robustness of the results though deterministic and probabilistic sensitivity analyses using Monte Carlo simulations. Finally, based on cost-effectiveness findings, we assessed the affordability of implementing the mCARE program using a budget impact analysis and cost-effectiveness affordability curves from the perspective of a budget holder.

Results: At a cost of $12 per newborn death averted and $0.41 per DALY averted, the comprehensive mCARE program, which includes pregnancy surveillance and personally scheduled SMS and home visit reminders, is highly cost-effective from a program perspective, compared to a basic mCARE program, which does not include scheduled SMS and home visit reminders (Chapter 5). When delivered at scale over a 10-year analytic time horizon (2016 to 2025) and compared against a paper-based alternative, the comprehensive mCARE model costs $580,185 in the first year (2016) to start up and incrementally increases from $1,730,599 to $6,917,807 in the subsequent years (2017 to 2025) with incremental geographical expansion to another district each year. An estimated 19,682 total lives (including maternal, neonatal, and stillbirth) would be saved as a result, over a 10-year period. This corresponds to an incremental cost per DALY averted of $47 (Chapter 6). Assuming a willingness to fund $1,080 per DALY averted, based on the Bangladesh gross national income (GNI) per capita, the program has a 97% probability of being highly cost-effective. Key activities driving costs and estimates of cost-effectiveness, include census enumeration, pregnancy surveillance, and supervision and training. The annual program budget impact of implementing the comprehensive mCARE program versus the existing paper-based system in Gaibandha district is an additional $258,508 in the first year (2015) and $102,658 in subsequent years (2016 to 2020) – without adjusting for inflation and excluding overhead costs (Chapter 7). Above a budget threshold of $2.5 million, the program has a 93% probability of being cost-effective. Nationwide implementation of the comprehensive mCARE program would cost an estimated $47 million over the 2015-2020 period, comprising 0.9% of total annual health expenditure ($5.4 billion) and 2.5% of public health expenditure ($1.9 billion).

Conclusion: The results suggest that implementing the comprehensive mCARE program in Bangladesh may be cost-effective and affordable. Study findings are based on the primary data of 690 pregnant women; additional data are needed to verify forecasted costs and consequences of implementation at scale. Assumptions of the translation of changes in coverage for key maternal and newborn health services, including antenatal care, facility delivery and postnatal care, are dependent on supply side factors – relying on adequate human resources, supplies and commodities, and other inputs associated with quality of care, the measurement of which was beyond our scope. Even given these limitations, the study findings provide information that can help project the resources necessary to fund the program, and the consequences of potential variations of cost inputs at different levels of scale, which can be used to guide efforts of the government of Bangladesh to adopt, implement and sustain the mCARE program.

COMMITTEE OF THESIS READERS

Committee Members:

Alain B. Labrique, Ph.D. MHS, MS
Associate Professor, Ph.D. Advisor
Department of International Health

David Holtgrave, Ph.D.
Professor, Committee Chair
Department of Health Behavior and Society

Harold Lehmann, Ph.D. M.D.
Professor
Division of Health Sciences Informatics, School of Medicine

Alan Sorkin, Ph.D. MA
Adjunct Professor
Department of International Health

Alternative Committee Members:

Laura Morlock, Ph.D.
Professor
Department of Health Policy and Management

Krishna Rao, Ph.D.
Assistant Professor
Department of International Health

ACKNOWLEDGEMENTS

Over the past six years, I have received support and encouragement from a great number of wonderful and caring individuals. First, I am most grateful to my PhD advisor, Dr. Alain Labrique. Everything I have learned and done is based on his guidance, support and patience. I learned quite a lot not only from his practical and insightful advice for my research, but also his outstanding leadership to keep such large and diverse teams both capable and cordial. His pioneering spirit and enthusiasm for mHealth always inspired me throughout my research. I also have utmost gratitude to my thesis advisor, Dr. Amnesty LeFevre for her constant guidance on the cost-effectiveness methods as well as monitoring and evaluation practice, which were the essential parts of my research. Whenever I requested a meeting with queries, she made time and always provided a very thorough, critical and constructive feedback on my work. Both have been indispensable and complementary sources not only of knowledge and experience, but also of unwavering support and guidance. I would also never forget how they did not mind spending extra hours to review my dissertation and help me to prepare my defense seminar.

The intellectual contributions of the members of my various thesis committees have been invaluable. I would like to acknowledge Dr. David Holtgrave for his theoretical and practical insights on cost-effectiveness studies; Dr. Harold Lehmann for his guidance to further advance the analytic methods toward decision science and the discussions on the philosophical foundations behind them; Dr. Alan Sorkin for his advice of explaning concepts through the economic principles and theories; Dr. Laura Morlock for her advice on the presentation and use of the research findings for the policy decision-making; and Drs. Krishna Rao, Antonio Trujillo, Saifuddin Ahmed for their valuable feedback on my proposal and dissertations; their advice was instrumental in the application and advancement of my research finding as well as in my personal development as a researcher.

I cannot thank enough to all the members of Center for Human Nutrition and JiVitA team from whom I learned most of the essential parts of public health field studies and what makes a tradition of excellence. It's impossible to name them all here, but Dr. Keith West and Dr. Parul Christian for their great insights in the public health research as well as caring leadership and respect; Sucheta Mehra for her fair and solid advice and impressive leadership in team management as well as critical guidance for the IRB preparation and submission; Katie for her indispensable support on data processing and outcome-side analyses; Neelu and Kelsey for sharing their experience and expertise of the mCARE program implementation and technical systems as well as being my dear companions in Gaibandha; Dr. Hasmot Ali for his wonderful leadership for the field study; Dr. Saijuddin Shaikh, Rezwanul Haque, and Azaddu Zzaman for their supportive leadership. Especially during challenging times, the field study was not possible without dedicated and excellent support of the interviewers: Eshrat Jahan, Zia Haque, Tanjila Aker, Hafiz Rahman, and Abdullah Mamun for making a number of calls to arrange appointments for the field site visits; Shabita Sarkar and Kajol Kumar for their prompt help on data entry; Emdadul Haque for his willingness to help gather financial data of JiVitA; the field supervisors, Mahabubul Islam, Rashidul Hassan, Zahidur Rahman for bringing me to the study sites and sharing their expertise and experience; Dr. Abu Hanif, Dr. Abu Ansari and Sabiha Chowdhuri for their kind help in the earlier phase of field study; Dr. Faizah Farah and Asif Ary for many valuable discussions and joyful memories in Gaibandha.

I also greatly appreciate mPOWER colleagues: Mridul Chowdhury and Rubayat Kahn for their supportive leadership; Ismail, Numera, and Azdi, for activity specification and cost data gathering, and Sammur for almost all the questions related to the community health workers' activities in the field. I also thank our partner organizations, the Bangladesh Ministry of Health and Family Welfare (in Gaibandha district), BRAC, and Smiling Sun Franchise Program for their kind support and cooperation in collecting data at their facility sites. I also would like to gratefully acknowledge the generous financial support of UBS Optimus Foundation, which made this dissertation research possible.

I would like to acknowledge my mentors and colleagues: Dr. Garrett Mehl for his great mentorship in 2012 summer at World Health Organization and gracious support for me to visit the field sites which had become the start of my dissertation research; Professor Edward Bunker for his invaluable support for my classes toward undergraduate students as well as his very thoughtful comments on my dissertation draft; Dr. David Alyward, who was my first inspiration toward mHealth in 2010 at the United Nations Foundation, for his encouragement for me to pursue a PhD program at Hopkins; Dr. Neff Walker and Dr. Ingrid Friberg for their advice and guidance for me to learn the Lives Saved Tool. I am very grateful for Esther Pak for her terrific support to review and edit the dissertation manuscripts with much encouragement and cheerful energy.

Special thanks to the Global mHealth Initative and the department of International Health – especially Yorghos Carabas, Carol Buckley, Cristina Salazar, Karla McCarthy for their help and kindness during my life at Hopkins. I also thank Dr. Jim Goodyear and Dr. Ann Riley for their encouragement and guidance for the Gordis Teaching Fellowship, which was an immensely rewarding experience to enhance my academic competencies.

I also thank my incredible peers and dear friends: Young-Eun Kim, Sung-Eun Choi, Holly Schuh, Sun-Eun Lee, Yunhee Kang, Esther Pak, Jinhee Hur, Lois Park, Manuela Villar, Jiho Cha, Goro Yamada, Shreya Pereira, Anshul Pachouri, Parichoy Chowdhury, Hyunggu Jung, Jongjae Lee, Suenghee Lee, Jiyong Dijkhuis, Nick Puts and many others for their gracious care, advice, and many lovely memories during my doctoral program. I am especially indebted to In Joong Kim for his trust, humor and emotional support in tackling all of the hurdles and challenges in this journey.

This PhD dissertation is dedicated to my late parents, Honghee Jo and Myoungja Ryu for their sacrifice and love for me to pursue my life goals and realize my fullest potentials. I am truly grateful to my extended families, grandmother, uncles, aunts, cousin sisters and brothers-in-law, for their care and love, always ensuring that I am not alone in any life challenge and achievements. Lastly, my relationship with God has ever been deepened during this time and I thank for His grace and promise, which have guided all the paths of my life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Appendix

ABBREVIATIONS

ANC	Antenatal Care
BDHS	Bangladesh Demographic and Health Survey
BIA	Budget Impact Analysis
BMRC	Bangladesh Medical Research Council
BRAC	Bangladesh Rural Advancement Committee
CI	Confidence Interval
CEA	Cost Effectiveness Analysis
CEAC	Cost Effectiveness Acceptability Curve
CHEERS	Consolidated Health Economic Evaluation Reporting Standards
CHW	Community Health Worker
CPI	Consumer Price Index
CRVS	Civil Registration and Vital Statistics
DALY	Disability Adjusted Life Year
DHIS	District Health Information System
ELCO	Eligible Couple
ENC	Essential Newborn Care
FWA	Family Welfare Assistant
FD	Facility Delivery
FWC	Family Welfare Clinic
FWV	Family Welfare Visitor
FPI	Family Planning Inspector
GDP	Gross Domestic Product
GNI	Gross National Income
HIS	Health Information System
ICER	Incremental Cost Effectiveness Ratio
ICT	Information Communication Technology
IMF	International Monetary Fund
IQR	Interquartile Range

ISPOR	International Society for Pharmacoeconomics and Outcomes Research
JHU	Johns Hopkins University
LiST	Lives Saved Tool
LMIC	Low and Middle Income Countries
LOE	Level of Effort
M&E	Monitoring and Evaluation
MCWC	Maternal and Child Welfare Clinic
MDG	Millennium Development Goal
MNCH	Maternal, Newborn and Child Health
MNH	Maternal and Newborn Health
MOHFW	Ministry of Health and Family Welfare
MWRA	Married Women of Reproductive Age
NCD	Non Communicable Disease
NGO	Non-Government Organization
OOP	Out of Pocket Payment
OpenSRP	Open Smart Register Platform
PNC	Postnatal Care
SBA	Skilled Birth Attendant
QALY	Quality Adjusted Life Year
SDG	Sustainable Development Goal
SMS	Short Message Service
SD	Standard Deviation
UHC	Upazila Health Complex
UHC	Universal Health Coverage
UN	United Nations
UNICEF	United Nations International Children's Fund
THE	Total Health Expenditure
WB	World Bank
WHO	World Health Organization

Chapter 1. Introduction

1.1 Problem statement

Efforts to improve access to health service delivery systems have taken many innovative approaches since the Alma Ata Declaration of 1978, which demonstrated a global consensus that "primary healthcare service improvements are necessary to achieve a minimum standard quality of life".[1] Much of the global disease burden and its impacts – especially maternal, newborn, and child deaths – could be addressed if existing, proven interventions were deployed at a large scale within a country's primary healthcare system. In many low- and middle-income countries (LMICs), however, the household coverage levels of these interventions are still low.

In light of the shortage of professional health workers and inadequate health infrastructures in LMICs, in the past decades, the use of community health workers (CHWs) has become an increasingly popular strategy to deliver primary health care at the community level.[2, 3] Many countries have developed large-scale national CHW programs (e.g. Pakistani Lady Health Worker program[4], Ethiopian Health Extension Worker system[5], and India Accredited Social Health Activist system[6]), recognizing the potential of CHWs to address several key obstacles of delivering primary health services beyond health facilities.[2, 7] CHWs, as members of the communities they serve, can facilitate informational and educational campaigns through existing social networks, enabling outreach to vulnerable populations such as women and children, who often have limited mobility and decision-making power.[8]

mHealth – the facilitation of improved healthcare services, health outcomes and provision of information via mobile and wireless technologies[9] – has created a unique opportunity to transform the way in which global health challenges can be tackled. In recent decades, numerous organizations have recognized the potential of harnessing mobile platforms[10, 11] and have begun to explore ways to employ mobile applications for strengthening the capacity of frontline health workforces and improving service access and quality in low-resource settings.[12]

Several pilot mHealth projects have been conducted around the world. Their evaluations have revealed positive results to improve access, quality, efficiency of health service delivery as well as intended health outcomes.[13] Yet, few of these successfully piloted innovations have been taken to scale, with fewer still scaled up in a sustainable way.[14] Growing concern with the number of mHealth programs, consisting largely of pilot projects or small-scale implementations, acknowledge that the failure is partly due to a lack of knowledge on how to deliver proven interventions at scale, how to build capacity in countries, and determining what resources are needed. Accordingly, policymakers and donors are demanding evidence on the costs and effectiveness of health innovations that can help investments and decision-making to obtain governments' buy-in and scale up mHealth programs in national health systems.[15]

Similar to many other LMICs, in Bangladesh, lack of access to quality health services and a shortage of skilled health professionals still remain major health system challenges.[16] The Bangladeshi government is recognizing the impact of mobile communication as an effective means of bringing healthcare services to the people, even to those in some of the most remote and resource-poor environments.[17, 18] In particular, given the fact that 70% of Bangladeshis live in rural areas and 85% of births take place at home[19], mHealth can be an effective solution for poor and marginalized populations, by increasing access to healthcare and health-related information.[20]

To achieve universal health coverage as part of the United Nations Sustainable Development Goals and a health reform agenda, the Bangladeshi government promotes innovative approaches for strengthening the health workforce.[21] A *Lancet* study also recommended community-based approaches and partnerships in pursuing innovations in health service delivery, through "rapid adoption of context-specific innovative technologies and policies that identify country-specific systems and mechanisms."[22] Since 2008, the government has promoted the Digital Bangladesh 2021 initiative, which places special emphasis on information communication technology (ICT) for a broad range of public services.[23]

This study presents evidence on the costs, consequences, and affordability of alternative packages of the mCARE program in Bangladesh, the core package of which includes pregnancy surveillance using mobile tools and scheduled SMS and CHWs' home visit reminders to promote utilization of essential maternal and newborn care services.[24] Comprehensive and systematic pregnancy surveillance is the first step for a continuum of care of maternal and newborn health services in the population and the integrated health information system within the health system. Surveillance can help determine the required amount of resources in financing, help the planning of when and how to distribute services in communities, ensure timely service and care administration, and facilitate management of treatment or crises. The addition of SMS reminders may serve to bolster timely and appropriate care-seeking, and ultimately save lives.

Our study supports the policy interest and vision of the Bangladeshi Ministry of Health by examining alternative strategies for harnessing the potential of mHealth to improve service delivery and bolster demand. The study intends to contribute to the evidence on economic evaluations and affordability of mHealth interventions in Bangladesh and globally, which is currently limited. The study also expects to contribute to the literature on implementation research of scaling up mHealth programs, by providing a feasible model and contextualized input parameters of mHealth programs in LMIC settings. Accordingly, the study findings can serve as evidence to develop strategies and guidelines to introduce proven, cost-effective innovations into a health system, and to promote large-scale use and sustainability.

1.2 Research goals, **questions***, objectives & hypothesis*

Research goals

The overall aim of this study is to examine the costs, consequences and affordability of alternative packages of the mCARE program in Bangladesh, the core package of which includes pregnancy surveillance using mobile tools and scheduled SMS reminders to promote utilization of essential maternal and newborn care services. The findings are intended to provide evidence to program managers and national policymakers for informed decision-making.

Research objectives

Objective 1: To determine the incremental cost-effectiveness of a comprehensive mCARE program of SMS and home visit reminders to promote care seeking of maternal and newborn health services, versus a basic mCARE program in rural Bangladesh.

Sub-objectives:

- To describe specific activities and resource requirements for program development, from start-up to implementation
- To evaluate program costs associated with the intervention and control groups
- To evaluate health impact associated with the intervention and control groups
- To determine an incremental cost-effectiveness ratio (ICER) between intervention and control groups

Objective 2: To forecast the incremental cost-effectiveness of a comprehensive mCARE program including pregnancy surveillance and care-seeking reminders, compared to paper-based systems, from 2016 to 2025 in the Rangpur Division of Bangladesh.

Sub-objectives:

- To develop scenarios and required input parameters
- To identify data sources and assumptions of input parameters associated with each scenario
- To determine program costs associated with each scenario
- To determine provider and user costs associated with each scenario
- To evaluate health impact associated with each scenario
- To determine ICERs among the following scenarios: comprehensive mCARE program, basic mCARE program, and paper-based groups

Objective 3: To determine the affordability of a comprehensive mCARE program implementation, compared to a paper-based system, over the 2015-2020 period in Gaibandha district in Bangladesh.

Sub-objectives:

- To develop scenarios and required input parameters
- To determine the affordability curve
- To determine the cost-effectiveness affordability curve

- To determine the financial expenditures of implementing the program
- To estimate the budget impact on nationwide scale-up of the program in the context of national health expenditures

1.3 Organization of the dissertation

Below is an overview of consecutive chapters.

Chapter 1 provides the problem statement, study goal and objectives, and organization of the dissertation.

Chapter 2 provides background on the country of Bangladesh to understand the research context. It presents the demographic and epidemiologic profiles of the country and an overview of health system governance and financing as well as the country's health information systems.

Chapter 3 summarizes the literature on mHealth and economic evaluation. This section describes the opportunities and challenges associated with mHealth in low- and middle-income countries (LMICs), economic evaluation in public health, eHealth and mHealth economic evaluation, and cost-effectiveness studies of maternal and newborn health (MNH) services in LMICs.

Chapter 4 explains the methodologies used in the study, describing the preparation, data collection and analysis strategies for both costing and effectiveness, and cost-effectiveness analyses steps based on a standardized guideline.

Chapters 5-7 present the analysis and findings of the four research objectives. Chapter 5 examines the cost-effectiveness of the comprehensive versus basic mCARE programs;

Chapter 6 forecasts the cost-effectiveness of the comprehensive mCARE program implemented at scale across one district as compared to existing paper-based systems; Chapter 7 provides an evaluation of the affordability and financial impact of the comprehensive mCARE program.

Chapter 8 summarizes the main findings, discusses the relevance of the study results and describes challenges of the study, policy and program implications, and recommendations to policymakers in Bangladesh and the Ministry of Health. This chapter also describes strengths and limitations of the study, suggests future areas of research, and offers a conclusion.

Chapter 2. Background

2.1 Demographic and epidemiologic profile of Bangladesh

Country overview (geographic, political, economic overview). Bangladesh is a country located in South Asia and is one of the world's most densely populated countries, with a population of more than 160 million in a land mass of 147,570 square kilometers.[25] Bangladesh is a lower-middle-income country with a gross national income (GNI) per capita of $1,190 and an estimated gross domestic product (GDP) per capita of $1,572.[26] About 50% of the population live with an income of less than $1 a day and two-thirds live on the agricultural industry in rural areas. Income inequality is high in the country, with a Gini coefficient index of 33.2 – the 11th largest in the world.[26] Despite a number of major challenges the country faces, including poverty, corruption, political turmoil and frequent natural disasters, the past decade has been marked by sustained growth, stable macroeconomic management, a significant reduction of poverty, rapid social transformation, and in particular, human development. Bangladesh has made more notable gains in a number of health indicators especially when compared to some of its neighboring countries that have higher income per capita, such as India and Pakistan.[1][28][29]

[1] "During the past decades, Bangladesh has made more notable gains in a number of indicators than some of its neighboring countries, which have higher per capita income. For instance, GDP per capita in Bangladesh ($1,777) was half that of India ($3,650) in 2011, and lower than that of Pakistan ($2,567), yet average life expectancy, percentage of children immunized against diphtheria and measles, and the literacy rate for young women were higher in Bangladesh than in Pakistan and in India (Baxter, 2003). In the two decades between 1990 and 2010, under-five mortality has fallen by more than 60%, while infant mortality and neonatal mortality have declined by around half (Table 1.3). The under-five mortality rate (46 deaths per 1,000) in Bangladesh is significantly lower than India (41 per 1,000) and Pakistan (86 per 1,000)." Source: World Health Organization, *Bangladesh Health System Review.* 2015: p. 1-214.

Demographic status. Bangladesh's population has gone through the second stage of its demographic transition (i.e. the population grows rapidly as the death rate begins to fall while birth rates remain high) and is now in the third stage of the transition (i.e. the population growth rate decreases as birth rates start to decline).[30] The population growth rate has declined to 1.7% due to continuous reductions in mortality and fertility rates over the past decades. Yet, the population is expected to continue growing due to a large population of reproductive age (Figure 1.1). While the mortality and fertility rates remain relatively high compared to other countries, Bangladesh has made significant progress in reducing maternal and child mortality rates as well as the fertility rate. According to UNICEF's 2009 estimates, the crude death rate is 7 per 1,000 and crude birth rate is 21 per 1,000 (Table 1.1). Total fertility rate is 2.3 births, and life expectancy at birth is 66 years. During the 1960s and 1970s, Bangladesh's population growth rate was among the highest in the world at 2.5%, and the total population nearly doubled during the two decades from 65 to 110 million.[30] However, the population started to decrease since the 1980s due to a considerable reduction in fertility through successful family planning and birth control programs, and as a result, population growth has declined to about 1.5%.[30]

Epidemiologic transition. With the decline in birth and death rates and an increase in the proportion of mortality due to noncommunicable diseases (NCDs), Bangladesh has entered the epidemiological transition.[31] Bangladesh now faces a double burden of disease with acute, infectious, and parasitic diseases as well as noncommunicable, degenerative and chronic diseases. There has been a substantial change in the leading causes of mortality in Bangladesh over the last two decades. Mortality from communicable, maternal, neonatal and nutritional disorders fell dramatically from 583 deaths per 100,000 in 1990 to 178 deaths per 100,000 in 2010. This decline was principally the result of decreases in childhood infectious diseases, together with declines in maternal mortality and nutritional deficiencies. Mortality rates from NCDs remained steady at around 360 deaths per 100,000 population.[32] However, death rates from cardiovascular and circulatory diseases, including ischemic heart disease rose. Death rates from cancers and other NCDs remained fairly steady. Mortality rates from injuries also fell significantly during this period.[34]

Progress in health status. Bangladesh has made sustained and remarkable progress in many areas of maternal and child health in recent decades. The country is one of only nine Countdown countries that were on a successful track to achieve the fifth Millennium Development Goal (MDG) by 2015.[33] The maternal mortality rate significantly decreased from 322 deaths per 100,000 live births between 1998 and 2001, to 194 deaths per 100,000 live births from 2007 to 2010, an annual rate of decrease of 5.6%.[33] In terms of child (age 12-59 months) health, Bangladesh is one of the few countries that were on track to achieve MDG 4 (reducing the under-five mortality rate by two-thirds by 2015). The significant progress in improving child health has reduced the country's child mortality rate by more than half, from 133 deaths per 1,000 live births in 1990 to 53 deaths per 1,000 live births in 2011.[34] The infant mortality rate has also declined considerably, from 87 per 1,000 live births in 1990 to 43 per 1,000 in 2011.[27] There are several factors that have contributed to the significant improvement in maternal and child health in Bangladesh.[27] Among them are improved access to essential health programs such as the Expanded Program on Immunization (EPI), oral rehydration therapy (ORT), and antenatal care (ANC), the use of skilled birth attendants and family planning, higher levels of women's education, and improved economic conditions.[21, 22]

Remaining challenges. Although it is improving, the maternal health status remains poor for many women in Bangladesh. Around 50% of Bangladeshi women suffer from chronic malnutrition with a body mass index less of than 18.5.[34] Low birth weight incidence is estimated at 45%, and multiple micronutrient deficiencies are often found among pregnant women. In terms of causes of maternal deaths, 69% are due to direct obstetric causes, 14% are related to injury and violence, leaving 17% of maternal deaths due to indirect causes.[34] The most common obstetric causes of maternal deaths are postpartum hemorrhage (31%), eclampsia (20%), complications of unsafe abortion (1%), obstructed labor (7%), and postpartum sepsis (5%), and other direct and indirect causes (35%).[35] Currently, neonatal (a life less than one month) deaths contribute to more than two-thirds (70%) of infant (a life less than one year) deaths and more than half (57%) of under-five deaths in Bangladesh.[36][37] Neonatal mortality declined at a slower pace than infant and child mortality over the last 20 years. Each year 171,000 neonates die in the country, the majority in the first month of life, with the most common cause of death being serious infections (24%), followed by birth asphyxia (21%), pneumonia (13%), and pre-term birth (11%).[34] The majority of these deaths occur in low-resource settings where most births occur at home. These neonatal losses can be prevented with simple interventions or behavior changes such as exclusive breastfeeding or home-visiting postnatal care after childbirth.[38]

Essential maternal and newborn care. Increased use of antenatal care (ANC) can potentially help decrease the high maternal mortality ratio. However, nearly two-thirds (63%) of mothers do not receive quality ANC in Bangladesh. The percentage of women who have had at least one ANC visit is 51% (among the total pregnant population), and the percentage having had at least four visits is only 21%. Within the small population receiving ANC, the difference between rural and urban areas is high. 59% of urban mothers receive ANC, while in rural areas only 28% do.[39] Many studies suggest that delivery of a child with a skilled birth attendant is one of the most important health interventions in reducing maternal mortality.[40] However, in Bangladesh only 31% of births are delivered at health facilities, and skilled attendants assist only 41% of women during childbirth. Furthermore, almost 62% of births are delivered at home, often in unsafe and unhygienic conditions. Traditional birth attendants assist 56% of births.[41] Again, there are significant differences depending on area of residence – professionally trained health workers attend 64% of births in urban areas, compared to only 8% in the rural areas.[34] The status of postnatal care (PNC) is even worse than ANC among poor mothers who do not deliver at a health facility – only 8% receive PNC. In 2004, only 18% of mothers received (PNC) from a trained provider within six weeks after delivery. There is a great room for improvement of maternal and newborn care in Bangladesh, much of which could be addressed by increasing access to ANC and PNC services.

2.2 Health systems in Bangladesh

The governance of the public health system in Bangladesh is complex . The system remains highly centralized, with planning undertaken by the Ministry of Health and Family Welfare (MOHFW) and little authority delegated to local levels. The organizational structure of health services in Bangladesh follows the general administrative division of the country. While the MOHFW is responsible for overseeing, managing and regulating health, family planning and nutrition programs countrywide, health services are delivered by a complex mix of public and private institutions. For example, different ministries are responsible for primary health care in rural and urban areas. The MOHFW directly oversees primary healthcare facilities in rural areas, and the Ministry of Local Government, Rural Development and Cooperatives (MOLGRDC) is responsible for the urban areas. Family planning services are managed and delivered separately from other health services at all levels of the public health system.[27, 42]

Public health system. Bangladesh's public health system, which was established during the 1970s, reflects the country's general administrative pattern.[50] The MOHFW directly oversees a network of health facilities (see Figure 2.1), which stretches from the national level down through seven divisions, 64 districts, 485 sub-districts (known as Upazilas), 4,501 unions and 13,503 wards.[50] Bangladesh has a well-established network of public health facilities across the country from field-based domiciliary services and facilities at different levels like village (e.g. community clinics), union (e.g. union sub-centers, union health and family welfare centers, etc.), Upazila (e.g. 31-50 bed Upazila health complexes), district (100-250 bed district hospitals), division (250-500+

bed medical college hospitals) and several specialized hospitals (mostly in Dhaka).[27] The number of heatlh personnel in the public system is more than 100,000, including doctors, nurses, paramedics and community health workers; this accounts for 26% of the country's total health expenditure.[43, 44]

Nongovernmental organizations. There is also a substantial private not-for-profit health care sector. Largely enabled by donor funding, nongovernmental organizations (NGOs) have played an enormous role in Bangladesh since the country's independence in 1971, stepping in to deliver health care services, respond to famine and natural disasters, and fight poverty during a time when the country lacked strong public institutions. There are more than 2,000 local and international NGOs working on health in Bangladesh [45], and many focus on providing primary health care services to the poor, including in urban slums. In 2007, 9% of the country's total health expenditure was managed by NGOs.[27]

Private Sector. Alongside the public system in Bangladesh is a large and heterogeneous private sector. The private spending accounts for more than three-fifths of the country's total expenditure on health.[27] The private for-profit sector has been growing steadily in line with rapid urbanization. Some 45,000 formally trained doctors and nurses are employed in private secondary and tertiary care facilities.[44] However, private services are poorly regulated.

Informal sector. There is a large cadre of health care providers in the country's informal sector. This comprises semi-qualified allopathic providers (e.g. community health workers, medical assistants, trained midwives), unqualified allopathic providers (e.g. drug shop retailers, rural doctors), traditional healers (e.g. practitioners of Ayurvedic, Unani and homeopathic medicine) and faith healers.[43] It is estimated that there are more than 500,000 traditional medical and homeopathic practitioners, village doctors and drug vendors working, largely unregulated, countrywide.[43] They are not a part of the mainstream health system, and the quality of their services cannot be properly monitored. However, given that they comprise a major source of healthcare provision for the poor rural population, circumstances force the poor to compromise quality of healthcare, especially in remote rural and hard-to-reach areas.

Health financing. Health services in Bangladesh are predominantly financed by households' out-of-pocket payments, comprising 64% of total health expenditure. Of the remaining 36% coming from public financing, about 60% is financed by the government from tax revenues and development outlays, and the remaining 40% through international development assistance.[27] In 2012, total health expenditure accounted for 3.6% of the country's GDP, lower than the average of 5% for other low-income countries, and well below the global average of 9.2%. Public allocations to fund the health sector comprised around 7.7% of total government expenditure. This was slightly lower than the average of 8.1% for other low-income countries and well below the global average of 15%. Donor financing accounted for only 7% of total health sector expenditure in 2012. This was considerably lower than the average for low-income countries, 28%.[27, 46]

2.3 Health information systems in Bangladesh

Digital Bangladesh. Being the world's eighth largest country in terms of population, there are 134 million mobile phone users and 53 million Internet users in Bangladesh. The population is predominantly rural, with almost 80% living in rural areas and with limited access to education, health care, clean drinking water and proper hygiene. Most people living in the countryside are excluded from many of the facilities available in urban areas. The rapid spread of Information and Communication Technology (ICT) in Bangladesh over the past decade offers opportunities to solve some of these problems. In this vein, the country has declared its national vision on Digital Bangladesh 2020 since 2007, which promotes the use of information technology (IT) for management, administration and governance to ensure transparency, accountability and accessibility at all levels of society and state.[18][47] The government's effort to modernize Bangladesh through an ICT initiative was highly acclaimed by the world community. Bangladesh received the ICT's Sustainable Development Award in 2015 from the International Telecommunication Union (ITU) and the South-South Cooperation Visionary Award in 2014 from the United Nations for effectively using ICT in public service delivery and improving people's lives, and in 2015 the nation was elevated from the World Bank's low-income status to lower-middle-income status.

There are a number of areas and ongoing initiatives where ICT can tap into the potentials not only within health but also in education, agriculture, climate change, and mobile banking**.** For instance, in the health sector, lack of access to quality health services and a shortage of skilled health professionals are major system challenges in Bangladesh.

mHeath – the facilitation of improved healthcare services via mobile and wireless technologies – has the potential to open access and deliver healthcare services at low costs in collecting surveillance data, sending SMS text messages for health promotion, using sensors for diagnostic support or using calls for basic consultation.

In the education sector, ICT can harness the potential of Bangladesh's large unutilized and unemployed youth workforce through technical and vocational education and training by employing appropriate education and training into a skilled, "ICT-capable" labor force. The use of ICT can also help poor, remote populations and women access education and gain skills that can increase their chances of finding better employment.

A third area where ICT can provide value is the agriculture sector, which by itself employs 44% of the labor force and comprises around 21% of the total GDP. ICT can help provide important information to farmers such as weather forecasting, production and cultivation advice about diseases and insects, and the latest information on price. ICT can empower rural farmers to make informed decisions about their production and can facilitate market linkages by connecting them to distributors and retailers.

Climate change is another area in which ICT can have a positive impact. Bangladesh is highly vulnerable to climate change and recurrent natural disasters such as floods, cyclones or riverbank erosion due to its location and topography. Besides the traditional ICT media such as radio or television, rapid advancement in ICT in the form of the Internet, Geographic Information System (GIS), remote sensing and satellite-based communication can facilitate the process of preparedness, response and mitigation through better forecasting, early warning systems, and effectively coordinating relief efforts.

Fifth and finally, ICT can make mobile banking more effective. About 60% of Bangladeshi adults do not have any formal bank account, which limits access to financial services. Moreover, around 6 million Bangladeshis work abroad and send about $13 billion annually back to their families, which accounts for more than 10% of the country's GDP.[48] Mobile banking can allow millions of previously unbanked people and migrant workers to send remittances via mobile phone to family members in the villages from which they came.

eHealth/mHealth initiatives. A recent study showed that there are 26 eHealth and mHealth initiatives in Bangladesh.[49] Popular eHealth programs include "video conferencing, a uniquely designed monitoring cell at health management information system (MIS) in reducing doctors' absenteeism from remote health facilities; telemedicine networks over eight hospitals; free-of-charge mobile phone health services available in all of 418 Upazilas and 64 district hospitals". [44] There are also a number of mHealth services, such as SMS-delivered advice for safe pregnancy, and use of mobile phones as a data collection tool. The most common initiatives include tele-consultation, prescriptions and referrals.[49]

Bangladesh is beginning to establish country-level health information systems such as District Health Information Systems (DHIS2) and Open Medical Record Systems (OpenMRS) that enable national aggregate record-keeping and facility-level medical records via a robust, low-cost, open-source platform. OpenMRS is a powerful tool for data collection, allowing huge amounts of detailed information to be compiled about individual cases. DHIS2 is a tool for aggregating, compiling and analyzing data. By June 2014, data was being captured directly in DHIS2 at more than 4,500 health facilities from the national level down to the union level, and at 3,500 of the country's 13,500 community clinics.[50]

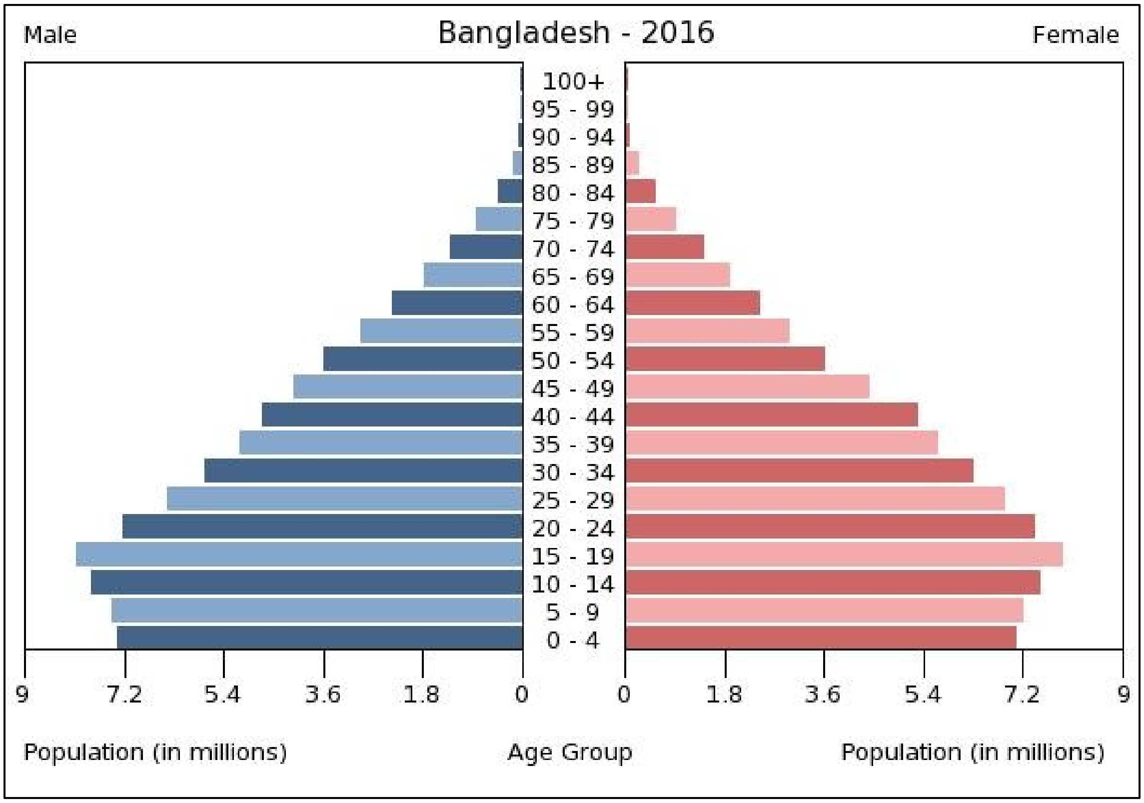
Other initiatives both within and outside the health sector such as MOVE-IT (Measurement of Vital Events through IT)[51], NPR (National Population Register) and Civil Registration (Birth and Death Registration) can help improve data availability and utilization. Recently, the Prime Minister's Office started to receive sufficient resources for SDMX-HD (Statistical Data and Metadata Exchange-Health Domain) from WHO (which provides a standard set of core indicators with data definitions, standards, standard sources of data, mechanisms of data collection, utilization of data, and more), ICD-10 (International Classification of Diseases)[52], HL7 (vocabularies of health information communications), Open MRS and Care2x (Open source software for Hospital Information System)[53], iHRIS (Open source software for Integrated Human Resource Information System), and Open ELIS (Open source software named District Health Information System version2) for collecting public health program data.[50]

Challenges of health information system (HIS). Bangladesh's HIS is highly fragmented. Each health care provision sector has their own routine data collection method with various service delivery channels. For example, the public sector operates a routine surveillance and multiple information systems, connecting different level of health facilities. Large NGOs, such as BRAC, have their own information systems, often designed to meet the monitoring and evaluation requirements of donor agencies. Other private providers use their own systems for various purposes such as managing patient records, drug supplies and human resources.[50] Each system uses its own platforms, definitions of terms, standards for capturing data and procedures for collecting and analyzing information. The result is siloed data, which makes it challenging to understand population health and health system performance in a given region.[50]

By collecting data on the same indicators yet using their own systems, different departments and programs would generate differing results. Multiple overlapping reporting systems result in unnecessarily heavy paperwork and poor data quality, which affects timeliness, completeness, and accuracy. The data may be useful to those running individual information systems, but this method of information collection makes it extremely challenging to obtain an accurate overview of service coverage distribution of antenatal care, delivery care, or treatment of sick children by different types of providers. As a result, these health data are rarely used for national-level health planning. Such weak routine information systems also hamper the management of health services at a decentralized level. Local health planners or facility managers are less likely empowered and seldom use data to improve outcomes in their facilities from such one-way information flows – “where data is collected at the point of delivery, then compiled into summary reports and sent upwards through vertical hierarchies”.[50]

An effective health information system brings together information from a wide range of population- and facility-based data sources – censuses, civil registration systems, population surveys, health service records and health facility surveys – to generate an up-to-date information of the population health.[54] Further, the performance of a country’s health information system depends not only on data sources, but also upon certain policy, administrative and organizational prerequisites, which allow the institutions that produce and use health information to interact effectively with one another. In Bangladesh, the absence of these prerequisites and fragmented health information systems have prevented policymakers from monitoring population health in a timely manner and targeting interventions accordingly.[55]

Figure 2.1 Population pyramid for Bangladesh



Reference: US Census Bureau.
(URL: http://www.census.gov/population/international/data/idb/country.php Retrieved February 5, 2017)

Table 2.1 Demographic and economic indicators for Bangladesh

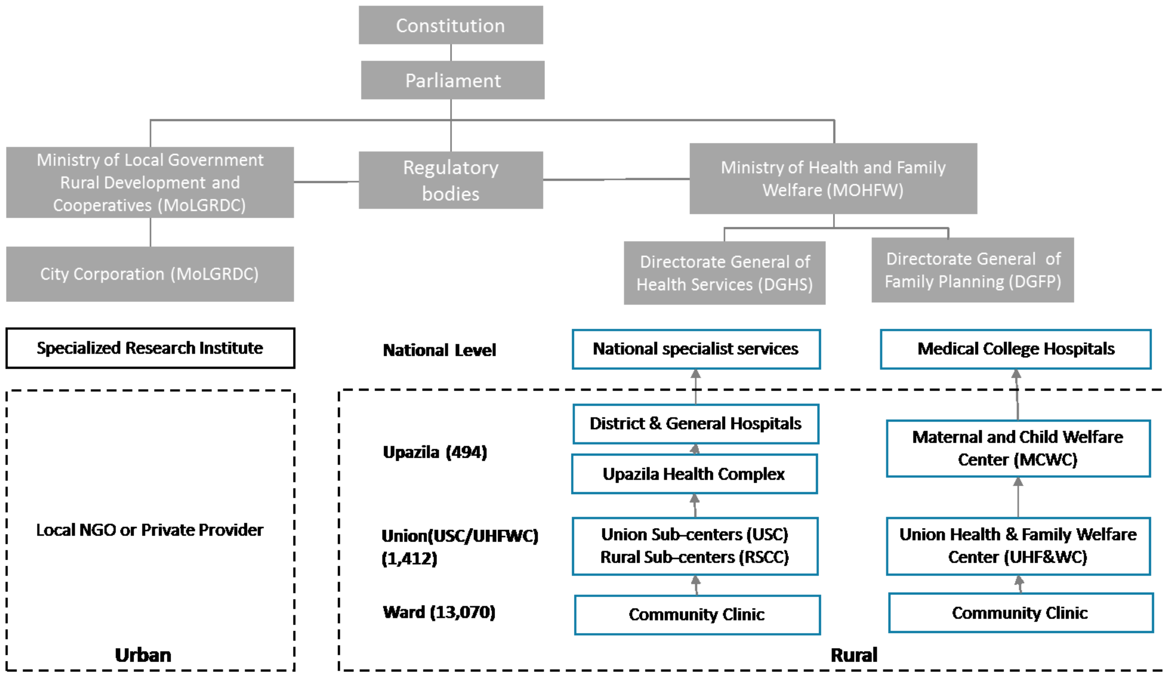
Indicators	Year	Value	Source
Demographic Indicators:			
Total population	2015	160,995,642	World Bank
Annual population growth rate (%)	2016	1.02	U.S. Census Bureau
Sex ratio (male/female)	2015	1.026	Bangladesh Health Bulletin
Population growth rate	2015	1.37%	Bangladesh Health Bulletin
Population density (people/sq km)	2015	1108	World Statistics Pocket Book Series
Distribution of population (rural/urban)	2014	Rural: 66.5% Urban 33.5%	World Urbanization Prospects
Crude death rate (per 1,000 population)	2014	5.40/1,000	World Bank
Crude birth rate (per 1,000 population)	2014	19.80/1,000	World Bank
Life expectancy at birth	2015	71.63	Human Development Report
Urban population (% of total)	2014	34.28%	World Bank
Total fertility rate	2014	2.18	World Bank

Contraceptive prevalence, any methods (% of women ages 15-49)	2015	62.4%	World Bank
Total adult literacy rate (population 15+ years) (%)	2014	61.49%	
Economic Indicators:			
GDP (current US$)	2015	$195.079 billion	World Bank
GNI per capita, Atlas method (current US$)	2015	$1,190	UN Data
% population with an income of less than $1.25 PPP per day	2010	43.3%	World Bank
Health expenditure, public (% of total health expenditure)	2014	23.1%	World Bank
Health expenditure, public (% of government expenditure)	2014	15.91%	World Bank
Health expenditure, public (% of GDP)	2014	5.99%	World Bank
Out of pocket payments as proportion of total health expenditure	2014	63.3%	World Bank
Voluntary health insurance as proportion of total health expenditure	2015	0.1%	Bangladesh National Health Accounts
Proportion of households experiencing catastrophic health expenditure	2013	9%	Rahman MM et al [56]
IBRD/IDA Operations Approved by Fiscal Year	2016	$493.71 million	
Income or wealth inequality (Gini coefficient)	2015	32.1	Human Development Report
Healthcare Workforce Indicators:			
Number of doctors per 1,000 population	2006	0.26	World Health Report
Number of nurses per 1,000 population	2006	0.14	World Health Report
Estimated number of community health workers per 1000 population	2013	1.37	El Arifeen et al[57]
Relative geographical distribution (rural/urban) of doctors/nurses/community health workers (CHWs), respectively	2011	Doctors: 1.1/18.2 Nurses: 0.8/5.8 CHWs: (Govt) 3.6/2, (NGO) 49.5/10.1	Ahmed SM et al.[58]
Proportion of informal providers, and practitioners of traditional complementary and alternative medicine (TCAM), out of the total health care workforce	2011	Semi-qualified (allopathic): 4.29% Unqualified (allopathic): 2.39% Traditional: 6.42% Homeopath: 0.59% Others: 0.17%	Ahmed SM et al.[58]

Table 2.2 Burden of disease in Bangladesh

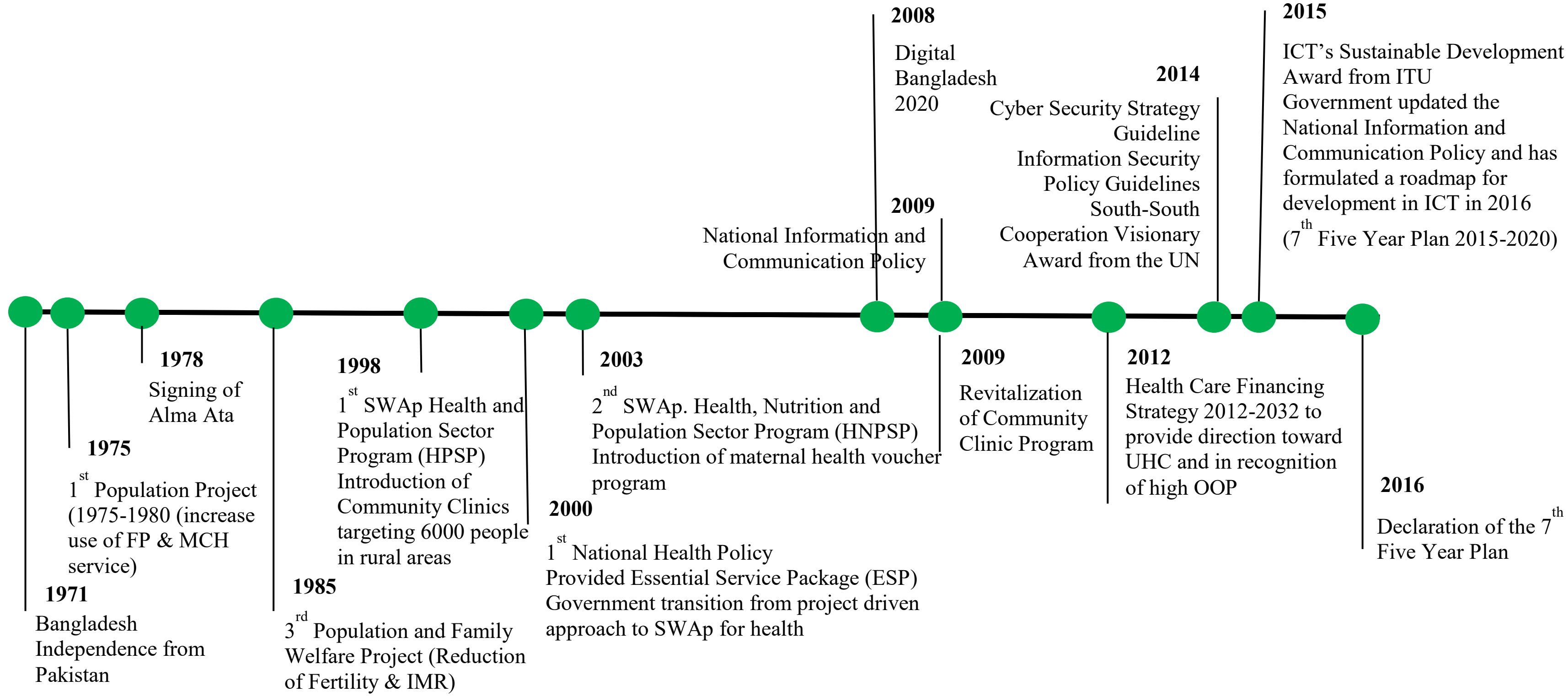
	Value	Reference
World Health Organization region	South-East Asia Region	WHO
Mortality stratum	Sear-D	WHO
Three most populous countries in this stratum (Under-five mortality rate)	Country 1: India (69) Country 2: Bangladesh (52) Country 3: Myanmar (98)	UNICEF 2008
Total DALYs lost in this stratum	426,573	World Health Report
DALYs lost to communicable, maternal, perinatal & nutritional diseases/conditions	184,649 (43.2%)	World Health Report
Top three causes of DALY loss for this category	Infectious and parasitic diseases (88,953 DALYs Perinatal conditions (39,147 DALYs) Respiratory infections (33,026 DALYs)	World Health Report
DALYs lost to non-communicable diseases/ conditions	186,376 (43.7%)	World Health Report
Top three causes of DALYs lost for this category	Neuropsychiatric conditions (48,314 DALYs) Cardiovascular diseases (42,987 DALYs) Sense organ diseases (22,368 DALYs)	World Health Report
DALYs lost to injuries	55,547 (13%)	World Health Report
Top three causes of DALY loss for this category	Unintentional injuries (Road traffic accidents) (10,016 DALYs) Intentional injuries (Self-inflicted) (7,191 DALYs) Unintentional injuries (Fires) (6,554 DALYs)	World Health Report
Maternal mortality ratio (per 100,000 live births)	176	The World Bank (2015)
Infant mortality rate (per 1,000 live births)	31	The World Bank (2015)
Under-5 mortality rate (per 1,000 live births)	38	The World Bank (2015)
Top five main causes of death (ICD - 10 classification)	Diseases of the circulatory system (33.2%) Perinatal conditions (15.93%) Diseases of the respiratory system (13.9%) External causes (injuries) (11.02%) Injury & poisoning (9.26%) Diseases of the nervous system (3.89%)	Bangladesh Health Bulletin 2014. Note: Figures based on combined reports from all public hospitals in Bangladesh and classified according to ICD 10.

Figure 2.2 Governance and health service architecture for Bangladesh



Source: World Health Organization. Julie Evans and Md. Imtiaz Alam B. Pharm, PRIMARY CARE SYSTEMS PROFILES & PERFORMANCE (PRIMASYS): Bangladesh Case Study. http://www.who.int/alliance-hpsr/projects/AHPSR-Bangladesh-300916.pdf

Figure 2.3 Timeline of relevant policies to primary healthcare and 'Digital Bangladesh'



Source: Modified from World Health Organization. Julie Evans and Md. Imtiaz Alam B. Pharm, PRIMARY CARE SYSTEMS PROFILES & PERFORMANCE (PRIMASYS): Bangladesh Case Study. http://www.who.int/alliance-hpsr/projects/AHPSR-Bangladesh-300916.pdf

Chapter 3. Literature review

3.1 Remaining challenges in maternal and newborn health in low- and middle-income countries

Globally, about 830 women died every day in 2015 due to complications related to pregnancy and childbirth, resulting in more than 303,000 maternal deaths a year[59], with 99% of these deaths occurring in developing countries.[60] Of such deaths, the largest proportion is avoidable complications such as obstetric hemorrhage, mostly during or just after delivery, followed by eclampsia, sepsis, complications of unsafe abortion or indirect causes such as malaria and HIV.[61] Additionally, nearly 3.5 million babies die each year in their first month of life from largely preventable or treatable conditions such as birth asphyxia, prematurity and neonatal infections.[62] As the United Nations Millennium Development Goals (MDGs) 4 and 5 had set country targets to reduce the maternal mortality ratio (MMR) by three-quarters and the under-five mortality rate (U5MR) by two-thirds by 2015, governments have sought to identify promising solutions to improve the delivery of effective life-saving interventions, although often with limited financial and human resources.

3.2 mHealth opportunities and challenges in low-and middle-income countries

Opportunities for mHealth. "mHealth enables the facilitation of improved healthcare services, health outcomes and provision of information via mobile and wireless technologies.[63], thereby creating a unique opportunity to transform the way in which global health challenges can be tackled. At the end of 2013, there were more than 6.8 billion mobile subscriptions worldwide, with 89% in developing countries.[64] Most people living on no more than $1 per day have access to mobile phones, which have leapfrogged the pace of conventional landline infrastructure development. Numerous organizations have recognized the potential of harnessing mobile platforms[11] and are exploring ways to employ mHealth innovations to improve the delivery of maternal and neonatal health interventions and practices. Among the persistent health system challenges of improving maternal and newborn indicators are the lack of timely and actionable disease surveillance, a shortage of professional health workers, delays throughout the health delivery system, poor supply chain management and use of counterfeit drugs.[65] Driving the many experiments with mHealth is a belief that such strategies can help to overcome health system challenges through improved access, efficiency and quality while reducing cost and time.[66] mHealth initiatives also show promise in reaching underserved populations, particularly those in the developing world, changing health behaviors and outcomes, and addressing a wide variety of healthcare challenges.[10] The mobile platform presents the unique capability to strengthen the role of community health workers (CHWs) to deliver higher quality healthcare services wherever people are –not just in healthcare facilities".[2][67, 68]

Key functions of mHealth in developing countries can be categorized into three types: 1) Data collection for surveillance (e.g. risk assessment and classification, vital event tracking)[69][70][71]; 2) SMS reminders for health promotion or service

[2] An excerpt from a published article by the author: Jo et al. Using the Lives Saved Tool (LiST) to Model mHealth Impact on Neonatal Survival in Resource-Limited Settings, PLOS One, 2014.

adherence[72][73][74]; and 3) Emergency medical referral[75] and point-of-care support[76], often through two simple functions, voice communication[77] and texting[78], and sometimes with customized applications linked to more complex back-end, or server-side, messaging and information services. One key mHealth function is data collection for census enumeration or disease surveillance. Some studies show positive benefits in terms of reduction of errors and time as well as cost savings compared to paper-based systems.[79] For example, Mobile Technology for Community Health (MOTECH)[80][81] and Cell-PREVEN[82] used mobile phones and personalized digital assistants (PDAs) for data collection and automated patient tracking management to help CHWs register, identify, and track women and newborns in their area who need healthcare services. In a similar fashion, mobile phone applications can be used for decision support in treatment compliance. For example, Electronic Integrated Management of Childhood Illness (eIMCI)[83] has been used to guide point-of-care support to reduce mortality and morbidity among children under five years of age. The system is designed for CHWs to adhere to standardized Integrated Management of Childhood Illness (IMCI) protocols, developed by the World Health Organization and UNICEF.[84][85]

A second key function of mHealth is the use of SMS applications to promote healthy behaviors by helping patients adhere to timely drug intake, and reminding them of appointments. For example, during the maternal postpartum or neonatal postnatal period, Mobile Alliance for Maternal Action (MAMA)[78, 86][87] and Mobile for Reproductive Health (m4RH)[88] used voice communication and SMS texting to remind clients of their scheduled antenatal care (ANC) or postnatal care (PNC) visits and to promote behavior change communication (BCC) messages in the antenatal or early pregnancy period. To improve child health, Interactive Research and Development (IRD)[89], mTika[90] and M-SIMU[91] "use text messaging systems with cash incentives to facilitate routine immunization programs, sending reminders to registered parents when their child is due for immunization and/or to provide health promotion notifications for immunization campaign days. These programs help improve health-seeking and preventative behaviors of pregnant women, new mothers and their families such as antenatal care attendance, immediate exclusive breastfeeding, wrapping of the newborn, clean postnatal practices, and danger sign recognition". [3]

mHealth can also facilitate emergency medical referrals. One way is by using a hotline to allow patients to request a service during an emergency crisis. The success of this type of mHealth strategy requires a well prepared, timely, organized health system that includes transportation access, medical commodities and equipment and skilled health professionals. In Uganda, the Rural Extended Services and Care for Ultimate Emergency Relief (RESCUER) Project[92] demonstrated the improved referral practice between traditional birth attendants and health posts to a large number of pregnant women, which led to a reduction of about 50% in the maternal mortality rate (MMR) in three years (although the evaluation was not based on an exclusive attribution to the mHealth intervention).

---

[3] An excerpt from a published article by the author: Jo et al. Using the Lives Saved Tool (LiST) to Model mHealth Impact on Neonatal Survival in Resource-Limited Settings, PLOS One, 2014.

Challenges of mHealth implementation. Ideally, mHealth strategies are expected to tackle both supply and demand side barriers in health systems. However, in reality, there may be multiple barriers on the ground that are challenging to overcome. First and foremost, stable Internet is critical to be able to use mobile phones, as is wireless technology and electricity connections. While the increasing use of mobile phones is widespread in many developing countries, critical challenges remain in remote or rural areas. In addition to limited or no network connectivity, many countries lack a common technical architecture that would enable interoperability and scale.[93] In this respect, studies and practitioners emphasize the need for an agreed mHealth and eHealth technical architecture, including data exchange standards, to overcome barriers to integration and interoperability with relevant national health systems.[93] It is critical not only to enhance country ownership but also managing policy, business rules and incentives for entrepreneurship or public-private partnerships and information flow for better health provision.[93]

Furthermore, given the multifaceted complexity and logistical challenges of scaling up health services, the effectiveness of mHealth is significantly affected by fundamental conditions of health systems. These include stable technological platforms, literacy of the population, availability of well-trained healthcare providers, consistent and affordable drug supplies and geographical access to health facilities. For instance, while SMS reminders or call referrals could promote skilled birth attendance or facility delivery (SBA/FD), if geographical accessibility or availability of skilled health professionals are lacking, then an mHealth strategy is likely to have limited impact. Alternatively, if health systems constraints are more related to low service utilization but not availability, accessibility, and affordability, then the reminder strategy may be able to effectively increase service uptake. Therefore, health systems strengthening as a whole would be critical to the success of mHealth for treatment compliance, since reminders to attend clinics in the absence of reliable services and a steady drug supply would not lead to desired outcomes. "In this respect, some successful mHealth strategies may incorporate additional incentive mechanisms (e.g. conditional cash transfer, voucher programs)[94, 95] or access mobilization strategies (e.g. ambulance services)[96] together to promote care-seeking practices or facility delivery for pregnant women living in remote areas."[4]

3.3 Economic evaluation in public health

In public health, policymakers are increasingly faced with difficult decisions with scarce resources and growing demand for healthcare services under financial constraints.[97] Such financial constraints are much more binding in developing countries. In this respect, economists argue that achievement of greater efficiency from scarce resources should be a major criterion in priority setting. Economic evaluation attempts to identify ways in which scarce resources can be allocated efficiently. Efficiency is concerned with how to compare between resource 'inputs' (costs, labor, capital or equipment) and intermediate or final 'outputs' (coverage of service provision or a number of lives saved).[98] Types of economic efficiency can be categorized based on the three different purposes of choice; 1) Technical (operational) efficiency, which concentrates on maximizing the

[4] An excerpt from a published article by the author: Jo et al. Using the Lives Saved Tool (LiST) to Model mHealth Impact on Neonatal Survival in Resource-Limited Settings, PLOS One, 2014.

achievement of a given objective within a given budget – “doings things right”; 2) Productive efficiency: choosing different combinations of resources to achieve the maximum health benefit for a given cost; 3) Allocative efficiency: a broader concept that focuses on choosing the *optimal* mix of interventions for a given level of expenditure, in the sense that they maximize health gains in a societal perspective – “doing the right things”.[99] Ultimately, the best choice in decision-making in economic efficiency implies that society makes choices that maximize the health outcomes gained from the resources allocated to healthcare.[100]

Determining the *best* in the context of utilitarian philosophy suggests that economic evaluation of healthcare programs consist of four main forms: cost analysis, cost-effectiveness analysis, cost-utility analysis and cost-benefit analysis.[101] Each form deals with costs but differs in the way that the consequences of healthcare programs are measured and valued.[101] The first type of economic evaluation, cost analysis, determines three important aspects: the viewpoint of analysis (scope of cost), type of cost (fixed and variable cost or capital or recurrent costs), and timing of the cost (techniques of discounting and annualization). The second form, cost-effectiveness, compares associated costs to the consequences of programs that are measured in the most appropriate natural effects or physical units, such as ‘years of life gained’ or ‘cases correctly diagnosed’. Cost-effectiveness analysis (CEA) may present an array of output measures alongside cost and allow decision-makers to determine the relative importance. On the other hand, a cost-utility analysis (the third type of economic evaluation) considers the *value* of the outcomes, adjusted by health state preference scores or utility weights (i.e. states of health associated with the outcomes are valued relative to one another). The most common measure of consequences in cost utility analysis is the Quality Adjusted Life Years (QALY). Lastly, cost-benefit analysis attempts to value the consequences of programs in *money* terms, so as to make them commensurate with the costs. This can help assess whether the benefits of a program justify the costs. In this study, the net benefit of a healthcare program could be determined by a threshold value of the decision-maker's willingness to pay for a life-year or QALY.[101, 102]

Costing tools in public health. Numerous costing tools have been developed to estimate the cost and impact of strategies to reach the Millennium Development Goals (MDGs). To harmonize the various approaches to costing and budgeting health sector plans and activities, several international development partners conducted a technical review of 13 selected costing tools in 2015.[103][104] The findings show that while each tool has a different approach and logic (framework, formulas and parameters), costing involves two basic production functions: intervention and health. The intervention production function is based on a combination of inputs (labor, drugs, medical supplies, equipment, vehicle, mobile phone, training, etc.) to produce a given intervention (or output). The sum of the input price in conjunction with input quantity can generate total intervention quantity and total intervention costs. For each intervention, based on a ingredients approach, costs were estimated using country-specific prices and quantities of goods and services needed, based on WHO's evidence-based clinical guidelines[105][106-109] and expert opinions. The intervention production function is used to compute total intervention quantity and costs. The intervention cost is then calculated by multiplying the quantity of inputs by the input prices. Following best practice protocols, the calculations for each of the interventions are determined according to a set of required resources (e.g. human resources, equipment, supplies, medicines, etc.). In addition to the direct costs of the intervention, other planning and management activity costs are also considered, such as a) program planning and management; b) supervision of services and staff; c) health education and promotion; d) advocacy and campaign and e) monitoring and evaluation.[104] Further, considering the efforts of strengthening the health system while scaling up coverage, additional elements were considered such as; a) upgrading and maintenance; b) acquiring means of transport and communication and c) human resource development (training and upgrading skills).[104, 110] The second function, the health production function, is used to compute health outcome. Health outcome is generally calculated by multiplying the quantities of interventions produced by their effectiveness (e.g. effect size). Total intervention coverage is determined by dividing the intervention quantity by the size of the population, a subset of demographics. Demographic trends are partially influenced by disease prevalence and incidence. Total utilization of the intervention can be proportional to the total coverage based on demand and supply side factors in the health system. All these variables are considered over a set period of time and under specific geographic contexts as well as macroeconomic conditions. The findings of the review noted the significant complexities of the tools, which have limited transparency and usability as well as a lack of standardization in the use of terminologies across the tools.[111]

WHO-CHOICE (CHOosing Interventions that are Cost-Effective). A standard cost-effectiveness guideline follows WHO-CHOICE (http://www.who.int/choice/en/), which was developed in 1998 with the objective of providing policymakers with evidence to help them decide which interventions and programs maximize health given available resources. Using a complied regional database, WHO-CHOICE uses a country contextualization tool including disease models and costing tools that are appropriate to the local setting. Based on that, a WHO publication, "*Methodology and Assumptions used to estimate the Cost of Scaling Up selected Child Health Interventions,*" presented an ingredient-based approach to calculating financial requirements in implementing maternal and newborn health (MNH) interventions on a nationwide scale.[112] In terms of intervention and delivery mechanisms, costs were first estimated for 16 priority interventions, selected based on feasibility of implementation and ability to reduce child mortality and morbidity, and then were regrouped into seven strategic intervention sets according to the associated illness or condition and their level of delivery in the health system. In terms of specific inputs, costs are captured and divided into 'patient costs' and 'program costs' considering a societal perspective. Patient costs refer to costs at the point of delivery, such as those related to bed days, outpatient visits, drugs, or transportation. Program costs include costs incurred at the administrative levels of the district, provincial or central levels – rather than the delivery point of an intervention to beneficiaries – and components include such items as infrastructure, equipment, training, supervision or media campaigns.[112] These inputs are defined in accordance with current standards of treatment and are based on the general experience of health system requirements. The WHO-CHOICE team has developed CostIt (Costing Interventions templates) to help calculate the economic costs of interventions, as well as to estimate financial costs.[113] WHO-CHOICE provides a set of separate templates for the reporting and analysis of costs at the program, hospital, primary health facility and household levels.

Costs of scaling up. Although the phrase 'scaling up' is now frequently used in the international health literature, the meaning often is ambiguous. The notion is primarily used to describe the objective or process of expanding coverage of health interventions[114][115] and increasing the financial, human or capital resources required to expand coverage.[116] WHO-ExpandNet has defined scale up as "efforts to increase the impact of innovations successfully tested in pilot or experimental projects so as to benefit more people and to foster policy and program development on a lasting basis."[115]

Yet, little empirical work has been done on the cost of scaling up interventions. A few studies attempt to evaluate changing cost functions at different levels of coverage.[117] Ideally, tracking time series cost data by activity or intervention may be the best method for determining the cost functions.[118] However, such a method can be time-consuming and expensive. Thus, many studies use cross-sectional data (point-in-time measurements) and annualize over the lifetime of the intervention program to generate average costs or incremental costs compared with a control program. It is a widely used practice for studies to present average costs per recipient and multiply them by projected future need to calculate the total costs of scaling up. [119] However, the World Development Report 1993 acknowledges caveats of such approaches and suggests that cost-effectiveness ratios would vary with population coverage, though it did not provide clear guidance or methodology of how to address the difference.[117]

There has been continued interest in understanding scaling up health interventions in efforts to achieve the MDGs.[120, 121] Some studies have reviewed the literature and suggested key issues on the cost of scaling up. WHO-CHOICE identified a number of factors that affect economies or diseconomies of scale: "geography and transportation, fixed costs of establishing a health infrastructure, human resources, and management transition costs."[117] A systematic review by Johns and Tan Torres demonstrates that costs of scaling up an intervention vary according to the type of intervention and its particular setting as well as size of the population at risk, type of illness, demographic and socio-economic factors, geography and infrastructure, availability of health workers, and other characteristics of the health system in each country.[119] Taking into account these factors can be a complex and challenging task as each interacts differently depending on the intervention. Therefore, the study recommended that cost-effectiveness researchers address the heterogeneity in costs, outcomes, or cost-effectiveness with sensitivity analyses by accounting any observed and possible variations of inputs or subgroup analysis of populations or regions with different baseline characteristics.[122]

In addition, many studies have looked at understanding various dimensions and constraints – from system, supply and demand aspects – of scaling up health interventions. First, in considering health systems, scaling up the coverage of priority health interventions not only requires additional financial resources but a capable health system in delivering the interventions on a large scale.[123] The ability to scale up health service delivery can be influenced by multiple constraints[123, 124], including a lack of infrastructure and equipment[125]; inadequate drugs and medical supplies; shortage and distribution of qualified staff; weak management[126], technical knowledge and inadequate supervision.[127, 128] Hanson et al. demonstrated conceptual work on the constraints related to expanding coverage of health interventions, and categorized five levels at which barriers may occur: "(1) community and household; (2) health services delivery; (3) health sector policy and strategic management; (4) public policies cutting across sectors; and (5) environmental and contextual characteristics".[127] Still, understanding these major constraints in health systems may not be enough to guide practical actions on how to account for or manage certain components in consideration of many others. Further, uncertainties and unpredictable change of political interests[129] and program management[130] are also major sources of variation in the scaling up process.

Secondly, in terms of supply, human resources is highlighted as a major cost driver in many cost-effectiveness studies and an impediment in scaling up of health interventions.[131] [132, 133] Insufficient number of health workers, as well as problems with their distribution, range of skills and motivation are common critical challenges in low- and middle-income countries. Challenges like these cannot be simply be solved with additional funding. Building capacity and improving providers' practice require time.[134, 135] Patient demand for services is a third important factor to consider when determining the cost-effectiveness and scale-up of a service.[136-138] Access barriers on the demand side, such as acceptability or affordability, affect service utilization; this is especially true for poor or marginalized populations in remote regions.[139] In addition, lack of trust or poor quality of health provision often will dampen demand for services.[140] Lack of demand and utilization or physical, financial, or social barriers may lead to higher average or marginal costs; in other words, average costs can be lower where service demand and utilization are high.[141] Understanding these factors could help provide insights to develop an analytical framework for cost-effectiveness analyses as well as inform practical questions of planning, implementation, monitoring, and evaluation for scale-up.

3.4 Economic evaluation of eHealth/mHealth

eHealth economic evaluation. Confronting the challenges of increasing healthcare spending in recent decades, some innovative approaches to medical care delivery have been deployed in various forms such as health information systems (HIS) and telehealth. These innovations require significant upfront and ongoing costs; thus there has been growing interest in economic evaluations of such healthcare technologies to justify investment decisions.[142] However, economic evaluations of HIS or telehealth remain rare, and little evidence exists on how to present 'value' and how that value needs to be considered in relation to investment in the system to determine whether it is worth the cost.[5] While these healthcare technologies involve different characteristics in terms of

[5]"There is general agreement that mHealth can be a cost-saving method to collect health data and widely disseminate health information to increase health knowledge and promote healthy behaviors. However, very few studies we reviewed included a cost analysis or a financial evaluation of any kind to confirm this assumption. In fact, a retrospective analysis of telemedicine projects noticed this gap, and concluded that cost analysis of future mobile technology interventions for health must be prioritized for better decision making (Kahn, Yangn & Kahn, 2010). Later studies and meta-analyses have affirmed the importance of cost analysis of mhealth interventions (Aranda-Jan et al.,

their motivations, intervention settings, or value propositions, earlier studies in this similar domain provide relevant lessons for mHealth economic evaluation. In general, the value of health information has been characterized in terms of cost savings, system efficiencies (e.g. increased coverage or quality of services), or improved health outcomes (e.g. DALYs saved or improved health equity). In terms of methodological techniques, most papers have used historical costs to estimate future outcomes for a specified time period. Many adjust for inflation, discounting, and amortization or depreciation. Accounting for financial costs was the most commonly used method. The values were demonstrated as incremental cost-effectiveness ratios (ICER), return on investment, net present value, net benefit, operating margin, least cost, average cost, and cost savings.[143][144][145] Some rigorous studies used statistical methods such as t-test, chi-squared ($\chi 2$) test, linear and logistic regression, scenarios, econometric or financial modeling methods.[146][147]

Health Information Systems, utilizing computerized information systems, have been widely deployed in hospital-based institutional settings to support physicians in managing order entry systems, medical records and billing systems, or medication and disease management systems.[142, 146] Some studies demonstrate favorable impacts to cost saving by reducing service utilization associated with hospitalizations, laboratory tests or medications.[148] Some studies show the value as "revenue metrics," increases in cases,

2014; Eysenbach, 2011; Mbuagbaw, 2011; Mechael et al., 2012; Schweitzer and Synowiec, 2012; Zolfo et al., 2010). Still, few studies on mHealth have incorporated an extensive cost analysis, likely because most of the studies have not moved beyond the pilot phase." Source: USAID, Measure Evaluation, Mobile Technology for Monitoring and Evaluation and Health Information Systems in Low to Middle Income Countries. 2015. http://pdf.usaid.gov/pdf_docs/PA00KB8K.pdf patient days, or outpatient volumes[149, 150], and a few studies presented "clinical impact," using adverse drug events. The value proposition presented in the studies ranged from process measures (e.g. diagnostic accuracy and agreement in reading of transmitted data, medication compliance, time spent on diabetes care for both patients and professionals, number of days to independent pouch change after abdominal surgery and colostomy and length of stay) and health-related outcome measures such as blood glucose levels, hypoglycemic events, percentage reduction in wound size and body mass index. Many studies used disease-specific surrogate measures related to future health statuses such as QALYs or DALYs.[146]

Telehealth, utilizing telecommunications technology to improve service delivery and health outcomes, has been deployed at homecare or local health post settings to deliver healthcare services to patients who are remotely located or have limited access to specialty care.[151] Studies show that the use of telemedicine was most common in chronic disease management such as diabetes care and cardiology in a homecare setting.[152] Most studies suggest that telemedicine-related cost savings are related to its impact on health care delivery, reducing health service utilization such as "physician office visits, emergency department visits, number of hospitalizations, hospital readmissions, home visits, length of hospital stay, use of ambulance services, number of referrals, duration of consultations, number of laboratory tests, and avoided transfers and evacuations."[153] Many studies in telehealth significantly consider how much telehealth can reduce travel time and costs, since one of the common objectives of telehealth is to reach those in remote areas.[154] Some studies demonstrate the impact of medication adherence on the reduction of healthcare utilization and costs[155] through early detection of a condition, timely treatment, and the preventing need for further tests.[156]

mHealth economic evaluation. Many studies present the potential benefits of mHealth to overcome traditional obstacles to the delivery of health services in developing countries – issues related to access, quality, time, and shortage of health workers.[157] Tools and frameworks, such as total cost of ownership model, for assessing costs have been developed and applied.[158][159] Schweitzer et al. compiled a list of potential mHealth outcomes that can be used in economic evaluations.[157] A few empirical studies conducted costing or cost-effectiveness studies in mHealth. Existing evidence of mHealth costing or cost-effectiveness studies can be summarized by two major types of strategies: (1) surveillance or survey tools for data collection[160-163] and (2) SMS reminders or video monitoring for treatment adherence.[164-170] Most studies[171] on using mobile phones for self-monitoring for asthma presented positive effectiveness and cost-savings for mHealth compared to paper-based or other conventional approaches. The perspective of costing was mostly based on program managers, accounting financial costs with a time horizon ranging from 2-3 months to 2-3 years. Only a few studies have conducted a systematic evaluation of costs or outcomes linked to such investments.[164, 170] A recently published systematic review evaluated and summarized the mHealth cost-effectiveness studies by following the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement.[122] [172]

The first type of study, on mHealth-facilitated data collection, compares the mHealth approach to paper-based systems based on accounting financial costs of implementation from a program manager's perspective. Studies involved a community-based household survey or hospital-based study settings in developing countries. Studies reported total cost, setup costs and operational costs and derived average unit costs (e.g. cost per case, patient or attendance) and compared them to paper-based systems. Common benefits were reported on data accuracy, reduction in processing time and completeness. Most studies reported that the paperless system was less costly.[160-163]

The second type of mHealth strategy is the SMS reminder approach. Rigorous economic evaluation studies were done on this approach for treatment adherence through various methods. A study of a pilot in Malawi found that "giving 75 CHWs cellphones for patient adherence reporting, appointment reminders, and physician queries saved the hospital $2,750 in fuel costs and doubled the capacity of the hospital's tuberculosis program". [173] Guerriero C, et al. considered the lifetime incremental costs and benefits of adding text-based support to smoking cessation practices. Using Markov modeling, the cost-effectiveness was measured as 0.3 LYs per quitter; 0.5 QALYs per quitter.[164] Under various conditions, the deterministic and probabilistic sensitivity analyses confirmed the mHealth approach is beneficial and cost-saving. In addition, Hoddinott et al.[166] examined the cost-effectiveness of telephone support for breastfeeding women and compared proactive and reactive calls in a randomized control trial study. Results showed incremental cost per change in breastfeeding behavior (any or exclusive breastfeeding at 6-8 weeks), demonstrating the feasibility of the mHealth intervention.

Furthermore, Zurovac et al.[165] evaluated costs and cost-effectiveness of text-message reminders to improve health workers' adherence to Malaria Guidelines in Kenya with three implementation scenarios based on a randomized control trial setting: (1) Text-messaging intervention under the trial condition; (2) Text-messaging intervention under a routine condition; and (3) Scaling up to the national level. The latter two scenarios were designed to estimate actual implementation costs in routine conditions managed by district public health nurses and then nationwide scaled-up costs. The study demonstrated that if mHealth can be adopted by the Ministry of Health (data collection conducted by district public health nurses), the costs would be 28% lower than the trial setting and if the program is scaled up nationwide, the major cost driver would be sending text messages. Sensitivity analyses were performed with higher program costs and lower effect sizes. The findings demonstrated economies of scale ($0.03 per additional child correctly managed) for implementing this intervention at the national level. In developing a scaled-up scenario, the study also addressed important considerations: (1) Reasonable frequency and duration of a text message reminder intervention; (2) Effectiveness of the intervention under a trial condition; (3) Differing effectiveness for different population groups (age, gender, region); (4) Potential change in effectiveness over a longer-term period; and (5) Integrated management of the most common outpatient disease. [165]

Other two studies were found for mobile phone monitoring in treatment adherence for TB and asthma.[170, 174] Wade et al. conducted a comprehensive cost-effectiveness study of home videophones to improve direct observation in TB treatment in South

Australia.[170] An incremental cost-effectiveness ratio, comparing the video call and traditional forms (in-person) of observation, showed a favorable effect of mHealth with AUD$1.32 (95% CI: $0.51-2.26) per extra day of successful observation. One-way deterministic sensitivity analyses were conducted with various parameters (e.g. number of patients, type of patient, driving time, cost of technology, staff salaries, and length of service). Major cost savings can be driven from less staff time if implemented at a large scale.[170] Another randomized control study (performed in a UK primary care setting) on mobile phone-supported self-monitoring of asthma demonstrated that there was no significant difference in the change in asthma control or self-efficacy (based on scores of knowledge, attitude, and self-efficacy from a questionnaire, KASE-AQ). [174]

3.5 Cost-effectiveness of maternal and newborn health services in low and middle-income countries

Substantial evidence exists on the effectiveness of maternal, newborn and child health (MNCH) services that have been widely studied over the past decades in efforts to achieve MDGs 4 and 5. Several studies have summarized the evidence on the effectiveness of these strategies to improve MNCH care in low- and middle-income countries.[175-177] Examples include "iron supplements to prevent anemia, tetanus toxoid immunization, magnesium sulphate for eclampsia, uterotonics to prevent and manage post-partum hemorrhage, hygienic cord care, immediate thermal care, exclusive breastfeeding, and management of neonatal sepsis, meningitis and pneumonia".[178] A recent study in the *Lancet* journal estimated that increased coverage and quality of pre-conception, antenatal, intra-partum, and postnatal interventions by 2025 could avert 71%

of newborn deaths.[179] However, given resource constraints, it is important to know not only what strategies are effective at improving coverage of MNCH interventions, but also whether the strategies are cost-effective.

In this respect, a recent systematic review identified 48 publications on the cost-effectiveness of strategies to improve the utilization and provision of MNH care in low-income and lower-middle-income countries.[180]The most common theme of the synthesized studies focuses on community-based strategies and care during pregnancy. However, there was considerable diversity in the strategies used to improve MNH care, and also intensity and scale of implementation. Overall, the synthesis presented various demand and supply-side strategies that are cost-effective in enhancing the utilization and provision of MNH care and improving health outcomes.[180] Specifically, identified cost-effective strategies included the use of women's groups[181, 182]; home-based newborn care using community health workers, volunteers and traditional birth attendants[183][184]; adding services to routine antenatal care[185]; a facility-based quality improvement initiative to enhance compliance to care standards[186]; and the promotion of breastfeeding in maternity hospitals.[187]

The studies presented large differences in terms of the content, approach and methods used to estimate costs in economic evaluation. In terms of the study design, the vast majority of studies compared the strategy to the situation prior to or without the strategy, though seven studies were conducted in the context of cluster randomized trials. The effect of the strategies was measured using various indicators, such as the change in maternal or newborn mortality rates, the percentage of pregnant women having at least three antenatal visits, or the proportion of facility births. These studies referred to health-specific cost-effectiveness measures such as cost per life-year saved and cost per DALY averted or strategy-specific cost-effectiveness measures such as the cost per insecticide-treated mosquito net (ITN) delivered, cost per facility-birth, or cost per home visit.

Most studies reported the incremental cost-effectiveness of a strategy (either compared to an alternative strategy or doing nothing) and reported on sensitivity analyses that had been undertaken to explore uncertainty around the cost-effectiveness ratio. In most studies, the mHealth strategy was found to be more effective but also more costly than its comparator. Therefore, the decision on whether to adopt a strategy depends on the decision-maker's willingness to pay for improvements in health or health care. Using GDP per capita as a benchmark to consider the measures such as the cost per DALY averted, cost per QALY gained and cost per life-year saved, the review considered cost-effective all the strategies that report these measures.[108] Among the selected 16 high quality studies, 10 focused on or included ANC interventions, which are highlighted in Appendix 1.

3.6 Importance and evaluation of antenatal care service delivery

Why ANC? Today we have better evidence and knowledge about what works and what does not work in reducing maternal mortality and morbidity, and the role that antenatal care (ANC) can play. ANC is widely known as an accessible and cost-effective method for improving maternal and perinatal health outcomes. It offers the opportunity to connect women to the health system, improve maternal and child health outcomes through treatment, prevention, and health promotion during pregnancy. It can also serve as a vehicle for integrated care of the multiple programs through an operational continuum of care.

For example, ANC is particularly important in the early detection and management of hypertension (pre-eclampsia and eclampsia), and antepartum hemorrhage, two leading causes of maternal death.[188, 189] There is evidence of effective interventions including those on tetanus immunization, detection and treatment of anemia, prevention and treatment of malaria, and management of sexually transmitted infections (STIs).[123] These interventions, together with a combination of interventions to improve women's nutritional status, can significantly improve fetal outcomes and improve maternal health. Moreover, ANC can help start discussions on breastfeeding and contraception, two critical interventions that should be reinforced and implemented in the postpartum period.[190]

In particular, ANC can increase the access to and chance of using a skilled attendant at birth around labor and delivery – which is when most maternal deaths occur – through a birth and emergency preparedness plan. The plan includes "identification of the following elements: the desired place of birth; the preferred birth attendant; the location of the closest appropriate care facility; funds for birth-related and emergency expenses; a birth companion; support in looking after the home and children while the woman is away; transport to a health facility for the birth; transport in the case of an obstetric emergency;

and identification of compatible blood donors in case of emergency".[191] A study conducted in rural Bangladesh showed that attendance of at least one antenatal visit was associated with increased odds (adjusted OR: 1.7 95% CI:1.5-1.9) of skilled attendance at delivery compared to women who received no ANC.[125] Improving the quality of ANC and sustaining its implementation should be key priorities.

Considerations for ANC evaluation. In 2001, WHO published the conclusions of a randomized controlled trial of a new model of ANC and also carried out a systematic review of other randomized trials that looked at the effectiveness of different models of ANC.[192] This work has led to a growing consensus around a general recommended frequency of the visits (i.e. 4+ ANC visits) and key ANC elements that are likely to improve maternal and perinatal health outcomes.[193-197]

Despite the broad consensus on what the content and quality should be, the actual service delivery of ANC currently provided in many parts of the world fail to meet WHO-recommended standards due to various challenges and limitations faced in the field. In addition, available data in most surveys and studies provide no information on the specific content or quality of the services. Current efforts to monitor progress in ANC coverage (e.g. DHS and MICS surveys) have generally focused on quantifiable issues such as the number and timing of visits, type of care provider, characteristics of ANC users and non-users.[198] These indicators alone present missed opportunities to deliver essential care to the mothers, leading to sub-optimal effectiveness of the interventions. For example, in Bangladesh, 78% of pregnant women have at least one ANC visit, but the percentage of women who make four or more antenatal visits from skilled health professionals was only 26% in 2011.[199] Further, there are also equity gaps in ANC uptake between the rich and poor and between urban and rural areas. For example, according to the 2011 Bangladesh DHS, 74% of urban women receive ANC from a trained provider, compared with only 49% of rural women. In terms of the median number of visits, women residing in urban areas make on average 1.3 visits more than rural women.[199]

Moreover, in recent years, attention has been directed to the essential elements of the postnatal care package, to ensure that quality is not overlooked in favor of quantity. WHO emphasizes renewed interest on coverage, suggesting effective coverage as an intermediate goal for health system performance measurement.[200] Effective coverage involves multidimensional concepts encompassing traditional concepts of access, utilization and effectiveness. In his earlier work, Tanahashi (1987) presented a conceptual diagram on effective coverage, illustrating the five measures of coverage including: (1) Availability coverage (people for whom the service is available), (2) Accessibility coverage (people that can use the service), (3) Acceptability coverage (people that are willing to use the service), (4) Contact coverage (people who use the service) and (5) Effectiveness (people that receive care).[201] These factors address various aspects of health systems bottlenecks, including the physical availability of services, distance or time to a facility, economic costs associated with seeking and receiving care and services, cultural and social factors that may hinder access and quality and therefore the effectiveness of services offered. Tanahashi's approach allows for assessment of the capacity of the health system – both supply (service provision) and demand (service utilization) – to achieve effective coverage.[202] These efforts help identify gaps in ANC coverage and uptake and can, therefore, guide considerations for effective strategies towards improving access to healthcare for pregnant mothers.

Chapter 4. Methodology

4.1 mCARE I study preparation, data collection, and data analysis

mCARE program. mCARE is a mobile phone-based maternal and newborn health information system designed to connect rural frontline health workers with pregnant women and their families through a cloud-based server. The system is designed to standardize the way frontline health workers engage with their clients when performing their key responsibilities such as population enumeration, pregnancy surveillance, pregnancy registration and promoting the uptake of antenatal, postnatal and essential newborn care. To improve coverage and utilization of antenatal and postnatal interventions, the mCARE system reminds community health workers (via phone alerts and day-to-day scheduling systems) and pregnant women (via text messages) when a pregnant client is due to receive antenatal care (ANC) or postnatal care (PNC). Additionally, the program has an additional in-person component, where the health workers conduct household visits on the scheduled dates to remind the women to seek care.

mCARE study design. For the pilot phase, we selected a quasi-experimental design, with two comparable regions within the broader, well-characterized JiVitA study site (one of the largest population research sites in the Gangetic region, established by, the Center for Human Nutrition at Johns Hopkins University), to serve as the intervention and comparison arms of the study. (Figure 4.1) In each arm, 20 community health workers (CHWs) were assigned to either the mobile or non-mobile group. Both groups conducted mobile census enumeration and pregnancy surveillance, but only the mobile group's clients received personally scheduled phone reminders and in-person reminders to access ANC and PNC. Women in the non-mobile arm did not receive personally scheduled reminders. The primary feature of the intervention being measured is whether personally scheduled reminder text messages have an impact on increased antenatal and postnatal care utilization and on reducing neonatal and maternal mortality.

1) Research preparation

The mCARE system was developed through intensive and collaborative efforts with various stakeholders of national and local health systems. The research preparation, which took place between from October 2011 to April, involved program development activities like building partnerships with local public and private stakeholders; performing key informant interviews to document process and information flow; developing digital forms for data collection; designing backend scheduling systems; testing system functionality and stabilization; developing training manuals and implementation protocols; training community health workers on mCARE system implementation; and debugging and system stabilization.

For the first step in the research preparation stage, the JHU-JiVitA team formally launched the mCARE project in October 2011 in the JiVitA study area. The team organized an event and invited major stakeholders including health practitioners and government officers to build partnerships and consensus.

In May 2012 the JiVitA field management team conducted key informant interviews to document process flows and information use within the government health system. After gaining an understanding of the overall health system and CHWs' role and responsibilities, the team designed a series of manual forms for systematic census enumeration, pregnancy surveillance and registration, information on socio-economic status, and forms to verify the receipt and content of antenatal and postnatal care as well as during emergency events.

JHU-JiVitA contracted mPOWER (a social enterprise of mobile information technologies and data) in August 2012 to provide technical system support to the mCARE project. The two teams jointly designed the scheduling logic and skip patterns to automate the future event reminders based on reported outcomes and events. These automation include the server-based calculation of up to four ANC reminders for every enrolled pregnant woman. The timing is based on the date of her last menstrual period (LMP) and the expected delivery date, as well as postnatal follow-up appointments for pre-term infants (if a birth notification was sent a week or more prior to the due date).

In November 2012 the mPOWER programming team initiated the technical coding to develop the system platform through several iterative processes. The team field tested these platforms and feedback loops to optimize performance based on prior experience using the system. The Johns Hopkins investigators and the JiVitA field management team developed field implementation plans to guide data collection and management by using the smartphone-based mCARE system.

In May 2013 the JiVitA team procured and distributed Android phones to 40 female CHWs and eight team leaders who would supervise and support the CHWs and conduct verification interviews during implementation. The team conducted training with CHWs, team leaders, field supervisors, quality control teams and research physicians. During this process, the team observed the field workers' enthusiasm about working with touchscreen phones and their ability to quickly learn how to manipulate the devices.

In July 2013 JHU-JiVitA began implementing the mCARE system. Their tasks included a baseline master list of census and registration data of married women of reproductive age (MWRA) from the catchment areas, mapping of households, and pregnancy surveillance, using mCARE. The management team held intensive monitoring and evaluation sessions with the CHWs to understand challenges the workers faced and to evaluate whether the system was performing with fidelity in regards to the intended technical design and study protocols.

2) Data collection

From July 2013 to August 2013, JiVitA conducted census enumeration and ascertaining pregnancy status. Initially, CHWs visited each household in their catchment area to list all MWRAs in the community. Pregnancy status was ascertained by asking women if they are pregnant and by eliciting a history of menstruation in the previous month. All women who self-reported their pregnancies were asked permission to be registered with the mCARE system. Additionally, women were asked questions regarding mobile phone ownership and use as well as whether they are able to read and send an SMS. During the first five weeks of census enumeration, the team registered around 12,000 MWRAs through the mCARE system.

Between August 2013 and June 2014, CHWs conducted pregnancy surveillance and registration. Non-pregnant women were asked to consent in participating in the routine pregnancy surveillance, which entailed being visited at their home every five weeks by JiVitA CHWs, who would ask about their menstruation in the previous month. During the 10 months, a total of 800 pregnant women (400 in each study arm) were identified and enrolled.

CHWs received consent from all women identified as pregnant for enrollment in the mCARE study. Based on the date of last menstrual period, the mCARE system scheduled up to four ANC visits, depending on the gestational age at enrollment. The server also sent reminders to CHWs to notify them to remind pregnant women in person of upcoming ANC or PNC visits. Accordingly, women who had access to phones in the intervention arm received these reminders on their phones during week 8, 16, 24 and 32 for ANC care seeking. Women in the control group did not receive any ANC SMS reminders on their phone. Neither did they receive any in-person visits from CHWs to remind them of upcoming ANC or PNC visits.

Throughout August 2013 to July 2015, CHWs in both groups visited their clients to check on their experience of the ANC visits. Post-delivery, CHWs in both groups visited the new mothers as soon as possible and within 24 hours of delivery to remind them to access PNC and encourage essential newborn care.

3) Data analysis

We used Stata 14 for data analysis, first checking the data for completeness and accuracy and screening for missing values. We tabulated frequency distributions for categorical variables to explore the data. We performed chi-square tests to assess differences between outcome categories. We retained variables strongly associated with care seeking in the literature as well as potential confounders in the base model. To determine additional variables to include, we used a selection procedure based on Akaike Information Criterion (AIC) values. The model, which we selected based on AIC values, suggested that all independent variables significantly contributed to the model.

Characteristics of study participants: After checking and screening the data and tabulating frequency distributions, we conducted simple t-tests to compare the study participants in the two groups. Most basic biological, nutritional and economic statuses were similar in both groups, although there were differences in literacy levels.

Multinomial logistic regressions. To ascertain the association between the intervention and coverage increase (any ANC or PNC visit), we performed multinomial logistic regressions to obtain an odds ratio, which would allow us to estimate the association between the intervention and mortality impact (miscarriage, stillbirth, early neonatal death, perinatal death). We tested the assumption of independence of irrelevant alternative using a generalized Hausman test, which showed that the assumption was not violated for the multinomial model. We conducted univariable and multivariable analyses and examined variables expected to mediate, confound or modify the effectiveness of association. These associations were hypothesized from the literature review. The multivariable regression model controlled for demographic factors (maternal age, parity), and socioeconomic status (living standards index). We used a 0.05 p-value cutoff to assess levels of significance.

Population standardization. To ensure standardization of the sample denominator (number of pregnant women) between the two groups, we proportionally extrapolated the number of deaths for a scenario in which the population was 1 million in each group's catchment area. We estimated the number of pregnant women in a given year by assuming the number of women of reproductive age in 2015, given the fertility rate, abortion rate, and fetal loss rate . These figures are based on the Bangladesh national statistics report; there was no available district level information. Accordingly, we estimated the number of CHWs, assuming a ratio of one CHW per 20 pregnant women for the pregnancy surveillance and program intervention over a year.

LiST modeling. We used the Lives Saved Tool (LiST) to estimate mortality impact based on service outcome measures (e.g. coverage) for mHealth-based strategies, aimed at reducing maternal, newborn and child mortality. With a special focus on coverage as a primary measure of mHealth impact, we used LiST to incorporate two potentially advantageous aspects of mHealth: accelerated coverage uptake and improved coverage quality. In terms of coverage uptake, we first set the baseline coverage from the Demographic and Health Survey (DHS) and assumed different coverage increase rates among various interventions based on historical evidence and feasibility. In terms of service quality, we chose the defined intervention criteria in LiST, which are similar to the current intervention protocols and subcomponents observed in Gaibandha district. Additionally, given that LiST default data is based on national statistics in Bangladesh, we adjusted the national estimation to the relevant district level based on the proportional ratio of population size.

LiST validation. We compared the extrapolated number of lives saved in a standardized mCARE program – population of 1 million – and adjusted the number of deaths averted in a LiST subnational adjustment. The extrapolation and subnational adjustment were made by the proportional ratio of population size. In this modeling, we selected service subcomponents based on the Bangladeshi government guidelines and interviews with local service provision stakeholders. The specific subcomponents that were included for LiST modeling are listed in Appendix 3. We used these measures forecast estimations.

DALY. After estimating the number of lives saved through LiST, we calculated the Disability-Adjusted Life Years (DALYs) – years of life lost (YLL) and years lost due to disability (YLD) – using the standard formula from the Global Burden of Disease study. [203] Since our study did not have information related to morbidities, we only accounted for the YLL component of DALYs. Based on the estimates from WHO life tables, a life expectancy estimate of a newborn was based on the age less than 1 year; a life expectancy estimate of mothers would be based on the average age (29 years) of women in the study sites when delivering a child between 2013 and 2014. A discount rate of 3% was used in reference case calculations.

4.2 Costing preparation, data collection, and analysis

1) Program costing preparation, data collection, and analysis

Preparation. Based on the WHO CostIt guideline (http://www.who.int/choice/en/), the mHealth characteristics and costing categories were incorporated to develop an mHealth costing template. We also referred to other studies and costing templates such as Integrated Community Case Management (ICCM) costing tools[204] or the Coreplus tool[205] to develop the template. The template aims to help estimate resource requirements and associated costs to deliver the necessary services at scale in addition to primary data collection.

Data collection. mCARE I provider costs involve two major stakeholders, mPOWER and JHU-JiVitA. Referring to the WHO and SNL standardized guidelines, we chose the relevant program activities and resources to identify costs from each stakeholder through informant interviews with key program staff and financial records. First, we found that costs can be categorized according to the *phases of program development and implementation* and mCARE I timeframe (2011-2015), which is divided into three phases: 1) Development phase – program and system development activities; 2) Startup phase – preparation activities, including training and community outreach and advocacy; and 3) Implementation phase – execution of data collection, processing and analyses. This categorization allowed us to determine what major activities and resources are required in different development stages. Within each phase, we captured costs using an 'ingredients' approach per activity and divided into capital costs and recurrent costs. We obtained cost data from a retrospective review of program financial records and categorized them into relevant activities through the informant interviews. We also divided activity costs into major subcategories like personnel, equipment and supplies, transportation, and building costs, within each phase, by time period of occurrence.

Analysis. Beyond the expenditure and budget line items, activity-based costing requires a deep level of conceptualization to define major activity components and to identify the scope of the cost inputs. For each stakeholder's activity-based costing, we first carefully distinguished and processed relevant identifying input factors as well as the time-variant determinants of unit quantities (e.g. a number of staff, their level of effort, salaries etc.), classifying them into major activity components. We performed this analysis for each stakeholder and program phase. We then divided these components into capital and recurrent costs based on the purpose of the activities and items (instead of simply dividing them by expenditure cycle). For example, our capital costs included not only furniture and equipment costs, but also activity costs related to program and system development, including personnel and office maintenance costs, since these can be considered one-time costs for the entire program and do not recur through program implementation. Capital item costs were annualized according to international or local estimates of each item's life expectancy with an annual 3% discount rate (WHO CHOICE), presented in 2015 base year US dollars and adjusting for inflation according to IMF consumer price indices.[206] We considered activity costs and office maintenance costs during the development and start-up phases as capital costs, and therefore annualized them with a life expectancy of three years and 3% annual discount rate, considering a three-year program implementation period.

Personnel costs were attributed to each activity based on the estimated level of effort (LOE) incurred each month. Time allocation estimates were obtained through in-depth interviews with personnel. Office maintenance costs were also attributed to each year based on the estimated level of utilization of the space, facilities, and supplies toward the mCARE project by each stakeholder. Three years of life expectancy were accounted for annualization for each program phase. Acknowledging staff or organizations involve multiple programs and responsibilities beyond mCARE, so we took into account the time-variant nature of resource utilization (e.g. a number of staff, their LOE, salaries, etc.) and calculated costs attributed to the mCARE project. Financial costs of each stakeholder were then aggregated for the main components of global capital and recurrent costs, for each development phase. For recurrent costs, we estimated standard unit costs of the intervention per relevant client (MWRAs/mothers) in the implementation phases for intervention and control groups. These unit costs were used to calculate an estimated measure per 1 million population for both groups. In this process, we carefully reviewed characteristics of each cost item and proportionally adjusted any variable costs based on the increased number of CHWs for mobile phone procurement, training, server maintenance, census enumeration, pregnancy surveillance, SMS, ANC home visit reminders and data collection. We did not include research costs here. We considered program costs such as partnership development, system development and optimization, furniture and equipment, office maintenance, community outreach, and supervision as one-time fixed costs that are not likely changed by the increased number of beneficiaries.

2) Provider/User costing preparation, data collection and analysis

Preparation. The mCARE program measured service coverage as an intermediate outcome indicator given that the mCARE intervention – SMS and home visit reminders promote pregnant women's care-seeking, which increases service utilization. While our intervention provides reminders for care seeking, pregnant women decide themselves where to seek care in their community. In defining the scope of the study, therefore, we considered comprehensive service provision channels including government, NGOs, and the private sector from community to primary to secondary care.

Study setting. The study was conducted from July to September in 2016 in a well-characterized population research site, JiVitA, located in northern Bangladesh, where 18.5% of pregnant women reported receiving any ANC service, of which a majority (71%) received care (Figure 4.2) from a community-based NGO (i.e. BRAC) and some from government health workers (15%). Assessing service provision at the study site requires an understanding of community and facility level health services. Community

ANC services are mainly provided by CHWs via household visits anchored to mobile or temporal clinics like satellite clinics that are often set up on days in community members' homes or in public spaces where people can gather. Major stakeholders in the formal sector of these services in Gaibandha district include the government and the country's largest NGO, BRAC, and the Smiling Sun franchise satellite clinics. ANC service provision at the facility level involves different levels of public and private actors and NGOs in primary and secondary care. The public facilities include Community Clinics (CC), Family Welfare Centers (FWC), Union-sub centers, Upazila Health Complex (UHC), and Maternal and Child Welfare Center (MCWC). NGO facilities include the Smiling Sun franchise static clinics or emergency obstetric care (EMoC) clinics. Private facilities include doctors' private chambers set up in their own houses and private secondary care clinics in Gaibandha district.

The study was implemented at JiVitA in rural northwest Bangladesh, a project of the Center for Human Nutrition of Johns Hopkins School of Public Health, which has been conducting community trials for the last 15 years. This longtime established partnership and good reputation of JiVitA facilitated support from the Project Investigator and JiVitA Senior Management Team in identifying key stakeholders and initiating conversations for this study. We contacted and discussed with the local government's Deputy Director of Family Planning and leaders of relevant service provision organizations from BRAC (Director, Health Nutrition & Population, BRAC) and Smiling Sun (Chief of Party, USAID-DFID NGO Health Service Delivery Project, NHSDP). We used convenience sampling to choose the facilities or communities, on the basis of relevance of the mCARE I research site, availability of facilities' service schedule, the volume of service provision, and perceived representativeness of organization's routine practices. At each respective service provision site, we purposively recruited an organization manager for a structured interview and the most representative 1-2 ANC service providers for an observational study. The identification of pregnant women within a community or facility was purposive and made on the day of observation. We conducted the study with the community level group at the satellite clinics, which are often set up on certain days in a community member's house. Each CHW's working area is divided into 3-5 clusters and each cluster generally consists of 75-100 households and has a satellite clinic set up twice a month. Community mobilizers, who visit each house for pregnancy surveillance, family planning and other health promotion activities in their assigned catchment areas, inform clients of specific ANC provision dates and locations of satellite clinics. At facilities, research staff approached pregnant women in the ANC waiting area and received consent for observational and exit interviews prior to the start of ANC clinical services.

Sample size. Our primary research intent is to describe and differentiate the content of ANC services in the community and facility groups. This descriptive study consists of the observation of 50 ANC consultations conducted in health facilities and 50 in communities as well as exit interviews with ANC recipients. This builds upon a previous study [207] that collected data on 36 ANC consultations in a facility setting in Tanzania. We aimed to include all 50 women observed during ANC in the community and 50 observed in the health facility, because it is possible that some women may drop out prior to the completion of the exit interview due to health, work, family or other responsibilities. In Bangladesh, according to proportional sampling based on mCARE I study finding, our sample at a community level included service provision by Family Welfare Visitors (20 samples) and by BRAC *Shyastho Kormi* (SK) (20 samples), and by Smiling Sun Paramedic/CHW (10 samples) in satellite clinics. In primary health centers at the facility level, we observed and conducted exit interviews among FWVs in FWCs/CCs (20 samples), SACMOs in UHCs (10 samples) in public facilities and paramedics in the Smiling Sun static clinic (10 samples). In secondary health centers at the facility level, we also observed ANC provided by an MBBS/Gynecologist doctor in MCWC (10 samples). In case service contents and costs were associated with delivery and PNC, we conducted in-depth interviews with the seven facility managers in each care setting.

Data collection. According to standardized guidelines, we devised service costing and coverage tools that can be used for various stakeholders at different levels of care (e.g. community and facility settings), throughout the continuum of maternal and newborn health (MNH) care services to capture the service content, practice, and commodities such as equipment (e.g. blood pressure meter) and supplements (e.g. micronutrient, iron-folic acid tablet). These tools, reviewed by project investigators and local health experts, are largely adapted from standardized service quality assessment tools (e.g. Service Availability and Readiness Assessments from WHO; Service Provision Assessments survey conducted by USAID's Demographic and Health Survey) and they include relevant indicators from the Lives Saved Tool for subnational modeling to estimate mortality impact from coverage measures. Data collection was carried out by a student investigator and four interviewers in JiVitA. Two interviewers were in charge of observing providers' service provision and two other interviewers in charge of client exit interviews.

The study uses four different data collection methods with three modules. The first method is a desk review of service protocol and guideline documents, which collects information on service provision activities and required equipment at an accepted standard of quality in the local setting. The second method consists of a structured interview guideline, which the interviewer uses to ask organization managers and health service providers for information on overall organization governance, financing, staffing, service capacity, volume, protocols, and related issues. The student, with assistance from a translator, interviewed organization representatives (Deputy Director of Family Planning, BRAC district manager and Smiling Sun NHSDP country representative) or clinic managers (Maternal and Child Welfare Center, Upazila Health Clinic, Family Welfare Center, Community Center, and Smiling Sun).

The third method consists of observing actual service provision, categorizing ANC service contents into five components: clinical history, general examination, counseling, screening and lab testing, and treatment. It also categorizes the types of providers, the average time of service provision and any consumed commodities in specific service provision activities. At the community level, CHWs observed and interviewed during their service provision activities at satellite clinics. Assuming 8-10 ANC service provisions per day per satellite clinic, in order to observe 20 ANC service provisions, interviewers would spend 2-3 days observing practices. There are specifically scheduled dates for ANC service provision in these satellite clinics, which correspond to the data collection dates. At the facility setting, ANC service provider roles may take on a range of occupation categories from family welfare visitors, paramedics, Sub-Assistant Community Medical Officer (SACMO), to doctors. In primary healthcare centers, the interviewer identifies a provider and observes the ANC services at CC, FWC, UHC and Smiling Sun static clinic, respectively. In secondary healthcare centers, interviewers identify a provider and observe the ANC service provision events from MCWC.

The fourth data collection method consists of exit interviews with clients at the end of each service provision observation. They are asked about direct costs and indirect costs such as fees for transportation, drugs and services and loss of schooling or wage due to care seeking. In total, 100 pregnant women (50 in community settings and 50 in facility settings) are asked to participate in the user cost survey. The community-level study was conducted at the satellite clinics. Each CHW's working area is divided into 3-5 clusters and each cluster generally consists of 75-100 households. In each cluster, a satellite clinic is set up twice a month. Community mobilizers, who visit each house for pregnancy surveillance, family planning and other health promotion activities in their assigned catchment areas, inform clients of the specific ANC provision dates and locations of satellite clinics. Based on the scheduled dates, pregnant women are recruited purposively on the observation/interview day at the community or facility site.

Data analyses. The data from the structured interviews regarding organization profiles were analyzed descriptively. Characteristics of samples including both providers and pregnant women were described overall and independently for each group. The basic demographic and epidemiologic profile were compared to the entire district and national profile. We analyzed ANC observation data and described ANC service content, including counseling and clinical care provided, at the community and facility levels independently and overall, and juxtaposed them against recommended ANC according to national guidelines using basic cross-tabulations and frequencies. We used a t-test to compare the content of care provided within and between groups as well as across pregnancy stages. Data about service practice from the observations were used to contextualize and validate the findings from the in-depth interviews. We estimate the cost of ANC service provision based on unit price and quantity of commodities provided (e.g. micronutrient supplementation, etc.) as well as staff category, average salary, and service time. The study also determined the direct and indirect costs incurred by users (e.g. out-of-pocket payments for services and drugs, transportation, as well as lost wages) due to seeking ANC. Costs were determined based on pregnancy stages of care seeking (first, second and third trimester) and level of care setting (community or facility).

4.3 Cost-effectiveness analysis following the Drummond's 10-step checklist

Once the effectiveness and costs measures were determined, the study set up an analytical framework for cost effectiveness analysis. The standardized guidelines of Drummond's 10-step checklist [208] is as follows; 1) define the objective; 2) define the perspective; 3) define the counterfactual; 4) define the health program; 5) define implementation period and time horizon; 6) identify major cost categories; 7) collect costing data; 8) identify and define effectiveness measures; 9) perform analysis; and 10) interpret and disseminate costing results.

Step 1: Define the study objective. The main objective of the thesis is to assess the value for money and affordability of investing in mHealth strategies for pregnancy surveillance and care-seeking reminders in rural Bangladesh. In this economic evaluation, we considered three efficiency principles depending on the research questions. We defined the following three alterative health program scenarios: comprehensive mCARE, basic mCARE and paper-based – to determine incremental cost-effectiveness ratios.

1) **Study Aim 1 examines productive efficiency** based on the research question, “How much can mHealth improve a particular health outcome for a given cost, compared to an alternative option?” In this study, we assessed the value of investing in specific subcomponents of mCARE intervention strategies on SMS and home visit reminders, based on systematic pregnancy surveillance, by using the mCARE system in both intervention and control groups.

2) **Study Aim 2 examines allocative efficiency** based on the research question, “How much can mHealth maximize the welfare of the society through the right mixture of resource allocation?” In this study, we assessed the value of investing in an mCARE program to scale up over 10 years, compared to a status quo

scenario. We considered a wide spectrum of service provision costs in a given heath system and user costs including opportunity costs from a societal perspective.

3) **Study Aim 3 examines technical efficiency** based on the research question, "How much can an mHealth program maximize improvement in outcomes from a set of resource inputs or minimize resources required for a given set of outputs?" In this study, we assessed financial costs associated with the government implementing the mCARE program compared to the status quo scenario, with a six-year timeframe. We also considered specific subcomponents of activities and resource inputs to determine major cost drivers and factors associated with cost savings over time with scale.

Step 2: Define the perspective. The costing perspective determines the methodology to be used and the scope of data to be collected. The stakeholders bearing the costs may differ from those experiencing the benefits, and thus it is important to be clear about the viewpoint is chosen for the analysis and how this affects the results. Such a clarification is also helpful to examine whether all the relevant costs are included. Aim 1 takes a program perspective in order to evaluate the value of the specific program intervention and determine major cost drivers. Aim 2 takes a societal perspective and includes program, provider and user costs to evaluate the value of the program at the expenses associated with overall resource requirements within the health systems. The societal perspective is helpful for evaluating the directions for enhancing allocative efficiency in a variety of setting across various strategies. Aim 3 sees government from a payer's perspective to estimate the financial impact related to national health expenditures. This is to help government investment decisions for health and utilize cost-saving strategies.

Step 3: Define the health program. We compared the two study arms of the mCARE I pilot study for study aim 1 and developed scenarios for aims 2 and 3, describing all required activities and resources that are expected to lead to implementation of the mCARE intervention (defined as comprehensive mCARE), mCARE I control (defined as basic mCARE) and a paper-based status quo groups. For aim 1, definitions of intervention and control are below.

1) Comprehensive mCARE program group: 35 CHWs used mobile phones for census enumeration and pregnancy surveillance. Pregnant women receive automated SMS and home visit reminders delivered by CHWs on their personally scheduled first to fourth ANC dates.

2) Basic mCARE program group: 35 CHWs used mobile phones for census enumeration and pregnancy surveillance.

For aims 2 and 3, we developed the scenarios and described the definitions of intervention, control, and status quo below. The analytic framework and input parameters are presented in Table 4.1.

1) **Comprehensive mCARE program scenario:** CHWs use mobile phones for population mapping and census enumeration and pregnancy surveillance. Pregnant women receive automated SMS and home visit reminders by CHWs on specific personally scheduled ANC for four appointment dates.

2) **Basic mCARE program scenario:** CHWs use mobile phones for population mapping and census enumeration and pregnancy surveillance.

3) **Paper based status quo scenario:** CHWs use the traditional paper-based census enumeration and pregnancy surveillance method. Pregnant women receive community-based ANC promotion activities.

<u>Step 4: Define the counterfactual/competing alternatives.</u> WHO cost-effectiveness analysis (CEA) guidelines suggest a generalized CEA[209] where "the costs and benefits of a set of related interventions should be evaluated with respect to the counterfactual of the null set of the related interventions." For study aim 1, the comparison group is the basic mCARE program. The research question is to evaluate the cost-effectiveness of the add-on component of SMS and home visit reminders in the comprehensive mCARE program, compared to basic mCARE program – not the entire comprehensive mCARE program itself. For study aims 2 and 3, we set the comparison group as paper-based system as a status quo scenario, a counterfactual of the null set, and mCARE I control. The research design allowed CEA of the mCARE program compared to the current paper-based practice. Accordingly, we evaluated whether and to what extent the mCARE program would increase or offset costs compared to the existing paper-based practice over time, with geographical expansion, sustainability and scale in mind. The study findings are widely comparable to other community-based MNH strategies and programs (e.g. women's group program, conditional cash transfer, etc.) in LMICs.

Step 5: Define the scope of program and time horizon. For study aim 1, the scope of program costing included a program life cycle from development, start-up to implementation. This study was based on JiVitA CHWs with retrospective costing from 2011 to 2015. For study aim 2, the scope of program costing assumed the system was developed and thus, included start-up and implementation from 2016 to 2025. Here, we assumed an incremental geographical expansion in Rangpur district. This study was based on government CHWs (FWAs) for pregnancy surveillance and home visit reminders. For study aim 3, the scope of program costing assumed the system to be implemented in Gaibandha district from 2015 to 2020. We used the cost as a reference case to project national budget impact assuming replications of the program to all 64 districts in the country. In terms of providers, we defined the comprehensive service delivery channels including government and NGOs, from community to primary to secondary care. In terms of users, we estimated the number of pregnant women who seek care for ANC, delivery, and PNC based on demographic projections. For care-seeking practices we assumed different increase rates for each scenario.

Step 6: Identify input parameters and data sources. Data sources were drawn from mCARE I with reference to current standard practices, large-scale studies, and historical data. Data collection included a literature review, review of financial records of implementation agencies, observation for service costs and exit interview for user costs. Informant interviews were conducted for program costs. Data on program costs, coverage, and a number of deaths averted for aim 1 were mostly drawn from an mCARE I pilot. To forecast scaled-up costs and effectiveness for aims 2 and 3, we collected and synthesized multiple data sources to set up assumptions to estimate relevant coverage and costs. First, demographic assumptions of relevant population and epidemiologic parameters were drawn from health statistics reports from the World Bank and Bangladeshi Bureau of Statistics database. Baseline service coverage data were drawn from the 2014 Bangladeshi Demographic Health Survey (BDHS). In the second step, program assumptions of activity-based costing were identified from informant interviews with program staff. We identified FWVs' routine activity protocols and general time allocation for each activity in the current paper-based practice. Based on field expert interviews, we set assumptions about the change in time allocation to each activity component (caused by productivity and efficiency change) by using the mCARE system in the first year and each subsequent year over time. The rate of service coverage increase was drawn from mCARE I data results. The rate of service coverage increase in the status quo scenario was drawn from the past five years of service coverage trends from BDHS 2014. For the third step in identifying input parameters, we assumed service provision content and costs for ANC delivery and PNC at the community and facility level. Service provision content and costs were drawn from 100 samples collected through the structured observation study and in-depth interviews from various health service provision agencies in Gaibandha district. User costs were drawn from 100 samples collected through exit interviews with pregnant women who sought ANC care in the community and facilities in the district.

Step 7: Adjustments of costs and consequences for different timing.

Discounting. Discounting refers to "the process of determining the present values of payment to be received at some point in the future."[210] In forecasting cost estimation, the study used a 3% discount rate as a base to adjust future costs to its present value. Based on WHO recommendations, we tested our total program costs results with a discount rate of 0%, 3%, and 6% in sensitivity analyses. LMICs generally use higher discount rates than high-income countries.

Annualization. We annualized capital spending to allocate the cost of fixed assets to the accounting time periods that are expected to benefit, and simultaneously reduced the value of fixed assets on an organization's balance sheet.[211] For example, in the case of the equipment purchased in the year of evaluation, we used its purchase price.[212] In the case of old equipment, we used the cost of replacing the item today, or the original cost of the item inflated to the base year and a full useful life.[212] The useful life of a component is the amount of time that it serves its function, not its physical life. For mHealth, a life cycle of technology may be a few years, as a newer technology that has more functionality with equivalent technology may be less expensive in the future. To make them comparable to variable costs, we amortized the capital costs by calculating the annual value of capital costs. To obtain lifespans for annualizing capital costs, we referred to WHO-

CHOICE[109], or used asset life estimated by the local team. To find corresponding annuity factors for different discount rates, we referred to standard textbooks and manuals such as Drummond et al.[208] and Saving Newborn Lives (SNL) (2004) costing guidelines.[213] We used the straight line method assuming that the value of assets reduces by the same amount over time.

Inflation. For some variable cost items, for which expenditures are made over several years, we considered using Consumer Price Index (CPI) methods, accounting for domestic inflation by comparing prices of a single basket of goods to an average consumer over time. We chose the base year as 2015 and adjusted future costs to be presented for the same year.[214] CPI estimates for global regions or countries can be obtained from the International Monetary Fund (IMF) website in the 'Data and Statistics' section.[215] Using this method, we multiplied the costs in their original currency by the ratio of the CPI index of the base year, and divided by the CPI index of the year they were reported.

Step 8: Incremental cost effectiveness ratios

Cost effectiveness estimates are presented from a program perspective for aims 1 and 3 and from a societal perspective for aim 2. With estimated total costs and health effects for each group – mCARE intervention, mCARE control and status quo paper system – findings were presented in league tables (Table 5.6; Table 6.6; Table 7.3) of incremental cost effectiveness ratios (ICERs) for mCARE intervention versus mCARE control; mCARE intervention versus status quo paper system; and mCARE control versus the status quo paper system. ICERs represent cost difference between the intervention (C1) and comparison arm (C2), divided by the difference in effectiveness between arms (E2-E1).

<u>Step 9: Uncertainty analysis</u>

Sensitivity analyses allow a certain range of variation to the parameters to test the robustness of the model. At large, there are two forms of uncertainty: parameter uncertainty and model (or structural) uncertainty.[216] The first is internal to the model and the latter is external to the model. Parameter uncertainty is from the estimated parameters (not true value) of a given model. A standard statistical method, using standard error measure, can be employed to represent uncertainty to the estimate. On the other hand, model (or structure) uncertainty is related not to the parameters, but to the assumptions imposed by the modeling framework. In fact, any estimated parameter uncertainty through the model will be contingent upon the structural assumptions of the model.[217]

Model (structure) uncertainty. As there is little empirical evidence on scaling up the mHealth program, structural uncertainty may exist in the model framework, scenario and intervention patterns. We addressed structural uncertainty from the process of conceptualizing and building a model by incorporating major implementation and scale-up concerns, based on field implementers' experiences. For the mCARE program, defining the analytical framework and determining an appropriate scope of analyses involve a great level of conceptualization and understanding of the operational mechanisms as well as their impact within a broad health system. Referring to the recently published conceptual framework (i.e.Tanahashi 2.0)[218], implementation principles (i.e. MAPS)[219], and evaluation guideline (i.e. mERA)[220] of mHealth programs, we incorporated the recommended key components of operational and evaluation principles in designing the analytic framework. Table 4.2 describes how the general concerns and interest in mHealth program evaluation were incorporated into the modeling framework. The table also defines scenarios, time horizons, and parameters in the mCARE cost-effectiveness analyses.

Parameter uncertainty. To evaluate the robustness of the findings when key variables change, we used one-way deterministic sensitivity analyses (DSA) and probabilistic sensitivity analyses (PSA). The impact of a single parameter's uncertainty was assessed with one-way DSA, "which varies one of the input variables from its baseline values while observing the effect on the outcome of the model." [221]Tornado diagrams were presented to depict results from a number of one-way sensitivity analyses. For a multivariate sensitivity analysis, in "which more than one input variable is varied," PSA allows the analyst to assign a range and distribution to input variables.[222] Considering that the final estimates are driven by joint effects of multiple parameters, we conducted multivariate PSA with all the variables examined in the one-way DSA.

Parameter selection. The parameters included cost items for program costs, provider costs, and user costs. Also, parameters included population coverage of census enumeration and pregnancy surveillance for each scenario (e.g. 90% and 80%), service coverage increase rates in each scenario (e.g. 10%, 5% and 1%) as well as the modeled a number of lives saved for each scenario. Considering the census enumeration and pregnancy surveillance as major costs drivers, we assessed one-way DSA on factors related to CHW productivity such as a number of household visits per day, level of effort, and CHW salary. We also examined one-way DSA on factors related to technological components such as costs of mobile phone device, server maintenance, or network connection, which generally pose high uncertainty and potential changes within a short time period based on innovation, scale, and competition in the market. The results of one-way DSA are presented as a tornado diagram.

Parameter distributions were chosen to represent statistical uncertainty in the parameter values of the model.[223, 224] These were assumed for the target population, program costs, provider and user costs as well as population and service coverage rates. In terms of program costs, based on our activity-based costing, the parameter ranges were determined by results of respective input variation of level of productivity, LOE and overtime, salaries, and time duration for activity components. We drew the mean and variance from a plausible range reported by an expert. A conservative approach was adopted with an appropriately broad range of possible estimates elicited from each expert. Based on the mean and variance measures, we drew the values of scale and shape for gamma distribution and values of alpha and beta for a beta distribution based on statistical equations. We produced probability distribution functions for each parameter based on standard statistical methods. In case of provider and user costs drawn patient level data, we checked the fitness of the distribution from the actual dataset and defined the distribution shapes (Chapter 6, Table 5). In estimating the target population, we referred to historic data based on the past five years for population growth rate[225], fertility rate[199], fetal loss rate[226] and abortion rate[227] from the World Bank database and other literature.

Simulation. The study used Monte Carlo simulation (MCS) assuming that the data came from a probability distribution and made inferences about the parameters of the distribution such as gamma, beta or lognormal distributions. The statistical distribution was chosen based on the characteristics of the input parameters and standard recommendations in the literature. A total of 1,000 iterations were generated using a Visual Basic macro in Excel. This approach predicts the results that might arise from our trial if it were performed a large number of times. The means of each cost component were summed by calculating each iterated incremental cost-effectiveness ratio. By demonstrating how a variable affects the output of a model over a range of values, sensitivity analyses can help determine whether results are generally consistent (robust) with a plausible variation in a parameter.

Step 10: Presentation and discussion of the study results

We presented results from the analyses in a variety of ways – numerical outputs and graphical demonstrations based on the costing categories; program phases, subtotal and total program costs, as well as unit cost per CHW per pregnant woman over time; and key cost drivers with cost categories as a percent of total costs. These findings can be used to inform decisions about resource allocation, budgeting or policy planning.

ICER league table: In comparing costs among three scenarios, together with effectiveness measures, an lCER league table was constructed to guide prioritization among possible options and determine the most efficient strategy to achieve a goal.[214]

Cost-effectiveness plane: To address uncertainty surrounding the estimates of the expected costs and effects, cost-effectiveness planes were constructed to show the scatter plot points of incremental cost-effect pairs (between the intervention and the alterative), coming out of each iterated input parameter from the MCS.[228] The plane is divided into four quadrants by the origin, each quadrant having different costs and effect implications in economic decision-making.

Cost effectiveness acceptability curves (CEAC) is "a method for summarizing information on uncertainty in cost effectiveness."[229-231] CEAC illustrates the proportion of the scatter plot points that fall below a range of threshold ceiling ratio values, which can be drawn as a diagonal line joining the origin (0) on the cost-effectiveness plane. It is derived from the joint distribution of incremental costs and incremental effects.[228] Setting a series of hypothetical threshold values was considered for net benefit analysis and a cost-effectiveness acceptability curve. Based on the standardized guideline[6], Bangladesh GNI per capita was considered as the willingness to pay to avert deaths from government decision-makers' perspective.[233]

Generalizability of the study findings was discussed in regards to population characteristics and the condition of the health systems. First, we considered that population characteristics may include care-seeking practice, mobile phone ownership level, literacy, socioeconomic status and barriers to care seeking. These characteristics determine to what extent the intervention (SMS and home visit reminders) may contribute to increasing service coverage. Secondly, health systems conditions may include wireless network connectivity, availability of qualified health workers and medical supplies, and other ongoing primary health service programs such as family planning in the community. These characteristics determine the size of target population, the extent to which reminder intervention contributes to service uptake, and the extent to which service coverage contributes to the health outcome.

4.4 Inclusion and exclusion of costs and outcome analyses

1) **Costs:**

Costs of the health system. Our scenarios focused on optimizing and strengthening existing health systems capacity under financial constraints. We included costs for

---

[6] "The World Health Report 2002 proposed a different approach to setting CE threshold. "The recent report of the Commission on Macroeconomics and Health, which was commissioned by WHO, suggested that interventions costing less than three times GDP per capita for each DALY averted represented good value for money." In the report of the Commission, this threshold is justified on the basis of expected direct and indirect benefits to national economies, though the report does not specify the types of costs that should be considered. This is remarkable for the intent to base allocation decisions not on the appeal of arbitrary round numbers, but on an objective national benchmark that is directly related to the affordability criterion." Source: 232. Eichler, H.G., et al., *Use of cost-effectiveness analysis in health-care resource allocation decision-making: how are cost-effectiveness thresholds expected to emerge?* Value Health, 2004. **7**(5): p. 518-28.

building the existing workforce capacity. We assumed medical supplies and health providers would be available at the time of care seeking by pregnant women at facilities. However, we did not include costs for increasing the number of CHWs or upgrading health facilities, although it may be desirable in some regions.

Costs of scaling up. In this study, we assumed horizontal scale up (i.e. "replication in different geographic sites or expansion to serve larger or different population groups"), not vertical scale up (i.e. "policy, political, legal, regulatory, budgetary or other health systems changes needed to institutionalize the innovation at the national or sub-national level").[234] We did not account for potentially critical direct and indirect costs associated with economies and diseconomies of scale. For example, we did not include additional costs to deliver services to households in hard-to-reach areas. We did not include additional incentives to promote their care seeking to reduce access barriers for the poor. We considered costs based on market-based mechanisms. We did not include potential health systems-negotiated costs such as donation, or cost sharing through partnerships, as it is difficult to predict if and when it will happen. For a similar reason, we did not include certain new types of technology or innovation that may have changed the cost or process.

Hidden costs. There may be substantial hidden costs during the startup and implementation periods that this study could not incorporate. These include costs from technical or system errors, complex tasks associated with assigning unique identification values to households and population for mapping and census enumeration, incentives for health workers and managers due to increased workload during the transition time, partnership and advocacy activities when the program scales up, and unpredicted political turmoil and blockages that can suspend program activities. We excluded these costs because of high uncertainty and difficulty of anticipating them in advance. However, local experts addressed that these are feasible scenarios to consider.

2) **Outcome:**

Service delivery. We included a wide spectrum of service delivery channels including government and major NGOs in both community and facility settings. However, our study did not include private and informal sectors, although they play a major role in semi-urban and rural areas. The focus of our study is to see whether and to what extent formal health sectors' general practices follow the national service quality guidelines, in order to identify gaps and provide actionable recommendations to improve their service and organization management. The mCARE reminders and standard recommendation of referrals suggest that pregnant women should seek care at the formal health sectors.

Service quality. We considered that service quality may differ between community and facility levels. Therefore, for LiST modeling, we designed the selection of service subcomponents differently by community and facility level for each scenario. This approach generated a range (low and high) of the number of deaths averted for the respective scenarios. The selected list of LiST interventions is presented in Appendix 3. For each choice of service (such as ANC or skilled health attendance), the specific subcomponents of the service are automatically calculated following the model default values that are based on DHS, MICS and other nationally representative household surveys.

Other interventions that may impact the target population or service coverage and quality have been excluded in these estimates such as family planning programs, conditional cash transfer programs, or upgrading service quality of health facilities or the communities. These programs are financed and implemented through other sectors with different objectives, and there is no clear evidence base on how and to what extent they will happen.

4.5 Ethical clearance

The original mCARE I trial and the service contents and costing study received ethical approval from the Bangladesh Medical Research Council (Reference number: BMRC/NREC/2013-2016/375, dated 14/10/2015) and the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB00006999). For the data from the observation study and exit interviews, subjects enrolled in the study completed consent procedures from pregnant women. (Appendix 7)

Figure 4.1 mCARE I pilot study design with 70 community health workers and 690 pregnant women in Gaigandha district (2011~2015)

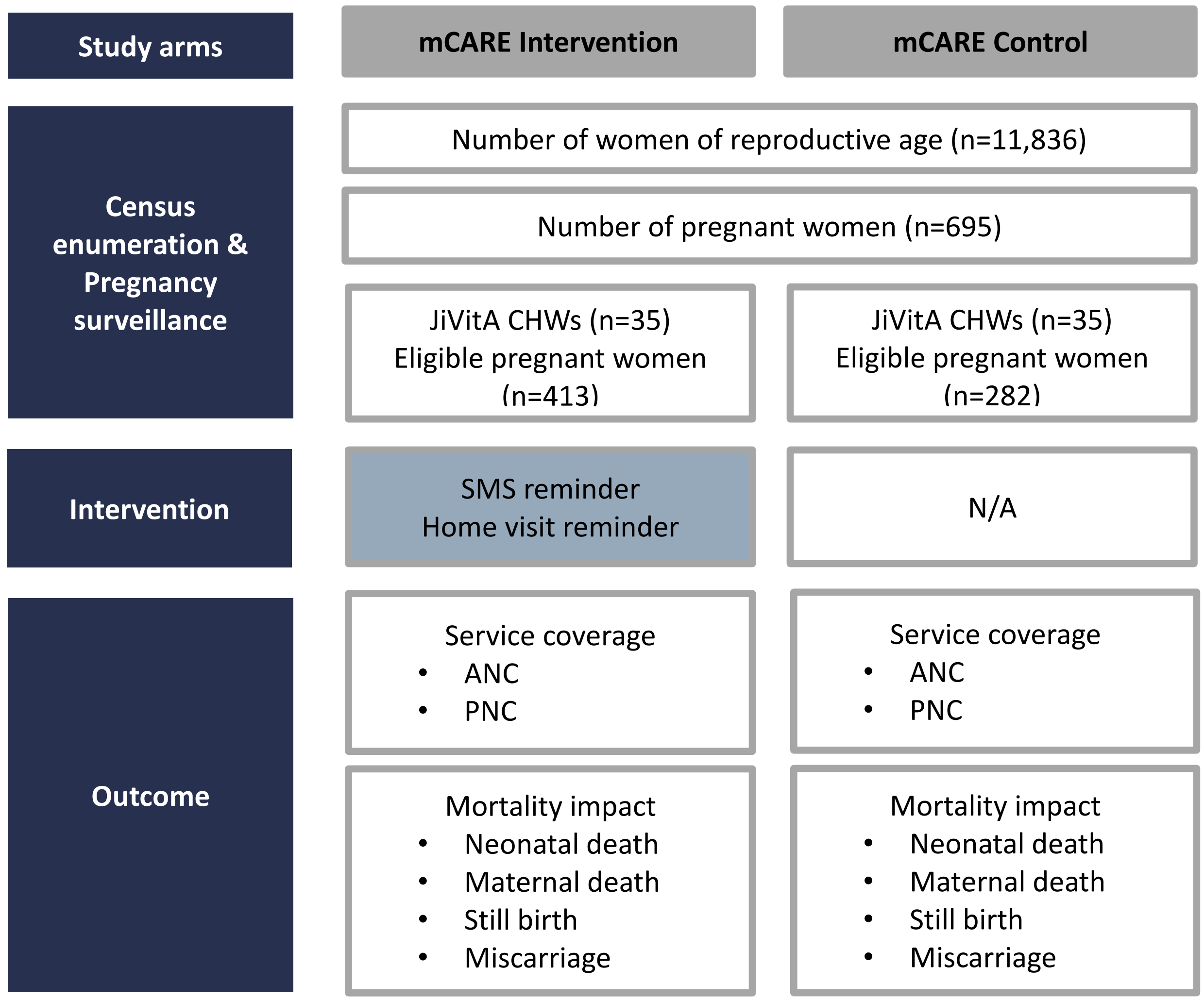


Figure 4.2 Conceptual framework illustrating essential maternal and newborn health care service provision agencies in Gaibandha district for observations of service provision and exit interviews with 100 pregnant women

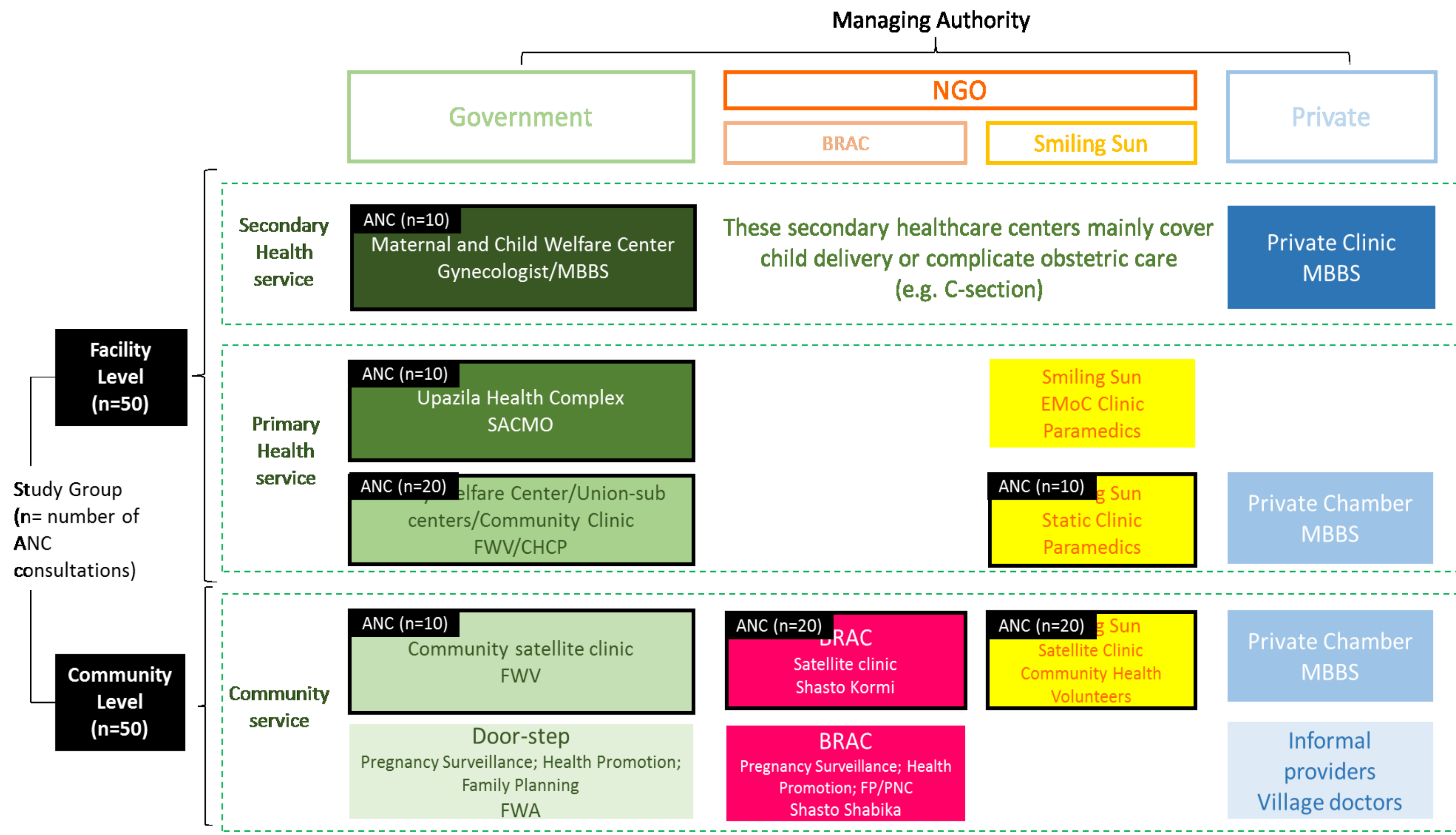


Table 4.1 Development of model scenarios for the three groups: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo

Study arms	Comprehensive mCARE program	Basic mCARE program	Paper based status quo
Study area	Rangpur division in Bangladesh		
Target population	Number of women in reproductive age		
	Fertility		
	Fetal loss rate		
	Abortion rate		
	Number of pregnant women		
Population coverage	Census enumeration 90%		Census enumeration 80%
	Population surveillance 90%		Population surveillance 80%
	Number of registered pregnant women		Number of registered pregnant women
Intervention	SMS reminder	N/A	N/A
	Home visit reminder	N/A	N/A
Service coverage	Annual coverage increase rate 10% for ANC, facility delivery, and PNC	Annual coverage increase rate 5% for ANC, facility delivery, and PNC	Annual coverage increase rate 1% for ANC, facility delivery, and PNC
	Number of women who seek care of ANC, facility delivery, and PNC	Number of women who seek care of ANC, facility delivery, and PNC	Number of women who seek care of ANC, facility delivery, and PNC
Health outcome	Maternal, stillbirth, neonatal deaths averted	Maternal, stillbirth, neonatal deaths averted	Maternal, stillbirth, neonatal deaths averted

Table 4.2 Structural uncertainty and model translation

Reference	Unique characteristics/challenges of mHealth	Translation (Model/Assumptions)
The MAPS Toolkit: (WHO,2015)[219]; Scaling up Health Innovation (ExpandNeT and WHO, 2009, 2010)[234, 235]	Planning: (a) Addressing key elements of planning and implementation: ground work, partnership, technology, M&E (b) Program/research health workers as subject of study (not gov't buy-in)	• Include activity costs such as partnership, system optimization, data reporting and processing • Consider program operation in a phased approach: start-up (first year) and implementation (subsequent years) • Set government as program implementation agency for scale-up/sustainability with integration of national health information system

K4Health: The mHealth Planning Guide [236]	<u>Implementation:</u> (a) Training (b) Operational transition from paper-based data collection to phone-based data collection	• Include not only FWAs training but also training of trainers for their supervisors who will monitor and evaluate FWAs' data collection activities • Determine government CHWs' overall role and responsibility and adjust the respective time allocation by scenarios for activity-based costing. • Assume intensive workload of census enumeration and pregnancy surveillance in the first year of implementation
mERA guideline (Agawal et al, 2016)[220] Tanahashi framework (Science, 2014)[218]; Modeling LiST for mHealth (Jo et al, 2014)[68]	<u>Evaluation:</u> (a) Addressing intermediate outcome of mHealth strategies—pregnancy surveillance and care seeking reminders (b) Comparing service coverage impact for each scenario on a same denominator (c) Lacking a null counterfactual to evaluate mHealth program as a whole (d) Care-seeking/service utilization across various service delivery channels within health systems (e) Measuring health effect from service coverage outcome	• Estimate 'population coverage' as a measure of mCARE performance in pregnancy surveillance coverage (# of registered pregnant women women/total pregnant women in a district) • Define 'service coverage' as an outcome of the mCARE demand promotion strategy (# of pregnant women who seek care/# of registered pregnant women) • Set same baseline service coverage and population for the comparison of three scenarios • Set a scenario of a comparison arm of status quo paper-based system • Include various service provision agencies and level of care including government and NGOs as well as satellite clinic and primary/secondary level clinics in sampling • Consider different provider/user costs and service contents (quality) in community and facility • Use Lives Saved Tool to project mortality impact
MEASURE: mHealth M&E (USAID,2015)[237]	<u>Scale-up:</u> (a) Economies of scale in mHealth program (b) Concern over factors associated with technological components	• Assess cost function by increasing CHW productivity (# of household visits per day) over time with scale • Include sensitivity analyses on cost of mobile phone device, phone loss/break rate, SMS connection fee, etc. • Consider 'horizontal scale up'—not 'vertical scale up' • Do not consider increasing number of CHWs or facilities

Table 4.3 CHEERS/ISPOR guideline for thesis aims and analyses

Research question		What is the value of investing in mCARE intervention to improve pregnancy surveillance and care seeking reminders in Bangladesh?		
Type of efficiency		Productive efficiency	Allocative efficiency	Technical efficiency
Research objectives		Objective 1: To determine the incremental cost-effectiveness of a comprehensive mCARE program of SMS and home visit reminders to promote care seeking of maternal and newborn health services, versus a basic mCARE program in rural Bangladesh	Objective 2: To forecast the incremental cost effectiveness of a comprehensive mCARE program including pregnancy surveillance and care-seeking reminders, compared to paper-based systems, from 2016-2025 in the Rangpur Division of Bangladesh.	Objective 3: To determine the affordability of a comprehensive mCARE program implementation, compared to a paper-based system, over 2015-2020 in a Gaibandha district in Bangladesh
Research aims		Aim 1: Retrospective mCARE I CEA (2011-2015)	Aim 2: Forecasting mCARE CEA (2016-2025)	AIm 3: Budget Impact Analysis of mCARE (2015-2020)
Guideline		CHEERS	ISPOR Modeling study	ISPOR BIA study
Introduction	Background & Objectives	To determine incremental cost effectiveness ratio of mCARE intervention compared to mCARE control from program perspective	To forecast incremental cost effectiveness ratio of mCARE intervention compared to mCARE control and status quo from societal perspective over the next 10 years	To estimate budget and resource requirement to implement mCARE in Gaibandha district over the next 5 years
Methods	Target population	mCARE I study sites (2 unions in Gaibandha districts)	Rangpur region (8 districts)	Gaibandha district (2.4 million population)
	Setting and location	Rural Bangladesh	Rural Bangladesh	Rural Bangladesh
	Study perspective	Program	Societal	Government
	Comparators	mCARE I control	mCARE control and status quo (paper system)	mCARE control and status quo (paper system)
	Time horizon	2011-2015	2016-2025 (10 years)	2015-2020 (6 years)
	Discount rate	3%	0%,3%,6%	No discounting
	Choice of health outcome	Newborn deaths averted, DALY	Maternal, newborn, child deaths averted (LiST), DALY	n/a
	Measure of effectiveness	Number of death, DALY	Number of death, DALY	n/a

	Measure of valuation and preference based on outcome	Discounting (3%), no age weighting	Discounting (3%), no age weighting	n/a
	Estimating resource and costs	Primary field data	Extrapolation of primary field data Secondary data: DHS, LiST	Extrapolation of primary field data
	Currency, price date, and conversion	USD	USD	USD
	Choice of model	Retrospective	Prospective forecasting	Prospective forecasting
	Assumptions	Discounting, including overhead costs	Accounting scaling up factors, time variant factors (e.g. population / service coverage)	No discounting, not including overhead costs
	Analytical methods	Cost-effectiveness	Cost-effectiveness	Payer specific costing
Results	Study parameters	Total cost, program costs, number of deaths, DALY	Total cost, program/provider/user costs, average unit cost per MWRA/Pregnant woman/CHW; number of deaths, DALY	Total cost, program/provider/user costs, average unit cost per MWRA/Pregnant woman/CHW
	Incremental costs and outcomes	mCARE intervention vs. control	mCARE intervention vs control; mCARE intervention vs status quo; mCARE control vs status quo	mCARE intervention vs control; mCARE intervention vs status quo; mCARE control vs status quo
	Characterizing uncertainty	Deterministic Sensitivity Analysis, Probabilistic Sensitivity Analysis	Deterministic Sensitivity Analysis, Probabilistic Sensitivity Analysis	Deterministic Sensitivity Analysis, Probabilistic Sensitivity Analysis
	Characterizing heterogeneity	Discussion	Discussion	Discussion
Discussion	Study findings, limitations, generalizability, and current knowledge	Discussion with other MNCH or mHealth CEAs	Discussion on mHealth CEA with scaling up context	Discussion based on financing options in Bangladesh context

Chapter 5. Costs and cost-effectiveness analyses of mCARE strategies for promoting care seeking of maternal and newborn health services in rural Bangladesh

5.1 Abstract

Despite growing recognition of the potential benefits of mHealth, little economic evaluation research exists to guide priority setting or policy making in developing countries. This study presents findings from the implementation of two mCARE programs, implemented from 2013 to 2015 in rural Bangladesh: (1) Comprehensive mCARE program and (2) Basic mCARE program. Both programs included a core package of services provided by an established cadre of digitally enabled community health workers (CHWs). The package includes census enumeration and pregnancy surveillance. In the comprehensive package, short message service (SMS) and home visit reminders were additionally sent to pregnant women (n=690) from CHWs (n=70). In this study, we aim to compare the costs and consequences of the comprehensive and basic mCARE packages. Economic costs were assessed from a program perspective for an analytic time horizon of August 2011 to June 2015, which included development, start-up, and implementation phases. We drew from implementing partners' activity specifications and financial records. Coverage estimates inputted into the Lives Saved Tool (LiST) were used to estimate incremental lives saved and Disability-Adjusted Life Years (DALYs) averted for newborns. For comparative purposes, we normalized our evaluation to estimate total costs and total deaths averted per 1 million people in a community to the intervention and control groups. Uncertainty was assessed using one-way and probabilistic sensitivity analyses (with Monte Carlo simulation). Costs associated with mobile phones and health worker training were key drivers of cost effectiveness. Study findings suggest that the addition of

SMS and home visit reminders based on an existing mobile intervention of census enumeration and pregnancy surveillance corresponds to an incremental cost per DALY averted as \$0.41 (\$0.31-0.72). The comprehensive mCARE program had at least 97% probability of being highly cost-effective as compared to the basic mCARE program based on the threshold of Bangladesh's GNI per capita. Overall study findings suggest that in this context, the addition of SMS and reminders atop an existing digital health intervention represents good value for money. Future research should aim to generate evidence on the comparative costs and consequences of implementing alerts and reminders in the absence of a basic mobile health intervention. Study findings compare favorably with other low-cost, high priority community-based interventions recommended for use in South Asia. Additional analyses are needed to compare the costs and consequences of mHealth strategies versus existing paper-based services.

5.2 Introduction

Globally, every 90 seconds a woman dies of complications related to pregnancy and childbirth, resulting in more than 303,000 maternal deaths in 2015.[238] Almost one-fourth (24%) of these occur in South Asia.[239] Among children under five years of age, 45% of the estimated 298,000 annual deaths annually occurred within the first 28 days of life.[240] Bangladesh, home to 156 million people, is the eighth most populous country in the world and accounts for 5,200 maternal deaths and 76,722 newborn deaths each year.[241] Efforts to reduce maternal newborn and child morbidity and mortality in Bangladesh have sought to bolster access to and utilization of high-quality health services.[242] Community health workers (CHWs) have been a key strategy for promoting health services, and in some cases providing preventive services and clinical care in the home with the broader aim of extending the reach of the health system. The widespread availability of technology, including mobile phones, has the potential to improve the efficiency of and access to health services in communities.

Mobile-health (mHealth) – defined as the use of mobile and wireless technology for health – aims to improve health outcomes by addressing critical health systems constraints to service delivery, coverage, and utilization.[243] In Bangladesh, a wide array of mHealth initiatives have been piloted, yet few have been scaled to the national level.[49] The mCARE program was initiated in 2011 as a partnership between research, technical and implementation organizations, including Johns Hopkins University, mPOWER Social, and the JiVitA Project in Bangladesh.[244] The aim of mCARE is to develop and test a mobile phone-based system to improve communication and coordination between government health providers and the pregnant women they serve.

In this chapter, we present findings on the incremental cost-effectiveness of two alternative mCARE strategies implemented until the larger mCARE-I pilot: (1) Comprehensive mCARE program; and (2) Basic mCARE program. Both programs included a core package of services provided by an established cadre of digitally enabled community health workers (CHWs), including census enumeration, and pregnancy surveillance. In the comprehensive package, short message service (SMS) and home visit reminders were additionally sent to pregnant women (n=690) from CHWs (n=70). By exploring the incremental costs and consequences of these two alternative programs, we hope to inform efforts to streamline mCARE program content and optimize the use of mobile tools in providing health services and bolstering uptake. Study findings aim to contribute to the current paucity of data on the cost-effectiveness of digitally enabled CHW programs in low- and middle-income countries (LMICs).

5.3 Methods

Setting: The mCARE I pilot program was implemented in 19 unions of Gaibandha district of the Rangpur Division in northern Bangladesh. Gaibandha has been part of the Johns Hopkins University JiVitA field site for 16 years and is home to an estimated population of 2.4 million, 80% residing in rural areas and 60% being women.[245] Public health services are mainly provided through the following primary health care facilities: Satellite Clinics, Community Clinics/Family Welfare Clinics, and Upazila Health Complexes. Private sector services include informal and formal providers, with the latter comprising of clinics supported by nongovernmental organizations (NGOs), including BRAC and Smiling Sun.

Study design: In a quasi-experimental design, two comparable regions were selected within the JiVitA study site for an intervention arm and a comparison arm. In each study arm, community-based services were provided by a cadre of 35 full-time, paid community health research workers (CHRWs) responsible for enrolling and conducting follow-up visits for approximately 400 pregnant women in each study arm. In two weeks, 70 JiVitA CHRWs were trained in the use of the mCARE mobile application, and in five weeks they conducted a census of 11,836 women. 6,652 women were found to be eligible for the study and consented to be visited every five weeks for pregnancy surveillance. 800 pregnant women were enrolled in mCARE phase I, 50% (n=400) of those being part of a quasi-experimental intervention arm and the remaining 50% (n=400) part of a control arm. The final sample based on eligibility criteria was 408 pregnant women in the intervention group and 282 pregnant women in the control group.

Program description: Table 5.2 depicts key activities for the intervention and comparison areas. The program activities began in August 2011 and continued through June 2015. In both study arms the following activities were performed, in three phases: 1) Development phase (August 2011 to April 2013) – partnership development, program and system development; 2) Startup phase (May 2013 to August 2013) – system optimization, training, community outreach and advocacy; and 3) Implementation phase (September 2013 to July 2015) – the four major activities: pregnancy surveillance (including census enumeration), SMS reminders, and ANC reminder home visits.

First, the team sought to create a complete household enumeration by registering every resident with a unique identifier in the catchment area, and then identifying married women of reproductive age (MWRAs, 15-45 years old), eligible for regular pregnancy surveillance in both intervention and comparison areas. Routine pregnancy surveillance was conducted every five weeks with the broader aim of identifying pregnancies among MWRAs based on self-reported last menstrual period and urine pregnancy test confirmation.

After identifiying the timing of ANC, based on gestational age, women were enrolled into two program interventions – (i) scheduled SMS reminders and (ii) ANC advocacy home visits – implemented to promote care-seeking for ANC, SBA/FD, and PNC in the intervention group. First, based on a woman's last menstruation period, the system calculates gestational age and automatically schedules four ANC visits (+8-10, +12-27, +26-28 and +32-34 weeks) and sends SMS reminders to the pregnant woman on the scheduled dates. During labor or (after) birth, a pregnant woman or her family or CHWs can send an SMS text, by using the "6969" short code with their identification number, to notify the CHRWs of the labor or birth. The birth notification then triggers SMS reminders on day 1, 2 and 7 of the newborn's life for postnatal visits for the woman and essential newborn care for the baby. Second, in addition to the scheduled SMS reminders to the pregnant women, CHWs (field distributors, n=20) visited pregnant women (n=436) shortly in advance of the scheduled ANC visit dates.

In the intervention arm, SMS and home visits reminders were implemented as the two major components. In the comparison arm, these two interventions were not implemented. All other activities including partnership and system development, mobile phone procurement, training, community outreach, supervision, census enumeration, pregnancy surveillance, data processing and reporting throughout the development, startup and implementation phases were conducted and shared identically in both study arms. This study design allowed for a systematic evaluation of the program outcomes – differing service coverage and health outcomes based on a comparable denominator — the number of enrolled pregnant women – between the two arms.

Costing: Economic costs were measured from a program perspective for the analytic time horizon of August 2011 to July 2015. Program costs were drawn from the financial records of the two implementing partners, mPOWER and JHU-JiVitA. Using standardized guidelines[246] and an ingredients-based approach, costs per activity were captured for the three phases: Development phase (August 2011-April 2013), Start-up phase (May 2013-August 2013) and Implementation phase (September 2013-July 2015). Within each phase, costs were divided into capital costs and recurrent costs and categorized into relevant activities through informant interviews with key program staff. All capital costs were annualized according to international or local estimates of each item's life expectancy using a 3% discount rate.[247] Together with recurrent costs, these costs give an estimate of the annual program costs of running a program or intervention. Costs are presented in 2015 as the base year and in US dollars, adjusting for inflation according to consumer price indices from the IMF.[248] All costs related to the development and start-up phases were also treated as capital costs, and similarly annualized using a 3% discount rate and an assumed life expectancy of three years.

To allow for a more approximate allocation of shared costs between the arms, we adjusted for differences in the sample sizes between study arms and standardized costs to a population of 1 million per arm.[249] In this adjustment, we carefully reviewed characteristics of each cost item such as activity-based costs and overhead costs and divided the costs into capital and variable costs. Capital costs, unlikely to change based on the number of beneficiaries, include partnership development, system development, system optimization, data processing and analyses, furniture and equipment procurement, and office maintenance during development and start-up phases. Variable costs include mobile phone procurement, training, community outreach, supervision, server maintenance, census enumeration, pregnancy surveillance, SMS reminders, ANC reminder home visits and data collection home visits. In terms of the variable costs, unit costs were calculated per CHW, except SMS air-time costs, which are calculated per client (pregnant woman). We chose the CHW and not the client as the unit because most program activity costs are directly drawn from their work capacity, salary and time. Given a scenario of 1 million people in each group's catchment area, the number of pregnant women was estimated as 3,400 in a given year by assuming the number of women of reproductive age (243,478) in 2015, fertility rate (2.21), abortion rate (18.20), and fetal loss rate (37.00) based on the national and district health bulletin statistics reports. Based on the ratio of one CHW to 10 pregnant women enrolled (1 year) and management (1 year), 340 CHWs were assumed to manage pregnancy surveillance and program intervention in a year. Accordingly, each unit cost was then extrapolated by the estimated number of CHWs and clients to calculate standardized costs per 1 million people.

Effects: Effects were calculated as disability adjusted life years (DALYs) and the number of newborn deaths averted. Estimates of the Years of Life Lost (YLLs) to newborns were drawn from the primary data collected from the household survey implemented during the mCARE I program, from 2014 to 2015. Findings from unadjusted analyses suggest that there was a significant reduction ($p<0.05$) in the number of neonatal deaths. While declines in maternal deaths and stillbirths were observed, they were not statistically significant.

Accordingly, the primary outcome measure used was neonatal deaths averted. Once adjusting for a population of 1 million, we estimated that total averted number of deaths between the intervention and comparison groups are 80 (range 35~123). Newborn YLLs were determined using the mean life expectancy of males and females in Bangladesh, which is 72 years. Due to the lack of morbidity data, YLDs were not included in the DALY calculation, assuming their impact to total DALY measure is negligible based on the literature. Base case DALYs for newborns were discounted at a rate of 3% without age weighting. Incremental DALYs averted through the mCARE interventions were calculated by subtracting the respective estimates of DALYs for each arm.

Cost-effectiveness analysis: Comparisons of costs and effects for each study arm were used to generate incremental cost-effectiveness ratios (ICERs). Variations in individual parameters were tested within this framework using one-way deterministic and multi-way probabilistic sensitivity analyses. ICERs were estimated in both sensitivity analyses. Deterministic sensitivity analyses (DSA) tested uncertainty around each cost parameter according to a plausible range of input values, such as mobile phone costs, CHWs salaries and time periods of key interventions. Collectively, we assumed +/- 20% as a plausible range of variation from each cost based on expert opinion, as we did not have survey-based data for each input value. The DSA was only applied for variable costs because the purpose of DSA is to identify key determinants and cost drivers in the implementation of the program. A tornado diagram was generated to depict results of variations in total costs from the univariate sensitivity analyses to key variable cost items.

For probabilistic sensitivity analyses (PSA), as the cost estimates are not based on sampled data, we assumed distributions following common standards based on data characteristics. For example, cost parameters are assumed as a gamma distribution, as the cost distribution is generally right-skewed. The number of deaths parameter is assumed as a triangular symmetric distribution as a general standard practice for the value without sample data and evidence of a particular distribution pattern.[250] For a gamma distribution, standard errors were estimated based on 20% of the point estimate. For triangular symmetric distribution, upper and lower values were from 95% confidence intervals from the outcome samples.

To test the effect of simultaneous variations in multiple parameters, a Monte Carlo simulation was used to generate a PSA. The mean of each variable cost component (e.g. census numeration, pregnancy surveillance, training, SMS) was used to calculate each iterated incremental cost-effectiveness ratio. A total of 1,000 iterations were generated using a Visual Basic macro in Excel. Following the recommendation by the Commission for Macroeconomics and Heath, the ICERs were then compared with the per capita value for the GNI of Bangladesh 2015. Cost-effectiveness acceptability curves were generated in further sensitivity analyses to test the robustness of the results.

5.4 Results

Study participant characteristics: Table 5.1 illustrates general characteristics of the study population. Our study sample draws from the 690 pregnant women – 330 in the intervention and 280 in the control arm – who reported pregnancy outcomes between

September 2013 and August 2015. Most basic biological, nutritional and economic statuses were similar in both groups, although literacy level differed. Approximately 87-88% women in both groups were aged 18-35 years. 56% women reported a parity status of 1-2 births and 22-25% were null parity and 18-22% had more than two births. In terms of nutritional status, 87% women in both groups reported a Mid-Upper Arm Circumference (MUAC) measure of greater than 21.5 cm, a typical cutoff for malnutrition. In terms of economic status, both groups reported a similar number (24-27% for each quintile in both groups based on household wealth index) of women across household wealth quintiles. 57% of women in the intervention arm and 71% in the control were literate.

Program costs: Table 5.3 depicts total program costs as well as program costs, by study arm. The standardized program costs for a population of 1 million for the development phase was $83,001 and for start-up was $48,988. The substantial cost of development is in part due to the long time period of this phase (21 months), compared to the start-up phase (4 months). Office maintenance (overhead costs) makes up about 50% of the costs in each phase. Among the activity costing components, system development and mobile phone procurement were the major cost drivers, at $23,723 and $13,940, respectively, in the development phase. In the start-up phase, training was the major cost at $22,440. The first year of implementation costs were $127,012 and second year costs were $131,252 due to the additional activity of data processing and analyses in the second year. Besides office maintenance costs, supervision (program governance) and pregnancy surveillance were the major costs: $49,640 and $20,400, respectively, during the implementation phase.

Interestingly, server maintenance and connection fees were estimated at only $170 for ANC home visits and $306 for SMS reminders, a mere 0.4% in the implementation phase. This is because of a very low unit cost for each activity of $0.5 per CHW and $0.1 per client. Unit costs of these activities are low because SMS airtime cost is very inexpensive in Bangladesh and ANC reminder home visits were conducted by staff with low salary levels, and the visits required a small amount of time from their working hours. Calculations of the annual cost for implementation including development and start-up with one year of implementation costs turned out to be $243,662 for the intervention arm, and $243,186 for the control arm. In the second year, they amounted to $247,903 for the intervention arm and $247,427 for the control arm. The slight increase in annual costs in the second year is due to additional activities like data processing and reporting.

Effects: Table 5.4 summarizes key outcomes of the mCARE program. In the intervention area, a total of seven neonatal deaths, 17 stillbirths and 30 miscarriages were observed out of 413 pregnant women. Over the same time period, in the comparison area, a total of 10 neonatal deaths, one maternal death, seven stillbirths and 14 miscarriages were observed out of 282 pregnant women. Findings from unadjusted analyses suggest that there was a significant reduction ($p<0.05$) in the number of neonatal deaths. While a lower number of maternal deaths and greater numbers of miscarriages and stillbirths in the intervention arm were observed then the control arm, they were not statistically significant. Accordingly, the primary outcome measure used was neonatal deaths averted. Once adjusting for a population of 1 million, we estimated a difference of 63 (range 32-94) newborn deaths averted between the intervention and comparison groups.

Incremental Cost Effectiveness Analyses: Our results indicate that the mCARE intervention (SMS and home visit reminders) was highly cost-effective compared to the control group, from a programmatic perspective. The incremental cost per death averted was $12 and per DALY averted was $0.41, suggesting high cost-effectiveness as it is well below Bangladesh's per capita GNI. It is important to acknowledge that the only cost difference between the two arms are from the SMS and ANC home visits costs, which were very low. Both study arms had the same activities during the preparation phases and implemented pregnancy surveillance using mobile phones with supervision and technical assistance.

Sensitivity analyses: Figure 1 depicts a tornado diagram based on one-way sensitivity analyses, indicating that total program costs were driven by supervision following pregnancy surveillance, technical assistance, server maintenance, training, and mobile phone procurement. As discussed, the impact of SMS and home visit reminders were minimal due to the small amount of costs. The cost-effectiveness plane (Figure 5.2) depicts individual results of 1,000 points of incremental costs and the number of neonatal deaths averted from the Monte Carlo simulation. The PSA with Monte Carlo simulation quantified that the probability that the program would be highly cost effective is 97% at a threshold value of $1080, Bangladesh GNI per capita.

5.5 Discussion

Summary/highlights/implications of findings: Despite a relatively small difference in mortality impact between intervention and control groups, study findings suggest that the comprehensive mCARE program is highly cost-effective according to thresholds recommended by WHO and the Commission for Macroeconomics and Health. In the absence of a 'status quo' comparator, study findings compare the minimal added costs and consequences attributed to the SMS and home visit reminders components of the mCARE program. Key drivers of cost effectiveness included supervision and pregnancy surveillance, which were associated with increasing numbers of CHWs and management. The results suggest that once surveillance is initially conducted via mobile phone, marginal costs of adding personally scheduled SMS and home visit reminders to promote care-seeking are almost negligible, and this small investment can make a life-saving impact in low-resource settings.

To consider the broader health systems implications of adopting a mobile health strategy in Bangladesh, we conducted a detailed activity-based costing to identify who is involved, what the new resource requirements are, how and why the processes are changed, and to what extent these changes are occurring over the full course of program development, preparation and implementation. With this approach, we conceptualized and categorized major activities based on their purpose and characteristics and identified the costs of the activity item based on relevant staff salaries, working months, and their levels of effort. Compared to alternative approaches to costing that broadly defines a cost item as human resource for staff salaries, this activity-based costing helped to identify major activities and the associated time of completion, and consequently, their implications on resources required.

Comparison with other MNCH CEA studies: Several recent community-based trials of maternal and neonatal intervention packages in low-resource settings in South Asia have shown statistically significant reductions in neonatal mortality, employing a variety of healthcare delivery approaches. To provide preventive and curative services in low-resource settings, strategies have taken into account “the risk factors for and causes of mortality, the quality and accessibility of the health care system, and community perception and acceptance of the interventions.”[251] In Bangladesh, there have been seven CEA studies on MNCH[252][181, 253, 254], according to a recent systematic review.[180] Most studies used service output measures as effectiveness units such as the number of ANC services provided, the number of clients per year, percent of deliveries; and only two studies demonstrated mortality outcome as an effectiveness unit based on randomized controlled trials.[181] Another study used conditional cash transfer as demand promotion strategy to improve child delivery with skilled birth attendance.[255]

A study by Fottrell et al. used a women’s group to stimulate community mobilization and presented the prospective cost-effectiveness as $11,974 per neonatal death averted and $393 per year of life lost averted.[181] The study highlights that the size of a population in a CHW’s areas of responsibility may be an important determinant of a community health intervention’s effect on behavior and mortality. Thus, it concluded that mobilizing a women’s group community, delivered at an adequate size of target population coverage per CHW, is a highly cost-effective approach to improve newborn survival and health behavior indicators in rural Bangladesh. In a similar fashion, a study by LeFevre et al,[253] evaluated CHW home visits for neonatal infection prevention and treatment and presented cost per neonatal death averted at $2,939, and cost per DALY averted at $103. The study concludes that the home care package of interventions is highly cost-effective and thus should be considered for replication and scale up throughout Bangladesh in similar settings where neonatal mortality is high, and the utilization of facility-based delivery and postnatal care services is low. A study by Hatt et al.[256] used vouchers for free MNH care with conditional cash transfers, which showed that each additional delivery with a qualified provider that can be attributed to the demand-side financing program costs roughly $70. These studies suggest that successful strategies of the cost-effective community-based interventions include adequate care package programs, human resource management to cover populations in needs, and demand promotion incentives in a Bangladeshi context.

Our findings are comparable to the results of a global summary of meta-analyses of the costs per DALY averted in community-based programs for MNCH, recently published in Disease Control Priorities: Reproductive, Maternal, Newborn and Child Health (Figure 14.1; Figure 17.1).[257] In terms of the measure for cost per deaths per DALY averted, the addition of SMS and home visit reminders in the mCARE program – on the basis of the mobile phone based pregnancy surveillance system – is similar to or less expensive than community-based MNH interventions such as vitamin A supplementation, zinc added to oral rehydration therapy or pneumococcus vaccines in low-income countries. While these studies involve different strategies for different purposes, overall findings indicate that mHealth strategies can be complementary to or may enhance the cost-effectiveness of these interventions as demand promotion strategies. mHealth may introduce other benefits such as information sharing, increased workers' empowerment, economies of scale and efficiency. A study by Lund et al., for example, added a voucher system to an mHealth program to improving ANC care-seeking, which resulted in statistically significant coverage uptake and perinatal mortality reduction in Tanzania.[258]

Comparison with other mHealth CEA studies**:** Few rigorous economic evaluations exist in the mHealth domain. Most existing studies include mHeath strategies of SMS reminders for treatment adherence for HIV/ART treatment[259], malaria[165, 167] and TB treatments[260] and smoking cessation[164]. Other studies also include mHealth strategies for data collection[261, 262] family planning training[263] and telephone support for breastfeeding[166]. These studies presented feasibility, quality and efficiency improvement, cost-effectiveness, and cost-saving potential when scaled up. However, no study has yet examined value for money regarding SMS reminders on top of an existing digital surveillance system. Only two studies[164, 260] presented cost effectiveness as cost per Quality Adjusted Life Years (QALY) gained, and cost per DALY averted, but most other studies demonstrated the findings as costing and cost savings or cost-output measures with some processing time and quality improvement indicators. While there is growing evidence of mHealth on MNCH in LMICs, there is yet little systematic mHealth CEA research being done in LMICs. This analysis is thus an important contribution to the field because it evaluates major mHealth strategies for MNCH interventions, including surveillance data collection by CHWs and SMS reminders to clients.

5.6 Limitations

Our study has some limitations. First, the mCARE I study was a pilot study using a quasi-experimental design, which lacks the statistical power and adjustment of confounding factors in evaluating mortality impact. Thus, the findings of statistical significance on health impact are suggestive and not definitive. Given the fact that the mHealth intervention was a reminder for care seeking, not provision of care itself, the health impact can be influenced by access to and quality of the local health facilities and the pregnant women's care-seeking habits. The enabling components of a health system, such as level of a mobile phone penetration and ownership in the community, stable electricity and network connection, and available community health workforce to manage operations at scale are critical aspects to consider.

Based on the study design, it is important to clarify that our work demonstrates incremental benefits of adding SMS and home visit reminders, rather than an entire mHealth program. Since our comparison group, basic mCARE program, also used mobile phone for pregnancy surveillance, our finding does not present mCARE effectiveness compared to the current best practice – paper based system. Rather, as discussed above, this allows for a systematic comparison and evaluation of the mHealth intervention's impact on service coverage improvement and mortality reduction based on similar population denominators between the intervention and control groups.

We took a program perspective, and thus did not include household costs or service provision costs associated with the intervention. However, in this setting where ANC services are largely free of charge in all public facilities and very inexpensive (e.g. $0.06 per ANC) in some NGO clinics, we consider that user or provider costs would not affect our cost-effectiveness conclusions. Similarly, our study measured mortality and not morbidity; however, because estimates suggest that inclusion of morbidity would have a negligible effect on the DALYs averted by newborn home visits, we believe our use of DALY-based thresholds for assessment of cost-effectiveness remains broadly appropriate.

Our cost adjustment for standardized estimations to a population of 1 million may not systematically incorporate potential changes with scaling up. The proportional extrapolation based on the relevant user and beneficiaries may not consider potential productivity or efficiency gains associated with mHealth programs at scale over time. However, the method of extrapolation with a unit cost to the increased number of the target population is a common practice in economic evaluation of health programs.[249] Besides the mortality impact, mHealth is expected to provide great benefits in operational practices with improved accuracy, quality, and efficiency, shown in many qualitative studies. The currently limited evidence makes it difficult for systematic quantification of these features for cost-effectiveness analyses. Considering these direct benefits as well as positive externalities, our measure of cost per death averted may be considered a conservative estimate of the value of the mHealth strategy.

5.7 Conclusions

The study contributes to the currently available economic evaluation data on mHealth interventions in Bangladesh and globally. Study findings suggest that in this context, the addition of SMS and home visit reminders based on a mobile phone-facilitated pregnancy surveillance system was highly cost effective at a cost per DALY averted of $0.41 according to thresholds recommended by WHO and the Commission for Macroeconomics and Health. Future research should aim to generate evidence on the comparative costs and consequences of implementing alerts and reminders in the absence of a basic mobile health intervention. Based on our findings on a broader evidence landscape of community-based MNCH practices, we suggest that incorporating simple mHealth strategies such as SMS reminders to clients and workflow optimization to proven community-based delivery strategies may improve service utilization and program cost-effectiveness in low-resource settings.

Table 5.1 Characteristics of pregnant women (n=610) by study group from mCARE I pilot study

Characteristics of pregnant women		Comprehensive mCARE (n=330)	Basic mCARE (n=280)
		%	%
Women's age	<18 years	7.3%	8.9%
	18-35 years	89.1%	86.8%
	>35 years	3.6%	4.3%
	Missing	0.0%	0.0%
Parity	Nulliparity	21.2%	25.4%
	1-2 births	56.7%	56.1%
	>2 births	22.1%	18.2%
	Missing	0.0%	0.4%
Mid-upper arm circumference	<21.5 cm	12.7%	13.2%
	>= 21.5 cm	87.3%	86.8%
	Missing	0.0%	0.0%
Women's Literacy	Illiterate	41.2%	25.7%
	Literate	57.3%	71.1%
	Missing	1.5%	3.2%
Household wealth index	Lowest quartile	24.8%	24.3%
	2nd quartile	24.2%	23.9%
	3rd quartile	24.5%	24.6%
	Highest quartile	26.4%	27.1%

Table 5.2 Activity based program costs definitions over mCARE I program development (August 2011-April, 2013), start up (May-August, 2013), and implementation (September 2013-August, 2015)

Program activities	Activity descriptions	Study arms		Cost type
		Comprehensive	Basic	
Development (August 2011-April 2013): 21 months				
Partnership development	JHU/JiVitA / mPOWER held leadership meetings and an official launch on mCARE project among central, regional, and district health management teams. JHU contracted mPOWER as technical system developer.	√	√	Capital costs (3 yrs of useful time; annualized)
Systems development	mPOWER prepared systems requirement specifications; developed scheduling logic, skip patterns, question type feedback; development of detailed technical specifications (end user centered design criteria; CHW workflow and information flow analysis)	√	√	
Mobile phone procurement	Mobile phones procurement (n=70) and distribution; system embedment	√	√	
Furniture and equipment	JiVitA/mPOWER computers, desks, chairs, cabinets, vehicles etc.	√	√	
Office maintenance	JiVitA/mPOWER office rent, office supplies, utilities (electricity, gas, water etc.)	√	√	
Start up (May-August 2013): 4 months				
System optimization	mPOWER developed system prototype and testing : outsourced SMS service component	√	√	Capital costs (3 yrs of useful time; annualized)
Training	JiVitA / mPOWER prepare training manuals; conduct 3 weeks trainings with mobile phones to 70 CHWs; evaluate CHWs performance and acceptability; print out survey forms; prepare data management/ data entry screen generation; field testing	√	√	

Community outreach	JHU/JiVitA established MOU with government DGFP; held an official launching meeting by inviting local leaders and partners in Gaibandha; distributed mCARE brochure to community	√	√	
Office maintenance	JiVitA/mPOWER office rent, office supplies, utilities (electricity, gas, water etc.)	√	√	
Implementation (September 2013-August 2014): 12 months				
Supervision	JiVitA senior management team and field supervisor monitor field implementation activities and progress through weekly meetings, field visiting, data monitoring, quality control activities etc.	√	√	Recurrent costs
Census enumeration	Field distributers visit all households for census enumeration, MWRA registration through mobile phones for 5 weeks.	√	√	
Pregnancy surveillance	Field distributors visit eligible couple's households for pregnancy registration, receive consent for the study through mobile phones for 10 months.	√	√	
SMS	SMS automatically sent from server to pregnant women's phones at their expected ANC 1-4 dates.	√		
Reminder home visit	Field distributers visit pregnant women' houses four days before their scheduled ANC 1-4 dates to remind/encourage ANC care-seeking.	√		
Server maintenance	Server to automatically send scheduled SMS to pregnant women and update workflow (e.g. list of households to be visited in the week) to CHWs	√	√	
Office maintenance	JiVitA/mPOWER office rent, office supplies, utilities (electricity, gas, water etc.)	√	√	
Implementation (September 2014-August 2015): 12 months				
Supervision	JiVitA senior management team and field supervisor monitor field implementation activities and progress through weekly meetings, field visiting, data monitoring, quality control activities etc.	√	√	Recurrent costs
Pregnancy surveillance	Field distributors visit all households for pregnancy registration, consent for the study through mobile phones for 10 months.	√	√	
SMS	SMS automatically sent from server to pregnant women's phones at their expected ANC 1-4 dates.	√		

Reminder home visit	Field distributers visit pregnant women's houses four days before their ANC 1-4 dues to remind/encourage ANC care-seeking.	√		
Server maintenance	Server to automatically send scheduled SMS to pregnant women and update workflow (e.g. list of households to be visited in the week) to CHWs	√	√	
Data processing & management	mPOWER provide technical assistance, trouble shooting, data cleaning etc.	√	√	
Data reporting & documentation	JiVitA data cleaning; analysis; reporting	√	√	
Office maintenance	JiVitA/mPOWER office rent, office supplies, utilities (electricity, gas, water etc.)	√	√	

Table 5.3 1 million population standardized program costs by study arm mCARE I program

	Program costs (Annualized)	%	mCARE I program		unit cost/unit (USD$)	1 million standardized estimations	
			Comprehensive	Basic		Comprehensive	Basic
Number of population	~40000		~20,000	~20,000		1 million	1 million
Number of pregnant women (1 year)	700		350	350		3400	3400
Number of CHWs	70		35	35		340	340
Development costs (21 months)							
Partnership development	$14,811	11%	$7,406	$7,406	n/a	$7,406	$7,406
System development	$47,446	34%	$23,723	$23,723	n/a	$23,723	$23,723
Mobile phone procurement	$2,852	2%	$1,426	$1,426	$41/CHW	$13,940	$13,940
Office maintenance	$66,419	47%	$33,209	$33,209	n/a	$33,209	$33,209
Furniture and equipment	$9,446	7%	$4,723	$4,723	n/a	$4,723	$4,723
Total development costs (A)	$140,974		$70,487	$70,487		$83,001	$83,001
Start-up costs (4 months)							
System optimization	$11,988	23%	$5,994	$5,994	n/a	$5,994	$5,994
Community outreach	$2,060	4%	$1,030	$1,030	$13/CHW	$4,420	$4,420
Training	$6,832	13%	$3,416	$3,416	$66/CHW	$22,440	$22,440
Office maintenance	$32,269	61%	$16,134	$16,134	n/a	$16,134	$16,134
Total start-up costs (B)	$53,149		$26,574	$26,574		$48,988	$48,988
Implementation cost--Year 1							
Supervision	$61,900	37%	$30,950	$30,950	$146/CHW	$49,640	$49,640
Pregnancy surveillance	$29,732	18%	$14,866	$14,866	$60/CHW	$20,400	$20,400
ANC reminder home visit	$643	0%	$643	0	$18/CHW	$6,120	$0
Technical assistance	$6,256	4%	$3,128	$3,128	$40/CHW	$13,600	$13,600
Data processing & analyses	$0	0%	$0	$0	n/a	$0	$0
SMS	$17	0%	$17	0	$0.09/Client	$306	$0
Server maintenance	$8,116	5%	$4,058	$4,058	$35/CHW	$11,900	$11,900
Office maintenance	$61,991	37%	$30,996	$30,996	n/a	$30,996	$30,996
Total implementation Yr1 costs (C)	$168,654		$84,657	$83,997		$127,012	$126,536
Total program year 1 costs (A+B+C)	**362,776**		**$181,718**	**$181,058**		**$259,001**	**$258,525**
Implementation costs-- Year 2							
Supervision	$61,900	35%	$30,950	$30,950	$146/CHW	$49,640	$49,640
Pregnancy surveillance	$29,732	17%	$14,866	$14,866	$60/CHW	$20,400	$20,400

ANC reminder home visit	$643	0%	$643	$0	$0.5/CHW	$170	$0
Technical assistance	$6,256	4%	$3,128	$3,128	$40/CHW	$13,600	$13,600
Data processing & analyses (2nd year)	$8,481	5%	$4,240	$4,240	n/a	$4,240	$4,240
SMS	$17	0%	$17	$0	$0.09/Client	$306	$0
Server maintenance	$8,116	5%	$4,058	$4,058	$35/CHW	$11,900	$11,900
Office maintenance	$61,991	35%	$30,996	$30,996	n/a	$30,996	$30,996
Total Implementation Yr2 costs (D)	$177,135		$88,897	$88,237		$131,252	$130,776
Total program year 2 costs (A+B+D)	**$371,257**		**$185,958**	**$185,298**		**$263,241**	**$262,765**

Table 5.4 Health outcome: unadjusted multinomial logistic regressions and 1 M population standardization

Birth Outcomes n (%) = # of pregnant women	mCARE I pilot		1 Million population standardized estimation	
	Comprehensive (n=413)	**Basic (n=282)**	**Comprehensive (n=3,400)**	**Basic (n=3,400)**
Miscarriage**	5 (1.5%)	14 (5.2%)	52	170
Stillbirth	13 (3.9%)	7 (2.6%)	134	85
Neonatal death*	4 (1.3%)	10 (4.1%)	41	121
Perinatal mortality	17 (5.2%)	17 (6.3%)	175	206
*p<0.05; **p<0.01; ***p<0.001, based of X^2 test for categorical variables				

(Note: Annual number of pregnant women (3,400) was calculated based on estimated women of reproductive age (243,000), fertility rate (2.21), abortion rate (18.20), fetal loss rate (37.00) based on a formula published by CDC)

Table 5.5 Standardized costs per 1 million population by study groups for sensitivty analyses

Standardized cost per 1 million population		Comprehensive mCARE			Basic mCARE			Probabilistic Sensitivity Analysis Distribution	
One time capital costs		**Deterministic sensitivity analysis**							
Development	Partnership development	$7,406			$7,406			n/a	
	Systems development	$23,723			$23,723				
	Furniture and equipment	$4,723			$4,723				
	Office maintenance	$33,209			$33,209				
Start-up	System optimization	$5,994			$5,994				
	Office maintenance	$16,134			$16,134				
Implementation	Data processing/analyses	$4,240			$4,240				
Total fixed costs		$95,429			$95,429				
Variable costs		**Base**	**Lower (-20%)**	**Upper (+20%)**	**Base**	**Lower (-20%)**	**Upper (+20%)**	**Gamma distribution#**	
								Shape (k)	**Scale (θ)**
Development	Mobile phone procurement	$13,940	$11,152	$16,728	$13,940	$11,152	$16,728	25	558
Start-up	Community outreach	$4,420	$3,536	$5,304	$4,420	$3,536	$5,304	25	177
	Training	$22,440	$17,952	$26,928	$22,440	$17,952	$26,928	25	898
Implementation	Supervision	$99,280	$79,424	$119,136	$99,280	$79,424	$119,136	25	3,971
	Pregnancy surveillance	$40,800	$32,640	$48,960	$40,800	$32,640	$48,960	25	1,632
	Server maintenance	$23,800	$19,040	$28,560	$23,800	$19,040	$28,560	25	952

	SMS reminder	$612	$490	$734	n/a			25	24
	ANC reminder home visit	$340	$272	$408				25	14
	Technical assistance	$27,200	$21,760	$32,640	$27,200	$21,760	$32,640	25	1,088
	Office maintenance	$61,991	$49,593	$74,389	$61,991	$49,593	$74,389	25	2,480
Total variable costs		$294,823	$235,859	$353,788	$293,871	$235,097	$352,645		
Total program costs		$390,252	$235,859	$353,788	$389,300	$235,097	$352,645		
Incremental costs		$952	$762	$1,142	n/a				
Effectiveness		**Mean**	**95% CI lower**	**95% CI upper**	**Mean**	**95% CI lower**	**95% CI upper**	**Probabilistic Distribution**	
Newborn deaths		41	11	71	121	47	194	Triangular symmetric	
Total neonatal deaths averted		n/a			80	$36	$123		

(Note: the one way sensitivity analyses were only applied to the variable costs to see the major cost drivers during implemetnation. The one time fixed costs are shared equallty between the two groups as they both groups invovled the major developemtn and start up activities together and used mobile phone for pregnanty surveillance and data processing.)

Table 5.6 Summary of incremental cost effectiveness ratios between comprehensive mCARE vs. basic mCARE programs (2011~2015) based on 1 million population standardized estimations

Summary Incremental cost effectiveness ratios		Comprehensive mCARE vs. Basic mCARE	lower	upper
Deterministic Calculations	Total incremental costs	$952	$762	$1,142
	Incremental neonatal death averted	80	36	123
	Incremental DALY averted	2,347	1,054	3,640
	Incremental cost per neonatal death averted	$11.96	$9.26	$21.32
	Incremental cost per DALY averted	$0.41	$0.31	$0.72
Probabilistic calculation	Total incremental costs	$953	$910	$996
	Incremental neonatal death averted	65	62	67
	Incremental DALY averted	1,905	1,841	1,968
	Incremental cost per neonatal death averted	$14.76	$14.58	$14.92
	Incremental cost per DALY averted	$0.50	$0.49	$0.51

Figure 5.1 Tornado diagram of total costs of comprehensive mCARE program based on 1 million population standardized estimations

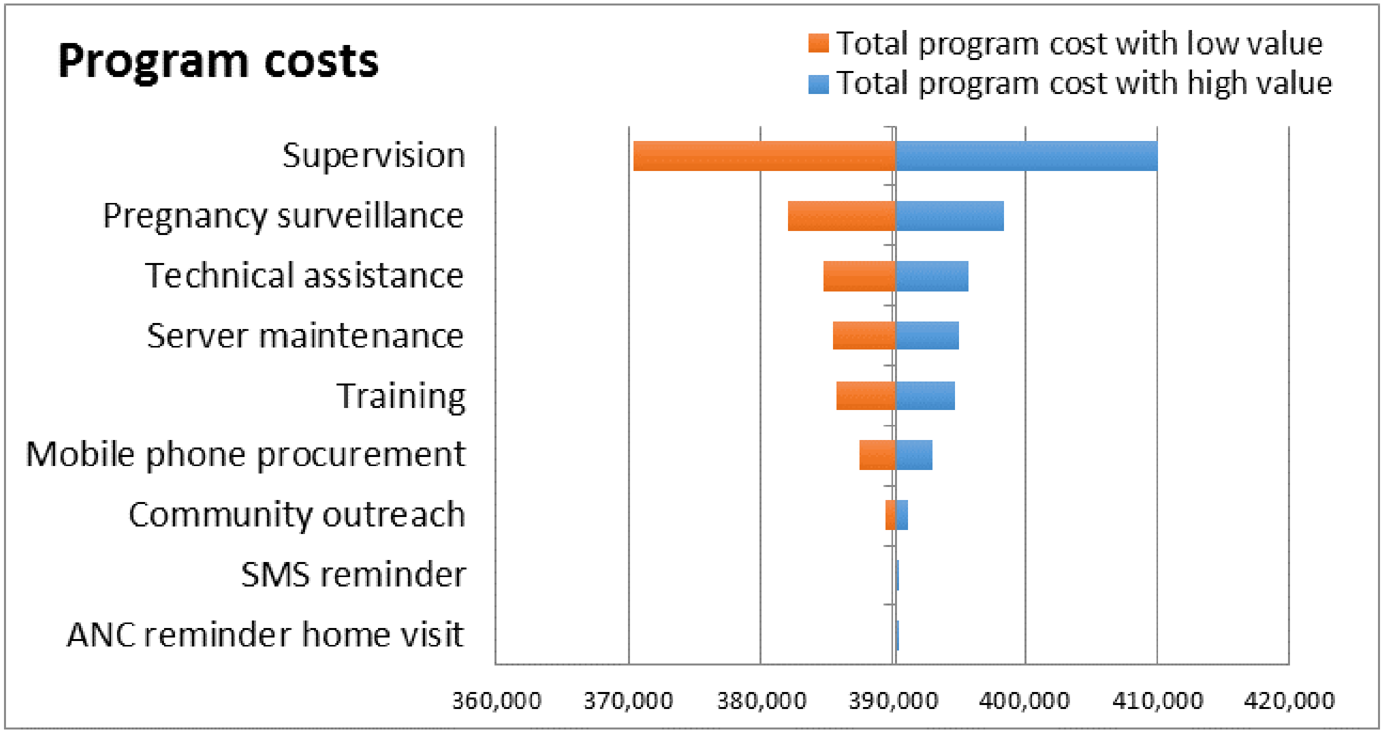


Figure 5.2 Cost-effectiveness plane showing the results (n=1000) of Monte Carlo Simulation

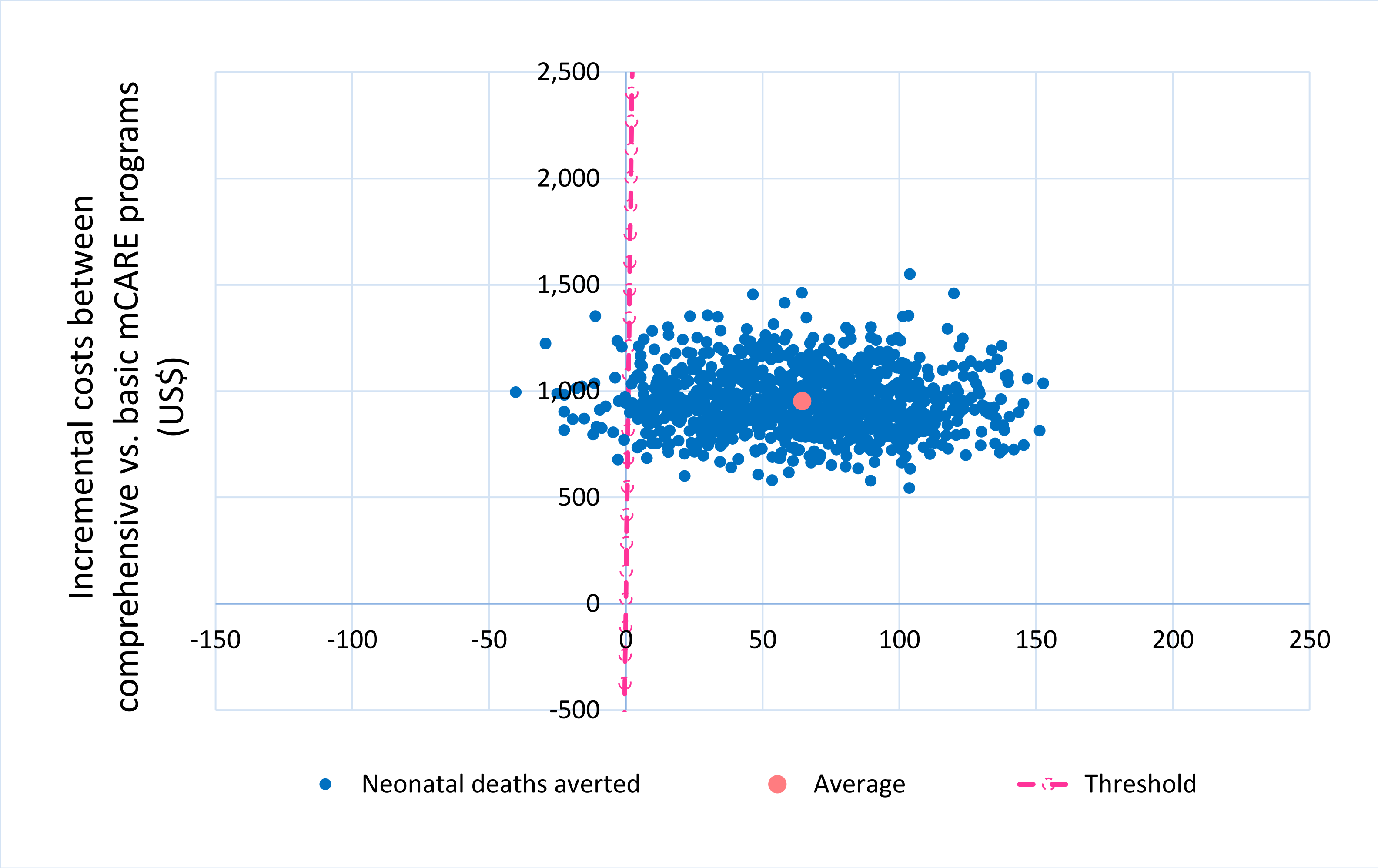


Figure 5.3 Cost effectiveness acceptability curve showing 97% probability of being cost effective at a threshold value defined as Bangladesh GNI per capita ($1,080)

Chapter 6. Forecasting of the cost effectiveness of the mCARE program on pregnancy surveillance and care-seeking reminders from 2016-2025 in rural Bangladesh

6.1 Abstract

Despite growing recognition of the potential benefits of mHealth in improving knowledge, care seeking, and treatment adherence, little economic evaluation research exists to guide priority setting or policymaking in developing countries. Following established guidelines, we conducted a costing and cost-effectiveness analyses of a comprehensive package of the mCARE program including pregnancy surveillance and scheduled SMS and home visit reminders provided by community health workers (CHWs) and compared these to existing paper-based practices in order to promote utilization of essential maternal and newborn care services in rural Bangladesh. The study used datasets from the mCARE project, financial records from implementation and technical organizations, interviews with local experts and stakeholders, observation studies and exit interviews, and a literature review related to mHealth and Bangladeshi health systems. We used an ingredients approach to measures costs by activity and developed an Excel spreadsheet model to forecast program, provider and user costs for implementation at scale across one district in Bangladesh. We also used the Lives Saved Tool (LiST) to model service coverage increase and to project the number of lives saved from each scenario of service delivery. We tested the robustness of the results though deterministic and probabilistic sensitivity analyses with Monte Carlo simulation. Study findings suggest that with a cost per DALY averted of $47 the comprehensive mCARE program had at least 98% probability of being highly cost effective when compared to paper systems based on the threshold of Bangladesh GNI per capita. Program costs were

driven by two major activities of census enumeration and pregnancy surveillance. This study suggests that incorporating mCARE strategies to proven community-based interventions may enhance cost effectiveness of the program and health outcomes in low-resource settings.

6.2 Introduction

Improving maternal, newborn, and child health (MNCH) remains an essential health priority for Bangladesh despite progress over the past decades. Home to 156 million people, Bangladesh is the eighth most populous country in the world and accounts for 5,200 maternal deaths and 76,722 newborn deaths each year.[264] Many maternal and neonatal deaths can be averted using evidence-based interventions such as utilization of antenatal care, early initiation of breastfeeding, and timely access to healthcare. In many low and middle-income countries, however, coverage levels of these interventions are still low. The first 1,000 days between pregnancy to a child's second birthday is a critical window for maternal and child survival and wellbeing.[265] Under these circumstances, use of mobile and digital health solutions to improve access and quality of service delivery of critical MNCH services is increasing.[266] Emerging evidence suggests that mHealth solutions may be effective in improving knowledge, care seeking and treatment adherence, and can contribute to reductions in mortality. [258][267] However, less is known, about the value for money of mobile and other digital health solutions. The absence of this evidence limits efforts to compare solutions against alternative resource uses and ultimately, advocating for their scale up.[268-270]

A number of pilot studies of health innovations have been conducted around the world.

Evaluations have revealed positive results on intended health outcomes. Yet, few of these successfully piloted innovations have been taken to scale, with even fewer scaled up sustainably. There are growing concerns with the number of mHealth programs – that are they are mostly pilot projects or implemented on a small scale. Studies acknowledge that the gap is partly due to a lack of knowledge on how to deliver proven interventions at scale using health innovations, how to build capacity in countries, and what resources are needed.[271][219] Accordingly, efforts to determine the value for money of mHealth programs have largely been constrained to small-scale pilot programs or model-based analyses that forecast costs and consequences over time.[272] While the latter may provide important insights into the probable value for money, often these analyses fail to consider alternative program design scenarios wherein stakeholders that are likely to assume responsibility for the program at scale (e.g. governments) carry out the implementation.

In Bangladesh, a wide array of digital health solutions have been piloted throughout the last decade, including eHealth (e.g. health information system, telemedicine), and mHealth (e.g. short message service (SMS) advice for safe pregnancy, use of the mobile phone as a data collection tool).[49] However, no program to date has been scaled at a national level. The mCARE program was implemented from 2011 to 2015 as a digital health platform that supports CHWs' pregnancy surveillance activities and promotes care-seeking behaviors to pregnant women in the Gaibandha district of Rangpur division (study area). Emerging findings suggest that the mCARE intervention was associated with a 2.6 times increase in utilization of antenatal care, 1.6 times increase in postnatal care, (as reported in the prior Chapter 5), and highly cost effective as compared to the mCARE control with an estimate of $15 per death averted.

Less is known about the costs and consequences of a larger scale deployment of mCARE, which would be implemented by the Ministry of Health. As part of efforts to improve the scalability of mCARE, a second phase (mCARE-II) is presently underway, which will shift implementation away from non-government organization (NGO) staff toward government CHWs such as Family Welfare Assistants (FWAs) and Family Welfare Visitors (FWVs). In this analysis, we model the incremental cost effectiveness of mCARE II over a 10-year analytic time horizon (2016-2025), with implementation occurring at scale across the Rangpur division (15.8 million population, 8 districts, 6,249 square). We consider three scenarios: (1) mCARE program inclusive of pregnancy surveillance, CHW home visits, and automated scheduled SMS reminder for pregnant women; (2) mCARE program inclusive of pregnancy surveillance only; and (3) status quo – existing services with no added program. Study findings suggest recommendations to introduce proven, cost-effective innovations into a health system, or to promote their large-scale use and sustainability.

6.3 Methods

Study setting. The Rangpur division is home to approximately 15.8 million people disbursed across eight districts. An estimated 52% are married women and 44% are literate. Agriculture remains the primary source of employment. As of 2011, coverage for maternal and newborn health (MNH) services for four or more antenatal care visits is

31%, 38% for facility delivery, and 36% for postnatal care, which compares favorably with national estimates reported in the 2014 Demographic Health Survey (DHS). Health services are provided through a mix of private and public health facilities. The public facilities include Community Clinics (CC), Family Welfare Centers (FWC), Union-sub centers, and Upazila Health Complex (UHC) as primary healthcare centers and Maternal and Child Welfare Center (MCWC) as a secondary health care center. NGO facilities include Smiling Sun franchise static clinics or emergency obstetric care clinics. Private facilities mainly cover complex obstetric care services such as caesarian section in the community. Frontline health workers in rural Bangladesh take on many important responsibilities including identifying and registering married women of reproductive age for routine pregnancy surveillance, distributing services in their communities (e.g. family planning), administering essential MNH services, promoting public health campaigns or programs (e.g. immunization), managing treatment or referrals in emergency situations, and keeping records and reporting to health workers. The FWAs (the lowest level of government health workers) and Shastoshebika of BRAC are the two major types of frontline heath workers in this region.

Target population. Model-based analyses explored the costs and consequences of the mCARE program from one district in Rangpur (Gaibandha district, approximately 2.4 million population) up to total eight districts (15.8 million population) in the entire Rangpur region over the 10-year time horizon 2016-2025. The number of CHWs and married women of reproductive age (MWRAs) in the division wascalculated by multiplying the total number of districts in the division based on the numbers of CHWs and MWRAs in one district (Gaibandha district). The number of pregnant women was calculated in each district based on the respective number of married women of reproductive age (15-49 years) in each district, fertility rate[273], abortion rate, and fetal loss rate, based on the World Bank database and a formula published elsewhere.[274]

Program description. We developed an Excel spreadsheet-based model[275] to project cost and resource requirements and potential mortality impact resulting from averting maternal, neonatal, stillbirths and child deaths in Bangladesh by 2025, in the three scenarios. In this analysis, we consider three comparators and their implementation over the 10-year time horizon recommended by WHO CHOICE[276] and the Bangladesh investment plan for health data collaboration by 2025.[277] The programmatic activities for each scenario are briefly described below and their specific cost components defined in Table 6.1. The scenarios are purely illustrative and not prescriptive for any particular project or country.

- **Comprehensive mCARE program scenario:** Population mapping and census enumeration, pregnancy surveillance by using mobile phone based system through government CHWs (family welfare assistants); automated SMS and CHWs' home visit reminders to pregnant women at specific personally scheduled ANC 1-4 dates

- **Basic mCARE program scenario:** Population mapping and census enumeration, pregnancy surveillance by using mobile phone based system through government CHWs (family welfare assistants)

- **Paper based status quo scenario:** Paper-based census enumeration and pregnancy surveillance and community-based ANC promotion activities to pregnant women by government CHWs (family welfare assistants)

The focus of the model is to see how much the mCARE program would improve service utilization and heath impact based on the change of existing operational processes, workforce productivity and pregnant women's care-seeking levels. Therefore, we set the three scenarios starting from the same target population (number of pregnant women) and same baseline service coverage in 2016 for a systematic comparison of the costs and consequences. Also, as the model focuses on the value of the mCARE program in improving existing workforce productivity and operational efficiency, we did not consider additional investment to increase the number of CHWs or health facilities.

In terms of operational change, the model determined relevant pregnancy surveillance, population coverage and service coverage for each scenario, listed in Table 6.2. In terms of workforce productivity, the model assumed incremental increase of the number of household visits per day by a CHW within a feasible range of capacity, for mCARE groups, while the model assumed a constant number of household visits per day by a CHW for the paper-based system. The model assumed the existing number of CHWs and health facilities to be constant over time, given the current health system conditions and health budget constraints. In terms of pregnant women's care seeking level, the model assumed differing incremental increases of service utilization levels for each scenario. Given the mCARE intervention – SMS and home visit reminders – as demand promotion strategies, the model considers the increased level of service utilization as an intermediate outcome as a function of each scenario over the 10-year time horizon.

Measuring effectiveness

Target population. The model set the target population and its change overtime to be equal across the three scenarios to compare the cost and consequences associated with each scenario. Based on a feasible number of daily household visits per CHW in the current paper-based system, different census enumeration and pregnancy surveillance coverage rates were assumed for the mCARE system as 90% and 80% for the paper group. This determines 'population coverage' for each scenario, which represents the number of pregnant women who are registered in the program through census enumeration and pregnancy surveillance, over the actual number of pregnant women in each district. We used data from multiple sources including government health reports, national and regional statistics, published literature, primary data collection, and interviews with relevant local stakeholders. Demographic data are drawn from the Bangladesh Demographic and Health Survey (BDHS) [34] and World Bank database. Regional service coverage information was drawn from the BDHS and mCARE I study. When no regional data was available, we used the national average for fertility rate, abortion rate, and fetal loss rate from the DHS, Bangladesh Bureau of Statistics (BSS) or

World Bank database. Service quality and cost data are mainly drawn from observation of the field sites and interviews with relevant local stakeholders.

Service coverage. Based upon the estimated number of registered pregnant women, the model forecasts incremental changes in the utilization of health services, 'service coverage', as a function of each scenario over the 10-year program time horizon. 'Service coverage' was calculated as the number of pregnant women who sought care, over the number of registered pregnant women in the system. Different coverage increase rates were assumed for the mCARE intervention (10%), mCARE control (5%), and the paper system (1%) from 2016 to 2025, using the same baseline from 2016 across the three scenarios. The coverage increase rate for the mCARE intervention was based on early findings from the pilot phase implementation of mCARE in Gaibandha district. The coverage increase rates for the mCARE control group (which does not have a demand promotion component) and the paper system were based on the past trend of the relevant service coverage from the BDHS – an increase from 58% in 2004 to 88% in 2014 with a 3-5% annual coverage increase rate. Estimates of the incremental changes in coverage assumed a linear increase for each of the 10 years of implementation. This resulted in a 2.4 times increase for the mCARE intervention group, 1.6 for the mCARE control group, and 1.1 times increase in coverage for the status quo group, from the baseline in 2016 to 2025.

The Lives Saved Tool (LiST) was used to generate estimates of incremental lives saved based on respective incremental service coverage increase for ANC, home delivery, facility delivery and PNC for each scenario. Assumptions of co-coverage of interventions embedded into LiST were used for each intervention (ANC, delivery and PNC). This resulted in the number of lives saved for mothers, stillbirths, newborns, and children based on national default values. Considering the geographical expansion over time, for each year, we adjusted the number of lives saved based on a proportional ratio between increasing number of districts over the total number of districts, which is 64, in the country. Specific input assumptions and model outputs are described in Appendix 3.

The number of lives saved was used to generate an estimate of DALYs using the standard formula from the Global Burden of Disease study.[278] Given the lack of data on disabilities, we only accounted for years of lives lost (YLL) for the DALY calculation based on the number of lives saved. Life expectancy was estimated as 72 years based on World Health Organization life tables. A life expectancy estimate of mothers would be based on average age of women in the study sites when they delivered a child between 2013-2014. Without adjusting age weighting, a discount rate of 3% was used in reference case calculations.

Measuring Costs

Economic costs were measured from a societal perspective and included incremental costs to the program, health system, and user. In terms of program costs, we interviewed and consulted with relevant local experts and program developers for operational practice and technical requirements. Standard service provision protocols and supplementation as well as their approximate costs were identified based on observation and consultation with the government health workers and local program officers. When historical data – such as the cost of system optimization and customization – were lacking, we consulted relevant stakeholders like technology firms and local experts, to estimate the activities and resources required. Provider and user costs were identified based on observations and exit interviews at various levels of service provision in Gaibandha district. We used market-based approaches to account for costs of items and to estimate the value of activities or services, although some costs involved no expenditure due to procurement from higher government authorities. The specific methods we used in the model are described below.

Program costs. The program costing consists of two stages: one year of start-up preparation and subsequent years of implementation. For each scenario, we identified relevant activities and resource requirements in each phase as described above. Following the activity-based costing, we defined and categorized the cost items based on the activity or purpose of the expenditure rather than simply following financial line items such as staff salaries. This approach helps measure specific costs associated with the mHealth project in an organization where multiple projects are running simultaneously and staff has multiple responsibilities. For each activity component, we calculated costs based on relevant input costs, quantities and time period consumed. As we assumed that the program rolls out from one to eight districts in each year, the program costs gradually increase over time. Based on the population size and cost estimation in one district (Gaibandha district), program activity costs – except system optimization and customization, which are one-time fixed costs as described above – in other districts were proportionally adjusted based on their respective population sizes. Based on such an incremental geographical expansion, total program implementation costs are increased stepwise annually. We did not include the costs for expanding or upgrading infrastructure related to these interventions, nor potentially increasing program costs for conducting pregnancy surveillance in hard-to-reach areas, given the lack of information to make these estimates.[279] We also did not account for a potential change of unit input costs based on economies or diseconomies of scale. We accounted for an annual inflation rate of 6% [280] and capital costs annualized with five years of life expectancy. Costs were calculated using the year 2015 in US dollars. Details regarding costing assumptions and data used in calculations are summarized in Table 6.1.

Provider costs. Provider costs were calculated based on service coverage, which is the number of pregnant women who seek care multiplexed with relevant service unit costs. As the total number of pregnant women who seek care gradually increases over time due to geographical program expansion, so does service coverage. Accordingly, provider costs are gradually increasing over time. We estimated a unit cost of service provision in rural Bangladesh for an ANC, a facility delivery, a home delivery, and a PNC based on the survey data, which is described in Chapter 4: Methodology. We estimated only the costs to providers of delivering these interventions and not costs from other activities. A unit cost of service provision mainly consists of service cost and supplementation cost. Service costs are calculated based on the provider's salary and time consumed for providing a service. Supplementation costs are calculated based on quantity and unit costs of any supplementation such as micronutrients or vitamin A, distributed or consumed during the service provision. To calculate the market based economic costs from the provider's aspect, considering that the supplementation is procured from a higher government agency without charge or is distributed to clients for free, we accounted an approximate market price for the item and included in the supplementation cost calculation. We did not take into account local variations in supply or costs. Information regarding staff salary, service time, quantity or unit cost of supplementation were obtained based on consultation with government health workers and were reviewed by local health experts and program officers. Unit costs for service provision and supplementation were obtained from observation study conducted in Gaibandha, which is described in Chapter 4: Methodology section.

User costs: Similar to provider costs, user costs were calculated based on the number of pregnant women who seek care, multiplexed with relevant user costs. We estimated a service user cost in rural Bangladesh for an ANC, a facility delivery, a home delivery, and a PNC based on the survey data, which is described in Chapter 4: Methodology. A user cost mainly consists of direct and indirect costs. Direct user cost is any cost spent to seek care, including round trip costs (e.g. transportation), or fees for service, medical tests or drugs. Indirect user cost is an opportunity cost that is foregone due to the care seeking, which we mainly considered as wage loss and total time spent for care seeking including round trip transportation, waiting, consultation, and treatment. The input measures for direct and indirect user costs as well as average wage level were obtained from exit interviews conducted with 100 pregnant women in Gaibandha district. The information required for calculation of direct and indirect costs were obtained based on interviews with pregnant women in the village. Along with an increasing number of pregnant women who seek care as mentioned above, user costs are gradually increasing over time.

Sensitivity analyses

To evaluate the robustness of the findings when key variables change, we used one-way deterministic sensitivity analyses (DSA) and probabilistic sensitivity analyses (PSA). The impact of a single parameter's uncertainty to the total program cost was assessed with one-way DSA. We conducted one-way sensitivity analyses to examine the impact of parameters related to total program costs. Tornado diagrams were presented to depict the major cost drivers of total program costs. Considering that the final estimates are driven by joint effects of multiple parameters, we conducted multivariate PSA with all the variables examined in the one-way DSA.

Parameter selection. The parameters included cost items for program costs, provider costs, and user costs. Also, parameters included population coverage of census enumeration and pregnancy surveillance for each scenario (e.g. 90% and 80% coverage rates, respectively), service coverage increase rates in each scenario (e.g. 10%, 5% and 1%, respectively), as well as the modeled number of lives saved for each scenario.

Parameter distribution. For PSA, we attached statistical distributions of the cost items, coverage, and a number of deaths averted and fitted to relevant data (Table 6.4 and Figure 6.1). In terms of program costs, based on our activity-based costing, the parameter ranges were determined by results of respective input variation of the level of productivity, a level of effort, overtime, salaries, and time duration for activity components. We drew the mean and variance from the plausible range reported by an expert. A conservative approach was adopted with an appropriately broad range of possible estimates elicited from each expert. In the case of provider and user costs, we drew mean and variance from the survey data, and fitted to the relevant data. For population and service coverage, which has no historic reference to set a plausible range, we set +/- 20% of the point estimate as low and high values and estimated the mean and variance. For a number of deaths averted, we modeled different service quality scenarios for each service over time and determined a potential range of health impact for each scenario by 2025. We attached the LiST model input assumptions and results to the Appendix of this chapter. The statistical distribution was chosen based on the shape and characteristics of the data. We produced the probability distribution functions for each parameter based on the standard statistical equation, published elsewhere.[281]

Simulation. We used the Monte Carlo simulation for multivariate PSA. In total, 1,000 iterations were generated using a Visual Basic macro in Excel. The means of each cost component were summed by calculating each iterated incremental cost-effectiveness ratio. Cost-effectiveness planes show the distributions of costs and effects from each iterated input parameters (Figure 6.4). Cost-effectiveness acceptability curves show the probability of cost effectiveness from comparisons among the scenarios. Setting a series of hypothetical threshold values was considered as the willingness to pay. Finally, in comparing the comprehensive mCARE group and the paper based group, we populated an ellipse of confidence to the cost effectiveness plane as a graphical presentation of 95%

confidence intervals of probability of cost effectiveness between the two groups (Figure 6.4). Accordingly, we also calculated net benefit values by multiplying the threshold ratios to the incremental death averted and then subtracting incremental costs between the two groups. The result was presented as a cost effectiveness acceptability curve as a function of the incremental threshold values. (Figure 6.5) We set Bangladesh GNI per capita as a threshold from government decision makers' perspective based on the standardized guideline.

6.4 Results

Program costs: Table 6.3 demonstrates the total program costs and major cost drivers in each group. Total program costs are $37 million for the intervention group, $31 million for the status quo group, and $24 million for the control group. With a geographical expansion of the program of an additional district per year, the annual program cost would increase from $468,294 to $5,613,986 in the intervention group, $468,294 to $4,780,953 in the control group, and $220,124 to $3,728,556 in the paper group between 2016 and 2025. Figure 6.3 depicts the major cost driver per study arm. In the intervention group, the major cost drivers are training (26%), supervision (21%), pregnancy surveillance (18%) and reminder home visits (16%). Phone procurements, SMS reminders or SMS server hosting have a fairly marginal impact on the total program costs. In the control arm, the major cost drivers are training (31%), supervision (26%), and pregnancy surveillance (22%). In the paper group, the major cost drivers are supervision (32%), pregnancy surveillance (31%), and data processing (25%).

Provider costs over the period of 2016-2025 are $9.5 million in the intervention group, $8.9 million in the control group, and $6.7 million in the paper group. The major costs drivers are facility and home delivery, as their unit costs are much higher than ANC or PNC. Similarly, user costs over the period of 2016-2025 are $11.6 million in the intervention group, $1.3 million in the control group, and $7.7 million in the paper group. Major costs are from child delivery. Given the high out-of-pocket payment in Bangladesh, the results also show higher user costs than provider costs. Consequently, total societal costs throughout 2015-2025 including program, provider and user costs are estimated as $58 million in the intervention group, $41 million in the control group, and $39 million in the paper group.

Effects. Table 6.5 summarizes key outcomes for the mCARE program based on LiST modeling. In the intervention area, a total of 761 estimated deaths was averted including one maternal death, 594 neonatal deaths, 56 stillbirths and 110 child deaths. Over the same time period, in the comparison area, an estimated total of 397 deaths were averted including one maternal death, 311 neonatal deaths, 29 stillbirths, and 56 child deaths. In the status quo group, a total of 94 deaths were estimated to be averted, including 76 neonatal deaths, 5 stillbirths, and 12 child deaths.

Incremental cost-effectiveness analyses. The summary of Incremental Cost Effectiveness Ratio (Table 6.6) indicates that the mCARE intervention (SMS and home visit reminders) is highly cost effective compared to the mCARE control and status quo groups respectively, from a societal perspective. The incremental cost per death averted is

$973 and cost per DALY averted is $33, which is well below Bangladesh' per capita GNI ($1,080), suggesting high cost effectiveness. Similarly, the mCARE intervention (SMS and home visit reminders) was highly cost effective compared to the status quo group, from a societal perspective. The incremental cost per death averted $1,385 and per DALY averted as $47. Comparing the control and status quo groups, the incremental cost per death averted $1,873 and per DALY averted as $63, suggesting cost effectiveness. The cost effectiveness planes and cost effectiveness acceptability curves of comparison of the three groups are presented in Figures 6.3 and 6.4.

Sensitivity analyses. Figure 6.3 indicates that total program costs were mostly driven by census enumeration and pregnancy surveillance, followed by supervision, reminder home visits, training, and data processing – for the intervention group. In the control group, it was similar except the reminder home visit was not the main cost driver. In the status quo group, the major cost drivers were pregnancy surveillance, supervision, data processing and survey printing. Comparing the mCARE control and status quo groups, the cost-effectiveness acceptability curve with a threshold (Figure 6.6) quantified that the probability of the program to be highly cost-effective is at least 70% at $1,080 of the threshold value.

Net benefit analyses. Figure 6.5 presents an ellipsis of confidence based on alpha 5% and estimated correlation (-0.05) between the iterated incremental costs and incremental numbers of deaths averted between mCARE intervention and paper based group. The Figure 6.7 shows that the net benefit between the two group had about 27.5% probability of cost effectiveness at a (‘highly cost effectiveness’) threshold value of Bangladesh GNI per capita ($1,080) and 99% probability of cost effectiveness at a (cost effectiveness) threshold value of three times of Bangladesh GNI per cap ($3,240).

6.5 Discussion

Cost-effectiveness analyses of mHealth programs on pregnancy surveillance and care seeking reminders are complex due to technical and organizational arrangements and the nature of the services being provided by different types of providers. A recent study[283] acknowledged the complexities in the aspects of broader program delivery characteristics by the addition of SMS technology. Referring to a recently published conceptual framework (Tanahashi)[218], implementation principles (MAPS)[219], and evaluation guidelines (mERA)[220] of mHealth programs, we designed model scenarios and an analytic framework based on the recommended key components of operational and evaluation principles. Based on the Tanahashi Framework 2.0[218], which describes how mHealth programs could promote coverage in a given population, we first considered that mCARE programs could promote ‘population coverage’ by improving workforce productivity and task efficiency in pregnancy surveillance activities. We also considered that mCARE programs could promote ‘service coverage’ by encouraging pregnant women to seek essential maternal and newborn care services. In terms of care-seeking patterns, we assumed that mCARE strategies could cause women to seek care more frequently (e.g. ANC visit 4) and toward higher quality services (e.g. from home delivery to facility delivery). These aspects were incorporated in designing scenarios and assumptions for the analyses. Based on MAPS, in planning the scale-up process, we incorporated key activity and strategic components related to planning as well as monitoring and evaluation, in a phased program approach such as partnership building, system optimization, and data reporting and processing. Throughout this process, we clarified the specific mHealth intervention and incorporated local data related to its technical features and the contextual grounds for evaluation.[220]

In recent years, there have been some interesting quantitative analyses and evidence in the context of how scaling up of mHealth programs improves task efficiency and accuracy in a given standardized process or protocol (such as data collection or data reporting) or how mHealth improves user behavior to achieve uptake of certain practice such as adherence to drug intake, vaccinations, etc.[282-284] For example, Kukla et al[.284] (D-tree) presented that the mobile tool costs an additional $10.43 per annum in Malawi for a CHW, compared with the existing paper-based system, to improve his/her diagnostic and treatment accuracy by 1%. The study also demonstrated that the tool's cost effectiveness improves as more CHWs enter the program – from $5.24 for 50 CHWs to $1.07 for 5,000 CHWs. Zurovac et al.[165] evaluated the cost effectiveness of text message reminders for CHW adherence to malaria case management guidelines. The study showed that the cost per additional child correctly managed was $0.50 under study conditions in Kenya, $0.36 if implemented by the MoH in the same area, and estimated at only $0.03 if implemented nationally. Additionally, Larsen-Cooper et al.[285] showed a cost outcome of an mHealth program (texting and communication among workers) in Malawi as $29.33 per user. The sensitivity analyses showed that cost per user could be reduced by 48% if the service were to operate at full capacity. Most of these studies demonstrate the value of mHealth interventions from the supply side, such as CHW adherence and accuracy in task performance. These studies demonstrate economies of scale based on the shared fixed and overhead costs with a larger number of users and beneficiaries.

From an overall program evaluation point of view, much is unknown regarding how and to what extent mCARE changes the operational process, workforce productivity, and how and to what extent all these changes might affect overall societal costs and service coverage as well as health impact. mHealth is not just about improving efficiency or accuracy, but changing how the health system works. Acknowledging the comprehensive aspects of operational practice, our study determined program activities for each scenario, examined major factors that can be influenced by mCARE practices and tested the key input parameters by using uncertainty analyses. In terms of service provision, our study incorporated relevant survey data drawn from direct observations and exit interviews at major service provision agencies including government and NGOs and various levels from community satellite clinics to primary and secondary level clinics. Based on the contextualized understanding around service costs and content in the given settings, we calculated provider and user costs. Throughout the analyses, we synthesized a large volume of local demographic and service coverage data from various sources into a unified method for projecting the mHealth program costs and health outcomes in Bangladesh. These scenarios were further refined by verifying the feasibility of assumptions in consultation with relevant stakeholders consisting of policymakers, local experts, program developers, public health experts, health economists, and donors.

For the analytic framework of scaling up a program**,** we considered horizontal scaling up as 'geographical expansion' by replicating the program in a new district each year, thus assuming a linear increase of costs and effectiveness based on the size of population. The scaling-up pathway may also involve vertical scale up, which is associated with integrating different levels of health information systems, health institutions and service delivery platforms. A well-established community-based pregnancy surveillance system using an mHealth platform linked to primary health service delivery can serve as a powerful tool to create new incentives, value-added services and even business models throughout continuum of care among various health systems stakeholders. As mHealth is often referred as a "disruptive innovation" in the health sector, rapid technological innovation and the scale-up process may occur in an exponential manner**.**

In this regard, future studies may consider incorporating a modeling approach in mHealth for scaling up monitoring and evaluation. In an effort to achieve the United Nations Millennium Development Goals, modeling approaches in scaling up health program evaluation have been widely developed and used in various demographic and epidemiological studies over the past decades. These include mathematical dynamic models to project population growth (PopMod)[286] and discrete event simulation of infectious disease transmission and progression (e.g. EPIFIL; AEM, EMOD-HIV, SIR, etc.)[287, 288] or state transition models of noncommunicable diseases (e.g. obesity, cancer). With a growing interest in implementation science and health systems research in recent years, some innovative studies have conceptualized scaling-up pathways[289] and incorporated systems dynamic modeling approaches in program evaluation such as agent-based modeling, causal loop diagrams, or stock and flow diagrams.[290] These modeling approaches may be used to evaluate mHealth strategies on particular disease domains or intervention approaches to understanding the role of technology in service delivery processes and scaling-up pathways. For example, the feedback loop model[291] may help understand the learning effect within providers' network (e.g. telemedicine or hotline call center), neighborhood effects through information sharing among individuals in a community[292] (e.g. text messages for health promotion and behavior change), or effective referral strategies through a positive reinforcement process between provider (supply) and client (demand) sides in service delivery. In addition, scale-free networks[289] can be used in modeling the diffusion of knowledge and behaviors by mHealth strategies on a geospatial platform (e.g. GIS system) or a social network platform (e.g. Facebook); understanding what the focal points or hubs of the systems are and how to manage them in a given local context could offer useful insights in planning and managing for successful strategies for scaling up and sustainability.

6.6 Limitations

Parameter/scenario uncertainties: While cost effectiveness often requires substantial data inputs, only a few scaled-up (more than 500 CHWs) programs exist and little empirical data has been collected in the mHealth domain.[293] Evaluation of mHealth scaling up thus involves many structural and parameter uncertainties. First, given the early stage of mHealth programs, there is limited data for many of the parameters, and much of the parameter uncertainty cannot be meaningfully quantified. Moreover, scaling up of programs involves many structural uncertainties that cannot be easily parameterized. For example, we assumed a constant coverage increase rate of 10% for all districts in the intervention group, but the coverage increase rates can vary depending on local health system conditions such as mobile phone penetration, availability of sufficient CHWs, access to health services, health facility condition and district characteristics. Through conceptualization and systematic and conservative assumptions based on the best existing knowledge, we attempted to incorporate these multiple factors in the evaluation mechanisms through a cost effectiveness analysis framework. Given that our analytic focus is on the different implications from cost, performance, and effectiveness among the three scenarios, we simplified our assumptions of baseline service coverage, scaling up patterns and geographical heterogeneity to be consistent among the districts in the scenarios. Accordingly, we undertook linear proportional adjustments of costs and effectiveness measures based on a proportional population size. This is also in part due to the lack of regional data – such as fertility rate, abortion rate, fetal loss rate, or specific coverage in district level, in currently published resources.

Generalizability of the findings: Given that scaling up of programs is influenced by health systems conditions, we will consider level of mobile phone uptake, wireless network, current status of availability and training of CHWs, and quality or capacity of major MNCH service provision agencies to meet the needs and demand of the target population in the given setting.[294] Together, the effectiveness of mHealth programs is influenced by a series of factors, including literacy and education, geographical and financial access to health facilities, social and cultural norms, and women's access to information technology.[295] These factors determine the way a technological innovation is spread as well as the distribution of benefits from the technology and the diversity of ways the technology can be applied. It is also important to acknowledge that the process of expanding into new target areas involves significant planning around a set of inter-related activities, which include identifying target facilities, districts, and mobilizing resources. In forecasting costs over the 10-year time horizon with incremental expansion of service coverage, additional investment to strengthening health systems (e.g. additional recruitment or training of CHWs, upgrading health facilities or health information systems) should be considered in developing scaling-up assumptions. In many developing countries, services are generally underutilized and facilities are generally under-resourced, especially in terms of staffing. In most cases, significant investment would be required to provide sufficient resources for the expected numbers of services provided, and much more to expand services to cover the whole population. Plans for scaling up primary health services should take into account that current levels of services may be under-funded and that it may be more important to improve quality before expanding packages of services or utilization.[296] Throughout the course of the program, and as a result of increased experience and learning, the decision to invest in adopting mHealth practices should be informed by broad assessments considering demographic condition, technical feasibility, social and cultural characteristics, and capacity of and impacts on health systems.

6.7 Conclusions

The main program cost drivers are census enumeration and pregnancy surveillance. We suggest that the program implementers consider strategies to improve workforce productivity and cost sharing on the activity. On the policy level, we suggest cooperation with other public agencies that can share activities and information such as Civil Registration and Vital Statistics (CRVS) initiatives or the census bureau, to share costs. While system optimization is a one-time cost, system algorithm would be the key to determining the efficiency and impact of the program by optimizing personalized and scheduled reminders, workflow management, and automated data reporting and management. The algorithm can be used for risk-screening based on proven and well-known maternal risk factors such as age, multiple pregnancy and mal-presentation, and symptoms or signs related to previous or current pregnancy complications. Finally, to improve health impact, it is important to promote not only care-seeking behaviors but also service access and quality in the given health system. In this regard, additional incentives such as conditional cash transfers or a voucher system for facility delivery can help reduce financial constraints for users and thus improve health impact further. Information collected through pregnancy surveillance in the mCARE system can be better utilized to identify the poor or vulnerable and to strategically target such incentives or provide more attention at a timing of delivery. Overall, by leveraging the intelligence of the IT system and individual health information, mHealth could further improve not only health outcomes but also equity of access to care through better prevention and targeted strategies for the most vulnerable populations.

Table 6.1 Key activities and resource requirements for model scenarios

Item	Definition	Resources	Scenarios*			Cost type
			C	B	P	
Program phase I: Start up						
System optimization with technical assistance	• Assume that community based pregnancy surveillance OpenSRP system architecture is developed. • Customize the system and database based on language, indicators, and geographic unit etc. • Conduct field testing for user feedback, operations, data verification etc. • To provide direct support to fix the bugs within the application to ensure functionalities of the developed system. • To manage and develop improvements within the application • To maintain the overall system to ensure the integrity of the collected data and maintain the data center for the system. • To customize reporting based on the collected data to enhance decision making by stakeholders.	Numbers/level of staff, Staff salaries, number of working months, level of effort (%), travel expenses for field testing	√	√		Capital costs (one-time costs with 5 years of useful time: annualized)
Survey form printout	• Central government office to print out registries for FWA: 1. Couple Roster (ELCO Register), 2. Child Roster (0-1 year), 3. Child Care Log (0-5 years), 4. Adolescent Health Service Delivery Log, 5.Pregnant Woman Roster (ANC Register), 6. Birth Roster,7. Death Register, 8. Daily Activities Log, 9.Register of Injectable Contraceptive Users, 11. Monthly Supply and Distribution Roster, 12. Village Population Roster, 13. Register family planning receiver eligible couple by # of children & age	Total number of registries for pregnancy surveillance by FWAs, Average unit price for printing out one registries approximate market price in 2015)			√	Capital costs (5 years of useful time: annualized)
Partnership and consensus building	• Hold meetings at regional/province/state level to build partnership and consensus to implement and sustain the program • Educate and advocate community leaders about the project • Involve activities for community outreach campaign with brochures and leaflets	Per diem, travel expenses, facility rent, printing	√	√		Capital costs (5 years of useful time: annualized)
Phone procurement	• Purchase phones and embed the system • Mobile phone with 5 years of useful time	Unit price of phone and total quantities, Staff salaries, number of working months, level of effort (%)	√	√		Capital costs (5 years of useful time: annualized)

Census enumeration (with phone)	• FWAs to visit every household in the district to register the household with demographic information through phones • Assign household ID and identify households with married women of reproductive age for pregnancy surveillance • Automate data processing and reporting	Staff salaries, number of working months, level of effort (%)	√	√		Capital costs (5 years of useful time: annualized)
Census enumeration (with paper)	• FWAs to visit every household in the district to register the household with demographic information through papers • Assign household ID and identify households with married women of reproductive age for pregnancy surveillance • Data entry staff to manually enter data to computers	Staff salaries, number of working months, level of effort (%)			√	Capital costs (5 years of useful time: annualized)
Training (with phone)	• Develop capacity of trainers and health workers • Train FWAs to implement phone based pregnancy surveillance • Train FPIs (FWA's supervisors) to monitor and evaluate FWAs' data collection activities • Train local experts to handle complicated technology related issues that are encountered by users • Enhance local capacity to maintain software and hardware which may include programming, application development, and data management needs.	Staff salaries, number of working months, level of effort (%)	√	√		Recurrent costs (every year)
Training (with paper)	• Develop capacity of trainers and health workers • Train FWA to implement paper based pregnancy surveillance	Staff salaries, number of working months, level of effort (%)			√	Recurrent costs (every year)
Supervision (mCARE system)	• Regular visit to the sites by district health managers, coordinators, data managers etc. • Track and evaluate surveillance performance • Hold regular review meetings at district levels • Build database, enter and validate data • Manage teams for effective and proper use of phone/tablet • Monitor data processing and reporting between the different levels of reporting system (i.e. community level to primary health clinics level)	Staff salaries, level of effort (%), number of months	√	√		Recurrent costs (every year)
Supervision (paper system)	• Regular visits to the sites by district health managers, coordinators, data managers, etc. • Track and evaluate surveillance performance • Hold regular review meetings at district levels • Build database, enter and validate data	Staff salaries, level of effort (%), number of months			√	Recurrent costs (every year)
Program phase II: Implementation						

Pregnancy surveillance (with phone)	• Regular visits to households with married women of reproductive age for pregnancy identification and registration • Assign unique identification number(ID) to each woman and conduct survey about economic status, pregnancy history/complications, health condition etc. • Automated data processing and reporting	Number of CHWs, CHWS's salaries, level of effort (%), number of months	√	√		Recurrent costs (every year)
Pregnancy surveillance (with paper)	• Regular visits to households with married women of reproductive age for pregnancy identification and registration • Assign women ID and conduct survey about economic status, pregnancy history/complications, health condition etc. • Data entry staff to manually enter data to computers	Number of CHWs, CHWs' salaries, level of effort (%), number of months			√	Recurrent costs (every year)
SMS	• mCARE server system automatically sends SMS to registered pregnant women at scheduled ANC dates during their pregnancy period	SMS unit cost to client, number of clients, frequency of SMS texting	√	√		Recurrent costs (every year)
Server hosting/maintenance	• Connection fee • Server maintenance	Monthly mobile phone connection fee per CHW, number of CHWs, server maintenance monthly fee, number of months	√	√		Recurrent costs (every year)
Reminder home visits	• FWAs to visit to pregnant women's house to remind her of ANC schedule and promote care-seeking • Monitoring and evaluation of her previous care-seeking characteristics	Number of CHWs, CHWs' salaries, level of effort (%), number of months	√	√		Recurrent costs (every year)
Automated data processing/ reporting (with phone)	• Data collected by CHWs on the phone are stored on the mCARE server and can be automatically viewed and analyzed in real time through a dashboard. • These data also can be reported in real time to higher authority for monitoring and evaluation in decision making.	Number of CHWs, CHWs' salaries, level of effort (%), number of months	√	√		Recurrent costs (every year)
Manual data processing/ reporting (with paper)	• FWA/FWV record data to registries • FWV/FWV to count, aggregate, and synthesize data manually to report to FPI • FPI collect forms from FWA/FWV from six unions and aggregate data into summary forms to report to Upazila FPO	Number of CHWs, CHWs' salaries, level of effort (%), number of months			√	Recurrent costs (every year)

C: Comprehensive mHealth program group
B: Basic mCARE program group
P: Paper based status quo group

Table 6.2 Model estimations for pregnancy, population coverage, and service coverage for three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2016-2025

		Comprehensive mCARE		Basic mCARE		Paper based status-quo	
Pregnancy surveillance	**Target population**	2016	2025	2016	2025	2016	2025
	Population assumption	2.4 million	16 million	2.4 million	16 million	2.4 million	16 million
	ELCO	560,000	3,738,787	560,000	3,738,787	560,000	3,738,787
	Woman of reproductive age (WRA)	560,000	3,738,787	560,000	3,738,787	560,000	3,738,787
	Fertility rate (B)	2.17	1.98	2.17	1.98	2.17	1.98
	Abortion rate (A)	18.20	17.55	18.20	17.55	18.20	17.55
	Fetal loss rate (D)	37.00	35.68	37.00	35.68	37.00	35.68
	Pregnant women (in 2015)	7,793	49,872	7,793	49,872	7,793	49,872
Population coverage	**Coverage assumptions**	2016	2025	2016	2025	2016	2025
	Census enumeration	0%	90%	0%	90%	0%	80%
	Pregnancy surveillance	0%	90%	0%	90%	0%	80%
	Number of eligible clients	6,313	40,396	6,313	40,396	6,313	31,918
Service coverage	**Coverage assumptions**	2016	2025	2016	2025	2016	2025
	ANC	31%	73%	31%	48%	31%	34%
	No ANC	69%	27%	69%	52%	69%	66%
	Facility delivery	38%	90%	38%	59%	38%	42%
	Home delivery	62%	10%	62%	41%	62%	58%
	PNC	36%	100%	36%	56%	36%	39%
	No PNC	64%	0%	64%	44%	64%	61%

- The number of pregnant women was calculated in each district based on the respective number of married women of reproductive ages (ages 15-49) in each district, fertility rate, abortion rate, and fetal loss rate, based on the World Bank database (http://data.worldbank.org/) and a formula published elsewhere.[274]
- Population coverage represents the number of pregnant women who are registered in the program through census enumeration and pregnancy surveillance, over the actual number of pregnant women in each district.
- Service coverage represents the number of pregnant women who sought care, over the number of registered pregnant women in the system.

Table 6.3 Model estimations for program costs, provider costs, and user costs of the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2016-2025

<table>
<tr><th></th><th></th><th colspan="4">Comprehensive mCARE program</th><th colspan="4">Basic mCARE program</th><th colspan="4">Paper based status quo</th></tr>
<tr><td rowspan="16">Program costs</td><td rowspan="2">Activity based cost items</td><td colspan="3">Actual costs</td><td rowspan="2">Total costs</td><td colspan="3">Actual costs</td><td rowspan="2">Total costs</td><td colspan="3">Actual costs</td><td rowspan="2">Total costs</td></tr>
<tr><td>One district (2016)</td><td></td><td>Eight districts (2025)</td><td>One district (2016)</td><td></td><td>Eight districts (2025)</td><td>One district (2016)</td><td></td><td>Eight districts (2025)</td></tr>
<tr><td>Capital costs</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>System optimization</td><td>30,274</td><td>…</td><td>30,274</td><td>302,744</td><td>30,274</td><td>…</td><td>30,274</td><td>302,744</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Partnership building</td><td>6,672</td><td>…</td><td>44,145</td><td>313400</td><td>6,672</td><td>…</td><td>44,145</td><td>313,400</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Phone procurement</td><td>60,280</td><td>…</td><td>398,846</td><td>2,831,554</td><td>60,280</td><td>…</td><td>398,846</td><td>2,831,554</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Recurrent costs</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Survey printing</td><td>1,648</td><td>…</td><td>10,902</td><td>77,394</td><td>1,648</td><td>…</td><td>10,902</td><td>77,394</td><td>34,270</td><td>…</td><td>226,752</td><td>1,618,463</td></tr>
<tr><td>Training</td><td>165,232</td><td>…</td><td>1,093,278</td><td>7,761,577</td><td>165,232</td><td>…</td><td>1,093,278</td><td>7,761,577</td><td>10,874</td><td>…</td><td>71,950</td><td>513,551</td></tr>
<tr><td>Supervision</td><td>184,173</td><td>…</td><td>1,218,600</td><td>8,651,278</td><td>184,173</td><td>…</td><td>1,218,600</td><td>8,651,278</td><td>184,173</td><td>…</td><td>1,218,600</td><td>8,697,871</td></tr>
<tr><td>Census enumeration</td><td>131,907</td><td>…</td><td>872,776</td><td>6,196,153</td><td>131,907</td><td>…</td><td>872,776</td><td>6,196,153</td><td>19,477</td><td>…</td><td>128,874</td><td>919854</td></tr>
<tr><td>Pregnancy surveillance</td><td>n/a</td><td>…</td><td>1,167,619</td><td>7,121,728</td><td>n/a</td><td>…</td><td>1,167,619</td><td>7,121,728</td><td>n/a</td><td>…</td><td>1,310,816</td><td>8,045,259</td></tr>
<tr><td>Data processing</td><td>n/a</td><td>…</td><td>649,166</td><td>3,959,498</td><td>n/a</td><td>…</td><td>649,166</td><td>3,959,498</td><td>n/a</td><td>…</td><td>1,148,524</td><td>7,049,179</td></tr>
<tr><td>SMS</td><td>n/a</td><td>…</td><td>2,855</td><td>17,417</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td></tr>
<tr><td>SMS server hosting</td><td>n/a</td><td>…</td><td>229,115</td><td>1,397,453</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Reminder home visit</td><td>n/a</td><td>…</td><td>998,717</td><td>6,091,535</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td><td>n/a</td><td>…</td><td>n/a</td><td>n/a</td></tr>
<tr><td></td><td>Total program costs</td><td>580,185</td><td></td><td>6,716,293</td><td>44,721,730</td><td>580,185</td><td></td><td>5,485,606</td><td>37,215,325</td><td>203,650</td><td></td><td>3,806,814</td><td>24,712,162</td></tr>
<tr><td rowspan="2">Provider costs</td><td></td><td>One district</td><td></td><td>Eight districts</td><td>Total costs</td><td>One district</td><td></td><td>Eight districts</td><td>Total costs</td><td>One district</td><td></td><td>Eight districts</td><td>Total costs</td></tr>
<tr><td>ANC</td><td>4,441</td><td>…</td><td>52,053</td><td>293,910</td><td>4,441</td><td>…</td><td>38,548</td><td>245,919</td><td>3,509</td><td>…</td><td>23,874</td><td>169,216</td></tr>
</table>

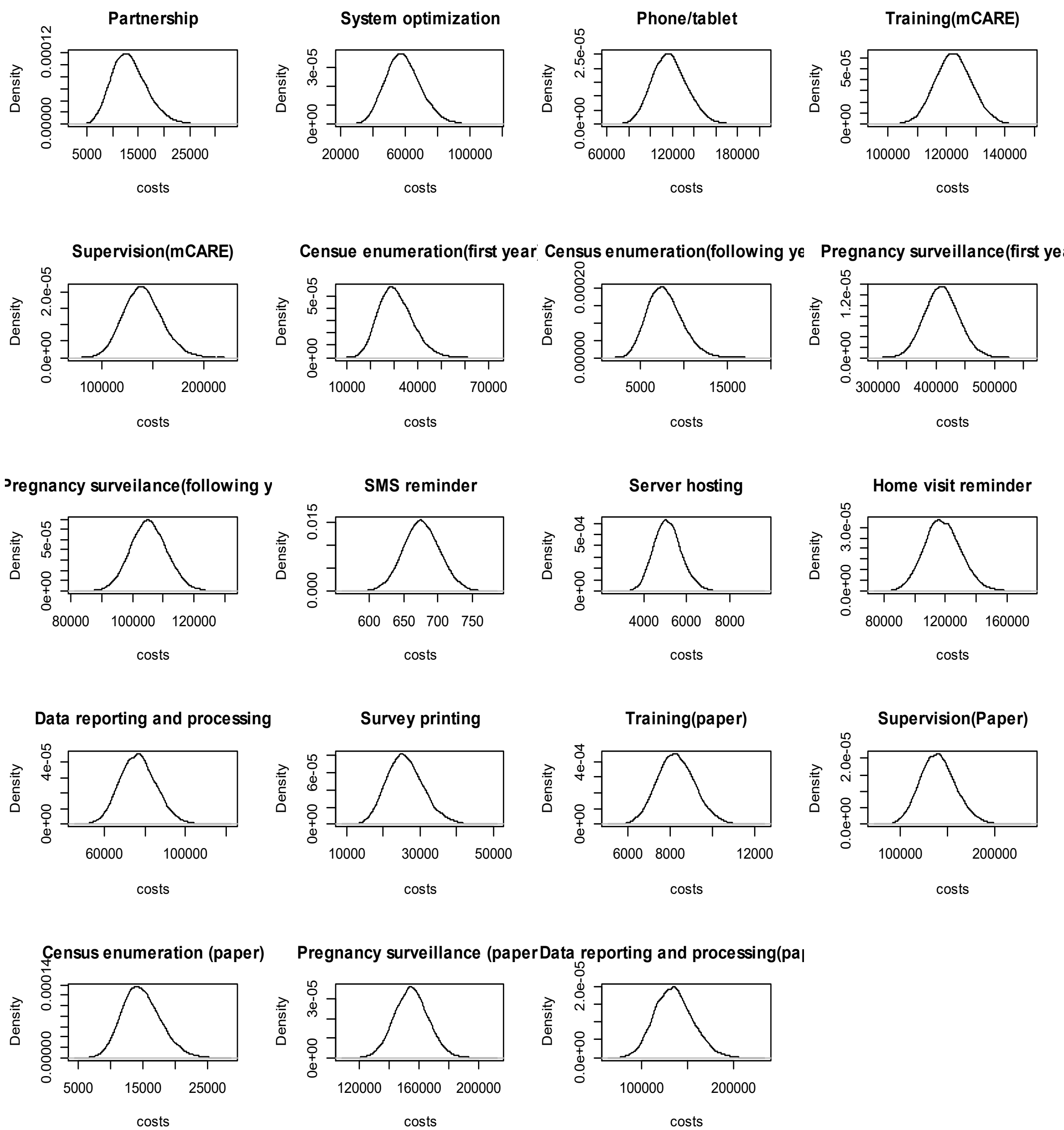
	Facility delivery	95,114	…	1,114,817	6,294,676	95,114	…	825,578	5,266,841	75,151	…	511,308	3,624,111
	Home delivery	76,321	…	239,453	2,642,650	76,321	…	381,701	3,148,143	60,303	…	370,936	2,751,689
	PNC	3,693	…	48,743	262,865	3,693	…	32,054	204,493	2,918	…	19,852	140,712
	Total provider costs	179,568		1,455,066	9,494,101	179,568		1,277,882	8,865,396	141,881		925,970	6,685,728
User costs		One district		Eight districts	Total costs	One district		Eight districts	Total costs	One district		Eight districts	Total costs
	ANC	4,870	…	57,077	322,279	4,870	…	42,268	58,863	3,848	…	26,178	185,549
	Facility delivery	124,739	…	1,462,054	8,255,313	124,739	…	1,082,726	442,751	98,559	…	670,568	4,752,933
	Home delivery	71,233	…	223,490	2,466,474	71,233	…	356,255	758,345	56,283	…	346,207	2,568,243
	PNC	7,681	…	101,386	546,758	4,727	…	41,030	20,020	3,735	…	25,411	180,111
	Total user costs	208,523		1,844,007	11,590,823	205,568		1,522,278	1,279,979	162,424		1,068,364	7,686,836
Total costs		968,276		10,015,365	65,806,653	965,321		8,285,766	47,360,700	507,955		5,801,148	39,084,726

Table 6.4 Summary of model parameters and distributions for probabilistic sensitivity analysis

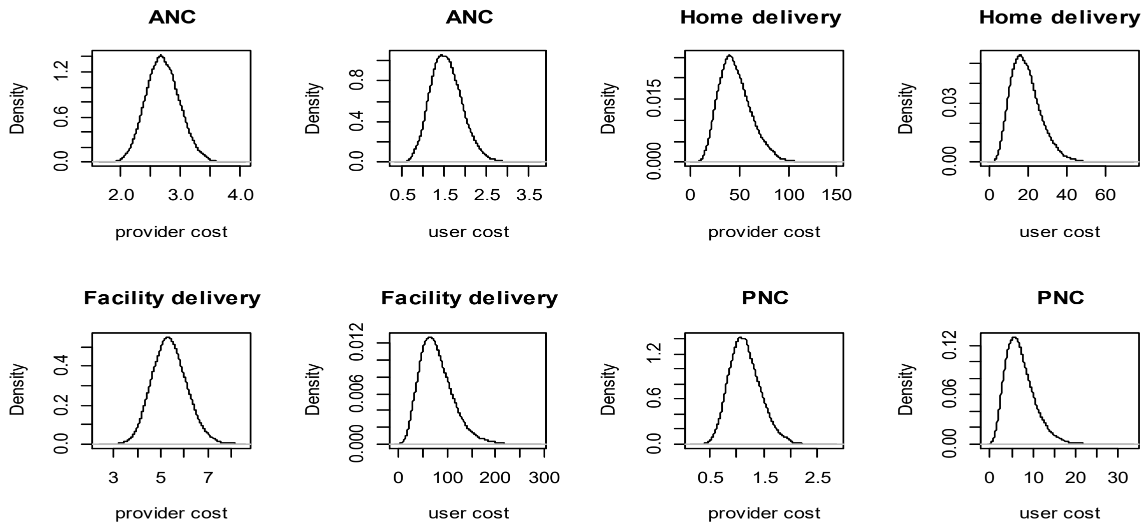
Model parameters		Average	Standard deviation	PSA distribution	
				Gamma	
				shape (K)	scale (Ѳ)
Program costs					
mCARE system	Partnership and consensus building	13,068	3,404	15	886
	System optimization	59,300	10,950	29	2,022
	Phone/tablet procurement	118,073	16,039	54	2,179
	Training (w/ phone)	122,500	6,250	384	319
	Survey/registries printing	1,250	125	100	13
	Supervision	139,728	18,696	56	2,502
	Census enumeration (first year)	30,047	7,142	18	1,698
	Census enumeration (following year)	7,881	1,970	16	493
	Pregnancy surveillance (first year)	409,500	29,250	196	2,089
	Pregnancy surveillance (following year)	105,300	5,850	324	325
	SMS reminder	338	13	676	1
	Server hosting	5,120	640	64	80
	Home visits reminder	118,217	11,822	100	1,182
	Data reporting and processing	76,841	8,866	75	1,023
Paper system	Survey/registries printing	26,000	5,000	27	962
	Training (w/ paper)	8,250	875	89	93
	Supervision	139,728	18,696	56	2,502
	Census enumeration (paper)	14,777	2,955	25	591
	Pregnancy surveillance (paper)	155,160	11,083	196	792
	Data reporting and processing	135,949	20,688	43	3,148
Provider & User costs					
ANC	provider unit cost	2.47	0.26	90.25	0.03
	user costs	1.50	0.36	17.49	0.09
Home delivery	provider unit cost	46.00	17.00	7.32	6.28
	user costs	19.00	8.00	5.64	3.37
Facility delivery	provider unit cost	5.50	0.75	53.78	0.10
	user costs	79.00	34.00	5.40	14.63
PNC	Provider unit cost	1.23	0.30	16.52	0.07
	user costs	7.05	3.39	4.31	1.63
Model parameters		Average	Standard deviation	Beta	
				Alpha	Beta
Populatio n coverage	mCARE system	0.90	0.80	1.60	0.18
	Paper system	0.80	0.70	4.20	1.05
Service coverage	Coverage increase rate (intervention)	0.10	0.08	22.40	201.60
	Coverage increase rate (control)	0.05	0.04	23.70	450.30
	Coverage increase rate (status quo)	0.01	0.01	24.74	2449.26
Model parameters		Average	Confidence interval	Lognormal distribution	

				Media ln(x)	SD ln(x)
Death averted	Intervention	761	609-913	6.64	0.10
	Control	397	317-476	5.98	0.10
	Status quo	94	75-113	4.54	0.10

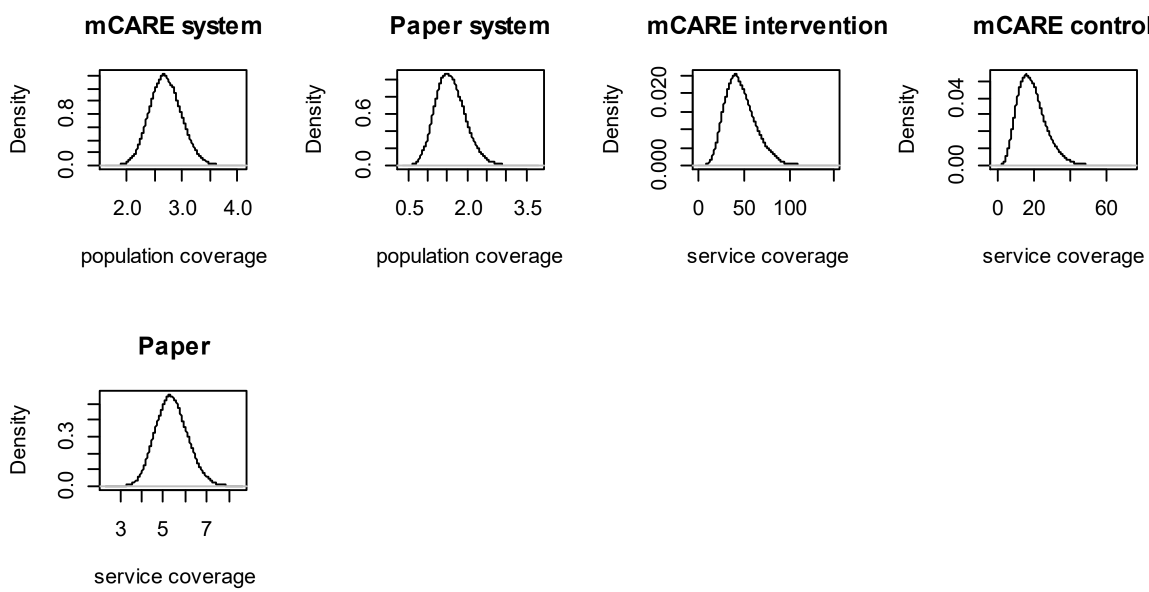
6.4.1. Gamma distributions for estimated program costs



6.4.2. Gamma distributions for provider and user unit costs.



6.4.3. Beta distributions for coverage increase rates for each scenario



6.4.4. Lognormal distributions for number of death averted for each scenario

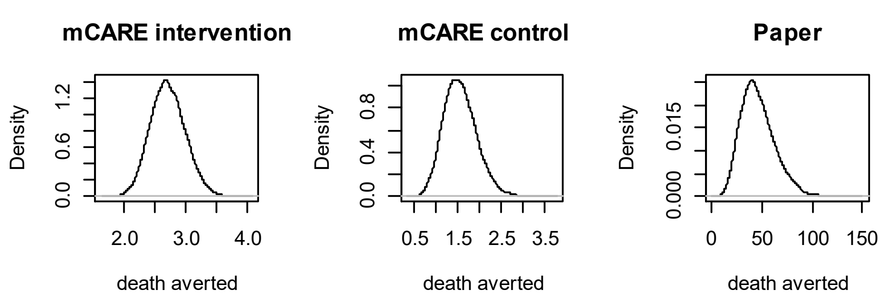


Figure 6.1 Total program costs of the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2016-2025

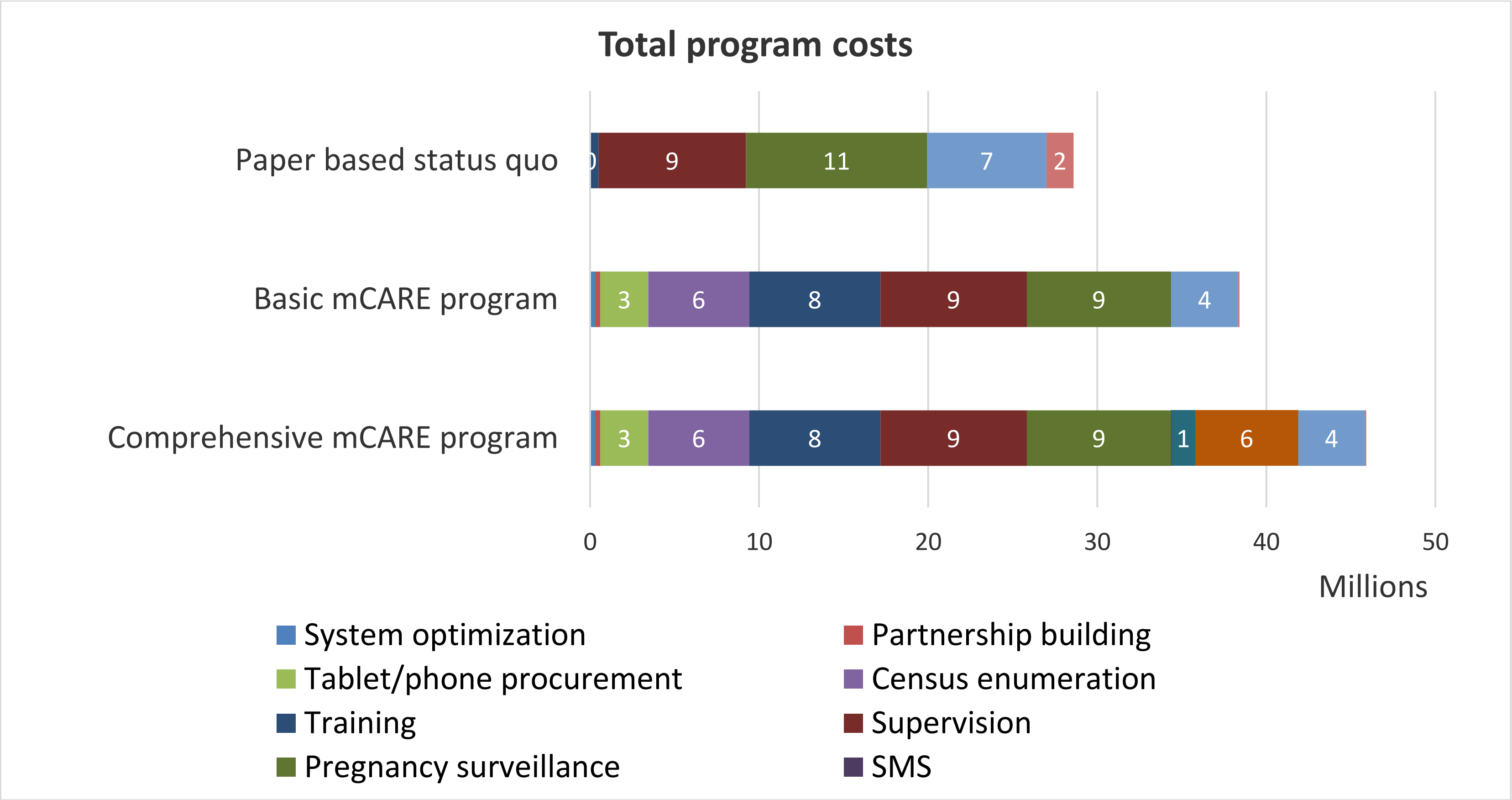


Table 6.5 Number of deaths averted based on LiST modeling of the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2016-2025

Comprehensive mCARE program	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved (community)	0	0	1	2	2	3	4	6	7	7	32
Maternal lives saved (facility)	3	10	22	38	58	81	107	135	148	159	759
Neonatal lives saved (community)	27	106	234	408	625	881	1174	1500	1650	1792	8397
Neonatal lives saved (facility)	67	259	560	956	1432	1976	2577	3223	3471	3690	18211
Still birth lives saved (community)	11	45	100	176	273	389	524	677	753	826	3773
Still birth lives saved (facility)	33	131	293	516	797	1135	1528	1971	2190	2401	10994
Total death averted (low scenario)	38	151	335	586	900	1273	1702	2183	2409	2625	12203
Total death averted (high scenario)	103	400	875	1509	2286	3192	4211	5330	5808	6249	29964
Total DALY averted (low scenario)	795	3126	6919	12059	18463	26039	34697	44338	48773	52956	248165
Total DALY averted (high scenario)	2025	7787	16839	28722	43039	59414	77501	96976	104460	111079	547842
Basic mCARE program	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved(community)	0	0	0	1	1	1	2	2	3	3	13
Maternal lives saved(facility)	1	6	12	21	33	46	61	78	86	94	439
Neonatal lives saved (community)	12	48	106	186	286	407	545	701	775	847	3912
Neonatal lives saved (facility)	31	119	263	457	697	980	1301	1657	1817	1966	9288
Still birth lives saved (community)	5	18	40	71	110	158	213	275	305	335	1529
Still birth lives saved (facility)	17	67	150	265	410	584	787	1015	1128	1238	5661
Total death averted (low scenario)	17	66	147	258	397	566	759	978	1083	1185	5454
Total death averted (high scenario)	49	192	425	743	1139	1610	2149	2751	3032	3298	15388
Total DALY averted (low scenario)	356	1408	3127	5487	8451	12016	16104	20702	22907	25019	115576
Total DALY averted (high scenario)	919	3601	7925	13769	21011	29555	39247	49986	54803	59311	280128
Paper based status quo	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved(community)	0	0	0	0	0	0	0	0	0	1	2
Maternal lives saved(facility)	0	0	1	1	2	3	4	5	5	6	26
Neonatal lives saved (community)	2	8	18	31	48	68	92	119	132	145	661
Neonatal lives saved (facility)	4	17	39	68	105	149	201	259	287	314	1443
Still birth lives saved (community)	1	3	7	12	18	26	35	45	50	55	250
Still birth lives saved (facility)	1	5	11	20	30	43	58	76	84	92	421
Total death averted (low scenario)	3	11	24	43	66	94	127	164	182	200	913
Total death averted (high scenario)	6	23	51	89	137	195	263	339	376	412	1890
Total DALY averted (low scenario)	59	233	519	914	1415	2013	2712	3501	3892	4270	19527
Total DALY averted (high scenario)	130	516	1151	2024	3124	4444	5968	7696	8536	9347	42935

Figure 6.2 Annual total number of deaths averted based on LiST modeling of the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2016-2025

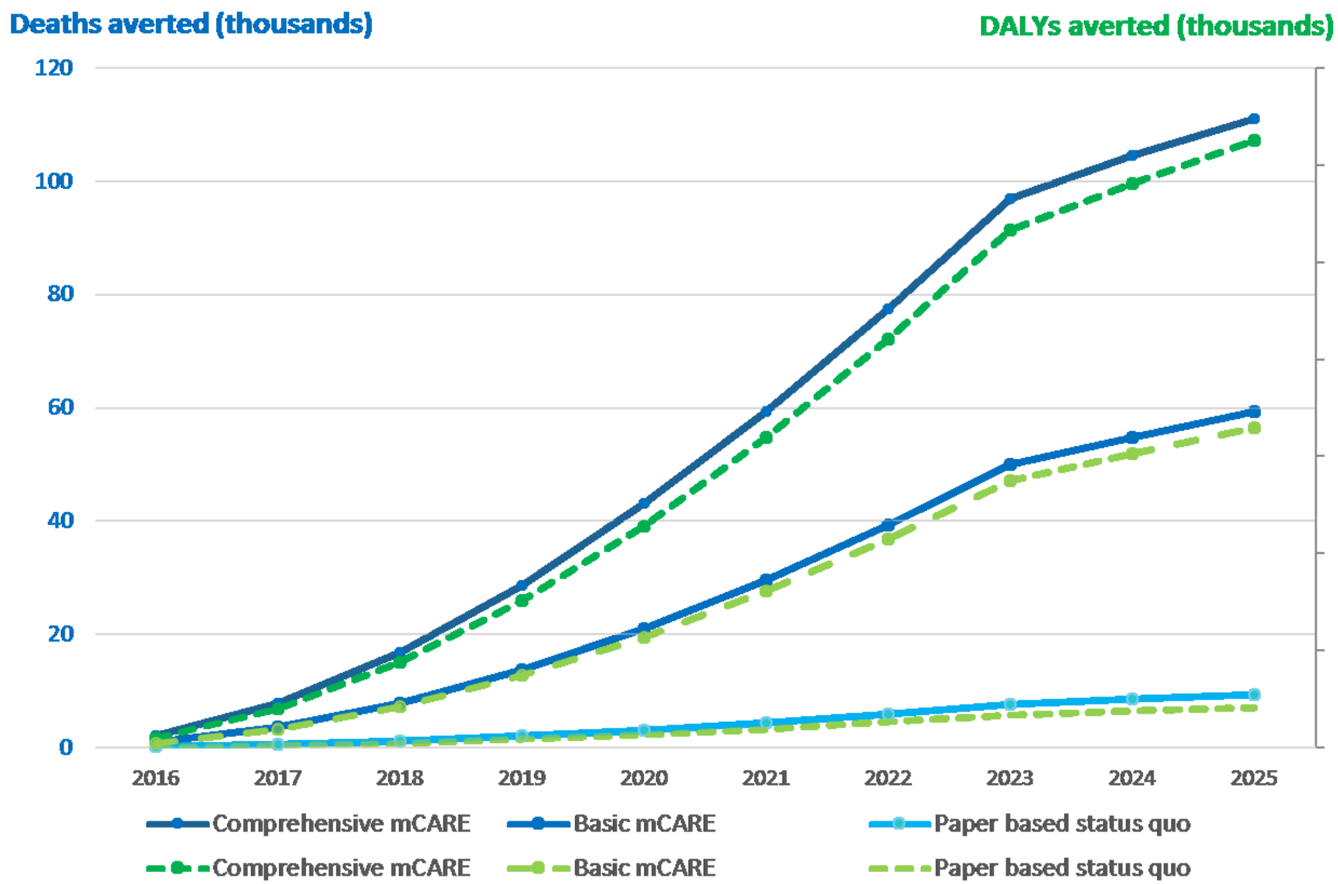


Table 6.6 Summary of incremental cost effectiveness ratios of the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2016-2025

Summary incremental cost effective ratios		Comprehensive mCARE vs. Basic mCARE	Comprehensive mCARE vs. Paper based status quo	Basic mCARE vs. Paper based status quo
Deterministic calculation	Total incremental costs	10,370,249	27,260,042	16,889,793
	Incremental all death averted	10,662	19,682	9,019
	Incremental DALY averted	314,539	580,608	266,069
	Incremental cost per any death averted	973	1,385	1,873
	Incremental cost per DALY averted	33	47	63
Probabilistic calculation	Total incremental costs	12,744,836	27,320,544	14,575,708
	Incremental all death averted	11,014	20,257	9,243
	Incremental DALY averted	318,470	596,118	277,648
	Incremental cost per any death averted	1,157	1,349	1,577
	Incremental cost per DALY averted	40	46	52

Figure 6.3 One-way deterministic sensitivity analysis for annualized total program costs (2016~2025) of the comprehensive mCARE program in one district

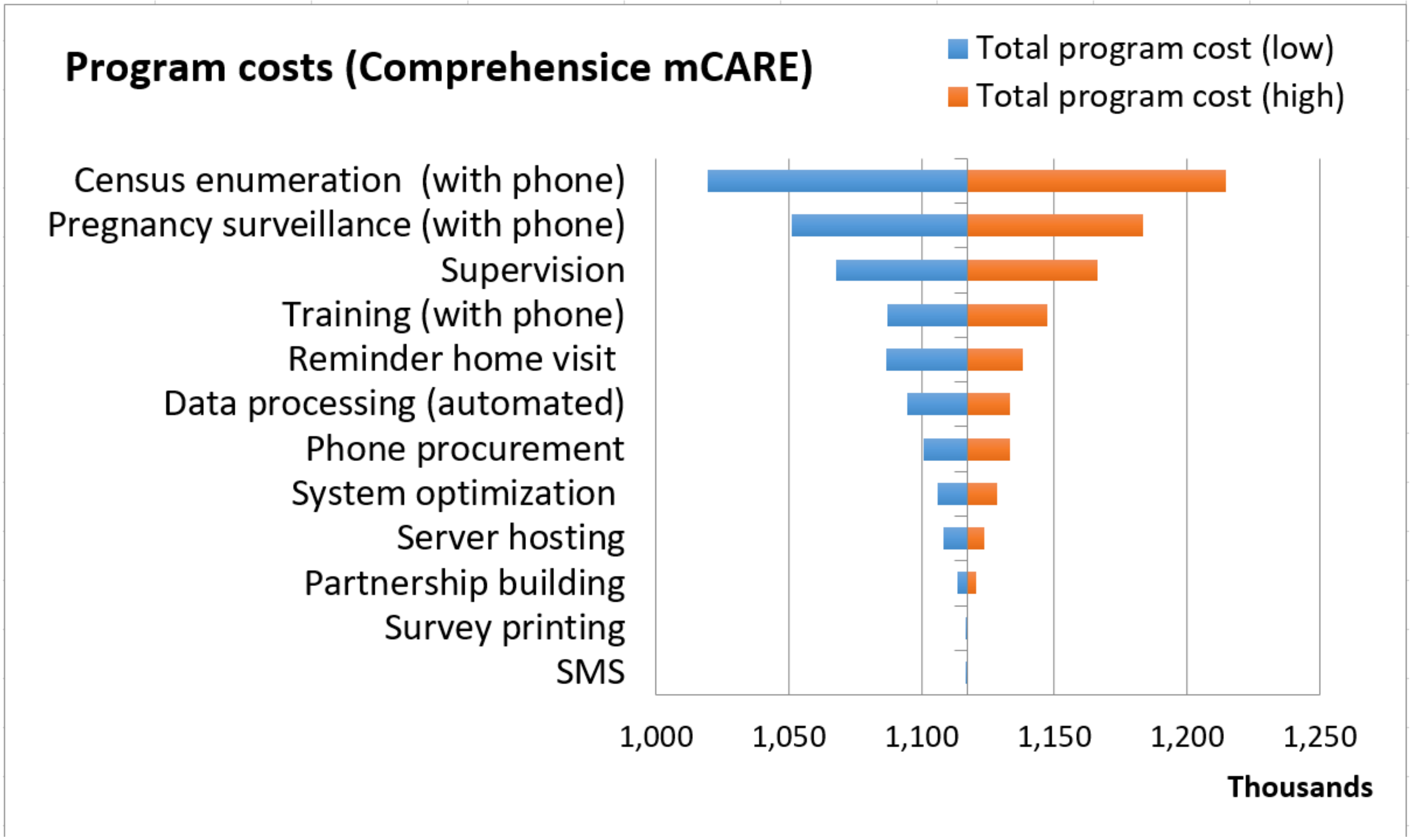


Figure 6.4 Cost effectiveness plane of comparisons of respective two scenarios among: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo

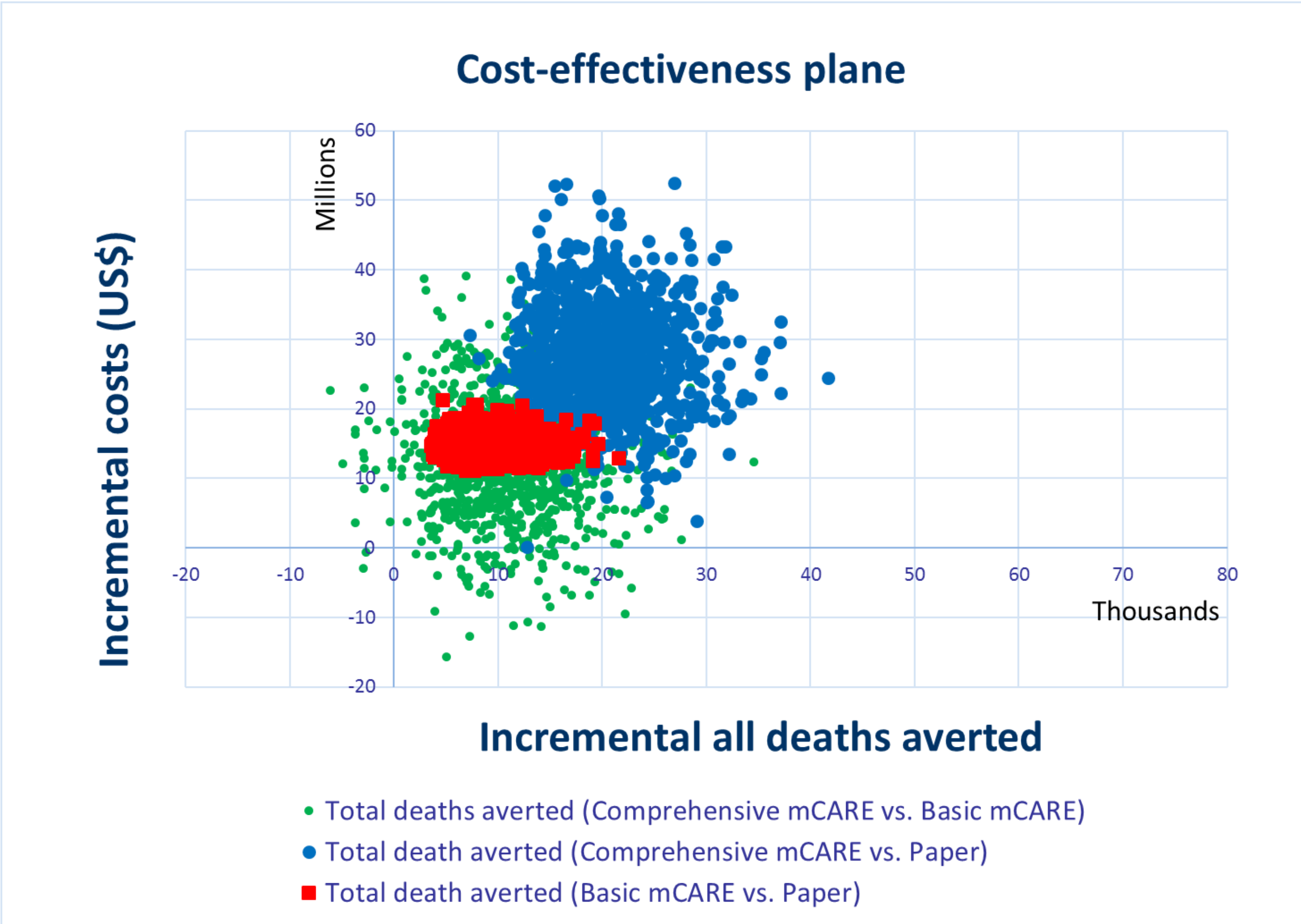


Figure 6.5 Cost effectiveness plane with a line of threshold ratios and an ellipse of confidence (alpha = 5%)

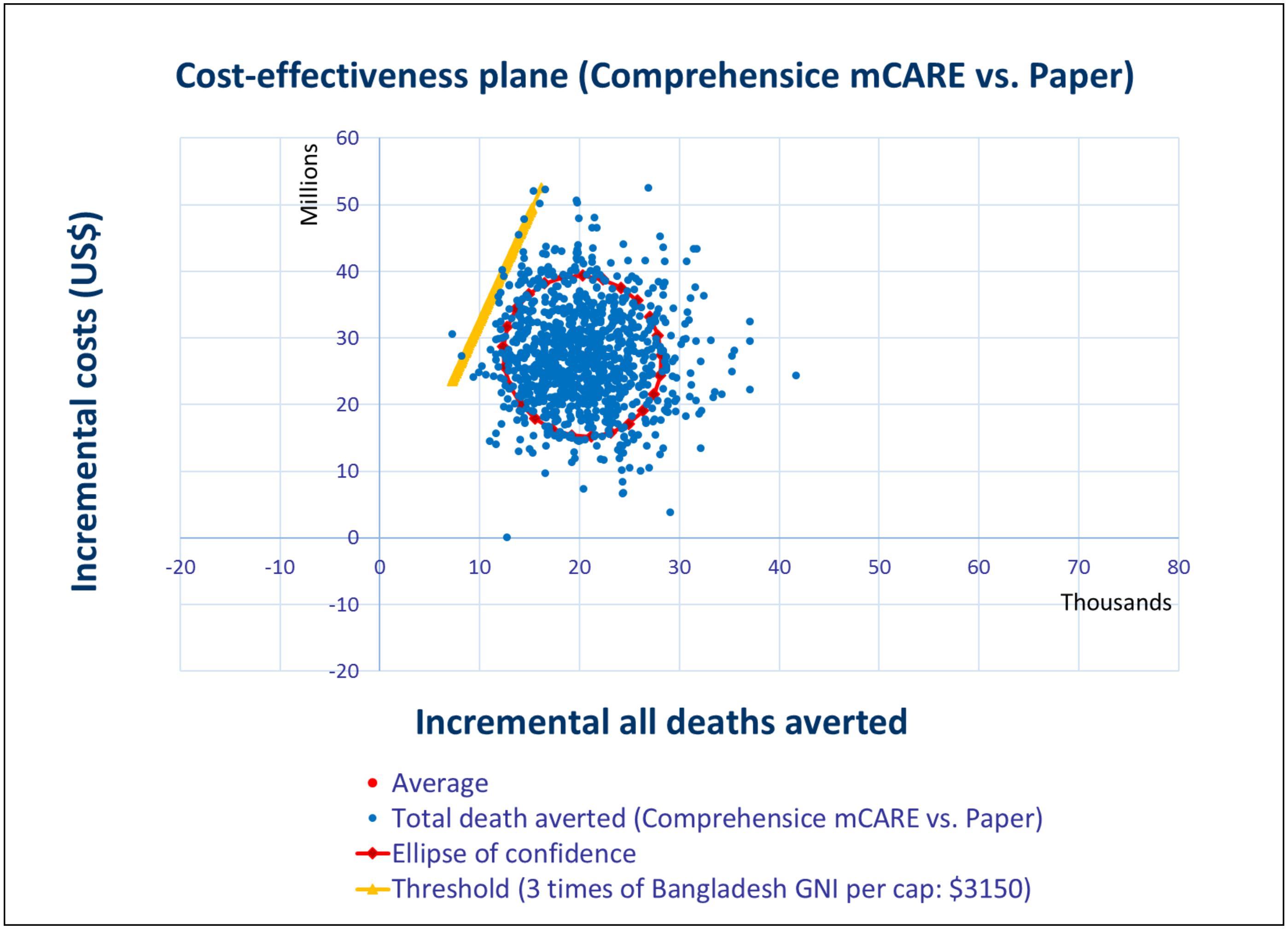


Figure 6.6 Cost effectiveness acceptability curves of comparisons of respective two scenarios among: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo

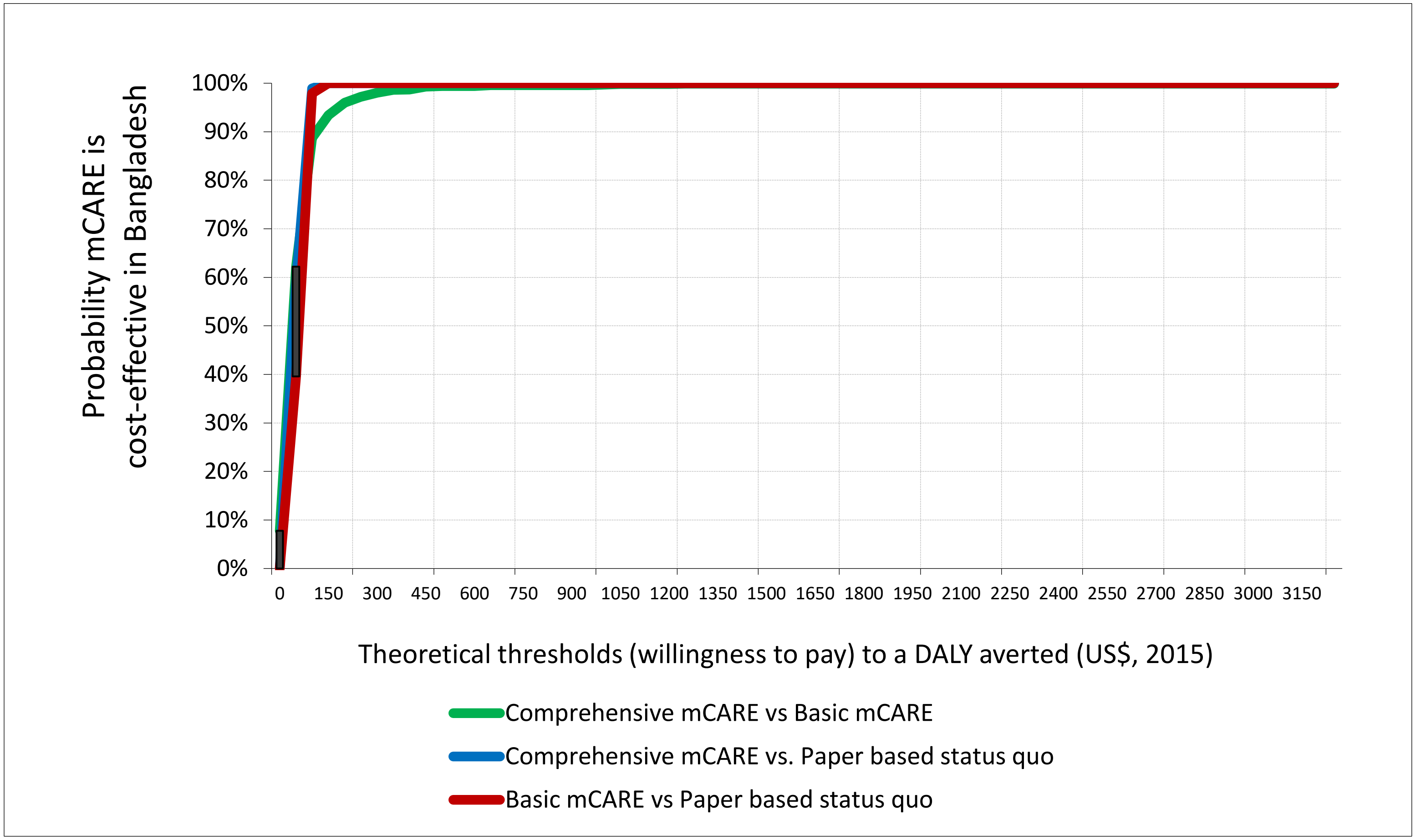
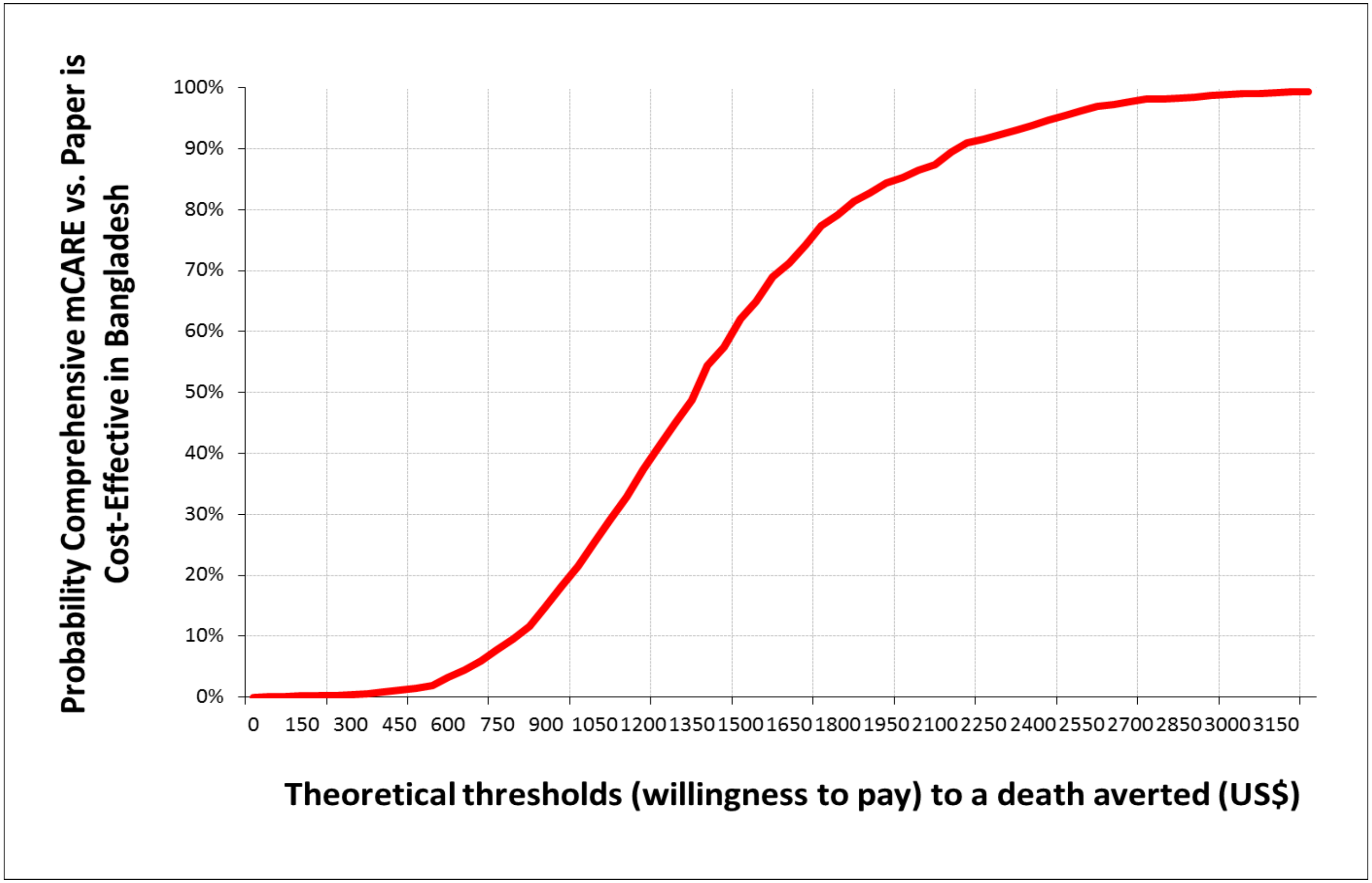


Figure 6.7 Cost effectiveness acceptability curve based on net benefit with a series of willingness of pay to death averted



Chapter 7. Cost effectiveness and budget impact analyses of mCARE program provided through the public sector at scale during 2015-2020 in rural Bangladesh

7.1 Abstract

Economic evaluation is a comparative analysis that may assist in the prioritization of interventions. However, it is not sufficient in predicting whether an intervention is affordable in light of finite resource constraints. mCARE has been implemented since 2013 with the goal of transforming community health workers' (CHWs) routine surveillance activities and promoting pregnant women's care-seeking behaviors through short message service (SMS) and home visit reminders. Based on the favorable cost-effectiveness profile from previous studies, we assessed the affordability of implementing the comprehensive mCARE program over a six-year time horizon (2015~2020) across the entire Gaibandha district (with a population of approximately 2.4 million) by using a cost-effectiveness affordability curve and financial budget impact estimation from the government as a budget holder perspective. The cost-effectiveness affordability curve shows that the comprehensive mCARE program can have at least a 92% probability of cost effectiveness at a threshold ($3,150, three times that of the country's GNI per capita), under the budget constraints of $2.5 million. For the budget impact analysis, we adjusted our activity-based costing into financial costing for a budget expenditure perspective. Following the standardized guideline (ISPOR), the results show that the annual program budget impact is an additional $258,508 in the first year (2015) and $102,658 in subsequent years (2016~2020) without adjusting for inflation in the comprehensive mCARE program compared to the paper system in Gaibandha district. The financial impact estimated over 2015-2020 ($47 million) for the mCARE

intervention in the entire country makes up 0.9% of total annual health expenditure ($5.4 billion) and 2.5% of public health expenditure ($1.9 billion), which is favorable to the current financial arrangement in the country. As the goal of a successful mHealth program is to be integrated into the public health system for scalability and sustainability, our study provides useful information to help project the amount of resources necessary to fund the program, and the consequences of potential variations of cost inputs and scaled-up scenarios, which can guide real-world decisions.

7.2 Introduction

The central health reform agenda in Bangladesh includes building the capacity of human resources and strengthening health information systems.[297][298] Comprehensive and systematic pregnancy surveillance is the first step for the continuum of care of maternal and newborn health services in the population and for the integration of health information systems within the health system. Pregnancy surveillance can help determine the required amount of resources for financing, inform the planning of when and how to distribute the services in communities, administer service and care in a timely fashion, and improve management of treatments or crises. Systematic and comprehensive pregnancy surveillance also allows early pregnancy identification and risk management for antenatal care (ANC) and beyond.

ANC is widely known as an accessible and cost-effective method for improving maternal and perinatal health outcomes.[196, 197] ANC can increase access to and chances of using a skilled attendant at birth around labor and delivery – which is when most deaths occur – through a birth and emergency preparedness plan. Studies show that attending four quality ANC sessions have led to over 60% of facility-based delivery with skilled birth attendants. Due to a lack of access to health providers and facilities, however, nearly two-thirds (73%) of mothers do not attend four or more antenatal visits from skilled health professionals in Bangladesh. Further, while 74% of urban women receive ANC from a trained provider, only 49% of rural women do.[299]

Moreover, the current traditional paper-based system has failed to generate a systematic and comprehensive understanding of the population's health and health system performance. Without mechanisms to systematically verify these data, there is a greater risk of error involved in capturing information. Multiple overlapping reporting systems result in unnecessarily heavy paperwork and poor data quality, which affects timeliness, completeness and accuracy. As a result, these health data are rarely used for national health planning. Weak routine information systems also hamper the health services management at a decentralized level.[50]

In the seventh five-year plan (FY 2016~2020) [300], the government promotes proper management of the large network of public sector health care delivery systems with appropriate referral systems and quality assurance. In this vein, mCARE has been implemented since 2013 with the goal to transform community health workers' (CHWs) routine surveillance activities and to promote pregnant women's care-seeking behaviors through short message service (SMS) and home visit reminders. From 2011 to 2015, a pilot study project, mCARE I, has been developed and implemented with community health research workers to assess the feasibility of the mHealth strategies. Based on the positive impact on service coverage, a larger scale project, mCARE II, has been implemented since 2014 with an open source platform with government CHWs to assess the impact of the program on saving lives of mothers and newborns at scale.

While economic evaluations may assist the prioritization of interventions, they are not sufficient to predict whether an intervention is affordable in light of finite resource constraints. This study examined cost effectiveness, affordability and budget impact of implementing the mCARE program through the public sector to improve pregnancy surveillance and care-seeking of ANC in Gaibandha district over the next six years. We assess scenarios for implementing the comprehensive mCARE program (surveillance and reminders), the basic mCARE program (surveillance) and a status quo comparator as a traditional paper-based system over a six-year analytic time horizon 2015-2020.

7.3 Methods

Perspective and population. The study was conducted using a program perspective, considering the government as a program implementer that is investing in an mHealth program to improve pregnancy surveillance and pregnant women's care-seeking for ANC in Gaibandha district. The number of pregnant women was calculated in each district based on the number of married women of reproductive age (MWRA) (15-49 years) in Gaibandha district in 2015, fertility rate, abortion rate, and fetal loss rate, based on the World Bank database[301] and a formula published elsewhere.[274] These numbers were projected based on trends of the past five years in the database.[302] The number of CHWs (FWAs) is considered to be constant (421) over the five years.

Time horizon. Model-based analyses explored the costs and consequences of the mCARE program in Gaibandha district (approximately 2.4 million population) over the six-year time horizon 2015-2020. The six years consist of one baseline year (2015) for start-up activities and five years (2016~2020) of implementation activities. The time horizon was determined based on the Bangladeshi seventh five-year plan (FY 2016-2020).[300]

Scenarios to be compared. We developed an Excel spreadsheet-based model[303] to project cost and resource requirements in Bangladesh by 2020, in the three groups. The programmatic activities for each scenario are summarized below, and their specific cost components are defined in Chapter 6: Table 1. The scenarios are purely illustrative and not prescriptive for any particular project or country.

- **Comprehensive mCARE program scenario:** Population mapping and census enumeration, pregnancy surveillance via the mobile phone-based system through government CHWs (family welfare assistants); automated SMS and CHWs' home visit reminders to pregnant women on the dates of their four personally scheduled ANC visits.

- **Basic mCARE program scenario:** Population mapping and census enumeration, pregnancy surveillance via using mobile phone-based system through government CHWs (family welfare assistants).

- **Paper based status quo scenario:** Paper-based census enumeration and pregnancy surveillance and community-based ANC promotion activities to pregnant women by government CHWs(family welfare assistants)

The focus of the model is to see how much the mCARE program would increase or decrease program financial costs over time and improve service utilization based on the change of existing operational processes, workforce productivity and pregnant women's care-seeking levels. Therefore, we set the three scenarios starting from the same target population (the number of pregnant women) and same 2016 baseline service coverage to allow for a systematic comparison of the costs and consequences. Also, as the model focuses on the value of the mCARE program in improving existing workforce productivity and operational efficiency, we did not consider additional investments to increase the number of CHWs or health facilities. In terms of operational changes, the model determined relevant program activity components for each scenario, listed in Chapter 6, Table 1. The specific model assumptions for the number of pregnant women, population coverage, and service overage over 2016-2020 was based on similar methods as those described in Chapter 6 and is summarized in Table 7.1.

Population coverage: The model set the target population (number of married women of reproductive age) to be equal across the three scenarios to allow for comparison of costs and consequences associated with each scenario. We used a feasible number of daily household visits per CHW based on the current paper-based system, to assume different census enumeration and pregnancy surveillance coverage values – 90% for the mCARE system and 80% for the paper system. This determines 'population coverage' for each scenario, which is the number of pregnant women who are registered in the program through census enumeration and pregnancy surveillance, divided by the actual number of pregnant women in each district.

Service coverage: Based on the estimated number of registered pregnant women, the model forecasts incremental changes in the utilization of health services, 'service coverage', as a function of each scenario over the five-year program implementation time horizon. 'Service coverage' was calculated as the number of pregnant women who sought care, over the number of registered pregnant women in the system. Different coverage increase rates were assumed for the mCARE intervention (10%), mCARE control (5%), and the paper system (1%) from 2015 to 2020, using the same baseline from 2015 across the three scenarios. Estimates of the incremental changes in coverage assumed a linear increase for each year of implementation. The baseline coverage in 2015 was set as 31% for ANC (more than four visits), facility delivery at 38%, and 36% for PNC, based on the Bangladesh Demographic and Health Survey data.[304] Coverage of home delivery was calculated by deducting facility delivery coverage from 100%. As a result, in the intervention group, the ANC coverage reached 50%, which reflects the target set by the government; facility delivery reached 61% and PNC coverage reached 58% by 2020. Consequently, this resulted in a 1.6 times increase for the mCARE intervention group, 1.3 for the mCARE control group, and 1.05 times increase in coverage for the status quo group, from the baseline in 2015 to 2020.

The program costing consists of two stages: one year of start-up preparation (2015) and subsequent years of implementation (2016~2020). Preparation activities include partnership building, system optimization, phone procurement, survey printing, and training. Implementation includes training, supervision, census enumeration, pregnancy surveillance, SMS, server connections, reminder home visits, and data processing. The activity-based costing followed a similar method as described in Chapter 6. To estimate costs of census enumeration and pregnancy surveillance, we considered that the operational transition from using a paper-based system to phone-based data collection would require intensive efforts in the first year of implementation. Therefore, we assumed a greater level of effort and a longer time period to complete the data collection for these activities in the first year of implementation. We then assumed a lower level of effort and shorter time period in the subsequent years of implementation. As a consequence of the operational transition, we also expected that the mCARE system would reduce the volume of activities and time required for FWAs to complete data entry, processing, and reporting. As a result, FWAs could spend more time on pregnancy surveillance or service provision activities, as we assumed increased population coverage and service coverage in the model when using the mobile system, compared to the traditional paper-based practice.[305] We applied a 6% annual inflation rate for the program costs. We did not include overhead costs such as the cost of office maintenance or furniture or equipment.

Sensitivity analyses. We conducted sensitivity analyses to examine the impact of parameters related to total program costs. The parameters included activity-based cost items and selected cost inputs perceived as key cost determinants and high uncertainty with no historic reference, based on researchers and local experts' recommendations. Given the census enumeration and pregnancy surveillance as major costs drivers, we assessed one-way deterministic sensitivity analysis (DSA) with particular interest on factors related to CHW productivity such as a number of household visits per day, the level of effort, and CHW salary. We also examined one-way DSA on factors related to technological components such as costs of mobile phone device, server maintenance, or network connection, which can be damaged, lost, or stolen, need upgrading or can change their prices within a short time period due to innovation, scale, and competition in the market. The key determinants from the one-way DSA were used for scenario analyses in the budget impact analyses are presented in Table 7.4. For probabilistic sensitivity analysis (PSA), we followed similar methods as described in Chapter 6. We used Lives Saved Tool to estimate the number of lives saved during 2015-2020 in a similar way as described in Chapter 6. Based on total program costs and estimated number of deaths averted for each scenario, we summarized incremental cost effectiveness ratios in Table 7.3.

Affordability analysis. We assessed affordability based on the method described by Sendi and Brigg (2001)[306] and Kim et al. (2007)[307] First, we evaluated the program's cost-effectiveness and derived cost-effectiveness acceptability curves from a program perspective. A cost-effectiveness acceptability curve presents the probability that a program will be cost-effective in relation to a range of incremental thresholds, as a hypothetical value of willingness to pay or fund. Next, we assessed the affordability of the incremental program cost between mCARE I and paper groups compared with a specified budget constraint. We derived probability–within a multivariate PSA – under which the program might be assigned a single fixed budget, for which we set a wide range between $0.1 million to $6.5 million. An affordability curve was then used to present the probability that a program (based on incremental program costs) will be affordable under various program budgets.

We evaluated program affordability based on the incremental costs of the mCARE 1 group compared to the paper group from a program perspective. On the cost effectiveness plane with a cost effectiveness threshold, budget constraints distinguish the simulated outcomes, where the joint distributions of costs and effects that share the same correlations between these two dimensions but differ in scale.[306, 308] Graphically, as we plot the simulated outcomes on a cost-effectiveness plane, cost effectiveness acceptability curve captures the proportion of points in this plane that fall below the diagonal line representing a particular cost effectiveness threshold (here, Bangladesh GNI per capita). An affordability curve captures the proportion of points in this planes that fall below the horizontal line, representing a particular budget line. (Figure 7.4)[306]

Collectively, a cost-effectiveness affordability curve combines the results from a cost-effectiveness acceptability curve and an affordability curve to represent the proportion of the points under the threshold and budget lines on the plane. (Figure 7.5) These curves depict the probabilities that a program will be both cost-effective and affordable under a set of budget constraints such as $2 million and $2.5 million and at a range of threshold values of cost-effectiveness. The sizes of budget constraints were set by increasing the current budget spending (here, estimated program cost in the paper based group) by 1.5-2 times the ceiling ratios.

Budget impact analysis (BIA). We formed BIA to assess the financial consequences of implementing and scaling up mCARE comparing mCARE I and paper groups in Bangladesh, following the ISPOR guideline[309] and Dee at al.[310, 311] While the government is both a program implementer and a service provider, our analysis only included program costs and excluded provider costs associated with service provision. This is mainly because while our intervention sends care seeking reminders to pregnant women, the women could receive care from various channels including government, nongovernmental organizations (NGOs) and the private sector. It is also because within government, our analysis focused on the frontline health workers – here, FWAs – who will use the mobile phone-based mCARE system in pregnancy surveillance activities.

Service provision, however, is done by different level workers, such as FWVs, SACMO, or nurses at various care settings that this study did not take into account.

For the BIA, we adjusted our activity-based costing into financial costing for a budget expenditure perspective. We simplified assumptions to demonstrate our rationales and analytic framework in the most transparent manner possible. In this process, we comprised different activity costs (e.g. census enumeration, pregnancy surveillance, home visit reminders) into an FWA's same fixed annual salary in both groups because these activities would be conducted within FWAs' routine workflow based on the given salary expenditures. In that sense, the supervision costs were also same between the two groups. However, we accounted for different financial expenditures for survey printing, data processing and training between the two groups based on respective cost implications. We considered that mCARE would lower survey printing and data processing costs but increase training costs from the paper group. We also included additional new expenditures for partnership building, system optimization, phone procurement, SMS and server maintenance costs in mCARE I group. We did not account for annual inflation or discounting in this calculation.

We conducted sensitivity analyses to project budget impact based on the variation of parameters used in the analysis. The parameters included the cost of training, phones lost or broken, server maintenance, and SMS unit costs. This was done as a series of one-way sensitivity analyses, i.e., only one parameter was varied at a time, maintaining all others in the reference case. We also estimated budget impact, assuming an incremental geographical expansion over the next five years. Finally, we estimated national scaled-up costs by 2020 by multiplexing the total number of districts (64) in Bangladesh for each scenario. The simple extrapolation of program costs intended to estimate incremental financial consequences across scenarios based on total national health expenditures. We did not take into account local variations in cost inputs.

7.4 Results

Total program costs: Table 7.2 illustrates the total program costs and the major cost drivers in each group. Total program costs are $5.0 million for the intervention group, $4.2 million for the status quo group, and $2.8 million for the control group. There were significant upfront capital costs in the start-up phase in the mCARE system at $350,616, more than 10 times the paper-based system at $34,250. Figure 7.1 depicts the major cost-drivers per study arm. In the intervention group, the major cost-drivers are training (22%), pregnancy surveillance (19%), supervision (16%) and census enumeration (17%). Phone procurement (2%), SMS reminder (0.04%) or server hosting (3%) have a fairly marginal impact compared to total program costs. In the control arm, the major cost drivers are training (27%), pregnancy surveillance (17%), and supervision (19%). In the status quo group, the major cost drivers are pregnancy surveillance (32%), supervision (29%), and data processing (28%).

Annual program costs: Figure 7.2 shows the annual program costs throughout 2015-2020. There were significant upfront costs in the first two years, 2015 and 2016, including start-up and implementation costs mainly due to the operational transition from paper to phone-based data collection in census enumeration and pregnancy surveillance in the comprehensive mCARE program (estimated $1.6 million) and basic program (estimated $1.5 million). In the subsequent year (from 2016), the annual program cost is $768,730 in the comprehensive program and $614,324 in the basic program, gradually increasing over time with a 6% inflation rate. On the other hand, in the paper group, there was a minimal cost of $34,250 in the first year of the start-up phase (2015), and annual program costs of $481,919 in the subsequent year (from 2016), gradually increasing over time with 6% inflation.

Tornado diagram on program costs. The one-way DSA on program cost items (Figure 7.3) showed that census enumeration and pregnancy surveillance are the most influential, followed by supervision, training, reminder home visits, data processing, server connection, and telephone procurement among the other costs. SMS reminders showed the least cost implications as the proportion of these costs were only marginal to the total program costs. This suggests that on the basis of systematic population surveillance, the add-on personalized SMS and home visit reminders could substantially improve cost-effectiveness with a small amount of cost implications.

Affordability curve. The affordability curve (Figure 7.4) shows that the probability that the mCARE intervention is affordable is 0% up to a budget of $1 million but increases as the budget increases, reaching 93% when the budget increases to $3 million and beyond. The cost-effectiveness affordability curve (Figure 7.5) shows that the mCARE intervention can have at least 93% probability of cost effectiveness at the standard cost-effectiveness threshold ($3,150, 3 times the Bangladesh GNI per capita), with budget constraints of $2.5 million.

Budget impact analysis. Table 7.4 shows the budget impact reference case between the mCARE I and paper groups over 2015-2020 in Gaibandha district. The annual program budget impact is an additional $258,508 in the first year and $102,658 in the subsequent years without adjusting for inflation in the mCARE I group compared to the paper group. If we included costs associated with resource utilization by service provision in government from increased pregnant women's care-seeking, the annual budgetary impact would be greater than $102,568, under the current public/private service provision mix. In terms of sub-cost items, costs of survey printing and data processing are decreased, while training, partnership building, system optimization, phone procurement, SMS and server maintenance are increased in the mCARE group when compared to the paper group. Assuming staff salaries are constant, the result of sensitivity analyses show that budget impact is most sensitive to the training costs as it is the major cost-driver, while other costs associated with technological components are marginal in the total costs. The results also show that if mCARE is incrementally scaled up to another district each year, about a $4 million budget would be required throughout 2015-2020. Given the budget impact in one district, if mCARE is implemented in all 64 districts, a total budget of $47 million and $16.5 million in the first year (in 2015) and $6.1 million in subsequent years would be required throughout 2016-2020. In the budget impact reference case, the estimated unit cost per registered pregnant woman who seeks an ANC service is $630 in the mCARE I group, which is $14 less than $644 in the paper group. This is because the mCARE intervention, compared to the paper group, contributed to a greater number of pregnant women who seek care at a given expenditure. This suggests that the mCARE intervention is likely to achieve cost savings at scale when making pregnant women seek care, compared to the paper-based system.

In the context of health financing,[7] Table 7.5 shows that the national estimated costs of the mCARE intervention scenario ($47 million) makes up 0.9% of total annual health expenditure (THE) ($5.4 billion), 2.5% of public health expenditure ($1.9 billion), 12% of international development assistance ($387 million) in 2015. In regards to annualized national estimated costs, the mCARE implementation ($6.1 million) makes up 0.08% of total health expenditure, 0.2% of public health expenditure, and 1% of international development assistance.[27] In terms of dollar per capita expenditure, the country currently spends $26.6 per capita, and only $4.2 per person per year is spent on health from the government budget. In the budget impact implementation reference case (excluding the startup cost in the first year), the estimated unit cost per MWRA is $3 and unit cost per pregnant woman is $215 in the comprehensive mCARE program scenario, which requires only an additional $0.18 and $14 from the status quo scenario. This

[7] In 2015, total health expenditure accounted for 3.6% of the country's Gross Domestic Product (GDP), an amount that was lower than the average of 4.5% for other low-income countries, and well below the global average of 9.9%. Of this, 64% comes from individual pocket which is one of the highest and has a serious impoverishing effect on household economy. Of the remaining 36% comes from public financing, about 60% is financed by the Government out of tax revenues, development outlays, and the remaining 40% through interventional development assistant. Public allocations to fund the health sector were around 7.7% of total government expenditure. This was slightly lower than the average of 8.1% for other low-income countries and well below the 15% the global average. Donor financing accounted for only 7% of total health sector expenditure in 2012. This was considerably lower than the low-income country average of 28%. To tackle financing issues, a Health Financing Strategy (2012-32) has also been developed for addressing this issue of reducing out of pocket expenditure. (Source: World Health Organization. Bangladesh Health System Review. 2015)

indicates that a district with 1 million pregnant women would require an additional $14 million budget to implement the mCARE intervention (assuming a similar ratio between CHWs and pregnant women). While per capita THE grew at a higher pace (11%) than per capita GDP (8%) in recent years [312][313], THE in Bangladesh as a share of GDP has remained one of the lowest in the WHO South-East Asian Region, and is still lower than that of even lower middle-income countries (4.5%), as classified by the World Bank.[314] Under the current funding arrangement, the results from the affordability curve based on cost-effectiveness analysis and the incremental budgetary measure from BIA suggest that mCARE may be an affordable option in a limited budget expenditure scenario, if the government is willing to invest in and prioritize scaling up the program.

7.5 Discussion

Since the concept was first introduced by Trueman in 2001 [315], budget impact analysis (BIA) has been increasingly used in various settings – national, district, hospital, or community program levels – to predict the potential financial impact of the adoption and diffusion of a new technology into a healthcare system with finite resources.[309, 316, 317] Notable studies have used BIA in actual budget planning processes and investment decision making. For example, Meyer-Rath conducted BI modeling in changing the policy of antiretroviral therapy in South Africa. The budget impact model, named the National ART Cost Model, has been used for the government's Conditional Grant for HIV/AIDS. In the field of pharmaceutical budget planning and decision making, other studies also used BIA to assess drug acquisition costs from the reimbursement payer's point of view.[318] [319, 320]

In the field of health information systems, some earlier studies on telehealth and electronic health record (EHR) system in hospital-based institutional settings used budget impact analysis and total cost ownership model (TCO) for decision making in business and for IT infrastructure acquisition. In the field of mHealth, tools and frameworks for assessing costs have been developed, and applied in real-world settings. [321, 322] Some programs have used the TCO method to assess costs over the project life cycle for designing, piloting, and scaling up such technologies to help program managers in their budget planning and advocacy efforts.[284]

The study assessed the affordability of implementation of the mCARE intervention in Gaibandha district over 2015-2020 through a cost-effectiveness affordability curve and budget impact estimations from a program perspective. The results show that incremental cost to implement the comprehensive mCARE program from the current paper based system is a cost effective and affordable health intervention in Bangladesh. The incremental total program costs (2015-2020) between the comprehensive mCARE program and paper based system is $2.3 million (i.e. annual average program cost estimation: $374,855) according to activity based costing in CEA and $736,130 (i.e. annual average program cost estimation: $138,513) based on financial costing in BIA. The estimated annual average program budget $138,513 is only 1.28% out of the sectoral budget allocation to health (FY16), estimated as $10.8 million to one district.[8]

[8] The Seventh Plan Annual Development Plan Sectoral Allocations to Health Sector is $692 million (5.5%) out of the total national budget $12.6 billion (FY16) in Bangladesh. Given the total number (64) of districts in Bangladesh, we

The budget impact estimate is much lower than the estimates based on activity based costing. This is because latter accounts for different respective cost implications from activities such as census enumeration, pregnancy surveillance, home visit reminders into the analysis, while BIA accounted for them in a fixed amount of CHW salary between the two groups. For a program such as mCARE, which involves multiple stakeholders and substantially complex operational transition, these results show that ingredient-based activity costing and a particular payer's financial expenditure can be substantially different.

Based on the favorable cost-effectiveness profile, in BIA, we focused on the government (as a budget holder) planning and budget cycle for its analytic scope and time frame – rather than a project life cycle – under the budget constraints. As a recommended strategy of the successful mHealth program is to be integrated into the government health systems for scalability and sustainability, the result of BIA provides useful information to project the magnitude of resources needed to fund the program, and the consequences of potential variations of cost inputs and scale-up scenarios, which can guide real-world decisions.

Cost saving strategies. From a program manager's perspective, the study findings suggest several cost-saving strategies. First, findings from sensitivity analyses on CHW

---

estimated the budget allocation to health sector to one district as $10.8 million (FY16). (Source: Seventh Five Year Plan, FY2016-FY2020. General Economic Division. Planning Commission. The Government of the People's Republic of Bangladesh.)

productivity suggests that the system may consider setting a target of a number of routine household visits or designing the user interface to encourage CHWs to conduct comprehensive census registration and pregnancy identification. Costs can be substantially saved by reducing the number of required months with increased daily household visits by a CHW to complete the registration of estimated target population in a given district. Also, given the major cost-drivers of phones breaking or being lost, the program could consider these particular aspects in the choice of tablet devices and in the process of maintenance and training for how to use the tablet or phone to minimize phones lost or broken. Program managers could also consider SMS unit costs and the frequency of texting to clients in designing the intervention strategies and negotiating with telecommunications companies, as the target population increases with scaling up. In addition, as the system algorithm can be continuously upgraded over time or server system may need to be upgraded with increasing size of clients, program managers should also consider the maintenance costs associated with software or system upgrades and troubleshooting in addition to the existing monthly server connection fee.

Implications of scale up. The results also indicate greater benefits of cost-saving and health impact by sustaining and scaling up these programs over time in the entire country. First, the results of CEA show that the major cost drivers are census enumeration, pregnancy surveillance, training and supervision which involve substantial operational changes from the paper system, especially in the beginning of the program implementation. The marginal costs of these activities, however, can be reduced over time, because an established master list of households and population in the system can reduce time and costs associated with registering new clients and survey form printing, data collection and reporting process, and can also improve data quality and accuracy, compared to the paper system. In addition, the relatively small proportion of costs for reminder interventions indicates that greater benefits can be achieved by scaling up these programs in the entire country. While the costs for pregnancy surveillance would increase with population size, the add-on reminder intervention costs are relatively small despite substantial impact. Given the nature of census enumeration and pregnancy surveillance, we suggest cooperation with other public agencies that can share activities or costs, such as Civil Registration and Vital Statistics (CRVS) initiatives or the census bureau. In this way, the Ministry of Health may then save budget costs to invest in other life-saving public health priorities.

In terms of financial implications to health systems, increasing service coverage with the currently high level of out-of-pocket payment (OOP) in Bangladesh may result in regressive impact and financial burden to poor households. We suggest that mHealth programs consider including some demand-side financing schemes, especially for the poor, in order to reduce the risk of catastrophic health expenditures that may result from receiving care. These types of support can reduce financial and access barriers to seek care and can reduce inequity for service utilization. Regarding service provision, effective mHealth programs demand quality health services so that care-seeking can be attributed to health efficacy. In this study, while we considered the government a main formal stakeholder in the health system as the program implementer and service provider, in reality, service provision consists of many other stakeholders such as NGOs, the private sector, as well as informal sectors, including unqualified providers such as village doctors and drug vendors. They play a major role in the private healthcare market in Bangladesh, especially in semi-urban and rural areas.[323] Even in urban areas where there is relatively good access to public providers, the majority of the poor tend to see unqualified practitioners as they are comparatively less expensive, easier to access, and their services are more familiar to patients.[43] Strategies for scaling up mHealth programs may need to consider this aspect based on the care-seeking characteristics and available service provisions in the given health system.

NGOs provide some health services, especially at the grassroots level. They provide mainly primary and preventive care services, which complement public health services in Bangladesh. NGOs, especially BRAC, conduct their own pregnancy identification activities apart from government programs. This is partly due to the insufficient human workforce capacity in the government to cover the population's needs. However, with the implementation of mHealth programs overtime, the government may focus on this pregnancy surveillance systematically, and best practices can be shared with other providers. In Bangladesh, NGOs have taken the lead in health care innovation, often in partnership with government. In collaborating with NGOs, the government could better allocate resources in quality service provision and promote innovative approaches with mHealth strategies.

Why invest in mHealth? Bangladesh set its vision to achieve universal health coverage by 2035.[21] Global recommendations[324][21] and government policy plans[325][326][327] discuss a health reform agenda and suggest a roadmap toward universal health coverage. Priorities of the agenda include improving the responsiveness, equity and quality of healthcare services, human resource policy, national insurance system, use of information communication technology (ICT), and governance capacity. Among these many competing priorities, investment decision-making may not be an easy task for policymakers. Further, amidst a shrinking health budget and financial constraints, the solution would require more than just increasing financial resources for health but in addition, improving ways of "organizing resource mobilization, allocation and expenditure in order to obtain the maximum value for money to ensure equitable and sustainable financing and financial protection against health expenditures for the entire population." [328]

In this regard, the study argues that investing in mHealth can help improve address a better way to coordination through a sector-wide approach to strengthen health financing and the health system at large. First, an mHealth approach for census enumeration and pregnancy surveillance can serve as a platform for not only health services, but also for broader social welfare benefits through its ability to facilitate public service delivery such as education, financial services, and even ensuring the right to vote. Achieving these policy and development outcomes may invite creative opportunities with a multi-sectoral and collaborative approach with other government ministries in financing and pooling resources. Second, individual health and socioeconomic information collected through health information systems can be better used in identifying and targeting the poor to improve equity in health financing and service delivery. For instance, using a voucher scheme can support the poor to reduce their out-of-pocket expenditures and allow them to access necessary and quality health services. Third, the quality data collected from health information systems can generate better evidence for decision-making on resource allocation that can be based on performance or outcome measures, rather than on the basis of historical or political patterns. Clearly, mHealth is not just about increasing coverage, but it requires promoting workforce capacity, improving ways of managing workflow and organizing resource allocation in order to achieve effective coverage. Finally, these processes can promote dynamic and proactive stewardship in policy making and enforcement to enable health systems transition and advancement in practice.[16, 329]

7.6 Limitations

The results presented in this study should be interpreted while considering the limitations of the approach and data used. To estimate program activities and costs, we relied on our observations and experience from the mCARE I project, which might only approximately represent the actual costs in project scale-up. We did not include potential leaning effects as the relevant detailed information is proprietary and unavailable. We did not consider health systems negotiated costs such as donations or cost reduction through negotiation or new partnerships (e.g. mobile network operators to reduce airtime costs) to reflect market-based values of implementing the program, as it is difficult to predict or plan in advance. If it did happen, program costs may decrease. We also did not consider alternative business or financing models (e.g. 'Freemium' models where users pay for some features) as potential revenue generation or cost-sharing strategies.[219] However, such potential approaches are encouraged to promote, as there can be many creative innovations and strategic partnerships that can add value in this field with scale-up.

There are other factors that could affect resource utilization but were not included in the analysis. We did not consider illness effects in increasing service coverage. Besides the program effect of promoting care-seeking in the intervention group, people in the status quo or control group might be sicker due to less care-seeking in the earlier state of pregnancy and thus seek more care in the later stages of pregnancy. If that were to happen, service coverage may increase based on the severity of illness in the control and status quo groups. We did not consider the people who were not enrolled in the system but might seek care for the service coverage. In our approach, the denominator of service coverage is bound to the population coverage. This might result in a different measure of service coverage than the actual measure of service utilization, but we hold this approach as we evaluated the mCARE impact to be based on its capacity to capture population coverage. We did not consider the potential impact of new interventions or advanced tools because it is difficult to predict when they would be developed and operationalized. If new effective and affordable tools (such as risk prioritization or workflow algorithms on openSRP) are operationalized, the strategies of surveillance and care-seeking reminders could change, thereby influence costs. We did not consider any unexpected political unrest that could interrupt interventions. Overall, given the early stage of mHealth programs being implemented, there are limited data for many of the parameters, and much of the parameter uncertainty cannot be meaningfully quantified. Moreover, much of the uncertainty is structural and not easily parameterized.

Our budget impact analysis may not reflect some other important policy priorities or constraints. The budget thresholds were based on standard guidelines such as GNI per capita and a relative increase (e.g. 1.5-2 times) based on the cost estimates of the status quo scenario, as we did not have enough information to set specific values of willingness to pay. In the scenarios, we did not consider costs associated with vertical scale up, while it may be an important policy priority and substantial initial cost drivers for data and system integration across the different levels of health facilities, as stated in the recent report.[50] Future studies may conduct a survey with policymakers and relevant stakeholders to better incorporate realistic policy considerations and improve our assumptions.

7.7 Conclusions

In limited resource settings, efficient allocation of available personnel and resources are difficult decisions, which are common challenges in many developing countries. A key aspect of the national eHealth policy is "the development of an integrated health information system, which includes a health management information system and an integrated human resource information system."[329][330] This study is the first of its kind in Bangladesh to estimate the comparative costs and consequences of a digital health solution at scale compared to existing services and measure its affordability from a budget holder perspective. We believe our study is a meaningful contribution to the field and will help to guide decision-making in Bangladesh and globally related to investing in healthcare innovations based on evidence – cost effectiveness and affordability – rather than historic or political patterns.

Table 7.1 Model assumptions for pregnancy, population coverage, and service coverage for the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2015-2020

Model components		**Comprehensive mCARE program**				**Basic mCARE program**				**Paper based status quo**			
		Start-up	Implementation			Start-up	Implementation			Start-up	Implementation		
Target population	**Estimation of eligible population**	2015	2016	…	2020	2015	2016	…	2020	2015	2016	…	2020
	Population assumption	2.4 million	2.4 million	…	2.4 million	2.4 million	2.4 million	…	2.4 million	2.4 million	2.4 million	…	2.4 million
	Number of eligible couple	560,000	560,560	…	562,806	560,000	560,560	…	562,806	560,000	560,560	…	562,806
	Married woman of reproductive age	560,000	560,560	…	562,806	560,000	560,560	…	562,806	560,000	560,560	…	562,806
	Fertility rate (B)	2.17	2.15	…	2.06	2.17	2.15	…	2.06	2.17	2.15	…	2.06
	Abortion rate (A)	18.2	18.16	…	18.02	18.2	18.16	…	18.02	18.2	18.16	…	18.02
	Fetal loss rate (D)	37.00	36.93	…	36.63	37.00	36.93	…	36.63	37.00	36.93	…	36.63
	Pregnant women	7,793	7,778	…	7,719	7,793	7,778	…	7,719	7,793	7,778	…	7,719
Population coverage	**CHW performance**	2015	2016	…	2020	2015	2016	…	2020	2015	2016	…	2020
	Census enumeration	0%	90%	…	90%	0%	90%	…	90%	0%	80%	…	80%
	Pregnancy surveillance	0%	90%	…	90%	0%	90%	…	90%	0%	80%	…	80%
	Number of eligible clients	0	6,300	…	6,094	0	6,300	…	6,094	0	4,978	…	4,815
Service coverage	**Service care-seeking**	2015	2016	…	2020	2015	2016	…	2020	2015	2016	…	2020
	ANC (more than 4)	31%	34%	…	50%	31%	33%	…	40%	31%	31%	…	33%
	ANC (less than 4)	69%	66%	…	50%	69%	67%	…	60%	69%	69%	…	67%
	Facility delivery	38%	42%	…	61%	38%	40%	…	48%	38%	38%	…	40%
	Home delivery	62%	58%	…	39%	62%	60%	…	52%	62%	62%	…	60%
	PNC	36%	40%	…	58%	36%	38%	…	46%	36%	36%	…	38%
	No PNC	64%	60%	…	42%	64%	62%	…	54%	64%	64%	…	62%

- The number of pregnant women was calculated in each district based on the respective number of married women of reproductive ages (ages 15-49) in each district, fertility rate, abortion rate, and fetal loss rate, based on the world bank database (http://data.worldbank.org/) a formula published elsewhere.[274]
- Population coverage represents the number of pregnant women who are registered in the program through census enumeration and pregnancy surveillance, over the actual number of pregnant women in each district.
- Service coverage represents the number of pregnant women who sought care, over the number of registered pregnant women in the system.

Table 7.2 Model estimations for pregnancy, population coverage, and service coverage the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2015-2020

Program costs (2015~2020)	**Comprehensive mCARE program**	**%**	**Basic mCARE program**	**%**	**Paper based status quo**	**%**
Partnership building	13,068	0%	13,068	0%	n/a	
System optimization	59,300	1%	59,300	1%	n/a	
Tablet/phone procurement	118,073	2%	118,073	3%	n/a	
Survey printing	7328	0%	7328	0%	181,358	7%
Training	1,117,272	22%	1,117,272	27%	57,546	2%
Supervision	787,660	16%	787,660	19%	787,660	29%
Census enumeration	689,880	14%	689,880	17%	83,300	3%
Pregnancy surveillance	953,081	19%	953,081	23%	874,649	32%
Data processing	433,159	9%	433,159	10%	766,359	28%
SMS	1,905	0%	n/a		n/a	
Server hosting	152,878	3%	n/a		n/a	
Reminder home visit	666,399	13%	n/a		n/a	
Total program costs	5,000,003	100%	4,178,821	100%	2,750,872	100%

Figure 7.1 Total program costs for the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2015-2020

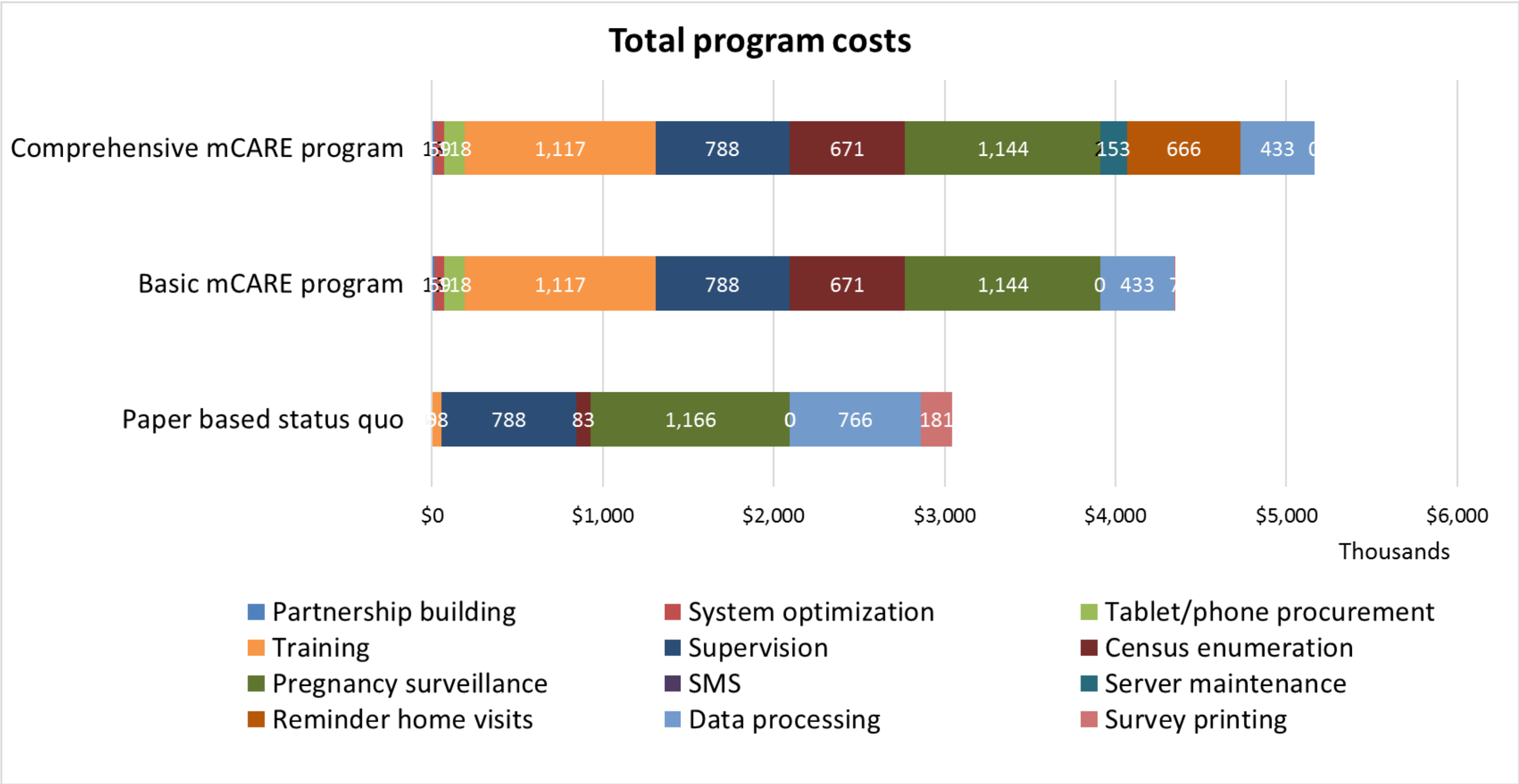


Figure 7.2 Annual program costs and service coverage for the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2015-2020

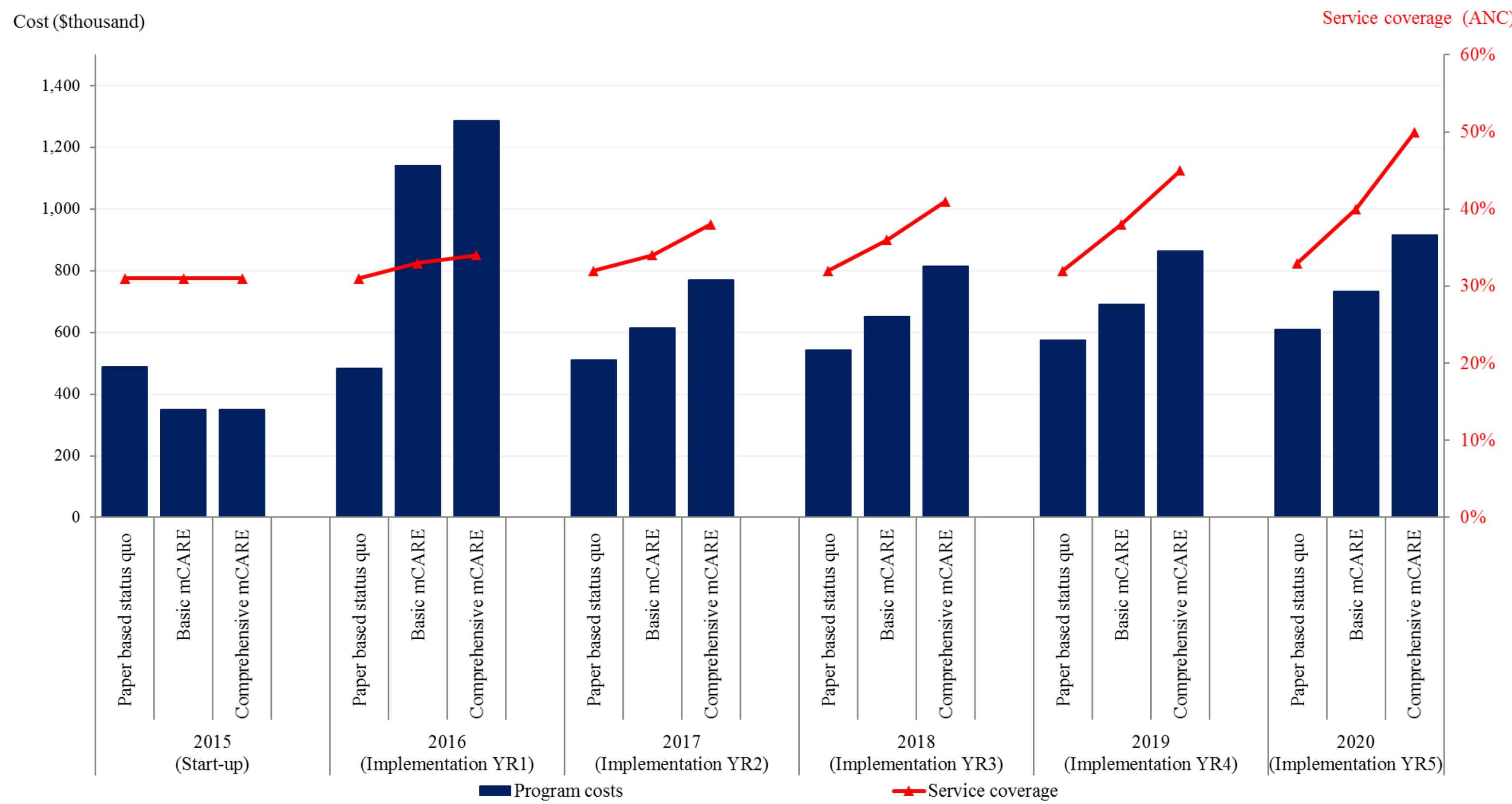


Figure 7.3 One-way deterministic sensitivity analysis of the total program costs (2015-2020) of the comprehensive mCARE program

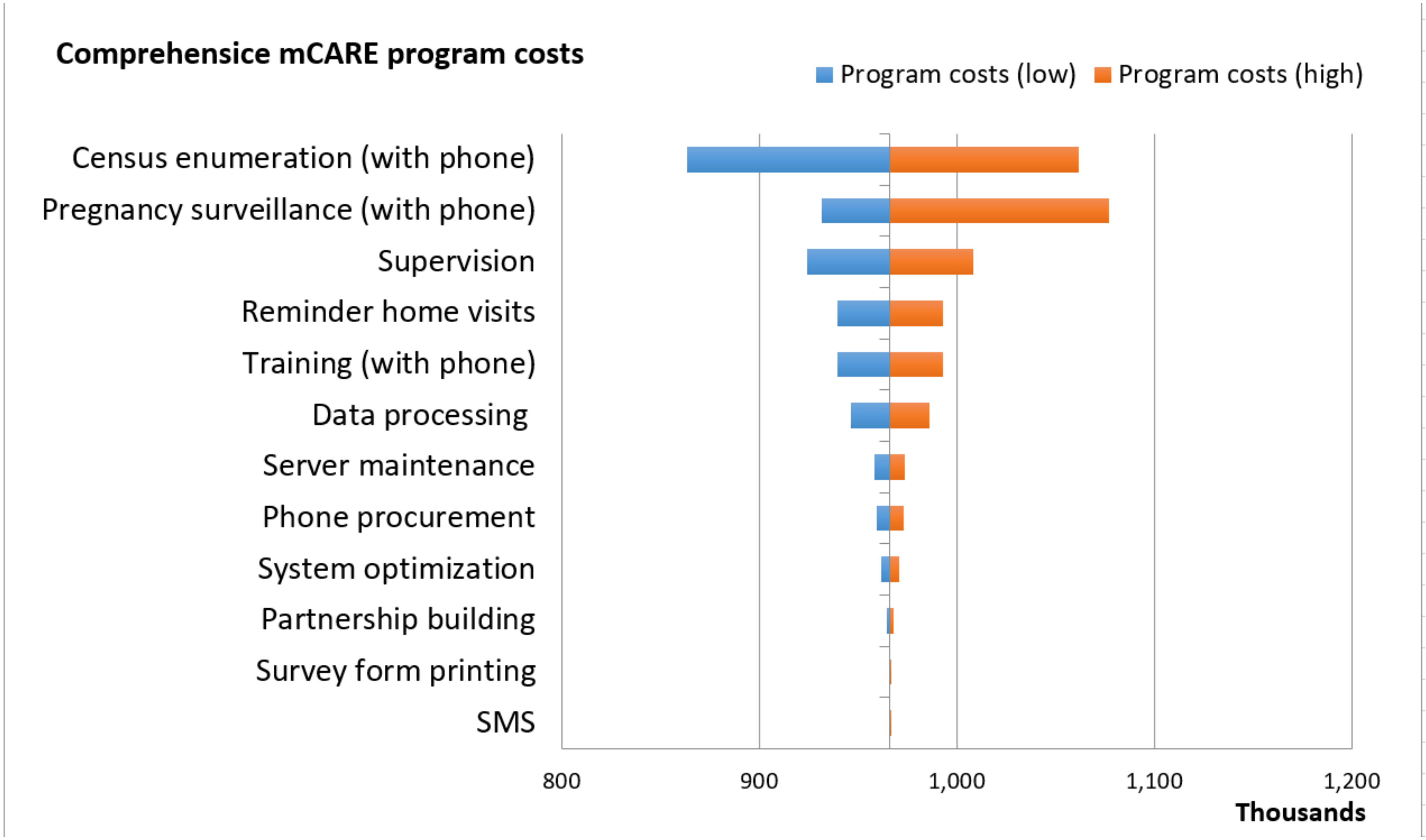


Table 7.3 Summary of incremental cost effectiveness ratios of the three scenarios: (i) comprehensive mCARE program; (ii) basic mCARE program; (iii) paper based status quo, over 2016-2025

Summary of incremental cost effectiveness ratios		Comprehensive mCARE vs. Basic mCARE	Comprehensive mCARE vs. Paper based status quo	Basic mCARE vs. Paper based status quo
Deterministic calculation	Total incremental costs	821,182	2,257,850	1,436,668
	Incremental all death averted	845	1,254	409
	Incremental DALY averted	10,261	17,966	7,705
	Incremental cost per any death averted	972	1,801	3,513
	Incremental cost per DALY averted	80	126	186
Probabilistic calculation	Total incremental costs	669,754	2,260,853	1,591,099
	Incremental all death averted	853	1,278	425
	Incremental DALY averted	10,409	18,226	7,817
	Incremental cost per any death averted	785	1,769	3,741
	Incremental cost per DALY averted	64	124	204

Figure 7.4 An affordability curve showing the probability that the incremental cost of comprehensive mCARE program compared to paper based system over 2015-2020 is affordable as a function of the budget constraint

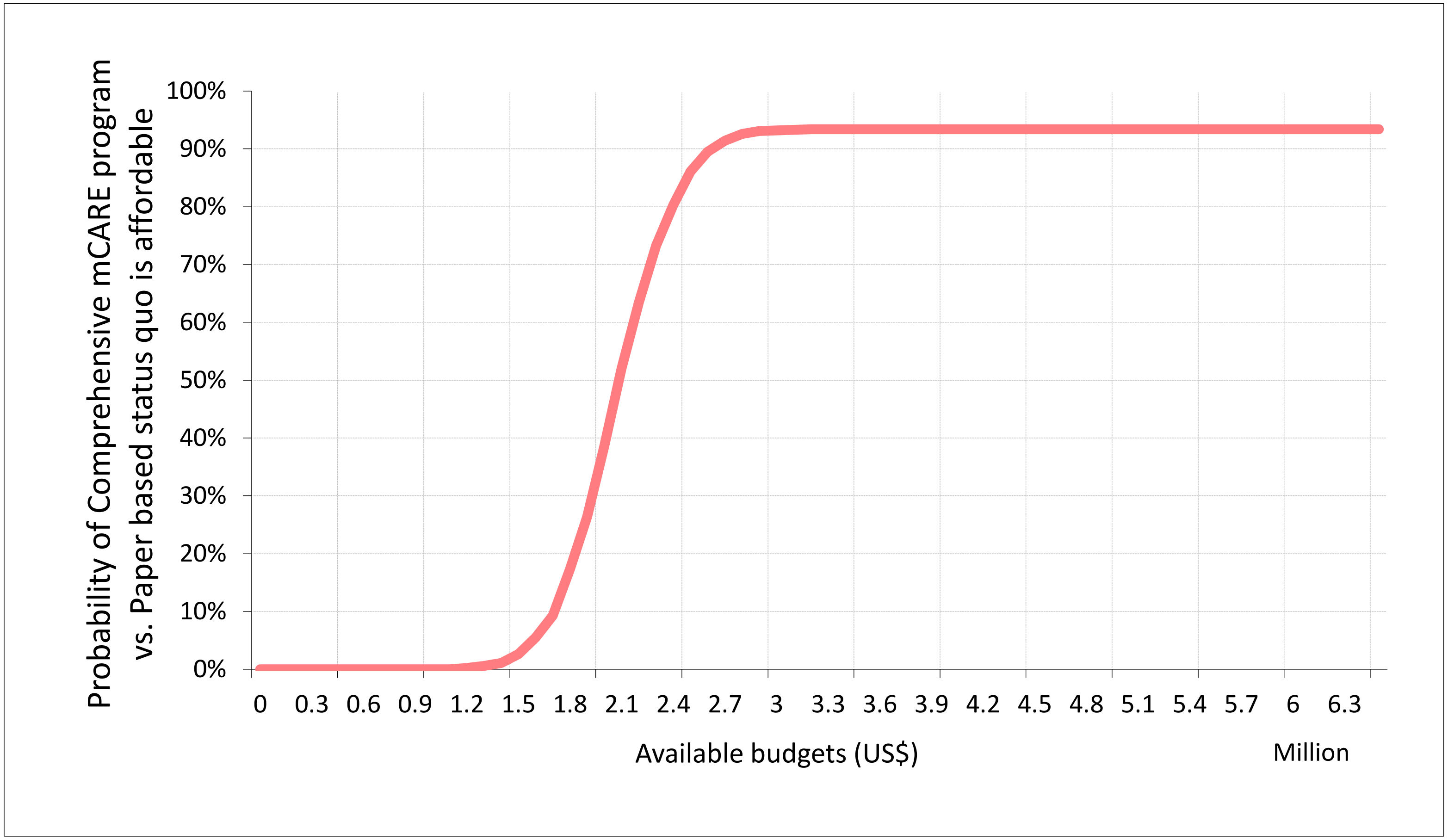


Figure 7.5 Cost effectiveness affordability curve showing the probability that the comprehensive mCARE program is simultaneously cost-effective and affordable as a function of the ceiling ratio (Bangladesh GNI per capita) and the budget constraint

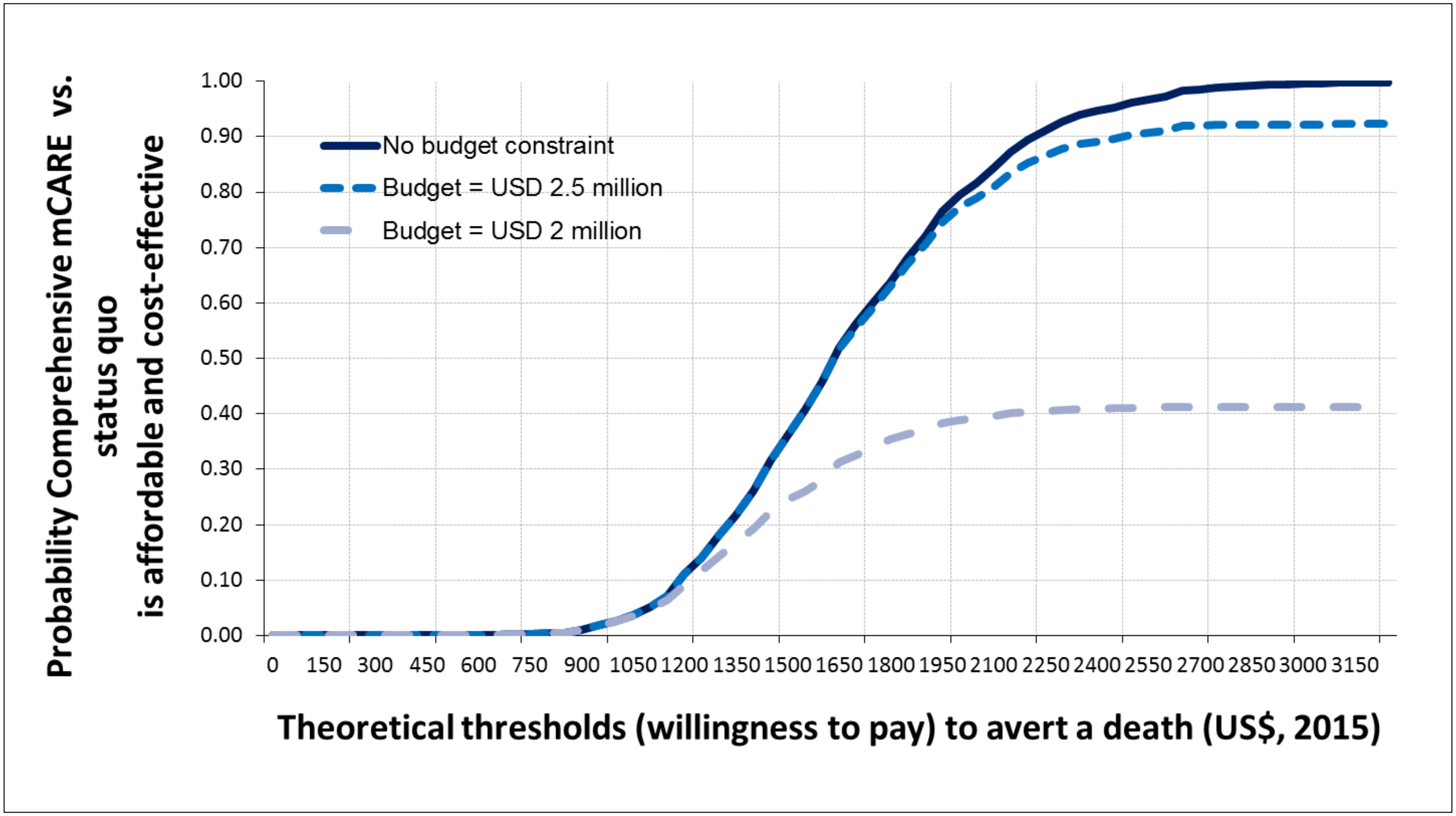


Table 7.4 Budget impact reference case of program financial costs of comprehensive mCARE program and paper based groups over 2015-2020

Paper based system							**Comprehensive mCARE program**						
Phase	Status quo						Phase	Start-up	Implementation				
Year	2015	2016	2017	2018	2019	2020	Year	2015	2016	2017	2018	2019	2020
Survey printing	26,000	26,000	26,000	26,000	26,000	26,000	Survey printing	1,250	1,250	1,250	1,250	1,250	1,250
Supervision	139,728	139,728	139,728	139,728	139,728	139,728	Supervision	139,728	139,728	139,728	139,728	139,728	139,728
CHW salary	1,263,000	1,263,000	1,263,000	1,263,000	1,263,000	1,263,000	CHW salary	1,263,000	1,263,000	1,263,000	1,263,000	1,263,000	1,263,000
Training	8,250	8,250	8,250	8,250	8,250	8,250	Training	160,175	160,175	160,175	160,175	160,175	160,175
Data processing	135949	135,949	135,949	135,949	135,949	135,949	Data processing	76,841	76,841	76,841	76,841	76,841	76,841
							Partnership building	13,068	0	0	0	0	0
n/a	n/a	n/a	n/a	n/a	n/a	n/a	System optimization	59,300	0	0	0	0	0
							Phone procurement	118,073	0	0	0	0	0
							SMS	0	338	338	338	338	338
							Server maintenance	0	34253	34253	34253	34253	34253
Total costs	1,572,927	1,572,927	1,572,927	1,572,927	1,572,927	1,572,927	Total costs	1,831,435	1,675,585	1,675,585	1,675,585	1,675,585	1,675,585
Budget impact								258,508	102,658	102,658	102,658	102,658	102,658

Table 7.5 Results of effect on key cost determinants brought about by variation of parameters used in the analysis

	2015	2016	2017	2018	2019	2020	Total
Budget impact (reference case, Gaibandha district)	258,508	102,658	102,658	102,658	102,658	102,658	771,798
If cost of training increases by 20%	290,543	127,560	127,560	127,560	127,560	127,560	928,340
If cost of training decreases by 20%	226,473	63,490	63,490	63,490	63,490	63,490	543,920
If phone break rate increases by 15%	265,435	102,658	102,658	102,658	102,658	102,658	778,723
If phone break rate decreases by 15%	240,435	102,658	102,658	102,658	102,658	102,658	753,723
If server maintenance cost increases by 10%	258,508	114,515	114,515	114,515	114,515	114,515	831,080
If server maintenance cost decreases by 10%	258,508	94,753	94,753	94,753	94,753	94,753	732,270
If SMS unit cost increases by 20%	258,508	102,752	102,752	102,752	102,752	102,752	772,265
If SMS unit cost decreases by 20%	258,508	102,560	102,560	102,560	102,560	102,560	771,305
If mCARE is incrementally scaling up to another district each year	258,508	293,099	569,883	828,885	964,520	1,027,075	3,941,969
If mCARE is implementing in the entire country (64 district)	16,544,480	6,113,574	6,113,574	6,113,574	6,113,574	6,113,574	47,112,352

Chapter 8. Policy implications

8.1 Summary of findings

This dissertation conducted an economic evaluation of the mCARE program to demonstrate its cost effectiveness, to forecast the program's resource requirements and health outcomes under various scaled-up scenarios, and to assess financial impact and the program's major cost drivers. This chapter summarizes the main findings, the policy and programmatic implications of this research, as well as strengths and limitations and directions for further research.

Paper 1: Results of this study indicate that adding SMS and home visit reminders is highly cost-effective, based on the established mCARE pregnancy surveillance system, given the program perspective in rural Bangladesh. The incremental cost-effectiveness ratio estimates $12 per newborn death averted and $0.41 per DALY averted. The program was conducted in three phases: program development (22 months), start-up (4 months) and implementation (21 months) from 2011 to 2015. Calculations of the annual cost for implementation including development and start-up turned out to be $243,662–$247,903 for the comprehensive mCARE arm and $243,186–$247,427 for basic mCARE arm. One-way sensitivity analysis revealed that the major program cost drivers are supervision and pregnancy surveillance. SMS and home visits reminders have a marginal impact on the total program costs. Since mCARE strategies are reminders to seek care and not provision of care, the health impact can be influenced by access to and quality of the local health facilities and the pregnant women's care-seeking habits. This study suggests that incorporating mCARE strategies to proven community-based interventions may enhance cost-effectiveness of the program and health outcomes in low-resource settings.

Paper 2: The results of the study, which takes a societal perspective, confirm that the mCARE program (pregnancy surveillance and care-seeking reminders) is cost-effective compared to paper-based systems. The $47 per DALY averted fell well below Bangladesh's per capita gross national income ($1,080). If the mCARE program were incrementally scaled up from one district up to the total eight districts in the Rangpur division by government community health workers (CHWs) from 2016-2025, the total program costs would be an estimated $37 million; provider costs would be $9.4 million; and user costs are estimated at $12 million – more cost effective than scaling up a paper-based system: $24 million, $6.7 million, user costs, $7.7 million, respectively. The projected total number of lives saved (including maternal, newborn, and stillbirths) from 2016 to 2025 would be 12,203–29,964 lives in the mCARE intervention group, and 913–1,890 in the paper group. One-way sensitivity analysis revealed that census enumeration and pregnancy surveillance are the major cost drivers of scaling up. These costs are high in the first year due to the operational transition from the paper system to the mCARE system.

Paper 3: Based on the favorable cost effectiveness profile from the previous studies, the study assessed affordability of implementing the mCARE program over the 6-year time horizon (2015-2020) in the entire Gaibandha district (approximately 2.4 million population) by using a cost effectiveness affordability curve and financial budget impact estimation from perspective of the government as a budget holder. The cost effectiveness affordability curve shows that the mCARE intervention would have at least 93% probability of cost effectiveness at a threshold ($3,140, three times the Bangladesh GNI per capita), under the budget constraints of $2.5 million. For the budget impact analysis, we adjusted our activity-based costing into financial costing from a budget expenditure perspective. Following the standardized guideline (ISPOR), the annual program budget impact is an additional $258,508 in the first year (2015) and $102,658 in subsequent years (2016-2020) without adjusting for inflation in the mCARE 1 group compared to the paper group in Gaibandha district. The financial impact estimated over 2015-2020 ($47 million) of the comprehensive mCARE program scenario makes up 0.9% of total annual health expenditure ($5.4 billion) and 2.5% of the public health expenditure ($1.9 billion), which is favorable to the current financial arrangement in the country.

8.2 Implications for policy and programs

This study comes at an important point in time when global health agencies and national governments are beginning to establish country-level health information systems such as District Health Information Systems (DHIS2) and Open Medical Record Systems (OpenMRS). These types of systems enable robust recordkeeping of national-level aggregate data as well as facility-level medical records via low-cost, open-source platforms.

This section presents the implications for policy and programs through the following questions: How can mCARE change public health service delivery processes in Bangladesh? What are potential unintended consequences of the transition from a paper to the mobile phone based system? What are ethical and equity considerations? How can mHealth be a platform for strengthening health systems in low-resource settings?

How can mCARE change health service delivery processes?

One way that mCARE can change health service delivery is through systematic pregnancy surveillance, which can help identify the appropriate denominators that will enable the calculation of population-based morbidity and mortality rates using routinely available information. Pregnancy surveillance can also reduce gaps and instances of 'double counting' since each pregnant woman and infant would be individually identified and entered into a shared electronic register. The traditional paper-based system takes manual summations and compiling of daily records to derive monthly data from paper registers at different administrative levels and various health service provision points. Without mechanisms to systematically verify these data, there is a greater risk of error involved in capturing information. The paper-based system records patient information and service items being provided, but it is almost impossible to track previous patient records. The data are rarely used for performance monitoring and resource allocation. On the other hand, if individual records are linked to the health information system (e.g. DHIS2) at community clinics across the country, it is possible to track an individual's health status over time or know when a patient is overdue for a check-up. If an mCARE system is established at scale, the amount of costs and time spent on reporting data may decrease significantly, allowing providers to better serve patients. In terms of health planning and policy, the mCARE program can facilitate automatic generation of many disaggregated reports and actionable public health measures to help mitigate risk and protect the poor. Moreover, a mobile system would allow for real-time monitoring and evaluation, which can strengthen decentralized decision-making processes and enable resource allocation based on performance and needs.

What are possible unintended consequences of the change?

A change from the current paper system to the mCARE system would require a substantial period of time to fully transition. Unintended consequences may occur. For example, during the transition process, family welfare assistants may be faced with a double burden of data collection activities handling both paper documents and a mobile phone. The change will also require time and intensive training and supervision until system operation and staff performances are stabilized. Considering that family welfare assistants will undertake census enumeration and pregnancy surveillance (who conduct routine household visits), the transition may reduce their dedication to other important responsibilities such as their roles in family planning, health promotion or referrals of emergency cases in the community. Given the intensive workload it demands, (although the initiative may be positively received by the data collectors and possibly even result in increased motivation and respect in the community), the program may be expected to increase workers' salaries or provide additional incentives to retain staff as well as supervisors.

In addition, it would be important to ensure the access, availability, and quality within the health system in advance of promoting care-seeking to the pregnant women. In the case that the mCARE SMS and home visit reminders promote care-seeking but there is no available staff or medical supplies in the facilities, negative consequences may result, such as waste of user time and costs, complaints or reduced trust toward the health system. Moreover, increased demand to seek care at public facilities – where there are often shortages of supplies and are often congested with people – may result in longer waiting times for patients who need urgent care. Consequently, poor women or families may be more likely to end up receiving care from informal or unqualified health providers. In regards to service provision and referrals, it would be important to collaborate with nongovernmental organizations (NGOs) or private facilities in the community to ensure adequately responsive services.

What are the ethical and equity considerations?

In designing and implementing the mobile program in Bangladesh, it is important to consider equity during the transition process in regards to the social and cultural implications of program consequences. Increasing service demand along with the currently high level of out-of-pocket spending in the country may result in a regressive financial impact on poor households. As a result of care seeking promotion, rich women may increasingly utilize private service, while among the poor, use of informal providers may increase. Without adequate investment in public health service provision, this may increase stock-outs of medical supplies and exacerbate the equity gap of service quality in the community.

A second consideration is that during pregnancy surveillance, certain households (e.g. those in hard-to-reach areas or households with members who internally migrate into cities to earn money) may be missed and therefore excluded from receiving system-related benefits and become even more marginalized from the formal health system. Third, in the process of monitoring the performance of CHWs using a mobile phone, the program may likely incentivize workers who are younger, of a higher socioeconomic status and more adept at using new technologies. Judicious management and staff recruitment practices may minimize unnecessary competition or discomfort among younger and older staff, the latter group who likely receive the respect of their community based on their longstanding experiences and knowledge gained from participation in the existing paper-based program. Once fully established, mHealth may promote equitable access to marginalized populations due to the powerful connectivity introduced by information and communication technologies; but in the process of deployment, this may exacerbate a preexisting gap, thereby preventing the poor and marginalized population from gaining the full benefits of an accessible healthcare system. Given this potential concern, one notable component designed into the mCARE program is the personally scheduled home visit reminders delivered by CHWs, which addresses the issue of equity and inclusion of poor households without mobile phones or with low literacy.

In addition to equity, ethical aspects of the program transition should be considered.[331] A first consideration to note is the privacy, security, and safety of individual records. Personal and identifiable information is recorded by portable devices like mobile phones, which are not centrally controlled. While paper-based information can be stored in a secured location that is physically inaccessible and discarded years later, data recorded on a mobile device are not as protected from confidentiality risks. In terms of ethics, ownership issues related to the collected personal health data among various stakeholders (e.g. software and data storage companies, hospital and healthcare providers, patients) can compromise patient autonomy if their health data are shared or linked without their consent. There is also the risk that the information may be used for commercial purposes without permission. Lack of confidence in the system's ability to securely manage private health data may negatively affect program participation or cause patients to conceal sensitive personal information.[332]

A second ethical issue to consider is proper verification and security protection mechanisms to avoid potential misuse of the program and system. For example, the program needs to consider how to provide special financial support or priority of care for poor and at-risk populations given the possibility that women in the community who are not poor or at-risk may purposely report false health conditions or economic status to receive benefits or priority care. Moreover, as CHWs become increasingly familiar with the system, including the algorithms that optimize workflow and reward CHWs based on their performance monitoring score, CHWs may be tempted to manipulate their score or passively follow the system instructions instead of responding to the real needs of the community. To prevent these issues from occurring, verification mechanisms would be required in the operational plan and management. Another challenge related to ethics is ensuring validity and trust toward the system algorithm (e.g. criteria for risk stratification and prioritization). Overall, it would be important to design the system and program to best use the local knowledge and optimize human interaction for better timing, access, and quality, instead of replacing these factors with technology. Without proper verification and security protection mechanisms in place, technical or system errors that arise may be exposed to malicious attack by hackers and can jeopardize community health through incorrect prescriptions and referrals or misuse of critical individual health data.

How can mHealth be a platform for strengthening health systems in low-resource settings?

mHealth can serve as a platform for people-centered health systems strengthening in various ways. First, health information systems (HIS) can improve the accuracy of data and efficiency of data processing and reporting that can promote transparency and accountability of governance and encourage evidence-based planning, budgeting, supervision and monitoring of health-related policy and programs. Using mobile technology can also improve district health managers' capacity and promote decentralized decision-making based on the needs and demands of the district. Second, HIS research can increase capacity in the collection, analysis and use of data with innovative technologies and tools available at a global level. mHealth can offer new insights to understand human behavior, disease transmission patterns, and effective health service delivery strategies. Third, through improved information and governance, HIS can strengthen national and sub-national procurement and supply and distribution systems of medicine and technology. In terms of human resources, HIS can boost workforce productivity and capacity by promoting e-learning, tele-health, tools for guideline adherence, and communication among workers. In regards to financing, HIS can help establish social health insurance as a social protection mechanism and plan for financing universal health coverage.[50] This is an important benefit of HIS because every element of a health insurance system – from documentation of services, to claims processing, to the identification of beneficiaries and their entitlements – depends on accurate information. Finally, mHealth can strengthen the community's service delivery platform for demand generation, social accountability, social inclusion and reduction of financial barriers.[50] A well connected and functioning mHealth network from community to primary and secondary level clinics can build resilient health systems, particularly in emergency prevention, preparedness and response. Moreover, through multi-sectoral partnerships, mHealth can add even more value through services offered beyond the health sector to create business models or opportunities for social entrepreneurship.

8.3 Recommendations for policy and programs

Promote cost containment strategies. Under the financial constraints in LMICs, cost containment is important to ensure that resources are available to spend on the necessary workforce, medical supplies, equipment and invest in innovation and infrastructure**.** First of all, given that the major cost drivers are staff activities such as training, census enumeration, pregnancy surveillance, and supervision, we suggest developing coordinated plans and strategies to improve workforce productivity and efficiency on these particular activities, especially during the initial years of implementation. Once the system foundation and operational transition are stabilized, we suggest considering the technical components such as reducing phone breakage and loss rate or SMS unit costs and optimizing server capacity or data processing and reporting system to reduce maintenance costs.

Promote mHealth as a platform of community health service delivery. The main cost drivers of the mCARE program are supervision and pregnancy surveillance. We suggest that program implementers consider strategies to improve work efficiency and cost sharing. Given the common operational characteristics and high-level coordination that census enumeration and pregnancy surveillance require, we suggest cooperating with other public agencies like CRVS initiatives or the Census Bureau, to obtain support for sharing activity costs. This may allow the Ministry of Health to save budgets and invest more on other lifesaving public health priorities. Moreover, using mHealth for census enumeration and routine household visits can serve as a platform for not only health service delivery (e.g. medicine selling, risk identification and referral, community health promotion or campaigns), but also for broader social welfare by facilitating public service delivery such as education, financial services, and even ensuring the right to vote.

Develop an mHealth early risk identification and prioritization system, which can be beneficial for large-scale implementation in a limited-resource setting**.** While system optimization is a one-time cost, developing a system algorithm would be the key to determining overall operational efficiency and workflow process of personalized and scheduled reminders, routine household visits, and automated data reporting and management. Based on personal health data, the system algorithm can also be used for screening risks based on proven and well-known maternal risk factors for mothers under the age of 16 years; multiple pregnancies and malpresentation; and previous or current pregnancy complications. A risk scoring system based on computerized risk screening or a stratification algorithm could triage pregnant women to appropriate risk groups. Enhanced prevention and protection interventions can be introduced with such a risk identification and prioritization system and with coordinated CHWs' referral practices.

Provide demand-side financing for the poor. We suggest that the mHealth program includes a demand-side financing scheme, especially for the poor, to reduce potentially catastrophic health expenditures that can result from receiving care. Incentives (e.g. conditional cash transfers, voucher system) for facility delivery can help reduce potential financial constraints for users and allow for greater health impact.[258] With careful identification and verification measures, information collected through mCARE pregnancy surveillance can be better utilized to identify poor or vulnerable households and to strategically target such incentives or provide more attention to these vulnerable groups by the timing of delivery. By leveraging the IT system and individual health information, mHealth could further improve not only health outcomes for the poor but also access to care through better prevention and strategies targeted toward reaching the most vulnerable populations.

Strengthen health systems preparedness. Our study finding suggests that in order to achieve improved health outcomes, mCARE may create opportunities to focus on health systems readiness; however, this does not happen automatically. Perhaps most important to consider is that scaling up the mCARE program must be accompanied (or even preceded by) a scale-up of in-country capacities and systems so that health facilities are prepared to respond to sustained demand for health services that are available, accessible and of good quality. In this study, while we considered the government a main formal stakeholder in the health system with the roles of program implementer and service provider, in reality, services are offered through many other stakeholders like nongovernmental organizations (NGOs), the private sector companies, as well as informal sector providers. Strategies for scaling up an mHealth program may need to consider this multi-actor involvement based on care-seeking characteristics and available service provisions in the given health system. Building the capacities of varied service providers, in consonance with efforts to strengthen health systems and workforce capacity will ensure that countries are ready to take proven interventions to full scale effectively and efficiently.

Collaborate with NGOs and private sector. NGOs provide some health services, especially at the grassroots level. They provide mainly primary and preventive care services and limited hospital services. To some extent, these services complement public health services. NGOs (especially BRAC) conduct their own pregnancy identification activities separately from a government program. This is partially due to the insufficient human workforce capacity in government to cover the population needs. However, with the implementation of mHealth over time, the government may prioritize a focus on the pregnancy surveillance systematically, and implementation activities can be shared with other providers. In Bangladesh, NGOs have taken the lead in health care innovation, often in partnership with the government. Collaboration with NGOs could help the government better allocate resources to ensure quality service provision and promote innovative approaches using mHealth strategies. Complicated obstetrics care is usually performed by private sector providers, so in order to establish effective referral services, there is a need for the government to cooperate with the private sector.

Link the scale up practice and M&E practice. mHealth CHW programs grow and evolve in phases of continuous learning, improvement, and expansion of coverage. Monitoring and evaluation (M&E) strategies should take these evolutions into account. First, a scaling up strategy should include considerations for how to advocate for the innovation and plan for how to implement the innovation at multiple levels (policy, program, and service delivery), the organizational processes related to implementation and the costs and resources needed.[333] The linking of the scale-up and M&E process includes both the expansion of services (horizontal scale-up) as well as the integration of the innovation into the country's monitoring systems to achieve sustainability (vertical scale-up). Accordingly, developing and implementing a robust, comprehensive M&E plan will help practitioners operationalize their scale-up strategy. An M&E plan will allow for well-defined benchmarks and tracking of progress towards established goals.[333]

8.4 Strengths and limitations

Strengths of this study. This research shows that the mCARE program and strategies will be economically advantageous compared to the paper-based system in terms of both cost-effectiveness and long-term cost saving. The result of study aim 1 demonstrated the cost effectiveness of a particular mHealth strategy on care seeking reminders based on an empirical pilot project implemented from 2011-2015 by the JiVitA research team in rural Bangladesh. The study conducted detailed activity-based costing, demonstrating time and resource requirements of the entire program life cycle including partnership building, planning, and development of the mHealth operational system, testing of the mHealth platform, training staff, start-up preparations and implementation. Although the product of the open source platform can be a global public good, the analytic process and findings can be valuable lessons for other countries who are planning to develop or customize an mHealth platform for other disease priorities or health interventions.

The result of aim 2 demonstrated the cost effectiveness of mCARE program including pregnancy surveillance and care seeking reminders, compared to the current paper-based system at scaled-up scenarios by government CHWs. We used Excel spreadsheet-based modeling to forecast costs and the used the Lives Saved Tool (LiST) modeling to estimate the number of deaths averted based on incremental service coverage change over 2016-2025. For the model-based analyses, we synthesized evidence from a wide variety of sources and published literature related to mHealth and Bangladesh health systems. To estimate societal costs, including provider and user costs, we also conducted a field study to collect service costs and content data through in-depth interviews, observations, and exit interviews with local stakeholders, service providers and 100 pregnant women at various service provision agencies in Gaibandha district.

The study aim 3 calculated total program costs of implementing the mCARE program in Gaibandha district and nationwide from 2015-2020. We conducted one-way deterministic sensitivity analyses on factors associated with high uncertainty such as CHW productivity and technological components. Based on the cost function of increasing CHW productivity (i.e. number of household visits per day by CHW), and incremental geographical expansion over time (i.e. program expansion to one additional district per year), we also demonstrated the quantitative measure of cost saving and economies of scale through the decreasing unit cost of registering MWRAs from 2015-2020. Finally, we discussed program affordability with respect to national health expenditure and suggested demand-side financing based on program implications to the health systems.

Many economic evaluation studies are conducted based on assumptions regarding target populations, unit cost from published literature and politically expedient coverage targets. The aim of this thesis was to improve on this situation, by using the following approaches: the study conducted detailed ingredient-based costing throughout the entire program development and implementation spectrum. The study projected the number of pregnant women based on local demographic and epidemiologic information for the time period to be examined. The study also used the Lives Saved Tool to project the number of deaths averted based on the empirical evidence of service coverage uptake and service contents and practice in the given setting. The thesis describes the methods used in generating the inputs for the model, including activity-based program costs, provider and user costs from various service provision settings in Gaibandha district, population coverage, and service coverage increase rates, the number of deaths averted for each scenario, as well as key determinants of program cost drivers and uncertainty that were used in the model.

While economic evaluation may assist the prioritization of interventions, it is not sufficient to predict whether an intervention is affordable with given resources. Based on the favorable cost effectiveness profiles reported in the mCARE pilot (aim 1) and a scaled-up model of the mCARE program (aim 2), we extended our analyses to assess affordability and budget impact, considering budget constraints to guide real-world decisions. First, the study showed how cost-effectiveness affordability curves could enhance the information provided by traditional analyses of cost-effectiveness. Cost-effectiveness affordability curves distinguish the joint distributions of costs and effects that share the same correlations between these two dimensions but differ in scale.[306, 308] This is especially useful for a case that has a high incremental health impact at a low net cost. For example, our study showed that the addition of SMS reminder is low cost yet can substantially improve pregnant women's care seeking practices. In this case, the consideration of budget constraints in addition to cost-effectiveness thresholds can provide new information to guide better investment decision-making.

Second, our results from BIA provides guidance relevant to actual budget planning and policy making. For the program, such as mCARE, which involves multiple stakeholders and a complex operational transition, the ingredient-based activity costing estimates and estimates based on a particular payer's financial expenditures can be substantially different. As the strategy of the successful mCARE program is to be integrated with the government health systems for scalability and sustainability, the result of BIA provides useful information to project the amount of funding required for the program and for the consequences of potential variation of cost inputs and scale-up scenarios. Based on the BIA results, we calculated true annual program costs at scale and 'unit costs' per beneficiaries, which are compared to the annual total health expenditure and government health expenditure per capita to discuss the affordability in the country.

Our evaluation followed the established guideline (MAPS, CHEERS, and ISPOR) in designing the analytical framework and reporting the findings. We believe our results are a unique and significant contribution to the field, as we addressed the unique characteristics and challenges of evaluating the mHealth program in a systematic and transparent way to the established cost-effectiveness evaluation methods and practices. We hope our models can facilitate policy development [32] as well as implementation, by providing the architecture for organizing evidence for a specific policy initiative, and helping generate policy questions.[33] With these results and recommendations, mHealth could be better utilized as a strategy to deliver proven interventions in a cost-effective manner.

Limitations of the study. The results presented in this study should be interpreted considering the limitations of the approach and data used. First, the mCARE I program is a small scale pilot study with 70 CHWs involved. Given the early stage of mHealth in this field, lack of data and experience made it challenging to determine model parameters and assumptions, which resulted in considerable structural and parameter uncertainties. The study is not a randomized controlled trial so there may be confounding factors that have an influence when assessing coverage impact between the two groups. Also, given the nature of the mHealth program, which may be influenced by variables like mobile ownership, literacy, or care-seeking characteristics, heterogeneity would be another important factor to consider when evaluating coverage and health impact.

In regards to the field data collection for service content and costs, our sampling of the facilities and pregnant women were purposive based on their availability on any date that the facility managers agreed to welcome visits from September to December 2016. As our observations and exit interviews were conducted at the point of ANC service provision, the ANC service content and cost data presented a high level of completeness and accuracy, while delivery and PNC service content and cost data had many missing values and recall biases. Since our data collection was conducted in Gaibandha district, the results might not necessarily reflect service practice and costs in other districts or urban settings. Measuring accurate marginal costs of service provision in a rural community was a challenging task due to the unpredictable availability of drugs and staff. Considering supply shortage, our provider and user costs might be overestimated. Measuring wage loss for user indirect costs was also a challenge given the high level of informal workers with a high variation of and unsystematic information about their income. Measuring service time for delivery and PNC was also challenging especially when mothers were hospitalized for child delivery. Identifying specific service costs from a pregnant woman during her delivery was also difficult because in most cases, her husband or another senior member of the household made the payment. As the bills were often issued based on all services used, it was also difficult to expect mothers to know and remember the specific service costs. To avoid bias from extreme values in our survey data, we used an interquartile range of 25% and 75% of the dataset excluding missing values.

There are also some limitations to our modeling analysis. First, given the early stage of mHealth programs with no historic reference or records, there are limited data for many of the parameters, and much of the parameter uncertainty cannot be meaningfully quantified. Moreover, much of the uncertainty is structural and not easily parameterized. The parameter uncertainty is drawn from various complex factors that can influence population and service coverage rates, CHW productivity in pregnancy surveillance practice, cost inputs of technological components, and factors associated with care seeking practices. These factors include staff motivation, capacity, population socioeconomic status, literacy level, mobile phone ownership, network and electricity connectivity, other new interventions in the community such as family planning, conditional cash transfer, or health facility upgrades, as well as the country's macroeconomic stability.

The structural uncertainty includes activities and resources required for operational transitioning and scaling up. Our model did not consider activities or resources required for system or data integration across different health facilities (vertical scale-up), although it would be a key cost driver. Our model also did not consider any potential partnership, business models or other financing mechanisms that can lead to cost saving or cost sharing, although these are typically desirable features during scale-up.

Second, while the LiST model allowed systematic comparisons of health outcomes based on service coverage impact across the scenario, we assumed a linear service coverage uptake and efficacy of sub-components of service contents embedded in the tool. Given the characteristics of the mCARE intervention as care seeking reminders, health impact can be highly dependent upon the given health systems condition (access to and quality of services) and mothers' care seeking characteristics (e.g. the rich versus the poor).

Third, in calculating provider and user costs based on the projective number of pregnant women seeking care in our model, we assumed that there are sufficient resources at the point of care seeking at the health facilities so that women's care seeking decisions can be directly related to receiving appropriate care. However, in reality, it is commonly seen in rural Bangladesh that drugs are stocked out, and there is a shortage or absence of health providers at facilities. Also there are many informal health providers in rural villages, from whom the poor women often receive care. If these factors were to be considered, provider and user costs as well as health impact may be lower than our estimates.

Fourth, our scenarios to assess cost effectiveness and affordability assessments only considered the comprehensive mCARE program, basic mCARE program and status quo scenarios. We cannot draw conclusions from outside these scenarios, as we did not consider other competing interventions in the analyses for the real-world decision making. The usefulness of a theoretical method such as cost-effectiveness affordability curves is more useful when a resource allocation problem needs to be addressed generally at a single new program's fixed budget.[307] If there is to be a separate budget to support mCARE, the result may be useful and further considerations can be added to determine the best technology mix portfolio (frequency of SMS or home visit reminders, eligible target population for pregnancy surveillance, etc.) to enhance the decision-making under the given budget constraints, as discussed by Sendi and Gafni[334] through a 'decision making plane'. If this is not the case, a more comprehensive approach including other competing program would be required to assess the cost effectiveness and affordability under a shared budget. Future research could consider all relevant programs under a shared budget and incorporate complicated constraints to enhance resource allocation problems in the given setting.

Nevertheless, given that such research would require an enormous amount of effort in a practical setting, and that our model took a reasonably conservative approach and assumptions necessary for the existing budget constraints. Based on the favorable cost-effectiveness profiles, our approach including affordability and budget impact analyses can provide valuable information to decision-makers in low-income countries in the context of increasing potential and use of digital healthcare solutions within severe budget constraints.

8.5 Future research directions

Our study suggests a further need for operational research and considerations of equity that can help policymakers and program managers to scale up delivery of effective interventions through mHealth strategies. A recent STEPS Centre publication described that the introduction and process in the spread of technological innovation could be characterized as "the *direction* of development and the way organizations incorporate the new technology into their operations; the *distribution* of benefits from the technology and the *diversity* of ways the technology is applied."[335] Although the mCARE program is a promising strategy for expanding access for women to service coverage, important questions remain about how these programs can be successfully implemented and scaled up as well as how the benefits can be distributed equally in society. Continued research on mHealth can provide new research insights though enhanced capacity in data collection, access and management for not only biomedical research but also health systems research through capturing data on service processes, human behavior, and location of health service provision – which were previously unobtainable in a systemic way.

First, as presented in our modeling approach in the study, the subject deserve further research attention, particularly addressing what factors contributed to the operational change and CHW productivity and efficiency gains and the scaling-up process. Given that the key cost determinant was CHW productivity during household visits, more in-depth studies such as time and motion studies can be helpful to assess the impact of the mCARE program on CHW workload and to inform future decisions about assigning new responsibilities to CHWs. The impact of mHealth to the determinants of service delivery and referral practice can be also an important research question. Studies that are undertaken prospectively during the initial program rollout and are able to document operational processes would be useful. The model could continuously improve its assumptions and accuracy through iterative processes with applicable lessons.

Second, although our study demonstrated the cost-effectiveness of the mCARE program compared to the control and status quo scenarios, further research is needed to evaluate the cost-effectiveness of the diverse strategies within mHealth (e.g. SMS texting versus a call-center, SMS texting with different frequency, timing, and contents)[237] and of mHealth compared with other community-based demand promotion programs (e.g.

conditional cash transfer). Additional comparative research that tests the cost-effectiveness of different promotional strategies can offer insights about the role of technology and dynamics of specific factors that affect the process of developing delivery strategies. Another important research consideration is understanding the process mechanisms between reminders for care-seeking and what happens between care-seeking and change in coverage.

Lastly, while the benefits of mHealth are widely acknowledged (e.g. improving access and quality in resource-limited settings), it would be important to assess whether and to what extent mHealth ultimately contributes to poverty reduction and economic inequality in society. As discussed in the policy and program implications section, mHealth programs and research have a paradoxical dilemma—especially during the transitional and transformative process. While mHealth is expected to help overcome health systems constraints through improved access and quality, the capacity to realize the potential requires significant pre-existing competences in the health systems such as electricity and wireless broadband network connections, available human resource capacity with training and supervision to data management. Bangladesh still faces significant constraints in terms of infrastructure and human resource development, which are necessary for successful and sustainable mHealth program implementation. Scaling up and M&E practices should consider this aspect carefully to avoid exacerbating the existing disparities in access to information technology between urban and rural residents and the rich and the poor.

8.6 Conclusion

Throughout the past decades, Bangladesh has shown impressive development related to not just what they have achieved – significant improvement on several human development indicators – but also how they have achieved through grassroots community-based efforts.[21] Moving forward from the United Nations Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs), Bangladesh has shown unequivocal lessons in achieving the MDGs and promoting a new vision: Digital Bangladesh 2020 – for the world. Despite many challenges such as political instability, financial constraints, and power shortages, many innovative and ambitious projects are ongoing to achieve a digital Bangladesh.

Developing integrated and well-functioning health information systems on an open source platform (e.g. DHIS, OpenMRS, and OpenSRP) can be a 'global public good' and would potentially benefit many countries and save resources. Furthermore, the scaling up pathways of mHealth programs involves dynamic and transformative processes with integration, replication, and expansion within health systems. Valuable lessons can be learned through experience if financing is available to scale up mHealth systems and when impacts of large-scale programs and the implementation process are rigorously and systematically documented and analyzed.

We know much in terms of which interventions to scale up, yet we know less about how to deliver these interventions at scale, how to build capacity in countries, and how to minimize costs during the implementation and scaling-up process. Our study presented the cost-effectiveness and budget impact of developing, implementing, and scaling up mCARE for CHWs in support of pregnancy surveillance and SMS messages and home visit reminders in rural Bangladesh, a positive step for improving access to health services for a population in need. The value for money would continuously evolve as mHealth becomes a global platform sustained through local knowledge. As such, this study contributes to filling critical needs for economic evaluation and implementation research by providing actionable evidence for improving community-based Open SRP program in Bangladesh and for informing program policy and design in other settings.

BIBLIOGRAPHY

1. International Conference on Primary Health, C., *Declaration of Alma-Ata.* WHO Chron, 1978. 32(11): p. 428-30.
2. Liu, A., et al., *Community Health Workers in Global Health: Scale and Scalability.* Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine, 2011. 78(3): p. 419-435.
3. Tulenko, K., et al., *Community health workers for universal health-care coverage: from fragmentation to synergy.* Bull World Health Organ, 2013. 91(11): p. 847-52.
4. World Health Organization, G.H.W.A., *Pakistan's Lady Health Worker Programme: Global Health Workforce Alliance, World Health Organization, Case study.* 2008.
5. Nejmudin Kedir Bilal, C.H.H., Feng Zhao, Agnes Soucat, and Christophe Lemiere, *Health Extension Workers in Ethiopia: Improved Access and Coverage for the Rural Poor.* The World Bank.
6. Saprii, L., et al., *Community health workers in rural India: analysing the opportunities and challenges Accredited Social Health Activists (ASHAs) face in realising their multiple roles.* Hum Resour Health, 2015. 13: p. 95.
7. Global Health Workforce Alliance, W.H.O., *Global Experience of Community Health Workers for Delivery of Health Related Millennium Development Goals: A Systematic Review, Country Case Studies, and Recommendations for Integration into National Health Systems.* 2010.
8. Lehmann U, S.D., *Community health workers: What do we know about them? The state of the evidence on programmes, activities, costs and impact on health outcomes of using community health workers.* January 2007.
9. USAID. mHealth Compendium. Available: http://www.mhealthworkinggroup.org/resources/mhealth-compendium. (Accessed March 7, 2017)
10. World Health Organization, *mHealth: New horizons for health through mobile technologies.* 2011. Global Observatory for eHealth series - Volume 3.
11. Labrique, A., et al., *H_pe for mHealth: more "y" or "o" on the horizon?* Int J Med Inform, 2013. 82(5): p. 467-9.
12. Agarwal, S., et al., *Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: systematic review.* Tropical Medicine & International Health, 2015. 20(8): p. 1003-1014.
13. Free, C., et al., *The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review.* PLoS Med, 2013. 10(1): p. e1001362.

14. Shuchman, M., *The promise and pitfalls of global mHealth.* CMAJ, 2014. 186(15): p. 1134-5.
15. Mechael, P., et al., *Capitalizing on the characteristics of mHealth to evaluate its impact.* J Health Commun, 2012. 17 Suppl 1: p. 62-6.
16. Islam, A., *Health System in Bangladesh: Challenges and Opportunities.* American Journal of Health Research, 2014. 2(6): p. 366.
17. Ashraf, S., et al., *Overview of a multi-stakeholder dialogue around Shared Services for Health: the Digital Health Opportunity in Bangladesh.* Health Res Policy Syst, 2015. 13: p. 74.
18. Government of the Peoples' Republic of Bangladesh. Finance Division, M.o.F., *Journey Towards A Digital Bangladesh: Update 2013.* 2013: p. 1-73.
19. M. Z. Hossain , "Rural-Urban Migration in Bangladesh: A Micro-Level Study "Shahjalal University of Science & Technology, 2001
20. GSMA intelligence, *Country overview: Bangladesh.* August 2014.
21. Adams, A.M., et al., *Innovation for universal health coverage in Bangladesh: a call to action.* Lancet, 2013. 382(9910): p. 2104-11.
22. El Arifeen, S., et al., *Community-based approaches and partnerships: innovations in health-service delivery in Bangladesh.* The Lancet, 2013. 382(9909): p. 2012-2026.
23. Ministry of Health and Family Welfare, Bangladesh: Health Metrics Network. Health information Systems Assessment: Bangladesh Country Report. July 2009. https://www.k4health.org/sites/default/files/hmn_bgd_assess_final_2009_07_en.pdf (Accessed March 7, 2017)
24. The JiVitA Journal. Mobile Technology for Health in Rural Bangladesh, September 2012. http://www.jhsph.edu/research/centers-and-institutes/center-for-human-nutrition/research/jivita/journal/JivitaJournal08_mHealth_September%202012_compressed.pdf
25. World Health Organization, *Bangladesh: Maternal and Perinatal Health Profile.* http://www.who.int/maternal_child_adolescent/epidemiology/profiles/maternal/bgd.pdf (Accessed March 7, 2017)
26. Julie Evans, I.A.B.P., *Primary Care Systems Profile & Performance : Bangladesh Case Study* The Alliance for Health Policy and Systems Research, World Health Organization., 2016: p. 1-8.
27. World Health Organization, *Bangladesh Health System Review.* 2015: p. 1-214.
28. Economist. The path through the fields. Nov 3 2012. http://www.economist.com/news/briefing/21565617-bangladesh-has-dysfunctional-politics-and-stunted-private-sector-yet-it-has-been-surprisingly (Accessed March 7, 2017)

29. World Health Organization, Bangladesh health system review (Health Systems in Transition, Vol. 5 No. 3 2015)
30. Bairagi R, D.A., *Demographic Transition in Bangladesh: What Happened in the Twentieth Century and What Will Happen Next?* Asia-Pacific Population Journal, December 2001
31. Ahsan Karar, Z., N. Alam, and P. Kim Streatfield, *Epidemiological transition in rural Bangladesh, 1986-2006.* Glob Health Action, 2009. 2.
32. Institute for Health Metrics and Evaluation., *GBD Profile: Bangladesh.* The Global Burden of Disease Study 2010.
33. El Arifeen, S., et al., *Maternal mortality in Bangladesh: a Countdown to 2015 country case study.* Lancet, 2014. 384(9951): p. 1366-74.
34. National Institute of Population Research and Training (NIPORT), Bangladesh Demographic and Health Survey 2014. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT, Mitra and Associates, and ICF International.
35. World Health Organization, Maternal Mortality. Fact Sheet, Updated November 2016 http://www.who.int/mediacentre/factsheets/fs348/en/ (Accessed March 7, 2017)
36. Dobson, R., et al., *Diabetes Text-Message Self-Management Support Program (SMS4BG): A Pilot Study.* JMIR Mhealth Uhealth, 2015. 3(1): p. e32.
37. Hashima-e-Nasreen et al, "Maternal, Neonatal and Child Health Programmes in Bangladesh" Brac Research, July 2007. http://www.bracresearch.org/monographs/Monograph_32.pdf (Accessed March 7, 2017)
38. Hamine, S., et al., *Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review.* J Med Internet Res, 2015. 17(2): p. e52.
39. Rahman, M.H., et al., *What do they do? Interactions between village doctors and medical representatives in Chakaria, Bangladesh.* Int Health, 2015. 7(4): p. 266-71.
40. de Bernis, L., et al., *Skilled attendants for pregnancy, childbirth and postnatal care.* Br Med Bull, 2003. 67: p. 39-57.
41. Sarker, B.K., et al., *Reasons for Preference of Home Delivery with Traditional Birth Attendants (TBAs) in Rural Bangladesh: A Qualitative Exploration.* PLoS One, 2016. 11(1): p. e0146161.
42. Vaughan, J., E. Karim, and K. Buse, *Health care systems in transition III. Bangladesh, Part I. An overview of the health care system in Bangladesh.* Journal of Public Health, 2000. 22(1): p. 5-9.
43. Ahmed, S.M., M.A. Hossain, and M.R. Chowdhury, *Informal sector providers in Bangladesh: how equipped are they to provide rational health care?* Health Policy Plan, 2009. 24(6): p. 467-78.

44. Banagldesh Ministry of Health and Family Welfare: Human Resource Management Unit, *Human Resources for Health: Country Profile.* August 2013.
45. Koehlmoos, TP, Islam, Z, Anwar, S et al. Health transcends poverty: the Bangladesh experience. in: D Balabanova, M McKee, A Mills (Eds.) 'Good health at low cost' 25 years on: what makes a successful health systems. London School of Hygiene and Tropical Medicine, London; 2011: 47–81
46. Khanna, A., et al., *Financing Reproductive Health in Bangladesh.* Journal of Health Management, 2013. 15(2): p. 177-201.
47. Hasanuzzaman Zaman and Rokonuzzaman. Achieving Digital Bangladesh by 2021 and Beyond. Background paper for the 7th Five Year Plan (7FYP)
48. GSMA Intelligence. Country Overview: Bangladesh. August 2014. https://www.gsmaintelligence.com/research/?file=140820-bangladesh.pdf&download (Accessed March 7, 2017)
49. Ahmed, T., et al., *eHealth and mHealth initiatives in Bangladesh: a scoping study.* BMC Health Serv Res, 2014. 14: p. 260.
50. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), *A Quiet Revolution. Strengthening the Routine Health Information System in Bangladesh.* 2014: p. 1-44.
51. World Health Organization. Move it: Report on Monitoring of Vital Events using Information Technology. http://www.who.int/healthinfo/civil_registration/crvs_report_it_2013.pdf (Accessed March 7, 2017)
52. *Government of the People's Republic of Bangladesh. Directorate General of Health Services. Ministry of Health and Family Welfare.*
53. *Care2x: The Open Source Hospital Information System. http://www.care2x.org/.*
54. Munshi AH et al. Health Information System Assessment: Bangladesh Country Report. Dhaka: Health Metrics Network Secretariat, Ministry of Health and Family Welfare.2009
55. Kabir, M.H., *Strengthening the Routine Health Information System of the Ministry of Health and Family Welfare in Bangladesh.* 2015: p. 1-36.
56. Rahman, M.M., et al., *Health-related financial catastrophe, inequality and chronic illness in Bangladesh.* PLoS One, 2013. 8(2): p. e56873.
57. El Arifeen DrPH, S., et al., *Community-based approaches and partnerships: innovations in health-service delivery in Bangladesh.* The Lancet, 2013. 382(9909): p. 2012-2026.
58. Ahmed, S.M., et al., *The health workforce crisis in Bangladesh: shortage, inappropriate skill-mix and inequitable distribution.* Hum Resour Health, 2011. 9: p. 3.
59. Noordam, A.C., et al., *Improvement of maternal health services through the use of mobile phones.* Trop Med Int Health, 2011. 16(5): p. 622-6.

60. Kassebaum et al. Lancet. 2014. Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013
61. United Nations. (2011) The Millennium Development Goals Report. Available: http://www.un.org/millenniumgoals/11_MDG%20Report_EN.pdf. (Accessed March 7, 2017)
62. Baqui, A.H., et al., *Effect of timing of first postnatal care home visit on neonatal mortality in Bangladesh: a observational cohort study.* BMJ (Clinical research ed.), 2009. 339.
63. USAID. mHealth Compendium. Available: http://www.mhealthworkinggroup.org/resources/mhealth-compendium. (Accessed March 7, 2017)
64. International Telecommunication Union (ITU) Key statistical highlights: ITU data release June 2012. https://www.itu.int/ITU-D/ict/statistics/material/pdf/2011%20Statistical%20highlights_June_2012.pdf (Accessed March 7, 2017)
65. Peters, D.H., et al., *Poverty and access to health care in developing countries.* Ann N Y Acad Sci, 2008. 1136: p. 161-71.
66. Fiordelli, M., N. Diviani, and P.J. Schulz, *Mapping mHealth research: a decade of evolution.* J Med Internet Res, 2013. 15(5): p. e95.
67. Labrique, A.B., et al., *mHealth innovations as health system strengthening tools: 12 common applications and a visual framework.* Global Health: Science and Practice, 2013. 1(2): p. 160-171.
68. Jo, Y., et al., *Using the lives saved tool (LiST) to model mHealth impact on neonatal survival in resource-limited settings.* PLoS One, 2014. 9(7): p. e102224.
69. Hsieh, S.H., et al., *Newborn screening healthcare information system based on service-oriented architecture.* Journal of Medical Systems, 2010. 34(4): p. 519-530.
70. UNICEF. Uganda: Innovations. Available: http://www.unicef.org/uganda/9903.html. (Accessed March 7, 2017)
71. RapidSMS. Available: http://www.rapidsms.org. (Accessed March 7, 2017)
72. Li, M., et al., T*ext message to promote breastfeeding and obesity-protective eating behaviours in young children: Feasibility and acceptability.* Obesity Research and Clinical Practice, 2012. 6: p. 55.
73. Mobile Alliance for Maternal Action (MAMA). *What is MAMA?* Available: http://www.healthunbound.org/mama/what-is-mama. (Accessed March 7, 2017)
74. Lund S, N.B., Hemed M, Boas IM, Said A. , M*obile phones improve antenatal care attendance in Zanzibar: A cluster randomized controlled trial.* BMC Pregnancy and Childbirth, 2014. 14(29):29.

75. Al-Abdullah, T., et al., *The appropriateness of referrals to a pediatric emergency department via a telephone health line.* Canadian Journal of Emergency Medicine, 2009. 11(2): p. 139-148.
76. Fairbrother, G. and L.A. Simpson, *It is time! Accelerating the use of child health information systems to improve child health.* Pediatrics, 2009. 123(SUPPL. 2): p. S61-S63.
77. DeRenzi, B., et al. A *framework for case-based community health information systems.* 2011.
78. m*Health Alliance. Mobile Alliance for Maternal Action (MAMA): Global Monitoring and Evaluation Framework.* 2012.
79. Ngabo, F., et al., D*esigning and implementing an innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda.* Pan African Medical Journal, 2012. 13.
80. Grameen Foundation. *Mobile Technology for Community Health in Ghana (MOTECH). What it is and what grameen foundation has learned so far.* Available: http://www.cs.washington.edu/education/courses/cse490d/12sp/docs/MOTECH.pdf. (Accessed March 7, 2017)
81. Healthcare Innovation Technology, Evaluating MOTECH: Researching the impact of mHealth on patient outcomes, behavior and attitudes toward health services. 2013. Available: http://www.hitlab.org/healthy-innovations/2013/9/25/evaluating-motech-researching-the-impact-of-mhealth-on-patient-outcomes-behavior-and-attitudes-toward-health-services. (A pilot report is available: http://ghsmotech.files.wordpress.com/2011/06/motech-end-of-pilot-durbar-report.pdf). (Accessed March 7, 2017)
82. Curioso WH, K.B., Campos PE, Buendia C, Holmes KK, Kimball AM. , D*esign and implementation of Cell-PREVEN: a real-time surveillance system for adverse events using cell phones in Peru. .* American Medical Informatics Association, 2005.
83. Mitchell et al. "Using electronic technology to improve clinical care – results from a before-after cluster trial to evaluate assessment and classification of sick children according to Integrated Management of Childhood Illness (IMCI) protocol in Tanzania" BMC Medical Informatics and Decision Making 2013, 13:95
84. DeRenzi B et al. e-IMCI: Improving Pediatric Health Care in Low-Income Countries. Healthcare in the Developing World. 2008.
85. Mitchell, M., et al., *Perceived improvement in integrated management of childhood illness implementation through use of mobile technology: qualitative evidence from a pilot study in Tanzania.* J Health Commun, 2012. 17 Suppl 1: p. 118-27.

86. Coleman, J., M*onitoring MAMA: Gauging the Impact of MAMA South Africa.* Journal of Mobile Technology in Medicine, 2013. 2(4S): p. 9-9.
87. Ahsan A and Raihan A. Understanding mHealth impact among Aponjon (MAMA Bangladesh) subscribers through a phone survey in Bangladesh. ICTD '13 Proceedings of the Sixth International Conference on Information and Communications Technologies and Development: Notes - Volume 2. Available: http://dl.acm.org/citation.cfm?id=2517920&dl=ACM&coll=DL&CFID=462649559&CFTOKEN=87893547. (Accessed March 7, 2017)
88. Engle, K.L., and Vadhat, H., *Mobile Phone Interventions for Reproductive Health (m4RH):Testing the Feasibility of Text Messaging to Improve Family Planning.:* p. Available: http://www.c-hubonline.org/sites/default/files/resources/main/M4RH%20Formative%20Results.pdf. (Accessed March 7, 2017)
89. World Health Organization and mHealth Alliance, *Small incentives improve vaccine coverage in Pakistan: IRD's Interactive Alerts. 2*013.
90. Uddin, M.J., et al., *Use of mobile phones for improving vaccination coverage among children living in rural hard-to-reach areas and urban streets of Bangladesh. V*accine, 2016. 34(2): p. 276-283.
91. Gibson, D.G., et al., *Mobile phone-delivered reminders and incentives to improve childhood immunisation coverage and timeliness in Kenya (M-SIMU): a cluster randomised controlled trial. L*ancet Glob Health, 2017. 5(4): p. e428-e438.
92. Musoke, M., Ma*ternal health care in rural Uganda leveraging traditional and modern knowledge systems. Indigenous Knowledge Notes 1–4. 2*002.
93. Mechael, P.,et al., *Barriers and Gaps Affecting mHealth in Low and Middle Income Countries A Policy White Paper.* Columbia University. The Earth Institute. May, 2010. http://www.globalproblems-globalsolutions-files.org/pdfs/mHealth_Barriers_White_Paper.pdf (Accessed March 7, 2017)
94. Lund, S., et al., *Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial. B*MC Pregnancy Childbirth, 2014. 14: p. 29.
95. Ra*tes, timing and causes of neonatal deaths in rural India: implications for neonatal health programmes. 2*006: p. 1-8.
96. Krasovec, K., *Auxiliary technologies related to transport and communication for obstetric emergencies. I*nt J Gynaecol Obstet, 2004. 85 Suppl 1: p. S14-23.
97. Lim, J., et al., *Usability and Feasibility of PIERS on the Move: An mHealth App for Pre-Eclampsia Triage. J*MIR Mhealth Uhealth, 2015. 3(2): p. e37.
98. Palmer, S. and D.J. Torgerson, *Economic notes: definitions of efficiency. B*MJ, 1999. 318(7191): p. 1136.
99. Johns Hopkns University. Economic Evaluation II Lecture slides.
100. Palmer S, T.D., *Definitions of efficiency. B*MJ 1999.

101. Drummond MF, S.M., Torrance GW, Obrien BJ, Stoddart GL, Me*thods for the Economic Evaluation of Health Care Programmes. O*xford University Press. Third Edition, 2005.
102. Cleveringa, F.G., et al., *Cost-effectiveness of the diabetes care protocol, a multifaceted computerized decision support diabetes management intervention that reduces cardiovascular risk. D*iabetes Care, 2010. 33(2): p. 258-63.
103. World Health Organization. Costing Tools. http://www.who.int/pmnch/knowledge/publications/costing_tools/en/ (Accessed March 7, 2017)
104. World Health Organization, *Final Reports of Technical Review Of Costing Tools Se*ptember 2008. Commissioned by an Inter-agency Steering Committee and the Partnership for Maternal, Newborn and Child Health
105. Managing complications in pregnancy and children: a guide for midwives and doctors. WHO, 2000
106. World Health Organization, *Managing complications in pregnancy and children: a guide for midwives and doctors. 2*007.
107. World Health Organization, *Pregnancy, childbirth, postpartum and newborn care: a guide for essential practice. 2*015.
108. World Health Organization, *Managing newborn problems: a guide for doctors, nurses, and midwives. 2*003.
109. World Health Organization, *General standards of care for healthy pregnancy and childbirth. D*epartment of Making Pregnancy Safer and Department of Reproductive Health and Research, 2007.
110. World Health Organization, *Final Reports of Technical Review of Costing Tools MDG. 2*008.
111. Muller, A.M., et al., *The effectiveness of e-& mHealth interventions to promote physical activity and healthy diets in developing countries: A systematic review. I*nt J Behav Nutr Phys Act, 2016. 13(1): p. 109.
112. Catan, G., et al., *Health information technology implementation - impacts and policy considerations: a comparison between Israel and Portugal. I*sr J Health Policy Res, 2015. 4: p. 41.
113. World Health Organization. Cost effectiveness and strategic planning (WHO-CHOICE) http://www.who.int/choice/toolkit/cost_it/en/ (Accessed March 7, 2017)
114. Victora CG, Hanson K, Bryce J, Vaughan JP. 2004. *Achieving universal coverage with health interventions.* The Lancet 364: 1541–8.
115. Ruth Simmons, P.F., and Laura Ghiron, *Scaling up health service delivery: from pilot innovations to policies and programmes. 2*007.
116. Organization, W.H., *Macroeconomics and Health : Investing in Health for Economic Development. 2*001.

117. Johns, B. and R. Baltussen, *Accounting for the cost of scaling-up health interventions. H*ealth Econ, 2004. 13(11): p. 1117-24.
118. Benjamin Johns, M.O.-A., Damian Walker, *Assessing the costs and cost-effectiveness of rapidscale up for the maternal, neonatal, and child health: The economic component of the impact evaluation strategy for the Catalytic Initiative. T*he Johns Hopkins University Bloomberg School of Public Health, The Institute for International Programs.
119. Johns, B., T.T. Torres, and C. Who, Co*sts of scaling up health interventions: a systematic review. H*ealth Policy Plan, 2005. 20(1): p. 1-13.
120. Travis, P., et al., *Overcoming health-systems constraints to achieve the Millennium Development Goals. T*he Lancet, 2004. 364(9437): p. 900-906.
121. Yousuf Hussein, S., et al., *Smartphone hearing screening in mHealth assisted community-based primary care. J* Telemed Telecare, 2016. 22(7): p. 405-12.
122. Husereau, D., et al., *Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement. B*MC Med, 2013. 11: p. 80.
123. Mangham, L.J. and K. Hanson, Sc*aling up in international health: what are the key issues? H*ealth Policy Plan, 2010. 25(2): p. 85-96.
124. World Health Organization, *Constraints to Scaling Up and Costs.* 2009. http://who.int/choice/publications/d_ScalingUp_MDGs_WHO_finalreport.pdf
125. Levine R, 'What Works' Working Group, Kinder M: Millions Saved: Proven Successes in Global Health Washington, DC: Center for Global Development; 2004.
126. Medlin CA, Chowdhury M, Jamison DT, Measham AR: Improving the health of populations: lessons of experience. In Disease control priorities in developing countries.. 2 edition. Edited by: Jamison DT, Berman JG,Measham RA, Alleyne G, Claeson M, Evans BD, Musgrove P. Washington, D.C: World Bank; 2006:181-194.
127. Kumaranayake, L. and C. Watts, *Economic costs of HIV/AIDS prevention activities in sub-Saharan Africa. A*IDS, 2000. 14 Suppl 3: p. S239-52.
128. Mendiola, M.F., M. Kalnicki, and S. Lindenauer, Va*luable features in mobile health apps for patients and consumers: content analysis of apps and user ratings.* JMIR Mhealth Uhealth, 2015. 3(2): p. e40.
129. Yothasamut J, Putchon C, Sirisamutr T, Teerawattananon Y, Tantivess S:Scaling up cervical cancer screening in the midst of human papillomavirus vaccination advocacy in Thailand. BMC Health Services Research 2010, 10(Suppl 1):S5.
130. Schneider, H., et al., *Differences in antiretroviral scale up in three South African provinces: the role of implementation management. B*MC Health Serv Res, 2010. 10 Suppl 1: p. S4.
131. Chen, L., et al., Hu*man resources for health: overcoming the crisis. L*ancet, 2004. 364(9449): p. 1984-90.

132. Hongoro, C. and B. McPake, *How to bridge the gap in human resources for health.* Lancet, 2004. 364(9443): p. 1451-6.
133. Marchal, B., G. Kegels, and V. De Brouwere, *Human resources in scaling up HIV/AIDS programmes: just a killer assumption or in need of new paradigms?* AIDS, 2004. 18(15): p. 2103-5.
134. Van Damme, W., K. Kober, and G. Kegels, *Scaling-up antiretroviral treatment in Southern African countries with human resource shortage: how will health systems adapt?* Soc Sci Med, 2008. 66(10): p. 2108-21.
135. Hanvoravongchai, P., *Scaling up health workforces in response to critical shortages.* Lancet, 2007. 370(9605): p. 2080-1.
136. Over, M., *The effect of scale on cost projections for a primary health care program in a developing country.* Soc Sci Med, 1986. 22(3): p. 351-60.
137. Brenzel, L. and P. Claquin, *Immunization programs and their costs.* Soc Sci Med, 1994. 39(4): p. 527-36.
138. Phillips, M., *Setting global priorities for strategies to control diarrhoeal disease: the contribution of cost-effectiveness analysis.* Oxford: Oxford University Press, 214–49, 1993.
139. Levin A, England S, Jorissen J, Garshong B, Teprey J. Case study on the costs and financing of immunization services in Ghana. 2001. Bethesda, MD: Abt Associates Inc.
140. Annis, S., Ph*ysical access and utilization of health services in rural Guatemala.* Soc Sci Med D, 1981. 15(4): p. 515-23.
141. Soucat, A., et al., *Affordability, cost-effectiveness and efficiency of primary health care: the Bamako Initiative experience in Benin and Guinea.* Int J Health Plann Manage, 1997. 12 Suppl 1: p. S81-108.
142. Fleming, N.S., et al., *The financial and nonfinancial costs of implementing electronic health records in primary care practices.* Health Aff (Millwood), 2011. 30(3): p. 481-9.
143. Byrne CM, Mercincavage LM, Pan EC, et al. *The value from investments in health information technology at the US Department of Veterans Affairs.* Health Aff 2010;29:629–38
144. Kaushal R, Jha AK, Franz C, et al. *Return on investment for a computerized physician order entry system.* J Am Med Inform Assoc 2006;13:261–6.
145. Miller RH, West C, Brown TM, et al. *The value of electronic health records in solo or small group practices.* Health Aff 2005;24:1127–37.
146. Bassi, J. and F. Lau, *Measuring value for money: a scoping review on economic evaluation of health information systems.* J Am Med Inform Assoc, 2013. 20(4): p. 792-801.
147. Zlabek JA, Wickus JW, Mathiason MA. Early cost and safety benefits of an inpatient electronic health record. J Am Med Inform Assoc 2011;18:169–72.

148. Li, K., et al., *Study of the cost-benefit analysis of electronic medical record systems in general hospital in China. J* Med Syst, 2012. 36(5): p. 3283-91.
149. Driessen, J., et al., *Modeling return on investment for an electronic medical record system in Lilongwe, Malawi. J* Am Med Inform Assoc, 2013. 20(4): p. 743-8.
150. Wang, S.J., et al., A *cost-benefit analysis of electronic medical records in primary care. T*he American Journal of Medicine, 2003. 114(5): p. 397-403.
151. Reardon T: *Research findings and strategies for assessing telemedicine costs.* Telemed J E Health 2005, 11:348-369.
152. Aoki N, Dunn K, Fukui T, Beck JR, Schull WJ, Li HK: *Cost-effectiveness analysis of telemedicine to evaluate diabetic retinopathy in a prison population.* Diabetes Care 2004, 27:1095-1101
153. Bergmo, T.S., *Can economic evaluation in telemedicine be trusted? A systematic review of the literature. C*ost Eff Resour Alloc, 2009. 7: p. 18.
154. Kwan, A., *Inventory of Information and Communication Technology Solutions for Supply Chains. Prepared for the United Nations Commission on Life-saving Commodities for Women and Children. m*Health Alliance., April 2014.
155. Sokol MC, McGuigan KA, Verbrugge RR, Epstein RS. Impact of medication adherence on hospitalization risk and healthcare cost. Med Care 2005;43:521–530.
156. Mulholland HC, Casey F, Brown D, Corrigan N, Quinn M, McCord B, Rogers J,Craig BG. *Application of a low cost telemedicine link to the diagnosis of neonatal congenital heart defects by remote consultation.* Heart 1999;82:217–221.
157. Schweitzer, J. and C. Synowiec, Th*e economics of eHealth and mHealth. J* Health Commun, 2012. 17 Suppl 1: p. 73-81.
158. Dimagi. Total Cost of Ownership Model: Use the Total Cost of Ownership Model to Budget for your Mobile Solution. http://sites.dimagi.com/totalcostownership (Accessed March 7, 2017)
159. Futures Group. Community Health Workers (CHW) Training- Total Cost of Ownership [ppt slide: http://solutionscenter.nethope.org/assets/collaterals/Final_TCO_CHW__02_13_14.pdf]
160. Byass, P., et al., *Direct data capture using hand-held computers in rural Burkina Faso: experiences, benefits and lessons learnt. T*rop Med Int Health, 2008. 13 Suppl 1: p. 25-30.
161. Seebregts, C.J., et al., *Handheld computers for survey and trial data collection in resource-poor settings: development and evaluation of PDACT, a Palm Pilot interviewing system. I*nt J Med Inform, 2009. 78(11): p. 721-31.

162. Shirima, K., et al., *The use of personal digital assistants for data entry at the point of collection in a large household survey in southern Tanzania. E*merg Themes Epidemiol, 2007. 4: p. 5.
163. Zaidi, S.M., et al., Ge*ographic variation in access to dog-bite care in Pakistan and risk of dog-bite exposure in Karachi: prospective surveillance using a low-cost mobile phone system. P*LoS Negl Trop Dis, 2013. 7(12): p. e2574.
164. Guerriero, C., et al., *The cost-effectiveness of smoking cessation support delivered by mobile phone text messaging: Txt2stop. E*ur J Health Econ, 2013. 14(5): p. 789-97.
165. Zurovac, D., et al., *Costs and cost-effectiveness of a mobile phone text-message reminder programmes to improve health workers' adherence to malaria guidelines in Kenya. P*LoS One, 2012. 7(12): p. e52045.
166. Hoddinott, P., et al., *The FEeding Support Team (FEST) randomised, controlled feasibility trial of proactive and reactive telephone support for breastfeeding women living in disadvantaged areas. B*MJ Open, 2012. 2(2): p. e000652.
167. Asiimwe, C., et al., *Use of an innovative, affordable, and open-source short message service-based tool to monitor malaria in remote areas of Uganda. A*m J Trop Med Hyg, 2011. 85(1): p. 26-33.
168. Chen, Z.W., et al., *Comparison of an SMS text messaging and phone reminder to improve attendance at a health promotion center: a randomized controlled trial. J* Zhejiang Univ Sci B, 2008. 9(1): p. 34-8.
169. Cho, S.J., et al., *A Randomized Controlled Trial of SMS Text Messaging versus Postal Reminder to Improve Attendance after Lipid Lowering Therapy in Primary Care. K*orean Journal of Family Medicine, 2010. 31(4): p. 284.
170. Wade, V.A., et al., *Home videophones improve direct observation in tuberculosis treatment: a mixed methods evaluation. P*LoS One, 2012. 7(11): p. e50155.
171. Ryan, M., D.A. Scott, and C. Donaldson, *Valuing health care using willingness to pay: a comparison of the payment card and dichotomous choice methods. J*ournal of Health Economics, 2004. 23(2): p. 237-258.
172. Iribarren, S.J., et al., *What is the economic evidence for mHealth? A systematic review of economic evaluations of mHealth solutions. P*loS one, 2017. 12(2): p. e0170581-20.
173. Mahmud, N., J. Rodriguez, and J. Nesbit, *A text message-based intervention to bridge the healthcare communication gap in the rural developing world. T*echnol Health Care, 2010. 18(2): p. 137-44.
174. Ryan, D., et al., *Clinical and cost effectiveness of mobile phone supported self monitoring of asthma: multicentre randomised controlled trial. B*MJ, 2012. 344: p. e1756.

175. Bhutta, Z.A., et al., *Alma-Ata: Rebirth and Revision 6 Interventions to address maternal, newborn, and child survival: what difference can integrated primary health care strategies make? L*ancet, 2008. 372(9642): p. 972-89.
176. Bhutta, Z.A., et al., C*ommunity-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. P*ediatrics, 2005. 115(2 Suppl): p. 519-617.
177. Bhutta, Z.A., et al., *Stillbirths: what difference can we make and at what cost? L*ancet, 2011. 377(9776): p. 1523-38.
178. Mangham-Jefferies, L., et al., *Cost-effectiveness of strategies to improve the utilization and provision of maternal and newborn health care in low-income and lower-middle-income countries: a systematic review.* BMC Pregnancy Childbirth, 2014. 14: p. 243.
179. Bhutta AZ, Das JK, Bahl R, Lawn JE, Salam RA, Paul VK, Sankar JM, Blencowe H, Rizci A, Chou VB, Walker N, For The Lancet Newborn Interventions Review Group and The Lancet Every Newborn Study Group: *Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost?* Lancet 2014. Early online publication: doi: 10.1016/S0140-6736 (14) 60792-3.
180. Mangham-Jefferies, L., et al., *Cost-effectiveness of strategies to improve the utilization and provision of maternal and newborn health care in low-income and lower-middle-income countries: a systematic review. 2*014. 14(1): p. 1-23.
181. Fottrell, E., et al., *The effect of increased coverage of participatory women's groups on neonatal mortality in Bangladesh: A cluster randomized trial. J*AMA Pediatr, 2013. 167(9): p. 816-25.
182. Tripathy, P., et al., *Effect of a participatory intervention with women's groups on birth outcomes and maternal depression in Jharkhand and Orissa, India: a cluster-randomised controlled trial. L*ancet, 2010. 375(9721): p. 1182-92.
183. LeFevre A, Shillcutt SD, Waters HR, Haider S, Arifeen SE, Mannan I, Seraji HR, Shah R, Darmstadt Gary L, Wall S, Williams E, Black R, Santosham M, Baqui A, the Pronjahnmo Study Group: Economic evaluation of neonaral care packages in a cluster-randomized controlled trial in Sylhet, Bangladesh. Bull World Health Organ 2013, 91:736–745.
184. Bang, A.T., R.A. Bang, and H.M. Reddy, *Home-based neonatal care: summary and applications of the field trial in rural Gadchiroli, India (1993 to 2003). J* Perinatol, 2005. 25 Suppl 1: p. S108-22.
185. Becker-Dreps, S.I., et al., *Cost-effectiveness of adding bed net distribution for malaria prevention to antenatal services in Kinshasa, Democratic Republic of the Congo. A*m J Trop Med Hyg, 2009. 81(3): p. 496-502.

186. Broughton, E., et al., *Cost-effectiveness of a quality improvement collaborative for obstetric and newborn care in Niger.* Int J Health Care Qual Assur, 2013. 26(3): p. 250-61.
187. Horton, S., et al., *Breastfeeding promotion and priority setting in health. H*ealth Policy Plan, 1996. 11(2): p. 156-68.
188. Ornella Lincetto, S.M.-A., Patricia Gomez, Stephen Munjanja, Op*portunities for Africa's Newborns: Chapter 2. Antenatal Care. p*. p51-62.
189. Khan, K.S., et al., *WHO analysis of causes of maternal death: a systematic review.* Lancet, 2006. 367(9516): p. 1066-74.
190. World Health Organization. Antenatal care in developing countries. 1990-2001. http://www.childinfo.org/files/antenatal_care.pdf (Accessed March 7, 2017)
191. Maternal Health Task Force. http://www.mhtf.org/antenatal-care/ (Accessed March 7, 2017)
192. Villar et al. COCHRAN review. Patterns of routine antenatal care for low-risk pregnancy. 2007.
193. Villar, J. and P. Bergsjo, *Scientific basis for the content of routine antenatal care. I. Philosophy, recent studies, and power to eliminate or alleviate adverse maternal outcomes.* Acta Obstet Gynecol Scand, 1997. 76(1): p. 1-14.
194. Bergsjo, P. and J. Villar, *Scientific basis for the content of routine antenatal care. II. Power to eliminate or alleviate adverse newborn outcomes; some special conditions and examinations.* Acta Obstet Gynecol Scand, 1997. 76(1): p. 15-25.
195. Villar, J., et al., *The WHO antenatal care randomised controlled trial: rationale and study design. P*aediatr Perinat Epidemiol, 1998. 12 Suppl 2: p. 27-58.
196. Carroli, G., C. Rooney, and J. Villar, *How effective is antenatal care in preventing maternal mortality and serious morbidity? An overview of the evidence. P*aediatr Perinat Epidemiol, 2001. 15 Suppl 1: p. 1-42.
197. Carroli, G., et al., *WHO systematic review of randomised controlled trials of routine antenatal care. L*ancet, 2001. 357(9268): p. 1565-70.
198. World Health Organization. Antenatal care in developing countries. 1990-2001. http://www.childinfo.org/files/antenatal_care.pdf (Accessed March 7, 2017)
199. USAID, Bangladesh Demographic and Health Survey 2014 [FR311]. 2014: p. 1-354.
200. World Health Organization. Background paper for the Technical Consultation on Effective Coverage of Health Systems 27–29 August 2001 Rio de Janeiro, Brazil
201. Coverage matters. 2014. A collation of content on coverage monitoring of CMAM programmes
202. United Nations Children's Fund, "Reaching Universal Health Coverage through District Health System Strengthening: Using a modified Tanahashi model subnationally to attain equitable and effective coverage" (New York, USA, 2013).

203. World Health Organization: Global burden of disease. http://www.who.int/topics/global_burden_of_disease/en/ (Accessed March 7, 2017)
204. Prescott, T.L., et al., *Reaching Adolescent Gay, Bisexual, and Queer Men Online: Development and Refinement of a National Recruitment Strategy. J* Med Internet Res, 2016. 18(8): p. e200.
205. MSH. Cost Revenue Analysis Tool Plus. http://www.msh.org/resources/cost-revenue-analysis-tool-plus (Accessed March 7, 2017)
206. International Monetary Fund. Database. https://www.imf.org/external/pubs/ft/weo/2016/01/weodata/index.aspx (Accessed March 7, 2017)
207. Gross, K., et al., *Antenatal care in practice: an exploratory study in antenatal care clinics in the Kilombero Valley, south-eastern Tanzania. B*MC Pregnancy Childbirth, 2011. 11: p. 36.
208. Drummond, M.F.e.a., *Methods for the Economic Evaluation of Health Care Programmes (3rd edition). O*xford University Press, 2005.
209. Glick, G., et al., *Use of mobile technology in a community mental health setting. J* Telemed Telecare, 2016. 22(7): p. 430-5.
210. Investopedia., *What is a 'Discount'.* http://www.investopedia.com/terms/d/discount.asp.
*21*1. Walker, D. and L. Kumaranayake, *Allowing for differential timing in cost analyses: discounting and annualization. H*ealth Pol Plan, 2002. 17(1): p. 112-8.
212. Drummond, M.F., et al., *Methods for the Economic Evaluation of Health Care Programs 3r*d ed. 2005, Oxford: Oxford University Press.
213. SNL, *Saving Newborn Lives Initiative: Project costing guidelines.* 2004, Save the Children: Washington DC.
214. Gold MR, S.J., Russell LB, Weinstein MC. , *Cost-Effectiveness in Health and Medicine. . N*ew York, NY: Oxford University Press, 1996.
215. International Monetary Fund. *World Economic Outlook Database.* Available from: http://www.imf.org/external/ns/cs.aspx?id=28. (Accessed March 7, 2017)
216. Peter Muenning. Cost-Effectiveness Analysis in Health: A Practical Approach, Second edition, 2007
217. Briggs et al. Decision Modeling for Health Economic Evaluation. Oxford University Press. 2006
218. Mehl, G. and A. Labrique, *Prioritizing integrated mHealth strategies for universal health coverage. S*cience, 2014. 345(6202): p. 1284-7.
219. World Health Organization. Johns Hopkins University-Global mHealth Initiative. United Nations Foundation., *The MAPS Toolkit: mHealth Assessment and Planning for Scale. . 2*015.

220. Agarwal, S., et al., G*uidelines for reporting of health interventions using mobile phones: mobile health (mHealth) evidence reporting and assessment (mERA) checklist.* BMJ, 2016. 352: p. i1174.
221. Nuijten, M.J., T. Mittendorf, and U. Persson, *Practical issues in handling data input and uncertainty in a budget impact analysis.* Eur J Health Econ, 2011. 12(3): p. 231-41.
222. Doubilet, P., et al., Pr*obabilistic sensitivity analysis using Monte Carlo simulation. A practical approach.* Med Decis Making, 1985. 5(2): p. 157-77.
223. Briggs, A.H., *Statistical approaches to handling uncertainty in health economic evaluation.* Eur J Gastroenterol Hepatol, 2004. 16(6): p. 551-61.
224. Briggs, A., et al., *The use of probabilistic decision models in technology assessment : the case of total hip replacement.* Appl Health Econ Health Policy, 2004. 3(2): p. 79-89.
225. US Census Bureau. Bangladesh. Population growth rate. http://www.census.gov/population/international/data/idb/country.php (Accessed March 7, 2017)
226. World Health Organization. Bangladesh: Maternal and Perinatal Health Profile. http://www.who.int/maternal_child_adolescent/epidemiology/profiles/maternal/bgd.pdf
227. Guttmacher Institute. Menstrual Regulation and Induced Abortion in Bangladesh. September 2012. https://www.guttmacher.org/fact-sheet/menstrual-regulation-and-induced-abortion-bangladesh (Accessed March 7, 2017)
228. Fenwick, E., et al., *Using and interpreting cost-effectiveness acceptability curves: an example using data from a trial of management strategies for atrial fibrillation.* BMC Health Serv Res, 2006. 6: p. 52.
229. Fenwick, E. and S. Byford, *A guide to cost-effectiveness acceptability curves.* Br J Psychiatry, 2005. 187: p. 106-8.
230. van Hout, B.A., et al., *Costs, effects and C/E-ratios alongside a clinical trial.* Health Econ, 1994. 3(5): p. 309-19.
231. Briggs, A. and P. Fenn, *Confidence intervals or surfaces? Uncertainty on the cost-effectiveness plane.* Health Econ, 1998. 7(8): p. 723-40.
232. Eichler, H.G., et al., *Use of cost-effectiveness analysis in health-care resource allocation decision-making: how are cost-effectiveness thresholds expected to emerge?* Value Health, 2004. 7(5): p. 518-28.
233. World Health Organization, *Macroeconomics and health: investing in health for economic development.* 2001.
234. World Health Organization and ExpandNET, *Nine steps for developing a scaling-up strategy. .* 2010.
235. World Health Organization and ExpandNET, *Practical guidance for scaling up health service innovations.* 2009.

236. USAID., *The mHealth Planning Guide: Key Considerations for Integrating Mobile Technology into Health Programs.*
237. Xiong, K., Mo*bile Technology for Monitoring and Evaluation and Health Information Systems in Low- to Middle-Income Countries. U*SAID. Measure Evaluation., March 2015.
238. World Health Organization, Maternal mortality. November 2015. http://www.who.int/mediacentre/factsheets/fs348/en/ (Accessed March 7, 2017)
239. Kassebaum, N.J., et al., Gl*obal, regional, and national levels and causes of maternal mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. L*ancet, 2014. 384(9947): p. 980-1004.
240. World Health Organization. Newborns: reducing mortality. January 2016. http://www.who.int/mediacentre/factsheets/fs333/en/ (Accessed March 7, 2017)
241. World Health Organization. Bangladesh. Maternal and Perinatal Health Profile. http://www.who.int/maternal_child_adolescent/epidemiology/profiles/maternal/bgd.pdf
242. World Health Organization. Bangladesh Health System Review.2015. http://www.wpro.who.int/asia_pacific_observatory/hits/series/bgd_health_system_review.pdf
243. World Health Orgnization. mHealth. mHealth: http://www.who.int/goe/publications/goe_mhealth_web.pdf (Accessed March 7, 2017)
244. Johns Hopkins University. JiVita. http://www.africanstrategies4health.org/uploads/1/3/5/3/13538666/mcare_-_enhancing_neonatal_survival_in_rural_south_asia.pdf (Accessed March 7, 2017)
245. Banglades Bureau of Statistics. http://203.112.218.65/ (Accessed March 7, 2017)
246. Saving Newborn Lives: Primary Health Care cost-effectiveness guideline. (printed)
247. World Health Organizaton. CHOICE. http://www.who.int/choice/cost-effectiveness/generalized/en/ (Accessed March 7, 2017)
248. International Monetary Fund, World Economic Outlook Database, April 2016 https://www.imf.org/external/pubs/ft/weo/2016/01/weodata/index.aspx (Accessed March 7, 2017)
249. Bishai, D., et al., *Cost-effectiveness of using a social franchise network to increase uptake of oral rehydration salts and zinc for childhood diarrhea in rural Myanmar. C*ost Eff Resour Alloc, 2015. 13: p. 3.
250. Armstrong N, Wolff R, van Mastrigt G, et al. A systematic review and cost-effectiveness analysis of specialist services and adrenaline auto-injectors in anaphylaxis.Health Technology Assessment, No. 17.17. Southampton (UK): NIHR Journals Library; 2013 Apr.https://www.ncbi.nlm.nih.gov/books/NBK260527/ (Accessed March 7, 2017)

251. Darmstadt, G.L., et al., E*valuation of a cluster-randomized controlled trial of a package of community-based maternal and newborn interventions in Mirzapur, Bangladesh. P*LoS One, 2010. 5(3): p. e9696.
252. Howlander S: Costing and Economic Analysis of Strengthening Union Level Facility for Providing Normal Delivery and Newborn Care Services in Bangladesh. Dhaka, Bangladesh: Population Council; 2011.
253. LeFevre, A.E., et al., Ec*onomic evaluation of neonatal care packages in a cluster-randomized controlled trial in Sylhet, Bangladesh. B*ull World Health Organ, 2013. 91(10): p. 736-45.
254. Hutchinson, P., et al., Me*asuring the cost-effectiveness of a national health communication program in rural Bangladesh. J* Health Commun, 2006. 11 Suppl 2: p. 91-121.
255. Hatt, Laurel, Ha Nguyen, Nancy Sloan, Sara Miner, Obiko Magvanjav, Asha Sharma, Jamil Chowdhury, Rezwana Chowdhury, Dipika Paul, Mursaleena Islam, and Hong Wang. February 2010. Economic Evaluation of Demand-Side Financing (DSF) for Maternal Health in Bangladesh. Bethesda, MD: Review, Analysis and Assessment of Issues Related to Health Care Financing and Health Economics in Bangladesh, Abt Associates Inc.
256. Hatt, Laurel, Ha Nguyen, Nancy Sloan, Sara Miner, Obiko Magvanjav, Asha Sharma, Jamil Chowdhury, Rezwana Chowdhury, Dipika Paul, Mursaleena Islam, and Hong Wang. February 2010. Economic Evaluation of Demand-Side Financing (DSF) for Maternal Health in Bangladesh. Bethesda, MD: Review, Analysis and Assessment of Issues Related to Health Care Financing and Health Economics in Bangladesh, Abt Associates Inc.
257. World Bank Group. Disease Control Priorities: Reproductive, Maternal, Newborn and Child Health, Third edition
258. Lund, S., et al., Mo*bile phone intervention reduces perinatal mortality in zanzibar: secondary outcomes of a cluster randomized controlled trial. J*MIR Mhealth Uhealth, 2014. 2(1): p. e15.
259. Chang, L.W., et al., Co*st analyses of peer health worker and mHealth support interventions for improving AIDS care in Rakai, Uganda. A*IDS Care, 2013. 25(5): p. 652-6.
260. Hunchangsith, P., et al., Co*st-effectiveness of various tuberculosis control strategies in Thailand. V*alue Health, 2012. 15(1 Suppl): p. S50-5.
261. Njuguna, H.N., et al., A *comparison of smartphones to paper-based questionnaires for routine influenza sentinel surveillance, Kenya, 2011-2012. B*MC Med Inform Decis Mak, 2014. 14: p. 107.
262. Thriemer, K., et al., Re*placing paper data collection forms with electronic data entry in the field: findings from a study of community-acquired bloodstream infections in Pemba, Zanzibar. B*MC Res Notes, 2012. 5: p. 113.

263. Diedhiou, A., et al., Su*ccessful mLearning Pilot in Senegal: Delivering Family Planning Refresher Training Using Interactive Voice Response and SMS. G*lob Health Sci Pract, 2015. 3(2): p. 305-21.
264. World Health Organization. Bangladesh. Maternal and Perinatal Health Profile. http://www.who.int/maternal_child_adolescent/epidemiology/profiles/maternal/bgd.pdf
265. USAID. Multi-sectoral nutrition strategy. 2014-2025. https://www.usaid.gov/sites/default/files/documents/1864/1000-days-brief-508.pdf
266. World Health Orgnization. mHealth: New horizons for health through mobile technologies. 2011. balhealthaction.net/index.php/gha/article/view/31473
267. Global mHealth Initiative. Mobile Technology In Support of Frontline Health Workers. 2015
268. Kahn, J.G., et al., Th*e Cost and Cost-Effectiveness of Scaling up Screening and Treatment of Syphilis in Pregnancy: A Model. P*loS one, 2014. 9(1): p. e87510-10.
269. Aranda-Jan, C.B., N. Mohutsiwa-Dibe, and S. Loukanova, Sy*stematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. B*MC Public Health, 2014. 14: p. 188.
270. Eysenbach, G. and C.-E. Group, CO*NSORT-EHEALTH: improving and standardizing evaluation reports of Web-based and mobile health interventions. J* Med Internet Res, 2011. 13(4): p. e126.
271. World Health Organization. mHealth MAPS toolkit: mHealth Assessment and Planning for Scale. 2015. http://who.int/life-course/publications/mhealth-toolkit/en/
272. de la Torre-Diez, I., et al., Co*st-utility and cost-effectiveness studies of telemedicine, electronic, and mobile health systems in the literature: a systematic review. T*elemed J E Health, 2015. 21(2): p. 81-5.
273. World Bank data base. http://data.worldbank.org/
274. Centers for Disease Control and Prevention (CDC): Division of Reproductive Health, Es*timating the Number of Pregnant Women in a Geographic Area.*
275. Bryce J, Black RE, Walker N, et al. Can the world afford to save the lives of 6 million children each year? The Lancet 2005;365:2193-200.
276. Cost effectiveness and strategic planning (WHO-CHOICE): http://www.who.int/choice/en/
277. Measurement and Accountability for Health in Bangladesh A Status Report. USAID. June 2016.
278. Global Burden of Disease. Lancet. http://thelancet.com/gbd (Accessed March 7, 2017)

279. Mulligan J, Fox-Rushby J, Adam T, et al. DCPP Working Paper No. 9. Bethesda, MD: Disease Control Priorities Project; 2003. Unit costs of health care inputs in low and middle income regions.
280. International Monetary Fund: Bangladesh.http://www.imf.org/external/country/ (Accessed March 7, 2017)
281. Kim, Y.E., et al., *Control, elimination, and eradication of river blindness: scenarios, timelines, and ivermectin treatment needs in Africa.* PLoS Negl Trop Dis, 2015. 9(4): p. e0003664.
282. Tomlinson, M., et al., *Scaling up mHealth: where is the evidence?* PLoS Med, 2013. 10(2): p. e1001382.
283. Noordam, A.C., et al., *Assessing Scale-Up of mHealth Innovations Based on Intervention Complexity: Two Case Studies of Child Health Programs in Malawi and Zambia.* Journal of Health Communication, 2014. 20(3): p. 343-353.
284. Snow, T., *Evaluating the cost effectiveness of a mobile decision support tool in Malawi* 2016: p. 1-54.
285. Larsen-Cooper, E., et al., *Scale Matters: A Cost-Outcome Analysis of an m-Health Intervention in Malawi.* Telemedicine and e-Health, 2016. 22(4): p. 317-324.
286. Lauer, J.A., et al., *PopMod: a longitudinal population model with two interacting disease states.* Cost Eff Resour Alloc, 2003. 1(1): p. 6.
287. Norman, R.A., et al., *EPIFIL: the development of an age-structured model for describing the transmission dynamics and control of lymphatic filariasis.* Epidemiol Infect, 2000. 124(3): p. 529-41.
288. Bershteyn, A., D.J. Klein, and P.A. Eckhoff, *Age-dependent partnering and the HIV transmission chain: a microsimulation analysis.* J R Soc Interface, 2013. 10(88): p. 20130613.
289. Paina, L. and D.H. Peters, *Understanding pathways for scaling up health services through the lens of complex adaptive systems.* Health Policy Plan, 2012. 27(5): p. 365-73.
290. Peters, D.H., *The application of systems thinking in health: why use systems thinking?* Health Res Policy Syst, 2014. 12: p. 51.
291. Rickles D, Hawe P, Shiell A. A simple guide to chaos and complexity. Journal of Epidemiology and Community Health 61: 933–7. 2007.
292. Montgomery MR, Hewett PC. 2004. Urban poverty and health in developing countries: household and neighborhood effects. Policy Research Division Working Paper No. 184. New York: Population Council
293. Global mHealth Initiative. Mobile Technology In Support of Frontline Health Workers. 2015

294. Wilson K et al. The Journey to Scale. Moving together past digital heatlh pilots. PATH. December 2014. http://www.path.org/publications/files/TS_dhs_journey_to_scale.pdf
295. Hafkin, N., G*ender Issues in ICT Policy in Developing Countries: An Overview. U*nited Nations. Division for the Advancement of Women (DAW), 25 October 2002.
296. Collins, D.H., et al., Th*e cost of scaling up primary health-care services—comparisons from studies in six countries: economic research using systematic sampling. T*he Lancet, 2013. 381: p. S30.
297. Expanding Social Protection for Health: Towards Universal Coverage. Health Care Financing Strategy 2012-2032. Ministry of Health and Family Welfare.Government of the People's Republic of Bangladesh, September 2012. (URL: http://p4h-network.net/wp-content/uploads/2013/10/2012_10_HCFS_Bangladesh_2012-2032.pdf) (Accessed March 7, 2017)
298. National Health Workforce Strategy (2012-2032), National Health Policy 2011. Ministry of Health and Family Welfare, Government of Bangladesh
299. Syed Azizur Rahman et al, "Maternal Health Review Bangladesh" Health Systems Development Programme, Policy Research Unit (PRU) Ministry of Health and Family Welfare Government of Peoples Republic of Bangladesh 2003. https://assets.publishing.service.gov.uk/media/57a08cf4ed915d622c0016a7/02-03_bangladesh.pdf (Accessed March 7, 2017)
300. Government of the People's Republic of Bangladesh: General Economic Division (GED). Planning Commission. *Seventh Five Year Plan. FY 2016-FY 2020.* December 2015.
301. World Bank data base. http://data.worldbank.org/
302. CDC Division of Reproductive Heath. Estimating the number of pregnant women in a geogrphic area. https://www.cdc.gov/reproductivehealth/emergency/pdfs/pregnacyestimatobrochure508.pdf
303. Bryce J, Black RE, Walker N, et al. Can the world afford to save the lives of 6 million children each year? The Lancet 2005;365:2193-200.
304. USAID. Bangladesh Demographic and Health Survey 2014.
305. Manda TD. Herstad J. Berlin, "Implementing Mobile Phone Solutions for Health in Resource Constrained Areas: Understanding the Opportunities and Challenges." E-Infrastructures and E-Services on Developing Countries. Heidelberg: Springer; 2010. pp. 95–104.
306. Pedram Sendi, P. and A.H. Briggs, Af*fordability and cost-effectiveness: decision-making on the cost-effectiveness plane. H*ealth Economics, 2001. 10(7): p. 675-680.

307. Kim, S.Y, et al., *Economic evaluation of hepatitis B vaccination in lowincome countries: using costeffectiveness affordability curves.* Bulletin of the World Health Organization 2007. 85: p. 1-11.
308. Groot Koerkamp, B., et al., L*imitations of Acceptability Curves for Presenting Uncertainty in Cost-Effectiveness Analysis. M*edical Decision Making, 2007. 27(2): p. 101-111.
309. Sullivan, S.D., et al., Bu*dget impact analysis-principles of good practice: report of the ISPOR 2012 Budget Impact Analysis Good Practice II Task Force. V*alue Health, 2014. 17(1): p. 5-14.
310. Dee, A., M. Hutchinson, and D. De La Harpe, A *budget impact analysis of natalizumab use in Ireland. I*rish Journal of Medical Science, 2011. 181(2): p. 199-204.
311. Nuijten, M.J., In*corporation of statistical uncertainty in health economic modelling studies using second-order Monte Carlo simulations. P*harmacoeconomics, 2004. 22(12): p. 759-69.
312. Bangladesh Ministry of Health and Family Welfare, Health Economic Unit, Bangladesh National Heath Accounts 1997–2007. 2010.
313. USAID., Tr*acking Urban Health Expenditures—Preliminary Results from Secondary Analysis of Bangladesh National Health Accounts. M*ay 2015.
314. Bangladesh Ministry of Health and Family Welfare. Expanding Social Protection for Health: Health-care Financing Strategy 2012–2032. http://p4h-network.net/wp-content/uploads/2013/10/2012_10_HCFS_Bangladesh_2012-2032.pdf (Accessed March 7, 2017)
315. Trueman, P., M. Drummond, and J. Hutton, De*veloping guidance for budget impact analysis. P*harmacoeconomics, 2001. 19(6): p. 609-21.
316. Mauskopf, J.A., et al., Pr*inciples of good practice for budget impact analysis: report of the ISPOR Task Force on good research practices--budget impact analysis. V*alue Health, 2007. 10(5): p. 336-47.
317. Mauskopf, J.A., S. Earnshaw, and C.D. Mullins, Bu*dget impact analysis: review of the state of the art. E*xpert Rev Pharmacoecon Outcomes Res, 2005. 5(1): p. 65-79.
318. Mauskopf, J., et al., Dr*ug reimbursement recommendations by the National Institute for Health and Clinical Excellence: have they impacted the National Health Service budget? H*ealth Policy, 2013. 110(1): p. 49-59.
319. Dee, A., M. Hutchinson, and D. De La Harpe, A *budget impact analysis of natalizumab use in Ireland. I*r J Med Sci, 2012. 181(2): p. 199-204.
320. Chiao, E. and K. Meyer, Co*st effectiveness and budget impact of natalizumab in patients with relapsing multiple sclerosis. C*urr Med Res Opin, 2009. 25(6): p. 1445-54.

321. Dimagi, To*tal Cost of Ownership Model: Use the Total Cost of Ownership Model to Budget for your Mobile Solution.*
322. Futures Group, Co*mmunity Health Workers (CHW) Training- Total Cost of Ownership.*
323. Ahmed Mustafa and Tahmina Begum. Universal Health Coverage Assessment: People's Republic of Bangladesh. Global Network for Health Equity (GNHE). December, 2014.
324. The World Bank. Bangladesh: Health Nutrition and Population Sector Program. 2014. URL: http://projects.worldbank.org/P074841/health-nutrition-population-sector-program?lang=en&tab=overview (Accessed March 7, 2017)
325. Strategic Plan for Health, Population & Nutrition Sector Development Program (HPNSDP) 2011-2016, Ministry of Heath and Family Welfare, Government of the People's Republic of Bangladesh, April 2011.
326. Health Populaions & Nurition Secor Strategic Plan (HPNSSP) 2011-2016. Ministry of Health and Family Welfare, Government of the People's Republic of Bangladesh. September, 2010.
327. Background Paper on Health Strategy for preparation of 7th Five Year Plan, 31 December 2014.
328. World Health Organization: International Labour Office, Ex*tending Social Protection in Health. 2*007.
329. Islam, S.M. and R. Tabassum, Im*plementation of information and communication technologies for health in Bangladesh. B*ull World Health Organ, 2015. 93(11): p. 806-9.
330. A Quiet Revolution: Strengthening the Routine Health Information System in Bangladesh. German Health Practice Collection. November, 2014. (URL: https://www.mn.uio.no/ifi/english/research/networks/hisp/research-library/publications/his_bangladesh_long_en.pdf (Accessed March 7, 2017)
331. Mercuri, J.J., Th*e Ethics of Electronic Health Records. C*linical Correlations, The NYU Lagone Online Journal of Medicine, January 15, 2010.
332. Layman, E.J., Et*hical issues and the electronic health record. H*ealth Care Manag (Frederick), 2008. 27(2): p. 165-76.
333. Georgetown University : Institute for Reproductive Health, Th*eory and Practice: Monitoring & Evaluating Scale-Up of Health System Innovations. 2*013.
334. Sendi, P., A. Gafni, and S. Birch, Op*portunity costs and uncertainty in the economic evaluation of health care interventions. H*ealth Economics, 2002. 11(1): p. 23-31.
335. Arond, E., Rodríguez, I., Arza, V., Herrera, F. and Sanchez, M. Innovation Sustainability, Development and Social Inclusion: Lessons from Latin America, STEPS Working Paper 48, Brighton: STEPS Centre, 2011

APPENDIX

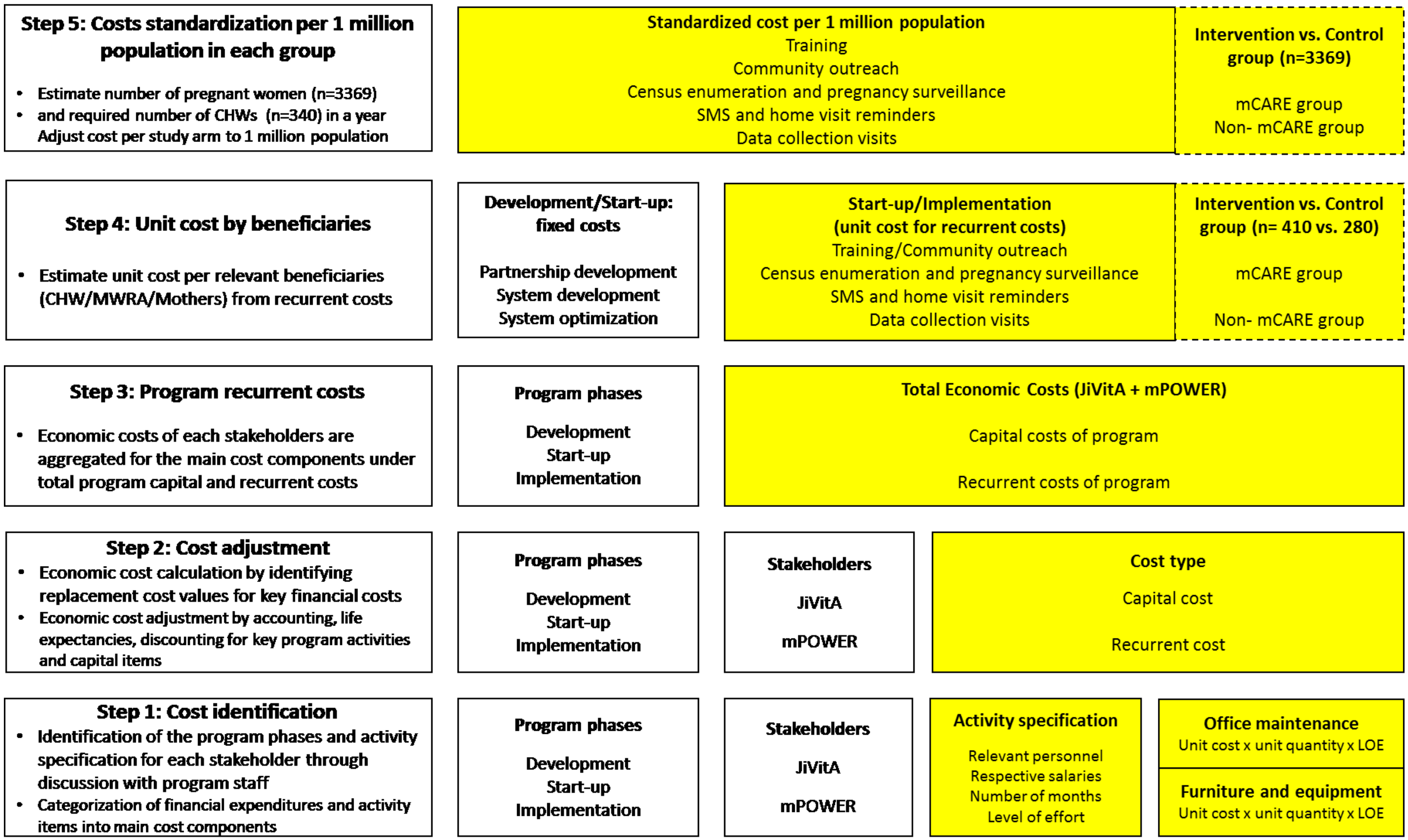
Appendix 1. Literature review

A 1.1 Cost effectiveness studies on community based maternal and newborn health services in Bangladesh

Author (year)	Strategies	Type of MNH Care	Study design	Costing perspective	Measure of effect	CE results
Fottrell (2013)	Women's group	MNH, especially newborn	Cluster RCT 2009- 2011	Program perspective	NMR per 1000 LB Adj RR = 0.62 (95% CI: 0.43-0.89)	The cost-effectiveness was US $220 to $393 per year of life lost averted.
Lefevre (2011)	MNH service delivered at home, with community mobilization and health system strengthening	All MNH	Cluster RCT 2003- 2005	Program & Societal perspective	NMR per 1000 LB: 31.2 (S), 43.1 (C)	The incremental programme costs of implementing the home-care package were $2939 per neonatal death averted and US$ 103.49 per disability-adjusted life year (DALY) averted. The corresponding total societal costs were US$ 2971 and US$ 104.62, respectively.
Hutchinson (2006)	Promotion of NGO health clinic: national media campaign, local activities	Facility-based ANC	Secondary data analysis 2001- 2004	Societal perspective	Estimated number of new ANC users	With respect to local promotion activities, the cost per attributable behavior change was considerably higher—nearly $8 per new ANC user, $37 per new DPT3 vaccination, and $32 per new measles vaccination.
Routh (2000)	Alternative delivery strategies FP & MCH	FP & MCH	Intervention & control Areas 1996-1997	Program perspective	Number of ANC services provided	Cost per birth averted and cost per QALY gained : $13 and $17 delivering services from static (fixed-site) clinics compared $18 and $42 for the doorstep strategy
Levin (1997 & 1999)	Outreach clinics for FP and ANC by facility staff	Pregnancy	Intervention & control Areas 1996-1997	Program perspective	Number of ANC services provided	The provision of a wider range of services is improving overall cost effectiveness.
Howlader (2011)	Improve health and family welfare clinics	Facility-birth	Cost Projection 2011	Program perspective	Estimated number of clients per year	In order to implement the intervention in all upazilas of the country, the required amount of expenditure in the first year of implementation will be TK. 252.31 crore. The amount in the second year will be TK. 117.37 crore. The amount will remain TK. 117.37 crore in each of the subsequent year.
Hatt (2010)	Vouchers for free MNH care, cash and in-kind transfers	All MNH	Intervention & control Areas 2008-2009		% of deliveries with qualified provider: 58-70% (S), 27% (C)	The average cost per voucher distributed (based upon the direct costs of the DSF program) is estimated to be US$ 41.

Appendix 2. Costing analyses

A 2.1 Conceptual Framework of Activity Based Costing for Estimating Program Costs for Study Groups



A 2.2 Cost Inputs from JiVitA

1. Human resources (staff salaries)

Staff categories	Designatiom	#	2012				2013				2014				2015			
			ary (BDT)/person	M	LOE	salary/person	DT)/person	M	LOE	salary/person	DT)/person	M	LOE	salary/person	DT)/person	M	LOE	salary/person
HQ Admin	Field Administrator	1	75,290	12	15%	135,522	60,000	12	20%	144,000	60,000	12	30%	216,000	66,000	7	10%	46,200
	Finance Officer	1	0	12	15%	0	37,000	12	20%	88,800	40,000	12	30%	144,000	44,000	7	10%	30,800
	Adm Officer-Accounts	1	21,800	12	15%	39,240	25,000	12	20%	60,000	27,000	12	30%	97,200	29,700	7	10%	20,790
	Admin Officer-Procurement	1	31,800	12	15%	57,240	33,210	12	20%	79,704	35,867	12	30%	129,121	39,460	7	10%	27,622
	Asst. Admin Officer	1	0	12	15%	0	30,000	12	20%	72,000	30,000	12	30%	108,000	0	7	10%	0
	Office Assistant	1	12,870	12	15%	23,166	10,000	12	20%	24,000	10,800	12	30%	38,880	9,510	7	10%	6,657
	Admin Officer-Logistics and M	1	26,160	12	15%	47,088	27,000	12	20%	64,800	29,160	12	30%	104,976	32,080	7	10%	22,456
HQ admin total costs																		
HQ Technical Staff	Research Translator	1	14,080	12	15%	25,344	16,500	12	20%	39,600	17,820	12	30%	64,152	19,610	7	10%	13,727
	Asst. IT Officer	1	15,000	12	15%	27,000	15,580	12	20%	37,392	24,840	12	30%	89,424	27,330	7	10%	19,131
	Data Enrty Operator	3	11,630	12	15%	62,802	10,500	12	20%	75,600	11,340	12	30%	122,472	12,480	7	10%	26,208
	Field Query Associate	1	14,830	12	15%	26,694	19,000	12	20%	45,600	22,680	12	30%	81,648	24,950	7	10%	17,465
	Associate Archivist	1	11,620	12	15%	20,916	10,000	12	20%	24,000	10,800	12	30%	38,880	11,880	7	10%	8,316
	Filling Asst.	1	9,000	12	15%	16,200	9,000	12	20%	21,600	9,720	12	30%	34,992	10,700	7	10%	7,490
HQ tech staff total costs																		
HQ Supporting Staff	Motor Mecanics	1	14,830	12	15%	26,694	14,930	12	20%	35,832	16,120	12	30%	58,032	17,740	7	10%	12,418
	Computer Operator	1	10,510	12	15%	18,918	10,580	12	20%	25,392	11,430	12	30%	41,148	10,060	7	10%	7,042
	Asst. Motor Mecanis	1	7,030	12	15%	12,654	7,300	12	20%	17,520	7,880	12	30%	28,368	8,680	7	10%	6,076
	Electrician	1	10,000	12	15%	18,000	10,070	12	20%	24,168	10,880	12	30%	39,168	11,970	7	10%	8,379
	Admin Asst.-Store	2	14,720	12	15%	52,992	12,000	12	20%	57,600	12,960	12	30%	93,312	11,410	7	10%	15,974
	Driver	3	14,640	12	15%	79,056	15,000	12	20%	108,000	16,200	12	30%	174,960	10,700	7	10%	22,470
	Office helper	1	6,600	12	15%	11,880	6,860	12	20%	16,464	7,410	12	30%	26,676	8,150	7	10%	5,705
	Support staff	2	7,260	12	15%	26,136	7,550	12	20%	36,240	8,150	12	30%	58,680	8,965	7	10%	12,551
	Admin Asst.	1	14,640	12	15%	26,352	12,420	12	20%	29,808	13,410	12	30%	48,276	14,760	7	10%	10,332
	Cook	1	11,990	12	15%	21,582	12,080	12	20%	28,992	13,050	12	30%	46,980	14,350	7	10%	10,045
	Cleaner	1	4,620	12	15%	8,316	4,800	12	20%	11,520	5,180	12	30%	18,648	5,710	7	10%	3,997
HQ supporting total costs																		
Total admin & supporting staff						783,792				1,168,632				1,903,993				361,851
SMT	Project Manager	1	307,692	12	100%	3,692,304	316,923	12	100%	3,803,073	326,430	12	100%	3,917,165	336,223	7	100%	4,034,680
	JiVitA Research Fellow	1	230,769	12	20%	553,846	237,692	12	10%	570,461	244,823	12	10%	587,575	252,168	7	10%	605,202
	Senior Research Physician	1	95,030	12	40%	456,144	102,443	12	60%	102,443	110,638	12	30%	110,638	121,710	7	30%	110,638
	Senior Finance and Admin Ma	1	95,030	12	10%	114,036	102,443	12	20%	102,443	110,638	12	30%	110,638	121,710	7	30%	110,638
	Data Centre Manager	1	64,000	12	10%	76,800	68,992	12	20%	68,992	68,992	12	40%	68,992	81,970	7	40%	68,992
Field Staff 1	Sr.FS	1	29,040	12	0%	0	33,170	12	40%	33,170	35,824	12	30%	35,824	39,410	7	10%	35,824
Field Staff 2	AC/Field Officer	4	18,060	12	0%	0	17,000	12	15%	122,400	18,360	12	15%	132,192	16,120	7	10%	45,136
Field Staff 3	MTL	6	14,170	12	0%	0	11,000	12	100%	792,000	11,880	12	100%	855,360	10,460	7	30%	131,796
Field Staff 4	FI	18	10,750	12	0%	0	11,000	12	20%	475,200	11,880	12	20%	513,216	10,460	7	0%	0
Field Staff 5	FD (Kanchibari)	20	2,680	12	0%	0	2,250	12	30%	162,000	2,470	12	30%	177,840	1,360	7	10%	19,040
	FD (Kupdola)	20	2,680	12	0%	0	2,250	12	20%	108,000	2,470	12	20%	118,560	1,360	7	0%	0
Total program implementation costs						4,893,130				6,340,182				6,628,000				5,161,946

2. Office equipments

No.	Designatiom	Table	Chair	Laptop/Desktop	Cabinet	Motorbike/bicycle	Mobile phone	Steel rack	Market price (year)
HQ Staff									
1	Project Scientist	6500	3500	50000			8559		2015
2	Project Manager	6500	3500	50000			8559		2015
3	Project Manager	6500	3500	50000			8559		2015
4	JiVitA Research Fellow	6500	3500	50000	12000		8559		2015
5	Senior Research Physician	6500	3500	50000	12000		8559		2015
6	Research physician	6500	3500	50000	12000				2015
7	Senior Finance and Admin Ma	6500	3500	50000	25000		8559		2015
8	Asst. Admin Officer	6500	3500	45000	12000		8559		2015
9	Finance Officer	6500	3500	45000	12000		8559		2015
10	Adminitration Officer-Accour	6500	3500	45000	13000		8559		2015
11	Admin Officer-Procurement	6500	3500	45000	12000		8559		2015
12	Research Translator	6500	3500	45000	12000				2015
13	Office Assistant						8559		2015
14	Admin Officer-Logistics and M	6500	3500	45000	12000	142000	8559		2015
15	Motor Mecanics								2015
16	Computer Operator	6500	3500						2015
17	Asst. Motor Mecanis								2015
18	Electrician								2015
19	Admin Asst.-Store	6500	3500				8559		2015
20	Admin Asst.-Store	6500	3500				8559		2015
21	Driver								2015
22	Driver								2015
23	Driver								2015
24	Office helper								2015
25	Support staff								2015
26	Support staff								2015
27	Admin Asst.	6500	3500	45000	13000		8559		2015
28	Cook								2015
29	Cleaner								2015
30	Data Centre Manager	6500	3500	50000	12000		8559		2015
31	Asst. IT Officer	6500	3500	50000	12000		8559		2015
32	Field Query Associate	6500	3500	45000	12000		8559		2015
33	Associate Archivist	6500	3500						2015
34	Filling Asst.								2015
35	Data Enrty Operator	6500	3500	45000					2015
36	Data Enrty Operator	6500	3500	45000					2015
37	Data Enrty Operator	6500	3500	45000					2015
38	Field Administrator	6500	3500	45000	13000		8559		2015
HQ total		162,500	87,500	990,000	196,000	142,000	162,621		

Field Staff									
39	FS	6500	3500		12000	142000	8559		2015
40	Sr.FS	6500	3500	45000	13000	142000	8559	3000	2015
41	AC/Field Officer	6500	3500		13000	142000	8559	3000	2015
42	AC/Field Officer	6500	3500		13000	142000	8559	3000	2015
43	AC/Field Officer	6500	3500		13000	142000	8559	3000	2015
44	AC/Field Officer	6500	3500		13000	142000	8559	3000	2015
45	MTL	8000	1500			6000	8559	3000	2015
46	MTL		1500			6000	8559		2015
47	MTL	8000	1500			6000	8559	3000	2015
48	MTL		1500			6000	8559		2015
49	MTL	8000	1500			6000	8559	3000	2015
50	MTL		1500			6000	8559		2015
51	MTL	8000	1500			6000	8559	3000	2015
52	FI		1500			6000	8559		2015
53	FI	8000	1500			6000	8559	3000	2015
54	FI		1500			6000	8559		2015
55	FI	8000	1500			6000	8559	3000	2015
56	FI		1500			6000	8559		2015
57	FI	8000	1500			6000	8559	3000	2015
58	FI		1500			6000	8559		2015
59	FI	8000	1500			6000	8559	3000	2015
60	FI		1500			6000	8559		2015
61	FI	8000	1500			6000	8559	3000	2015
62	FI		1500			6000	8559		2015
63	FI	8000	1500			6000	8559	3000	2015
64	FI		1500			6000	8559		2015
65	FI	8000	1500			6000	8559	3000	2015
66	FI		1500			6000	8559		2015
67	FI	8000	1500			6000	8559	3000	2015
68	FI		1500			6000	8559		2015
69	FI		1500			6000	8559		2015
70	FD		20,000				171180		2015
71	FD		20,000				171180		2015
Field Total		128,500	95,000	45,000	65,000	860,000	599,130	51,000	

3. Office maintenance

SL#	JiVitA office maintenace costs	2012	2013	2014	2015	Average
		Cost (monthly average)				
1	Utilities (electricity bill	39712	39011	65365	56291	50,095
2	wages,	53674	66509	39569	25000	46,188
3	fuel,	132964	149987	145862	84100	128,228
4	trevel and per diem,	116414	161585	101842	95932	118,943
5	repair and services,	36713	33843	70688	38648	44,973
6	bank charges,	3210	3210	4778	5037	4,059
7	supplies and other serv	173182	194741	227122	346925	235,493
8	stationaries	56247	57442	48170	53632	53,873
9	Office rent	307877	310855	245143	208687	268,141

A 2.3 Cost Inputs from mPOWER

1. Human resources (staff salaries)

Designatiom	#	2011			2012			2013			2014			2015		
		Salary (BDT)/person	M	LOE	Salary/person	M	LOE	Salary/person	M	LOE	Salary/person	M	LOE	Salary/person	M	LOE
Chairman	1	164,165	5	30%	167,224	12	8%	200,669	12	10%	274,725	12	4%	274,725	7	10%
Chief of Reseach & Innovation								157,668	12	10%	219,780	12	4%	219,780	7	10%
Managing Director	1	154,784	5	30%	180,602	12	17%									
Director	1	46,904	5	40%	47,778	12	25%									
Manager, Operations	1	37,523	5	20%	119,446	12	25%	137,602	12	40%	163,836	12	8%	188,811	7	10%
R & D Coordinator	1	30,019	5	50%	76,445	12	4%									
Strategic Initiative	1	34,709	5	60%	42,045	12	42%									
Research Associate	1	25,328	5	60%	30,578	12	42%	53,034	12	20%	69,930	12	8%	83,417	7	25%
System Analyst	1	46,904	5	20%	57,334	12	25%									
Manager, Communications	1				76,445	12	4%									
Project Manager	3				43,000	12	8%	43,000	12	60%	59,940	12	50%	70,929	7	25%
Research Coordinator	1				49,689	12	17%									
Asst. Project Manager	1				28,667	12	17%									
Software Developer	1				81,223	12	42%									
Android Developer	1				23,889	12	33%	47,778	12	40%	59,940	12	13%			
Jr. Quality Control Engineer	1				15,289	12	25%	21,022	12	20%						
Deployment Assistant	1				19,111	12	8%	28,667	12	30%						
Field Coordinator	1				21,022	12	8%									
QA Manager	2							66,890	12	40%						
Jr. QC Engineer	3							43,000	12	40%	56,444	12	8%			
Jr. QA Engineer	1							76,445	12	20%	119,880	12	8%			
Network Administrator	2							23,889	12	20%						
Senior Research Analyst	1							52,556	12	20%	57,443	12	8%			
Project Manager	1							33,445	12	33%						
											129,870	12	8%			
											59,940	12	25%			
											29,970	12	21%			
											43,956	12	8%			
											31,469	12	8%			

2. Office equipments

Designatiom	Table	Chair	Laptop
Chairman	7000	6000	55000
Chief of Reseach & Innovation	7000	6000	55000
Managing Director	7000	6000	55000
Director	7000	6000	55000
Manager, Operations	7000	6000	55000
R & D Coordinator	7000	6000	55000
Strategic Initiative Coordinator	7000	6000	55000
Research Associate	7000	6000	55000
System Analyst	7000	6000	55000
Manager, Communications	7000	6000	55000
Project Manager	7000	6000	55000
Research Coordinator	7000	6000	55000
Asst. Project Manager	7000	6000	55000
Software Developer	7000	6000	55000
Android Developer	7000	6000	55000
Jr. Quality Control Engineer	7000	6000	55000
Deployment Assistant	7000	6000	55000
Field Coordinator	7000	6000	55000
QA Manager	7000	6000	55000
Jr. QC Engineer	7000	6000	55000
Jr. QA Engineer	7000	6000	55000
Network Administrator	7000	6000	55000
Senior Research Analyst	7000	6000	55000
Project Manager	7000	6000	55000
Staff 1	7000	6000	55000
Staff 2	7000	6000	55000
Staff 3	7000	6000	55000
Staff 4	7000	6000	55000
Staff 5	7000	6000	55000

3. Office maintenance

Sl. No	Line Item	Total (BDT)	Total (USD)	Remarks
1	House Rent	300000	3,900	Monthly Office Rent
2	Maintenance Charges	46500	605	Monthly building maintenance charges which also
3	Server Equipment &	25000	325	On average cost of maintaining a server elsewhere
4	Internet Bandwidth	26000	338	Monthly charge for internet bandwidth used in the
5	Photocopies/Office	10000	130	On average monthly expenditure
6	Utilities (Water, Electricity,	61350	798	Average monthly expenditure for water, electricity
7	Telecommunication	1500	20	Average monthly telephone bill
8	Support Staff	40000	520	Monthly cummulative salary of support staff
9	Postage & Courier, Bank	2500	33	On average monthly expenditure

A 2.4 Activity Based Costing

Program activities	Organization	Activity descriptions	Role/designation	Aug 2011-Dec 2011			Jan 2012-Dec 2012			Jan 2013-Dec 2013			Jan 2014-Dec 2014			Jan 2015-July 2015			Total costs (BDT)	Total costs (USD)
				Monthly Salary	M	LOE	Monthly Salary	M	LOE	Monthly Salary	M	LOE	Monthly Salary	M	LOE	Monthly Salary	M	LOE		
Development (August 2011-April 2013): 21 months																				
Partnership building (Aug-Dec, 2011)	mPOWER	Contract agreementwith mPOWER as technical system developer, leadership meetings among central program leadership, regional, and district health management teams. Official launch of mCARE project with partners	Chairman	164,165	5	30%													246,248	
			Managing Director	154,784	5	30%													232,176	
			Director	46,904	5	40%													93,809	
			Manager, Operations	37,523	5	20%													37,523	
			R & D Coordinator	30,019	5	50%													75,047	
			Strategic Initiative Coordinator	34,709	5	60%													104,128	
			Research Associate	25,328	5	60%													75,985	
			System Analyst	46,904	5	20%													46,904	
			P_Total																**911,820**	**11,854**
	JHU-JiVitA		Program manager	307,692	5	100%													1,538,460	
			JiVitA Research Fellow	230,769	5	20%													230,769	
			Senior Research Physician	95,030	5	40%													190,060	
			Senior Finance and Admin Ma	95,030	5	10%													47,515	
			Data Centre Manager	64,000	5	10%													32,000	
			J_Total																**2,038,804**	**26,504**
	A .Total costs																		**2,950,624**	**38,358**
Program/System development (Jan-2012-April 2013)	mPOWER	mPOWER prepared systems requirement specifications; develop scheduling logic, skip pattern, question type feedback; Development of detailed technical specifications (Developing end user centered design criteria; CHW workflow and information flow analysis)	Chairman				167,224	12	8%	200,669	4	13%							267,559	
			Managing Director				180,602	12	17%										361,204	
			Director				47,778	12	25%										143,335	
			Manager, Operations				119,446	12	25%	137,602	4	25%							495,939	
			Manager, Communications				76,445	12	4%										38,223	
			Strategic Initiative Coordinator				42,045	12	42%										210,225	
			Project Manager				43,000	12	8%	43,000	4	75%							172,002	
			Research Associate				30,578	12	42%	53,034	4	25%							205,925	
			Research Coordinator				49,689	12	17%										99,379	
			Asst. Project Manager				28,667	12	17%										57,334	
			Software Developer				81,223	12	42%										406,116	
			System Analyst				57,334	12	25%										172,002	
			Android Developer				23,889	12	33%	47,778	4	63%							215,002	
			Jr. Quality Control Engineer				15,289	12	25%	21,022	4	63%							98,423	
			Deployment Assistant				19,111	12	8%	28,667	4	25%							47,778	
			Field Coordinator				21,022	12	8%										21,022	
			Chief of Reseach & Innovation							157,668	4	13%							78,834	
			QA Manager							76,445	4	25%							76,445	
			P_Total																**3,166,746**	**41,168**
	JHU-JiVitA		Project Manager				307,692	12	100%	316,923	4	100%							4,959,995	
			JiVitA Research Fellow				230,769	12	10%	237,692	4	10%							372,000	
			Senior Research Physician				95,030	12	40%	102,443	4	40%							620,053	
			Senior Finance and Admin Manager				95,030	12	10%	102,443	4	10%							155,013	
			Data Centre Manager				64,000	12	10%	68,992	4	10%							104,397	
			J_Total																**6,211,457**	**80,749**
	B. Total cost																		**9,378,204**	**121,917**
Mobile phone procurement	JHU-JiVitA	Phone purchase, system embed, test, verification	Data Centre Manager							68,992	1	10%							6,899	
			IT offcer							15,580	1	50%							7,790	
	C. Total cost																		**14,689**	**191**
Total development cost																			**12,343,517**	**160,466**

System optimization (May-Aug, 2013)	mPOWER	Prototype development and test;Training manual development ; SMS service integration/outsourcing: Dashboard design & development (Oct-Dec 2013)	Chief Executive Officer	200,669	7	17%							234,114
			Chief of Reseach & Innovation	157,668	7	33%							367,893
			Head of Operations	137,602	7	33%							321,070
			Project Manager	43,000	7	50%							150,502
			Senior Research Analyst	53,034	7	67%							247,492
			Android Developer	47,778	7	40%							133,779
			QA Manager	66,890	4	40%							107,023
			Jr. QC Engineer	43,000	4	40%							68,801
			Deployment Assistant	76,445	7	20%							107,023
				21,022	7	20%							29,431
				23,889	4	20%							19,111
				52,556	7	33%							121,405
				28,667	7	33%							66,221
			Android Developer	33,445	3	33%							33,445
	D. Total cost												**2,007,310**
Community outreach and advocacy (May, 2013)	JHU-JiVitA	Establish MOU with govern't DGFP ;mCARE brochure; print community briefs; visit community Field site demarcation	Project Manager	316,923	1	100%							316,923
			JiVitA Research Fellow	237,692	1	10%							23,769
			Senior Research Physician	102,443	1	40%							40,977
			Senior Finance and Admin Manager	102,443	1	20%							20,489
			Data Centre Manager	68,992	1	10%							6,899
			Senior field staff	33,170	1	60%							19,902
			AC/Field Officer	17,000	1	50%							8,500
			MTL	11,000	1	100%							11,000
	E. Total cost												**448,459**
Training (June-Aug 2013)	JHU-JiVitA	Prepare training manuals; Print forms & methodology ; Training: 3 weeks (2-3 days a week) Evaluate FD/TLI/FWA performance/satisfaction Printing forms (census enumeration, JiVitA ANC pamphlets; PSR consent; MWRA registration form etc) Data management: data entry screen generation (PRF, SES, BAF); field testing	Project Manager	316,923	3	100%							950,768
			JiVitA Research Fellow	237,692	3	10%							71,308
			Senior Research Physician	102,443	3	60%							184,397
			Senior Finance and Admin Manager	102,443	3	20%							61,466
			Data Centre Manager	68,992	3	20%							41,395
			Senior field staff	33,170	3	100%							99,510
			AC/Field Officer	17,000	3	50%							25,500
			MTL	11,000	3	100%							33,000
			FI	11,000	3	50%							16,500
			FD	2,250	3	50%							3,375
	F. Total cost												**1,487,219**
Total start-up costs													**3,942,988**
Implementation (Sep 2013-Jun 2015): 22 months													
Data collection (Sep,2013-	mPOWER	Technical assistance: to fix the bugs within the application in order to ensure functionalities of the developed system; to manage and develope improvements within the application which came as Change Request; to maintain the overall system to ensure the integrity of the collected data and maintain the data center for the system. Finally, mPower completed customized reporting based on the collected data to enhance decision making by the stakeholders. (Jan-Dec, 2014)	Chief Executive Officer				274,725	12	4%	274,725	2	10%	192,308
			Chief of Reseach & Innovation				219,780	12	4%	219,780	2	10%	153,846
			Head of Operations				163,836	12	8%	188,811	2	10%	201,598
			Project Manager				59,940	12	50%	70,929	2	25%	395,105
			Senior Research Analyst				69,930	12	8%	83,417	2	25%	111,638
			Android Developer				129,870	12	8%				129,870
							59,940	12	13%				89,910
							56,444	12	8%				56,444
							119,880	12	8%				119,880
							57,443	12	8%				57,443
							59,940	12	25%				179,820
							29,970	12	21%				74,925
							43,956	12	8%				43,956
							31,469	12	8%				31,469
													1,838,212
	JHU-JiVitA	Supervision; Census enumeration (Sep 2013-Jun, 2014); Pregnancy surveillance; Intervention (SMS & advocacy home visits); Follow-up data collection; Data collection management (Sep, 2013-Jun,2015)	Project Manager	316,923	4	100%	326,430	12	100%	336,223	6	100%	7,202,196
			JiVitA Research Fellow	237,692	4	10%	244,823	12	10%	252,168	6	10%	540,165
			Senior Research Physician	102,443	4	30%	110,638	12	30%	121,710	6	30%	740,306
			Senior Finance and Admin Manager	102,443	4	30%	110,638	12	30%	121,710	6	30%	740,306
			Data Centre Manager	68,992	4	40%	68,992	12	40%	81,970	6	40%	638,277
			Senior field staff	33,170	4	60%	35,824	12	60%	39,410	6	60%	479,417
			AC/Field Officer	17,000	4	50%	18,360	12	50%	16,120	6	50%	192,520
			MTL	11,000	4	100%	11,880	12	100%	10,460	6	100%	249,320
			FI	11,000	4	30%	11,880	12	30%	10,460	6	30%	74,796
			FD	4,500	4	50%	4,940	12	30%	2,720	6	30%	31,680
													10,888,984
	G. Total costs												**12,727,195**
Data processing/documentation	JHU-JiVitA	Data cleaning, data analysis, Presentation; report writing	Project Manager							30,769	4	100%	123,077
			Program analyst							30,769	4	50%	61,538
	H. Total costs												**184,615**
Total implementation costs													**12,911,811**
Total program activity costs													**29,198,316**

A 2.5 Total Program Costs of JiVitA

1. Capital costs (Activity costs + Furniture/Equipments cost)

Capital costs	Categories	Costs for mCARE I				Adjustment			Annualized Cost allocated to Component of Project (2015, USD)
		Cost per item	Number of staffs/quantity	Total costs (BDT)	Total costs (USD)	CPI adjusted	Life expectancy (yr)	Annualization	
Furniture and Equipments (HQ)	Desks	6,500	26	169,000	2,197	2,856	10	8.53	258
	Chairs	3,500	26	91,000	1,183	1,538	10	8.53	139
	Cabinets	12,000	17	204,000	2,652	3,448	10	8.53	311
	Computer	45,000	12	540,000	7,020	9,127	5	4.58	1,533
	Laptop	50,000	5	250,000	3,250	4,225	5	4.58	710
	Motorbike	142,000	2	284,000	3,692	4,800	10	8.53	433
Furniture and Equipments (Field)	Table 1	6,500	5	32,500	423	549	10	8.53	50
	Table 2	8,000	12	96,000	1,248	1,623	10	8.53	146
	Chair 1	3,500	5	17,500	228	296	10	8.53	27
	Chair 2	1,500	25	37,500	488	634	10	8.53	57
	Bench	20,000	10	200,000	2,600	3,380	10	8.53	305
	Cabinets	13,000	5	65,000	845	1,099	10	8.53	99
	Computer	45,000	1	45,000	585	761	5	4.58	128
	Motobike	142,000	7	994,000	12,922	16,800	10	8.53	1,515
	Bicycle	6,000	25	150,000	1,950	2,535	10	8.53	229
	Rack	3,000	17	51,000	663	862	10	8.53	78
Total Furniture and Equipments (HQ + Field)				3,226,500	41,945	54,533			**6,015**
Mobile phone procurement	Mobile phone	8,559	70	599,130	7,789	10,126	3	2.83	2,752
	Mobile phone procurement	14,689		14,689	191	248	3	1.91	100
Mobile phone procurement				613,819	7,980	10,374			**2,852**
Personnel: Development phase	Partnership & consensus building	2,038,804	N/A	2,038,804	26,504	34,459	3	2.83	9,366
	Program/System development	6,211,457	N/A	6,211,457	80,749	104,983	3	2.83	28,533
Personnel: Start-up phase	Community campaign & awareness	448,459	N/A	448,459	5,830	7,580	3	2.83	2,060
	Trainning	1,487,219	N/A	1,487,219	19,334	25,136	3	2.83	6,832
Imlementation	Data processing /analyses				24000	24000	3	2.83	8,481
Total Activity costs				10,799,759	140,397	182531.6284			**46,791**

2. Recurrent costs (Activity costs + Maintenance/Service costs)

Recurrent costs	Categories	2012				2013				2014				2015				Total costs (BDT)	Total costs (USD)	Adjustment		
		Average maintenance costs (month)	months	LOE		Average maintenance costs (month)	months	LOE		Average maintenance costs (month)	months	LOE		Average maintenance costs (month)	months	LOE				CPI adjusted	Life expectancy (yr)	Annualization
Office maintenance costs (*They exclude salaries and allowance, training/seminars /workshop, fixed asset)	office rent,	307,877	12	15%	554,179	310,855	12	20%	746,052	245,143	12	30%	882,515	268,141	7	10%	187,698	2,370,444	30,816			
	electricity bills, gas, purchases, printi	39,712	12	15%	71,482	39011	12	20%	93,626	65365	12	30%	235,314	56291	7	10%	39,404	439,826	5,718			
	wage	53,674	12	15%	96,613	66,509	12	20%	159,622	39,569	12	30%	142,448	25,000	7	10%	17,500	416,183	5,410			
	fuel,	132,964	12	15%	239,335	149,987	12	20%	359,969	145,862	12	30%	525,103	84,100	7	10%	58,870	1,183,277	15,383			
	trevel and per diem,	116,414	12	15%	209,545	161,585	12	20%	387,804	101,842	12	30%	366,631	95,932	7	10%	67,152	1,031,133	13,405			
	repair and services,	36,713	12	15%	66,083	33,843	12	20%	81,223	70,688	12	30%	254,477	38,648	7	10%	27,054	428,837	5,575			
	bank charges,	3,210	12	15%	5,778	3,210	12	20%	7,704	4,778	12	30%	17,201	5,037	7	10%	3,526	34,209	445			
	supplies and other services,	173,182	12	15%	311,728	194,741	12	20%	467,378	227,122	12	30%	817,639	346,925	7	10%	242,848	1,839,593	23,915			
	stationaries.	56,247	12	15%	101,245	57,442	12	20%	137,861	48,170	12	30%	173,412	53,632	7	10%	37,542	450,060	5,851			
	HQ Admin staff+Technical staff+				783,792				1,168,632				1,903,993				361,851	4,218,268	4,218,268			
Total office maintenance costs					2,439,779				3,609,871				5,318,734				1,043,445	**12,411,829**	**4,324,784**			
Development (Aug 2011- April 2013)					2,439,779				1,203,290									3,643,070	47,360	61,573	1.91	32,237
Start up (May 2013-Sept 2013)									1,504,113									1,504,113	19,553	19,553	1.00	19,553
Implementation (Oct 2013-July 2015)									1,203,290				5,318,734				1,043,445	7,565,469	98,351	98,351	1.91	51,493
Supervision	Project Manager					307,692	3	100%	923,076	307,692	12	100%	3,692,304	307,692	7	100%	2,153,844	6,769,224	88,000			
	JiVitA Research Fellow					230,769	3	10%	69,231	230,769	12	10%	276,923	230,769	7	10%	161,538	507,692	6,600			
	Senior Research Physician					95,030	3	30%	85,527	95,030	12	30%	342,108	95,030	7	30%	199,563	627,198	8,154			
	Senior Finance and Admin Manager					95,030	3	30%	85,527	95,030	12	30%	342,108	95,030	7	30%	199,563	627,198	8,154			
	Data Centre Manager					64,000	3	40%	76,800	64,000	12	40%	307,200	64,000	7	40%	179,200	563,200	7,322			
																		9,094,512	118,229	118,229	1.91	61,900
Census enumeratio/Pregnancy surveillance/Data collection home visits	Senior field staff					33,170	2	60%	39,804	33,170	12	60%	238,824	33,170	7	60%	139,314	417,942	5,433			
	AC/Field Officer					68,000	2	50%	68,000	68,000	12	50%	408,000	68,000	7	50%	238,000	714,000	9,282			
	MTL : socio economic status and other survey					66,000	2	100%	132,000	66,000	12	100%	792,000	66,000	7	100%	462,000	1,386,000	18,018			
	FI : Study consent, JiVitA brochers					198,000	2	30%	118,800	198,000	12	30%	712,800	198,000	7	30%	415,800	1,247,400	16,216			
	FD (40) : pregnancy registration					90,000	2	50%	90,000	90,000	12	30%	324,000	90,000	7	30%	189,000	603,000	7,839			
									448,604				2,475,624				1,444,114	4,368,342	56,788	56,788	1.91	29,732
Reminder home visits	FD (20)					45000	4	10%	18,000	45000	12	10%	54,000	45000	5	10%	22,500	94,500	1,229	1,229	1.91	643
SMS reminder	Bulk SMS are sent from the server to our clients ($0.06 per client for 4 ANC/Delivery/3PNC reminders, 350 clients in intervention group)																	1,615	21	21	1.91	11
	Birth and Labor notification SMS from client ($0.031 per client, 350 clients intervention group)																	835	11	11	1.91	6
																		2,450	32	32	1.91	17
Total activity costs																		**14,945,804**	**194,295**			
Total recurrent costs																		27,357,633	4,519,080	4,519,080		195,592

A 2.6 Total Program Costs of mPOWER

1. Capital costs (Activity costs+ Furniture/Equipments costs)										
Capital costs	Categories	Costs for mCARE I					Adjustment		Annualized Cost allocated to Component of Project (2015, USD)
		Cost per item	Number of staffs/quantity	Total costs (BDT)	Total costs (USD)	CPI adjusted	Life expectancy	Annualization	
Furnitures and equipments	Chair	6,000	15	90,000	1,170	1,521	10	8.53	178
	Desk	7,000	15	105,000	1,365	1,775	10	8.53	208
	Computer/labtop	55,000	15	825,000	10,725	13,944	5	4.58	3,044
Total Furniture and Equipment				1,020,000	13,260	17,239			3,431
Development phase	Partnership & consensus building	911,820		911,820	11,854	15,411	3	2.83	5,446
	Program & system development	3,166,746		3,166,746	41,168	53,523	3	2.83	18,913
Start-up phase	Prototype testing and optimization	2,007,310		2,007,310	26,095	33,926	3	2.83	11,988
Total activity costs				6,085,876	79,116	85,336			36,346
Total capital costs					92,376	102,575			39,777

2. Recurrent costs (Activity costs + Maintenance/Service costs)

Recurrent costs	Categories	2011				2012				2013				2014				2015				Total costs (BDT)	Total costs (yr, USD)	Adjustment		
		Average maintenance costs (month)	months	LOE			months	LOE			months	LOE			months	LOE			months	LOE				CPI adjusted	Life expectancy (yr)	Annualization
Office maintenance	House Rent	300,000	5	30%	450,000	300,000	12	40%	1,440,000	300,000	12	40%	1440000	300,000	12	10%	360000	300,000	7	5%	105000	3,795,000	49,335			
	Maintenance Charges	46,500	5	30%	69,750	46,500	12	40%	223,200	46,500	12	40%	223200	46,500	12	10%	55800	46,500	7	5%	16275	588,225	7,647			
	Internet Bandwidth	26,000	5	30%	39,000	26,000	12	40%	124,800	26,000	12	40%	124800	26,000	12	10%	31200	26,000	7	5%	9100	328,900	4,276			
	Photocopies;office supplies; stationery/printer toner etc.	10,000	5	30%	15,000	10,000	12	40%	48,000	10,000	12	40%	48000	10,000	12	10%	12000	10,000	7	5%	3500	126,500	1,645			
	Utilities (Water, Electricity, Gas bill	61,350	5	30%	92,025	61,350	12	40%	294,480	61,350	12	40%	294480	61,350	12	10%	73620	61,350	7	5%	21472.5	776,078	10,089			
	Telecommunication (Telephone Bill)	1,500	5	30%	2,250	1,500	12	40%	7,200	1,500	12	40%	7200	1,500	12	10%	1800	1,500	7	5%	525	18,975	247			
	Support Staff	40,000	5	30%	60,000	40,000	12	40%	192,000	40,000	12	40%	192000	40,000	12	10%	48000	40,000	7	5%	14000	506,000	6,578			
	Postage & Courier, Bank Charges	2,500	5	30%	3,750	2,500	12	40%	12,000	2,500	12	40%	12000	2,500	12	10%	3000	2,500	7	5%	875	31,625	411			
	Employ benefit: 1) Health Insurance; 2) Festival Bonus (twice every ye				1897				4973				5722				3379				445	9,546	124.098			
Total Office maintenance costs					733,672				2,346,653				2,347,402				588,799				171,193	6,180,849	80,351	80,351	1.91	42,069
Development (Aug 2011- April 2013)					733,672				2,346,653				782,467									3,862,792	50,216	65,287	1.91	34,182
Start up (May 2013-Sept 2013)													978,084									978,084	12,715	12,715	1	12,715
Implementation (Oct 2013-July 2015)													782,467				588,799				171,193	1,542,459	20,052	20,052	1.91	10,498
Server maintenance	Phone connection charge for 70 CHWs									325	3		34,125	325	12		273,000	325	7		159,250	466,375	6,063			
	Server hosting									8000	3		24000	8000	12		96000	8000	7		56000	176,000	2,288			
	Server equipment and maintenance									25,000	3		75000	25,000	12		300000	25,000	7		175000	550,000	7,150			
Total server maintenance costs																						1,192,375	15,501	15,501	1.91	8,116
Technical assistance	Chief Executive Officer													274,725	12	4%	137,363	274,725	2	10%	54,945	192,308	2,500			
	Chief of Reseach & Innovation													219,780	12	4%	109,890	219,780	2	10%	43,956	153,846	2,000			
	Head of Operations													163,836	12	8%	163,836	188,811	2	10%	37,762	201,598	2,621			
	Project Manager													59,940	12	50%	359,640	70,929	2	25%	35,465	395,105	5,136			
	Senior Research Analyst													69,930	12	8%	69,930	83,417	2	25%	41,708	111,638	1,451			
	Android Developer													129,870	12	8%	129,870					129,870	1,688			
														59,940	12	13%	89,910					89,910	1,169			
														56,444	12	8%	56,444					56,444	734			
														119,880	12	8%	119,880					119,880	1,558			
														57,443	12	8%	57,443					57,443	747			
														59,940	12	25%	179,820					179,820	2,338			
														29,970	12	21%	74,925					74,925	974			
														43,956	12	8%	43,956					43,956	571			
														31,469	12	8%	31,469					31,469	409			
Total activity costs																						1,838,212	23,897	23,897	1.91	12,511
Total recurrent costs																						**9,211,435**	**119,749**	119,749		78,022

Appendix 3. Lives Saved Tool Modeling

A 3.1 Model inputs

LiST Interventions (selected)		Baseline (2015)	Projected coverage increase in Bangladesh (2025)					
			Comprehensive mCARE		**Basic mCARE**		**Paper based status quo**	
			x 2.36 times		x 1.55 times		x 1.09 times	
			Community	Facility	Community	Facility	Community	Facility
Pregnancy	Antenatal care	31.2	73.6	73.6	48.4	48.4	34.0	34.0
Childbirth	Skilled birth attendance*	42.1	99.4	99.4	65.3	65.3	45.9	45.9
	Facility delivery* (Clinic and Hospital)	37.4	n/a	88.3	n/a	58.0	n/a	40.8
Breastfeeding	Promotion of breastfeeding (<1 month)	61.0	100.0	100.0	94.6	94.6	66.5	66.5
Preventive	Postnatal care (Clean postnatal practice)	31.5	74.3	74.3	48.8	48.8	34.3	34.3
	Complementary feeding (education only)	20.9	49.3	49.3	32.4	32.4	22.8	22.8
Curative	Case management of premature babies (Thermal care)	37.4	88.3	88.3	58.0	58.0	40.8	40.8
	Case management of neonatal sepsis/pneumonia	37.4	n/a	88.3	n/a	58.0	n/a	40.8

Notes: Baseline coverage data were compiled from Demographic and Health Surveys (DHS: Bangladesh, 2014); Multiple Indicator Cluster Survey (MICS Round 3: Bangladesh, 2006).

*Coverage measure of SBA includes coverage measure of FD. Thus we modeled coverage increase for SBA and FD simultaneously as 10%, 30%, and 50%. Data course of SBA and FD is from DHS/MICS and percentages of home deliveries and facility deliveries are based on LiST imbedded algorithms.

**Estimations of home deliveries (unassisted deliveries, and assisted deliveries), facility deliveries (Essential care, BEmOC, CEmOC), exclusive breastfeeding, predominant breastfeeding, and partial breastfeeding are derived from the LiST imbedded algorithms.

Antenatal care (ANC4+): Percent of pregnant women with at least 4 antenatal care visits during their pregnancy. The intervention includes Routine (TT, IPTp, Syphilis detection and treatment), Nutritional (Calcium supplementation), Case management (Diabetes, Management of pre-eclampsia), Other (Fetal growth restriction detection and management) This analysis does not include iron-folic acid. Data source of ANC is from DHS/MICS.

Skilled Birth Attendance (SBA): Percent of children born who are attended by a skilled attendance, including doctors, nurses, midwives- in a facility or home. An SBA in the home is defined as a skilled birth attendant who deliveries the infant at home without benefit of referral to a facility in case of emergency. An SBA in a facility is defined as a medically skilled attendant who has the ability and facilities needed to monitor labor progress with a partograph and detect complications. Episiotomy is available, if needed. Infection control is covered under clean birth practices; Facility delivery (FD): Percent of children born in an institution.

A 3.2 Model outputs (Comprehensive mCARE program)

Intervention	Percentage	Multiplying factor
Annual coverage increase rate	10%	1.10
Coverage increase rate (2016-2025)		2.36

Service coverage

Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	Source
ANC 4 or more	31%	34%	38%	41%	45%	50%	55%	60%	66%	73%	Baseline coverage (DHS 2014; p142)
ANC less than 4	69%	66%	62%	59%	55%	50%	45%	40%	34%	27%	Baseline coverage (DHS 2014; p142)
Facility delivery	38%	42%	46%	51%	56%	61%	67%	74%	81%	90%	Baseline coverage (DHS 2014; p145)
Home delivery	62%	58%	54%	49%	44%	39%	33%	26%	19%	10%	Baseline coverage (DHS 2014)
PNC	36%	40%	44%	48%	53%	58%	64%	70%	77%	85%	Baseline coverage (DHS 2014; p153)
No PNC	64%	60%	56%	52%	47%	42%	36%	30%	23%	15%	Baseline coverage (DHS 2014; p153)

Total Effectiveness (National)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved (community)	6	12	18	24	30	36	41	46	52	57	57~1271
Maternal lives saved (facility)	163	319	466	605	737	860	975	1,082	1,180	1,271	
Neonatal lives saved (community)	1,722	3,385	4,995	6,529	7,997	9,398	10,734	12,002	13,202	14,334	14,334~29,520
Neonatal lives saved (facility)	4,315	8,296	11,956	15,291	18,325	21,075	23,557	25,785	27,768	29,520	
Still birth lives saved (community)	719	1,430	2,136	2,822	3,493	4,149	4,790	5,414	6,020	6,607	6,607~19,204
Still birth lives saved (facility)	2,115	4,199	6,250	8,251	10,204	12,110	13,966	15,769	17,516	19,204	
Population adjustment factor	1.56%	3.13%	4.69%	6.25%	7.81%	9.38%	10.94%	12.50%	12.50%	12.50%	n/a
Total Effectiveness (District)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved (community)	0	0	1	2	2	3	4	6	7	7	7~159
Maternal lives saved (facility)	3	10	22	38	58	81	107	135	148	159	
Neonatal lives saved (community)	27	106	234	408	625	881	1,174	1,500	1,650	1,792	1792~3690
Neonatal lives saved (facility)	67	259	560	956	1,432	1,976	2,577	3,223	3,471	3,690	
Still birth lives saved (community)	11	45	100	176	273	389	524	677	753	826	826~2401
Still birth lives saved (facility)	33	131	293	516	797	1,135	1,528	1,971	2,190	2,401	
										Min	2,625
										Max	6,249

A 3.3 Model outputs (Basic mCARE program)

Control	Percentage	Multiplying factor
Annual coverage increase rate	5%	1.05
Coverage increase rate (2016-2025)		1.55

Service coverage

Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	Source
ANC 4 or more	31%	33%	34%	36%	38%	40%	42%	44%	46%	48%	Baseline coverage (DHS 2014; p142)
ANC less than 4	69%	67%	66%	64%	62%	60%	58%	56%	54%	52%	Baseline coverage (DHS 2014; p142)
Facility delivery	38%	40%	42%	44%	46%	48%	51%	53%	56%	59%	Baseline coverage (DHS 2014; p145)
Home delivery	62%	60%	58%	56%	54%	52%	49%	47%	44%	41%	Baseline coverage (DHS 2014)
PNC	36%	38%	40%	42%	44%	46%	48%	51%	53%	56%	Baseline coverage (DHS 2014; p153)
No PNC	64%	62%	60%	58%	56%	54%	52%	49%	47%	44%	Baseline coverage (DHS 2014; p153)

Total Effectiveness (National)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved (community)	3	5	7	10	12	14	17	19	21	23	23~751
Maternal lives saved (facility)	89	176	259	339	416	490	560	627	691	751	
Neonatal lives saved (community)	771	1,525	2,258	2,971	3,661	4,338	4,983	5,605	6,202	6,774	6774~15728
Neonatal lives saved (facility)	1,952	3,823	5,608	7,307	8,919	10,454	11,898	13,258	14,534	15,728	
Still birth lives saved (community)	291	579	862	1,139	1,411	1,683	1,943	2,196	2,441	2,679	2679~9902
Still birth lives saved (facility)	1,086	2,156	3,207	4,236	5,243	6,233	7,191	8,123	9,027	9,902	
Population adjustment factor	1.56%	3.13%	4.69%	6.25%	7.81%	9.38%	10.94%	12.50%	12.50%	12.50%	n/a
Total Effectiveness (District)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved (community)	0	0	0	1	1	1	2	2	3	3	3~94
Maternal lives saved (facility)	1	6	12	21	33	46	61	78	86	94	
Neonatal lives saved (community)	12	48	106	186	286	407	545	701	775	847	847~1966
Neonatal lives saved (facility)	31	119	263	457	697	980	1,301	1,657	1,817	1,966	
Still birth lives saved (community)	5	18	40	71	110	158	213	275	305	335	335~1238
Still birth lives saved (facility)	17	67	150	265	410	584	787	1,015	1,128	1,238	
										Min	1,185
										Max	3,298

A 3.4 Model outputs (Paper based status quo)

Status quo	Percentage	Multiplying factor
Annual coverage increase rate	1%	1.01
Coverage increase rate (2016-2025)		1.09

Service coverage

Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	Source
ANC 4 or more	31%	31%	32%	32%	32%	33%	33%	33%	34%	34%	Baseline coverage (DHS 2014; p142)
ANC less than 4	69%	69%	68%	68%	68%	67%	67%	67%	66%	66%	Baseline coverage (DHS 2014; p142)
Facility delivery	38%	38%	39%	39%	40%	40%	40%	41%	41%	42%	Baseline coverage (DHS 2014; p145)
Home delivery	62%	62%	61%	61%	60%	60%	60%	59%	59%	58%	Baseline coverage (DHS 2014)
PNC	36%	36%	37%	37%	37%	38%	38%	39%	39%	39%	Baseline coverage (DHS 2014; p153)
No PNC	64%	64%	63%	63%	63%	62%	62%	61%	61%	61%	Baseline coverage (DHS 2014; p153)

Total Effectiveness (National)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved (community)	0	1	1	2	2	2	3	3	3	4	4~46
Maternal lives saved (facility)	5	10	15	20	24	29	33	38	42	46	
Neonatal lives saved (community)	127	252	375	495	613	727	839	948	1,054	1,156	1156~2513
Neonatal lives saved (facility)	280	555	825	1,088	1,344	1,593	1,834	2,069	2,295	2,513	
Still birth lives saved (community)	48	95	141	187	231	275	317	358	399	438	438~737
Still birth lives saved (facility)	80	160	238	314	389	463	534	604	672	737	
Population adjustment factor	1.56%	3.13%	4.69%	6.25%	7.81%	9.38%	10.94%	12.50%	12.50%	12.50%	n/a
Total Effectiveness (District)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Maternal lives saved (community)	0	0	0	0	0	0	0	0	0	1	1~6
Maternal lives saved (facility)	0	0	1	1	2	3	4	5	5	6	
Neonatal lives saved (community)	2	8	18	31	48	68	92	119	132	145	145~314
Neonatal lives saved (facility)	4	17	39	68	105	149	201	259	287	314	
Still birth lives saved (community)	1	3	7	12	18	26	35	45	50	55	55~92
Still birth lives saved (facility)	1	5	11	20	30	43	58	76	84	92	
										Min	200
										Max	412

A 3.5 Causes of Deaths

Percent of neonatal deaths by proximate causes	Diarrhea	0.38	Percent of child deaths by proximate cause • Definition: The proportion of under-five deaths due to one of eight neonatal causes (diarrhea, sepsis, pneumonia, asphyxia, prematurity, tetanus, congenital anomalies, and other) and nine post-neonatal causes (diarrhea, pneumonia, meningitis, measles, malaria, pertussis, AIDS, injury, and other). • Default data source: WHO estimates for years 2000-2015. http://www.who.int/healthinfo/global_burden_disease/estimates_child_cod_2015/en/. • Notes: All causes of death can be modified in this table except the HIV deaths, which are brought in from the AIDS Impact Module (AIM). To modify these, you will need to open and edit within AIM. Also note that the sum of these causes should equal 100%.
	Sepsis	13.57	
	Pneumonia	5.36	
	Asphyxia	22.59	
	Prematurity	34.38	
	Tetanus	0.35	
	Congeital anomalies	16.22	
	Other	7.14	
	Total	100	
Percent of postnatal deaths by proximate causes	Diarrhea	11.88	
	Pneumonia	29.05	
	Meninigtis	3.54	
	Measles	8.54	
	Malaria	3.18	
	Pertussis	1.37	
	AIDS	2.06	
	Injury	11.42	
	Other	28.96	
	Total	100	
Percent of stillbirths by proximate causes	Antepartum	74.8	Percent of stillbirths by proximate cause ·Definition: Stillbirths are not categorized by cause due to a lack of data. Rather, they are categorized by time period, either antepartum (prior to delivery) and intrapartum (during delivery). ·Default data source: Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. Lancet 2016; 387: 587-603. http://www.ncbi.nlm.nih.gov/pubmed/26794078. (Supplementary appendix.) ·Notes: Values are by region.
	Intrapartum	25.2	
	Total	100	
Percent of maternal deaths by proximate causes	Antepartum hemorrhage	5.11	Percent of maternal deaths by proximate cause • Definition: The proportion of maternal deaths due to one of nine causes (antepartum hemorrhage, intrapartum hemorrhage, postpartum hemorrhage, hypertensive disorders, sepsis, abortion, embolism, other direct causes, and indirect causes). • Default data source: Say L, Chou D, Gemmill A, et al. Global causes of maternal death: A WHO systematic analysis. Lancet Global Health 2014; 2(6): e323-33. http://www.ncbi.nlm.nih.gov/pubmed/25103301. Data are from unpublished tables associated with this article.
	Intrapartum hemorrhage	2.05	
	Postpartum hemorrhage	28.68	
	Hypertensive disorders	16.9	
	Sepsis	4.97	
	Abortion	5	
	Embolism	11.82	
	Other direct causes	11.77	
	Indirect causes	13.7	
	Total	100	

A 3.6 Effectiveness Assumptions

Maternal		Effectiveness	Affected fraction
Antepartum hemorrhage	n/a	n/a	n/a
Intrapartum hemorrhage	n/a	n/a	n/a
Postpartum hemorrhage	n/a	n/a	n/a
Hypertensive disorders	Calcium supplementation	0.2	1
	Hypertensive disorder cause management	0.5	1
	MgSO4 management of pre-eclampsia	0.59	1
Sepsis	Maternal sepsis case management	0.8	1
Abortion	Safe abortion services	0.95	0.90526
	Post abortion case management	0.8	0.90526
	Ectopic pregnancy case management	0.9	0.09474
Other direct causes	n/a	n/a	n/a
Indirect causes	TT - Tetanus toxoid vaccination	0.98	0.0049
	Malaria case management	0.8	0.021

Maternal delivery effectiveness		**Effectiveness**					**Affected fraction**
		Unassisted delivery	**Assisted delivery at home (SBA)**	**Essential care**	**BEmOC**	**CEmOC**	**All deliveries**
Antepartum hemorrhage	Labor and delivery management	0	0	0	0.2	0.8	1
Intrapartum hemorrhage	Labor and delivery management	0	0	0	0.2	0.8	1
Postpartum hemorrhage	Labor and delivery management	0	0	0	0.35	0.65	1
	AMTSL- Active management of the third stage of labor	0	0.7	0.7	0.7	0.7	1
Hypertensive disorders	Labor and delivery management	0	0	0	0	0.68	1
	MgSO4 management of eclampsia	0	0.6	0.6	0.6	0.6	1
Sepsis	Clean birth practices	0	0.6	0.6	0.6	0.6	1
	Antibiotics for pPRoM	0	0.8	0.8	0.8	0.8	0.33
Abortion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Other direct causes	Labor and delivery management	0	0	0	0.38	0.93	0.07816
Indirect causes	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Stillbirth		Effectiveness	Affected fraction
Antepartum	Syphillis detection and treatment	0.82	0.0024
	Multiiple micronutrient supplemenetation in pregnancy	0.09	1
	Balanced energy supplementation	0.4	0.4365
	Diabetes case management	0.1	0.10634
	MgSO4 management of pre-eclampsia	0.2	0.08088
Intrapartum	Multiiple micronutrient supplemenetation in pregnancy	0.09	1
	Balanced energy supplementation	0.4	0.4365
	Diabetes case management	0.1	0.10634
	MgSO4 management of pre-eclampsia	0.2	0.08088

Maternal delivery effectiveness		**Effectiveness**					**Affected fraction**
		Unassisted delivery	**Assited delivery at home (SBA)**	**Essential care**	**BEmOC**	**CEmOC**	**All deliveries**
Antepartum hemorrhage	Induction of labor for pregnancies lasting 41+ weeks	0	0	0	0	0.69	0.036
Intrapartum hemorrhage	Labor and delivery management	0	0.23	0.23	0.45	0.75	1
	Induction of labor for pregnancies lasting 41+ weeks	0	0	0	0	0.69	0.036

Neonatal deaths		Effectiveness	Affected fraction
NN - Diarrhea	ORS - Oral rehydration solution	0.93	0.90
	Antibiotics for treatment of dysentery	0.82	0.10
	Zinc for treatment of diarrhea	0.23	1.00
NN - Sepsis	Syphillis detection and treatment	0.97	0.01
	Clean postnatal practices	0.40	1.00
	Oral antibiotics for neonatal sepsis/pneumonia	0.28	1.00
	Injectable antibiotics for neonatal sepsis/pneumonia	0.65	1.00
	Full supportive care for neonatal sepsis/pneumonia	0.80	1.00
NN - Pneumonia	Oral antibiotics for neonatal sepsis/pneumonia	0.42	1.00
	Injectable antibiotics for neonatal sepsis/pneumonia	0.75	1.00
	Full supportive care for neonatal sepsis/pneumonia	0.90	1.00
NN - Asphyxia	n/a	n/a	n/a
NN - Prematurity	Thermal care	0.20	1.00
	KMC - Kangaroo mother care	0.51	0.58

	Full supportive care for prematurity	0.80	1.00
NN - Tetanus	TT - Tetanus toxoid vaccination	0.94	1.00
	Clean postnatal practices	0.40	1.00
NN - Congenital Anomalies	Folic acid supplementation/fortification	0.46	0.70
NN - Other	n/a	n/a	n/a

Neonatal intervention effectiveness		Effectiveness					Affected fraction
		Unassisted delivery	Assited delivery at home (SBA)	Essential care	BEmOC	CEmOC	All deliveries
NN - Diarrhea	n/a	n/a	n/a	n/a	n/a	n/a	n/a
NN - Sepsis	Clean birth practices	0.15	0.23	0.27	0.27	0.27	1
	Antibiotics for pPRoM	0	0	0.39	0.39	0.39	0.198
NN - Pneumonia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
NN - Asphyxia	Immediate assessment and stimulation	0.1	0.1	0.1	0.1	0.1	1
	Labor and delivery management	0	0.25	0.25	0.4	0.85	1
	Neonatal resuscitation	0	0.2	0.3	0.3	0.3	1
NN - Prematurity	Immediate assessment and stimulation	0.1	0.1	0.1	0.1	0.1	1
	Labor and delivery management	0	0.1	0.1	0.1	0.1	1
	Neonatal resuscitation	0	0.05	0.1	0.1	0.1	1
	Antibiotics for pPRoM	0	0	0.12	0.12	0.12	0.33
NN - Tetanus	Clean birth practices	0.3	0.35	0.38	0.38	0.38	1
NN - Congenital Anomalies	n/a	n/a	n/a	n/a	n/a	n/a	n/a
NN - Other	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Impact of promotion of age-appropriate breastfeeding	Odds ratio (<1 month)
Health system promotion	2.03
Home/community promotion	2.17
Health system + home/community promotion	2.33
KMC - Kangaroo mother care	1.5
Impact of promotion on early initiation of breastfeeding	Odds ratio (<1 month)
Health system promotion	1.82
Home/community promotion	3.38
Health system + home/community promotion	4.96

Appendix 4. Community Health Workers Responsibilities and Workload

Staff	Major work responsibility and routine	Activity, process and resource specification	Paper based system	mCARE system First year	mCARE system Following year
			LOE	LOE	LOE
FWA responsibility (Time allocation % in a month)	Registration of households and eligible couple	Every three years, Family Welfare Assistants (FWAs) register all households (HH) and eligible couples (ELCO) in new register, which take about three months.			
	ELCO/MWRA registration	If FWAs find new ELCOs who came to the village during field visits, FWAs register the ELCO in their registers.	5%	10%	3%
	Pregnancy surveillance	FWAs identify and register pregnant women during field visits through observation or community referrals. FWAs refer the pregnant to Family Welfare Visitors.	17%	34%	9%
	MNCH Service provision	ANC: FWAs assist the pregnant women for coming to satellite or family welfare centers from their home; FWAs provide tt vaccine to pregnant women, measure their weights, check edema then refer them to family welfare centers.	48%	31%	64%
		Child delivery: When pregnant women expect due dates of child delivery, FWAs inform FWV over phone or verbally.			
		PNC: After child delivery, FWA enter child information to the register, advise mothers for postnatal and newborn care and birth control within 45 days			
		Family Planning: Among the total seven methods of family planning, here FWAs provide condom, long term injection (except first dose), and oral pills. FWAs also refer pregnant women to FWVs who want to take permanent method such as IUD.			
		EPI (immunization): FWAs inform villagers for vaccination and assist Health Assistant (HA) for injection of vaccines (bcg, tt etc)			
	Non MNCH service provision	TB or other general disease: FWAs only refer pregnant women to community clinic or family welfare centers			
	Meeting	FWAs attends by weekly meetings (two times in month) at union level and a one day meeting (once a month) at Upazilla level;	10%	10%	10%
	Data reporting/processing	FWAs prepare reports for the meetings mentioned above.	10%	5%	5%
	Personal (idle) time	n/a			
	Total		100%	100%	100%
FWV responsibility (Time	ANC	FWVs visit pregnant women four times for ANC, the 1st visit within 4 month, 2nd within 6 month, 3rd visit within 8 months and 4th visit within 9 month; FWVs do check up blood pressure, weight, edema; FWVS calculate ***last menstrual***	19%		

allocation % over a month)		***period*** (***LMP) and e***stimate date of delivery (EDD) pregnancy; FWVs provide iron folic acid, position of a baby etc.	
	DELIVERY	FWVs do normal deliveries at the pregnant women's home; FWVs provide some medicine for any complications or refer them to medical officers.	19%
	PNC	FWVs provide postnatal and newborn care service for one month after women's child delivery; FWVs measure child weight, mother's physical condition etc	17%
	Family planning	FWVs provide permanent method of family planning such as IUD to referred pregnant women	10%
	Referral	As mentioned above	5%
	Meeting	FWVs attends by weekly meetings (two times in month) at union level and a one day meeting (once a month) at Upazilla level;	10%
	Data reporting/processing		10%
	Personal (idle) time		10%
	Total		100%
FPI responsibility (Time allocation % over a month)	FWAs activities monitoring	Family Planning Inspectors(FPIs) visit field and review FWAs' registers frequently	30%
	FWVs activities monitoring	FPIs visit field and review FWVs' registers frequently	10%
	EPI monitoring	In every union, 8 EPI programs are held in a month, FPIs present at the EPI programs and assist and inspect data entry to the registers for HA	10%
	Meeting with UFPO	FPIs attend by weekly meeting as a chairperson, review/report the activities of FWAs and FWVs to UFPO.	10%
	Visiting community clinic	FPI monitor the activity of community health provider who treat as general and primary treatment	10%
	Motivational program with villagers on family planning	FPIs meet 1-3 times in a month with community residents for education and counseling of family planning at various places in the village that is called house indoor meeting, here.	5%
	Meeting with local government on family planning	FPIs hold a meeting to report and discuss on family planning in union council while government officers and NGO staff are present.	5%
	Data reporting/processing	Generally, FWAs prepare report and FPI review and modify them and then submit them to UFPO	10%
	Personal (idle) time		10%
	Total		100%

Appendix 5. Model Parameters

A 5.1 Parameters of Program Costs

Start-up		Input	Unit	Source
mCARE systems				
Partnership & consensus building (workshop, traveling, management)	Number of regional officials attending workshop	30~40	persons	mPOWE Field staff & JiVita Senior Management Team
	Number of days per district workshop	1	days	
	Number of district workshop over a year	4	times	
	Printing documents per session	2.6	USD	
	Refreshers (snacks or teas) per session	26	USD	
	Long distance traveling (5 staff for 3 days stay from Dhaka to Gaibandha)	1550	USD	
	Number of long distance traveling in a year	2	times	
	Number of Program officer/coodinator (manager in each district)	8	person	
	Average salary (based on UFPO salary)	650	UDS	
	Number of months (1 week 4 times of workshops in a year)	1	months	
	Level of effort (LOE)	100%	percentage	
	Total costs of partnership & consensus building	$5,314	USD	
System optimization	Type of software platform	OpenSRP	name	mPOWE Field staff & JiVita Senior Management Team
	Number of engineers working on this	6	persons	
	Salary: Chief of operation	6000	USD	
	Salary: Senior software lead	5000	USD	
	Salary: Senior engieneer	4000	USD	
	Salary: Tech software	2000	USD	
	Salary: Project manager	2500	USD	
	Salary: mHealth specialist (research and management)	2500	USD	
	Number of months required for system optimization (assuming they are working with 100% LOE)	2	months	
	Field testing with travels (3 tech staff 1 week staying in Gaibandha for requirement gathering and user tests)--including a round trip by bus, accomodation, local tranportation etc. $80 per diem with $70 travel costs per person	1410	USD	
	Number of traveling in a year	1	times	
	Total costs for system optimization	$45,410	USD	
Telephone / tablet procurements	Type and model of phone/tablet	Samsung	name	mPOWE Field staff & JiVita Senior Management Team
	Cost per phone/tablet	200	USD	
	Number of phones/tablets	546	phones	
	Phone breakage rate	5%	rate	
	Total costs for phone/tablet procurement	$114,660	USD	
Trainer's training (w/ tablet)	Total number of chief trainers (JiVitA and mPOWER)	10	person	mPOWE Field staff & JiVita Senior Management Team
	Total number of Government trainers (FPI/UFPO)	50	person	
	Number of trainers per training session	10	person	
	Average number of CHW per session	25	person	
	Total required number of training sessions (to train 50 trainnees)	2	sessions	
	Number of days per a training session	5	days	
	Total working days (including traveling) per a trainign session	1	Week	
	Total required number of weeks for training	2	weeks	
	Average "weekly" salary of a trainer	750	USD	
	Training cost per session (10 traners, 25 trainees, 1 week)	7500	USD	
	Traveling of trainners (5 staff from Dhaka to Gaibandha a round trip by bus)	350	USD	

	Refreshers to participants ($20/person/day)--meals and snacks	10000	USD	
	Daily allowance to trainers ($80/person/day for accomodation,transportation, meals etc)	8000	USD	
	Total annual training costs (10 trainers, 50 trainees, 2 week)	$33,350	USD	
Training (w/ Tablet)	Total number of trainners	50	person	mPOWE Field staff & JiVita Senior Management Team
	Total number of CHWs (FWA nad FWV in Gaibandha)	500	person	
	Number of trainers per training session	5	person	
	Average number of CHW per session	25	person	
	Number of days per a training session	5	days	
	Total working days (including traveling) per a training session	1	Week	
	Average "weekly" salary of a trainer	130	USD	
	Training cost per session (5 trainers, 25 CHWs, 1 week)	650	USD	
	Training cost 1 batch (5 trainers, 50 CHWs, 2 weeks)	1300	USD	
	Training cost 10 batch (50 trainers, 500 CHWs, 2 weeks)	13000	USD	
	Traveling (if any, please specify)	0	USD	
	Refreshers ($20 per person)	110000	USD	
	Daily allowance (if any, please specify)	n/a	USD	
	Total annual training costs (50 trainers, 500 CHWs, 2 week)	$123,000	USD	
Status quo (Paper system)				
Survey printing	Number of registries	20	items	mPOWE Field staff & JiVita Senior Management Team
	Total number of registries for all CHWs	10000	items	
	Average unit price for printing one registries	2.6	USD	
	Total costs of printing registries	$26,000	USD	
Training (paper)	Total number of trainers	50	person	mPOWE Field staff & JiVita Senior Management Team
	Total number of CHWs (FWA and FWV in Gaibandha)	500	person	
	Number of trainers per training session	5	person	
	Average number of CHW per session	25	person	
	Number of days per a training session	2	sessions	
	Total working days (including traveling) per a training session	1	days	
	Average "weekly" salary of a trainer	65	Week	
	Training cost per session (5 trainers, 25 CHWs, 1 week)	325	weeks	
	Training cost 1 batch (5 trainers, 50 CHWs, 2 weeks)	650	USD	
	Training cost 10 batch (50 trainers, 500 CHWs, 2 weeks)	$6,500	USD	
Implementation		**Input**	**Unit**	
mCARE Intervention				
Supervision	Number of senior staff (UFPO)	7	person	mPOWE Field staff & JiVita Senior Management Team
	Number of staff (FPI)	82	person	
	Salary: UFPO	650	USD	
	Salary: FPI	260	USD	
	Number of months	12	months	
	LOE	50%	percentage	
	Total cost	$127,920	USD	
Census enumeration (w/Phone)	Number of CHWs	421	persons	mPOWE Field staff & JiVita Senior Management Team
	Average salary of CHWs	234	USD	
	Number of months for census enumeration	2	months	
	LOE (First year)	10%	percentage	
	LOE (Following year)	3%	percentage	
	Total cost (First year)	19,703	USD	
	Total annual cost (Following year)	$5,911	USD	
Pregnancy surveillance (w/Phone)	Number of CHWs	500	person	mPOWE Field staff & JiVita
	Average salary of CHWs	234	USD	
	Number of months for pregnancy surveillance	10	percentage	

	LOE (First year)	34%	percentage	Senior Management Team
	LOE (Following year)	9%	percentage	
	Total cost (First year)	397,800	USD	
	Total annual cost (Following year)	$105,300	USD	
SMS	Birth and Labor notification SMS from client (dollar per SMS)	0.031	USD	mPOWE Field staff & JiVita Senior Management Team
	Bulk SMS are sent from the server to our clients (dollar per SMS)	0.007	USD	
	Frequency of SMS to a client	8	times	
	Total number of clients (pregnant women) in a year	6,300	times	
	Total costs	$328	USD	
Server maintenance & connection	Monthly connection fee	3.9	USD	mPOWE Field staff & JiVita Senior Management Team
	Number of CHWs	500	persons	
	Server maintenance monthly fee (8000 Taka)	234	months	
	Number of months	12	dollar	
	Total costs	$4,758	USD	
Reminder home visits	Number of CHWs	421	persons	mPOWE Field staff & JiVita Senior Management Team
	Salay of CHW	234	USD	
	Number of months	12	months	
	LOE of CHW	10%	percentage	
	Total costs	$118,217	USD	
Data reporting & processing (w/Phone)	Number of CHWs	421	persons	mPOWE Field staff & JiVita Senior Management Team
	Salay of CHW	234	USD	
	Number of months	12	months	
	LOE of CHW	5%	percentage	
	Total costs	$59,108	USD	
Status quo (Paper system)				
Census enumeration (w/Paper)	Number of CHWs	421	persons	mPOWE Field staff & JiVita Senior Management Team
	Average salary of CHWs	234	USD	
	Number of months for census enumeration	3	months	
	LOE	5%	percentage	
	Total costs	$14,777	USD	
Pregnancy surveillance (w/Paper)	Number of CHWs	421	persons	mPOWE Field staff & JiVita Senior Management Team
	Average salary of CHWs	234	USD	
	Number of months for pregnancy surveillance	9	months	
	LOE	17%	percentage	
	Total costs	$150,726	USD	
Reminder home visits (w/Paper)	Number of CHWs	421	persons	mPOWE Field staff & JiVita Senior Management Team
	Salay of CHW	234	USD	
	Number of months	12	months	
	LOE of CHW	10%	percentage	
	Total costs	$118,217	USD	
Data reporting & processing (w/Paper)	Number of CHWs	421	persons	mPOWE Field staff & JiVita Senior Management Team
	Salay of CHW	234	months	
	Number of months	12	months	
	LOE of CHW	10%	percentage	
	Total costs	$118,217	USD	

A 5.2 Parameters on Provider and User Costs

Demographic assumption			Unit	Source
Year	Baseline year	2015	year	
Geographic area	Area	16,184.99	km2	
	Rangpur division	15,787,758	person	Bangladesh 2011 Census
Population size	Gaibandha district	2,379,255	person	Bangladesh 2011 Census
	Rangpur	2,881,086	person	Bangladesh 2011 Census
	Kurigram	2,069,273	person	Bangladesh 2011 Census
	Dinajpur	2,990,128	person	Bangladesh 2011 Census
	Nilfamari	1,834,231	person	Bangladesh 2011 Census
	Larmonirhat	1,256,099	person	Bangladesh 2011 Census
	Panchagarh	987,644	person	Bangladesh 2011 Census
	Thakurgaon	1,390,042	person	Bangladesh 2011 Census
Pregnant women (in 2015)	Population size (Gaibandha district)	2.4 million	person	Bangladesh 2011 Census
	Woman of reproductive age (WRA) (15~49) (WRA)	604,436	person	LiST (2015)
	Fertility rate (B)	2.13	rate	LiST (2015)
	Abortion rate (A)	18.20	rate	LiST (2015)
	Fetal loss rate (D)	25.36	rate	LiST (2015)
	Pregnant women	6,635	person	CDC
Service assumption			Unit	Source
Baesline coverage (2015)	ANC 4 or more	31%	percentage	DHS 2014
	ANC 0	69%	percentage	DHS 2014
	Facility delivery	38%	percentage	DHS 2014
	Home delivery	62%	percentage	DHS 2014
	Any PNC	36%	percentage	DHS 2014
	No PNC	64%	percentage	DHS 2014
Coverage increase rate	mCARE intervention (ANC/Facility delivery/PNC)	10%	rate	mCARE I result
	mCARE control (ANC/Facility delivery/PNC)	5%	rate	Estimation from mCARE I result
	Status quo--paper(ANC/Facility delivery/PNC)	1%	rate	DHS 2014
Provider costs			Unit	Source
Community level (Satellite clinics: Govt, BRAC, SS)				
ANC	Service costs	$0.22	USD	Field data collection
	Supplementation costs	$1.30	USD	Field data collection
	Average unit cost per ANC	$1.95	USD	Field data collection
Delivery	Service costs	$3.55	USD	Field data collection
	Supplementation costs	n/a	USD	Field data collection
	Average unit cost per delivery	$3.55	USD	Field data collection
PNC	Service costs	$0.12	USD	Field data collection
	Supplementation costs	$0.52	USD	Field data collection
	Average unit cost per PNC	$0.62	USD	Field data collection
Facility level (CC, FWC, UHC, SS)				
ANC	Service costs	$0.39	USD	Field data collection
	Supplementation costs	$2.60	USD	Field data collection
	Average unit cost per ANC	$2.99	USD	Field data collection
Delivery	Service costs	$19.50	USD	Field data collection
	Supplementation costs	n/a	USD	Field data collection
	Average unit cost per delivery	$19.50	USD	Field data collection
PNC	Service costs	$0.49	USD	Field data collection
	Supplementation costs	$5.21	USD	Field data collection
	Average unit cost per PNC	$1.83	USD	Field data collection
User costs			Unit	Source
Community level (Satellite clinics: Govt, BRAC, SS)				
ANC	Direct costs	$0.65	USD	Field data collection
	Indirect costs	$0.52	USD	Field data collection

	Average unit cost per ANC	$0.78	USD	Field data collection
Delivery	Direct costs	$6.50	USD	Field data collection
	Indirect costs	$4.13	USD	Field data collection
	Average unit cost per delivery	$10.63	USD	Field data collection
PNC	Indirect costs	$0.26	USD	Field data collection
	Average unit cost per PNC	$0.26	USD	Field data collection
Facility level (CC, FWC, UHC, SS)				
ANC	Direct costs	$1.17	USD	Field data collection
	Indirect costs	$1.04	USD	Field data collection
	Average unit cost per ANC	$2.21	USD	Field data collection
Delivery	Direct costs	$39.00	USD	Field data collection
	Indirect costs	$7.10	USD	Field data collection
	Average unit cost per delivery	$46.10	USD	Field data collection
PNC	Direct costs	$13.00	USD	Field data collection
	Indirect costs	$0.83	USD	Field data collection
	Average unit cost per PNC	$13.83	USD	Field data collection

Appendix 6. Survey tools

A 6.1 Module 1 (Community Level)

Module 1: Organization, Staffing and Commodities

Community Level

Objective: The data collection instrument aims to identify organizational governance, staffing structure, service capacity and commodities as well as prices paid for inputs of major service provider agencies in Gaibandha district.

Instruction: The information can be collected through available registers, records, or informant interviews with appropriate authorities or mangers in the organization. For each section, please specify the source of information or respondent details who are interviewed. Provider consent may not be required for this module.

INTERVIEW VISITS		
100	Date of organization visited	a. Day |___|___| b. Month |___|___|
101	Information of organization	a. District name: b. Upazila name: c. Union name: d. Community facility/Household address:
102	Type of community health workers	a. Government/public (FWA/FWV) b. BRAC (SK/SS) c. Private (Smiling Sun CHW)
103	Managing authority	a. Government/public b. NGO/Not for profit c. Private-for profit
104	Interviewer name:	
105	Interviewee (organization authority/manager) name:	
SERVICE CAPACITY		

Through available registers, records or informant interviews, please identify staffing structure, staff productivity, operational practice, and service capacity. Some questions can be answered as open-ended responses.

Please specify the source of information or respondent details who were interviewed.

01 What are the general categorization/types of community health workers (CHWs) and their respective roles and responsibilities in this organization?

Type of works		Type of workers	Level of effort* of worker type A: *(specify type)*	Level of effort of worker type B: *(specify type)*	Level of effort of worker type C: *(specify type)*	Level of effort of worker type D: *(specify type)*
Eligible couple /Married women of reproductive age registration						
Pregnancy surveillance						
MNCH service	Family Planning					
	ANC					
	Delivery					
	PNC					
	ENC					
	Immunization					
	Others					
Non MNCH service (TB or other heatlh services)						
Referral						
Training						
Meeting						
Data keeping/reporting						
Personal (idle) time						
Others						

(Level of effort: % of time allocation out of their total working hours in a month)

- Worker types can be FWA, FWV, SACMO, and FPI in governemnt group
- Worker types can be Shasto sheitak, Shasto Kormi etc in BRAC
- Worker types can be Volunteers, Paramedies etc in Smiling Sun

02	How many number of CHWs of this organization work for maternal and newborn heatlh serivces in the given administriatve unit	

	(district/upazila/union etc)? (Speficy the relevant unit)	
03	What are approximate dimension of catchment area (i.e. how many households in a catchment area) for a CHW to conduct routine surveillance activities?	
04	What are the average number of household (or eligible couples) visits does each CHW make in their routine surveillance activities per day (based on the past three days records)? [Define specific purposes of activities for routine surveillance. Specify the source of information.]	
05	What are the average number of household (or eligible couples) visits does each CHW make for routine surveillance per month (based on the past three months records)? [Define specific purposes of activities for routine surveillance. Specify the source of information.]	
06	What are the average number of pregnancy identification per month (based on the latest three months records) by a CHW?	
07	What are the average number of ANC service provisions (based on the latest three months records) by a CHW per month?	
08	What are the average number of home delivery with a skilled birth attendance (based on the latest three months records) per month?	
09	What are the average number of PNC/ENC servic provision (based on the latest three months records) by a CHW per month?	
10	What other major activities that CHWs do, besides the household surveillance?	

SERVICE PROVISION & USER FEES

- Through available registers, records or informant interviews, please identify scope and contents of standard service practice as well as any prices paid for inputs for each relevant essential maternal and newborn health services.
- Some specific service items were checked * as relevant indicators for Lives Saved Tool modeling.
- User fee indicates any price for service or commodities to be paid by clients to receive the relevant service. This information will be used to estimate user costs from service uptake.
- The question may be answered based on standard protocols from existing documents, rather than prompted questions to providers.

01	Does this facility have any routine user-fees or charges for client services?	Yes	No

02	Does this facilty charge a fixed fee that covers all services that a client receive, or are there separate fees for different components of the services provided by the facility?		Fixed fee covering all services		No, charge fee for separate items
03	Does this facility have a fee for the following items? (Read out each response category and circle appropriately. If there is any user fee on specific service item, please specify the amount.)		Yes		No
ANC Service Does this facility offer any of the following client services?			**Yes**	**No**	**User fee**
04	Clinical history	Personal information	1	2	
05		Medical /surgical history	1	2	
06		Prior pregnancy information	1	2	
07		Current pregnancy information	1	2	
08		Pregnancy risk assessment	1	2	
09	Examination	General examination: (including at least one of the followings such as temperature, pulse, weight, height)	1	2	
10		BP	1	2	
11		Check for edema	1	2	
12		Anemia	1	2	
13		Jaundice	1	2	
14		Breast examination	1	2	
15		Abdominal examination (height of uterus/fundal height, fetal movement (applicable after 20 weeks), fetal heart sound (count 1 full minute, applicable after 24 weeks), presentation of fetus (applicable after 28 weeks), check for scars, previous c-sections)	1	2	
16	Counseling	Individual birth plan (place/person, money, transport, blood donor & identification of EMOC center)	1	2	
17		Maternal nutrition	1	2	
18		Avoiding harmful practice	1	2	
19		Hygiene	1	2	
20		Rest and activity	1	2	
21		Danger signs during pregnancy (bleeding, headache, eye problems, swelling of face and hands)	1	2	
22		Danger signs during delivery for the mother	1	2	
23		Danger signs for the newborn	1	2	
24		Essential newborn care	1	2	
25		Infant feeding	1	2	
26		Family planning	1	2	
27		Immunization	1	2	

28		Advising her next ANC visit	1	2	
29	Screening and laboratory tests	Haemoglobin	1	2	
30		Proteinuria	1	2	
31		Urine for RE (including presence of albumin & sugar, Bacteriuria)	1	2	
32		Blood/Rh group	1	2	
33		Ultrasonogram (ultra clinics) or referral to clinic offering this service)	1	2	
34		Syphilis* (VDRL: venereal disease research laboratory)	1	2	
35	Supplementation and treatment*	Treat syphilis if indicated*	1	2	
36		Treat bacteriuria if indicated	1	2	
37		Tetanus toxoid (TT immunization: 5 dose schedule)	1	2	
38		Iron and folate+	1	2	
38		Calcium supplementation	1	2	
39		Balanced energy supplementation (maternal)	1	2	
40		Multiple micronutrient supplementation (maternal)	1	2	
41		MgSO4 management of pre-eclampsia**	1	2	
42		Hypertensive disease case management	1	2	
43		Diabetes screening and management	1	2	
44		Case management of malaria	1	2	
What is the general ANC consultation time per session by a provider? (Minutes)					
Please specify the source of information of above informations:					
Child Delivery Service* Does this facility offer any of the following client services?			**Yes**	**No**	**User fee**
45	Labor and delivery management	Clean practices and immediate essential newborn care (home): Essential care for all women and immediate essential newborn care	1	2	
46		Basic emergency obstetric care (clinic): shock management, pain relief, ABC, parenteral antibiotics, IV fluids, instrumental delivery and manual removal of the placenta and retained products	1	2	
47		Magnesium sulfate for eclampsia during delivery:	1	2	
48		Chlorhexidine cord cleansing for newborn	1	2	
49	Neonatal resuscitation	Home: (Newborns with access to neonatal resuscitation (a bag and mask) if needed. This can be delivered by skilled birth attendants in the home or by trained)	1	2	

50		Facility: (Newborns with access to detection of breathing problems and resuscitation (with a mucus extractor), if needed)	1	2	
Please specify the source of information of above informations.					
PNC/ENC Service Does this facility offer any of the following client services?			**Ye s**	**No**	**User fee**
51	Clinical history	Personal information	1	2	
52		Postpartum danger signs for the mother	1	2	
53		Newborn care and symptoms	1	2	
54	Examination for mother	General examination: temperature, BP, pulse, edema, anemia, jaundice	1	2	
55		Examination of breasts: condition of nipples, engorgement	1	2	
56		Per abdominal and per vaginal examination: height of uterus, P/V bleeding, any perineal tears, foul smelling discharge	1	2	
57	Examination for newborn	General examination: weight, temperature, respiratory rate, jaundice, and skin rash	1	2	
58		Umbilicus	1	2	
59		Conjunctiva	1	2	
60		Congental anomaly	1	2	
61	Counseling	Danger signs after delivery for the mother	1	2	
62		Danger signs after delivery for the newborn	1	2	
63		Care for premature and/or low birth weight newborns	1	2	
64		Counseling on infant feeding (exclusive breast feeding; position and attachment)	1	2	
65		Counseling on maternal hygiene/recovery	1	2	
66		Counseling on maternal nutrition	1	2	
67		Advising PNC visits according to new GOB schedule and vaccination of newborn	1	2	
68		Family planning (postpartum contraception)	1	2	
70		Schedule and importance of EPI	1	2	
71		Breastfeeding promotion	1	2	
72		Thermal care (with wrapping and photo therapy)	1	2	
73		Kangaroo mother care (skin to skin)	1	2	
74		Clean postnatal practices	1	2	
75		Improved water source	1	2	
76		Water connection in the home	1	2	
77		Improved sanitation	1	2	
78		Hand washing with soap	1	2	
79		Hygienic disposal of children's stools	1	2	
80		Insecticide treated materials or indoor residual spraying	1	2	

83		Malaria		1	2	
84	Supplementation and treatment	Maternal sepsis case management		1	2	
85		Multiple micronutrients supplementation		1	2	
86		Vitamin A supplementation to newborn (after birth)		1	2	
87		Zinc supplementation to newborn		1	2	
88		Case management of severe neonatal infection	Oral antibiotics	1	2	
89			Injectable antibiotics	1	2	
90			Full supportive care	1	2	
91		ORS		1	2	
92		Antibiotics for dysentery		1	2	
93		Zinc for diarrhea treatment to newborn		1	2	
94		Case management of pneumonia (oral antibiotics)		1	2	
95		Therapeutic feeding for low weight newborn		1	2	
96		Cotrimoxazole for ARI (acute respiratory illness)		1	2	
97	Vaccines*	BCG vaccine (at birth)		1	2	
98		DPT/Hib/HEB (pentavalent) vaccination (at 6-14 weeks)		1	2	
99		PCV (Pneumococcal vaccine) (at 6-14 weeks)		1	2	
100		OPV/IPV (Polio vaccine) (at 6-14 weeks)		1	2	

What is the general PNC consultatioin time per session by a provider? (Minutes)

Please specify the source of information of above infomrations:

STAFFING

Community level : Please identify specific occupation categories and how many staff in each of the categories are currently assigned to, employed by, or seconded to this organization, whether full time or part-time as well as their average annual salary (including standard bonus). As salary may be vary depends on staff seniority, demand of workload, or other staff availability in the organization, if possible, please record a range of measures including average, lowest, and highest values.

Please specify the source of information and respondent details who were interviewed.

	Occupation categories		ANC/PNC/ENC Provider (Check all that apply)		Employment status (part-time/full time) (If part-time, Specify number of working days/time in a week)	Base monthly salary	Incentives / bonuses	Present in facility yes/no (If no, why absent?)
			ANC	PNC/ ENC				
01	Gov't CHWs	SACMO						
02		HA						

03		FWA						
04		FWV (ANC)						
05		CHCP						
06		Others						
	BRAC CHWs	SK (ANC)						
07		SS (Family Planning/referal)						
08		Others						
09	Smiling Sun CHWs	Doctor (Satellite)						
10		Paramedies						
11		Counselors						
12		Others						
	Please specify if there is any typical staff ratio:							
	Please speficy general staff productivity (working days/hours):							

DRUGS AND SUPPLIES

- Please identify inventory registers, or price records as source of information, and specify staff designation who are in charge of selling drugs or supplies.
- Unit cost indicates any procurement costs to purchase the drugs or equip the supplies in the organization/facility. This information will be used to estimate provider costs from service provision.
- The question may be answered based on standard protocols from existing documents, rather than prompted questions to providers..

Please specify the source of information or respondent details if these are interviewed.

Are any of the following drugs and supplies available with the CHWs today?

#	**Name of drugs/supplies**	**Yes**	**No**	**Unit cost**	**In stock today**
Family Planning commodities					
01	Male condoms	1	2		
02	Combined oral contraceptive pills	1	2		
03	Progestine-only contraceptive pills	1	2		
04	Emergent contraceptive pills	1	2		
05	IUDs	1	2		
06	Implants	1	2		
07	Injectables	1	2		
08	Sterilization (surgery)	1	2		
Drugs and supplies for maternal care					
09	Iron tablets	1	2		

10	Folic acid tablets	1	2		
11	Iron and folic acid combined tablets	1	2		
12	Tetanus toxoid vaccine	1	2		
13	Sodiumchloride injectable solution	1	2		
14	Calcium gluconate injection	1	2		
15	Magnesium sulphate injection	1	2		
16	Ampicillin powder for injection (Inj 250 mg, 500 mg)	1	2		
17	Gentamicin injection	1	2		
18	Hydralazine injection	1	2		
19	Metronidazole injection	1	2		
20	Misoprostol 200ug tablets	1	2		
21	Azithromycin cap/tab or oral liquid	1	2		
22	Ceflxime cap/tab	1	2		
23	Benzathine benzylpenicillin power for injection (Inj 5 lac unit, 10 lac unit)	1	2		
24	Betamethasone injection	1	2		
25	Dexamethasone injection	1	2		
26	Nifedipine cap/tab (10 mg)	1	2		
27	Methyldopa tablet	1	2		
28	Oxytocin injection	1	2		
29	Paracetamol (Tab 500 mg/Susp 120 mg/5 ml)	1	2		
30	Oral Rehydration Salts (ORS) sachets	1	2		
Drugs and supplies for newborn care					
31	Procaine benzylpenicillin injection	1	2		
32	Oral Rehydration Salts (ORS) sachets	1	2		
33	Zinc sulphate syrup or dispersible tablets (Tab 10 mg, 20 mg)	1	2		
34	Vitamin A (retinol) capsules (Cap 50,000 IU)	1	2		
35	Antibiotic eye ointment for newborn	1	2		
36	Co-trimoxazole syrup/suspension (Tab 480 mg/Susp 240 mg/5 ml)	1	2		
37	Amoxicillin 250mg or 500 mg dispersible tablet or syrup/suspension (Susp 125 mg/5 ml, Paediatric drop 100m g/1 ml)	1	2		
38	Routine Vaccines for EPI: BCG, Pentavalent, OPV, Measles	1	2		
39	Additional Vaccines (Typhoid, MR, Rabies, Hepatitis A, Influenza, Cholera, Chicken Pox)	1	2		
Emergency medicine commodities for delivery (adapted from Smiling Sun Emergency Medicine Kit)					
40	Injection Promethazine (HCL) 25 mg (2 ampoules)	1	2		
41	Injection Hydrocortisone 100 mg (with distilled water) 2 vials	1	2		
42	IV fluid 5% DNS & Hartman’s solution (500 cc) 2 bags or bottle with IV set (2 sets)	1	2		
43	Injection Atropine Sulphate 0.6 mg (2 ampoules)	1	2		
44	Injection Adrenaline (1:1000) (2 ampoules)	1	2		
45	Injection (Naloxone 0.4 mg (2 ampoules) (for clinics providing tubectomy services)	1	2		

46	Syringes	1	2		
47	Gloves	1	2		
Relevant service delivery guidelines, standards, and job aids					
48	IMCI Chart Booklet and Sick Child Form	1	2		
49	IMCI Recording (Sick Child) Form	1	2		
50	EPI Manual	1	2		
51	Family Planning Manual	1	2		
52	Technical Standard and Service Delivery Protocol for Management of RTI/STD	1	2		
53	Partograph	1	2		
54	Others, Specify any				
Laboratory Services/Tests					
55	Blood grouping and Rh typing	1	2		
56	Cross matching of blood	1	2		
57	Blood for CBC, TC, DC, ESR	1	2		
58	Blood for Hb %	1	2		
59	Random Blood Sugar	1	2		
60	Serum Bilirubin	1	2		
61	Urine R/E	1	2		
62	Ultrasonogram test	1	2		

A 6.2 Module 1 (Facility Level)

Module 1: Organization, Staffing and Commodities
Facility Level

Objective: The data collection instrument aims to identify organizational governance, staffing structure, service capacity and commodities as well as prices paid for inputs of major service provider agencies in Gaibandha district.

Instruction: The information can be collected through available registers, records, or informant interviews with appropriate authorities or mangers in the organization. For each section, please specify the source of information or respondent details who are interviewed. Provider consent may not be required for this module.

INTERVIEW VISITS		
100	Date of facility visited	a. Day |___|___| b. Month |___|___|
101	Information of facility	a. District name: b. Upazila name: c. Union name: d. Facility name/address:
102	Type of health facility setting:	a. Medical College Hospital (Public) b. District Hospital c. Maternal & Child Welfare Center (MCWC) d. Upazilla Health Complex (Health wing) e. Upazilla Health Complex (FP wing) f. Upgraded Union Heath Centre & Family Welfare Centre g. Non upgraded Union Heath Centre & Family Welfare Centre h. Union Sub-Center (RD) i. Community Clinic (CC) j. Static clinic k. Satelight clinic l. Medical College/Hospital (Private) m. Private Hospital/Clinic (Private) n. Smiling Sun Franchise Clinic (Private/NGO)

103	Managing authority	a. Government/public b. NGO/Not for profit c. Private-for profit
104	Interviewer name:	
105	Interviewee (organization manager) name:	

SERVICE CAPACITY		
Through available registers, records or informant interviews, please identify staffing structure, staff productivity, operational practice, and service capacity of the facility. Some questions can be answered as open-ended responses.		
Please specify the source of information or respondent details who were interviewed.		
01	How many numbers of the health facilities exist in Gaibandha district?	
02	How many numbers of beds (and rooms) exist in this health facility?	
03	What are the average number of total inpatient (based on the latest three months records) in this health facility?	
04	What are the average number of total outpatient (based on the latest three months records) in this facility?	
05	What are the average number of ANC service provisions (based on the latest three months records) in this facility?	Overall ANC: ANC 1st/GA (8-12 weeks): ANC 2nd/GA (24-26 weeks): ANC 3rd/GA (32 weeks): ANC 4th/GA (36-38 weeks):
07	What is the “total” amount of time a provider usually spend on ANC consultations in a day?	

	Note: If possible, kindly indicate ANC provision time window of the day (ex. 9am-2pm) and frequency of ANC provision dates in a week/month (e.g. every Wed, Thursday in a week: total 8 days in a month)	
08	What are the average number of normal delivery (based on the latest three months records) in this facility?	
09	What are the average number of c-section (based on the latest three months records) in this facility?	
10	What are the average number of PNC/ENC consultation (based on the latest three months records) in this facility?	
11	What is the amount of time (in minutes) provider usually spend on PNC/ENC consultation?	

SERVICE PROVISION & USER FEES

- Through available registers, records or informant interviews, please identify scope and contents of standard service practice as well as any prices paid for inputs for each relevant essential maternal and newborn health services.
- Some specific service items were checked * as relevant indicators for Lives Saved Tool modeling.
- User fee indicates any price for service or commodities to be paid by clients to receive the relevant service. This information will be used to estimate user costs from service uptake.
- The question may be answered based on standard protocols from existing documents, rather than prompted questions to providers.

01	Does this facility have any routine user-fees or charges for client services?	Yes	No
02	Does this facilty charge a fixed fee that covers all services that a client receive, or are there separate fees for different components of the services provided by the facility?	Fixed fee covering all services	No, charge fee for separate items
03	Does this facility have a fee for the following items? (Read out each response category and circle appropriately. If there is any user fee on specific service item, please specify the amount.)	Yes	No

ANC Service Does this facility offer any of the following client services?	**Yes**	**No**	**User fee**

04	Clinical history	Personal information	1	2	
05		Medical /surgical history	1	2	
06		Prior pregnancy information	1	2	
07		Current pregnancy information	1	2	
08		Pregnancy risk assessment	1	2	
09	Examination	General examination: (including at least one of the followings such as temperature, pulse, weight, height)	1	2	
10		BP	1	2	
11		Check for edema	1	2	
12		Anemia	1	2	
13		Jaundice	1	2	
14		Breast examination	1	2	
15		Abdominal examination (height of uterus/fundal height, fetal movement (applicable after 20 weeks), fetal heart sound (count 1 full minute, applicable after 24 weeks), presentation of fetus (applicable after 28 weeks), check for scars, previous c-sections)	1	2	
16	Counseling	Individual birth plan (place/person, money, transport, blood donor & identification of EMOC center)	1	2	
17		Maternal nutrition	1	2	
18		Avoiding harmful practice	1	2	
19		Hygiene	1	2	
20		Rest and activity	1	2	
21		Danger signs during pregnancy (bleeding, headache, eye problems, swelling of face and hands)	1	2	
22		Danger signs during delivery for the mother	1	2	
23		Danger signs for the newborn	1	2	
24		Essential newborn care	1	2	
25		Infant feeding	1	2	
26		Family planning	1	2	
27		Immunization	1	2	
28		Advising her next ANC visit	1	2	
29	Screening and laboratory tests	Haemoglobin	1	2	
30		Proteinuria	1	2	
31		Urine for RE (including presence of albumin & sugar, Bacteriuria)	1	2	
32		Blood/Rh group	1	2	
33		Ultrasonogram (ultra clinics) or referral to clinic offering this service)	1	2	
34		Syphilis* (VDRL: venereal disease research laboratory)	1	2	

<table>
<tr><td>35</td><td rowspan="11">Supplementation and treatment*</td><td>Treat syphilis if indicated*</td><td>1</td><td>2</td><td></td></tr>
<tr><td>36</td><td>Treat bacteriuria if indicated</td><td>1</td><td>2</td><td></td></tr>
<tr><td>37</td><td>Tetanus toxoid (TT immunization: 5 dose schedule)</td><td>1</td><td>2</td><td></td></tr>
<tr><td>38</td><td>Iron and folate+</td><td>1</td><td>2</td><td></td></tr>
<tr><td>38</td><td>Calcium supplementation</td><td>1</td><td>2</td><td></td></tr>
<tr><td>39</td><td>Balanced energy supplementation (maternal)</td><td>1</td><td>2</td><td></td></tr>
<tr><td>40</td><td>Multiple micronutrient supplementation (maternal)</td><td>1</td><td>2</td><td></td></tr>
<tr><td>41</td><td>MgSO4 management of pre-eclampsia**</td><td>1</td><td>2</td><td></td></tr>
<tr><td>42</td><td>Hypertensive disease case management</td><td>1</td><td>2</td><td></td></tr>
<tr><td>43</td><td>Diabetes screening and management</td><td>1</td><td>2</td><td></td></tr>
<tr><td>44</td><td>Case management of malaria</td><td>1</td><td>2</td><td></td></tr>
<tr><td colspan="6">What is the general average time for a “single” ANC consultation per client by a provider? (Minutes)

Note: If possible, please specify as a range of different duration of time (in minutes) between the first ANC and the subsequent ANCs. Here, I assume that the first ANC may take longer time than the subsequent ANCs in order to register pregnancy history and provide general introduction etc.

If possible, among the selected service package that they provide, kindly indicate how much time would be taken for each sub section in one ANC service session of a person. For example, (i) clinical history—2 minutes; (ii) examination -3 minutes; (iii) counselling—5 minutes; (iv) screening and lab test —2-7 days from exam to result notice or 0 as no service provided; (v) sup and treatment—1 minutes.</td></tr>
<tr><td colspan="6">Please specify the source of information of above informations:</td></tr>
<tr><td colspan="3">Child Delivery Service*
Does this facility offer any of the following client services?</td><td>Yes</td><td>No</td><td>User fee</td></tr>
<tr><td>45</td><td colspan="2">Antenatal corticosteroids for preterm labor
(women with suspected premature labor receiving an intramuscular injection of betamethasone sodium phosphate (6 mg, every 12 hours for 2 days))</td><td>1</td><td>2</td><td></td></tr>
<tr><td>46</td><td colspan="2">Antibiotics for premature rupture of membranes (PRoM)
(women with premature rupture of membranes (PRoM) who are not in labor and are given oral erythromycin (250mg, 4 times daily for 7 days) who are not in labor to prevent infection)</td><td>1</td><td>2</td><td></td></tr>
<tr><td>47</td><td>Labor and delivery management</td><td>Clean practices and immediate essential newborn care (home): Essential care for all women and immediate essential newborn care</td><td>1</td><td>2</td><td></td></tr>
</table>

48		Basic emergency obstetric care (clinic): shock management, pain relief, ABC, parenteral antibiotics, IV fluids, instrumental delivery and manual removal of the placenta and retained products	1	2	
49		Comprehensive emergency obstetric care (clinic): ultrasound, culdocentesis, induction, laparotomy, salpingectomy, blood transfusion, caesarian section, hysterectomy, symphisiotomy, balloon tamponade, uterine ligature, MRVOP, surgical infection control and episiotomy.	1	2	
50		Induction of labour to prevent births at or beyond 41 completed weeks. (by using clinical treatment)	1	2	
51		Active management of the 3rd stage of labour (AMTSL): controlled cord traction, uterine massage and appropriate oxytocics	1	2	
52		Magnesium sulfate for eclampsia during delivery:	1	2	
53		Chlorhexidine cord cleansing for newborn	1	2	
54	Neonatal resuscitation	Home: (Newborns with access to neonatal resuscitation (a bag and mask) if needed. This can be delivered by skilled birth attendants in the home or by trained)	1	2	
55		Facility: (Newborns with access to detection of breathing problems and resuscitation (with a mucus extractor), if needed)	1	2	
Please specify the source of information of above informations.					
PNC/ENC Service Does this facility offer any of the following client services?			**Yes**	**No**	**User fee**
55	Clinical history	Personal information	1	2	
56		Postpartum danger signs for the mother	1	2	
57		Newborn care and symptoms	1	2	
58	Examination for mother	General examination: temperature, BP, pulse, edema, anemia, jaundice	1	2	
59		Examination of breasts: condition of nipples, engorgement	1	2	
60		Per abdominal and per vaginal examination: height of uterus, P/V bleeding, any perineal tears, foul smelling discharge	1	2	

61	Examination for newborn	General examination: weight, temperature, respiratory rate, jaundice, and skin rash		1	2	
62		Umbilicus		1	2	
63		Conjunctiva		1	2	
64		Congental anomaly		1	2	
65	Counseling	Danger signs after delivery for the mother		1	2	
66		Danger signs after delivery for the newborn		1	2	
67		Care for premature and/or low birth weight newborns		1	2	
68		Counseling on infant feeding (exclusive breast feeding; position and attachment)		1	2	
70		Counseling on maternal hygiene/recovery		1	2	
71		Counseling on maternal nutrition		1	2	
72		Advising PNC visits according to new GOB schedule and vaccination of newborn		1	2	
73		Family planning (postpartum contraception)		1	2	
74		Schedule and importance of EPI		1	2	
75		Breastfeeding promotion		1	2	
76		Thermal care (with wrapping and photo therapy)		1	2	
77		Kangaroo mother care (skin to skin)		1	2	
78		Clean postnatal practices		1	2	
79		Improved water source		1	2	
80		Water connection in the home		1	2	
83		Improved sanitation		1	2	
84		Hand washing with soap		1	2	
85		Hygienic disposal of children's stools		1	2	
86		Insecticide treated materials or indoor residual spraying		1	2	
87		Malaria		1	2	
88	Supplementation and treatment	Maternal sepsis case management		1	2	
89		Multiple micronutrients supplementation		1	2	
90		Vitamin A supplementation to newborn (after birth)		1	2	
91		Zinc supplementation to newborn		1	2	
92		Case management of severe neonatal infection	Oral antibiotics	1	2	
93			Injectable antibiotics	1	2	
94			Full supportive care	1	2	
95		ORS		1	2	
96		Antibiotics for dysentery		1	2	
97		Zinc for diarrhea treatment to newborn		1	2	
98		Case management of pneumonia (oral antibiotics)		1	2	
99		Therapeutic feeding for low weight newborn		1	2	
100		Cotrimoxazole for ARI (acute respiratory illness)		1	2	

10 1	Vaccines*	BCG vaccine (at birth)	1	2	
10 2		DPT/Hib/HEB (pentavalent) vaccination (at 6-14 weeks)	1	2	
10 3		PCV (Pneumococcal vaccine) (at 6-14 weeks)	1	2	
10 4		OPV/IPV (Polio vaccine) (at 6-14 weeks)	1	2	

What is the general PNC consultation time per session by a provider? (Minutes)

Please specify the source of information of above infomrations:

STAFFING

Facility level : Please identify specific occupation categories and how many staff in each of the categories are currently assigned to, employed by, or seconded to this facility, whether full time or part-time as well as their average annual salary (including standard bonus). As salary may be vary depends on staff seniority, demand of workload, or other staff availability in the organization, if possible, please record a range of measures including average, lowest, and highest values. Out of full occupation categories, please identify staff who are reponsible or qualified to provide antenatal, postnatal or essential newborn care.

	Occupation categories	ANC/PNC/ENC Provider (Check all the apply)		Employment status (part-time/full time) (If part-time, Specify number of working days/time in a week)	Base monthly salary	Incentives/ bonuses	Present in facility yes/no (If no, why absent?)
		ANC	PNC/ENC				
01	General [Non-Specialist] Medical Doctors						
02	Specialsts Medical Doctors [Including Anesthesiologists & Pathologists]						
03	Non-Physician Clinicians/Paramedical Professionals (Including Clinical Officers, Medical Assistants, etc)						
04	Anesthestist						
05	Nursing Professionals (Excluding Associate Degree Nurses)						
06	Degree Nurses (e.g. BSc Nurse)						
07	Paramedies (e.g. SACMO)						
08	Counselor						
09	Pharmacist						
10	Pharmacy Technologist/Assistant						

11	Laboratory Scientist						
12	Laboratory Technician/Assistant						
13	MIS manager/Statistician/Record keeper						
14	Community Health Volunteer						
15	Messsenger						
16	Driver (including Ambulance driver)						
17	Cleaner						
18	Guard						
19	Others						

Please specify if there is any typical staff ratio among workers *(e.g. a ratio between a doctor and nurse or a ratio between lab scientist and lab technician or a ratio between pharmacist vs. pharmacist assistant etc.):*

Please speficy general staff productivity (working days/hours):

DRUGS AND SUPPLIES

- Please identify inventory registers, or price records as source of information, and specify staff designation who are in charge of selling drugs or supplies.
- Unit cost indicates any procurement costs to purchase the drugs or equip the supplies in the organization/facility. This information will be used to estimate provider costs from service provision.
- The question may be answered based on standard protocols from existing documents, rather than prompted questions to providers..

Please specify the source of information or respondent details if these are interviewed.

Are any of the following drugs and supplies available with the CHWs today?

#	Name of drugs/supplies	Yes	No	Unit cost	In stock today
Family Planning commodities					
01	Male condoms	1	2		
02	Combined oral contraceptive pills	1	2		
03	Progestine-only contraceptive pills	1	2		
04	Emergent contraceptive pills	1	2		
05	IUDs	1	2		
06	Implants	1	2		
07	Injectables	1	2		
08	Sterilization (surgery)	1	2		
Drugs and supplies for maternal care					
09	Iron tablets	1	2		

10	Folic acid tablets	1	2		
11	Iron and folic acid combined tablets	1	2		
12	Tetanus toxoid vaccine	1	2		
13	Sodiumchloride injectable solution	1	2		
14	Calcium gluconate injection	1	2		
15	Magnesium sulphate injection	1	2		
16	Ampicillin powder for injection (Inj 250 mg, 500 mg)	1	2		
17	Gentamicin injection	1	2		
18	Hydralazine injection	1	2		
19	Metronidazole injection	1	2		
20	Misoprostol 200ug tablets	1	2		
21	Azithromycin cap/tab or oral liquid	1	2		
22	Ceflxime cap/tab	1	2		
23	Benzathine benzylpenicillin power for injection (Inj 5 lac unit, 10 lac unit)	1	2		
24	Betamethasone injection	1	2		
25	Dexamethasone injection	1	2		
26	Nifedipine cap/tab (10 mg)	1	2		
27	Methyldopa tablet	1	2		
28	Oxytocin injection	1	2		
29	Paracetamol (Tab 500 mg/Susp 120 mg/5 ml)	1	2		
30	Oral Rehydration Salts (ORS) sachets	1	2		
Drugs and supplies for newborn care					
31	Procaine benzylpenicillin injection	1	2		
32	Oral Rehydration Salts (ORS) sachets	1	2		
33	Zinc sulphate syrup or dispersible tablets (Tab 10 mg, 20 mg)	1	2		
34	Vitamin A (retinol) capsules (Cap 50,000 IU)	1	2		
35	Antibiotic eye ointment for newborn	1	2		
36	Co-trimoxazole syrup/suspension (Tab 480 mg/Susp 240 mg/5 ml)	1	2		
37	Amoxicillin 250mg or 500 mg dispersible tablet or syrup/suspension (Susp 125 mg/5 ml, Paediatric drop 100m g/1 ml)	1	2		
38	Routine Vaccines for EPI: BCG, Pentavalent, OPV, Measles	1	2		
39	Additional Vaccines (Typhoid, MR, Rabies, Hepatitis A, Influenza, Cholera, Chicken Pox)	1	2		
Emergency medicine commodities for delivery (adapted from Smiling Sun Emergency Medicine Kit)					
40	Injection Promethazine (HCL) 25 mg (2 ampoules)	1	2		
41	Injection Hydrocortisone 100 mg (with distilled water) 2 vials	1	2		
42	IV fluid 5% DNS & Hartman's solution (500 cc) 2 bags or bottle with IV set (2 sets)	1	2		
43	Injection Atropine Sulphate 0.6 mg (2 ampoules)	1	2		
44	Injection Adrenaline (1:1000) (2 ampoules)	1	2		
45	Injection (Naloxone 0.4 mg (2 ampoules) (for clinics providing tubectomy services)	1	2		

46	Syringes	1	2		
47	Gloves	1	2		
Relevant service delivery guidelines, standards, and job aids					
48	IMCI Chart Booklet and Sick Child Form	1	2		
49	IMCI Recording (Sick Child) Form	1	2		
50	EPI Manual	1	2		
51	Family Planning Manual	1	2		
52	Technical Standard and Service Delivery Protocol for Management of RTI/STD	1	2		
53	Partograph	1	2		
54	Others, Specify any				
Laboratory Services/Tests					
55	Blood grouping and Rh typing	1	2		
56	Cross matching of blood	1	2		
57	Blood for CBC, TC, DC, ESR	1	2		
58	Blood for Hb %	1	2		
59	Random Blood Sugar	1	2		
60	Serum Bilirubin	1	2		
61	Urine R/E	1	2		
62	Ultrasonogram test	1	2		

SOURCE OF REVENUE

Please identify the source of revenue or funding for this organization. Please identify if the organization received any revenue or funding from any of the listed resources during 2015 financial year. If possible, please identify specific amount or approximate percentage of each source of revenue/funding out of total annual revenue/funding.

Please specify the source of information and respondent details who were interviewed.

	Soure of revenue	**Available (Y/N)**	**Amount**	**Percentage**
01	Government revenue (Ministry of health or other public ministries)			
02	Donor agencies			
03	NGOs			
04	Service fee			
05	Medicine sales/Lab test fee			
06	Maternal Health Voucher Scheme (Demand side Voucher Financing)*			
07	Insurance schemes/Social Security Fund			
08	Faith-based community programs			
09	Private donation/contribution			
10	Others (specify)			

REFERRAL PRACTICE				
This questions may be asked to different service providers in the organization who are in charge of respective services. Please specify the source of information and respondent details who were interviewed.				
Referral during pregnancy				
01	Provider category: Referral is made from		Doctors (specialist)	01
			Doctors	02
			Nurses/Midwifes	03
			Family Welfare Assistant	04
			Family Welfare Volunteers	05
			Traditional Birth Attendant	06
			Community Healthcare Provider	07
			Heath Assistant	08
			Village doctor	09
			Spiritual Healer	10
			Homeopathic	11
			Kobiral/Hakim	12
			NGO workers (SS/SK)	13
			Other (specify)	14
02	Referral is made to	Facility category	Medical College Hospital (Public)	01
			District Hospital	02
			Maternal & Child Welfare Center (MCWC)	03
			Upazilla Health Complex (Health wing)	04
			Upazilla Health Complex (FP wing)	05
			Upgraded UH&FWC	06
			Union Sub-Center (RD)	07
			Union Sub-Center (RD) + upgraded UH&FWC	08
			Union Sub-Center (RD) + non-upgraded UH&FWC	09
			Community Clinic (CC)	10
			Medical College/Hospital (Private)	11
			Private Hospital/Clinic (Private)	12
			Smiling Sun Franchise Clinic (Private/NGO)	13
			Other (specify)	14
		Provider category	Doctors (specialist)	01
			Doctors	02
			Nurses/Midwifes	03
			Family Welfare Assistant	04
			Family Welfare Volunteers	05
			Traditional Birth Attendant	06
			Community Healthcare Provider	07
			Heath Assistant	08
			Village doctor	09
			Spiritual Healer	10
			Homeopathic	11
			Kobiral/Hakim	12
			NGO workers (SS/SK)	13
			Other (specify)	14

03	How many referrals did you make for pregnant women in the last month?			
04	Which timing of pregnancy do you make most referrals?		ANC 1st/GA (8-12 weeks)	01
			ANC 2nd/GA (24-26 weeks)	02
			ANC 3rd/GA (32 weeks)	03
			ANC 4th/GA (36-38 weeks)	04
			Labor/Delivery	05
			Postnatal care	06
05	What were the major reasons (i.e. risk factors, diagnosis) of referrals?	Pregnancy	Vaginal bleeding	01
			Fever	02
			Headache or blurred vision	03
			Swollen face or hands	04
			Tiredness or breathlessness	05
			Fetal movement (loss of, excessive, normal)	06
			Cough or difficulty breathing for 3 weeks or longer	07
			Convulsions (pre-eclampsia/eclampsia)	08
			Lower abdominal pain	09
			Any other symptoms or problems the client thinks might be related to this pregnancy	10
			Other (specify)	11
06		Labor/Delivery	Excessive vaginal bleeding	01
			Foul smeling discharge	02
			High fever	03
			Baby's hand or feet come first	04
			Baby bad position/malpresentation	05
			Prolong labor (>12 hours)	06
			Retained placenta	07
			Torn uterus	08
			Prolapsed cord	09
			Cord around neck	10
			Convulsions	11
			Perineal Tear	12
			Other (specify)	13
07		After delivery (mother)	Excessive vaginal bleeding	01
			Foul smeling discharge	02
			High fever	03
			Baby's hand or feet come first	04
			Baby bad position/malpresentation	05
			Prolong labor (>12 hours)	06
			Retained placenta	07
			Torn uterus	08
			Prolapsed cord	09
			Cord around neck	10

			Convulsions	11
			Perineal Tear	12
			Other (specify)	13
08		After delivery (newborn)	Breastfeeding difficulties/failure to breastfeed	01
			Difficulty breathing	02
			Lethargy/limpness/always sleeping	03
			Convulsions/fits	04
			Blueness of lips, hands or skin	05
			Redness, bleeding, or discharge from umbilicus	06
			Fever	07
			Vomiting	08
			Low birth weight, including prematurity	09
			Jaundice/yellow color of the skin and eyes	10
			Red eyes with discharge	11
			Skin lesions/blisters	12
			Other (specify)	13
09	What are the general protocol/process of the referrals? (Record whether the provider did any of the following.)		Recommend that client be hospitalized urgenly (i.e. Admitted to the hospital or referred to another hospital)	01
			Referred client to another provider within facility for other care	02
			Referred client for laboratory test within or outside facility	03
			Explained the reason for (any) referral	04
			Gave referral slip to caretaker	05
			Explained where (or to whom) to go	06
			Provider explained when to go for referral	07
			Referrer accompanied the client to the facility	08
			Other (specify)	09
10	What are the general outcome of the referral?			
11	Did you use mobile phone in any of this process? If yes, could you explain how and to whom you used?			

A 6.3 Module 2

Module 2: Health Service Provision Observation of Antenatal Care Service

Objective: The data collection instrument aims to identify essential mother and newborn care service practice, contents and commodities to estimate marginal costs of antenatal care service provision of major service providers in Gaibandha district.

Instruction: While an interviewer will use the Module 2 questionnaires to record relevant items during service observation, the consultation may not be conducted in a sequential or consecutive manner as structured in the module. In this case, interviewer/interpreter should write down all conversations or activities on a blank sheet as they observe during the service provision process. The information will then be deconstructed and compiled according to the following categorizations later.

<table>
<tr><th colspan="4">INTERVIEW VISITS</th></tr>
<tr><td>100</td><td>Date of household/health facility visited</td><td colspan="2">a. Day |___|___|
b. Month |___|___|</td></tr>
<tr><td>101</td><td>Information of household/health facility</td><td colspan="2">a. District name:
b. Upazila name:
c. Union name:
d. Facility name/address:</td></tr>
<tr><td>102</td><td>Level of care</td><td>a. Health facility level
b. Community level</td><td>→Go 01
→Skip to 02</td></tr>
<tr><td>01</td><td>If facility level, type of health facility:</td><td colspan="2">a. Medical College Hospital (Public)
b. District Hospital
c. Maternal & Child Welfare Center (MCWC)
d. Upazilla Health Complex (Health wing)
e. Upazilla Health Complex (FP wing)
f. Upgraded Union Heath Centre & Family Welfare Centre
g. Non upgraded Union Heath Centre & Family Welfare Centre
h. Union Sub-Center (RD)
i. Community Clinic (CC)
j. Static clinic
k. Satelight clinic
l. Medical College/Hospital (Private)
m. Private Hospital/Clinic (Private)
n. Smiling Sun Franchise Clinic (Private/NGO)</td></tr>
</table>

02	If community level, type of community health workers	a. Government/public (FWA/FWV) b. BRAC (SK/SS) c. Private (Smiling Sun CHW)
103	Managing authority	a. Government/public b. NGO/Not for profit c. Private-for profit
104	Observer/interviewer name:	
105	Provider name:	Record provider ID number: ☐☐☐
106		Record client ID number: ☐☐☐
107	Record whether permission was received from the provider.	a. Yes b. No →End
108	Record the time the observation started.	____: ____

CHARACTERISTICS OF SERVICE PROVIDER

	Questions to client	Check all that apply	Comments
1	What is the provider category?	01=Qualified doctor	
		02=Nurse	
		03=Paramedic/Midwife	
		04=Family Welfare Assistant	
		05=Family Welfare Volunteers	
		06=MA/SACMO	
		07=Health Assistant	
		08=Traditional Birth Attendant	
		09=Community Healthcare Provider	
		10=BRAC Community Health Workers (Shastto Shebika, Shasto Kormi)	
		11=Others (Specify)	
2	What is the provider's age?	☐☐ years	
3	What was the highest class the provider completed in school?	00=No schooling	
		01-09=From class 1 to class 9	
		10=SSC/dakhil passed	
		11=11 years completed	
		12=HSC/Alim passed	
		13=13 years completed	
		14=Degree/Fazil or higher	
		99=Don't know	

4	How many years did the provider work on this service?	1= Less than 1 year	
		2=1-3 year	
		3=3-5 year	
		4=5-10 year	
		5=More than 10 year	
5	Where did the provider receive training on professional ANC service provision?	1=Government program	
		2= NGO program	
		3= Private program	
		4=Others (Specify)	
6	When was the latest professional ANC service training did the provider receive?	1=Less than 1 year ago	
		2=1-3 year ago	
		3=3-5 year ago	
		4=5-10 year ago	
		5=More than 10 year ago	
		9=Don't know	
7	How long was the training program that the provider received?	1=Less than 15 days	
		2=16-30 days	
		3=1-6 months	
		4=6-12 months	
		5=More than 1 year	
		9=Don't know	

OBSERVATION OF ANC CONSULTATION

201	How many weeks pregnancy is the client? [If not asked or identified, please skip to the next question no. 202]	Weeks of pregnancy:	
202	Has the client had a previous pregnancy, regardless of the duration or outcome of that pregnancy, or is this the client's first pregnancy?	First Pregnancy	1
		Not First Pregnancy	2
		Don't know	3
203	What number of ANC visit is this?	1st	1
		2nd→ Skip to 206	2
		3rd→ Skip to 206	3
		4th→ Skip to 206	4
		Other (Specify)	5
		If not asked/identified	6

Questions on Service Contents		**Yes**	**No**	**Commodities**
Code: For each of the groups that follow, circle any action taken by the provider or the client. If no action in the group is observed, circle "Y" for each group at the end of the observation. **Commodities:** Record any commodities which are consumed during the service provision (Specify the item and quantity, if any)				
204	**Client History**			
	Record whether the provider asked about or the client mentioned any of the following facts.			
01	Client's age	1	2	
02	Medications the client is taking	1	2	
03	Date client's last menstrual period began	1	2	
04	Number of prior pregnancies client has had	1	2	

205	**Aspects of Prior Pregnancies**			
	Record whether the provider or the client discussed any of the following aspects of the client's prior pregnancies (0 = No, 1=Yes)			
01	Prior stillbirth(s)	1	2	
02	Infant(s) who died in the first month of life	1	2	
03	Heavy bleeding, during or after delivery	1	2	
04	Previous assisted delivery (caesarean section, ventouse, or forceps)	1	2	
05	Previous spontaneous abortions	1	2	
06	Previous menstrual regulation and induced abortion	1	2	
07	Previous multiple pregnancies	1	2	
08	Previous prolonged labor	1	2	
09	Previous pregnancy-induced hypertension	1	2	
10	Previous pregnancy-related convulsions	1	2	
11	High fever or infection during prior pregnancy/pregnancies	1	2	
206	**Danger Signs of Current Pregnancy**			
	Record whether the provider asked/counselled about or the client mentioned any of the following for current pregnancy.			
01	Vaginal bleeding	1	2	
02	Fever	1	2	
03	Headache or blurred vision	1	2	
04	Swollen face, hands or legs	1	2	
05	Tiredness or breathlessness	1	2	
06	Fetal movement (loss of, excessive, normal)	1	2	
07	Cough or difficulty breathing for 3 weeks or longer	1	2	
08	Convulsions (pre-eclampsia/eclampsia)	1	2	
09	Lower abdominal pain	1	2	
	Vomiting with pregnancy	1	2	
10	Any other symptoms or problems the client thinks might be related to this pregnancy	1	2	
207	**Physical Examination**			
	Record whether the provider performed the following procedures.			
01	Take the client's blood pressure	1	2	
02	Examine conjunctiva/palms for anemia	1	2	
03	Examine legs/feet/hands for edema	1	2	
04	Examine for swollen glands	1	2	
05	Palpate the client's abdomen for fetal presentation	1	2	
06	Palpate the client's abdomen for uterine height	1	2	
07	Listen to the client's abdomen for fetal heartbeat (after 28 weeks)	1	2	
08	Conduct an ultrasound/refer client for ultrasound/look at recent ultrasound report	1	2	
09	Examine the client's breasts	1	2	
10	Conduct vaginal examination/exam of perineal area	1	2	
11	Others (specify; e.g. Examine height or weight)	1	2	
208	**Routine Tests**			

	In case of different providers involved for the sub elements of ANC service provision, please specify each type of service provider for relevant services. Record whether the provider, (1) asked about; (2) performed; (3) referred the client or (0) no action taken for the following test	Type of provider	Type of services			
01	Anemia test		1	2	3	0
02	Blood grouping		1	2	3	0
03	Any urine test		1	2	3	0
04	VDRL (Syphillis etc.) test		1	2	3	0
209	**Maintaining a Healthy Pregnancy**					
	Record whether the provider gave the client any of the following advice or counsel about preparations					
01	Discussed nutrition (i.e., quantity or quality of food to eat) during the pregnancy	1	2			
02	Informed the client about the progress of the pregnancy (e.g. based on abdominal girth, fundal height, weight, fetal heart sound)	1	2			
03	Discussed the importance of at least 4 ANC visits	1	2			
04	Informed or gave a card on next ANC scheduled visits	1	2			
210	**Iron Prophylaxis**					
	Record whether the provider gave the client any of the following treatment or counseling.					
01	Prescribed or gave iron pills or folic acid (IFA) or both	1	2			
02	Explained the purpose of iron or folic acid	1	2			
03	Explained how to take iron or folic-acid pills	1	2			
04	Explained side effects of iron pills	1	2			
211	**Tetanus Toxoid Injection**					
	Record whether the provider gave the client any of the following treatments.					
01	Prescribed or gave a tetanus toxoid (TT) injection	1	2			
02	Explained the purpose of the TT injection	1	2			
212	**Deworming**					
	Record whether the provider gave the client any of the following treatments.					
01	Prescribed or gave Mebendazole/ Albendazole	1	2			
02	Explained the purpose of Mebendazole/ Albendazole	1	2			
213	**Malaria**					
	Record whether the provider gave the client any of the following treatment or counseling.					
01	Gave malaria prophylaxis medicine (SP) to client during the consultation	1	2			
02	Prescribed malaria prophylaxis medicine (SP) to client to obtain elsewhere	1	2			
03	Explained the purpose of the preventive treatment with anti-malaria medicine	1	2			
04	Explained how to take the anti-malaria medicine	1	2			
05	Provided ITN to client as part of consultation or instructed client to obtain ITN elsewhere in facility	1	2			

06	Explicitly explained importance of using ITN to client	1	2	
214	**Preparation for Delivery**			
	Record whether the provider advised or counselled about delivery in any of the following ways.			
01	Asked the client where she will deliver	1	2	
02	Advised the client to prepare for delivery (e.g. set aside money, arrange for emergency transportation)	1	2	
03	Advised the client to use a skilled health worker for delivery	1	2	
04	Discussed with client what items to have on hand at home for emergencies (e.g. Birth kit)	1	2	
215	**Newborn and Postpartum Recommendations**			
	Record whether the provider advised or counselled about newborn or postpartum care in any of the following ways.			
01	Discussed care for the newborn (i.e. warmth, hygiene and cord care)	1	2	
02	Discussed early initiation (e.g. 30 minutes/as soon as after birth) and prolonged (e.g. 2 years along with complementary feeding) breastfeeding	1	2	
03	Discussed exclusive breastfeeding (e.g. 6 months)	1	2	
04	Discussed importance of vaccination for the newborn	1	2	
05	Discussed family planning options for after delivery	1	2	

216	**Overall Observations of interaction**		
01	Record whether the provider asked if the client had any questions and encouraged questions.	Yes	1
		No	2
02	Record whether the provider used any visual aids for health education or counseling during the consultation	Yes	1
		No	2
03	Record whether the provider looked at the client's health card (either before beginning the exam, while collecting information or examining the client)	Yes	1
		No	2
04	Record whether the provider wrote on the client's health record	Yes	1
		No	2
		No Health Card Used	3
05	Record the outcome of the consultation [Record the outcome at the end of the observation conclueded]	Client goes home	1
		Client referred (To lab or other provider) at same facility	2
		Client admitted to same facility	3
		Client referred to other facility	4
Record the time the observation ended.		____: ___	
Observer's Comments:			

A 6.4 Module 3

Module 3: Client Exit Interview on User Costs

Objective: The data collection instrument aims to determine user costs, including direct costs such as transportation costs, admission/service user fees, and drug costs, as well as any indirect costs such as loss of schooling or wage due to antenatal, postnatal or newborn care-seeking.

Instruction: At the end of the ANC service consultation/observation (Module 2), the interview will be conducted based on discussions with pregnant women who is receiving antenatal care service at community or facility settings. It is expected to take about 15-20 minutes.

<table>
<tr><th colspan="4">INTERVIEW VISITS</th></tr>
<tr><td>100</td><td>Date of household/health facility visited</td><td colspan="2">a. Day |___|___|
b. Month |___|___|</td></tr>
<tr><td>101</td><td>Information of household/health facility</td><td colspan="2">a. District name:
b. Upazila name:
c. Union name:
d. Facility name/address:</td></tr>
<tr><td>102</td><td>Level of care</td><td>a. Health facility level
b. Community level</td><td>→Go 01
→Skip to 02</td></tr>
<tr><td>01</td><td>If facility level, type of health facility:</td><td colspan="2">a. Medical College Hospital (Public)
b. District Hospital
c. Maternal & Child Welfare Center (MCWC)
d. Upazilla Health Complex (Health wing)
e. Upazilla Health Complex (FP wing)
f. Upgraded Union Heath Centre & Family Welfare Centre
g. Non upgraded Union Heath Centre & Family Welfare Centre
h. Union Sub-Center (RD)
i. Community Clinic (CC)
j. Static clinic
k. Satelight clinic
l. Medical College/Hospital (Private)
m. Private Hospital/Clinic (Private)
n. Smiling Sun Franchise Clinic (Private/NGO)</td></tr>
</table>

02	If community level, type of community health workers	a. Government/public (FWA/FWV) b. BRAC (SK/SS) c. Private (Smiling Sun CHW)	
103	Managing authority	a. Government/public b. NGO/Not for profit c. Private-for profit	
104	Observer/interviewer name:		
105	Provider name:	Record provider ID number:	
106		Record client ID number:	
107	Record whether permission was received from the client.	0 = No [Specify the reasons: severe health condition, time constraints, no permission by family member etc.]	→End
		1 = Yes	

CHARACTERISTICS OF PREGNANT WOMEN			
	Questions to client	**Check all that apply**	**Comments**
1	What is your age?	years	
2	Including this visit, how many times of ANC did you receive?	times [The range of number should be 1-4]	
3	What is your gestational age? /How many weeks have been passed since your last menstrual period?	1=1-12 weeks	
		2=13-26 weeks	
		3=27-32 weeks	
		4=33-38 weeks	
		9=Don't know	
4	Have you had a previous pregnancy?	0= No/First pregnancy (Conduct the survey until the section of User Cost for ANC)	
		1=Yes/Not first pregnancy (Continue the survey until the end)	
		9=Don't know	
5	Can you read or write a letter in Bangla?	0=No	
		1=Yes	
		9=Don't know	

6	What was the highest class you completed in school?	00=No schooling	
		01-09=From class 1 to class 9	
		10=SSC/dakhil passed	
		11=11 years completed	
		12=HSC/Alim passed	
		13=13 years completed	
		14=Degree/Fazil or higher	
		99=Don't know	
7	Aside from your own housework, do you do any work for which you are paid in cash or in kind?	0=No (Go to 8)	
		1=Yes (Go to 7a, do 7b)	
		9=Don't know (Go to 8)	
7a.	What kind of work do you spend most of your time doing?	1=Work on own farm / as share cropper	
		2=Day, unskilled laborer (agricultural & migrant etc)	
		3=Maid servant / Fisherman	
		4=Contracted laborer (long term domestic, agricultural)	
		5=Own business	
		6=Private service (salaried, skilled factory and office workers etc. salesperson, skilled laborer)	
		7=Government service (all GOB-paid employees)	
		8=Other, specify:______________________________	
		9=Don't know	
7b.	What is the average cash income you bring into the household per month?	☐☐☐☐☐ 00000-99997=Taka per month	
		99998=99998 or more	
		99999=Don't know	
8	Do your husband do any work for which he is paid in cash or in kind?	0=No (Go to User Cost for ANC section)	
		1=Yes (Go to 8a, do 8b)	
		9=Don't know (Go to User Cost for ANC section)	
8a.	What kind of work does he spend most of his time doing?	1=Work on own farm / as share cropper	
		2=Day, unskilled laborer (agricultural & migrant etc)	
		3=Maid servant / Fisherman	
		4=Contracted laborer (long term domestic, agricultural)	
		5=Own business	

		6=Private service (salaried, skilled factory and office workers etc. salesperson, skilled laborer)		
		7=Government service (all GOB-paid employees)		
		8=Other, specify:_______________		
		9=Don't know		
8b.	What is the average cash income he bring into the household per month?	☐☐☐☐☐	00000-99997=Taka per month	
			99998=99998 or more	
			99999=Don't know	
USER COSTS FOR ANC				
	Questions to client	**Check all that apply**		**Amount** (if any)
1	Did you have to spend any money during your ANC checkup?	0 = No		
		1 = Yes		
		9 = Don't Know		
2	What did you spend your money on? [Specify amount of expenditure to the relevant item, if any]	1 = Admission fee		
		2 = Provider/ consultation fees		
		3 = Medicines		
		4 = Medical tests		
		5 = Ultrasonography		
		6 = Supplements		
		7 = Immunization		
		8 = Transportation		
		9 = Food (in hospital/on way to facility)		
		10 = Hospitalization		
		11 = Other, specify		
		12 = Don't know		
3	How much of your own money did you spend in total on your ANC visit?	Specify the amount:		
4	How did you arrange to pay for the expenses?	1 = Personal savings		
		2 = Loans from friends/neighbors/relatives		
		3 = Sold assets		
		4 = Microcredit		
		5 = Conditional cash transfer		
		6 = Vouchers		
		7 = Other, specify		
		9 = Don't know		
5		0 = No		

	Did you or your husband take time off from work to receive ANC?	1 = Yes	
		9 = Don't Know	
6	How many days did your husband take off from work for your ANC? /How much money did you or your husband lose because of this absence from work?	Specify the number of days: Specify the amount:	
7	Did you have to pay someone to take care of any other children while you went to receive ANC?	0 = No	
		1 = Yes	
		3= Not applicable (Do not have children)	
7a	If yes, how much money did you spend?		
8	Which mode of transport did you use to reach the ANC facility?	0 = Not Applicable for ANC received at home	
		1= Walking	
		2= Paddled rickshaw/Van gari	
		3 = Electric rickshaw/van gari	
		4 = Nosimon/votvoti (converted shallow water pump into vehicle)	
		5 = CNG/Mahindra/ Tempo	
		6 = Private vehicle (Car/Micro)	
		7 = Ambulance (Government, private, NGO's)	
		8 = Bus/Train	
		9 = Other, specify (e.g. Wainwright, bullock carts, tractor, trolley van)	
		10 = Don't know	
9	What is the amount of time (in minutes) you usually spend on __________ during your ANC visits?	Travel time (Round trip: From the time you depart from your home/health facility until the time to arrive at the health facility/your home): (Minutes)	
10		Waiting time: (Minutes)	
11		Consultation time (Including physical examination, different test such as Hb, sugar and protein in urine etc.): (Minutes)	
12		Pharmacy time (obtaining medicines at the facility): (Minutes)	

USER COSTS FOR CHILD DELIVERY			
Note: These questions will be completed based on discussions with pregnant women who have previous experience of child birth from their previous pregnancy. It is expected to take about 10 minutes. The questions and answers may be based on the latest previous delivery experience.			
	Does she have previous child delivery experience?	0 = No	→End
		1 = Yes	
	Record whether permission was received from the client.	0 = No	→End
		1 = Yes	
	Questions	**Check all that apply**	**Amount** (if any)
1	Did you have to spend any money during your delivery?	0 = No	
		1 = Yes	
		9 = Don't Know	
2	How much of your own money did you spend during your delivery in total?	Specify the amount:	
3	Which of the following things did you spend your money on during your delivery? [Specify amount of expenditure to the relevant item, if any]	1 = Admission fee	
		2 = Provider/ consultation fees	
		3 = Medicines	
		4 = Medical tests	
		5 = Ultrasonography	
		6 = Supplements	
		7 = Immunization	
		8 = Transportation	
		9 = Food (in hospital/on way to facility)	
		10 = Hospitalization	
		11 = Other, specify	
		12 = Don't know	
4	How did you arrange to pay for the expenses of your delivery?	1 = Personal savings	
		2 = Loans from friends/neighbors/relatives	
		3 = Sold assets	
		4 = Microcredit	
		5 = Conditional cash transfer	
		6 = Vouchers	
		7 = Other, specify	
		9 = Don't know	
5	Did your husband take time off from work during your delivery?	0 = No	
		1 = Yes	
		9 = Don't Know	
6	How many days did your husband take off from work for your delivery? /How much money did you or your husband lose because of	Specify the number of days: Specify the amount:	

	this absence from work during your delivery?		
7	Did you have to pay someone to take care of any other children while you sought care for the child delivery?	0 = No	
		1 = Yes	
		3= Not applicable (Do not have children)	
7a	If yes, how much money did you spend?		
8	Which mode of transport did you use to reach the place of delivery?	0 = Not Applicable for home delivery	
		1= Pedaled rickshaw/Van gari	
		2 = Electric rickshaw/electric van gari/Auto	
		3 = Nosimon/votvoti (converted shallow water pump into vehicle)	
		4 = CNG/Mahindra/Tempo	
		5 = Private vehicle (Car/Micro)	
		6= Ambulance (Government, private, NGO's)	
		7=Train/Bus	
		8= Other	
		9 = Don't know	
USER COSTS FOR PNC/ENC			
Note: These questions will be completed based on discussions with pregnant women who have previous experience of postnatal care from their previous pregnancy. It is expected to take about 10 minutes. . The questions and answers may be based on the latest previous PNC/ENC experience.			
	Questions	**Check all that apply**	**Amount** (if any)
1	Did you have to spend any money on postnatal/essential newborn care since your delivery?	0 = No	
		1 = Yes	
		9 = Don't Know	
2	Which of the following things did you spend your money on for postnatal/essential newborn care since your delivery? [Specify amount of expenditure to the relevant item, if any]	1 = Admission fee	
		2 = Provider/ consultation fees	
		3 = Medicines	
		4 = Medical tests	
		5 = Ultrasonography	
		6 = Supplements	
		7 = Immunization	
		8 = Transportation	
		9 = Food (in hospital/on way to facility)	
		10 = Hospitalization	
		11 = Other, specify	
		12 = Don't know	
3	How many days did your husband take off from work for your PNC/ENC?	Specify the number of days:	

	/How much of your or your husband's money did you spend in total on postnatal/essential newborn care since your delivery?	Specify the amount:	
4	How did you arrange to pay for your postnatal/essential newborn care expenses?	1 = Personal savings	
		2 = Loans from friends/neighbors/relatives	
		3 = Sold assets	
		4 = Microcredit	
		5 = Conditional cash transfer	
		6 = Vouchers	
		7 = Other, specify	
		9 = Don't know	
5	Did you or your husband take time off from work for you to receive postnatal/essential newborn care since your delivery?	0 = No	
		1 = Yes	
		9 = Don't Know	
6	How much money did you or your husband lose because of this absence from work for your postnatal/essential newborn care since your delivery?	Specify the amount:	
7	Did you have to pay someone to take care of any other children while you took your youngest child for postnatal/essential newborn care since your delivery?	0 = No	
		1 = Yes	
		3= Not applicable (Do not have children)	
8	How much in total did you pay them to take care of your other children while you took your youngest child for postnatal/essential newborn care?	Specify the amount:	
10	Which mode of transport did you use most to reach the postnatal/essential newborn care facility?	0 = Not Applicable for PNC received at home	
		1= Walking	
		2= Paddled rickshaw/Van gari	
		3 = Electric rickshaw/van gari	
		4 = Nosimon/votvoti (converted shallow water pump into vehicle)	
		5 = CNG/Mahindra/ Tempo	
		6 = Private vehicle (Car/Micro)	
		7 = Ambulance (Government, private, NGO's)	
		8 =Train/Bus	
		9 = Other, specify (e.g. Wainwright, bullock	

		carts, tractor, trolley van)	
		10 = Don't know	
11	What is the average amount of time (in minutes) you spent on ___________ during your postnatal/essential newborn care visits, from the time you departed to the health facility until the time you returned?	Travel time (round trip): (Minutes)	
12		Waiting time: (Minutes)	
13		Consultation time: (Minutes)	
14		Pharmacy time (obtaining medicines at the facility): (Minutes)	

A 5.5 Consent forms

Understanding service contents and costs of maternal and newborn health services for mCARE program evaluation in rural Bangladesh
(A project of JiVitA – Johns Hopkins University Bangladesh)
and
Johns Hopkins Bloomberg School of Public Health, Baltimore, USA
CONSENT FOR CLIENT

Research Study Title: Understanding service contents and costs of maternal and newborn health services for mCARE program evaluation in rural Bangladesh

Principal Investigator: Dr. Alain B. Labrique

Student Investigator: Youngji Jo

IRB No.: 00006999

PI Version/Date: v3.0, June, 2016

Salaam alaikum. I am ______. We are from the JiVitA Project of Johns Hopkins University-Bangladesh. The reason we are here today is to observe antenatal care services provision in this facility/community.

Purpose: We would like to understand what services are given and what supplies and equipment are typically used in maternal and newborn service provision in rural Bangladesh. We are doing this to identify the gaps and scope of the service and to understand cost in community and facility care settings.

Procedures: You are being asked as a client who is receiving antenatal care service in this community/facility. If you give consent to participate in this study, we will be present while you are receiving services today and ask some questions at the end of the consultation. The questions will take about 10-20 minutes.

Confidentiality: The information received about you will be kept confidential by JiVitA staff. Your identity will not be revealed when the information is used.

Risk or Discomfort/Benefit: The risks are minimal, but you may feel uncomfortable or embarrassed to have someone present during your medical examination. I will stay out of the way and will be observing the medical care and the supplies being used. If at any point you feel uncomfortable you can ask me to leave or ask to stop the interview. At the end of the interview, we will provide a snack or drink in appreciation of your time and willingness to participate in the study.

Voluntariness: Please know that you can decide whether you allow me to observe the care that is provided and to interview you. You do not have to agree. Whether you agree or not, it will not affect services you receive today or during any future visit. You may refuse to answer any question, and you may stop the interview at any time.

Persons to Contact: If you have any questions about JiVitA or the study, I can answer them now or, you may contact our Field Officer (mention name) in the local field office. For questions about your rights as human subjects in this project you may contact Dr. Hasmot Ali or Dr. Saijuddin Sheikh, senior project officers through the Gaibandha JiVitA office (tel: 0541-52661).

Would you like to provide consent for participation in the study?
Your signature on this form means:

- You have been informed about this study's purpose, procedures, possible benefits and risks.
- You have been given the chance to ask questions before you sign.
- You have voluntarily agreed to be in this study.

If you agree can you please sign or make your mark below on two copies of this form? You will receive one copy of this form and we will keep the other one.

Thank you for your kind cooperation.

Name Signature or thumbprint of woman Date

Name Signature or thumbprint of witness Date

Name Signature of person obtaining consent Date

Understanding service contents and costs of maternal and newborn health services for mCARE program evaluation in rural Bangladesh

(A project of JiVitA – Johns Hopkins University Bangladesh)

and

Johns Hopkins Bloomberg School of Public Health, Baltimore, USA

CONSENT FOR SERVICE PROVIDER

Research Study Title: Understanding service contents and costs of maternal and newborn health services for mCARE program evaluation in rural Bangladesh

Principal Investigator: Dr. Alain B. Labrique

Student Investigator: Youngji Jo

IRB No.: 00006999

PI Version/Date: v3.0, June, 2016

Salaam alaikum. I am ______. We are from the JiVitA Project of Johns Hopkins University-Bangladesh. The reason we are here today is to observe essential maternal and newborn services provision in this facility/community.

Purpose: We would like to understand what services are given and what supplies and equipment are typically used in maternal and newborn service provision in rural Bangladesh. We are doing this to identify the gaps and scope of the service and to understand cost in community and facility care settings.

Procedures: You are being asked as a maternal and newborn service provider in this community/facility. We are not evaluating the service provision. Without any interruption, we will take notes about what types of care and items that you provide to your clients in what kind of methods or procedures.

Confidentiality: The information received about you will be kept confidential by JiVitA staff. Your identity will not be revealed when the information is used and no information about you or your clinical services will be shared with your supervisors.

Risk or Discomfort/Benefit/Voluntariness: There is no known risk or direct benefits to participate to the study. It is your choice to take part in the study. You may refuse to participate, or if at any point you feel uncomfortable you can ask me to leave. Your choice will not affect your current or future work in this facility or will not be shared with your supervisors.

Persons to Contact: If you have any questions about JiVitA or the study, I can answer them now or, you may contact our Field Officer (mention name) in the local field office. For questions about your rights as human subjects in this project you may contact Dr. Hasmot

Ali or Dr. Saijuddin Sheikh, senior project officers through the Gaibandha JiVitA office (tel: 0541-52661).

Would you like to provide consent for participation in the study?

Your signature on this form means:

- You have been informed about this study's purpose, procedures, possible benefits and risks.
- You have been given the chance to ask questions before you sign.
- You have voluntarily agreed to be in this study.

If you agree can you please sign or make your mark below on two copies of this form? You will receive one copy of this form and we will keep the other one.

Thank you for your kind cooperation.

Name	Signature or thumbprint of provider	Date

Name	Signature or thumbprint of witness	Date

Name	Signature of person obtaining consent	Date

Appendix 7. Understanding Service Contents and Costs of Antenatal Care in Rural Bangladesh

BACKGROUND: Current efforts to monitor progress of service coverage lack information on specific content, quality or cost of care, in fragmented health systems in many developing countries. Measuring antenatal care (ANC) service coverage is often limited to number of contacts or type of providers, which is a gap in understanding the quality as well as estimating costs and health impact. The study was conducted in rural Bangladesh, where 18.5% of pregnant women receive any one of ANC service and 82% of them receive the care from community-based service by the government and NGO (i.e. BRAC) health workers.

OBJECTIVE: 1) To determine antenatal care health service content and practice with the equipment or any supplements provided by major service providers in rural Bangladesh; 2) To determine the gaps in and scope of service provision as well as related costs in respective community and facility care settings.

METHODS: The data collection was conducted from September to October, 2016. Adapted from standardized guidelines, we designed and devised data collection methods and modules including ***observation studies of ANC service provision*** (n=72), and ***exit interviews with clients for user costs*** (n=72) in health clinics of community and facility levels. Based on standardized guidelines, the study assessed the service contents and costs of ANC in community level (i.e. satellite clinics) and facility level (i.e. primary and secondary health centers) services. The study samples were drawn from major service provision agencies including government and NGOs (e.g. BRAC and Smiling Sun) in this rural setting. Based on the scheduled dates, pregnant women were recruited purposively on the day of observation/ interview at the community or facility sites.

Table A 7.1. Study population characteristics

Service provision characteristics		Community (n=4)		Facility (n=5)		
Provider	Provider category	Family Welfare Visitor, BRAC SK, Paramedic		Nurse, Family Welfare Visitor, Paramedics		
	Age (years)	26, 28, 35, 36 years old		26, 29, 40 years old		
	Schooling (years)	11~14 years		10~14 years		
	Years of working on ANC service	3~10 years		3~10 years		
	Last training received (years)	1~10 years ago		3~10 years ago		
Mother's characteristics		Community (n=34)		Facility (n=36)		P-value
		n	%	n	%	
Age	<20	13	38%	9	25%	0.23
	20-34	20	59%	26	72%	0.24
	35-49	1	3%	1	3%	0.98
Parity	First pregnancy	18	53%	13	36%	0.16
	Not first pregnancy	16	47%	23	64%	0.16
GA	Within 12 week	8	24%	2	6%	<0.05*

	13-26 week	6	18%	19	53%	<0.05*
	27-32 week	14	41%	13	36%	0.66
	33-38 week	6	18%	2	6%	0.11
ANC	1st visit	14	41%	22	61%	0.10
	2nd visit	9	26%	6	17%	0.24
	3rd visit	8	24%	4	11%	0.17
	> 4th visits	3	9%	4	11%	0.75
Literacy	Yes	32	94%	30	83%	0.17
	No	2	6%	6	17%	0.17
Schooling	No schooling	5	15%	5	14%	0.92
	Class 1~9 completed	25	74%	21	58%	0.18
	SSC/HSC completed	3	9%	7	19%	0.19
	Degree or higher	1	3%	3	8%	0.57
Women/ Husband occupation	Work on own farm/unskilled labor/own business	28	82%	27	75%	0.59
	Private service/government	6	18%	9	25%	0.59

- Women in earlier pregnancy stages (gestational age less then 12 weeks) tend to seek care at the community level; Women in progressively later pregnancy stages (gestational age between 13-26 weeks) tend to seek care at the facility level.
- Women's first ANC visits to community/facility clinics are generally sought at a gestational age of 8-26 weeks.

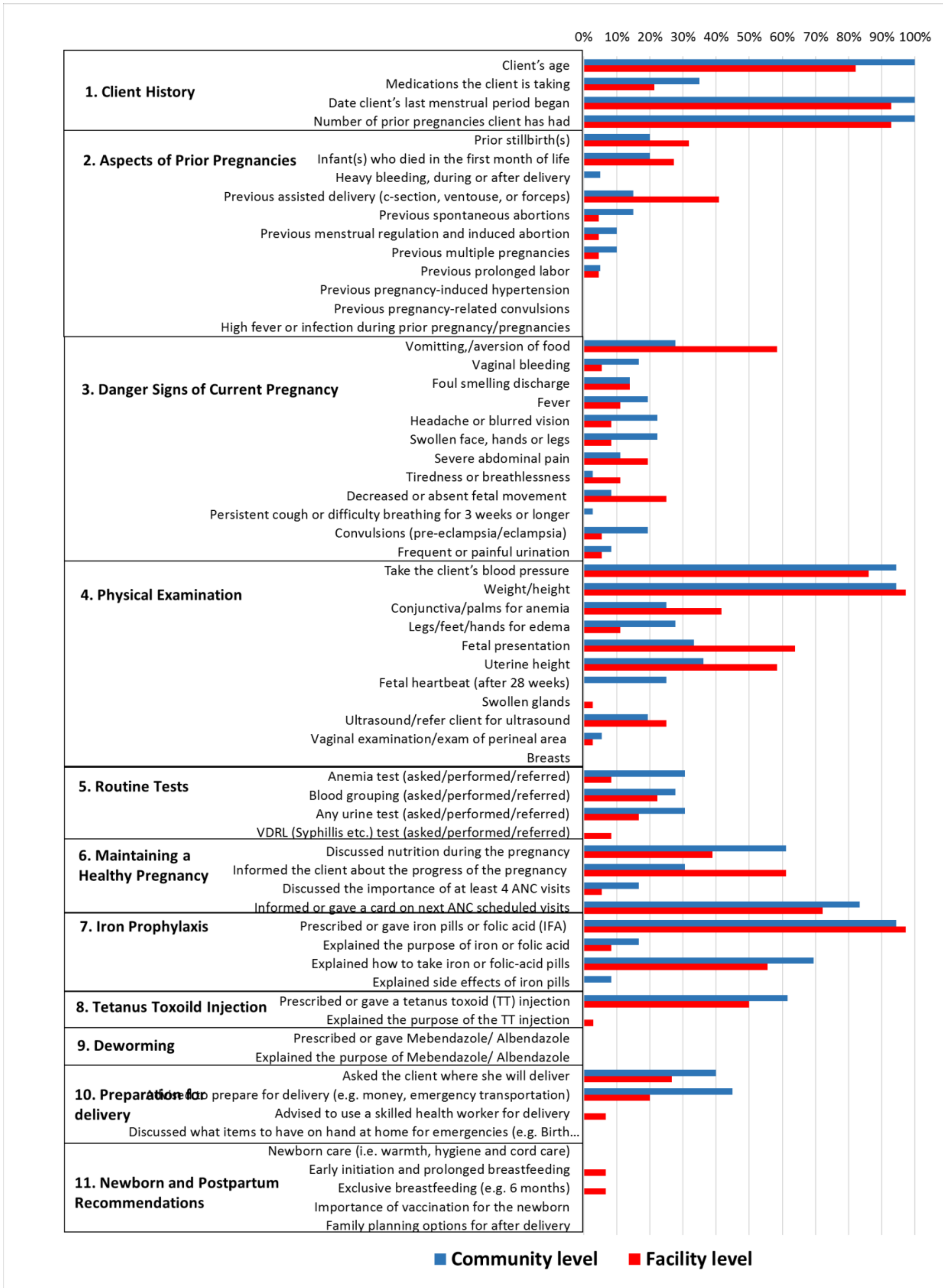
Table A 7.2. ANC Service contents in community vs. Facility levels.

		Community (n=34)		Facility (n=36)	
		n	%	n	%
204. Client History (first visit and not identified Fn=28;Cn=20)	Client's age	20	100%	23	82%
	Medications the client is taking	7	35%	6	21%
	Date client's last menstrual period began	20	100%	26	93%
	Number of prior pregnancies client has had	20	100%	26	93%
205. Aspects of Prior Pregnancies--(Not first pregnancy/not identified, Fn=22; Cn=20)	Prior stillbirth(s)	4	20%	7	32%
	Infant(s) who died in the first month of life	4	20%	6	27%
	Heavy bleeding, during or after delivery	1	5%	0	0%
	Previous assisted delivery (c-section, ventouse, or forceps)	3	15%	9	41%
	Previous spontaneous abortions	3	15%	1	5%
	Previous menstrual regulation and induced abortion	2	10%	1	5%
	Previous multiple pregnancies	2	10%	1	5%
	Previous prolonged labor	1	5%	1	5%
	Previous pregnancy-induced hypertension	0	0%	0	0%
	Previous pregnancy-related convulsions	0	0%	0	0%
	High fever or infection during prior pregnancy/pregnancies	0	0%	0	0%
206. Danger Signs of Current Pregnancy (n=36)	Vomitting,/aversion of food	10	28%	21	58%
	Vaginal bleeding	6	17%	2	6%
	Foul smelling discharge	5	14%	5	14%
	Fever	7	19%	4	11%
	Headache or blurred vision	8	22%	3	8%
	Swollen face, hands or legs	8	22%	3	8%
	Severe abdominal pain	4	11%	7	19%
	Tiredness or breathlessness	1	3%	4	11%
	Decreased or absent fetal movement	3	8%	9	25%

	Persistent cough or difficulty breathing for 3 weeks or longer	1	3%	0	0%
	Convulsions (pre-eclampsia/eclampsia)	7	19%	2	6%
	Frequent or painful urination	3	8%	2	6%
207. Physical Examination (n=36)	Take the client's blood pressure	34	94%	31	86%
	Weight/height	34	94%	35	97%
	Conjunctiva/palms for anemia	9	25%	15	42%
	Legs/feet/hands for edema	10	28%	4	11%
	Fetal presentation	12	33%	23	64%
	Uterine height	13	36%	21	58%
	Fetal heartbeat (after 28 weeks)	9	25%	0	0%
	Swollen glands	0	0%	1	3%
	Ultrasound/refer client for ultrasound	7	19%	9	25%
	Vaginal examination/exam of perineal area	2	6%	1	3%
	Breasts	0	0%	0	0%
208. Routine Tests (n=36)	Anemia test (asked/performed/referred)	11	31%	3	8%
	Blood grouping (asked/performed/referred)	10	28%	8	22%
	Any urine test (asked/performed/referred)	11	31%	6	17%
	VDRL (Syphillis etc.) test (asked/performed/referred)	0	0%	3	8%
209. Maintaining a Healthy Pregnancy (n=36)	Discussed nutrition during the pregnancy	22	61%	14	39%
	Informed the client about the progress of the pregnancy	11	31%	22	61%
	Discussed the importance of at least 4 ANC visits	6	17%	2	6%
	Informed or gave a card on next ANC scheduled visits	30	83%	26	72%
210. Iron Prophylaxis (n=36)	Prescribed or gave iron pills or folic acid (IFA)	34	94%	35	97%
	Explained the purpose of iron or folic acid	6	17%	3	8%
	Explained how to take iron or folic-acid pills	25	69%	20	56%
	Explained side effects of iron pills	3	8%	0	0%
211. Tetanus Toxoid Injection (GA >13 weeks, Fn=34;Cn=26)	Prescribed or gave a tetanus toxoid (TT) injection	16	62%	17	50%
	Explained the purpose of the TT injection	0	0%	1	3%
212. Deworming	Prescribed or gave Mebendazole/ Albendazole	0	0%	0	0%
	Explained the purpose of Mebendazole/ Albendazole	0	0%	0	0%
214. Preparation for Delivery (GA >27 week, Fn=15; Cn=20)	Asked the client where she will deliver	8	40%	4	27%
	Advised to prepare for delivery (e.g. money, emergency transportation)	9	45%	3	20%
	Advised to use a skilled health worker for delivery	0	0%	1	7%
	Discussed what items to have on hand at home for emergencies (e.g. Birth kit)	0	0%	0	0%
215.Newborn and Postpartum Recommendations (GA > 27 week, Fn=15; Cn=20)	Newborn care (i.e. warmth, hygiene and cord care)	0	0%	0	0%
	Early initiation and prolonged breastfeeding	0	0%	1	7%
	Exclusive breastfeeding (e.g. 6 months)	0	0%	1	7%
	Importance of vaccination for the newborn	0	0%	0	0%
	Family planning options for after delivery	0	0%	0	0%

Note: % of each service item was calculated based on eligible gestational stage of pregnant women for the relevant service categories in community/facility level.

Figure A.7.1. ANC Service contents in community vs. Facility levels.



- Service contents or provision lack in aspects of prior pregnancies, danger signs of current pregnancy, deworming, preparation for delivery, and newborn care.
- Blood pressure, weight check, Iron folic acid, TT vaccine were frequently conducted.
- Some educational consultation was better provided at the community level, while physical examination is better conducted at the Facility level.

Table A.7.3. Provider and User costs for antenatal care

Level of care			**Community Level (n=34)**			**Facility Level (n=36)**			
Provider type			Gov't FWV (n=14)	BRAC SK (n=12)	SS (n=8)	CC (n=10)	UHC (n=10)	MCWC (n=10)	SS (n=6)
Provider costs	Service costs	Staff level	FWV	SK	Paramedic	FWV	Nurse	FWV	Paramedic & Counseor
		Staff monthly salary	14000~30000 tk	6000 tk	22000 tk	14000~30000 tk	16000~35000 tk	14000~30000 tk	22000 tk
		Service provision time	6 (5~10) min	25 (21~25) min	10 (9~10) min	5 (5~6) min	17 (10~20) min	10 (5~14) min	28 (18~30) min
		Total service costs	13 tk	14 tk	21 tk	10 tk	42 tk	21 tk	58 tk
	Supplementation costs*	Iron & Folic acid	25-30 tk	10 tk	10 tk	25-30 tk	25-30 tk	25-30 tk	10 tk
		Calcium	35-50 tk	10-15 tk	10 tk	35-50 tk	35-50 tk	35-50 tk	10 tk
		Vitamin B Complex		20-36 tk	35 tk				35 tk
		Misoprostal	150 tk			150 tk	150 tk	150 tk	
		Total Supp. Costs	220 tk	51 tk	55 tk	220 tk	220 tk	220 tk	55 tk
Total provider costs (BDT)			233	65	76	230	262	241	113
Total provider costs (USD)			3.03	0.85	0.99	2.99	3.41	3.13	1.47
Average user costs (USD)			**$1.62**			**$2.75**			
User costs	Indirect costs	Hour wage*	45 (28~55) tk	40 (33~53) tk	68 (32~85) tk	37 (28~71) tk	40 (34~65) tk	48 (37~71) tk	51 (28~51) tk
		Travel time (a round trip)	20 (10~55) min	13(6~33) min	10 (10~17) min	10 (10~20) min	48 (41~60) min	120 (70~120) min	40 (25~70) min
		Waiting time	13 (5~56) min	15 (2~30) min	6 (4~17) min	20 (8~30) min	40 (15~105) min	120 (90~210) min	8 (1~10) min

		Consultation time	10 (8~10) min	30 (24~35) min	18 (9~20) min	4 (2~9) min	13 (10~28) min	10 (10~20) min	30 (23~41) min
		Pharmacy time	0 (0~0) min	0 (0~1) min	0 (0~0) min	0 (0~0) min	1 (0~4) min	0 (0~0) min	0 (0~0) min
		Total time	73 (46~114) min	75 (43~97) min	34 (27~44) min	43 (27~52) min	153(78~182)min	260 (195~292) min	90 (70~106) min
		Total wage loss	54 (37~74) tk	38 (24~79) tk	38 (24~70) tk	34 (19~47) tk	92 (53~176) tk	173 (108~459) tk	62 (31~72) tk
	Direct costs	Admission fee	0 tk	0 tk	0 tk	0 tk	3 tk	0 tk	0 tk
		Consultation/Medicines/Medical tests	0 tk	50 taka	0 tk	0 tk	0 tk	200 tk	120 tk
		Transportation	0 tk	0 tk	0 tk	10 tk	35 (25~43) tk	40 (40~70) tk	50 (40~60) tk
		Others	0 tk	0 tk	0 tk	0 tk	0 tk	55 (10~100) tk	0 tk
		Total direct costs	0 tk	50 tk	0 tk	0 tk	23 (3~43) tk	240 (98~345) tk	55 (43~105) tk
Total user costs (BDT)			54	88	38	34.00	115.00	413.00	117.00
Total user costs (USD)			0.70	1.14	0.49	0.44	1.50	5.37	1.52
Average user costs (USD)			**$0.78**			**$2.21**			

(Note: Medicines and supplements depend on government supply in stock. The medicine costs are based on 1 blister-pack (10 tablets). Wage, time, costs are calculated based on median estimates of interquartile ranges 1-3. Hour wages are estimated based on women/husbands' occupations and monthly salaries).

<u>Provider costs:</u>

- ANC service provision unit costs at the facility level ($2.75) were about double that in the community ($1.62). These estimates are similar or slightly higher to the existing evidence, based on the supplementation condition. (79.2 BDT: 1.1 USD, BRAC MNCH Costs report, 2012)
- Service provision times tend to be longer at NGO clinics (BRAC, Smiling Sun) than government clinics. This is in part due to the high volume of clients seeking care at government clinics.

<u>User costs:</u>

- ANC user costs at facility level ($2.21) were about 3 times higher than community level ($0.78).

- Travel and waiting times were considerable (40-120 min) when seeking care at secondary clinics at the facility level, while consultation time (10-13 min) was low.
- User costs in most satellite clinics or community clinics are free or minimal. Service fees and transportation costs are major cost drivers at the facility level.

Table A.7.4. Provider and User costs for child delivery

Level of care (Delivery)			**Community**	**Facility**
Number of samples			n=32	n=22
Provider costs	Service costs	Staff level	SK	FWV
		Staff monthly salary	6000 tk	14000~30000 tk
		Service provision time (Day)	1 (1~2)	1.5 (1~4.5)
Total provider costs (BDT)			273~545	1000~6136
Total provider costs (USD)			$4~7	$12~80
User costs	Indirect costs	Daily wage*	318 (261~386)	364 (227~455)
		Total time (day)	1 (1~2)	1.5 (1~4.5)
		Total wage loss	318 (261~772)	546 (227~2048)
	Direct costs	Total direct costs (Provider consultation, transportation, admission, medicine)	500 (0~1500)	3000 (589~9250)
Total user costs (BDT)			818 (261~2722)	3546 (816~11298)
Total user costs (USD)			$11 (3~35)	$46 (11~147)

Table A.7.5. Provider and User costs for postnatal care

Level of care (Postnatal care for mothers and newborns)			**Community**	**Facility**
Number of samples			n=16	n=22
Provider costs	Service costs	Staff level	SK	FWV
		Staff monthly salary	6000 tk	14000~30000 tk
		Service provision time (min)	15	18 (8~75)
		Total service costs	9	38
	Supplementation costs*	ORS	3.7	5
		Zinc for diarrhea treatment to newborn	1.42	20

		Case management of pneumonia (oral antibiotics)	32	57
		Multiple micronutrients supplementation	2.5	n/a
		Antibiotics for dysentery	n/a	1.5
		Cotrimoxazole for ARI(acute respiratory illness)	n/a	20
		Total Supp. Costs	40	104
Total provider costs (BDT)			48	141
Total provider costs (USD)			**$0.6**	**$1.8**
User costs	Indirect costs	Hour wage*	40 (27~57)	45 (38~57)
		Total time (travel time, waiting time, consultation time and pharmacy time)	0	1.42 (0.92~2.5)
		Total wage loss	0	64 (35~143)
	Direct costs	Total direct costs (Medicine, transportation)	0	1000 (45~4563)
Total user costs (BDT)			0	1064 (80~4706)
Total user costs (USD)			**$0.0**	**14 (1.04~61)**

CONCLUSION: The study demonstrates that ANC sub-components, contents and care-seeking/provision costs differ by service provision setting as well as by stage of pregnancy care-seeking, resulting in different quality and cost implications throughout the continuum of care in the health systems.

RECOMMENDATIONS:

- Community-level workers need to further improve in identifying pregnant women and encouraging to seek their first ANC at earlier gestational ages.
- ANC services at the community level could better focus on educational consultation, preventive measures, screening and referral strategies, while the facility level could better focus on physical examinations, laboratory tests, and treatment services.
- Risk factors from prior and current pregnancy can be more systematically identified for effective referral and prevention strategies at both the community and facility levels.
- ANC service could be more cost effective through better coordination between public and NGO clinics by reducing waiting time, transportation costs, and improving service quality at the community and facility levels

Appendix 8. Institutional Review Boards (IRB) Approval

A 8.1 Johns Hopkins School of Public Health

JOHNS HOPKINS
BLOOMBERG SCHOOL of PUBLIC HEALTH

FWA #00000287

Institutional Review Board Office

615 N. Wolfe Street / Room E1100
Baltimore, Maryland 21205-2179
Phone: 410-955-3193
Toll Free: 1-888-262-3242
Fax: 410-502-0584
Email: jhsph.irboffice@jhu.edu
Website: www.jhsph.edu/irb

INITIAL APPLICATION APPROVAL NOTICE

Date: October 11, 2016

To: Alain Labrique, PhD
(Youngji Jo)
Department of International Health

From: Luke C. Mullany, PhD, MHS
Chair, IRB-X

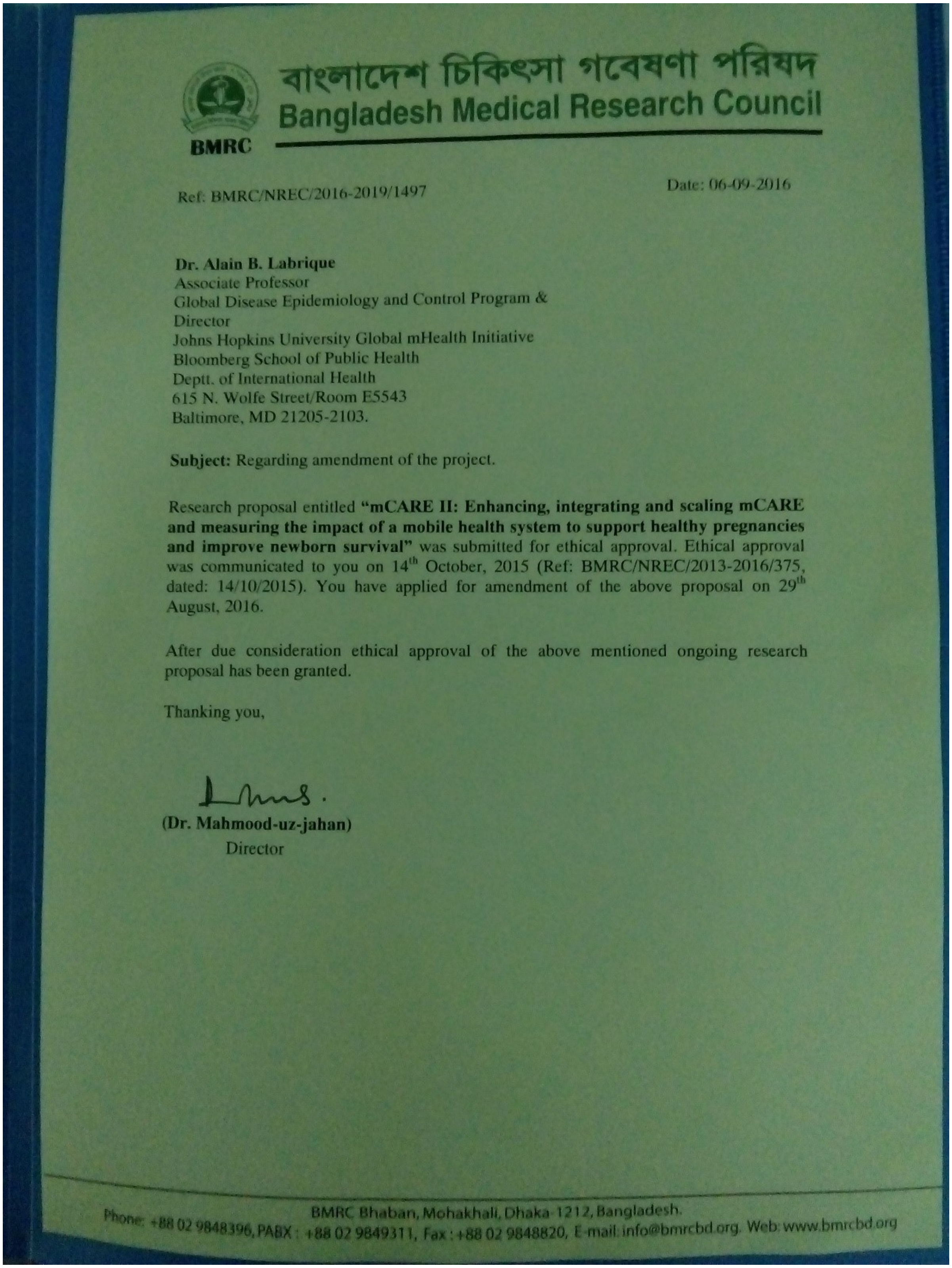
Re: **Study Title**: "Understanding Service Contents and Costs of Maternal and Newborn Health Services for mCARE Cost Effectiveness Analyses in Rural Bangladesh"
IRB No: 00006999

The **JHSPH IRB-X** voted to approve the above referenced application at its meeting on **June 9, 2016. The Board made the following determinations:**

Approval of the research is for the period of **June 9, 2016 to June 8, 2017. Please submit a progress report <u>no later than 6 weeks</u> before the approval lapse date. We recommend that YOU USE YOUR OUTLOOK CALENDAR, OR OTHER ELECTRONIC REMINDER CALENDAR TOOL, to set a timely reminder notification for this submission to avoid a lapse in approval.**

Single Reviewer ☐ Convened ☒ DHHS 46.110 . . ☒ DHHS....... ☐ FDA 56.110 . . . ☐ FDA......... ☐ Category: 7	**Consent/Parental Permission Required From:** Adult Participant.............. ☒ LAR .... ☐ One Parent .... ☐ Two Parents..................... ☐ Legal Guardian................. ☐ (Foster Care Children)	**Form of Consent/Permission:** Written Consent......................... ☒ Waiver of Signature..................... ☐ (Oral Script) Waiver of Informed Consent..... ☐ HIPAA Authorization.................. ☐ HIPAA Waiver............................ ☐ No Longer Enrolling.................. ☐	**Study Site(s):** U.S. ☐ International ☒ **List Country(ies):** Bangladesh
GWAS .... ☐			
Vulnerable Populations: Children .... ☐ Foster Care Children .... ☐	**Assent Required From:** No children (waived) ..... ☐ Children aged:________ ☐	**Pregnant Women/Fetuses** 46.204............................ ☒ Neonates 46.205 .... ☐	**Sample Size:** (screened plus enrolled) 100 **Final Enrollment:**

A 8.2 Bangladesh Medical Research Council (BMRC)



বাংলাদেশ চিকিৎসা গবেষণা পরিষদ
Bangladesh Medical Research Council
BMRC

Ref: BMRC/NREC/2016-2019/1497

Date: 06-09-2016

Dr. Alain B. Labrique
Associate Professor
Global Disease Epidemiology and Control Program &
Director
Johns Hopkins University Global mHealth Initiative
Bloomberg School of Public Health
Deptt. of International Health
615 N. Wolfe Street/Room E5543
Baltimore, MD 21205-2103.

Subject: Regarding amendment of the project.

Research proposal entitled **"mCARE II: Enhancing, integrating and scaling mCARE and measuring the impact of a mobile health system to support healthy pregnancies and improve newborn survival"** was submitted for ethical approval. Ethical approval was communicated to you on 14th October, 2015 (Ref: BMRC/NREC/2013-2016/375, dated: 14/10/2015). You have applied for amendment of the above proposal on 29th August, 2016.

After due consideration ethical approval of the above mentioned ongoing research proposal has been granted.

Thanking you,

(Dr. Mahmood-uz-jahan)
Director

BMRC Bhaban, Mohakhali, Dhaka-1212, Bangladesh.
Phone: +88 02 9848396, PABX : +88 02 9849311, Fax : +88 02 9848820, E-mail: info@bmrcbd.org, Web: www.bmrcbd.org

CURRICULUM VITAE

Youngji Jo

Address: 929 N. Wolfe St. APT #1703, Baltimore, MD 21205
E-mail : yjo5@jhu.edu | youngji1435@gmail.com **Phone :** +1 443 800 1626

Education

Johns Hopkins University, Bloomberg School of Public Health Baltimore, MD, USA
Ph.D. in Health Systems Program, Department of International Health *Sep. 2011-Mar. 2017*
• Academic advisor: Dr. Alain B. Labrique
• Dissertation title: Cost-effectiveness and scalability of an mHealth intervention to improve pregnancy surveillance and care seeking in rural Bangladesh
• Selected Coursework: Comparative Evaluation for Health Policy in International Health, Health Economics, E-health and M-health: Using Information Technology to Improve Health in Low and Middle-income Countries (LMICs), Health Information Systems, Managing Health Services Organizations, Health Systems in LMICs, Health Financing in LMICs, Statistical Methods in Public Health (longitudinal/multilevel/sample surveys analyses), Epidemiologic Methods, Econometric Methods For Evaluation Of Health Programs, Large-scale Effectiveness Evaluations of Health Programs

Johns Hopkins University, School of Advanced International Studies (SAIS) Washington D.C. USA
M.A. in International Relations & International Economics *Sep. 2009-May. 2011*
• Selected Coursework: Statistics, Econometrics, Introduction to Economics of Public Health, Introduction of International Law, Politics of International Economy, Comparative National Systems, Microeconomics, Accelerated Macroeconomics, International Trade Theory, International Monetary Theory, Energy Technology Future, Policy to Drive Energy Innovation, Asian Energy Security, Global Climate Change Policy, American Foreign Policy since World War II

Seoul National University (SNU), Graduate School of International Studies Seoul, Korea
Master's Program in International Commerce *Sep. 2008-Jun. 2009*
• Selected Coursework: Understanding International Economy, Research Methodology and Skill, Understanding Trade Law, Foreign Direct Investment

Seoul National University Seoul, Korea
B.E. Major in Electrical Engineering with minor in Business Management *Mar. 2002-Jun. 2008*
• Thesis on "Signal Processing in Radio Frequency Identification Devices (RFID) System"

Tohoku University, Department of Electrical Engineering Sendai, Japan
Research Exchange Student, Electric Power System Laboratory *Sep. 2005–Aug. 2006*
• Performed research on electric power system, industry, market restructuring in Japan
• Presented a thesis on "Efficiency of Electric Power Energy" (in Japanese)

Research Experiences

Johns Hopkins University-JiVitA Bangladesh Gaibandha, Bangladesh
Student Investigator, mCARE Project *Feb. 2015-Mar. 2017*
• Conducted field research for doctoral thesis on cost-effectiveness analysis of mCARE on Maternal and Newborn Child (MNCH) Health Services in Bangladesh
• Developed program/service costing and coverage tools and survey protocols, accounting various stakeholders, program life cycle, level of healthcare delivery throughout continuum of MNCH services

• Submitted IRBs to John Hopkins Bloomberg School of Public Health and Bangladesh Medical Research Council
• Conducted sampling, training, observation studies of antenatal care service, exit interview with local pregnant women, in-depth interviews with local stakeholders and policy makers
• Evaluated cost-effectiveness of the program and forecast scaling up estimations
• Designed sensitivity analyses and conduct Monte Carlo simulation, using Visual Basic for Applications in Excel
• PI: Dr. Alain Labrique

Johns Hopkins University-Jhpiego Baltimore, MD
Research Assistant, Expanding Maternal and Newborn Survival (EMAS) project in Indonesia *Jan, 2016-Feb. 2017*
• Project maternal and neonatal mortality impact of a program by modeling Lives Saved Tool based on health facility survey data, and subnational demographic and epidemiologic data
• Design and perform analyses to define the baseline and target coverage of selected obstetric service interventions
• Compile and integrate multiple sources of primary data (health facility survey comprised of 150 hospitals, 300 community health centers across in six provinces) and secondary data (Demographic and Health Survey, Multiple Indicator Cluster Survey)

World Health Organization Geneva, Switzerland
WHO-JHU Fellow, Reproductive Health and Research Department *Jun.-Aug, Nov. 2012*
• Researched on cost-benefit analysis tools (OneHealth Tool and Lives Saved Tool) for mHealth evaluation
• Developed a mHealth costing framework based on Total Cost Ownership Model and presented "Costing mHealth Strategies in Maternal and Child Health" at a meeting of WHO-RHR department.
• Conducted a field trip to India (Dimagi-Save the Children-India Health Action Trust) for costing data collection and stakeholder interviews
• Produced a mission report on "Total Cost Ownership model as a measurement and evaluation framework for mHealth costing and economic analysis"

Center for Strategic and International Studies (CSIS) Washington D.C. USA
Graduate Research Intern, Global Health Policy Center *May.-July. 2011*
• Researched on Japan Health Reconstruction and Radiation after the 311 Earthquake and Tsunami Disaster
• Provided various research reports and summary notes on Tobacco Law, Health System, and Water Security

Graduate Research Intern, Energy and National Security Program *Jan.-May. 2011*
• Contributed to research papers: "Unconventional Natural Gas Development and the Role of Technology" and "Geopolitics of India's Energy"
• Researched on various national security issues related to energy including technology transfer, water and environment, and global reaction on nuclear energy after Japan earthquake/tsunami

Federal Communications Commission (FCC) Washington D.C. USA
Research Assistant, Strategic Analysis and Negotiation Division *Sep.2009-Dec.2010*
• Researched internet broadband international development programs for in remote regions and regulatory mechanisms on net neutrality
• Analyzed cross country pricing and broadband service data for the International Broadband Development Research Project
• Assisted in production of national broadband policy presentation materials presented at OECD meetings

International Monetary Fund (IMF) Washington D.C. USA
Research Assistant, Statistics Department *Oct-Nov.2009*
• Assisted to evaluate compliance of balance of payment data for Republic of Korea

United Nations Foundation New York, USA
Research Intern *Mar.2007-Feb.2008*

• Researched various issues on Millennium Development Goals and provided reports related to economic development and racial cleansing in African countries, and educational empowerment of women in Africa and Asia; utilized research findings to assist transition team of United Nations Secretary-General Ban Ki-moon
• Briefed on current UN issues and participated in various UN meetings including General Assembly, Security Council and provided summary reports
• Joined UN Intern's group activities, including visits to eight Missions to the UN (Peru, U.S., Sudan, Spain, Italy, Russia, Afghanistan and Republic of Korea)

United Nations Asia and Pacific Centre for Information and Communication Technology Korea
Research Assistant *Jan.-Mar.2007*
• Prepared agenda/budgeting/registration for International Conference on ICT Capacity Building
• Researched Information Communication Technology for Development (ICT4D) and its application to Official Development Aid (ODA) policy in the Republic of Korea

Professional Experiences

The World Bank Group Washington D.C. USA
Consultant, Health Systems Practice; Growth and Competitiveness Practice *Oct.2012-Dec.2014*
• Provided operational, research, and other analytical support ranging from project preparation, appraisal, implementation, and supervision to Task Team Managers with respect to a wide range of Bank/Trust Funds products, including Frontiers in Development Policy, *Global Scaling-up Investment Program for strengthening Civil Registration and Vital Statistics*, *Strengthening health systems governance through health information systems: A case study of Health Information Review and Assessment (HIRA) in the Korean National Health Insurance System.*
• Participated in missions on knowledge sharing program with Korea Development Institute (KDI) and Memorandum of Understanding meeting between The World Bank and Seoul National University
• Authored and presented a policy case study on Ensuring Social Safety Net: Universal Health Coverage in Republic of Korea
• Analyzed World Bank Project Appraisal Documents for a Project on Mapping 20 years of World Bank Financing and Analysis in the Health Sector

Consultant, World Bank E- institute *Mar.2014-Jun. 2016*
• Actively contributed to develop e-learning package, pedagogical design, learning management system on selected topics such as Public Private Partnership, Tax policy, or Health policy
• Promoted partnerships and collaborations on e-learning programs with UN agencies and Universities
• Assessed emerging trends and value proposition of e-learning/MOOC to promote effective client learning and leadership as well as strengthen institution's capacity based on country strategic alignment and diagnostics
• Compiled Korean development policy cases on various thematic topics

United Nations Foundation Washington D.C. USA
Consultant, Millennium Development Goals Campaign in Korea *Jul. 2010-Jun.2011*
• Prepared agenda and invited Congressmen and government officials to a high-level symposium on "Korea's Role in Achieving the MDGs" hosted by the Office of Congressman Kim, Hyo-jae and the United Nations Foundation at the National Assembly of the Republic of Korea
• Produced speech notes delivered by several high-level guests or government officials, including Sun-Tak Yoo, the spouse of the Secretary-General of the United Nations, Dr. Soo-hee Chin, Minister of Health and Welfare for the Republic of Korea
• Provided various implementation supports for development of mHealth public private partnership between UNF and Korean government agencies and private enterprises

Samsung SDS, Samsung IT Junior Club Seoul, Korea
Leader of members from Seoul National University *May. 2004–Feb.2005*

• Conducted research on Database Administration (Oracle) and Computer Security and presented the results of the group's research

Teaching Experiences

Johns Hopkins University

Instructor, Gordis Teaching Fellowship *Sep-Dec. 2014*

• Conducted a semester long course on "Information Communication Technology for Health Systems Strengthening" for undergraduate students at Johns Hopkins University

• Lectured an online class on "E-Health and M-Health: Using Information Technology to Improve Health in Low and Middle Income Countries", 3rd term, 2014 in Johns Hopkins Bloomberg School of Public Health

The Geneva Foundation for Medical Education and Research *Oct.* 2013

• Lectured on "mHealth Costing" for online training course Mobile Phones for Sexual and Reproductive Health

United Nations Foundation

Instructor, Millennium Development Goals Campaign in Korea *Jul. 2010-Jun.2011*

• Produced educational materials and conducted weekly lectures on the UN history, organization, activities to interns

Seoul National University (SNU), Graduate School of International Studies

Graduate Teaching Assistant, Class on "Understanding of East Asia" *Sep-Dec. 2009*

• Coordinated joint conference classes and managed a course blackboard under the BESETOHA (Beijing-Tokyo-SNU-Hanoi Univ.) project of East Asia Universities

Publications and Conferences

Peer Reviewed Journal Publications

Jo Y. Labrique AL, Lefevre AE, Mehl G, Pfaff T, Walker N, Friberg IK. Using the Lives Saved Tool (LiST) to Model mHealth Impact on Neonatal Survival in Resource-Limited Settings. *PLOS ONE.* 2014.

Tran NT, Bachani AM, Pham C, Lunnen JC, Jo Y, Passmore, J, Hyder AA. Drinking and Driving in Vietnam: public knowledge, attitudes, and practices, *Traffic Injury Prevention*, 2012.

Jo Y. "Korea's Universal Health Coverage", *Frontiers in Development Policy: Innovative Development Case Studies. World Bank Institute-Korea Development Institute School*, 2013. (Proceedings)

Hwang B and Jo Y. "Bridging the Global Gap: Korea's Leadership Agenda for the G-20" *Tomorrow's Northeast Asia,* Joint U.S.-Korea Academic Studies, Korea Economic Institute, Volume 21, 2011. (Book chapter)

Referred Conferences

Jo Y, Lefevre AE, Singh N, Mehra S, Healy K, Zeller K, Ali H, Christian P, West K, Labrique A. Cost-Effectiveness Analyses of mCARE Program on Maternal and Newborn Health Services in Bangladesh. *Global Digital Health Forum*, Washington, D.C. December 13-14, 2016.

Jo Y, Mehra S, Ali H, Lefevre A, Zeller K, Christian P, West K, Labrique A. Understanding service contents and costs of antenatal care in rural Bangladesh, American Public Health Association. Denver, Colorado. Oct29-Nov 2, 2016.

Jo Y, Lefevre AE, Singh N, Mehra S, Healy K, Zeller K, Ali H, Hanif A, Christian P, West K, Labrique A. Cost-Effectiveness Analyses of mCARE Program on Maternal and Newborn Health Services in Bangladesh: Preliminary Findings and Lessons Learned. *Global mHealth Forum*, Washington, D.C. November 8-11, 2015.

Jo Y, Labrique AB, Lefevre AE, Mehl G, Pfaff T, Walker N, Friberg IK. Using the Lives Saved Tool (LiST) to Model mHealth Impact on Neonatal Survival. *mMonitoring: Metrics, Modeling, & Monitoring, Global mHealth Forum*. Washington, D.C. December 10–11, 2014.

Jo Y. "Korea's Universal Health Coverage: Challenges and Overcoming Strategies", *Workshop on Frontiers in Development Policy: Innovative Development Case Studies. World Bank Institute-Korea Development Institute School*, Seoul, Republic of Korea, November 21-22, 2013.

Jo Y. "Costing mHealth Strategies: Total Cost Ownership Model", *mHealth Summit*, Washington D.C. December 8-11, 2013.

Jo Y. "mHealth to Create A Better Health Market for the Poor", *International Conference on Technology and Innovation for Global Development Schumpeter and Polymer Research*. Harvard Kennedy School, Cambridge, MA. June 4-5, 2012.

Hwang B and Jo Y. "Bridging the Global Gap: Korea's Leadership Agenda for the G-20" *The Korea Economic Institute's 21st Annual Academic Symposium,* Washington D.C., October 2010.

Jo Y. "The Northeast Asia Regional Development Project: Greater Tumen Initiative". *The Annual SAIS-National Bureau of Asian Research, Asian Studies Student Conference*, Washington D.C., April 28, 2010.

Referred Blog Post

Jo Y. Launch of CSIS Report on DoD Overseas Research Laboratories, *CSIS Smart Global Health*, July 6 2011 (URL: http://www.smartglobalhealth.org/blog/entry/launch-of-csis-report-on-dod-overseas-research-laboratories/)

Extracurricular Activities

Organizing Committee, Tohoku University 10 Year Reunion of Exchange Student Program
Sendai, Japan
Tohoku University, International Student Affairs *Apr 17-18, 2016*
• Organized a reunion program, a field trip, a mentoring session for alumni and students in Tohoku University
• Invited 40 alumni from abroad and hosted by dean of international student affairs, faculty and students in Tohoku University

Volunteer, Seoul National University Seoul, Korea
University Services for Disabled Student *Sep.2008-Jun.2009*
• Typed lectures for hearing disabled students on 'Theory of Design' and 'Psychology and Society' classes

Team Leader, Korea Youth Overseas Volunteer Service Bangalore, India
Korean National Commission on Youth Protection *Dec. 2007*
• Led the India team and participated in a week training camp for team leaders.
• Led a team of 20 university students in clearing land, laying the physical foundation for a new school building, painting buildings, and educating children in basic English, arts and crafts, and other enrichment activities.

Member, Sharing Analysis on Regional Economies (SHARE) Seoul, Korea
International Student Club *Dec. 2005-Jul.2006*
• Participated in discussion and presentation on various international economic issue analyses

Volunteer, 'HABITAT for Humanity' Volunteer Service Program Manila, Philippines
United Nations Educational, Scientific and Cultural Organization (UNESCO) *Dec.2006*
• Participated in ten days volunteer service activities for constructing of houses and educating children

Organizing Committee, The 21st Annual Korea-Japan Student Forum (KJSF) Tokyo, Japan
Korea-Japan Student Forum *Feb. 2005–Aug.2005*
• Participated in various discussions concerning Japanese and Korean economies
• Authored and presented a thesis on "The Past, Present and Future of the Japanese Economy"

Professional Memberships

Coordinator, Korean Public Health Association (KPHA) Dec.2011-Present
Member, The American Public Health Association (APHA) Oct. 2011-Present
Member, mHealth Working Group Jun. 2010-Present
Member, The American Political Science Association (APSA) Dec.2009-Present
Member, Harvard Project for Asian & International Relations (HPAIR) Aug. 2005-2010

Technical Skills

• Data management and statistical analysis of large datasets in Stata
• Multivariate modeling (e.g. Linear and logistic regression)
• Longitudinal data analysis
• Lives Saved Tool (LiST) modeling
• TreeAge Decision Analysis modeling
• Visual Basic Excel Macro (Monte Carlo, Markov simulations)
• Reference managers: EndNote, Refworks, Mendeley
• Microsoft Office (Word, Excel, Power Point)
• Grants proposal writing
• Survey Monkey™/ Google forms
• Fluent in English, and Korean (Native); Intermediate in Japanese; Basic in Bengali and Chinese
• International Database Professional Administration License: Oracle 8i, ORACLE, 2005
• Computer Information Management License, Human Resource Development Service of Korea, 2003

Honors and Awards

Global mHealth Initiative-World Health Organization Fellowship, 2012
Global mHealth Initiative, mHealth Summit Scholarship, 2012, 2013
Gordis Teaching Fellowship, Johns Hopkins School of Public Health, $6000. 2014
STX Foundation Overseas Student Scholarship $50,000. 2009, 2010
'Young Climate Change Ambassador' Award, British Ambassador to Korea (Selected as The Top Five Winners in a National University Student Team Competition hosted by British Council to Korea, 2009)
Seoul National University Overseas Internship Program Fellowship, SNU, 2007
Seoul National University Academic Merit Scholarship, SNU**,** 2004, 2005
Japan Student Services Organization (JASSO) Scholarship, $10,000. 2005, 2006
6th Dale Carnegie Leadership Course Award, SNU, Sep 2004 – Jun 2005

Date of Birth: November 1, 1983
Place of Birth: Daegu, Republic of Korea