IMPACT OF SCALE-UP OF MATERNAL AND DELIVERY CARE ON REDUCTIONS IN NEONATAL MORTALITY IN USAID MCH PRIORITY COUNTRIES, 2000-2010

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Rebecca Winter

Thomas Pullum

Lia Florey

Steve Hodgins

ICF International

Rockville, Maryland, USA

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Corresponding author: Rebecca Winter, International Health and Development, ICF International, 530 Gaither Road, Suite 500, Rockville, Maryland, USA; telephone: 301–572– 0541; fax: 301- 407-6501; email: Rebecca.Winter@icfi.com

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Contents

Tables

Figures

Preface

The Demographic and Health Surveys (DHS) Program is one of the principal sources of international data on fertility, family planning, maternal and child health, nutrition, mortality, environmental health, HIV/AIDS, malaria, and provision of health services.

One of the objectives of The DHS Program is to analyze DHS data and provide findings that will be useful to policymakers and program managers in low- and middle-income countries. DHS Analytical Studies serve this objective by providing in-depth research on a wide range of topics, typically including several countries and applying multivariate statistical tools and models. These reports are also intended to illustrate research methods and applications of DHS data that may build the capacity of other researchers.

The topics in the DHS Analytical Studies series are selected by The DHS Program in consultation with the U.S. Agency for International Development.

It is hoped that the DHS Analytical Studies will be useful to researchers, policymakers, and survey specialists, particularly those engaged in work in low- and middle-income countries.

Sunita Kishor

Director, The DHS Program

Abstract

Globally, the impressive gains in under-five mortality between 2000 and 2010 have been accompanied by more modest reductions in neonatal mortality. Of the 18 USAID priority countries for maternal and child health with two DHS surveys available around the years 2000 and 2010, only nine have shown statistically significant reductions in neonatal mortality. In six of the nine countries, these reductions remain significant after restricting the study population to most recent children born in the five years preceding the survey. The study investigates the extent to which scale-up of maternal and delivery care is associated with reductions in neonatal mortality among most recent children born in the six countries. We find surprisingly little evidence that changes in coverage of measurable indicators of maternal and delivery care contributed to the improvements in neonatal survival. In the three malarious countries with complete mosquito bednet data for both surveys, household ownership of a mosquito bednet stands out as a driver of the observed reductions. This finding highlights the importance of malaria control in the arsenal of maternal and child health interventions. Overall, weak associations between other indicators of maternal and delivery care and neonatal survival were observed. This may be the result of limitations of population-based surveys to measure accurately the protective aspects of the interventions. The weak findings may also point to an issue of quality of care, highlighting the need to ensure that there is an emphasis on strengthening health systems and improving the quality of care alongside efforts to increase use of delivery health services.

Keywords: neonatal mortality, child survival, maternal and child health

Executive Summary

Globally, the impressive gains in under-five mortality between 2000 and 2010 have been accompanied by more modest reductions in neonatal mortality. As a result, the percentage of under-five deaths that are neonatal has increased from 38 percent in 2000 to 44 percent in 2012. To continue making gains in child survival, it has become increasingly important to understand and address the unique determinants of neonatal mortality, and to identify which interventions are effective in promoting neonatal survival. This report identifies USAID priority countries for maternal and child health (MCH) with a statistically significant reduction in neonatal mortality between about 2000 to 2010, and examines the extent to which the scale-up of coverage of measurable components of maternal and delivery care is associated with the observed reductions.

Of the 18 USAID MCH priority countries with two DHS surveys available around the years 2000 and 2010, only nine have shown statistically significant reductions in neonatal mortality. In six of the nine countries—Bangladesh, India, Madagascar, Malawi, Rwanda and mainland Tanzania—these reductions remain significant after restricting the study population to most recent children born in the five years preceding the survey. The study investigates the impact of maternal and delivery care in those six countries. The analysis has two main components. First, multivariate log probability models identify which components of maternal and delivery care are independently associated with neonatal mortality cross-sectionally within individual surveys, and second, decomposition of the observed reductions in the neonatal mortality rate (NMR) identifies components of maternal and delivery care that are significantly associated with the observed reductions.

In most settings there has been some improvement in the coverage of indicators of maternal and delivery care—e.g. four or more ANC visits made during the pregnancy, the provision of tetanus vaccination and iron/folic acid supplementation during pregnancy, the provision of two doses of sulfadoxine-pyrimethamine (SP) during pregnancy in malarious sub-Saharan African countries, delivery by a skilled birth attendant, and household ownership of mosquito bednets. Contrary to our expectation, however, coverage of these interventions is not consistently associated with lower risk of neonatal mortality. The number of antenatal care visits that a mother had made remains significantly associated with neonatal survival in the expected direction in only four of the six countries' 12 surveys, after adjusting for the mother's use of other components of care and for socio-demographic characteristics. In five of the 12 surveys, the number of tetanus injections the mother received during pregnancy remains independently associated with the child's risk of dying in the first month of life, in the expected direction. Household ownership of a mosquito bednet remains significantly associated with neonatal mortality in three of the seven surveys with available mosquito bednet information. The study finds no evidence that receipt of at least 90 days of iron and folic acid supplementation or at least two doses of SP during pregnancy is associated with the risk of neonatal mortality, independent of the benefits of other components of maternal and delivery care. The final model also shows no evidence that delivery by a skilled birth attendant (SBA) is protective against neonatal mortality, although in one survey there is a significant community-level effect of SBA use, such that children born in communities with no coverage of SBA are more likely to die during the first month of life compared with children born in clusters with full SBA coverage.

In line with the cross-sectional results, the decomposition of observed reductions in the NMR provides only weak evidence that the scale-up of maternal and delivery care has contributed to observed reductions in the NMR. No single indicator of care contributed significantly to the reduction in neonatal mortality in more than one country, except for mosquito bednet coverage. In the three malarious countries with data on mosquito bednet ownership—Malawi, Rwanda, and mainland Tanzania—the rapid increase in household ownership of mosquito bednets stands out as a driving force behind the observed reductions in neonatal mortality. In all three countries, mosquito bednet ownership was significantly associated with the reduction

in the NMR between the 2000 and 2010 surveys, even after adjusting for the effects of key components of maternal and delivery care, the spatial level of malaria risk, and key socio-demographic characteristics. Changes in the distribution of the mother's education level, the mother's age at child's birth, the child's birth order, and the preceding birth interval were each associated with changes in neonatal mortality in at least one country, highlighting the importance of women's education and family planning to neonatal survival.

In conclusion, between roughly 2000 and 2010 only nine of 18 USAID MCH priority countries showed significant improvements in neonatal survival—reinforcing the urgency of international commitment to preventing neonatal deaths. Study findings point to the importance of protecting the mother against malaria during pregnancy and reinforce the relevance of family planning to neonatal survival. The study found little evidence that the scale-up of other components of maternal and delivery care has contributed to observed reductions in neonatal mortality in the six countries for which the study investigated the impact of maternal and delivery care. Poor-quality services could in part explain this result, highlighting the need to ensure that there is an emphasis on strengthening health systems and improving the quality of care alongside efforts to increase use of delivery health services. The weak findings also highlight our current lack of data on other practices that could impact neonatal mortality, such as immediate newborn care, care of the cord, resuscitation, and kangaroo mother care for low birth weight babies.

1. Introduction

1.1. Rationale for This Study

Globally, there has been a substantial decline in under-five mortality since 2000, from 73 deaths per 1,000 live births in 2000 to 57 deaths per 1,000 live births in 2010 (United Nations Inter‐agency Group for Child Mortality Estimation 2011). Overall, most of the improvement has been after the first month of life. Declines during the first month of life—that is, neonatal deaths— have been modest and inconsistent over this period. As a result, the percentage of under-five deaths that are neonatal has increased from 38 percent in 2000 to 44 percent in 2012 (Liu et al. 2012; UNICEF 2013b). To continue making gains in child survival, it has become increasingly important to understand and address the unique determinants of neonatal mortality, and to identify which interventions are effective in promoting neonatal survival.

This report identifies countries with a statistically significant reduction in neonatal mortality during an interval roughly described as 2000 to 2010, and examines the extent to which the scale-up of coverage of measurable components of maternal and delivery care is associated with the observed reductions. The findings are intended to inform ongoing neonatal survival programs and help allocate future resources.

Chapter 1 provides background information on causes of neonatal mortality and on essential maternal and delivery care interventions that are known to promote neonatal survival. Chapter 2 describes the data and the methodology of the study, defines all variables, and presents study limitations. Chapter 3, with results, has two sections. First, we present trends in neonatal mortality in the 18 USAID maternal and child health (MCH) priority countries for which two Demographic and Health Surveys (DHS) are available between 2000 and 2010. Second, the analysis shifts to a focus on six countries identified with a significant reduction in the neonatal mortality rate (NMR) among most recent children born in the five years preceding the survey. In these six countries, we present (1) trends in coverage of components of maternal and delivery care and socio-demographic factors believed to be associated with neonatal mortality, (2) multivariate log probability models to identify which components of maternal and delivery care are independently associated with neonatal mortality, and (3) a multivariate decomposition to identify the components of maternal and delivery care that are significantly associated with the observed declines in NMR. Chapter 4 provides interpretation of key findings, overall conclusions, and policy implications.

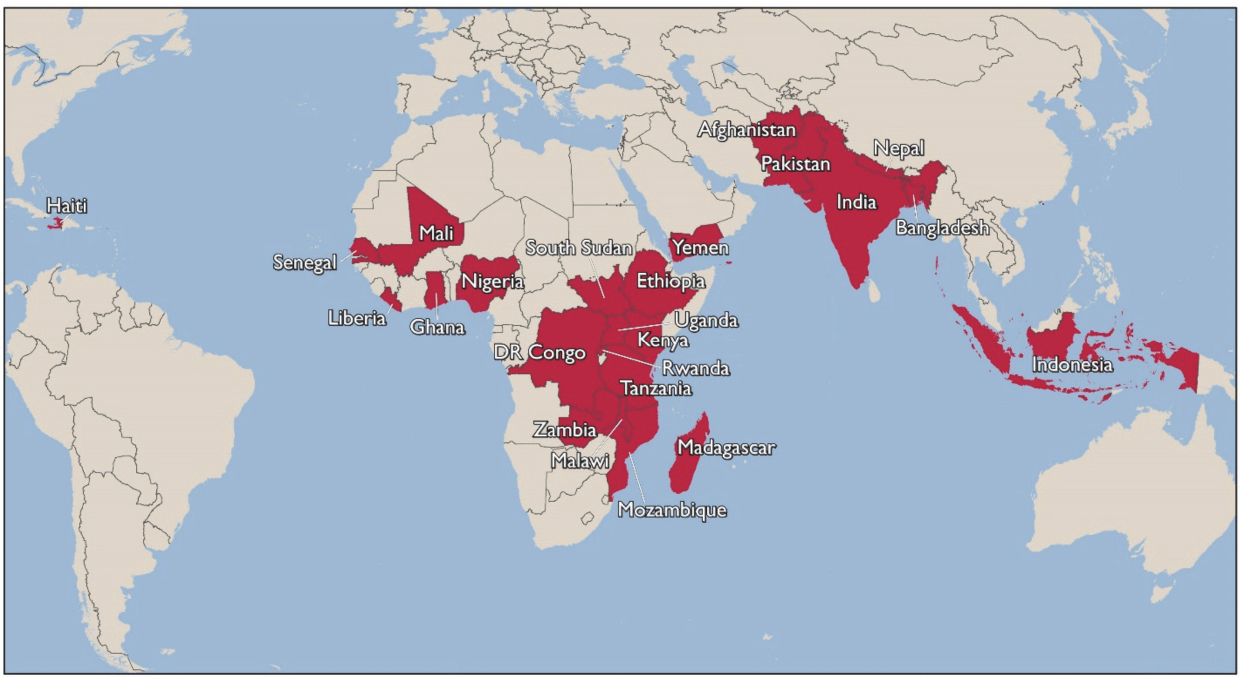
1.2. Background

Millennium Development Goal 4 (MDG 4) established the target of a two-thirds reduction in under-five mortality between 1990 and 2015. Global estimates from 2012 show that approximately 44 percent of all deaths in children under age 5 occur during the neonatal period (UNICEF 2013a). While many countries have made progress in reducing deaths among children under age 5—in fact, UNICEF estimates suggest that the overall global under-five mortality rate fell by nearly 50 percent between 1990 and 2012—these gains have been predominantly among children age 1-4 (UNICEF 2013a). Far less progress has been made in reducing the mortality risk for children under age 12 months, and especially in the first month of life. As a result, as total under-five morality has decreased, the proportion of those deaths that occur during the neonatal period has increased (Lawn et al. 2005). In order to continue making improvements in under-five survival, a better understanding of the unique, complex causes of neonatal death is needed.

There is an increasing recognition that improvements in newborn survival have lagged behind improvements in maternal and child survival, and international attention has shifted to focus more on protecting the life of the newborn. Catalyzing and guiding new commitments to saving newborn lives and preventing stillbirths, the *Every Newborn Action Plan* (ENAP) was released in Spring 2014. This action plan, coordinated by UNICEF and the World Health Organization (WHO) with other organizations, governments, and groups, incorporates the latest findings on the effectiveness of life-saving interventions for newborns and sets forth a vision of "a world in which there are no preventable deaths of newborns or stillbirths, where every pregnancy is wanted, every birth celebrated, and women, babies and children survive, thrive and reach their full potential" (WHO 2014). To the extent possible given data constraints, indicators in the current study align with those vetted in the ENAP framework.

The vast majority of neonatal deaths occur in low and middle income countries, with the highest numbers occurring in South Asia and sub-Saharan Africa. In fact, more than 40 percent of all neonatal deaths worldwide occur in just three countries: India, Nigeria, and Pakistan (UNICEF 2013a). Based on the distribution of the global burden of maternal and child death, USAID selected 24 MCH priority countries—displayed in Figure 1—to be the focus of programmatic efforts to scale up high-impact interventions and strengthen health systems. These 24 priority countries, which account for more than 70 percent of global maternal deaths (USAID 2013), are the focus of the current study.

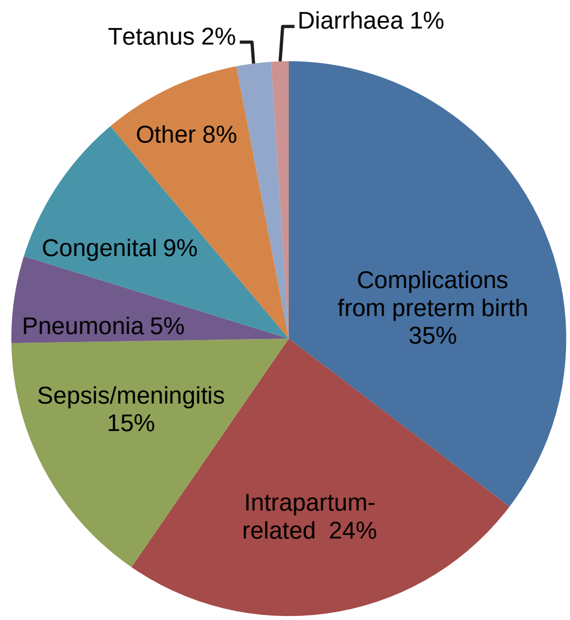
Figure 1. USAID priority countries for maternal and child health



1.2.1. Causes of neonatal death

Approximately three-quarters of neonatal deaths take place in the first seven days after birth (Lawn et al. 2005). Unlike older children, who often die of infections, newborns most often suffer from complications of preterm birth, intrapartum-related complications (such as birth asphyxia), and congenital conditions. In the remainder of the first month after birth, sepsis and other infections play a major role. As Figure 2 shows, globally in 2012, 35 percent of neonatal deaths were caused by preterm birth complications, 24 percent were caused by intrapartum-related complications, and 20 percent by sepsis, meningitis, or pneumonia. An additional 9 percent of neonatal deaths were caused by congenital conditions, 2 percent by tetanus, and 1 percent by diarrhea (WHO 2014).

Figure 2. Global causes of neonatal deaths, 2012



Source: WHO 2014.

1.2.2. Globally-recommended interventions

Most of the causes of neonatal deaths are treatable with simple interventions. It is estimated that over two-thirds of neonatal deaths are preventable without intensive care (UNICEF 2013a). Global health attention to promote newborn survival has focused on packages of interventions directed at women and infants along the continuum of care from preconception to infancy (Darmstadt et al. 2005; Liu et al. 2012; The Partnership for Maternal Newborn & Child Health 2011). These include 1) reproductive health services, health promotion, and education for girls and women before they become pregnant; 2) focused antenatal care; 3) skilled attendance at birth, including emergency obstetric and newborn care; 4) postnatal care for early identification and referral of illness and provision of preventive care; and 5) emergency newborn care and kangaroo mother care for infants with low birth weight. In addition to these packages, several cross-cutting programs have been emphasized for their impact on maternal and child health: nutrition and breastfeeding promotion, prevention of mother to child transmission of HIV, malaria prevention, and immunization. Together it has been estimated that these interventions could avert 41-72 percent of newborn deaths worldwide[1] (Darmstadt et al. 2005).

These packages of interventions are outlined in Table 1, which aligns the most common direct causes of neonatal death globally (Liu et al. 2012) with the most commonly recommended interventions to address

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[1] Darmstadt and colleagues estimated the percentage of neonatal deaths that could be averted using estimates from published work and expert opinion on the efficacy and effectiveness of 16 key interventions to prevent specific causes of neonatal death. This information was combined with country-specific information on intervention coverage, population dynamics, and cause-specific numbers of neonatal death for 75 countries (Darmstadt et al. 2005).

them at the community/family, health facility, and policy levels (Darmstadt et al. 2005; The Partnership for Maternal Newborn & Child Health 2011; Winter et al. 2013).

In addition to the direct causes of neonatal deaths listed in Table 1, there are indirect causes. Low birth weight (<2.5 kg), which makes newborns more vulnerable to infection and other stressors, is the most important indirect cause. Low birth weight is often due to prematurity but can also result from intrauterine growth restriction (Blencowe et al. 2012). In sub-Saharan Africa, low-birth-weight infants are three times more likely to die in the first year, and nine times more likely to die in the first month compared with infants born with a normal weight (Guyatt and Snow 2001).

Factors contributing to low birth weight include infections such as malaria and HIV, short birth intervals, poor maternal nutrition, the mother's age (under age 18 or over age 34), smoking, and alcohol abuse. Interventions that address direct causes of death also reduce the incidence of low birth weight, including early detection of problems and risk factors during the pregnancy; prevention or screening and effective treatment for infection or anemia; counseling for pregnant women on nutrition and self-care; and family planning to prevent unwanted pregnancies among adolescents and older women and to ensure optimal birth spacing (Lawn et al. 2005).

While interventions along the full continuum of care from preconception through infancy are important to neonatal survival, the 2014 *Every Newborn Action Plan* emphasizes the vital importance of the period directly surrounding the newborn's birth, when both the mother and the newborn are at highest risk for morbidity and mortality–that is, during labor, during childbirth, and in the first days of life (WHO 2014). According to the ENAP, two packages of care have the greatest impact on ending preventable neonatal deaths and stillbirths. These are (1) care during labor, childbirth, and the first week of life; and (2) care for the small and sick newborn. The first package includes skilled care at birth; basic and comprehensive obstetric care; management of preterm births with antenatal corticosteroids; and essential newborn care, which includes hygienic care, thermal control, support for breastfeeding, and newborn resuscitation if needed. Care for the newborn also includes early initiation of exclusive breastfeeding, prevention of hypothermia, clean postnatal care practices, and appropriate cord care. The WHO postnatal care recommendation is for the mother and the newborn to have close observation for 24 hours and three additional postnatal contacts in the six weeks following delivery (WHO 2014). The second package, care for small and sick newborns, includes interventions to respond to complications from preterm birth and/or low birth weight, and neonatal infections. Appropriate care for small and sick newborns includes extra thermal care and support for feeding for small or preterm babies, including kangaroo mother care, antibiotic treatment for infections, and full supportive facility care (WHO 2014).

To the extent possible, the study identifies indicators of coverage of the first package of care (care during labor, childbirth, and the first week of life), but given data limitations, the study is not able to assess extra care provided to small or sick newborns.

Table 1. Causes of neonatal mortality and globally recommended interventions

Category/cause of mortality	Community/family interventions	Health service interventions	Policy/health system interventions
Intrapartum-related complications (birth asphyxia)	birth preparedness planning, demand for skilled delivery services, rapid transportation or "waiting homes"	24-hour skilled care, including C-section, newborn resuscitation, thermal care	assure financial and geographic accessibility of services, general health system strengthening (ensure adequate human resources for health, hold providers accountable for quality, infrastructure, and supply chain)
Preterm birth complications	delay of first pregnancy, maternal nutrition, optimal birth spacing, kangaroo care, breastfeeding	eclampsia and pre-eclampsia prevention, intermittent presumptive treatment for malaria, detection and treatment of asymptomatic bacteriuria, antenatal steroids, PMTCT	same as above, plus provide access to family planning services, ensure services are accessible to adolescents
Sepsis/ meningitis/ tetanus	demand for ANC, breastfeeding, clean home delivery, handwashing, hygienic cord care, thermal care	immunization, antibiotics for premature rupture of membranes, support for early and exclusive breastfeeding, postnatal evaluation	same as for intrapartum-related complications, plus support for community-level interventions
Congenital abnormalities	self-care behaviors (smoking, alcohol)	folic acid	support for community-level interventions, food fortification
Other neonatal disorders (including severe malnutrition)	early and exclusive breastfeeding, support for improved nutrition of mother	support for early and exclusive breastfeeding, postnatal care	support for community-level interventions
Pneumonia	care seeking for sick newborns, community case management of pneumonia	facility supervision of CHWs, integrated management of childhood illness	support for community-level interventions, community case management
Diarrhea	care seeking for sick newborns, exclusive breastfeeding, handwashing and other hygiene behaviors	facility supervision of CHWs, integrated management of childhood illness, routine immunization against Rotavirus	support for community-level interventions, community case management

Source: The table, previously presented in Winter et al. 2013, compiles information from Darmstadt et al. 2005, Liu et al. 2012, and The Partnership for Maternal Newborn & Child Health 2011.

Note: Not all interventions included in this table are recommended or being implemented in all study countries.

1.2.3. Malaria in pregnancy

In many countries in sub-Saharan Africa, an important cause of low birth weight is that the mother had malaria during the pregnancy. As mentioned, the primary direct causes of neonatal death in sub-Saharan Africa are prematurity (33 percent), intrapartum-related complications (asphyxia) (20 percent), and sepsis and meningitis (10 percent) (Liu et al. 2012). Low birth weight, which encompasses both preterm birth and intrauterine growth retardation (IUGR), is a major indirect cause of neonatal death (Lawn et al. 2005). Thus malaria in pregnancy can be a major contributor to neonatal morbidity and mortality (Guyatt and Snow 2001). The recommended interventions to address malaria in pregnancy are sleeping under insecticide treated nets (ITN) and—in high and medium transmission countries in sub-Saharan Africa—intermittent presumptive treatment (IPTp) with sulfadoxine-pyrimethamine (SP). Both ITNs and IPTp have been found to be very effective in reducing malaria-attributable neonatal deaths (Eisele et al. 2012; Menéndez et al. 2010). WHO recommends universal coverage with ITNs for people living in or visiting a malaria-endemic region. Each household should own enough ITNs so that every household member could sleep under an ITN (assuming that each ITN can be used by two persons). Pregnant women are particularly susceptible to malaria and thus the use of ITNs is particularly important for women of reproductive age. Current recommendations for IPTp are for pregnant women in high and medium transmission settings in malaria endemic countries of Africa to receive a dose of SP at each ANC visit, at least one month apart, starting in the second trimester of pregnancy (WHO 2012). However, during the study period the recommendation was for all pregnant women in areas of stable (high) malaria transmission to receive at least two doses of IPTp after the first noted movement of the fetus (WHO 2007).

2. Data and Methods

2.1. Data

This study used data from DHS surveys in 22 of the 24 USAID MCH priority countries. These are nationally representative, population-based household surveys that monitor demographic trends, reproductive health behaviors, attitudes, and outcomes, and socio-demographic characteristics of women and men of reproductive age. All surveys include full histories of the live births of the interviewed women. The data are collected in face-to-face household interviews. A standard core questionnaire is included in each survey, enabling comparisons across countries and over time.

Table 2 lists the USAID priority countries alongside DHS survey availability. For 18 countries—Bangladesh, Ethiopia, Ghana, Haiti, India, Indonesia, Kenya, Madagascar, Malawi, Mozambique, Nepal, Nigeria, Pakistan, Rwanda, Senegal, mainland Tanzania[2], Uganda, and Zambia—two DHS surveys are available roughly around the years 2000 and 2010, with approximately 10 years between surveys. Baseline surveys conducted between 1997 and 2003 were eligible for inclusion, and endline surveys conducted between 2007 and 2013 were eligible[3]. For four additional countries—Democratic Republic of Congo, Liberia, Mali, and Yemen—just one eligible DHS survey was available as of June 2014.

The study population is restricted to women's most recent live birth that occurred during the five years[4] preceding each survey (1-59 months preceding the month of interview). While five-year neonatal mortality rates are typically calculated among live births that occurred 1-60 months preceding the interview, maternal and delivery care indicators are not available for the 60th month preceding the interview, so month 60 is not included in the study. The restriction to women's most recent birth was made because several of the maternal and delivery care indicators are available only for this subsample of births.

[2] Zanzibar is excluded from the analysis, as the context of maternal and newborn health is distinct from mainland Tanzania.

[3] Two exceptions were made: in India and Pakistan, where two surveys were available with closer spacing, both surveys were included in the study.

[4] For two surveys (India 1998/9 and Madagascar 1997), birth care information is available only for children born in the three years prior to interview, so in these two cases the sample is restricted to most recent children born in months 1-35 prior to interview.

Table 2. USAID priority countries for maternal and child health and DHS survey availability

	Baseline survey	Endline survey
Afghanistan		
Bangladesh	1999/2000 DHS	2011 DHS
DR Congo		2007 DHS
Ethiopia	2000 DHS	2011 DHS
Ghana	1998 DHS	2008 DHS
Haiti	2000 DHS	2012 DHS
India	1998/1999 DHS	2005/2006 DHS
Indonesia	2002/2003 DHS	2012 DHS
Kenya	1998 DHS	2008/2009 DHS
Liberia		2007 DHS
Madagascar	1997 DHS	2008/2009 DHS
Malawi	2000 DHS	2010 DHS
Mali	2001 DHS	
Mozambique	2003 DHS	2011 DHS
Nepal	2001 DHS	2011 DHS
Nigeria	2003 DHS	2013 DHS
Pakistan	2006/2007 DHS	2012/2013 DHS
Rwanda	2000 DHS	2010 DHS
Senegal	1997 DHS	2010/2011 DHS
South Sudan		
Tanzania	1999 DHS	2010 DHS
Uganda	2000/2001 DHS	2011 DHS
Yemen	1997 DHS	
Zambia	2001/2002 DHS	2007 DHS

Note: We have no data for Afghanistan or South Sudan, as of June 2014. While the 2010 Afghanistan Mortality Survey included a full birth history, recode files are not available.

2.2. Definitions of Indicators

The key outcome examined in this report, neonatal death, is defined as a death that occurred in the first month of life (days 0-29). The study examines the impact of eight indicators of maternal and delivery care within the broader context of known determinants of neonatal mortality, including socio-demographic characteristics of the household, mother, and child. Household-level indicators are expected to impact mothers' access to health care, access to economic resources, and access to social and familial support, and could also capture geographic variation in the quality of available services. Characteristics of the mother and the child primarily identify higher-risk pregnancies and births. The variables are coded such that the reference category is the value that is expected to be optimal for child survival, and any other value is expected to be disadvantageous. The variables are described in more detail below.

Indicators of maternal and delivery care:

Mother attended four or more ANC visits. This indicator distinguishes children whose mothers made fewer than four ANC visits from children whose mothers made four or more visits to any provider. Recommended ANC care is expected to reduce a newborn's risk of mortality. An estimated 4 to 7 percent of neonatal deaths could be averted if routine antenatal care—including routine ANC visits, tetanus immunization, screening and treatment of syphilis, and IPTp where appropriate—was implemented at high

(90 percent) coverage (Darmstadt et al. 2008). Children whose mothers made four or more visits are expected to have a lower risk of mortality and are the reference category. Note, however, that difficult pregnancies may lead to more ANC visits, so some of the women in the reference category may actually have high risk.

Number of tetanus injections during pregnancy. This indicator is grouped into three categories: women who received no tetanus toxoid vaccination injections, women who received one injection, and women who received two or more injections during the pregnancy for the most recent birth. Neonatal mortality is expected to be inversely associated with the number of tetanus injections the mother received. Children whose mothers had two or more injections are the reference category.

Mother received at least 90 days of iron and folic acid supplementation. Children whose mothers reported taking at least 90 days of iron and folic acid tablets/syrup during the pregnancy are distinguished from children whose mothers reported taking fewer than 90 days' worth, or no doses. Iron and folic acid supplementation during pregnancy has been shown to have a strong protective effect against early neonatal death (Titaley et al. 2010). Children whose mothers reported taking at least 90 days of iron/folic acid tablets or syrup are the reference category.

Delivered by a skilled birth attendant. Children whose births were attended by a skilled attendant are distinguished from those whose birth was not. The definition of skilled attendance varied across surveys in order to align with country-specific skilled care options and country-specific recommendations for delivery care; definitions used in this report agree with those in the DHS final country reports. Since detailed information about the quality and content of delivery care is unavailable in the DHS, delivery by a skilled birth attendant is interpreted as an imperfect proxy for the full package of appropriate care received during labor and childbirth, including skilled care at birth, basic and comprehensive obstetric care, management of preterm births with antenatal corticosteroids, and essential newborn care. Children whose births were attended by a skilled attendant are expected to have a lower risk of neonatal mortality, and comprise the reference category.

Delivered in a health facility. Children who were delivered in any public or private health facility are distinguished from with those who were not. While women's use of a skilled birth attendant and delivery in a facility most often occur together, use of a skilled birth attendant can occur at home, and delivery in a facility can take place without assistance from a skilled provider. Results for both indicators are presented, in order to identify any difference in effects. Children delivered in a health facility are expected to have a lower risk of neonatal mortality, and are the reference category.

Community-level coverage of skilled birth attendance: The proportion of women in each DHS cluster whose most recent birth was attended by a skilled birth attendant (SBA) is interpreted as a proxy for women's access to skilled assistance during birth. The measure, ranging from 0 to 1, is expected to be inversely associated with neonatal mortality, and is included as a continuous variable in regression models predicting neonatal death.

Household owns a mosquito bednet. The indictor of household mosquito bednet ownership identifies households that own at least one mosquito bednet of any type at the time of interview. Although long-lasting insecticide-treated nets (LLINs) are now the standard mosquito bednet commodity purchased and distributed by National Malaria Control Programs, this was not the case in 2000. For comparability across surveys, the analyses are restricted to looking at the potential protective effects of any mosquito bednets, whether treated with insecticides or not. Furthermore, while we are interested in the mother's use of a mosquito bednet during pregnancy—when it would be helpful to prevent malaria-associated neonatal death—this information is not available. Instead, we use ownership of a mosquito bednet at the time of interview as a proxy for ownership and use during the pregnancy. Children born into households that own a mosquito bednet are expected to have a lower risk of neonatal mortality, and are the reference category. This variable is available in four of the study's focus countries where malaria is endemic: Madagascar, Malawi, Rwanda, and mainland Tanzania.

Mother received two doses of sulfadoxine-pyrimethamine (SP) during pregnancy. This indicator identifies children whose mothers received at least two doses of SP during the pregnancy. Children whose mothers received two doses of SP are expected to have a lower risk of neonatal mortality, and are the reference category. This indicator is available in Malawi (2000 DHS and 2010 DHS), Madagascar (1997 DHS), and mainland Tanzania (2010 DHS). Since Rwanda discontinued its IPTp policy in 2008 and the information was not collected in the 2010 survey, we cannot examine this indicator in Rwanda.

Characteristics of the household:

Place of residence. This variable measures whether the household in which the child resides is in an urban or rural location. The DHS uses the prevailing definitions of urban and rural residence in each country. Children in urban locations are generally expected to have better access to interventions and care and reduced exposure to some infections. However, the benefits of urban residence are expected to depend on the economic resources of the household and community. Children in urban slums, for example, are particularly vulnerable during the neonatal period, due to overcrowding, unhygienic surroundings, poverty, and the absence of basic health infrastructure (Fernandez et al. 2003).

Comparative household wealth. Similar to the original DHS wealth index, the recently developed comparative wealth index (CWI) is based on household-level data on assets, services, and amenities, and ranks households according to their level of wealth. However, the CWI uses a fixed reference point, enabling comparisons across time and across countries (Rutstein and Staveteig 2014). The study population was classified by CWI tercile (thirds) for these analyses. The CWI terciles were identified using standard cut points derived from the distribution of wealth scores in the 2002 Vietnam DHS. The upper two-thirds were combined for the regression analysis, due to a small number of deaths in the wealthiest third. Furthermore, for the regression analysis we include the interaction between place of residence and comparative household wealth, since the effect of urban residence may well depend on the household's wealth, and vice versa. The interaction variable has four levels: urban upper two-thirds CWI, urban bottom-third CWI, rural upper two-thirds CWI, and rural bottom-third CWI. It is expected that children born in urban wealthier households have the lowest risk of neonatal death, and these children are used as the reference category.

Malaria risk. For Madagascar, Malawi, and mainland Tanzania, we were able to link spatial data on the level of malaria risk with DHS data using cluster-level GPS locations. These spatial malaria risk data, compiled by the Malaria Atlas Project, rely on the estimated proportion of children age 2-10 in the general population who are infected with *P. falciparum* at any one time ($Pf\mathrm{PR}_{2\text{-}10}$), averaged over the 12 months of 2010, as well as environmental covariates which help predict more accurately (Malaria Atlas Project). The indicator calculated with these data has three levels: no/low, intermediate, and high risk. In low-risk areas, the $Pf\mathrm{PR}_{2\text{-}10}$ is likely to be lower than 5 percent. In intermediate-risk areas, $Pf\mathrm{PR}_{2\text{-}10}$ is likely to be between 5 percent and 40 percent. In high-risk areas, $Pf\mathrm{PR}_{2\text{-}10}$ is likely to exceed 40 percent. Including this indicator of malaria risk in the analysis is important, due to potential variations in levels of use of malaria interventions by transmission as well as potential variations in the protective efficacy of the interventions based on level of transmission. Note that in Malawi the population falls completely in areas classified as having intermediate and high risk for malaria. In Madagascar, due to the small number of cases in the no/low-risk category in the 2008 survey, no/low risk was collapsed with intermediate risk.

Caste. For India, the multivariate analyses adjust for the mother's self-reported caste. The scheduled castes and scheduled tribes are historically disadvantaged groups in India. This indicator has four categories:

scheduled caste, scheduled tribe, other backward caste, and none of these. Children whose mothers reported being in none of these groups are the reference category.

Characteristics of the mother:

Mother's age at child's birth is divided into three categories: under age 18, 18-34, and 35 or older. Mother's age is expected to have a U-shaped relationship with the risk of neonatal death, such that children born to women of younger and older ages are at elevated risk. Age 18-34 is the reference category.

Mother's marital status is divided into two categories: currently married or in union and not currently married or in union. This information refers to women's status at the time of interview, as a proxy for marital status at the time of the child's birth. Children whose mothers are not currently married are expected to have an elevated risk of neonatal mortality. Married women are the reference category. Marital status was not included in the analyses for Bangladesh or India, as the samples were restricted to ever-married women.

Mother's educational attainment is grouped into three categories: no education, primary education, and secondary or higher education. Women's education is expected to be inversely associated with the risk of neonatal death. Women with secondary or higher education are the reference category.

Previous child to mother died under age 5. To adjust for other possible maternal and household characteristics that cannot be measured, including genetic risk, an indicator was created to identify mothers who had previously lost another child under age 5. Children whose mothers had not had any previous child deaths under age 5 are the reference category.

Characteristics of the child:

Sex of child. Male or female. Female is the reference category.

Preceding birth interval. Birth intervals are grouped into three categories: intervals of less than 24 months, 24-35 months, and 36 or more months. The preceding birth interval is expected to have a U-shaped relationship with neonatal mortality, such that births with either short or long preceding intervals are at elevated risk. Since first births do not have a preceding birth interval, they are included as a separate, fourth category in the regression analysis. The optimal birth interval, 24-35 months, is the reference category.

Birth order. This indicator is grouped into four categories: first births, second births, third births, and fourth or higher-order births. This variable is a count of all live births the mother had before the index child rather than a count of all pregnancies, since the standard DHS does not include a full pregnancy history. Birth order is expected to have a U-shaped association with neonatal mortality, such that first births and high-order births have increased risk of death during the neonatal period. For the multivariate analysis, first births and second-order births are combined into a single category, because the model also includes preceding birth interval, which has a separate category for first births. First and second births are the reference category.

Multiple birth. Whether the birth was single or multiple. Multiple births are known to have a higher risk of neonatal death. Single births are the reference category.

Several other indicators of maternal and delivery care were considered for inclusion, but are not shown in final models. These include caesarian versus vaginal delivery, early initiation of breastfeeding, and a postnatal care visit for the child within two days of birth. Since we cannot determine whether the caesarian section was medically necessary and are unable to identify pregnancy and/or delivery complications, the indicator is difficult to interpret and is not included. Despite a strong association with neonatal mortality, early initiation of breastfeeding is not included because of issues with reverse causality. Since newborns with life threatening conditions may not be put to the breast or may be unable to breastfeed, the observed association is difficult to interpret. Despite its relevance for neonatal survival, postnatal care is not included in the analysis because information about whether the child had a postnatal visit is not available for both surveys in any country.

The analysis does not examine the mother's HIV status or use of prevention of mother-to-child transmission of HIV (PMTCT) services during pregnancy for HIV-positive women. There is some evidence to suggest that women's HIV status has greater impact on child survival after the neonatal period. Naniche and colleagues (2009) found that infant mortality was 2.3 times higher among children born to HIV-positive women compared with children born to HIV-negative women; the difference in mortality was significant during the post-neonatal period but not during the early neonatal or neonatal periods. Using DHS data from 26 surveys in 15 countries, Fishel (2014) found that the neonatal mortality rate was less likely to be associated with the HIV status of the mother than post-neonatal, infant, child and under-five mortality rates. Note that HIV status was measured at the time of interview, and births preceded the interview (Fishel et al. 2014).

Several additional socio-demographic controls were also considered but ultimately excluded from analyses. The multivariate analysis did not adjust for child's size at birth because low birth weight is a key pathway through which we would expect several of the components of maternal care (particularly the mother's protection against malaria, tetanus vaccination, and other components of antenatal care) to result in lower levels of neonatal mortality. Mother's nutritional status (BMI and short stature) was not included, as anthropometry was collected only in a subsample of respondents in several surveys, and not at all in the Tanzania 1999 DHS. The wantedness of the child was explored as a potential predictor of NMR, but results are not shown because this variable was not associated with the probability of neonatal death in any country in the adjusted models.

2.3. Analysis

First, overall trends in neonatal mortality were calculated for the 18 USAID priority countries for which baseline and endline surveys were available. Trends in neonatal mortality were calculated first among *all children* born in the five years preceding each survey, and second, among the study population of *most recent children* born in the five years preceding the survey. Log probability models were used to estimate the probability of dying in the first month of life, and a two-tailed z-test was used to test the significance of the reduction in neonatal mortality observed between the two surveys in each country.[5] Next, the analysis turned to focus on the six countries identified with significant improvements in neonatal mortality in the study population. To test the association between key indicators of maternal and delivery care and neonatal mortality in these countries, multivariate versions of the log probability model were used to determine whether these key indicators were associated with neonatal mortality after adjusting for socio-demographic factors that could confound the association. In order to examine the extent to which the scale-up of coverage of components of maternal and delivery care is associated with observed neonatal mortality reductions in the six countries, multivariate decomposition procedures were used.

[5] The model agrees exactly with the CSPRO software normally used to calculate neonatal mortality rates, along with all the other standard under-five mortality rates, and follows the standard DHS mortality estimation protocol (Rutstein & Rojas 2006), but has several advantages. Because it falls within the framework of generalized linear models (with binomial error and log link), it can easily incorporate information on sample weights, survey stratification, and clustering of households, and it easily produces standard errors, confidence intervals, and test statistics. This model was first applied to DHS data in a study of child mortality in West Africa (Balk et al. 2004).

Multivariate decomposition analyzes differences in the outcome between two groups or, as in this case, between two points of time. In Equation 1, this difference is represented by $Y_A - Y_B$. This study used the mvdcmp procedure in Stata, which is comparable to the Oaxaca-Binder Method but with the flexibility to use non-linear models. The decomposition procedure divides the total decline in neonatal mortality into two portions: the portion that can be attributed to the change in the prevalence of a set of indicators (referred to as the *endowments* portion, and represented by X_A and X_B in Equation 1), and the portion that can be attributed to the change in the effect of these indicators (referred to as the *coefficients* portion, and represented by β_A and β_B in Equation 1) (Powers et al. 2011).

Equation 1:

$$
\begin{aligned}
Y_A - Y_B &= F(X_A\beta_A) - F(X_B\beta_B) \\
&= \underbrace{F(X_A\beta_A) - F(X_B\beta_A)}_{\textbf{Endowments}} + \underbrace{F(X_B\beta_A) - F(X_B\beta_B)}_{\textbf{Coefficients}}
\end{aligned}
$$

The decomposition procedure relies on two key pieces of information: the prevalence of all selected indicators at both points in time, and the coefficients derived from multivariate regression models predicting neonatal death run separately at each time point. In the decomposition model we include the same set of variables that are included in the final multivariate log probability model, but due to constraints of the mvdcmp procedure the decomposition model uses a Poisson model that closely approximates the log probability model. The mvdcmp procedure assumes additivity of the components for composition and effect (Powers et al. 2011). Six decompositions were performed, to examine the decline in neonatal mortality between the two surveys separately in each country. Stata 12 was used to make all calculations.

2.4. Study Limitations

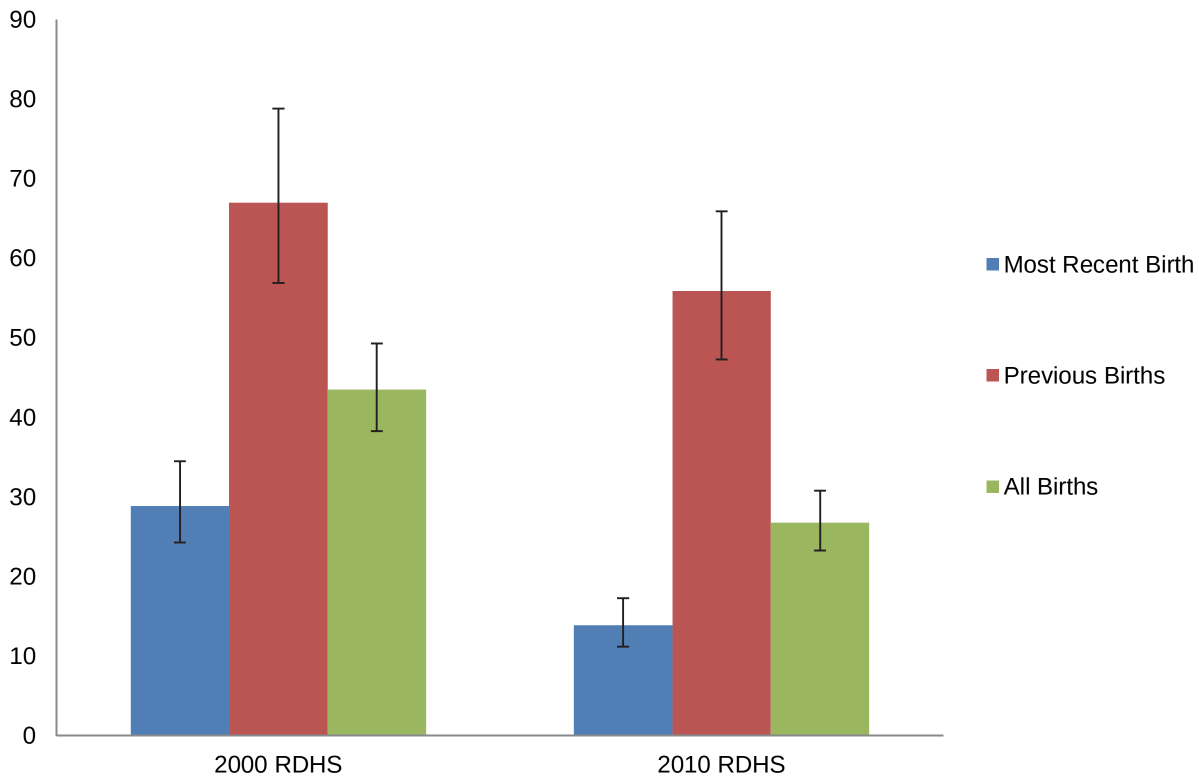
Several limitations to the study are worth noting. While we would like to know which interventions actually led to a reduction in neonatal mortality, the DHS is a cross-sectional survey and thus we are limited in our ability to make inferences regarding cause and effect.

In addition, the DHS collects information from respondents about past events, behaviors, and outcomes. Such information—for example, concerning women's use of maternal care services—is subject to recall bias. Recall bias may be particularly relevant to this study, as the death of a child could impact the mother's recollection of care received. Differential recall bias could potentially confound the observed relationships between maternal care and neonatal death. For several indicators of interest, there is an issue regarding the timing of measurement; while we are interested in assessing characteristics at the time of the mother's pregnancy and at the birth of the child, certain variables are only measured at the time of interview. For example, educational attainment and all household characteristics are measured at the time of the interview rather than during the pregnancy. Perhaps most problematically, to assess the mother's mosquito bednet use during pregnancy, we use the household's ownership of a mosquito bednet at the time of interview as a proxy, with the understanding that the findings must be interpreted cautiously.

While we would like to include the essential interventions for newborn survival as laid out in the *Every Newborn Action Plan*, we are limited in our ability to do so. Beyond place of delivery and whether the delivery was assisted by a skilled birth attendant (as defined by the attendant's occupation, rather than any measurement of actual training or skill), we do not have information about the content or quality of care received during labor or delivery. Because of revisions to the DHS questionnaires and definitions of some variables between 2000 and 2010, it was also not possible to assess the effect of either the mother's or child's exposure to postnatal care.

It is also important to remember that the analysis is restricted to a woman's most recent child born in the five years preceding the survey, rather than all children born in the five years preceding the survey, because several important indicators of maternal and delivery care are available only for this subgroup. The limitation to the most recent child tends to bias the sample toward women who had only one birth in the five-year interval, and such women tend to be better educated, have longer birth intervals, etc. As a result, the NMR is somewhat lower for the most recent birth than for all births. Figure 3 shows that, if we take Rwanda as an example, there is a substantial difference in neonatal mortality rates calculated for all births or for the most recent births in the last five years. Therefore, under a restriction to the most recent birth, interest should focus on changes and differences and not on the level of the NMR, because the estimates of the NMR are biased. The estimates of changes and differences may also be somewhat biased under this restriction, relative to what would be possible if data on the interventions were available for all births, but to a smaller degree. For the sake of completeness, a table is included in the appendix showing, among all children born in the five years preceding the survey, the effects of the three intervention variables that are available for all children (see Appendix Table A1).

Figure 3. Neonatal mortality rate among most recent births, previous births, and all births in the five years preceding the survey, Rwanda 2000 and 2010



Finally, it is important to bear in mind that the analysis is restricted to live births. Alongside the 2.9 million babies who die each year in the first month of life, worldwide, an estimated 2.6 million babies are stillborn (die in the last three months of pregnancy or during childbirth) (WHO 2014). Since the standard DHS survey collects a complete listing of women's live births only[6], it was not possible to include stillborn children in the study.

[6] In some countries such as Nepal, surveys have collected information on women's full pregnancy history, which would include information on stillborn children, but this information is not available for all study countries. Stillbirths can also be identified in the DHS contraceptive calendar, but we have no information about the care women received during the pregnancy ending in a stillbirth, so any analysis using these children would be limited.

3. Results

Before turning to focus on countries with observed reductions in neonatal mortality, we provide an overview of recent trends in neonatal mortality in all USAID MCH priority countries with available DHS data. Table 3 shows the trend in neonatal mortality in these countries, among all births and within the study population of most recent children born in the five years preceding the survey. Of the USAID priority countries with available data, neonatal mortality is highest at baseline in Mali and Pakistan, where 57 and 54 children, respectively, die during the first month for every 1,000 live births, among all children born in the five years preceding the baseline surveys. Among endline surveys, neonatal mortality remains highest in Pakistan, where 55 children die during the first month for every 1,000 live births, among all children born in the five years preceding the endline survey. Neonatal mortality is lowest at endline in Indonesia, where according to the 2012 Indonesia DHS, 19 children die during the first month for every 1,000 live births, among all children born in the five years preceding the survey.

Of the 18 USAID priority countries with baseline and endline surveys available, nine had a statistically significant reduction in neonatal mortality between the surveys, among all children born in the five years before the survey. Eight of the nine countries—Bangladesh, Ethiopia, Madagascar, Malawi, Nigeria, Rwanda, Senegal, and mainland Tanzania—experienced reductions of at least 10 deaths per 1,000 live births. In India the reduction was smaller, at four deaths per 1,000 live births. It should be noted that while we aimed to use surveys with 10 years between them, due to the timing of DHS surveys, in India, Pakistan, and Zambia the spacing between their surveys is only 5-7 years. The relatively small reduction in India is statistically significant because of the very large size of the India surveys.

After restricting to the study population of most recent children born, the reduction in neonatal mortality remained significant in six of the nine countries for which the reduction is significant among all births—Bangladesh, India, Madagascar, Malawi, Rwanda, and mainland Tanzania. Figure 4 identifies the 18 countries with two surveys available, the nine countries with significant reductions, and the study's six focus countries.

Figure 4. Reductions in neonatal mortality among USAID priority countries for maternal and child health

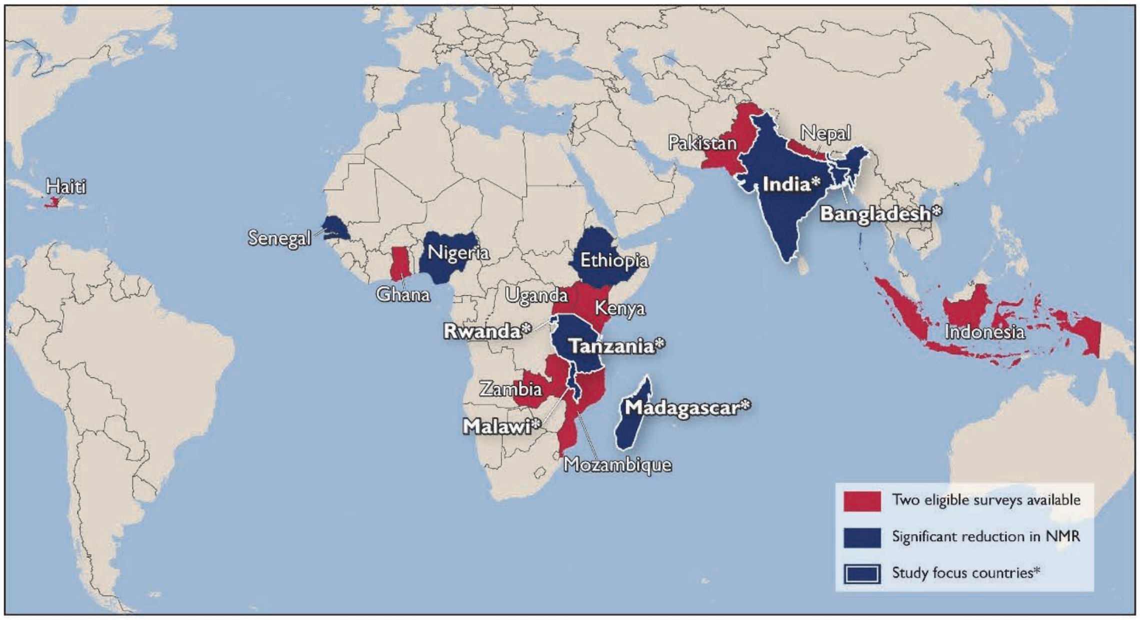


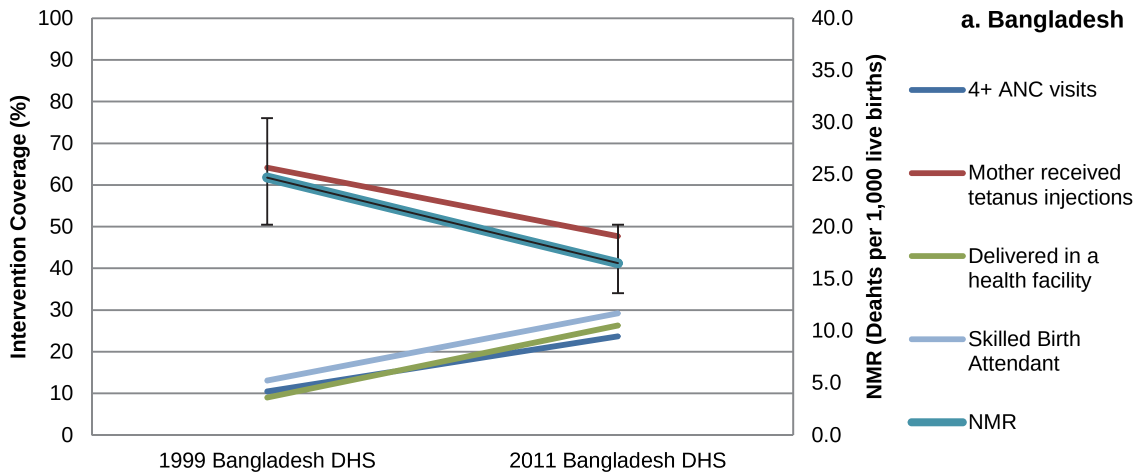
Table 3. Trend in neonatal mortality rate among children born in the five years preceding the survey, USAID MCH priority countries

	All children born in the five years preceding the survey							Most recent children born in the five years preceding the survey						
	Baseline			Endline				Baseline			Endline			
	NMR	LB	UB	NMR	LB	UB	Difference	NMR	LB	UB	NMR	LB	UB	Difference
Bangladesh (1999/2000, 2011)	41.8	36.8	47.6	32.0	28.0	36.5	9.8 **	24.7	20.2	30.4	16.5	13.6	20.2	8.2 **
Ethiopia (2000, 2011)	48.5	42.4	55.6	37.5	32.6	43.1	11.1 **	30.7	24.8	37.9	26.1	21.1	32.2	4.6
DR Congo (2007)				41.9	35.1	50.1					23.3	18.3	29.5	
Ghana (1998, 2008)	29.6	23.4	37.4	30.0	23.9	37.8	-0.5	16.2	11.6	22.5	18.6	13.1	26.5	-2.5
Haiti (2000, 2012)	32.2	26.5	39.2	30.7	26.4	35.8	1.5	20.0	14.7	27.0	23.0	18.7	28.2	-3.0
India (1998/9, 2005/6)	43.3	41.2	45.5	38.9	36.8	41.2	4.4 **	28.5	26.6	30.6	24.9	22.9	27.1	3.6 *
Indonesia (2002/3, 2012)	19.6	16.3	23.6	19.0	16.1	22.4	0.6	13.2	10.4	16.9	10.3	8.4	12.7	2.9
Kenya (1998, 2008/9)	28.2	22.9	34.7	31.0	24.5	39.2	-2.8	19.2	14.8	25.0	22.7	16.8	30.7	-3.5
Liberia (2007)				31.8	26.5	38.2					20.4	15.7	26.6	
Madagascar (1997, 2008/9)	40.2	34.2	47.3	24.2	20.7	28.2	16.1 ***	31.7	25.5	39.3	17.3	13.9	21.5	14.3 ***
Malawi (2000, 2010)	41.7	37.1	46.8	31.4	28.1	35.0	10.3 ***	25.9	22.2	30.3	20.0	16.9	23.7	5.9 *
Mali (2001)	57.2	51.3	63.8					40.7	35.3	46.9				
Mozambique (2003, 2011)	36.9	32.0	42.7	30.6	26.6	35.3	6.3	25.6	21.2	30.9	24.0	20.2	28.7	1.6
Nepal (2001, 2011)	38.5	32.9	45.0	33.0	27.0	40.2	5.5	23.4	18.8	29.0	18.4	13.4	25.3	5.0
Nigeria (2003, 2013)	47.9	41.5	55.3	37.4	34.6	40.4	10.5 **	31.9	25.7	39.7	27.5	25.0	30.2	4.5
Pakistan (2006/7, 2012/13)	53.8	48.0	60.3	55.3	48.8	62.7	-1.6	46.5	39.8	54.4	42.0	36.2	48.7	4.6
Rwanda (2000, 2010)	43.7	38.5	49.5	27.1	23.6	31.2	16.5 ***	29.4	24.7	35.1	14.1	11.4	17.5	15.3 ***
Senegal (1997, 2010/11)	37.8	32.9	43.5	28.8	25.0	33.1	9.1 **	26.0	21.6	31.3	22.7	18.9	27.3	3.3
Tanzania (1999, 2010)	40.4	31.8	51.3	25.8	21.5	31.0	14.6 **	31.5	23.3	42.5	17.7	14.0	22.3	13.8 **
Uganda (2000/1, 2011)	32.8	28.0	38.5	27.0	22.7	32.2	5.8	21.0	16.7	26.4	19.1	15.0	24.4	1.9
Yemen (1997)	33.9	30.2	38.0					28.0	24.0	32.6				
Zambia (20001/2, 2007)	37.0	32.0	42.8	34.5	29.6	40.3	2.5	24.7	20.3	30.1	25.5	21.0	31.0	-0.8

Note: * indicates p<.05; ** indicates p<.01;*** indicates p<.001. Rates presented for all births may not match rates presented in DHS final reports, as the study uses children born in months 1-59 preceding the interview rather than months 1-60 preceding the interview.

Figures 5a-r highlight the trend in neonatal mortality against trends in select indicators of maternal and delivery care, among most recent children born in the five years preceding the survey, for the 18 USAID MCH priority countries with baseline and endline surveys available. Figures 5a-i show the nine countries identified in Table 3 with significant reductions in NMR among all children born in the five years preceding the survey, and Figures 5j-r show the nine countries with no observed change in NMR. Generally speaking, the countries with significant reductions appear to have had somewhat more rapid scale-up of measurable interventions. However, the correspondence between scale-up of interventions and the movement of neonatal mortality is not uniform. For example, in Nepal (where there was no significant change in NMR) we observe rapid scale-up of all measurable maternal and delivery care interventions, while in Madagascar (where there was a substantial reduction in NMR), we observe virtually no scale-up of measurable maternal and delivery care interventions.

Figures 5a-i. Trends in maternal and delivery care and neonatal mortality, separately by country, USAID MCH priority countries with significant improvements in NMR



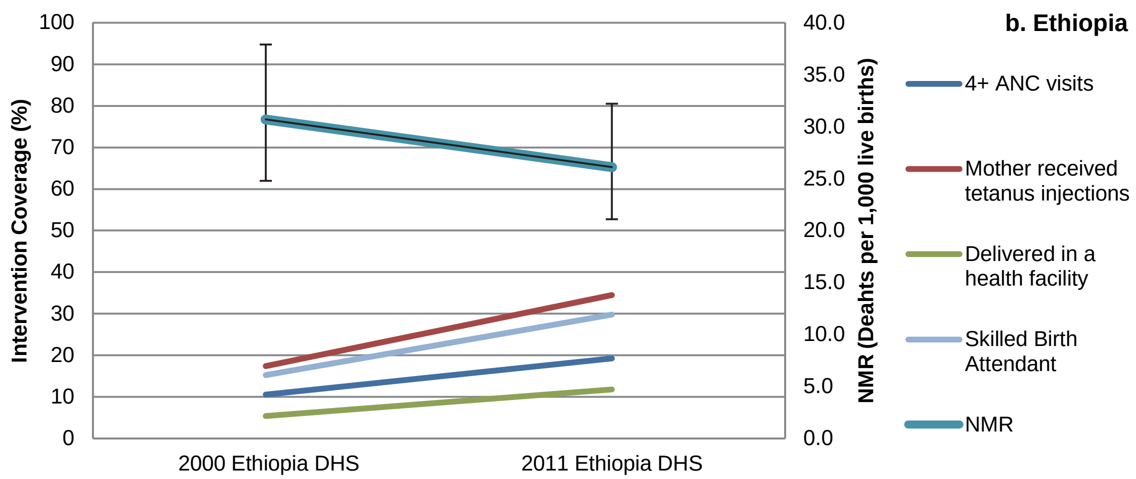


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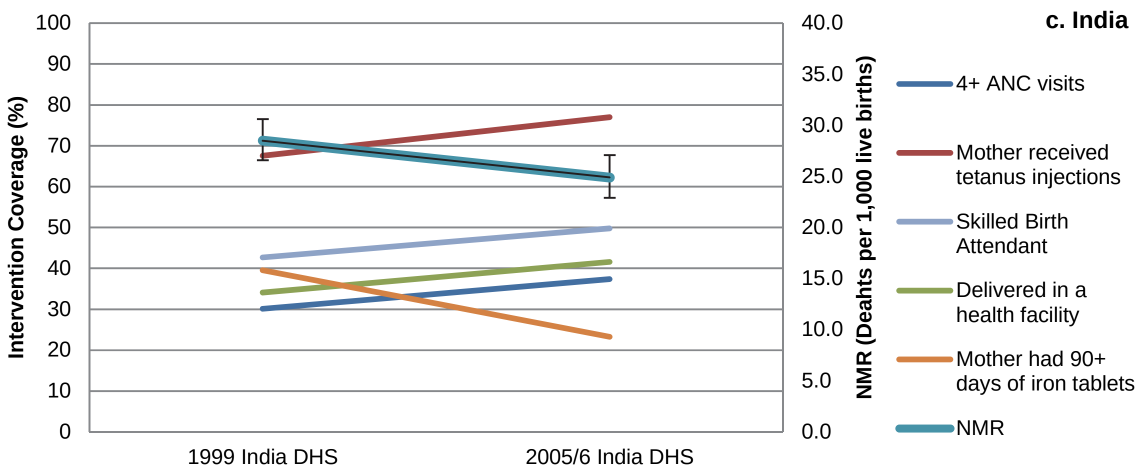
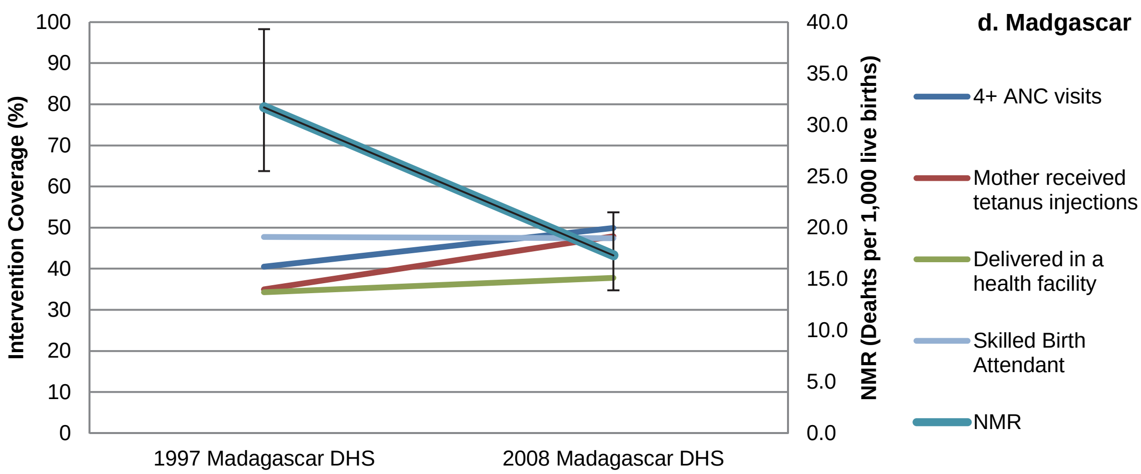
Figure 5a-i. – *Continued*





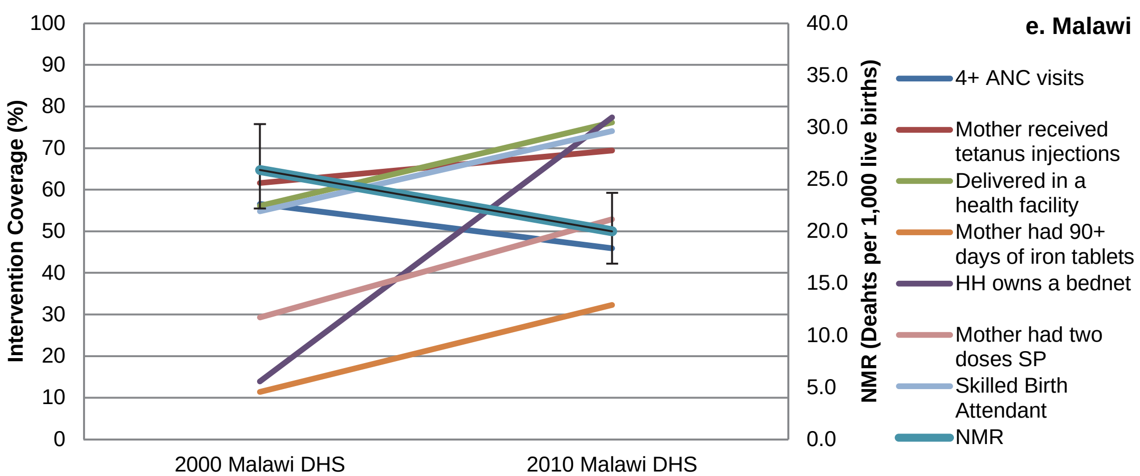


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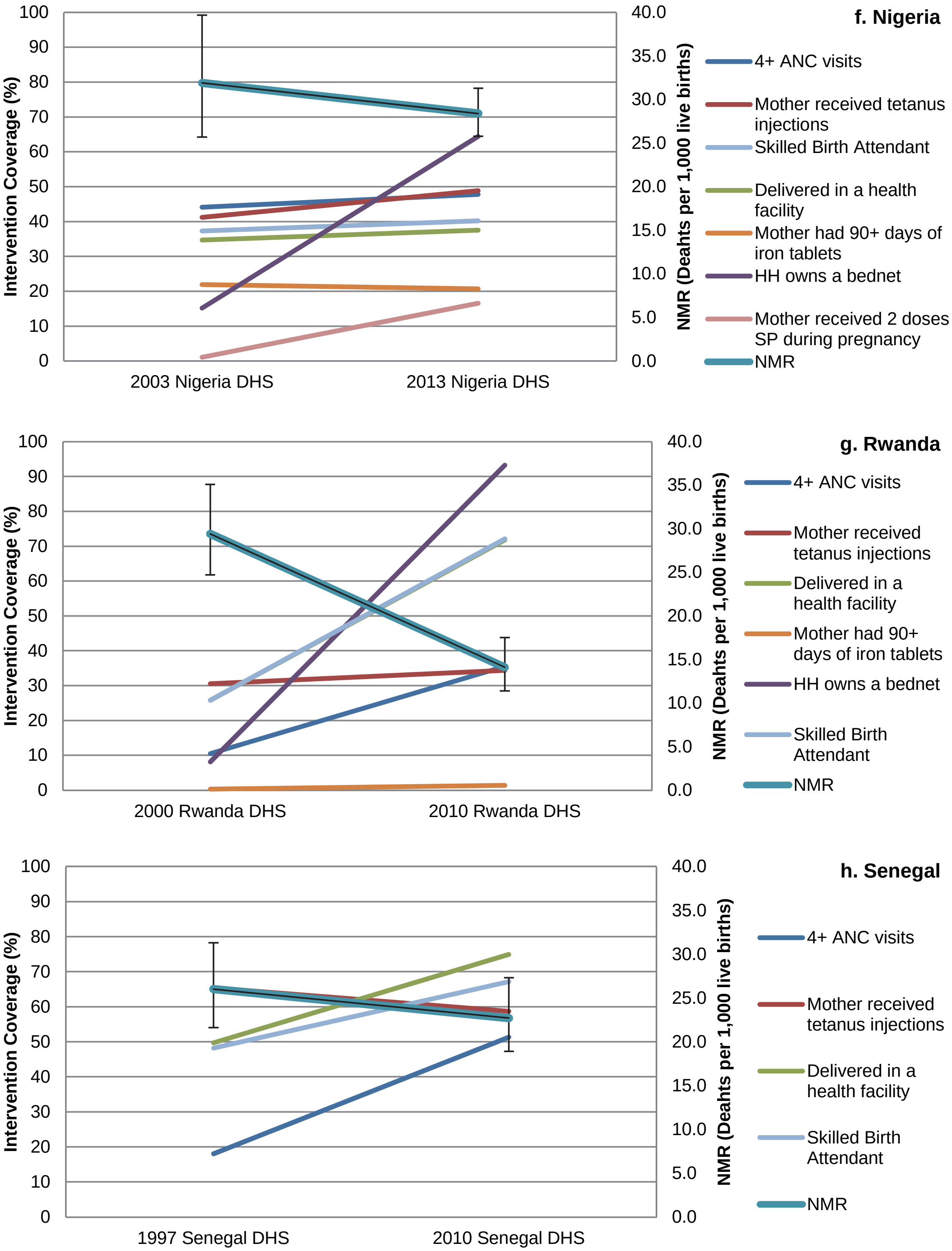
Figure 5a-i. – *Continued*



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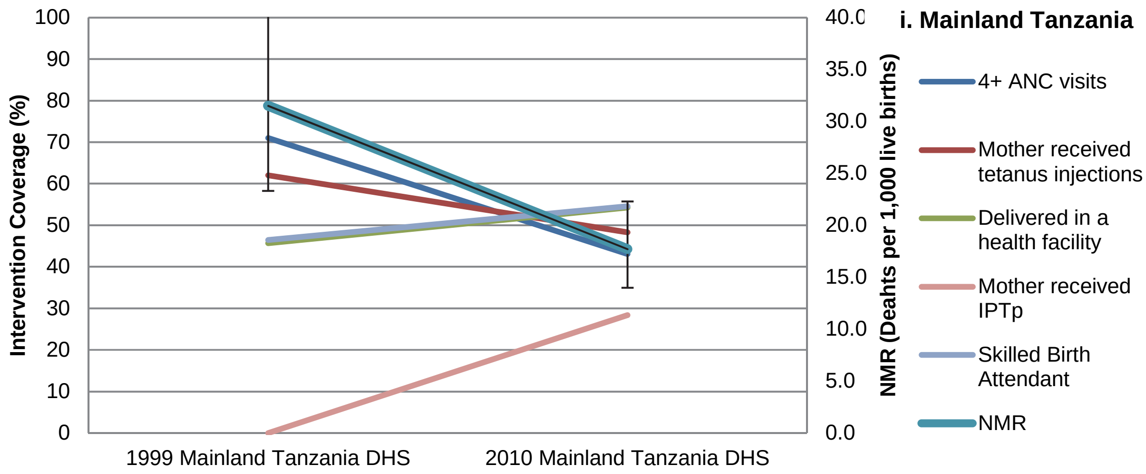
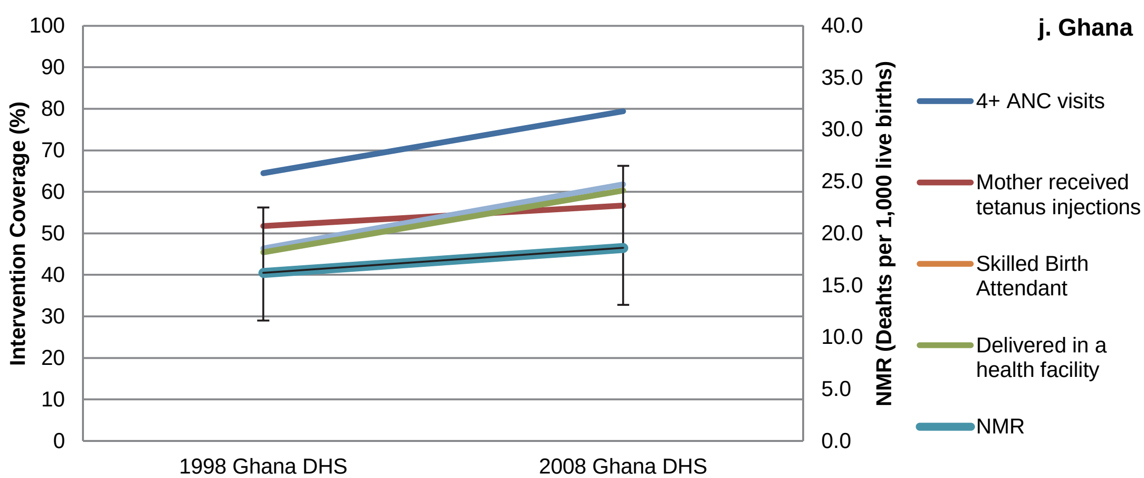


Figures 5j-r. Trends in maternal and delivery care and neonatal mortality, separately by country, USAID MCH priority countries with no significant improvement in NMR between surveys



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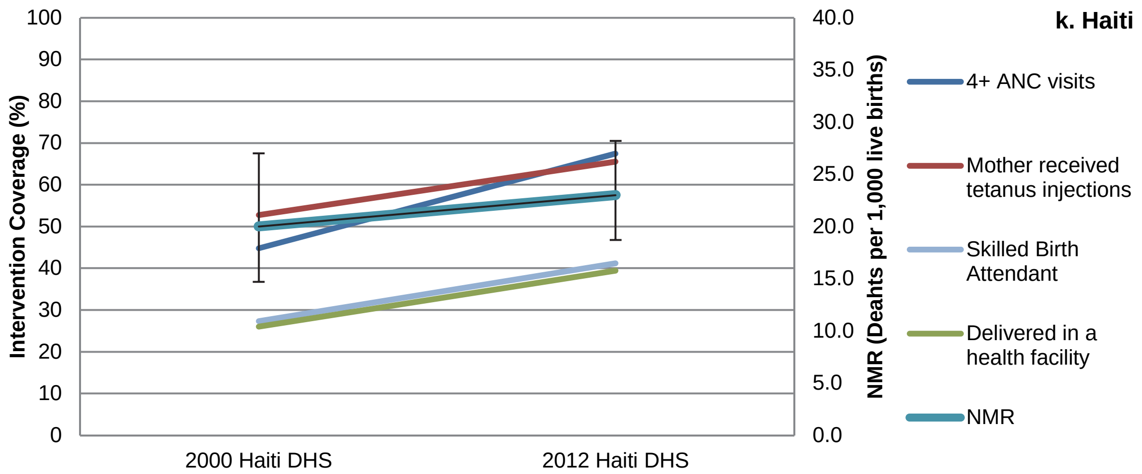

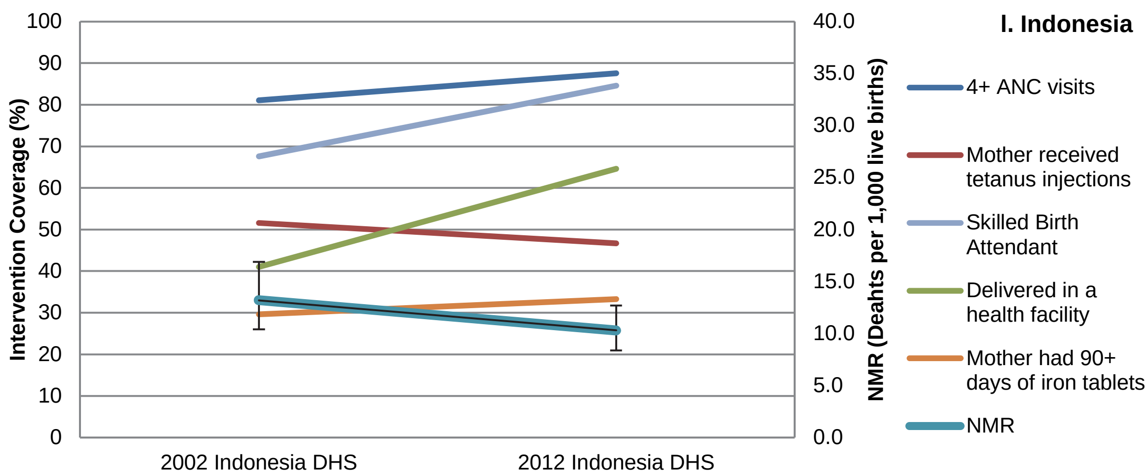

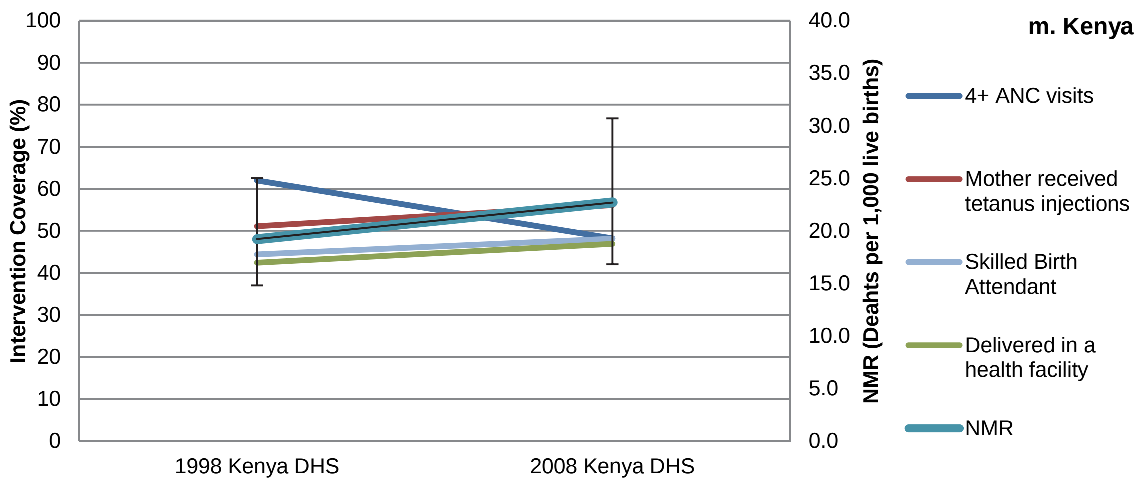

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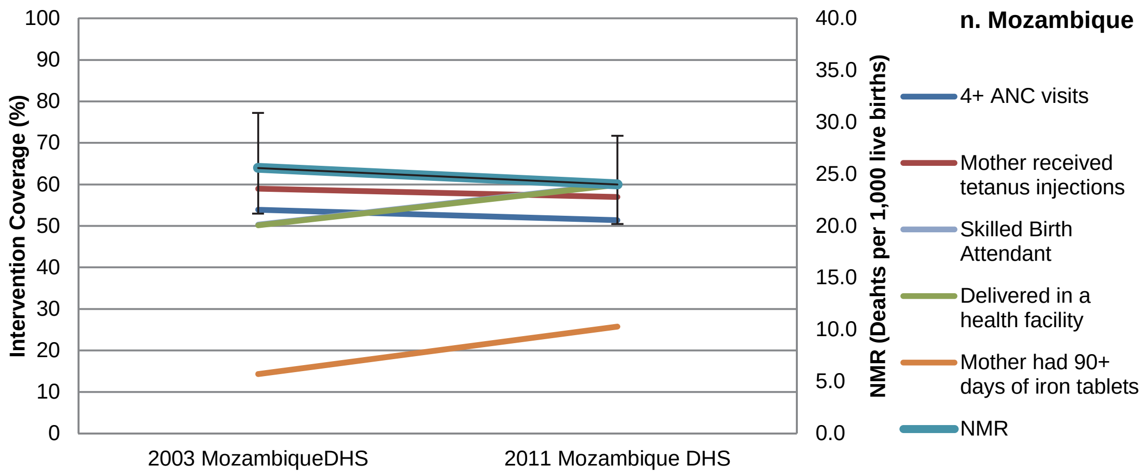

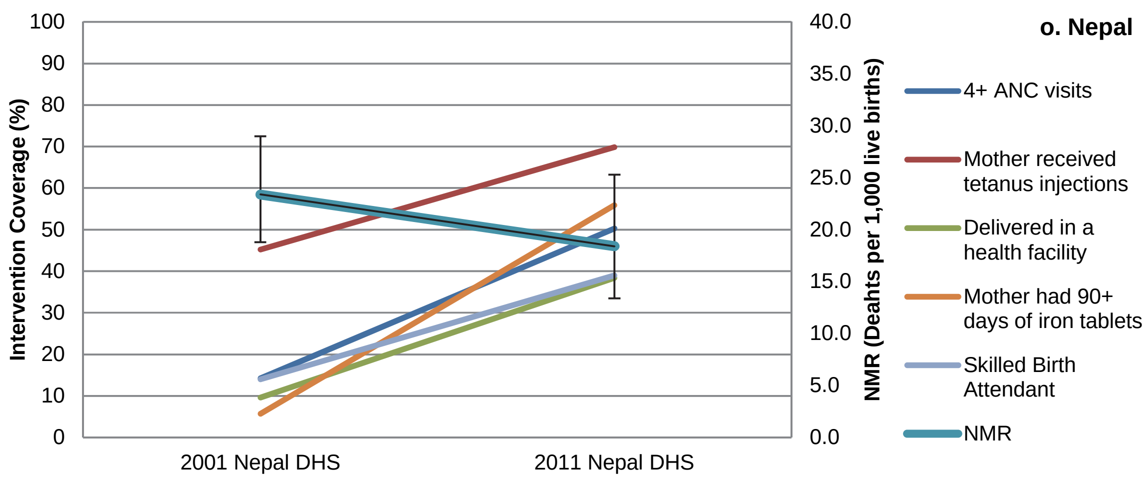

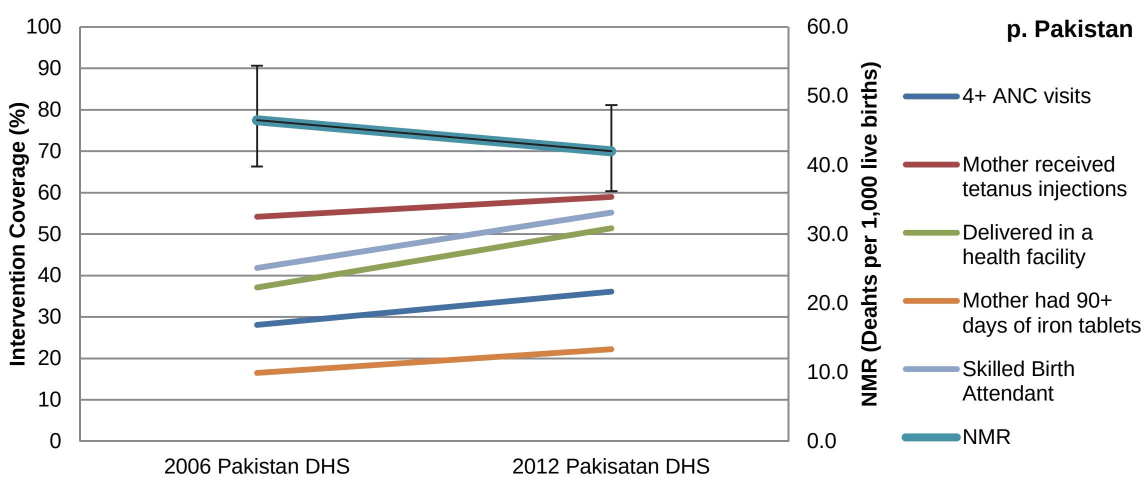

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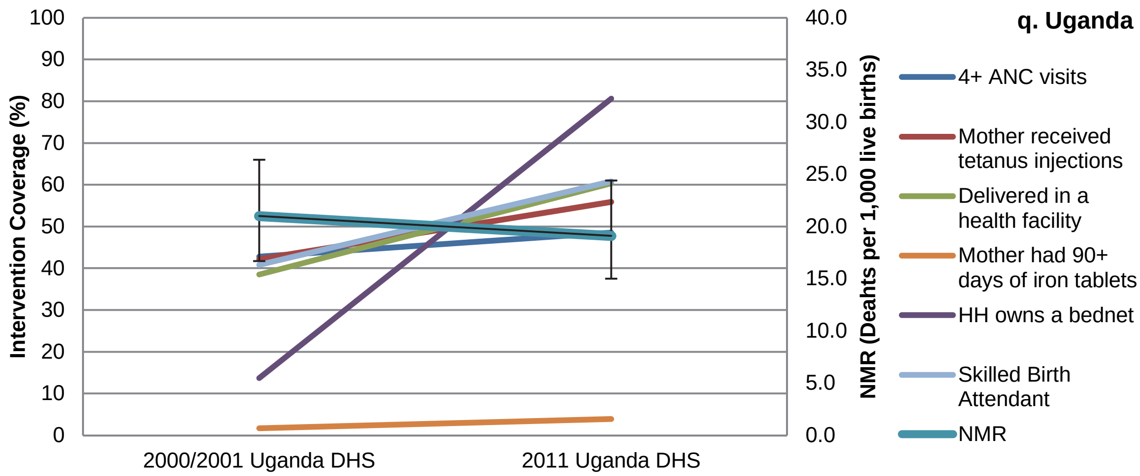
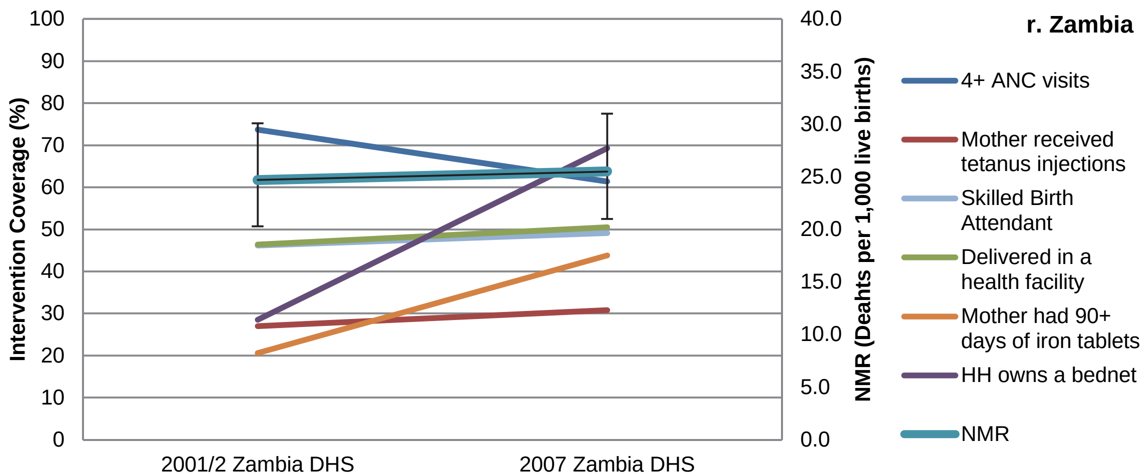




3.1. Trends in Coverage of Maternal and Delivery Care and Socio-Demographic Characteristics

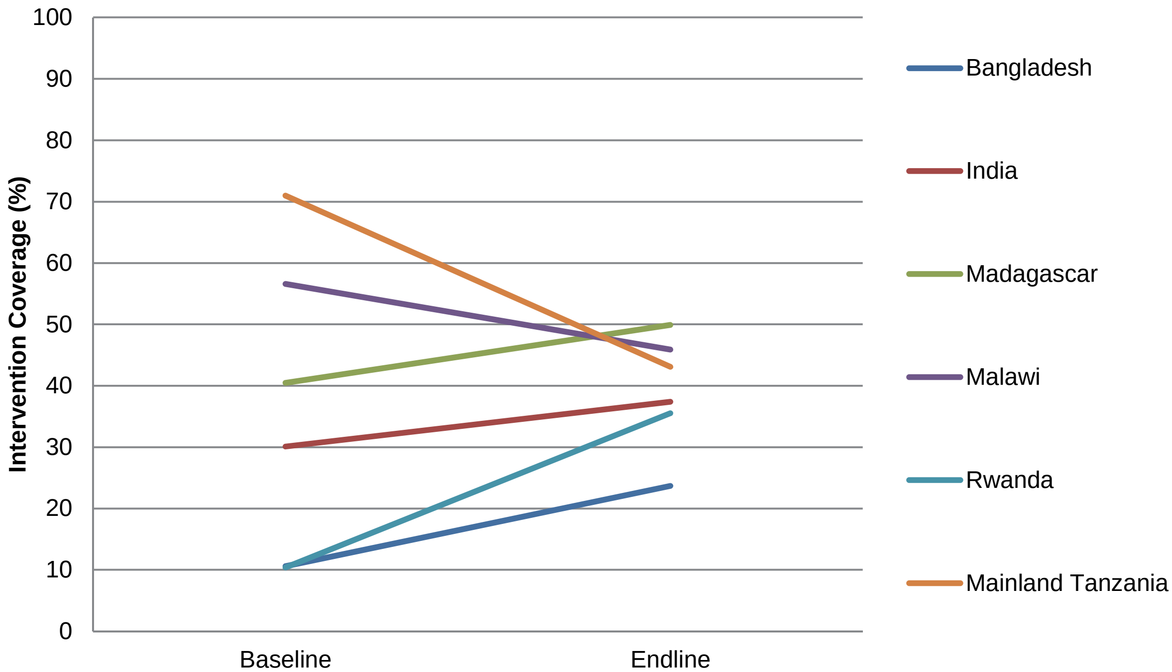
We now focus on the six countries with significant observed reductions in NMR among most recent children born in the five years preceding the survey. Table 4 presents trends in coverage of maternal and delivery care interventions, as well as trends in socio-demographic characteristics of the household, mother, and child, among most recent children born in the five years preceding each survey in Bangladesh, India, Madagascar, Malawi, Rwanda, and mainland Tanzania.

<u>Trends in coverage of maternal and delivery care:</u>

Antenatal care is an essential gateway into maternal care services, and provides an opportunity to identify and treat pregnancy-related problems. As Figure 6 shows, the percentage of women who had at least four antenatal care visits from any provider for the most recent birth (which of course tells us only that contacts occurred, not what happened during them) increased between the two surveys in four of the six focus countries. In Bangladesh the percentage doubled from 11 percent at baseline to 24 percent at endline, and in Rwanda the percentage tripled from 10 to 36 percent. By contrast, in two countries there was a decline in the percentage of women with at least four ANC visits, from 57 to 46 percent in Malawi, and from 71 to

43 percent in mainland Tanzania. These declines could reflect changes in antenatal care policies and goals during this period. Both Malawi and Tanzania adopted the WHO-recommended Focused Antenatal Care (FANC) framework during this period, shifting emphasis from the number of antenatal care visits to the provision of specific content during those visits (WHO 2002).

Figure 6. Trend in the mother's use of four or more antenatal care visits during pregnancy, among most recent children born in the five years preceding the survey



The provision of neonatal tetanus toxoid (TT) injections is an important component of antenatal care. Providing women with two doses of TT during pregnancy can prevent neonatal tetanus, which is nearly always fatal. If a woman has been previously vaccinated, one dose of TT during pregnancy is sufficient, and if she has already had five or more vaccinations, she will have acquired lifetime protection. Coverage of two or more doses of TT during pregnancy increased by roughly 10 percentage points between the two surveys in three countries—from 68 to 77 percent in India, from 35 to 48 percent in Madagascar, and from 62 to 69 percent in Malawi (see Figure 7). According to the endline Rwanda survey, 34 percent of mothers received at least two TT vaccinations for their most recent birth, essentially unchanged from the baseline survey. However, in Bangladesh and mainland Tanzania the percentage of children whose mother received at least two TT vaccinations during the pregnancy declined from over 60 percent to under 50 percent between the two surveys[7].

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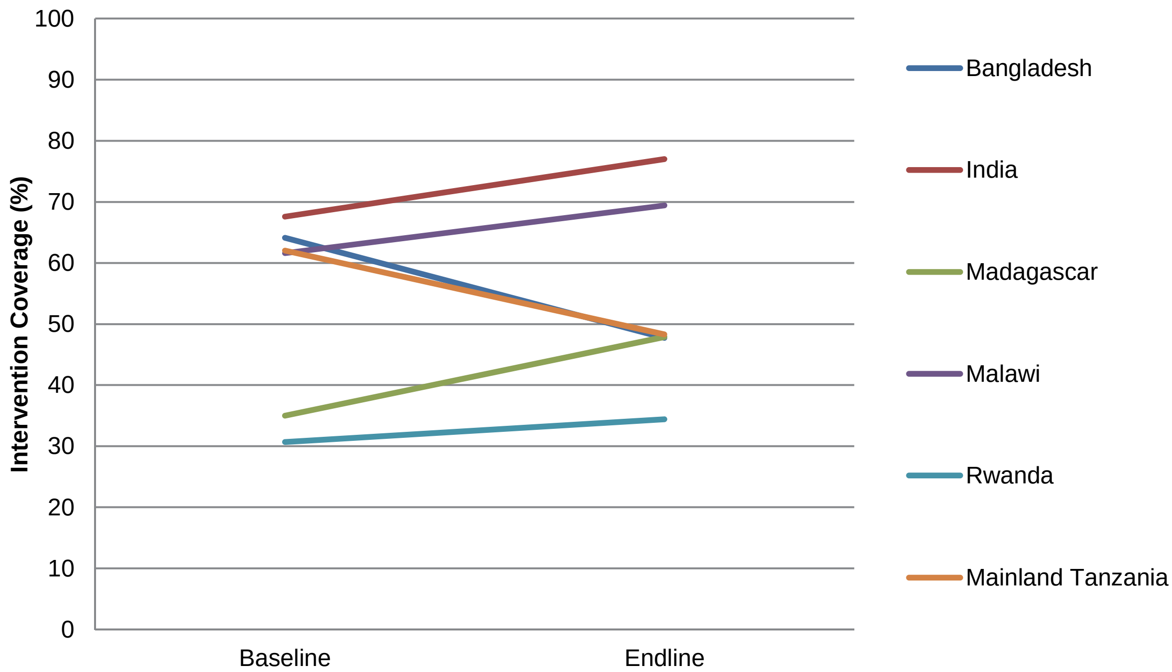
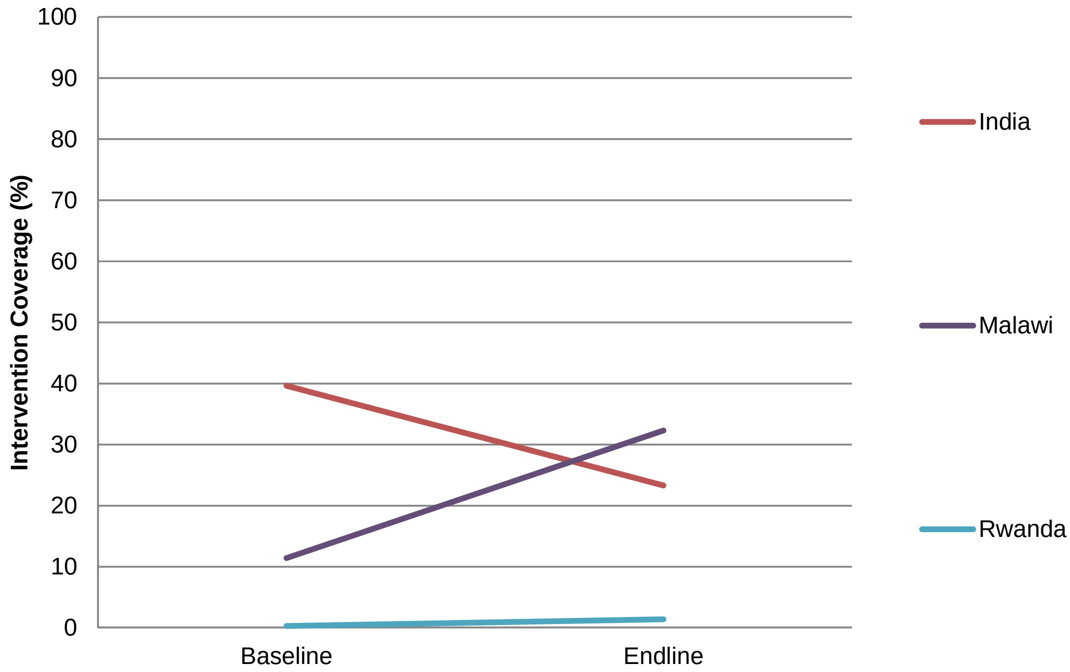
[7] The preferred indicator, “full tetanus protection,” takes into account whether a woman was fully vaccinated against tetanus prior to the most recent pregnancy and did not need two additional doses. However, because this indicator could not be calculated in the earlier surveys and we are interested in trends, we rely on this less precise measure. Values of “full tetanus protection” in our study population, according to the endline survey data were: 91 percent in Bangladesh, 77 percent in India, 71 percent in Madagascar, 89 percent in Malawi, 78 percent in Rwanda, and 89 percent in mainland Tanzania.

Figure 7. Trend in two or more tetanus injections given to the mother during pregnancy, among most recent children born in the five years preceding the survey



Iron and folic acid supplementation during pregnancy has been shown to be protective against neonatal mortality (Titaley et al. 2010). Coverage with the recommended 90+ days of iron and folic acid supplementation during pregnancy remains low, at under 10 percent according to the endline surveys in Madagascar, Rwanda, and mainland Tanzania. As Figure 8 shows, coverage in Malawi increased nearly threefold between the two surveys, reaching 32 percent at endline, while in India coverage fell from 40 to 23 percent between the two surveys.

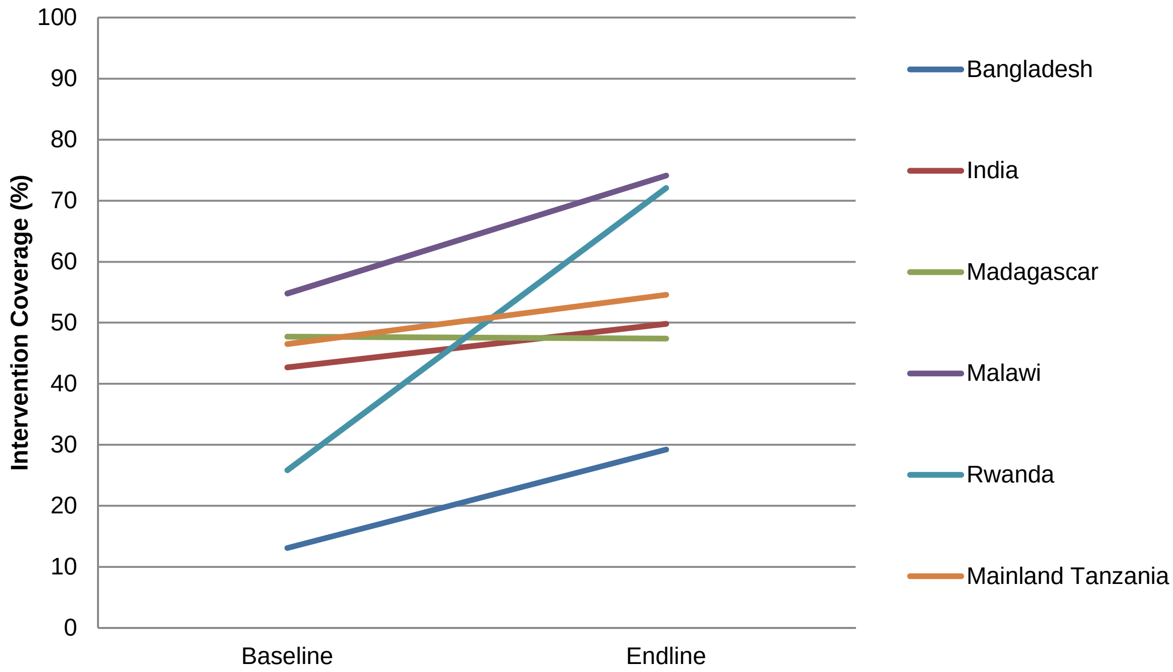
Figure 8. Trend in iron and folic acid supplementation for the mother among most recent children born in the five years preceding the survey



Delivery by a skilled birth attendant is a key recommended strategy for maternal and newborn survival (WHO 2014). Scale-up of coverage of skilled clinical care in facilities (including skilled maternal and immediate newborn care, emergency obstetric care, and emergency neonatal care) is believed to have the potential to avert 21 to 44 percent of global neonatal deaths (Darmstadt et al. 2008). Five of the six countries have made impressive gains in "skilled birth attendance"[8] between the two surveys (see Figure 9). In Rwanda, the percentage of children delivered by a skilled birth attendant increased most dramatically, from 26 to 72 percent between baseline and endline. In India, Malawi, and mainland Tanzania, the percentage of children delivered by a skilled birth attendant increased from 43 to 50 percent, from 55 to 74 percent, and from 47 to 55 percent, respectively, between the two surveys. Use of skilled birth attendants is lowest in Bangladesh. Nonetheless, use more than doubled between the two surveys, from 13 to 29 percent. The percentage of children delivered by a skilled birth attendant remained unchanged at 47 percent in Madagascar.

[8] We use quotation marks since our measure of SBA is based entirely on the occupation of the provider, and does not directly measure actual skills.

Figure 9. Trend in skilled birth attendance among most recent children born in the five years preceding the survey

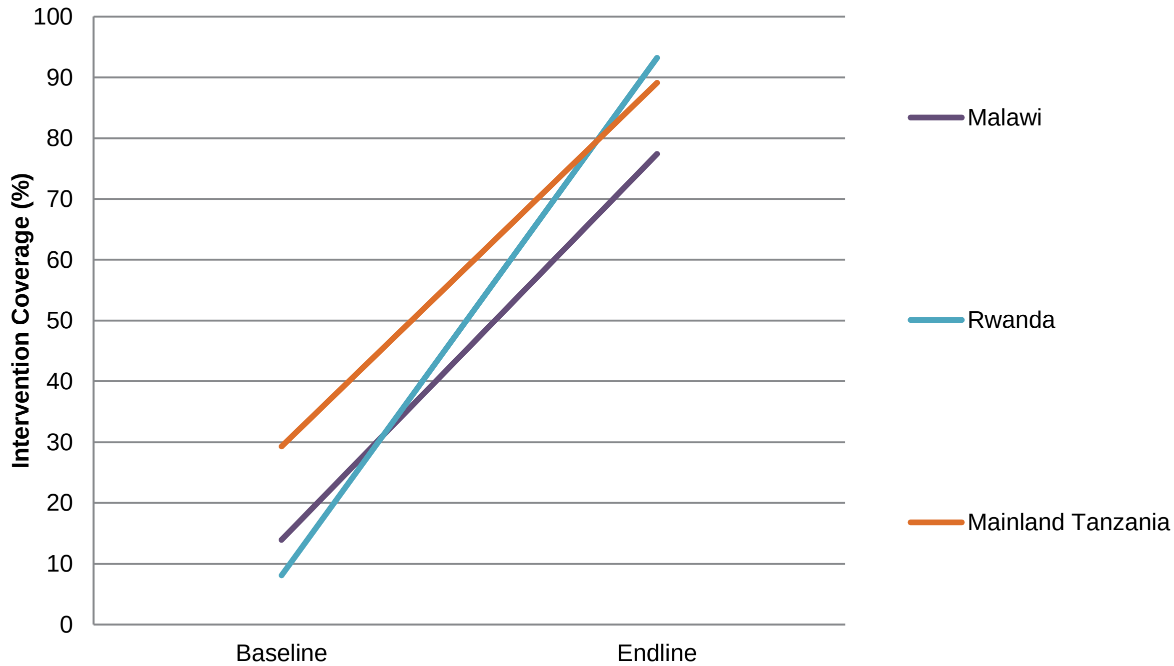


In most settings, skilled birth attendance corresponds closely with the place of delivery. In Malawi, Rwanda, and mainland Tanzania, the prevalence of deliveries in a facility closely follows the prevalence of skilled birth attendance. However, in Bangladesh, India, and Madagascar, skilled birth attendance for home births is more common, and coverage of facility delivery is lower than SBA coverage. For example, according to the endline Madagascar survey, 38 percent of most recent children were born in a facility, and 47 percent were born with assistance from a skilled attendant.

In many countries in sub-Saharan Africa, malaria during pregnancy is an important cause of low birth weight and is thus a major cause of neonatal morbidity and mortality (Guyatt and Snow 2001). In three of the four sub-Saharan African study countries, we were able to incorporate cluster-level spatial data on the level of malaria risk. This information, compiled by the Malaria Atlas Project, relies on the estimated proportion of children age 2-10 in the general population who are infected with *P. falciparum* at any one time, averaged over the 12 months of 2010, as well as environmental covariates which help predict more accurately (Malaria Atlas Project). The distribution of children across levels of malaria risk did not change substantially in Malawi, mainland Tanzania, or Madagascar between the two surveys. According to the recent Madagascar and Malawi surveys, over half of most recent children were born in areas of intermediate risk (i.e. areas where $Pf\text{PR}_{2\text{-}10}$ is likely to be between 5 and 40 percent), while over 40 percent of children were born in high-transmission areas (i.e. areas where $Pf\text{PR}_{2\text{-}10}$ is likely to be >40 percent). In mainland Tanzania, 68 percent of children were born in areas of intermediate transmission, 11 percent in high-transmission areas, and the remaining 21 percent in areas with low or no risk of transmission.

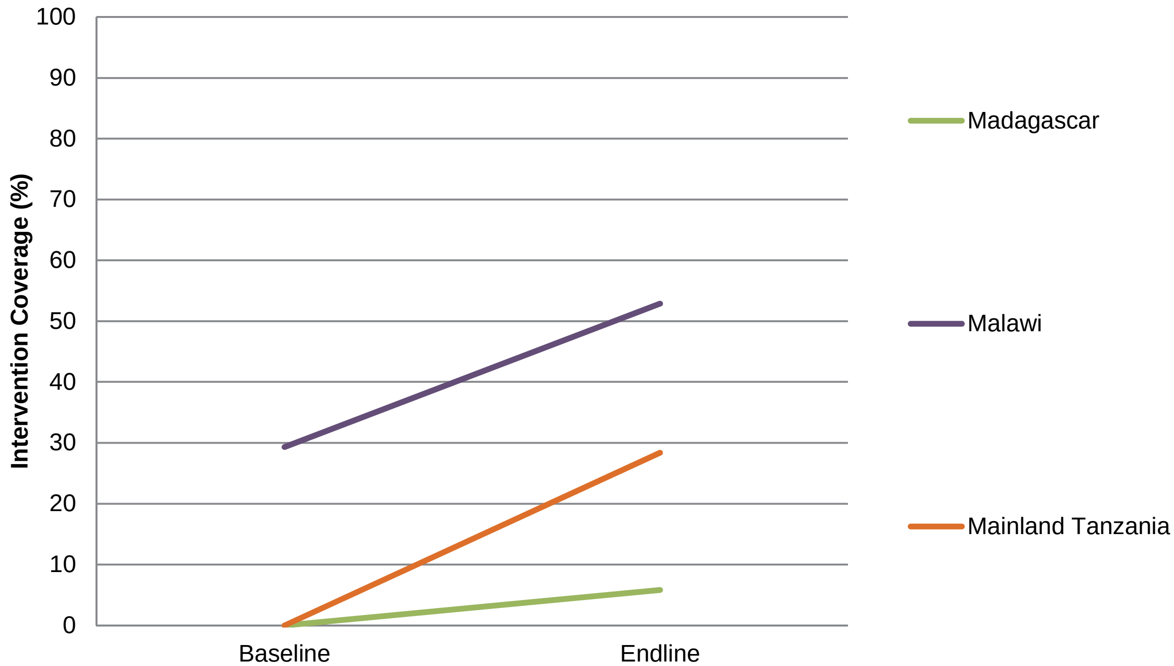
The recommended interventions to address malaria in pregnancy are sleeping under insecticide treated nets (ITN) and—in high and medium transmission countries in SSA—intermittent presumptive treatment (IPTp) with sulfadoxine-pyrimethamine (SP). Studies have shown coverage of either IPTp or ITN to be associated with an 18 percent reduction in neonatal mortality and a 21 percent reduction in low birth weight among women in their first or second pregnancies (Eisele et al. 2012). In Malawi, Rwanda, and mainland Tanzania, the first local ITN campaigns began targeting specific districts or regions in the 1990s. In Malawi, ITNs first became available nationwide commercially and at health facilities in 2003, in mainland Tanzania in 2004, and in Rwanda, in 2005. As Figure 10 shows, all three countries have had dramatic increases in mosquito bednet coverage between the baseline and endline surveys, from 14 to 77 percent in Malawi, from 8 to 93 percent in Rwanda, and from 29 to 89 percent in mainland Tanzania. Mosquito bednet campaigns began later in Madagascar; PMI supported the first mass ITN distribution campaign in 2009/2010 (President's Malaria Initiative 2014). We could not measure household ownership of a mosquito bednet at baseline, but coverage was as high as 68 percent in the endline survey.

Figure 10. Trend in household ownership of a mosquito bednet among most recent children born in the five years preceding the survey



A widely accepted estimate is that 10 to 30 percent of neonatal deaths could be averted with 90 percent coverage of IPTp (Darmstadt et al. 2005). Malawi was one of the first countries in sub-Saharan Africa to adopt the policy of giving all pregnant women IPTp with SP in 1993. Madagascar adopted IPTp as a national policy in late 2004 in the 93 districts where stable malaria transmission occurs, and Tanzania and Rwanda adopted the policy in 2001 and 2005, respectively (Eisele et al. 2012; President's Malaria Initiative 2014). However, in 2008 Rwanda discontinued the program due to increased resistance to SP (President's Malaria Initiative 2013). Both Malawi and Tanzania have achieved widespread implementation of the policy. In Malawi, the percentage of women who received at least two doses of SP during pregnancy increased from 29 to 53 percent. In Tanzania and Madagascar, we can assume that in the baseline survey no mothers had received two doses of preventative SP for their most recent birth; by endline this percentage was 28 percent in mainland Tanzania, and 6 percent in Madagascar (see Figure 11).

Figure 11. Trend in the mother's use of two doses of SP during pregnancy among most recent children born in the five years preceding the survey



Trends in socio-demographic characteristics:

Table 4 also presents trends in socio-demographic characteristics of the household, mother, and child. Household-level socioeconomic status and urban residence are expected to be positively associated with neonatal survival. The comparative wealth index shows that in five of the six countries there was improvement in absolute wealth across the decade. The percentage of children born into the poorest third of households[9] declined from 79 to 68 percent in Bangladesh, from 94 to 80 percent in Malawi, from 91 to 80 percent in Rwanda, and from 83 to 73 percent in mainland Tanzania between the baseline and endline surveys. Madagascar showed more modest improvements, from 83 to 79 percent, while in India–the wealthiest of the six study countries according to the comparative wealth index—the percentage of most recent children born into households in the poorest third of households did not decline, but increased from 45 to 58 percent between the two surveys[10].

Between baseline and endline surveys, the percentage of most recent children born into urban households compared with rural households did not increase substantially in Malawi, Rwanda, or mainland Tanzania. In Bangladesh and India there was an increase in the percentage of most recent children born into urban households—from 17 to 23 percent in Bangladesh and from 22 to 27 percent in India—while in Madagascar the percentage of most recent children born into urban households decreased from 20 to 12 percent[11].

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[9] The bottom comparative wealth third is identified using standard cut points derived from the distribution of wealth scores in the 2002 Vietnam DHS survey.

[10] This could be a reflection of differences in sampling between the two surveys rather than a reflection of economic change. Regardless, the analysis will adjust for changes in wealth between the two samples of children.

[11] This trend could be an artifact of the data, resulting from factors such as changes in criteria for classifying clusters as rural or urban. According to World Bank data, the percent of the total population of Madagascar that is rural has remained stable between 1999-2003 and 2009-2013 (The World Bank 2014).

Since the benefits of urban residence could depend on the economic status of the household (Matthews et al. 2010), we also examine the combination of place of residence and comparative household wealth. The contexts of urbanization and poverty are distinct across the six countries. In Bangladesh, the decline in the percentage of children born into households in the poorest comparative wealth tercile occurred almost entirely in rural areas, while the percentage of children born into urban households in the poorest wealth tercile remained constant, at 7 percent. In Malawi, Rwanda, and mainland Tanzania, the decline in the percentage of children born in households in the poorest comparative wealth tercile was shared between urban and rural households. By contrast, in Madagascar the percentage of children born into urban poor households decreased from 10 to 2 percent, but the percentage of children born into rural poor households increased slightly from 73 to 77 percent. In India, the percentage of children born into both urban and rural poor households increased.

Several characteristics of the mother, including age at the child's birth, educational attainment, and marital status, have been found to be associated with neonatal survival. The percentage of children born to mothers in the lowest-risk age range, age 18-34, increased the most in Rwanda, from 69 to 75 percent between baseline and endline, with a corresponding decline in the percentage of children born to mothers age 35 or older, from 30 to 24 percent. The percentage of children born to young mothers (under age 18) remained low in Rwanda, at 1 percent at endline. In Madagascar and mainland Tanzania, there was a slight increase in the percentage of children born to mothers age 35 or older, from 17 to 20 percent in Madagascar and from 18 to 21 percent in Malawi between surveys. In India, the percentage of children born to young mothers (under age 18) decreased from 9 to 6 percent between surveys, with a corresponding increase in births to mothers in the optimal age range.

There have been noteworthy improvements in mothers' educational attainment in Bangladesh, India, Malawi, and Rwanda. In Bangladesh, the percentage of mothers with secondary education or higher doubled from 25 to 51 percent between baseline and endline, and in India this percentage increased from 30 to 39 percent. In Malawi the percentage of mothers with secondary education increased from 8 to 16 percent, while the percentage with no education fell from 31 to 17 percent between the two surveys. In Rwanda the percentage of mothers with primary education increased from 55 percent at baseline to 71 percent at endline, while the percentage born to mothers with no education fell from 35 to 19 percent. In contrast, in Madagascar and mainland Tanzania the educational attainment of mothers remained unchanged between the two surveys; in both countries at endline, about one-fourth of mothers had no education, while 22 percent and 7 percent, respectively, had secondary or higher education.

According to the endline survey in Madagascar, Malawi, Rwanda, and mainland Tanzania, the great majority of children (over 80 percent) were born to mothers either married or in union, and this percentage was similar in the earlier surveys. In Bangladesh and India, the survey samples were restricted to ever-married women, so we did not examine the current marital status of women in these countries.

Several characteristics of the child affect the risk of neonatal death. Boys, children born after a short interval or after a long interval, first births, high-order births, and multiple births have an increased risk of neonatal mortality (Rutstein and Winter 2014). The prevalence of these risk factors among children has remained little changed across the two surveys in each country. In all countries about half of children are boys. In India, Rwanda, and mainland Tanzania, the percentage of children born after a short preceding birth interval (<24 months) or a long interval (>35 months) remained relatively unchanged. In Bangladesh, Madagascar, and Malawi there were modest declines between baseline and endline surveys in the percentage of children born after an optimal interval, from 25 to 19 percent in Bangladesh, from 39 to 32 percent in Madagascar, and from 37 to 33 percent in Malawi. The distribution of births by birth order was similar between the two surveys in India, Madagascar, Malawi, and mainland Tanzania. The percentage of children who were first births increased in Bangladesh and Rwanda, from 27 to 34 percent in Bangladesh, and from 17 to 22 percent in Rwanda, with corresponding declines in the percentage of children of fourth or higher order. In each country 1.5 to 2.5 percent are multiple births.

In order to control for potential unidentified genetic or household-level risk factors, a measure of whether the child's mother lost another child under age 5 is included in the analysis. In all countries except India (where the time period between surveys is shorter), there was a 5 to 10 percentage point reduction in the percentage of children whose mothers lost another child under age 5. This reduction reflects the gains in child survival during the decade.

Table 4. Trend in socio-demographic characteristics of the household, mother, and child, and in coverage of recommended maternal and delivery care, among women's most recent children born in the five years preceding the survey, USAID MCH priority countries with significant reductions in NMR

	Bangladesh		India		Madagascar		Malawi		Rwanda		Tanzania (Mainland)	
	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %
CHARACTERISTICS OF THE HOUSEHOLD												
Place of residence												
Urban	17.4	23.4	22.2	26.8	20.4	12.4	13.4	15.4	14.7	12.8	22.9	22.8
Rural	82.6	76.6	77.8	73.2	79.6	87.6	86.6	84.6	85.3	87.2	77.1	77.2
Comparative wealth index[1]												
Poorest third	78.6	67.8	44.6	58.2	82.7	78.8	93.9	80.1	91.3	79.9	82.6	72.9
Middle third	11.2	12.3	24.8	13.8	11.6	9.0	4.2	11.4	4.3	13.3	11.0	13.9
Richest third	10.1	19.9	30.6	28.1	5.7	12.2	2.0	8.5	4.5	6.8	6.4	13.2
Place of residence and comparative wealth index												
Urban upper two-thirds CWI	10.1	16.7	20.3	21.4	10.8	10.1	5.2	10.3	7.9	9.0	13.9	18.3
Urban bottom-third CWI	7.3	6.8	1.8	5.4	9.6	2.3	8.2	5.2	6.8	3.8	8.9	4.5
Rural bottom-third CWI	71.3	61.0	42.8	52.8	73.1	76.5	85.7	74.9	84.5	76.1	73.7	68.4
Rural upper two-thirds CWI	11.3	15.5	35.1	20.4	6.5	11.1	0.9	9.6	0.8	11.2	3.5	8.8
Malaria risk[2]												
None or low (<5% risk)	n/a	n/a	n/a	n/a	7.7	0.8	0.0	0.0	n/a	n/a	25.2	20.8
Intermediate (5%-40% risk)	n/a	n/a	n/a	n/a	52.2	58.1	56.1	56.8	n/a	n/a	65.5	68.2
High (>40% risk)					40.1	41.1	43.9	43.2			9.3	11.0
CHARACTERISTICS OF THE MOTHER												
Mother's age at child's birth												
<18 years	17.2	14.8	8.9	5.7	9.8	9.7	6.7	6.0	1.6	1.3	6.7	5.6
18-34 years	74.6	78.9	85.4	87.8	73.0	70.1	75.5	77.8	68.7	74.7	75.8	73.4
35+ years	8.2	6.3	5.7	6.6	17.2	20.3	17.9	16.2	29.7	24.0	17.5	21.0

(Continued...)

Table 4. – *Continued*

	Bangladesh		India		Madagascar		Malawi		Rwanda		Tanzania (Mainland)	
	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %
Mother's marital status												
Currently in union	n/a	n/a	n/a	n/a	79.5	84.7	87.0	85.5	78.5	82.8	83.5	81.9
Not currently in union	n/a	n/a	n/a	n/a	20.5	15.3	13.0	14.5	21.5	17.2	16.5	18.1
Mother's educational attainment												
None	45.6	19.3	54.4	47.3	23.4	23.2	30.7	16.6	34.7	18.9	26.6	23.7
Primary	29.0	30.1	15.4	14.0	55.2	54.6	61.7	67.0	55.2	71.4	70.0	69.7
Secondary or higher	25.4	50.7	30.2	38.7	21.3	22.2	7.6	16.4	10.2	9.7	3.4	6.6
Previous child to mother died under age five years												
No	75.4	86.0	80.1	82.2	63.8	78.8	60.7	70.8	62.3	73.8	66.7	75.6
Yes	24.6	14.0	19.9	17.8	36.2	21.2	39.3	29.2	37.7	26.2	33.3	24.4
CHARACTERISTICS OF THE CHILD												
Sex of child												
Female	48.4	48.3	47.4	46.1	49.9	49.6	50.3	50.1	49.4	48.4	50.0	49.7
Male	51.6	51.7	52.6	53.9	50.1	50.4	49.7	49.9	50.6	51.6	50.0	50.3
Preceding birth interval[3]												
<2 years	16.0	11.1	21.8	24.5	22.2	20.2	16.2	13.7	20.3	18.2	13.8	12.8
2 years	25.0	19.2	33.0	32.8	38.6	32.4	36.7	32.9	36.0	37.8	38.9	37.4
3+ years	59.0	69.7	45.2	42.7	39.2	47.4	47.1	53.5	43.6	44.0	47.3	49.8
Birth order												
First	27.2	33.5	27.4	26.3	21.3	21.4	21.2	18.3	17.1	22.4	22.9	19.2
Second	25.9	29.7	26.0	28.7	17.8	19.2	18.6	19.0	17.6	19.0	18.0	19.3
Third	17.7	18.0	18.2	17.3	14.1	15.7	15.8	17.3	15.5	15.1	15.1	16.6
Fourth or higher	29.3	18.8	28.4	27.7	46.8	43.6	44.4	45.4	49.8	43.4	44.0	45.0
Multiple birth												
Single birth	99.1	99.1	99.3	99.1	99.0	98.9	97.5	97.6	98.6	98.5	98.6	98.4

Multiple birth	0.9	0.9	0.7	0.9	1.0	1.1	2.5	2.4	1.4	1.5	1.4	1.6

(Continued...)

Table 4. – *Continued*

	Bangladesh		**India**		**Madagascar**		**Malawi**		**Rwanda**		**Tanzania (Mainland)**	
	Base-line %	**End-line %**	**Base-line %**	**End-line %**	**Base-line %**	**End-line %**	**Base-line %**	**End-line %**	**Base-line %**	**End-line %**	**Base-line %**	**End-line %**
RECOMMENDED MATERNAL AND DELIVERY CARE												
Mother attended 4 or more ANC visits												
Yes	10.6	23.7	30.1	37.4	40.5	49.9	56.6	45.9	10.4	35.5	71.0	43.1
No	89.4	76.3	69.9	62.6	59.5	50.1	43.4	54.1	89.6	64.5	29.0	56.9
Number of tetanus injections during pregnancy												
2+	64.1	47.7	67.6	77.0	35.0	47.9	61.6	69.4	30.7	34.4	62.0	48.3
1	17.2	22.6	8.4	6.7	14.7	15.0	20.4	18.5	34.7	42.6	21.4	24.7
0	18.7	29.7	24.0	16.3	50.2	37.1	18.0	12.2	34.6	23.0	16.7	27.0
Mother had 90+ days of iron and folic acid supplementation												
Yes	n/a	n/a	39.6	23.3	n/a	7.7	11.4	32.3	0.3	1.4	n/a	3.2
No	n/a	n/a	60.4	76.7	n/a	92.3	88.6	67.7	99.7	98.6	n/a	96.8
Delivered by a skilled birth attendant												
Yes	13.1	29.2	42.7	49.8	47.7	47.4	54.8	74.1	25.8	72.1	46.5	54.6
No	86.9	70.8	57.3	50.2	52.3	52.6	45.2	25.9	74.2	27.9	53.5	45.4
Delivered in a health facility												
Yes	9.0	26.3	34.1	41.6	34.3	37.8	56.1	76.2	25.8	71.8	45.7	54.3
No	91.0	73.7	65.9	58.4	65.7	62.2	43.9	23.8	74.2	28.2	54.3	45.7
Household owns a mosquito bednet												
Yes	n/a	n/a	n/a	n/a	n/a	68.4	13.9	77.4	8.1	93.2	29.3	89.1
No	n/a	n/a	n/a	n/a	n/a	31.6	86.1	22.6	91.9	6.8	70.7	10.9

(Continued...)

Table 4. – *Continued*

	Bangladesh		India		Madagascar		Malawi		Rwanda		Tanzania (Mainland)	
	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %	Base-line %	End-line %
Mother received two doses of SP during pregnancy[4]												
Yes	n/a	n/a	n/a	n/a	n/a	5.8	29.3	52.9	n/a	n/a	0.0	28.4
No	n/a	n/a	n/a	n/a	n/a	94.2	70.7	47.1	n/a	n/a	100.0	71.6
Total N	**5,177**	**7,254**	**28,313**	**39,251**	**3,249**	**8,569**	**7,943**	**13,497**	**5,062**	**6,355**	**2,101**	**5,316**

Note: Baseline surveys were conducted in 1999/2000 in Bangladesh, 1998/9 in India, 1997 in Madagascar, 2000 in Malawi, 2000 in Rwanda, and 1999 in mainland Tanzania. Endline surveys were conducted in 2011 in Bangladesh, 2005/6 in India, 2008/9 in Madagascar, 2010 in Malawi, 2010 in Rwanda, and 2010 in mainland Tanzania.

[1] The DHS-constructed comparative wealth index uses a fixed baseline (the 2002 Vietnam DHS) enabling measurement of improvements in wealth over time and comparison of absolute wealth across country.

[2] In low risk areas, the annual averaged plasmodium falciparum infection prevalence in 2-10 year olds is likely to be lower than 5%. In intermediate risk areas, plasmodium falciparum transmission is likely to be between 5%-40%. In high risk areas, transmission is likely to exceed 40% (Malaria Atlas Project).

[3] First births are excluded from the percentages.

[4] Coverage of women's use of two doses of SP is assumed to be 0% for the Madagascar and mainland Tanzania surveys, as the policy had not yet been implemented.

3.2. Multivariate Regression Results

The factors identified in Table 4 with improved coverage between the two surveys could have contributed to the observed declines in neonatal mortality only if they are associated with the probability of neonatal death. To examine the association between maternal and delivery care and neonatal mortality, log probability models were used to calculate the probability of dying during the first month of life, separately for each survey. In such a model the exponentiated intercept is the fitted NMR for the reference group or category of the variable. The exponentiated slopes are interpreted as relative risks or risk ratios (RR), the probability of dying in one group relative to the probability of dying in the reference group or category. If a slope coefficient is significantly different from zero, then there is a significant difference between the category of interest and the reference category.

We present results from two multivariate log probability models (see Appendix Table A2 for unadjusted model results). The first model, displayed in Table 5, adjusts for key socio-demographic characteristics of the household (place of residence and comparative household wealth, malaria risk), the mother (mother's age at the child's birth, marital status, educational attainment, loss of a previous child under age 5), and the child (sex, birth order, birth interval, multiple birth). In this model, we are interested in whether indicators of maternal and delivery care are associated with children's risk of dying in the first month of life after controlling for maternal, child, and household risk factors that could confound the association. In a second model, presented in Table 6, we include the full set of maternal and delivery care indicators together with the socio-demographic characteristics. In this model we are interested in which components of care remain independently associated with the probability of neonatal death, after further adjusting for the mother's use of the other components.

3.2.1. Protective effect of components of maternal and delivery care, adjusted for socio-demographic characteristics

As shown in Table 5, according to the baseline survey in five of the six countries and according to the endline survey in Malawi only, children whose mothers had made fewer than four ANC visits were between 1.5 and 2.5 times more likely to die in the first month of life compared with children whose mothers had made at least four visits, after adjusting for socio-demographic factors. In both Bangladesh and India the number of tetanus injections the mother received during pregnancy was significantly associated with the child's risk of dying in the first month of life. According to the endline Bangladesh survey, children whose mothers received no injections during the pregnancy were 1.8 times more likely to die during the neonatal period compared with children whose mothers received two injections, after adjusting for socio-demographic characteristics. In the baseline Malawi survey, not receiving the recommended two tetanus injections during the pregnancy was significantly associated with neonatal mortality, but the association was not significant in the endline survey. It was not significant in either the baseline or endline survey in Madagascar, Rwanda, and mainland Tanzania.

According to India's baseline survey, children whose mothers had received less than 90 days of iron and folic acid supplementation during pregnancy were 1.4 times more likely to die during the first month of life compared with children whose mothers received the recommended 90 days of supplementation, after controlling for socio-demographic characteristics. However, the protective effect of iron and folic acid supplementation was non-significant in all other surveys.

We found no evidence that delivery by a skilled birth attendant is associated with lower risk of neonatal mortality. To the contrary, according to the more recent Bangladesh survey, children whose birth was not attended by a skilled birth attendant were 50 percent *less likely* to die in the first month of life compared with children whose birth was attended by an SBA, after controlling for socio-demographic characteristics.

Table 5. Relative risk of dying during the neonatal period, adjusted for socio-demographic characteristics of the household, mother, and child, among women's most recent children born in the five years preceding the surveys, USAID MCH priority countries with significant reductions in NMR

	Bangladesh						India						Madagascar					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
RECOMMENDED MATERNAL AND DELIVERY CARE																		
Mother attended 4 or more ANC visits																		
Yes	1.00			1.00			1.00		.	1.00			1.00		.	1.00		
No	2.45	1.02	5.90*	0.90	0.54	1.50	1.51	1.19	1.91***	1.21	0.97	1.51	2.34	1.35	4.05**	1.01	0.63	1.61
Number of tetanus injections during pregnancy																		
2+	1.00			1.00			1.00			1.00			1.00			1.00		
1	2.14	1.32	3.46**	1.22	0.71	2.10	1.66	1.24	2.23***	1.09	0.79	1.53	1.44	0.68	3.08	0.57	0.27	1.19
0	1.87	1.18	2.96**	1.81	1.14	2.89*	1.86	1.52	2.27***	1.53	1.24	1.89***	1.35	0.80	2.27	1.36	0.81	2.27
Mother had 90+ days of iron and folic acid supplementation[1]																		
Yes	n/a			n/a			1.00		.	1.00						1.00		
No							1.40	1.16	1.69***	1.10	0.86	1.40	1.00	1.00	1.00	1.56	0.61	3.97
Delivered by a skilled birth attendant																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	0.68	0.36	1.27	0.50	0.31	0.81**	1.09	0.89	1.35	0.95	0.77	1.17	1.67	0.97	2.88	0.73	0.45	1.20
Community coverage of SBA	0.64	0.17	2.48	0.67	0.24	1.87	1.32	0.94	1.84	1.55	1.10	2.20*	2.75	1.02	7.42*	0.71	0.35	1.47
Delivered in a health facility																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	0.65	0.32	1.34	0.46	0.28	0.74**	0.93	0.74	1.16	0.84	0.68	1.04	1.40	0.82	2.40	0.93	0.55	1.57
Household owns a mosquito bednet																		
Net	n/a			n/a			n/a			n/a			n/a			1.00		
No net																1.41	0.89	2.23
Mother received two doses of SP during pregnancy																		
Yes	n/a			n/a			n/a			n/a			n/a			1.00		
No																0.78	0.39	1.59

(Continued...)

Table 5. – *Continued*

	Malawi						Rwanda						Mainland Tanzania					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
RECOMMENDED MATERNAL AND DELIVERY CARE																		
Mother attended 4 or more ANC visits																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	1.46	1.07	1.98*	1.77	1.24	2.53**	1.43	0.71	2.89	1.45	0.89	2.38	2.38	1.05	5.40*	1.34	0.85	2.12
Number of tetanus injections during pregnancy																		
2+	1.00			1.00			1.00			1.00			1.00			1.00		
1	1.39	0.91	2.11	1.31	0.90	1.92	1.26	0.83	1.92	0.84	0.45	1.57	1.13	0.36	3.55	1.10	0.59	2.08
0	3.19	2.32	4.38***	1.34	0.87	2.09	1.45	0.92	2.28	1.16	0.60	2.22	1.22	0.54	2.77	1.50	0.78	2.87
Mother had 90+ days of iron and folic acid supplementation[1]																		
Yes	1.00			1.00			n/a			n/a			n/a			1.00		
No	1.24	0.69	2.21	1.41	0.97	2.04										0.83	0.25	2.78
Delivered by a skilled birth attendant																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	1.29	0.94	1.76	0.86	0.58	1.27	0.86	0.55	1.34	0.84	0.50	1.41	0.95	0.46	1.94	0.85	0.45	1.62
Community coverage of SBA	1.07	0.52	2.21	1.29	0.46	3.64	0.74	0.31	1.77	1.55	0.50	4.82	0.96	0.24	3.81	0.81	0.30	2.18
Delivered in a health facility																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	1.39	1.02	1.91*	1.00	0.66	1.50	0.82	0.53	1.26	0.85	0.51	1.42	1.01	0.50	2.06	0.69	0.36	1.31
Household owns a mosquito bednet																		
Net	1.00			1.00			1.00			1.00		.	1.00			1.00		.
No net	0.73	0.48	1.11	1.75	1.22	2.52**	3.64	0.85	15.68	3.16	1.83	5.45***	1.09	0.41	2.89	3.32	1.94	5.69***
Mother received two doses of SP during pregnancy																		
Yes	1.00			1.00			n/a			n/a			n/a			1.00		
No	1.45	0.99	2.12	1.29	0.96	1.74										1.67	0.90	3.11

Note: * indicates p<.05; ** indicates p<.01;*** indicates p<.001. The table presents adjusted relative risk (aRR) estimates, which compare the probability of dying in one group relative to the probability of dying in the reference group, after adjusting for the following characteristics of the household (urban residence and comparative household wealth), the mother (age at child's birth, marital status, level of education, and loss of another child under five) and the child (sex, birth interval, birth order, and multiple birth). Malaria risk was included as a control in Madagascar, Malawi, and Mainland Tanzania, and caste was included in India. Marital status was not included in models for Bangladesh or India, since these were ever-married samples. Multiple birth was not included in models for Malawi or Mainland Tanzania, given the small number of multiple births. Baseline surveys were conducted in 1999/2000 in Bangladesh, 1998/9 in India, 1997 in Madagascar, 2000 in Malawi, 2000 in Rwanda, and 1999 in mainland Tanzania. Endline surveys were conducted in 2011 in Bangladesh, 2005/6 in India, 2008/9 in Madagascar, 2010 in Malawi, 2010 in Rwanda, and 2010 in mainland Tanzania.

[1] This indicator was calculated for Rwanda as well, but due to the low prevalence of coverage of iron supplementation, the relative risk could not be calculated.

We also examined a community-level measure of the proportion of women in the cluster whose most recent birth was attended by an SBA. This indicator was an attempt to circumvent selection biases introduced by the fact that mothers with complicated pregnancies are more likely to seek out an SBA—especially in contexts where use of an SBA is uncommon—and the risk of neonatal death is higher in these cases. We interpret this community-level measure as a proxy for women's access to skilled assistance during delivery. According to the endline India survey and the baseline Madagascar survey, children born in clusters with no SBA coverage were 1.6 and 2.8 times more likely to die during the first month of life, respectively, compared with children born in clusters with full SBA coverage[12], in the adjusted models. However, this community-level indicator was not significantly associated with neonatal mortality in any other surveys.

As expected, the association between place of delivery and neonatal mortality closely matches the association between skilled birth attendance and neonatal mortality. Only in one survey—Malawi's baseline—do we find facility delivery to be associated with neonatal survival in the expected direction; according to this survey, children not born in a health facility were 1.4 times more likely to die during the first month of life compared with children born in a facility, in the adjusted model.

In the four sub-Saharan African study countries, we were able to assess the benefit to the child of protection against malaria during pregnancy. Household ownership of a mosquito bednet was significantly associated with neonatal mortality in the endline survey, but not the baseline survey (when coverage for ITNs and IPTp was very low) in three of the four countries—Malawi, Rwanda, and Mainland Tanzania. In the endline Madagascar survey, the direction of association was consistent but the effect was non-significant. According to the endline Malawi survey, children born into a household without a mosquito bednet were 1.8 times more likely to die during the neonatal period compared with children born into a household with a mosquito bednet; according to the endline Rwanda and Tanzania surveys, children born into a household without a mosquito bednet were more than three times more likely to die during the neonatal period, after adjusting for socio-demographic factors.

In Madagascar, Malawi, and mainland Tanzania—where we were able to identify the number of doses of SP given to the mother during her most recent pregnancy—we did not find evidence that women's exposure to IPTp was associated with lower risk of neonatal mortality. The direction of association was generally in the expected direction but was not statistically significant.

3.2.2. Final adjusted multivariate model

Table 6, our final multivariate model, includes indicators of maternal and delivery care (the mother's use of antenatal care, receipt of tetanus toxoid vaccinations, iron and folic acid supplementation, delivery by a skilled birth attendant, household ownership of a mosquito bednet, and the mother's use of two or more doses of SP during pregnancy) and controls for the same set of socio-demographic characteristics included in Table 5. Due to its high correlation with skilled birth attendance, place of delivery is excluded from this model.

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[12] The proportion of women in the cluster who delivered with SBA assistance was included in the regression model as a continuous variable. Since the variable ranges between 0 and 1 (i.e. 0 percent to 100 percent coverage), the estimate of relative risk can be interpreted as a theoretical comparison of the risk of neonatal mortality among children born in clusters with 0 percent coverage to the risk among children born in clusters with 100 percent coverage, even though few clusters had these extreme levels of coverage.

Recommended maternal and delivery care:

After adjusting for the mother's use of other components of care and socio-demographic characteristics, the number of antenatal care visits that a mother had made remained significantly associated with neonatal survival in four of the 12 surveys. According to the baseline survey in three of the six focus countries, and according to the endline survey in Malawi, children whose mothers had made fewer than four ANC visits were between 1.7 and 2.9 times more likely to die in the first month of life compared with children whose mothers had made at least four visits; these effects can be interpreted as the benefit of ANC visits above and beyond the benefit of tetanus vaccinations, iron and folic acid supplementation, and provision of SP during those visits.

In Bangladesh and India, the number of tetanus injections the mother received during pregnancy remained independently associated with the child's risk of dying in the first month of life. According to the endline surveys in Bangladesh and India, children whose mothers received no injections during the pregnancy were 1.8 and 1.5 times more likely to die during the neonatal period, respectively, compared with children whose mothers received two injections, independent of the mother's use of other components of maternal and delivery care and after controlling for socio-demographic characteristics. Not having received the recommended two tetanus injections during the pregnancy also remained significantly associated with neonatal mortality in the baseline Malawi survey. In this final model, we found no evidence that receipt of at least 90 days of iron and folic acid supplementation during pregnancy was associated with the risk of neonatal mortality, independent of the benefits of other components of maternal and delivery care.

Similar to the results in Table 5, the final model in Table 6 showed no evidence that delivery by a skilled birth attendant was protective against neonatal mortality. According to the endline Bangladesh and India surveys, children whose birth was *not* attended by a skilled birth attendant were 52 percent and 22 percent less likely to die in the first month of life, respectively, compared with children whose birth was attended by an SBA. However, in the endline India survey there was a significant community-level effect of SBA use; after adjusting for individual-level SBA use, children born in communities with no coverage of SBA were 1.6 times more likely to die during the first month of life compared with children born in clusters with full SBA coverage. This community-level indicator was not significantly associated with neonatal mortality in any other survey.

Household ownership of a mosquito bednet remained significantly associated with neonatal mortality in the endline surveys in Malawi, Rwanda, and mainland Tanzania, even after adjusting for the mother's use of ANC and other components of care, as well as socio-demographic controls. According to the endline Malawi survey, children born into a household without a mosquito bednet were 1.8 times more likely to die during the neonatal period than children born into a household with a mosquito bednet; according to the endline Rwanda and Tanzania surveys, children born into a household without a mosquito bednet were more than three times more likely to die during the neonatal period. Additional models were run to see whether the effect of mosquito bednet ownership on neonatal mortality depended on the malaria risk zone; the interaction was not statistically significant in any of the three countries for which malaria risk zone was available (data not shown).

As in Table 5, in our final model (Table 6) we did not find evidence that women's use of two doses of SP during pregnancy was associated with lower risk of neonatal mortality, in Madagascar, Malawi, or mainland Tanzania.

Socio-demographic characteristics:

Several socio-demographic characteristics of the mother, child, and household were significantly associated with neonatal mortality in the final model. Children whose mothers were at least age 35 at the time of the birth had between 1.6 and 6.0 times the adjusted risk of dying in the neonatal period compared with children whose mothers were age 18-34, the lowest risk age range, according to at least one survey in Bangladesh, India, Malawi, and mainland Tanzania. The excess risk associated with the mother's young age at the child's birth was statistically significant only in one of 12 surveys, the baseline India survey, where children born to mothers under age 18 were 1.3 times more likely to die during the first month of life compared with children born to mothers age 18-34. In mainland Tanzania, children born to unmarried mothers were twice as likely to die during the neonatal period. Maternal education was associated with neonatal mortality in Bangladesh and India only; in the endline surveys in both countries, children whose mothers had primary education only were twice as likely to die in the first month of life compared with children whose mothers had secondary education or higher, and in India children whose mothers had no education were also twice as likely to die during the neonatal period. According to the endline surveys in India, Madagascar, and Malawi, children whose mothers had lost another child under age 5 were 1.6 to 2.6 times more likely to die during the first month than mothers who had not lost another child under age 5.

The length of the preceding birth interval was a significant predictor of neonatal mortality in four of the six countries, such that children born after a short interval had 1.5 to 3.9 times the adjusted risk of neonatal death compared with children born after a two-year interval. In four of the six countries, the child's birth order was also a significant determinant of neonatal mortality; according to the endline mainland Tanzania survey, third-order births had a 65 percent lower risk of neonatal death than first and second-order births. Boys had between 1.5 and 2.0 times the adjusted risk of dying in the neonatal period than girls, in one survey in Malawi, Rwanda, and mainland Tanzania. In all surveys, a multiple birth carried substantial excess risk.

We found little evidence that the child's place of residence or household wealth were associated with neonatal survival in the final models. Contrary to expectation, according to the baseline Madagascar survey and the endline Tanzania survey, children born in rural households in the lowest comparative wealth tercile were 63 percent and 53 percent less likely to die during the first month of life, respectively, compared with children born in urban households in the upper two comparative wealth terciles. These findings raise questions about potential differential underreporting of neonatal deaths, with more underreporting in poor and rural households in these surveys. In Madagascar, Malawi, and mainland Tanzania we found no evidence that the community-level risk of malaria was associated with the probability of neonatal death after adjusting for other socio-demographic characteristics and the mother's use of maternal and delivery services.

Table 6. Adjusted relative risk of dying during the neonatal period, among women's most recent children born in the five years preceding the surveys, USAID MCH priority countries with significant reductions in NMR

	Bangladesh						India						Madagascar					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
CHARACTERISTICS OF THE HOUSEHOLD																		
Place of residence and comparative wealth index[1]																		
Urban upper two-thirds CWI	1.00			1.00			1.00		.	1.00			1.00			1.00		
Urban bottom-third CWI	1.12	0.52	2.41	1.23	0.56	2.69	0.64	0.31	1.36 ns	0.97	0.66	1.42	0.58	0.17	2.02	1.19	0.41	3.44
Rural bottom-third CWI	1.25	0.58	2.73	1.13	0.57	2.23	1.04	0.79	1.38 ns	1.12	0.83	1.50	0.37	0.17	0.82*	1.31	0.64	2.69
Rural upper two-thirds CWI	1.06	0.44	2.58	0.83	0.38	1.78	1.13	0.88	1.47 ns	1.15	0.85	1.55	0.63	0.21	1.91	0.97	0.35	2.66
Malaria risk[2]																		
None or low (<5% risk)	n/a			n/a			n/a			n/a								
Intermediate (5%-40% risk)													1.00			1.00		
High (>40% risk)													0.98	0.59	1.64	1.31	0.81	2.11
CHARACTERISTICS OF THE MOTHER																		
Mother's age at child's birth																		
<18 years	1.13	0.65	1.95	0.76	0.39	1.49	1.33	1.02	1.73*	0.85	0.59	1.21	1.09	0.49	2.40	0.67	0.30	1.48
18-34 years	1.00			1.00			1.00			1.00			1.00			1.00		
35+ years	0.89	0.39	2.05	2.52	1.10	5.76*	1.60	1.14	2.25**	1.35	0.97	1.89	1.15	0.59	2.23	1.82	0.86	3.87
Mother's marital status																		
Currently in union	n/a			n/a			n/a			n/a			1.00			1.00		
Not currently in union													1.66	0.94	2.93	0.93	0.57	1.53
Mother's educational attainment																		
None	1.09	0.65	1.83	1.40	0.73	2.70	1.19	0.91	1.54 ns	1.92	1.47	2.51***	1.52	0.72	3.17	0.63	0.26	1.54
Primary	0.84	0.47	1.50	1.87	1.15	3.06*	1.03	0.77	1.39 ns	2.10	1.58	2.79***	1.35	0.66	2.79	1.16	0.57	2.34
Secondary or higher	1.00			1.00			1.00			1.00			1.00			1.00		
Previous child to mother died under age five years																		
No	1.00			1.00			1.00			1.00			1.00			1.00		
Yes	1.58	0.94	2.66	1.64	0.87	3.07	1.92	1.53	2.42***	1.80	1.41	2.30***	1.46	0.82	2.61	2.57	1.54	4.27***

(Continued...)

Table 6. – *Continued*

	Bangladesh						India						Madagascar					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
CHARACTERISTICS OF THE CHILD																		
Sex of child																		
Female	1.00			1.00			1.00			1.00			1.00			1.00		
Male	1.26	0.90	1.77	1.42	0.94	2.14	0.99	0.83	1.17 ns	1.10	0.93	1.32	1.40	0.93	2.12	1.45	0.90	2.35
Preceding birth interval																		
2 years	1.00			1.00			1.00			1.00			1.00			1.00		
<2 years	2.37	1.22	4.60*	3.20	1.29	7.92*	1.18	0.92	1.52 ns	1.53	1.18	1.98**	1.65	0.89	3.07	1.34	0.73	2.46
3+ years	0.70	0.35	1.39	1.87	0.82	4.29	0.76	0.60	0.96*	0.75	0.57	0.99*	0.88	0.46	1.69	1.13	0.65	1.96
First birth	3.65	1.86	7.15***	2.00	0.83	4.81	1.34	1.03	1.75*	1.75	1.28	2.40***	3.12	1.08	8.98*	1.93	0.80	4.64
Birth order																		
First and second	1.00			1.00			1.00			1.00			1.00			1.00		
Third	0.82	0.36	1.86	0.76	0.42	1.37	0.72	0.54	0.95*	0.57	0.41	0.78***	2.56	1.02	6.39*	0.69	0.27	1.78
Fourth or higher	0.96	0.46	2.00	0.34	0.14	0.86*	0.64	0.48	0.86**	0.70	0.51	0.96*	1.85	0.78	4.40	0.50	0.20	1.28
Multiple birth																		
Single	1.00			1.00			1.00			1.00			1.00			1.00		
Multiple	8.31	3.61	19.13***	5.15	1.71	15.49**	5.57	3.40	9.10***	4.12	2.45	6.92***	5.01	1.95	12.88***	6.30	2.33	17.05***
RECOMMENDED MATERNAL AND DELIVERY CARE																		
Mother attended 4 or more ANC visits																		
Yes	1.00			1.00			1.00			1.00			1.00		.	1.00		
No	2.87	1.19	6.89*	1.02	0.60	1.73	1.28	0.97	1.68	1.10	0.86	1.42	2.09	1.19	3.70*	1.00	0.64	1.58
Number of tetanus injections during pregnancy																		
2+	1.00			1.00			1.00			1.00			1.00			1.00		
1	2.09	1.29	3.39**	1.18	0.68	2.03	1.59	1.19	2.13**	1.07	0.76	1.50	1.39	0.63	3.04	0.60	0.29	1.25
0	1.88	1.18	2.98**	1.77	1.11	2.81*	1.69	1.36	2.10***	1.51	1.22	1.88***	1.15	0.65	2.02	1.34	0.79	2.27
Mother had 90+ days of iron and folic acid supplementation[3]																		
Yes	n/a			n/a			1.00			1.00			n/a			1.00		
No							1.13	0.91	1.41	0.97	0.75	1.25				1.54	0.61	3.88

(Continued...)

Table 6. – *Continued*

	Bangladesh						India						Madagascar					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
Delivered by a skilled birth attendant																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	0.57	0.30	1.08	0.48	0.27	0.82**	0.91	0.72	1.16	0.78	0.61	0.99*	1.24	0.61	2.50	0.71	0.33	1.54
Community coverage of SBA	0.66	0.13	3.40	1.40	0.44	4.42	1.01	0.68	1.52	1.61	1.06	2.46*	1.58	0.42	6.03	0.82	0.25	2.69
Household owns a mosquito bednet																		
Yes																1.00		
No																1.47	0.89	2.42
Mother received two doses of SP during pregnancy																		
Yes	n/a			n/a			n/a			n/a			n/a			1.00		
No																0.81	0.39	1.70

(Continued...)

Table 6. – *Continued*

	Malawi						Rwanda						Mainland Tanzania					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
CHARACTERISTICS OF THE HOUSEHOLD																		
Place of residence and comparative wealth index[1]																		
Urban upper two-thirds CWI	1.00			1.00			1.00			1.00			1.00			1.00		
Urban bottom-third CWI	2.07	0.64	6.65	0.76	0.27	2.17	0.52	0.12	2.36	3.25	0.98	10.86	1.42	0.31	6.49	0.75	0.27	2.09
Rural bottom-third CWI	2.04	0.68	6.13	0.83	0.42	1.61	1.46	0.52	4.11	1.49	0.53	4.24	0.74	0.21	2.57	0.47	0.22	0.99*
Rural upper two-thirds CWI	4.61	1.19	17.84*	0.73	0.30	1.74	2.83	0.37	21.59	1.18	0.36	3.87	0.83	0.12	5.70	0.68	0.29	1.61
Malaria risk[2]																		
None or low (<5% risk)							n/a			n/a			1.00			1.00		
Intermediate (5%-40% risk)	1.00			1.00									0.81	0.40	1.65	1.05	0.57	1.94
High (>40% risk)	1.30	0.94	1.80	0.83	0.59	1.17							1.33	0.41	4.30	2.12	0.89	5.04
CHARACTERISTICS OF THE MOTHER																		
Mother's age at child's birth																		
<18 years	1.27	0.76	2.10	0.62	0.31	1.26	1.50	0.53	4.25	1.39	0.17	11.04	1.86	0.70	5.00	0.81	0.28	2.31
18-34 years	1.00			1.00			1.00			1.00			1.00			1.00		
35+ years	1.44	0.87	2.38	2.23	1.44	3.46***	1.36	0.86	2.14	2.04	1.16	3.60	6.11	1.62	23.01**	1.97	0.94	4.12
Mother's marital status																		
Currently in union	1.00			1.00			1.00			1.00			1.00			1.00		
Not currently in union	1.17	0.77	1.78	0.80	0.51	1.26	0.98	0.63	1.52	0.71	0.36	1.41	1.56	0.61	3.97	1.95	1.08	3.54*
Mother's educational attainment																		
None	0.91	0.37	2.26	0.83	0.41	1.67	2.22	0.73	6.72	0.91	0.30	2.76	0.57	0.09	3.66	0.79	0.25	2.51
Primary	1.24	0.56	2.77	1.16	0.64	2.08	1.50	0.53	4.23	1.04	0.39	2.74	0.75	0.14	3.93	1.27	0.49	3.30
Secondary or higher	1.00			1.00			1.00			1.00			1.00			1.00		
Previous child to mother died under age five years																		
No	1.00		.	1.00			1.00			1.00			1.00			1.00		
Yes	1.89	1.22	2.93**	1.66	1.16	2.39**	1.09	0.74	1.62	1.48	0.92	2.37	2.51	0.91	6.92	0.93	0.47	1.87

(Continued...)

Table 6. – *Continued*

	Malawi						Rwanda						Mainland Tanzania					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
CHARACTERISTICS OF THE CHILD																		
Sex of child																		
Female	1.00			1.00			1.00			1.00			1.00			1.00		
Male	1.62	1.19	2.22**	1.59	1.16	2.20**	1.81	1.25	2.63**	1.41	0.88	2.27	1.67	0.74	3.79	1.85	1.11	3.07*
Preceding birth interval																		
2 years	1.00			1.00			1.00			1.00			1.00			1.00		
<2 years	1.62	0.97	2.71	2.84	1.62	4.98***	1.62	0.96	2.74	3.91	2.02	7.57***	0.43	0.10	1.83	1.61	0.61	4.24
3+ years	0.97	0.61	1.54	2.21	1.36	3.57**	0.97	0.63	1.50	1.32	0.68	2.57	1.11	0.36	3.44	1.33	0.68	2.61
First birth	2.70	1.47	4.95**	4.77	2.47	9.20***	1.18	0.63	2.23	2.31	0.92	5.80	1.31	0.33	5.14	1.10	0.51	2.37
Birth order																		
First and second	1.00			1.00			1.00			1.00			1.00			1.00		
Third	1.19	0.65	2.18	0.97	0.50	1.88	0.58	0.28	1.17	0.90	0.37	2.17	0.98	0.21	4.64	0.35	0.13	0.94*
Fourth or higher	0.87	0.48	1.55	0.82	0.49	1.36	0.63	0.37	1.07	1.04	0.44	2.46	0.11	0.02	0.63*	0.49	0.20	1.17
Multiple birth																		
Single	n/a			n/a			1.00			1.00			n/a			n/a		
Multiple							10.55	6.02	18.50***	3.77	1.32	10.80*						
RECOMMENDED MATERNAL AND DELIVERY CARE																		
Mother attended 4 or more ANC visits																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	1.22	0.90	1.65	1.74	1.23	2.45**	1.36	0.68	2.73	1.38	0.85	2.24	2.36	1.11	5.03*	1.33	0.84	2.10
Number of tetanus injections during pregnancy																		
2+	1.00			1.00			1.00			1.00			1.00			1.00		
1	1.34	0.89	2.03	1.23	0.83	1.81	1.24	0.81	1.89	0.81	0.43	1.52	0.98	0.31	3.03	1.01	0.52	1.96
0	2.98	2.16	4.12***	1.28	0.82	2.01	1.44	0.92	2.26	1.18	0.61	2.28	1.09	0.52	2.28	1.47	0.77	2.79
Mother had 90+ days of iron and folic acid supplementation[3]																		
Yes	1.00			1.00			n/a			n/a			n/a			1.00		
No	1.07	0.60	1.91	1.23	0.86	1.77										0.83	0.24	2.85

(Continued...)

Table 6. – *Continued*

	Malawi						Rwanda						Mainland Tanzania					
	Baseline			Endline			Baseline			Endline			Baseline			Endline		
	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB	aRR	LB	UB
Delivered by a skilled birth attendant																		
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	1.11	0.77	1.59	0.72	0.45	1.16	0.85	0.53	1.36	0.70	0.40	1.25	0.73	0.32	1.68	0.93	0.42	2.08
Community coverage of SBA	0.77	0.35	1.70	1.50	0.43	5.24	0.77	0.31	1.89	1.71	0.48	6.11	1.05	0.24	4.61	0.60	0.17	2.12
Household owns a mosquito bednet																		
Yes	1.00			1.00			1.00			1.00		.	1.00			1.00		
No	0.73	0.47	1.12	1.76	1.22	2.54**	3.45	0.82	14.53	3.35	1.95	5.76***	1.00	0.36	2.74	3.36	1.90	5.95***
Mother received two doses of SP during pregnancy																		
Yes	1.00			1.00			n/a			n/a			n/a			1.00		
No	1.19	0.80	1.77	1.19	0.87	1.62										1.58	0.83	3.00

Note: * indicates p<.05; ** indicates p<.01;*** indicates p<.001. The table presents adjusted relative risk (aRR) estimates, which compare the probability of dying in one group relative to the probability of dying in the reference group, after adjusting for after adjusting for all other variables in the model. Note that for India, the regression model also adjusted for the mother's caste. Baseline surveys were conducted in 1999/2000 in Bangladesh, 1998/9 in India, 1997 in Madagascar, 2000 in Malawi, 2000 in Rwanda, and 1999 in mainland Tanzania. Endline surveys were conducted in 2011 in Bangladesh, 2005/6 in India, 2008/9 in Madagascar, 2010 in Malawi, 2010 in Rwanda, and 2010 in mainland Tanzania.

[1] The DHS-constructed comparative wealth index uses a fixed baseline (the 2002 Vietnam DHS) enabling measurement of improvements in wealth over time and comparison of absolute wealth across country. This four-level indicator measures the effect of being in the bottom comparative wealth third separately in urban and rural households. Urban upper-two thirds is used as the reference.

[2] This indicator has three levels: no/low, intermediate, and high risk. In low risk areas, the annual averaged plasmodium falciparum infection prevalence in 2-10 year olds is likely to be lower than 5%. In intermediate risk areas, plasmodium falciparum transmission is likely to be between 5%-40%. In high risk areas, transmission is likely to exceed 40%. Note that in Malawi, the population falls in just intermediate and high risk areas. In Madagascar, due to the small number of cases in the no/low risk category in the 2008 survey, no/low risk was collapsed with intermediate risk.

[3] While this indicator was calculated for Rwanda, due to the low prevalence of coverage of iron supplementation, the relative risk could not be calculated.

3.3. Multivariate Decomposition Results

Table 7 identifies factors associated with the reduction in the NMR between the baseline and endline surveys in the six focus countries. To address how these factors have contributed, the change in neonatal mortality across surveys was divided into two parts, one representing changes in the distribution of socio-demographic characteristics and coverage of interventions ("endowments," already described in Table 4), and the other representing the strength of effect of those characteristics or interventions ("coefficients," summarized in Table 6). Within the population of most recent children born in the five years preceding each survey for which complete information on key indicators was available, the decline in the NMR was 8 points between the 1999/2000 and 2011 surveys in Bangladesh, 3 points between the 1998/9 and 2005/6 surveys in India, 12 points between the 1997 and 2008/9 surveys in Madagascar, 5 points between the 2000 and 2010 Malawi surveys, 16 points between the 2000 and 2010 Rwanda surveys, and 14 points between the 1999 and 2010 Tanzania surveys[13]. These declines will be partitioned into a component due to "endowments" or coverage and a component due to "coefficients" or effects. The two components add up to the total decline. As will be seen, the two components may reinforce each other, with both having the same sign, or they may counteract each other, and have opposite signs.

Each decomposition tested whether the available maternal and delivery care interventions—use of four or more ANC visits, provision of at least 90 days of iron and folic acid supplementation during pregnancy, the number of tetanus injections during pregnancy, presence of a skilled birth attendant at delivery, community coverage of skilled attendance at delivery, and where available, household ownership of a mosquito bednet and mother's use of IPTp—are associated with the observed declines in neonatal mortality. Each decomposition model included the same set of socio-demographic characteristics (place of residence and comparative household wealth, mother's age at the child's birth, mother's marital status, mother's education, loss of a previous child under age 5, child's sex, preceding birth interval, birth order, multiple birth[14]) that were included in the final multivariate log probability models presented in Table 6. Models also adjusted for the community's level of malaria risk in the three countries where these data were available, and for the mother's caste, in India.

3.3.1. Overview of decomposition results

In three of the six countries (India, Malawi, and Rwanda), the total change in "endowments" (i.e., coverage) in the covariates explained a significant portion of the observed reduction in NMR, while the change in "coefficients" (i.e. effects) of these covariates was not significant (see Table 7). In India, the change in endowments explained 75 percent of the total observed change, and in Malawi and Rwanda the change in endowments explained more than 100 percent of the change (207 percent and 228 percent, respectively), because the effect of the change in "coefficients" was in the opposite direction and served to reduce or dampen the effect of changes in "endowments".

While in mainland Tanzania the "endowments" portion of the decomposition did not reach statistical significance[15], mainland Tanzania followed the same pattern as India, Malawi, and Rwanda. The change in distribution of variables accounted for the majority (70 percent) of the improvement in NMR, while the change in effect of covariates accounted for 30 percent of the total change. Despite the non-significance of the endowments portion as a whole for mainland Tanzania, the endowment of several individual variables

[13] Reductions in NMR may not exactly match those presented in Table 3, as the decomposition is restricted to children with complete data on all variables included in the model.

[14] Due to the small number of multiple births, the variable was not included in the decompositions for two countries.

[15] The p-value for the "endowments" portion is 0.07, likely due to the small sample size of the Tanzania 1999 survey.

in the model—the mother's marital status, the child's birth order, sex of the child, and household ownership of a mosquito bednet—were significantly associated with the observed reduction in neonatal mortality.

The results for Bangladesh and Madagascar followed a different pattern. Unlike in the other four countries, the endowments portion explained very little of the observed reductions in NMR and is non-significant in both countries, while the change in coefficients explained over 100 percent of the observed reduction in Bangladesh (the change in endowments worked in the opposite direction) and nearly 80 percent of the observed reduction in Madagascar. While the total change in coefficients was significantly associated with the observed reductions in NMR, no individual covariate's coefficient portion was statistically significant in either country, making the results for these two countries difficult to interpret. In sum, in Bangladesh and Madagascar we found no evidence that either the scale-up of measurable maternal and delivery interventions or the change in distribution of socio-demographic characteristics contributed to the observed reductions in NMR.

3.3.2. Detailed decomposition results

Given that the decomposition did not identify any covariates—in any of the six focal countries—for which the change between surveys was significantly associated with the observed reduction in NMR, we will not discuss the results from the "coefficient" portion of the decomposition. Instead, we focus on the "endowments" portion and examine the extent to which the scale-up of key maternal and delivery interventions is associated with the observed reductions in NMR in the six countries with significant reductions.

Antenatal care and its components:

In four of the six study countries (Bangladesh, India, Madagascar, and Rwanda), there was an increase between the two surveys in coverage of women's use of four or more ANC visits during pregnancy, while in two countries (Malawi and mainland Tanzania) there was a decline in coverage. In Malawi, the reduction in coverage of women's having at least four ANC visits from 57 to 46 percent between baseline and endline surveys was associated with a 1.3 point increase in neonatal mortality. In mainland Tanzania the reduction in coverage from 71 to 43 percent between surveys was associated with a non-significant increase of 1.8 points in NMR. In India and Rwanda, the increase in coverage of women's use of four or more ANC visits corresponded with non-significant reductions in NMR.

In India, the increase in coverage of tetanus vaccination between baseline and endline was associated with a significant reduction in neonatal mortality of 0.8 deaths per 1,000 live births. While the change in coverage of tetanus vaccination during pregnancy was not significantly associated with changes in NMR in any other country, it is worth noting that in all countries the direction of the contribution was as expected, given the change of coverage. In Bangladesh and mainland Tanzania—where we observed reductions in coverage of women's use of at least two tetanus injections during pregnancy—the compositional changes were associated with non-significant increases in NMR, while in the remaining four countries—which all experienced increases in coverage of two or more tetanus injections—the compositional changes were associated with non-significant reductions in NMR. But the principal finding for tetanus vaccination is that, apart from India, the relationship between change in coverage and change in neonatal mortality is not statistically significant.

Table 7. Multivariate decomposition of socio-demographic and maternal and delivery care related differences in the NMR between baseline and endline surveys, showing contributions to the NMR gap attributed to differences in endowments and to differences in coefficients, USAID MCH priority countries with significant reductions in NMR

	Bangladesh	India	Madagascar	Malawi	Rwanda	Mainland Tanzania
	Coef.	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**
DUE TO DIFFERENCE IN CHARACTERISTICS (E)						
Household-level						
Place of residence and comparative wealth index[1]	-0.33	-0.24	-0.12	0.07	-1.49	0.58
Malaria risk[2]			0.02	0.03		0.23
Caste		0.15				
Mother-level						
Mother's age at child's birth	-0.18	0.19	0.35	-0.23*	-1.17*	0.57
Mother's marital status			0.04	-0.08	0.39	0.27*
Mother's educational attainment	-1.28	-1.30***	-0.01	0.83	0.51	0.03
Previous child to mother died under age five years	-0.77	-0.26***	-2.30**	-1.25**	-1.23	0.16
Child-level						
Preceding birth interval	0.22	0.16**	0.06	-0.20	0.05	0.22
Birth order	1.64*	0.18***	0.24	-0.06	-0.07	-0.57*
Sex of child	0.00	0.03	0.02	0.03**	0.10	0.00*
Multiple birth	-0.02*	0.08***	0.01***		-0.02*	
Recommended maternal and delivery care						
Mother attended 4 or more ANC visits	-0.04	-0.17	-0.03	1.32**	-2.19	1.83
Number of tetanus injections during pregnancy	1.05	-0.79**	-0.79	-0.39	-0.97	0.98
Mother had 90+ days of iron and folic acid supplementation		-0.13		-1.09		
Mother received two doses of SP during pregnancy				-0.92		
Delivered by a skilled birth attendant	1.86	0.43*	-0.02	1.53	4.23	0.12
Community coverage of SBA	-0.85	-0.67*	-0.05	-1.72	-5.97	0.59
Household owns a mosquito net				-8.61**	-28.44*	-15.10**
Total	1.31	-2.35*	-2.57	-10.74**	-36.27*	-10.07
Percent	-16.04	75.04	20.86	206.76	228.10	70.39

(Continued...)

Table 7. – *Continued*

	Bangladesh	India	Madagascar	Malawi	Rwanda	Mainland Tanzania
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
DUE TO DIFFERENCE IN COEFFICIENTS (C)						
Household-level						
Place of residence and comparative wealth index[1]	-2.91	0.41	32.59	-24.49	5.72	19.33
Malaria risk[2]		0.70		-27.85		9.54
Caste			-1.61			
Mother-level						
Mother's age at child's birth	0.33	-0.53	0.65	0.79	5.22	12.43
Mother's marital status			-19.80	-11.66	-15.48	-13.04
Mother's educational attainment	3.36	-1.14	15.60	0.50	16.62	-5.35
Previous child to mother died under age five years	-0.69	0.54	-10.44	2.03	-7.08	-31.03
Child-level						
Preceding birth interval	9.25	1.17	-1.50	13.62	15.83	-5.57
Birth order	-9.27	-0.19	-22.42	-1.66	14.72	-24.25
Sex of child	1.98	0.62	0.35	-0.18	-5.52	-2.21
Multiple birth	-0.13	-0.01	0.03		-0.67	
Recommended maternal and delivery care						
Mother attended 4 or more ANC visits	-29.05	-1.08	-12.05	3.83	0.73	7.46
Number of tetanus injections during pregnancy	-3.20	-0.61	-0.51	-4.77	-9.86	-3.52
Mother had 90+ days of iron and folic acid supplementation		-1.01		3.76		
Mother received two doses of SP during pregnancy				-0.18		
Delivered by a skilled birth attendant	-4.92	-2.86	-23.92	-16.50	-9.63	-16.21
Community coverage of SBA	19.66	2.81	-10.78	8.44	24.79	12.18
Household owns a mosquito bednet				42.93	-2.27	-97.39
Constant	6.07	0.39	44.05	16.94	-12.76	133.39
Total	-9.50**	-0.78	-9.76*	5.54	20.37	-4.24
Percent	116.04	24.96	79.14	-106.76	-128.10	29.61

(Continued...)

Table 7. – *Continued*

	Bangladesh	India	Madagascar	Malawi	Rwanda	Mainland Tanzania
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
NMR difference (per 1,000)	**-8.18****	**-3.13***	**-12.34****	**-5.19***	**-15.90*****	**-14.31***

[1] The DHS-constructed comparative wealth index uses a fixed baseline (the 2002 Vietnam DHS) enabling measurement of improvements in wealth over time and comparison of absolute wealth across country. This four-level indicator measures the effect of being in the bottom comparative wealth third separately in urban and rural households. Urban upper-two thirds is used as the reference.

[2] This indicator has three levels: no/low, intermediate, and high risk. In low risk areas, the annual averaged plasmodium falciparum infection prevalence in 2-10 year olds is likely to be lower than 5%. In intermediate risk areas, plasmodium falciparum transmission is likely to be between 5%-40%. In high risk areas, transmission is likely to exceed 40%. Note that in Malawi, the population falls in just intermediate and high risk areas. In Madagascar, due to the small number of cases in the no/low risk category in the 2008 survey, no/low risk was collapsed with intermediate risk.

In India and Malawi, we were also able to assess the independent contribution of taking at least 90 days' worth of iron/folate tablets or syrup during pregnancy to reductions in NMR. In India, coverage of iron/folate supplementation during pregnancy declined from 40 to 23 percent between surveys, while in Malawi coverage increased from 11 to 32 percent. In the decomposition, we found no evidence that these changes in coverage corresponded with changes in NMR.

Scale-up of skilled birth attendance:

In five of the six countries, coverage of skilled birth attendance at delivery increased between the two surveys. This increase was most dramatic in Rwanda, where skilled birth attendance during women's most recent birth increased from 26 to 72 percent between the baseline and endline surveys. Given methodological challenges in identifying the protective effect of skilled birth attendance (i.e. in settings where use of an SBA is low, high-risk pregnancies and births with preexisting complications are more likely to seek assistance, and the risk of NMR is higher among these births), we include two measures of skilled attendance in the decomposition model. In addition to an individual-level measure of whether the delivery was assisted by an SBA, we include a community-level measure of the mean level of SBA coverage among births in each cluster. The increase in individual use of an SBA was associated with an *increase* in NMR in five of the six countries (statistically significant in India only). However, after adjusting for individual-level use, the increase in cluster-level coverage of skilled birth attendance was associated with a *reduction* in NMR in the same five countries (again, statistically significant in India only). In India, the increase in coverage of individual SBA-use was associated with an increase in NMR of 0.4 deaths per 1,000 live births, while the increase in community-level coverage was associated with a decline in NMR of 0.7 deaths per 1,000 live births. This finding suggests that what is important to newborn survival is the availability of obstetric care services when needed, rather than routine recourse to institutional deliveries. In other words, this association seen at the community level but not at the individual level can be interpreted as indicating the benefit of having services genuinely available, in case of emergency. Again, however, apart from India, the increase in coverage is not significantly related to declines in neonatal mortality.

Scale-up of interventions to protect women against malaria during pregnancy:

Of all the indicators included in the decomposition models for the three malarious countries with mosquito bednet data available, the dramatic increase in household ownership of a mosquito bednet was responsible for the greatest portion of the observed declines in NMR. On its own, the increase in mosquito bednet coverage was associated with an estimated reduction in the NMR of 9 deaths per 1,000 live births in Malawi, a reduction of 28 deaths per 1,000 live births in Rwanda, and a reduction of 15 deaths per 1,000 live births in mainland Tanzania, after adjusting for socio-demographic characteristics, other indicators of maternal and delivery care, and the household's level of malaria risk. The association was statistically significant in all three countries.

In Malawi, where we were able to measure coverage of IPTp as well, we found no evidence to suggest that the increasing coverage of IPTp (i.e. the mother's being given two doses of SP during pregnancy) contributed to the reduction in the NMR.

Socio-demographic changes:

The changes in composition of several socio-demographic characteristics of the mother and child—including the mother's age at child's birth, marital status, educational attainment, and loss of another child under age 5, the child's sex, birth order, preceding birth interval, and multiple birth—were each associated with changes in neonatal mortality in at least one country. The change in composition of women's age at the child's birth, for example—and specifically, the increasing percentage of mothers in the lowest risk 18-34 age range—was significantly associated with a reduction in NMR of 1.2 points in Rwanda and 0.2 points in Malawi. In India, the increase in children born after a short birth interval from 22 to 25 percent was significantly associated with an increase in NMR of 0.2 points. In India, Madagascar, and Malawi, the reduction between surveys in the percentage of mothers who had lost another child under age 5 was significantly associated with reductions in NMR of between 0.3 and 2.3 points, suggesting that this indicator was able to capture and control for some of the unexplained residual household and maternal risk.

Surprisingly, we found no evidence to suggest that changes in the composition of births by urban-rural residence or increases in wealth during this period contributed to the decline in neonatal mortality. However, in India the increasing levels of maternal education—the proportion of births to women with a secondary education or higher rose from 30 to 39 percent—was associated with a significant reduction of 1.3 deaths per 1,000 live births. There was a similar effect size in Bangladesh, although it did not reach statistical significance.

3.3.3. Summary of decomposition results

Within our limited set of measured maternal and delivery care indicators, we found only weak evidence that the scale-up of maternal and delivery care has contributed to observed reductions in NMR. No single indicator contributed significantly to the reduction in NMR in more than one country, except for mosquito bednet coverage. However, in the majority of countries the direction of association was generally as expected for the contributions of antenatal care, tetanus vaccination, iron and folic acid supplementation, and IPTp. In settings with increased coverage the indicator was associated with a reduction in NMR, and in settings with reductions in coverage the indicator was associated with an increase in NMR, even if not statistically significant. While the correspondence between declines in coverage with increases in NMR points to the importance of these interventions for neonatal survival, it does not explain what factors have driven the observed improvements in NMR.

In the three malarious countries with data on mosquito bednet ownership, the rapid increase in household ownership of mosquito bednets stands out as a driving force behind the observed reductions in neonatal mortality. In all three countries, mosquito bednet ownership was significantly associated with the reduction in the NMR between the 2000 and 2010 surveys, even after adjusting for the effects of key components of maternal and delivery care, the spatial level of malaria risk, and key socio-demographic characteristics.

4. Discussion and Conclusions

Overall, of the 18 USAID MCH priority countries with two available DHS surveys around the years 2000 and 2010, only half showed significant reductions in neonatal mortality among all births in the five years preceding each survey. In the six countries with significant reductions within the study population of the most recent child in the past five years, the study investigated the extent to which scale-up of measured indicators of maternal and delivery care is associated with those reductions. In most settings there was some improvement in the coverage of indicators of maternal and delivery care—e.g. four or more ANC visits made during the pregnancy, the provision of tetanus vaccination and iron/folic acid supplementation during pregnancy, the provision of two doses of SP during pregnancy in SSA countries, delivery by a skilled birth attendant, and household ownership of mosquito bednets. Unexpectedly, there is little evidence that the scale-up of these interventions contributed to reductions in NMR. In Malawi, Rwanda, and mainland Tanzania, the rapid increase in mosquito bednet coverage stands out as a driver of improvements in neonatal mortality, but we did not find strong evidence that other interventions contributed to observed reductions.

There are several possible interpretations of the weak associations found in this report. First, we have *measurement error*. The specific data collected in the DHS as indicators of interventions of interest are only approximations—and may not correspond closely to the actual practice. For example, the fact that a survey respondent reports that there is an insecticide-treated net in the household at the time the surveyors come to visit may or may not be a good proxy for whether the woman consistently slept under a mosquito bednet during her last pregnancy. Likewise, the fact that a woman reports having received iron-folate supplements for at least three months during her last pregnancy may or may not mean she consistently took the tablets. Thus, even for an intervention that genuinely reduces risk of newborn death, the indicator may not show a strong correlation.

A second possible reason for a weak observed association may be that the underlying construct we are trying to measure is, in fact, *not closely associated with survival*. That is, the evidence of an intervention may be superficial. This is possible for the contact measures—skilled birth attendance and receipt of four or more ANC visits. That such a contact has occurred cannot be assumed to mean that specific interventions were actually delivered that would reduce risk of negative outcomes. Indeed there is a well-developed literature (Scott and Ronsmans 2009; Singh et al. 2012) showing the weak relationship between such contact measures and mortality outcomes, pointing to the need to develop, test, and collect valid indicators on the actual content of care received.

A third possible effect that can weaken or even reverse the expected relationships is *selectivity*. More ANC visits and delivery in a facility, for example, may tend to be associated with a difficult pregnancy and early warning signs of a difficult birth. If high-risk births are more likely to receive extra care, and that care is not completely successful in counteracting the higher risk, then the relationship between the outcome and the intervention may be misinterpreted.

A fourth important reason for the weak findings is the *lack of data* on other practices that could impact neonatal mortality, such as immediate newborn care, care of the cord, resuscitation, or kangaroo mother care for low birth weight babies. A technical working group convened by the Saving Newborn Lives program at Save the Children in 2008 brought together evaluation and measurement experts, researchers, and other stakeholders to reach consensus on the indicators needed to measure progress toward promoting newborn survival (Moran et al. 2013). The working group agreed on three additional indicators for care of the newborn after birth—drying, delayed bathing, and cutting the cord with a clean instrument—and agreed on the need for further testing of two additional indicators (immediate skin-to-skin care and applications to the umbilical cord) (Moran et al. 2013). Once indicators such as these become widely available in population-based survey data, more detailed analyses will become possible.

Finally, potentially effective interventions may have little impact if there are other, *counteracting factors* at play in a given population that attenuate the risk that that intervention addresses. For example, tetanus toxoid given in pregnancy can have a significant impact in settings where non-sterile blades are used for cutting the cord and cow dung is put on the cord-stump. In settings where sterile blades and other hygienic practices are already in use, the mortality effect of increasing TT coverage may be modest.

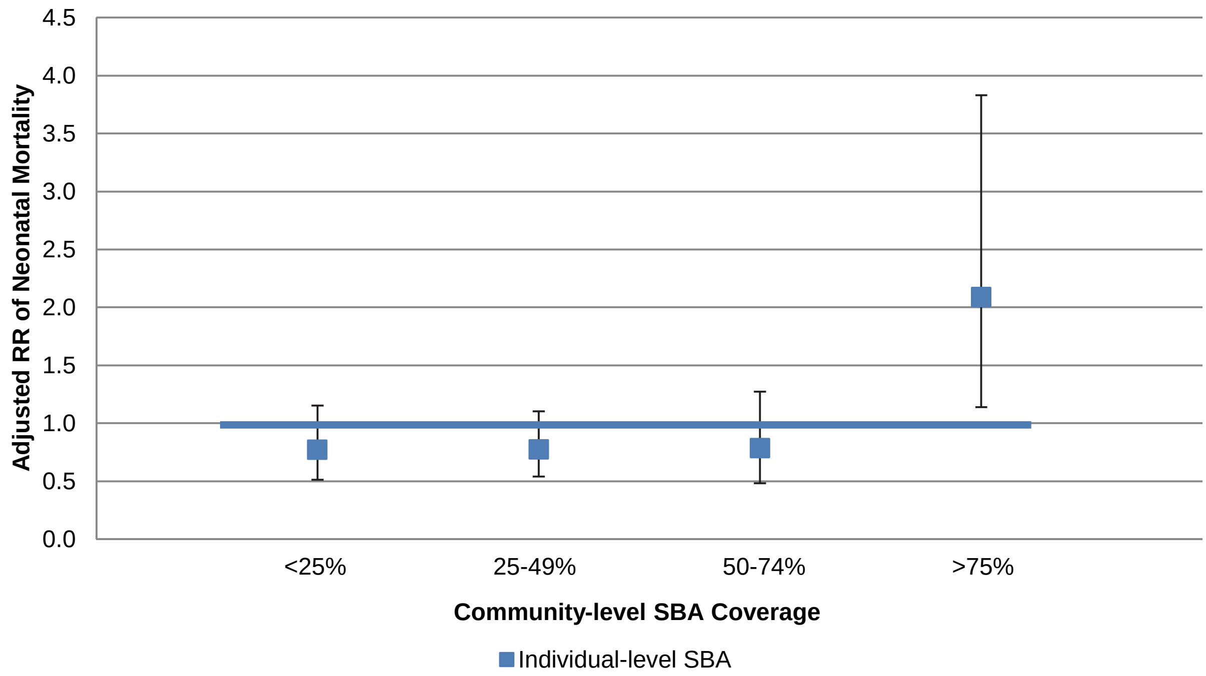
More detailed examples of how such factors may attenuate or even reverse the relationships between interventions and outcomes are given below:

Weak evidence that scale-up of skilled birth attendance contributed to reductions in neonatal mortality

A scale-up of coverage of skilled clinical care in facilities (including skilled maternal and immediate newborn care, emergency obstetric care, and emergency neonatal care) has been hypothesized to have the potential to avert 21 to 44 percent of global neonatal deaths (Darmstadt et al. 2008). Over the past 15 years, international maternal and newborn health efforts have focused above all on increasing the coverage of institutional deliveries, with notable increases in five of the study's six focus countries between 2000 and 2010. However, our analysis found only limited evidence that the scale-up of SBA coverage has in fact contributed to reductions in neonatal mortality. What conclusions can be drawn from these findings?

At the individual level, our null and inverse findings for the association between use of an SBA and neonatal mortality (in both the regression and decomposition analysis) are not surprising, as the results are likely to be driven in part by selection biases. In settings where use of SBAs is not the norm, women who seek out skilled birth assistance are more likely to have higher-risk pregnancies and birth complications, and the odds of survival are likely to be lower among these newborns. Lohela and colleagues (2012) report evidence of this pattern as part of a larger study examining distance to a health facility and early neonatal mortality in Zambia and Malawi. They report that in DHS clusters with a low frequency of facility delivery (<15 percent coverage), children born in a facility have greater odds of early neonatal death compared with children born at home (OR 1.33 in Malawi, OR 2.44 in Zambia), while in DHS clusters with a high frequency of facility delivery (>70 percent coverage), the odds of early neonatal deaths are lower among children born at a facility compared with children born at home (OR 0.58 in Malawi, OR 0.30 in Zambia) (Lohela et al. 2012). We see similar evidence of this confounding in India when we examine the effect of skilled birth attendance across levels of community-level SBA coverage (see Figure 12). In communities in India where delivery with an SBA is the norm (>75 percent coverage), use of an SBA is in fact associated with lower risk of neonatal mortality, whereas in areas where use of an SBA is not common practice, there is no association. While there are various possible interpretations for these associations, one such interpretation is that the pattern points to selection biases in care-seeking behavior.

Figure 12. Adjusted effect of individual SBA use, across levels of community-SBA coverage, India 2005/6 DHS



More surprising, perhaps, are the weak results for the community-level indicator of women's access to skilled birth attendance. This community-level measure should not be subject to the selection biases mentioned earlier. In the decomposition analysis for India, we did find that the increase in community-level coverage of SBA is associated with a reduction in NMR, suggesting the importance of community-level access to emergency care in case of complications, rather than routine and universal use of those services. However, we found no evidence that the increase in community SBA coverage contributed to the observed reductions in NMR in the five other countries.

In fact, these findings fit into a growing body of evidence that the scale-up of institutional deliveries has not resulted in improved newborn (Lohela et al. 2012; Singh et al. 2012) or maternal survival outcomes (Scott and Ronsmans 2009). Ecological analyses find little correlation between facility delivery coverage and neonatal survival. For example, unpublished secondary analysis of data from the 2008 Nigeria DHS finds no difference in the rate of neonatal death between states in Nigeria with very high coverage of facility delivery, compared to the rate in states with very low coverage (data not shown). Furthermore, at the national level, among 18 high-burden countries for maternal and newborn mortality for which SBA and NMR results are available from at least two DHS surveys on STATcompiler, we find that the larger the increase in SBA coverage, the smaller the reduction in NMR (Pearson's r = -.33, see Appendix Figure A3).

Together, these findings suggests that "skilled birth attendance" (or similarly, facility delivery) alone may not be protective against neonatal death. As mentioned, these indicators measure contact only; we do not know the content of care provided by the SBA, the level of training of the SBA, or the availability of emergency obstetric care during delivery. In other words, the scale-up in facility deliveries or "skilled birth attendance" may not correspond to an increase in the percentage of newborns delivered with comprehensive access to life-saving, high-quality obstetric care provided by genuinely skilled and well-equipped health workers.

The question remains, to what extent does the lack of association between SBA coverage and neonatal mortality reflect lack of real access to effective emergency obstetric care, and to what extent might the findings point to an issue of quality of routine delivery care. Lohela and colleagues (2012) were able to more precisely measure women's access to emergency obstetric care (EmOC) facilities in a study that combined individual-level data from two DHS surveys (Malawi 2004 and Zambia 2007) with facility-level data from national health facility censuses conducted two years before each DHS (2002 in Malawi and 2005 in Zambia). Using the facility data, they identified basic and comprehensive EmOC facilities, based on provision of key signal functions (see Lohela et al. 2012 for more detail), and measured straight-line distance from rural DHS clusters to the closest basic and comprehensive EmOC health facilities. Using these measures of distance, they still did not find an association between proximity to EmOC health facilities and early neonatal mortality.

In aggregate, the null findings may in fact point to an issue of quality of care. If we take Rwanda—the country with the most impressive scale-up in coverage of skilled birth attendance—as an example, previous studies suggest that there may still be important deficiencies in the quality of maternal care services, despite the expansion of services. The 2007 Rwanda Service Provision Assessment found considerable deficits in availability of the basic supplies necessary for ANC, normal and complicated deliveries, and postpartum care (National Institute of Statistics of Rwanda (NISR) et al. 2008). While Rwanda MOH norms state that all health centers should be able to provide basic emergency obstetric care and all district hospitals should be able to provide comprehensive emergency obstetric care, findings from a recent quality of care assessment show that the actual availability of such standards of care is much lower (Ngabo et al. 2012). In rural India as well, Singh and colleagues (2012) found that increases in coverage of hospital delivery were not associated with declines in perinatal mortality, and concluded that quality may not have improved along with the increased coverage, citing the shortage of qualified service providers, equipment, and supplies in primary-level and secondary-level health facilities in India as a potential part of the explanation (Singh et al. 2012). Poor-quality services could in part explain the absence of any protective association between skilled birth attendance and neonatal survival, highlighting the need to ensure that there is an emphasis on health system strengthening and improved quality of care alongside efforts to increase use of delivery health services.

These interpretations are reinforced by recent findings in the 2014 Every Newborn Lancet series. As part of this series, Dickson and colleagues (2014) emphasize that newborn care interventions around the day of delivery are "especially dependent on health-system infrastructure, capacity, and resources" and that "strengthening of clinical care in facilities is essential because it provides the backbone of services that save the lives of women and children, particularly newborn babies" (Dickson et al. 2014). Through a consultation with stakeholders in high-burden countries, they identified major bottlenecks to full scale-up of newborn survival interventions. They report that challenges around health financing, health workforce, health service delivery, and essential medical products and technologies emerged as the greatest barriers to scaling up newborn survival interventions in health facilities. Underlying shortages and inefficient distribution of skilled health workers emerged as a major challenge in many high-burden countries. The study found that even for supposedly assisted deliveries, skilled health staff was often unavailable to provide care for the newborn baby following the birth (Dickson et al. 2014).

<u>Weak evidence that scale-up of ANC and its components contributed to reductions in NMR</u>

In the decomposition analysis, we found no evidence that scale-up of coverage of four or more ANC visits contributed to reductions in NMR. Like skilled birth attendance, this is a measure of contact rather than content, with similar limitations. We know neither what happened during the antenatal care visits nor the skill level of the provider. The emphasis in global maternal health on contact coverage (with the wide use of four or more ANC visits as a key benchmark indicator) directs the attention of program managers away from ANC content.

The analysis did find limited evidence that the scale-up of two recommended components of antenatal care (tetanus vaccination and iron/folic acid supplementation) contributed to the observed reductions in NMR. In five of the 12 surveys, children whose mothers had received fewer than two doses of tetanus injections during the pregnancy were more likely to die during the neonatal period, even after controlling for socio-demographic characteristics and the use of other maternal and delivery services. However, only in India was there evidence that the scale-up of tetanus vaccination coverage contributed to the observed reduction in neonatal mortality. The tetanus immunization measure used here is crude; a more refined measurement identifying "full tetanus protection" might have produced stronger results. Furthermore, even though tetanus toxoid is known to be an efficacious treatment, the impact of increases in coverage may be small in settings where good umbilical cord hygiene practices are already the norm.

As for iron/folic acid supplementation, in the three countries where we were able to look at the scale-up of women's reported coverage of taking at least 90 days of iron and folic acid tablets/syrup during pregnancy, there was no evidence of an independent association with neonatal mortality after controlling for other components of maternal and delivery care and socio-demographic controls, and no evidence that scale-up of coverage contributed to the reductions in NMR in those countries. Two factors help explain the lack of contribution: first, coverage of full supplementation is relatively low in all three countries (<40 percent), which could make it difficult to detect an association. Second, only in one of the three countries (Malawi) was there an improvement in coverage. Furthermore, the responses to the survey question may not be a good reflection of the actual number of iron-folate tablets taken.

The importance of protecting the mother against malaria during pregnancy

Study findings contribute to a growing body of evidence pointing to the importance of malaria interventions for neonatal survival (Eisele et al. 2012; Hill and van Eijk 2014; Winter et al. 2013). Of all the indicators included in the decomposition models for the three malarious countries with mosquito bednet data, the dramatic increase in household ownership of a mosquito bednet was responsible for the greatest portion of the observed declines in NMR.

Ownership of a mosquito bednet at the time of interview is an imprecise proxy for the mother's use of an ITN during pregnancy, but the observed association is plausible, given the well-documented association between malaria during pregnancy and elevated risk of neonatal death (Eisele et al. 2012; Guyatt and Snow 2001). In a multi-country study examining the impact of protection against malaria during pregnancy on neonatal mortality and the child's birth weight in 25 malarious countries in Africa, Eisele and colleagues (2012) found that exposure to malaria protection during pregnancy (either through mosquito bednet ownership or through IPTp) was associated with reduced odds of neonatal mortality and reduced odds of low birth weight among first or second births.

In contrast to previous findings in malarious sub-Saharan African settings (Eisele et al. 2012; Menéndez et al. 2010), our study did not find a protective effect of IPTp on neonatal mortality in Malawi. The null finding could be driven by a lack of power, given the relatively low coverage of IPTp. Eisele and colleagues, for example, detected an effect of IPTp exposure in a pooled analysis combining data from 25 African countries (Eisele et al. 2012). Furthermore, in populations where there is a high level of ITN use, the marginal benefit of IPTp may be quite small.

Exploring the Results: Examples from Bangladesh, Malawi, and Nepal

Given the generally accepted causal relationships between maternal and delivery care and mortality risk, our study's weak results may be surprising. Three country snapshots, based on experience working in Bangladesh, Malawi, and Nepal by one of the authors (Steve Hodgins), provide some context for these unexpected findings.

Bangladesh

In Bangladesh, neonatal survival improved significantly between DHS surveys in 1999/2000 and 2011, but our study did not identify any coverage factors for which an improvement was associated with the reduction in the NMR. In the late 1990s and early 2000s Bangladesh made a considerable effort to promote a birthing center model, but most women continued to stay at home and deliver with traditional birth attendants instead of at the birthing centers. If they ran into problems, they bypassed birthing centers and delivered with physicians in hospitals. As a result, Bangladesh maternal and newborn mortality declined despite little increase in the use of skilled birth assistants. Also, in recent years, uptake in institutional deliveries has increased, mostly in the private sector. ANC use has remained low, but with some improvement in use of tetanus toxoid, delivered through the immunization program. Although use of ANC and delivery services has continued to be low, women's education has improved, and use of family planning has increased substantially.

Malawi

In Malawi the significant reduction in neonatal mortality was not associated with the observed scale-up in delivery care. Malawi has made noteworthy progress with regard to the proportion of deliveries conducted in a health facility. This has been accomplished in part through penalizing women who deliver at home, and those who assist in such deliveries. With the shift toward facility deliveries, however, there has not been a concomitant increase in health worker staffing in maternity facilities. Midwives still provide most delivery services, with limited access to comprehensive emergency obstetric and neonatal care services. There have been improvements in several expected drivers of newborn mortality risk. The proportion of mothers with no education dropped by almost half over the last decade, to 17 percent. Iron-folate supplement coverage improved, but remained at a low 32 percent as of 2010. ITN ownership markedly improved, from 14 percent to 77 percent.

Nepal

In Nepal there were major gains in coverage of maternal and delivery care over the decade, but our study found no evidence of improvement in neonatal mortality. Nepal experienced a marked increase in institutional deliveries, alongside considerable effort to provide in-service skilled birth assistance training to health workers responsible for delivery care. There has also been a substantial increase in iron-folate supplementation, and Nepal has done better than most countries in delivering ANC (Hodgins & D'Agostino, 2014). There has also been a considerable effort to scale up community-based newborn work. However, when one looks more closely at the content, quality, and coverage of care actually delivered at health facilities and in community programs, the results have generally been disappointing.

The measure of household ownership of a mosquito bednet was associated with neonatal survival in the endline survey for Malawi, Rwanda, and mainland Tanzania, but not in the baseline survey. There are several potential explanations for the increase in effect size. First, recall that mosquito bednet ownership on the day of interview is a proxy for ownership (and use) during pregnancy. Given the rapid expansion of ITN ownership in each country between baseline and endline, we can expect that the variable is a better proxy for mosquito bednet ownership during pregnancy in the endline survey than at baseline. Second, the indicator is the ownership of "any net;" ITNs are more protective than untreated nets[16], providing both barrier protection against mosquito vectors as well as direct insecticidal effects, and the composition of "any net" changed during this period, from largely untreated to majority insecticide-treated nets. For example, in Tanzania, according to the 2004/5 DHS, 49 percent of households that owned any mosquito bednet owned an ITN, while according to the 2007/8 HIV/AIDS and Malaria Indicator Survey (HMIS), this percentage had increased to 69 percent, and according to the 2009/10 HMIS the percentage had increased to 85 percent. Third, the increasing effect of household mosquito bednet ownership could reflect the additional community-level benefit of ITNs once overall mosquito bednet coverage reaches a certain threshold (Gimnig et al. 2003; Howard et al. 2000). That is, beyond protecting the individual who sleeps under an ITN, once ITN coverage is high in a community, ITNs serve to suppress transmission through direct insecticidal effects on mosquitos that have already taken blood from a malarious person and therefore reduce their ability to transmit malaria to new hosts.

The relevance of family planning to neonatal survival and the importance of identifying high-risk pregnancies

Several findings regarding the association between socio-demographic characteristics and neonatal mortality are worth noting. As expected, short preceding birth intervals are consistently associated with elevated risk of neonatal death. Initiatives should continue to emphasize optimal birth spacing (at least two to three years) to improve neonatal health outcomes. Multiple births are also associated with a substantially higher risk of dying during the first month after birth. Early identification of multiple pregnancies, referral for appropriate delivery care, and close monitoring during the neonatal period can prevent most of these deaths. *S*pecial initiatives should focus on identifying high-risk births with an emphasis on equity of care so that, regardless of household resources, precautions are available to all mothers with high-risk births.

As expected and in agreement with other recent findings (Dickson et al. 2014), in Bangladesh and India we found that higher levels of women's education were associated with lower risk of newborn death. In the decomposition analysis, the increases in women's educational attainment in India between the two surveys was associated with a reduction in neonatal mortality of 1.3 deaths per 1,000 live births. Surprisingly, the study found no evidence of an association between household wealth and neonatal survival. It is possible that the bottom third of the comparative wealth index did not adequately identify the poorest households. Another possibility is that differential underreporting of neonatal deaths, with higher frequency of omission among poorer and less educated households, is masking a true association between wealth and neonatal mortality. Other recent studies have also found weak associations between wealth and child mortality (Bishai et al. 2014; Subramanian and Corsi 2014). In a study of 36 countries in sub-Saharan Africa using DHS data, Subramanian and Corsi (2014), for example, found that changes in country-level per capita GDP were not consistently associated with reductions in child mortality. Similarly, in a country-level decomposition of reductions in under-five mortality in 142 low- and middle-income countries, Bishai and colleagues (2014) found that growth in GDP per capita accounted for a surprisingly small percentage (11 percent) of factor-level-related gains in under-five child survival between 1990 and 2010.

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[16] We use "any net" because we cannot construct household ownership of an ITN in the earlier surveys, as questions on treatment of nets were not asked in all households.

Despite major limitations in our ability to adequately measure the known, life-saving interventions for newborns using population-based survey data, the study has several strengths. First, the analysis was conducted at the individual level, thus providing a means for triangulation with other recent studies examining factors associated with reductions in child mortality at the country level (Bishai et al. 2014). Second, the study examines the contribution of interventions to actual observed reductions, rather than model-based approaches such as the LiST model, again, providing a source for triangulation and validation across methods. Multivariate decomposition provides a powerful tool for identifying factors that have contributed to major health outcomes. These methods will become even more useful as new, more precise measures of essential newborn interventions become available in survey data.

In conclusion, between roughly 2000 and 2010 only nine of 18 USAID MCH priority countries showed significant improvements in neonatal survival, reinforcing the urgency of international commitment to the vision of “a world in which there are no preventable deaths of newborns or stillbirths” (WHO 2014). Study findings point to the importance of protecting the mother against malaria during pregnancy and reinforce the relevance of family planning to neonatal survival. The study found little evidence that the scale-up of other components of maternal and delivery care during this period contributed to observed reductions in neonatal mortality in six focus countries. Poor-quality services could in part explain the absence of any protective association between skilled birth attendance and neonatal survival, highlighting the need to ensure that there is an emphasis on strengthening health systems and improving quality of care alongside efforts to increase use of delivery health services. The weak findings also highlight the current lack of data on other practices that could impact neonatal mortality, such as immediate newborn care, care of the cord, resuscitation, and kangaroo mother care for low birth weight babies. Once indicators such as these become widely available in population-based survey data, it will be possible to more precisely evaluate the impact of scale-up of essential newborn care.

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Appendix A1

Appendix Table A1. Unadjusted and adjusted relative risk of dying during the neonatal period, among children born in the five years preceding the surveys, USAID MCH priority countries with significant reductions in NMR

	Bangladesh								Ethiopia							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
UNADJUSTED																
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	0.80	0.55	1.17		0.68	0.51	0.89	**	1.32	0.73	2.40		0.75	0.48	1.18	
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	0.76	0.49	1.18		0.64	0.48	0.84	**	1.24	0.70	2.18		0.69	0.45	1.06	
Household owns a mosquito net																
Yes	n/a				n/a				1.00				n/a			
No									1.42	0.78	2.58					
ADJUSTED FOR SOCIODEMOGRAPHIC CHARACTERISTICS																
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	0.69	0.46	1.04		0.66	0.48	0.90	**	1.15	0.56	2.34		0.65	0.40	1.05	
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	0.63	0.38	1.04		0.61	0.45	0.84	**	1.10	0.57	2.12		0.58	0.37	0.90	*
Household owns a mosquito net																
Yes	n/a				n/a				1.00							
No									1.09	0.61	1.95		1.00	1.00	1.00	

(Continued...)

Appendix Table A1. – *Continued*

	India						Madagascar					
	Baseline			Endline			Baseline			Endline		
	RR	LB	UB sig	RR	LB	UB sig	RR	LB	UB sig	RR	LB	UB sig
UNADJUSTED												
Delivered by a skilled birth attendant												
Yes	1.00			1.00			1.00			1.00		
No	1.25	1.08	1.44 **	1.21	1.08	1.36 **	1.94	1.26	2.98 **	0.87	0.62	1.21
Delivered in a health facility												
Yes	1.00			1.00			1.00			1.00		
No	1.14	0.99	1.33	1.12	1.00	1.27	1.73	1.08	2.79 *	0.86	0.63	1.18
Household owns a mosquito net												
Yes	n/a			n/a			n/a			1.00		
No										1.12	0.80	1.57
ADJUSTED FOR SOCIODEMOGRAPHIC CHARACTERISTICS												
Delivered by a skilled birth attendant												
Yes	1.00			1.00			1.00			1.00		
No	1.11	0.94	1.31	1.03	0.90	1.18	1.98	1.23	3.20 **	0.84	0.59	1.19
Delivered in a health facility												
Yes	1.00			1.00			1.00			1.00		
No	0.99	0.83	1.19	0.89	0.78	1.02	1.68	1.03	2.73 *	0.88	0.61	1.25
Household owns a mosquito net												
Yes	n/a			n/a						1.00		
No							1.00	1.00	1.00	1.13	0.80	1.59

(Continued...)

Appendix Table A1. – *Continued*

	Malawi								Nigeria							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
UNADJUSTED																
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	1.37	1.09	1.72	**	1.22	0.98	1.53		1.35	0.94	1.94		0.94	0.80	1.10	
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	1.47	1.17	1.85	**	1.21	0.97	1.52		1.30	0.89	1.89		0.99	0.85	1.15	
Household owns a mosquito net																
Yes	1.00				1.00				1.00				1.00			
No	0.85	0.61	1.18		1.26	0.95	1.67		1.03	0.71	1.48		0.96	0.82	1.13	
ADJUSTED FOR SOCIODEMOGRAPHIC CHARACTERISTICS																
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	1.32	1.04	1.67	*	1.27	1.00	1.61		1.22	0.85	1.77		0.71	0.56	0.89	**
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	1.41	1.11	1.78	**	1.27	0.99	1.62		1.14	0.76	1.71		0.80	0.65	0.98	*
Household owns a mosquito net																
Yes	1.00				1.00				1.00				1.00			
No	0.78	0.57	1.05	ns	1.28	0.97	1.68		1.10	0.75	1.62		1.00	0.86	1.17	

(Continued...)

Appendix Table A1. – *Continued*

	Rwanda								Senegal							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
UNADJUSTED																
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	1.19	0.92	1.55		1.07	0.80	1.43		1.42	1.04	1.94	*	0.90	0.70	1.16	
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	1.17	0.91	1.51		1.03	0.76	1.38		1.36	1.00	1.85	*	0.87	0.65	1.15	
Household owns a mosquito net																
Yes	1.00				1.00				n/a				1.00			
No	2.08	1.19	3.66	*	2.23	1.42	3.49	***					1.01	0.74	1.38	
ADJUSTED FOR SOCIODEMOGRAPHIC CHARACTERISTICS																
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	1.01	0.75	1.35		1.05	0.77	1.44		1.40	1.00	1.96	*	0.83	0.63	1.09	
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	0.99	0.74	1.32		1.00	0.73	1.38		1.32	0.95	1.84		0.80	0.58	1.09	
Household owns a mosquito net																
Yes	1.00				1.00								1.00			
No	1.51	0.79	2.87		2.31	1.47	3.63	***	1.00	1.00	1.00		0.93	0.67	1.29	

(Continued...)

Appendix Table A1. – *Continued*

	Mainland Tanzania							
	Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig
UNADJUSTED								
Delivered by a skilled birth attendant								
Yes	1.00				1.00			
No	0.75	0.49	1.16		0.82	0.56	1.22	
Delivered in a health facility								
Yes	1.00				1.00			
No	0.71	0.46	1.11		0.73	0.49	1.09	
Household owns a mosquito net								
Yes	1.00				1.00			
No	0.92	0.54	1.56		1.61	1.05	2.48	*
ADJUSTED FOR SOCIODEMOGRAPHIC CHARACTERISTICS								
Delivered by a skilled birth attendant								
Yes	1.00				1.00			
No	0.96	0.61	1.53		1.10	0.68	1.79	
Delivered in a health facility								
Yes	1.00				1.00			
No	0.92	0.58	1.47		0.94	0.58	1.52	
Household owns a mosquito net								
Yes	1.00				1.00			
No	1.05	0.57	1.94		1.78	1.16	2.72	**

Note: * indicates p<.05; ** indicates p<.01;*** indicates p<.001. Unlike Tables 4-7, which include countries with significant reductions in NMR within the study population (most recent children born), this table includes the 9 countries with significant reductions in NMR among all children born in the five years preceding the survey. The adjusted relative risk estimates control for the following characteristics of the household (urban residence and comparative household wealth), the mother (age at child's birth, marital status, level of education, and loss of another child under five) and the child (sex, birth interval, birth order, and multiple birth). Malaria risk was included as a control in Madagascar, Malawi, and Mainland Tanzania, and caste was included in India. Marital status was not included in the models for Bangladesh or India, since these were ever-married samples. Multiple birth was not included in models for Malawi or Mainland Tanzania, given the small number of multiple births. Baseline surveys were conducted in 1999/2000 in Bangladesh, 2000 in Ethiopia, 1998/9 in India, 1997 in Madagascar, 2000 in Malawi, 2003 in Nigeria, 2000 in Rwanda, 1997 in Senegal, and 1999 in mainland Tanzania. Endline surveys were conducted in 2011 in Bangladesh, 2011 in Ethiopia, 2005/6 in India, 2008/9 in Madagascar, 2010 in Malawi, 2013 in Nigeria, 2010 in Rwanda, 2010/11 in Senegal, and 2010 in mainland Tanzania.

Appendix Table A1 shows the unadjusted and adjusted relative risk of neonatal mortality among all children born in the five years preceding the survey for the three maternal and delivery care intervention variables that are available for all births, as opposed to the study population of most recent births. Results are shown for the nine countries with a statistically significant reduction in neonatal mortality between the baseline and endline surveys among all births in the five years preceding the survey.

Of the three indicators shown, two are specific to the birth (skilled birth attendance and place of delivery) and one is specific to the household (ownership of a mosquito bednet). Comparing the results for the two birth-specific variables in this table with the results from Table 5, which are restricted to the study population of most recent children born, we find fairly good agreement between the results. In two of the six countries included in both tables, the statistically significant adjusted association between skilled birth attendance and neonatal mortality becomes non-significant after restricting the sample to the most recent children born (Table 5); however, the direction of association remains the same. Similarly, the association between place of delivery and neonatal mortality becomes non-significant in one survey after restricting the sample to the most recent births. We find a somewhat different pattern with mosquito bednet ownership. We can compare the association between mosquito bednet coverage and neonatal mortality in Appendix Table A1 and Table 5 for Malawi, Rwanda, and mainland Tanzania. In Malawi, a non-significant association among all births becomes significant after restricting to the sample of most recent births. In Rwanda and mainland Tanzania, the association is statistically significant in both samples, but the magnitude of the protective effect of ownership of a mosquito bednet is greater after restricting to most recent children born. Household-level variables may be better proxies for the context at the time of the child's birth within the sample of most recent births, as compared with the sample of all births in the five years preceding the survey.

The results for household ownership of a mosquito bednet for Ethiopia, Nigeria, and Senegal are not consistent with the results shown for Malawi, Rwanda, and mainland Tanzania. In Ethiopia, Nigeria, and Senegal we find no significant association between household ownership of a mosquito bednet and neonatal mortality. Several aspects of the malaria context in these three countries could help explain the null findings. In Senegal, levels of parasitemia are quite low, seasonal, and disparate throughout the country. In Ethiopia, the malaria context is similar—seasonal and varied based on elevation. Furthermore, the malaria control strategy in Ethiopia has relied heavily on indoor residual spraying (IRS) in some areas, which may dampen the observable impact of using mosquito bednets. In Nigeria, overall coverage of household ownership of a mosquito bednet remains lower (64 percent according to the 2013 DHS).

Appendix A2

Appendix Table A2. Unadjusted relative risk of dying during the neonatal period, among women's most recent children born in the five years preceding the surveys, USAID MCH priority countries with significant reductions in NMR

	Bangladesh								India							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
CHARACTERISTICS OF THE HOUSEHOLD																
Place of residence and comparative wealth index[1]																
Urban upper two-thirds CWI	1.00				1.00				1.00				1.00			
Urban bottom-third CWI	1.41	0.65	3.07		1.21	0.56	2.61		0.93	0.47	1.84		1.42	0.99	2.04	
Rural bottom-third CWI	1.33	0.68	2.60		0.99	0.55	1.80		1.60	1.27	2.01	***	1.81	1.44	2.28	***
Rural upper two-thirds CWI	1.10	0.46	2.59		0.76	0.35	1.67		1.34	1.05	1.70	*	1.32	1.00	1.74	*
Malaria risk[2]																
None or low (<5% risk)																
Intermediate (5%-40% risk)																
High (>40% risk)																
CHARACTERISTICS OF THE MOTHER																
Mother's age at child's birth																
<18 years	2.03	1.39	2.95	***	0.93	0.51	1.68		1.76	1.39	2.22	***	1.37	0.98	1.91	
18-34 years	1.00				1.00				1.00			.	1.00			
35+ years	0.85	0.41	1.80		1.64	0.90	2.98		1.63	1.23	2.16	***	1.65	1.23	2.21	***
Mother's marital status																
Currently in union																
Not currently in union																

(Continued...)

Appendix Table A2. – *Continued*

	Bangladesh								India							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
Mother's educational attainment																
None	1.06	0.70	1.60		1.13	0.66	1.95		1.56	1.29	1.89	***	2.04	1.68	2.47	***
Primary	0.83	0.51	1.34		1.49	0.96	2.29		1.09	0.83	1.44		2.00	1.54	2.60	***
Secondary or higher	1.00				1.00				1.00				1.00			
Previous child to mother died under age five years																
No	1.00				1.00				1.00				1.00			
Yes	1.14	0.75	1.73		1.65	1.03	2.62	*	1.75	1.47	2.08	***	1.79	1.49	2.15	***
CHARACTERISTICS OF THE CHILD																
Sex of child																
Female	1.00				1.00				1.00				1.00			
Male	1.14	0.83	1.57		1.40	0.94	2.10		1.02	0.86	1.20		1.06	0.89	1.27	
Preceding birth interval																
2 years	1.00				1.00				1.00				1.00			
<2 years	2.48	1.27	4.84	**	3.37	1.35	8.41	**	1.22	0.95	1.56		1.53	1.18	1.98	**
3+ years	0.60	0.30	1.20		1.96	0.88	4.38		0.84	0.67	1.06		0.75	0.58	0.98	*
First birth	2.38	1.33	4.27	**	1.97	0.84	4.60		1.22	0.98	1.52		1.38	1.08	1.78	*
Birth order																
First and second	1.00				1.00				1.00				1.00			
Third	0.53	0.28	0.98	*	0.99	0.60	1.63		0.76	0.61	0.95	*	0.61	0.46	0.81	***
Fourth or higher	0.75	0.48	1.16		0.76	0.44	1.30		0.99	0.83	1.18		1.20	0.99	1.45	
Multiple birth																
Single birth	1.00				1.00				1.00				1.00			
Multiple birth	6.55	3.17	13.55	***	4.94	2.32	10.51	***	5.74	3.97	8.32	***	3.25	2.02	5.24	***

(Continued...)

Appendix Table A2. – *Continued*

	Bangladesh								India							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
RECOMMENDED MATERNAL AND DELIVERY CARE																
Mother attended 4 or more ANC visits																
Yes	1.00				1.00				1.00				1.00			.
No	2.27	1.03	5.01	*	0.96	0.58	1.59		1.65	1.35	2.02	***	1.60	1.33	1.93	***
Number of tetanus injections during pregnancy																
2+	1.00				1.00				1.00			.	1.00			
1	1.70	1.11	2.62	*	1.13	0.65	1.95		1.67	1.26	2.22	***	1.23	0.89	1.70	
0	1.63	1.07	2.47	*	1.71	1.08	2.72	*	1.96	1.65	2.32	***	1.87	1.54	2.28	***
Mother had 90+ days of iron and folic acid supplementation[3]																
Yes									1.00				1.00			
No									1.54	1.29	1.84	***	1.42	1.14	1.76	**
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00			.	1.00			
No	0.65	0.40	1.06		0.57	0.38	0.86	**	1.26	1.07	1.48	**	1.23	1.04	1.46	*
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	1.16	0.42	3.22		0.94	0.52	1.69		1.46	1.23	1.74	***	1.55	1.30	1.84	***
Household owns a mosquito bednet																
Net																
No net																

(Continued...)

Appendix Table A2. – *Continued*

	Bangladesh								India							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
Mother received two doses of SP during pregnancy																
Yes																
No																

	Madagascar								Malawi							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
CHARACTERISTICS OF THE HOUSEHOLD																
Place of residence and comparative wealth index¹																
Urban upper two-thirds CWI	1.00				1.00				1.00				1.00			
Urban bottom-third CWI	1.24	0.54	2.86		1.06	0.38	2.99		1.24	0.36	4.28		0.75	0.28	2.02	
Rural bottom-third CWI	0.75	0.43	1.33		1.02	0.62	1.68		1.40	0.46	4.27		0.81	0.45	1.48	
Rural upper two-thirds CWI	0.65	0.23	1.79		1.05	0.44	2.51		3.25	0.74	14.24		0.70	0.32	1.54	
Malaria risk²																
None or low (<5% risk)																
Intermediate (5%-40% risk)	1.00				1.00				1.00				1.00			
High (>40% risk)	1.09	0.65	1.80		0.94	0.59	1.49		1.36	1.00	1.86		0.78	0.55	1.10	
CHARACTERISTICS OF THE MOTHER																
Mother's age at child's birth																
<18 years	1.50	0.75	3.00		1.21	0.63	2.33		2.02	1.29	3.17	**	1.22	0.66	2.24	
18-34 years	1.00				1.00				1.00				1.00			
35+ years	1.32	0.78	2.24		1.74	1.08	2.80	*	1.27	0.85	1.89		1.86	1.33	2.60	***

(Continued...)

Appendix Table A2. – *Continued*

	Madagascar								Malawi							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
Mother's marital status																
Currently in union	1.00				1.00				1.00				1.00			
Not currently in union	1.74	1.10	2.77	*	1.01	0.63	1.61		1.35	0.92	1.99		0.89	0.57	1.40	
Mother's educational attainment																
None	1.46	0.78	2.76		0.71	0.37	1.36		1.01	0.46	2.19		0.96	0.54	1.69	
Primary	1.29	0.73	2.27		1.16	0.67	2.00		1.22	0.60	2.48		1.09	0.67	1.77	
Secondary or higher	1.00				1.00				1.00				1.00			
Previous child to mother died under age five years																
No	1.00				1.00				1.00				1.00			
Yes	1.28	0.83	1.96		2.10	1.38	3.18	***	1.39	1.03	1.86	*	1.43	1.05	1.93	*
CHARACTERISTICS OF THE CHILD																
Sex of child																
Female	1.00				1.00				1.00			.	1.00			.
Male	1.41	0.95	2.10		1.32	0.86	2.04		1.59	1.17	2.15	**	1.60	1.17	2.18	**
Preceding birth interval																
2 years	1.00				1.00				1.00				1.00			
<2 years	1.94	1.09	3.43	*	1.34	0.72	2.49		1.74	1.05	2.88	*	2.94	1.70	5.06	***
3+ years	0.98	0.54	1.79		1.29	0.75	2.23		1.00	0.63	1.58		2.10	1.33	3.34	**
First birth	1.72	0.98	3.03		1.73	0.98	3.06		1.86	1.24	2.80	**	3.12	1.93	5.07	***
Birth order																
First and second	1.00				1.00				1.00				1.00			
Third	1.27	0.69	2.34		0.72	0.37	1.40		0.79	0.50	1.26		0.69	0.40	1.17	
Fourth or higher	1.01	0.62	1.63		0.94	0.61	1.45		0.82	0.60	1.12		0.93	0.66	1.29	

(Continued...)

Appendix Table A2. – *Continued*

	Madagascar								Malawi							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
Multiple birth																
Single birth	1.00				1.00			.								
Multiple birth	5.53	2.57	11.90	***	4.50	1.93	10.48	***								
RECOMMENDED MATERNAL AND DELIVERY CARE																
Mother attended 4 or more ANC visits																
Yes	1.00			.	1.00			.	1.00				1.00			.
No	2.46	1.41	4.30	**	1.02	0.66	1.59		1.48	1.08	2.04	*	1.66	1.17	2.34	**
Number of tetanus injections during pregnancy																
2+	1.00				1.00				1.00				1.00			
1	1.34	0.65	2.77		0.53	0.25	1.10		1.45	0.97	2.16		1.29	0.89	1.87	
0	1.30	0.78	2.18		1.23	0.75	2.00		3.19	2.32	4.40	***	1.24	0.82	1.89	
Mother had 90+ days of iron and folic acid supplementation[3]																
Yes					1.00				1.00				1.00			
No					1.57	0.65	3.82		1.12	0.65	1.92		1.32	0.92	1.89	
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	1.61	0.97	2.70		0.71	0.45	1.13		1.35	1.00	1.83		0.85	0.59	1.24	
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	1.33	0.81	2.20		0.84	0.54	1.30		1.46	1.08	1.99	*	0.97	0.66	1.42	

(Continued...)

Appendix Table A2. – *Continued*

	Madagascar								Malawi							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
Household owns a mosquito bednet																
Net					1.00				1.00				1.00			.
No net					1.46	0.94	2.27		0.82	0.52	1.28		1.70	1.17	2.47	**
Mother received two doses of SP during pregnancy																
Yes					1.00				1.00				1.00			
No					0.79	0.39	1.60		1.49	1.02	2.18	*	1.30	0.96	1.76	

	Rwanda								Mainland Tanzania							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
CHARACTERISTICS OF THE HOUSEHOLD																
Place of residence and comparative wealth index[1]																
Urban upper two-thirds CWI	1.00				1.00				1.00				1.00			
Urban bottom-third CWI	0.87	0.19	4.08		3.98	1.38	11.50	*	1.31	0.29	5.97		0.86	0.32	2.28	
Rural bottom-third CWI	2.69	0.98	7.36		1.84	0.79	4.29		0.59	0.25	1.36		0.50	0.29	0.87	*
Rural upper two-thirds CWI	2.80	0.34	23.30		1.33	0.43	4.06		0.73	0.13	4.03		0.65	0.27	1.53	
Malaria risk[2]																
None or low (<5% risk)									1.00				1.00			
Intermediate (5%-40% risk)									0.81	0.36	1.83		0.78	0.43	1.41	
High (>40% risk)									1.22	0.39	3.79		1.19	0.55	2.56	

(Continued...)

Appendix Table A2. – *Continued*

	Rwanda								Mainland Tanzania							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
CHARACTERISTICS OF THE MOTHER																
Mother's age at child's birth																
<18 years	1.70	0.62	4.65		1.23	0.17	8.89		2.81	1.27	6.20	*	1.18	0.39	3.57	
18-34 years	1.00				1.00				1.00				1.00			
35+ years	1.35	0.95	1.90		1.88	1.23	2.87	**	1.44	0.68	3.05		1.27	0.77	2.09	
Mother's marital status																
Currently in union	1.00				1.00				1.00				1.00			
Not currently in union	0.95	0.62	1.46		0.93	0.53	1.66		2.16	0.97	4.83		2.25	1.35	3.73	**
Mother's educational attainment																
None	2.92	1.16	7.34	*	1.52	0.62	3.74		0.57	0.13	2.43		0.51	0.17	1.52	
Primary	1.84	0.75	4.49		1.30	0.58	2.91		0.83	0.21	3.32		0.81	0.30	2.18	
Secondary or higher	1.00				1.00				1.00				1.00			
Previous child to mother died under age five years																
No	1.00				1.00			.	1.00				1.00			
Yes	1.25	0.88	1.77		2.10	1.37	3.23	***	1.01	0.48	2.14		0.81	0.47	1.41	
CHARACTERISTICS OF THE CHILD																
Sex of child																
Female	1.00				1.00				1.00				1.00			.
Male	1.68	1.16	2.43	**	1.43	0.91	2.27		1.69	0.82	3.50		1.93	1.20	3.12	**

(Continued...)

Appendix Table A2. – *Continued*

	Rwanda								Mainland Tanzania							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
Preceding birth interval																
2 years	1.00				1.00				1.00				1.00			
<2 years	1.46	0.85	2.50		3.43	1.76	6.67	***	0.87	0.23	3.28		1.75	0.69	4.46	
3+ years	1.10	0.68	1.79		1.56	0.83	2.95		1.26	0.41	3.90		2.01	1.04	3.87	*
First birth	1.27	0.76	2.12		1.42	0.70	2.89		2.24	0.87	5.80		2.50	1.19	5.27	*
Birth order																
First and second	1.00				1.00				1.00				1.00			
Third	0.60	0.32	1.15		0.70	0.33	1.49		0.92	0.32	2.69		0.34	0.14	0.81	*
Fourth or higher	1.04	0.74	1.46		1.47	0.93	2.32		0.40	0.19	0.82	*	0.60	0.37	0.97	*
Multiple birth																
Single birth	1.00				1.00											
Multiple birth	7.46	4.36	12.77	***	6.32	3.07	12.99	***								
RECOMMENDED MATERNAL AND DELIVERY CARE																
Mother attended 4 or more ANC visits																
Yes	1.00				1.00				1.00				1.00			
No	1.67	0.83	3.36		1.51	0.91	2.49		1.96	0.95	4.04		1.19	0.74	1.93	
Number of tetanus injections during pregnancy																
2+	1.00				1.00				1.00				1.00			
1	1.14	0.75	1.72		0.76	0.44	1.32		0.91	0.31	2.67		0.91	0.49	1.67	
0	1.45	0.95	2.22		1.38	0.83	2.31		1.08	0.52	2.26		1.11	0.65	1.90	
Mother had 90+ days of iron and folic acid supplementation[3]																
Yes													1.00			
No									1.00	1.00	1.00		0.81	0.25	2.64	

(Continued...)

Appendix Table A2. – *Continued*

	Rwanda								Mainland Tanzania							
	Baseline				Endline				Baseline				Endline			
	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig	RR	LB	UB	sig
Delivered by a skilled birth attendant																
Yes	1.00				1.00				1.00				1.00			
No	1.08	0.72	1.63		0.96	0.58	1.57		0.62	0.36	1.07		0.61	0.37	1.00	*
Delivered in a health facility																
Yes	1.00				1.00				1.00				1.00			
No	1.02	0.68	1.52		0.98	0.60	1.60		0.64	0.38	1.11		0.52	0.31	0.87	*
Household owns a mosquito bednet																
Net	1.00				1.00			.	1.00				1.00			.
No net	4.92	1.16	20.80	*	3.16	1.88	5.32	***	0.85	0.41	1.77		2.82	1.68	4.75	***
Mother received two doses of SP during pregnancy																
Yes													1.00			
No													1.51	0.83	2.73	

Note: * indicates p<.05; ** indicates p<.01;*** indicates p<.001. The table presents unadjusted relative risk (uRR) estimates, which compare the probability of dying in one group relative to the probability of dying in the reference group. Baseline surveys were conducted in 1999/2000 in Bangladesh, 1998/9 in India, 1997 in Madagascar, 2000 in Malawi, 2000 in Rwanda, and 1999 in mainland Tanzania. Endline surveys were conducted in 2011 in Bangladesh, 2005/6 in India, 2008/9 in Madagascar, 2010 in Malawi, 2010 in Rwanda, and 2010 in mainland Tanzania.

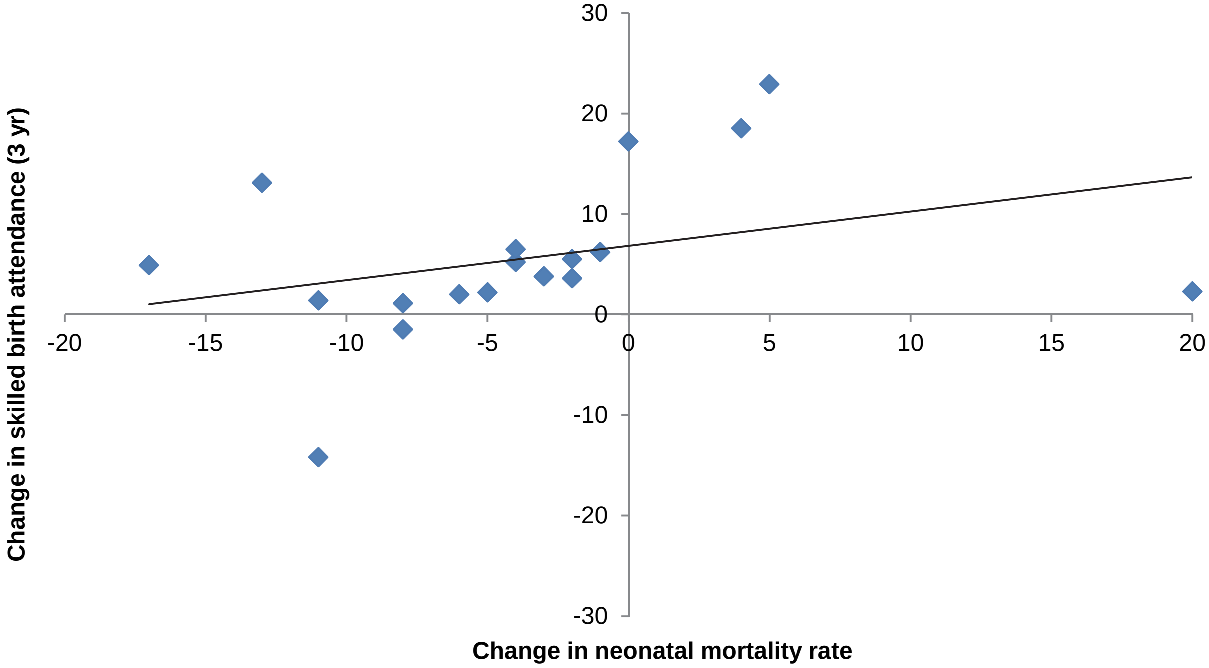
[1] The DHS-constructed comparative wealth index uses a fixed baseline (the 2002 Vietnam DHS) enabling measurement of improvements in wealth over time and comparison of absolute wealth across country. This four-level indicator measures the effect of being in the bottom comparative wealth third separately in urban and rural households. Urban upper-two thirds is used as the reference.

[2] This indicator has three levels: no/low, intermediate, and high risk. In low risk areas, the annual averaged plasmodium falciparum infection prevalence in 2-10 year olds is likely to be lower than 5%. In intermediate risk areas, plasmodium falciparum transmission is likely to be between 5%-50%. In high risk areas, transmission is likely to exceed 40%. Note that in Malawi, the population falls in just intermediate and high risk areas. In Madagascar, due to the small number of cases in the no/low risk category in the 2008 survey, no/low risk was collapsed with intermediate risk.

[3] This indicator was calculated for Rwanda but due to the low prevalence of coverage of iron supplementation, the relative risk could not be calculated.

Appendix A3

Appendix Figure A3. Correlation between the change in NMR and the change in skilled birth attendance in 18 high-burden countries for maternal and newborn mortality



Note: This figure includes data from the following 18 high-burden countries for maternal and newborn mortality: Cote d'Ivoire, Ghana, Mali, Niger, Nigeria, Chad, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Tanzania, Uganda, Zambia, Bangladesh, India, Pakistan, and Indonesia. Data were extracted from MEASURE DHS STATcompiler on January 18, 2013.