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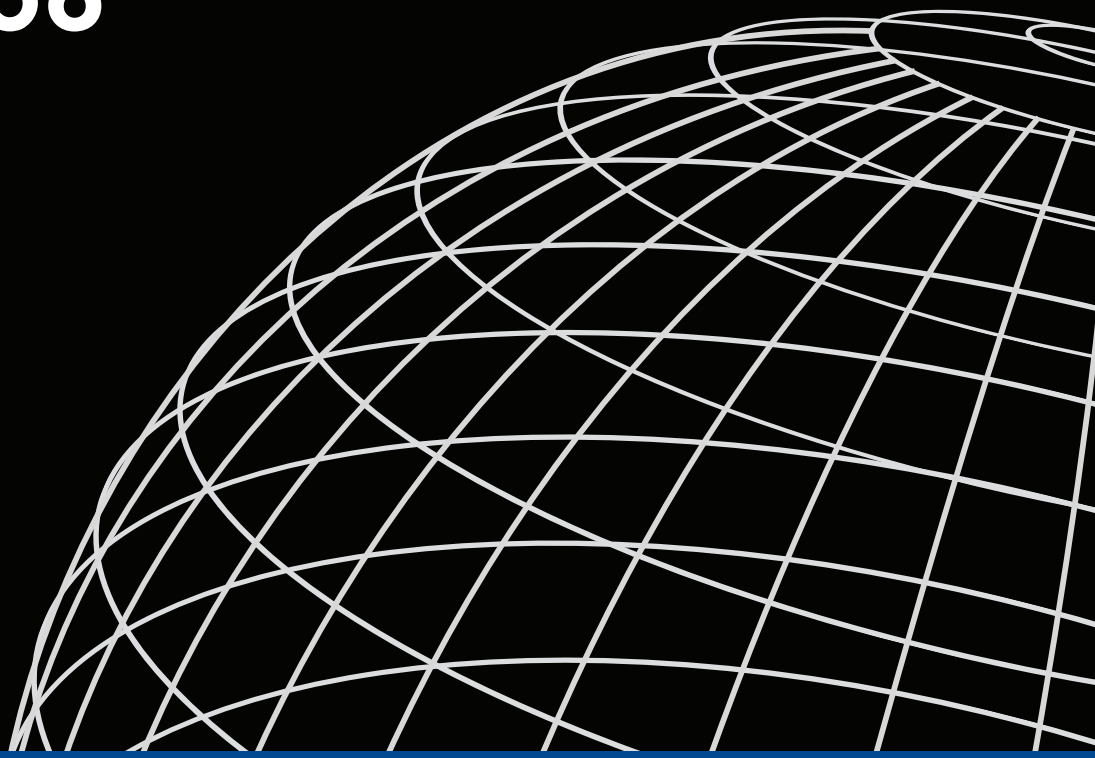
THERMAL CARE AND UMBILICAL CORD CARE PRACTICES AND THEIR ASSOCIATIONS WITH NEWBORN MORTALITY

DHS ANALYTICAL STUDIES 68



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Thermal Care and Umbilical Cord Care Practices and Their Associations with Newborn Mortality

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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 this 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

Although child mortality has decreased considerably in the last several decades, newborn mortality has declined less substantially and its share of all under-five mortality consequently has grown. While life-saving interventions such as skilled birth attendance and delivery in a health facility have increased, they have only contributed to a limited reduction in neonatal mortality. This calls for further study on specific interventions related to newborn care. This study examines the associations of thermal and cord care practices with newborn mortality.

This study used data from 16 Demographic and Health Surveys to examine changes over time in coverage of recommended newborn care practices—thermal care and hygienic cord care—and differences in coverage of recommended practices by place of delivery. Among home births, we further examined the associations between newborn care practices and newborn mortality over time, and the key predictors of receipt of the recommended practices. Sample size proved to be a limitation to exploring associations between recommended newborn care practices and neonatal mortality among home births within individual surveys; thus, we pooled data from recent surveys to draw from a larger sample. We also conducted an in-depth analysis of newborn care practices among home births in larger samples in South Asia. We performed multivariable logistic regressions to test the associations between newborn care practices and neonatal mortality, and to explore predictors of newborn care practices in these countries.

Overall, we found an increase in recommended newborn care practices over time, more implementation of practices among births delivered in a health facility than at home, and a relationship between cord care and mortality among home births. In Bangladesh and Nepal, we found that newborns who had only an antiseptic placed on their umbilical cord stump had significantly lower odds of dying compared with babies who had dry cord care. In recent surveys in South Asia, we found that antenatal care and skilled attendance at birth significantly increased the odds of receiving recommended newborn care practices; counseling on these interventions during antenatal care might help to ensure that women understand the recommended practices in the event that they cannot access a health facility to deliver. Finally, missing responses were common for mothers whose newborn died, indicating that a mother's recall or report of details surrounding the traumatic event of a loss of a child may be incomplete.

KEY WORDS: newborn care, thermal care, hygienic cord care, newborn mortality

1 INTRODUCTION

1.1 Background

Newborn survival is a prominent goal on the global health agenda and an important area of focus for programs seeking to ensure child survival (Carvajal-Aguirre et al. 2017). In 2016, an estimated 2.6 million children died within the first 28 days after birth, or an average of about 7,000 every day (IGME 2017). Newborn (neonatal) mortality—deaths within the first 28 days—currently accounts for 46% of all under-five mortality, an increase from 41% in 2000 (IGME 2017). While mortality at age 1-59 months declined by 62% between 1990 and 2016, the neonatal mortality rate (NMR) declined by only 50%. Geographically, neonatal deaths are most prevalent in southern Asia and sub-Saharan Africa, accounting for 39% and 38% of all neonatal deaths, respectively. About three-fourths of deaths among newborns occur in the first week of life, and 25-40% occur in the first 24 hours (Liu et al. 2012). The main causes of newborn death are prematurity (and consequently, low birthweight), intrapartum-related birth complications, and infections, but the root cause is poverty—when people cannot access the high-quality health care they need (UNICEF 2018).

The lag in the decrease of neonatal death rates indicates the need for a system wide approach to address the main causes of newborn deaths, but until recently there has been a lack of global focus on this issue (UNICEF 2018). Recommended interventions to limit or prevent premature birth and low birthweight include birth preparedness, folic acid supplementation, tetanus toxoid immunization, syphilis screening and treatment, intermittent preventive therapy for malaria, detection and treatment of bacteriuria (Darmstadt et al. 2014), and calcium supplementation for women with low calcium levels (Thapa et al. 2016). Life-saving interventions during the intrapartum period include antibiotics for premature rupture of membranes, corticosteroids for preterm labor, detecting and managing breech births and multiple pregnancy (twins, triplets, etc.), monitoring labor to identify complications, and clean birth practices (Lawn et al. 2012; Darmstadt et al. 2014). Recommended newborn care practices that reduce mortality include newborn resuscitation, immediate and exclusive breastfeeding, preventing and managing hypothermia, kangaroo mother care for low birthweight infants, and community case management of pneumonia (Darmstadt et al. 2014). Skilled care at birth can help avert further complications (Darmstadt et al. 2014). Births delivered in a health facility with better access to life-saving interventions are less likely to succumb to any of the preventable causes of mortality (Tura et al. 2013). Although the use of health facilities and skilled birth attendance for deliveries has increased, these interventions have contributed to only minimal reductions in maternal and neonatal deaths. The low impact of skilled birth attendance may be attributable to selection bias: women with higher-risk pregnancies seeking out facility delivery where most births are attended by skilled birth attendants (Amouzou et al. 2017, Singh et al. 2014). These newborns have lower odds of surviving, offsetting the hoped-for reduction in mortality (Winter et al. 2017).

Additionally, recommended interventions only protect newborn health if they are adequately resourced and implemented; newborns who do not receive the interventions due to inadequate investment and poor-quality care cannot benefit from them (Amouzou et al. 2017). WHO recognizes that coverage alone is not enough to reduce mortality; quality is a critical component of effective care (WHO 2016). The Quality of Care framework emphasizes skilled and dignified treatment of mothers and newborns (WHO 2016). Specifically,

WHO adopted this quality standard for newborns: "Newborns receive routine care immediately after birth" (WHO 2016).

Research about and advocacy for newborn care has accelerated (Lawn et al. 2014; Carvajal–Aguirre et al. 2017). At the 67th World Health Assembly, held in 2014, 194 member states endorsed the Every Newborn Action Plan, a roadmap to reduce infant mortality and improve health by 2030. The latest report (WHO 2018) states that improving newborn health is critical to achieve the Sustainable Development Goals, and there has been increasing demand from countries for technical assistance with creating action plans to improve newborn survival. Recommendations include greater focus on financial barriers to facility births and management of maternal and newborn complications, and strengthening responses to maternal and perinatal death review findings (WHO 2018). In addition, an expert committee—the Newborn Indicators Technical Working Group—established in 2008, identified key functions for service delivery, reviewed newborn indicators collected through household surveys, and developed and recommended new indicators (Moran et al. 2013). These have since been incorporated in a newborn module and used in DHS surveys in several countries. A measure of skin-to-skin contact immediately after birth is included in the core questionnaire.

Home births carry a higher risk of neonatal mortality compared with facility births in low- and middle-income countries (Tura et al. 2013). Our analysis examines the association between newborn care practices and newborn survival among home births in 10 countries. The newborn care practices we assess include immediate drying and wrapping, delayed bathing, immediate skin-to-skin contact after birth, cord cutting with a clean instrument, and the absence of any harmful substance on the cord. In the following sections, we review cultural and traditional newborn care practices and present recommendations of the World Health Organization (WHO) and related evidence concerning each practice (WHO 2017).

1.2 Thermal Care Practices

1.2.1 Drying and wrapping

Immediate drying and wrapping not only provide thermal care, with the benefit of preventing hypothermia, but the vigorous rubbing that accompanies wiping a baby dry can stimulate breathing (WHO 2017). Drying and wrapping typically occur together (Sitrin et al. 2017) and are prevalent practices, as reported by studies in Tanzania and Uganda (Dhingra et al. 2014, Waiswa et al. 2015). In Tanzania, both untrained and trained traditional birth attendants (TBAs) practiced immediate drying of the baby (Dhingra et al. 2014); however, in some settings, although women understand the importance of keeping babies warm, traditional beliefs or delivery in a home setting may interfere with a baby's receipt of proper thermal care (Haws et al. 2007; Hill et al. 2010). For example, women who deliver at home alone or with a TBA may believe it is more urgent to cut the cord and deliver the placenta before drying the baby because those are deemed more urgent safety issues (Hill et al. 2010; Falle et al. 2009).

WHO recommends immediately drying the newborn (WHO and Jhpiego 2015). One of the main interventions that may counteract birth asphyxia, which accounts for approximately 1 million newborn deaths a year (Black et al. 2010), is stimulation. When an infant is immediately dried, the stimulation may help an infant who is experiencing difficulty breathing. An estimated 5-10% of newborns need simple stimulation—done through drying and rubbing—to aid in breathing at birth (Stephen et al. 2009). Hypothermia, even in warm climates, is a risk factor for newborn morbidity and mortality, although the

contribution of hypothermia to neonatal mortality is poorly understood (Darmstadt et al. 2005; Kumar et al. 2009). Neonatal hypothermia occurs when the infant's temperature drops below 97.7 degrees Fahrenheit (36.5 degrees Celsius), and continued temperature reduction can cause adverse effects, from mild metabolic stress to death (Kumar et al. 2009). Specifically, heat loss occurs when amniotic fluid or bath water evaporates from an infant's skin; babies born prematurely or underweight are particularly vulnerable to heat loss because of the large surface area of skin relative to their weight; drying and wrapping an infant can prevent it (Kumar et al. 2009). Studies have shown that hypothermia was associated with an increase in neonatal mortality (Lunze et al. 2013; Sodemann et al. 2008). In addition, cold stress is a risk factor for low blood sugar (hypoglycemia), making the infant sleepy or irritable and unable to feed well, which further lowers blood sugar (Page-Goertz 2013). Some have postulated that hypoglycemia may be a cause rather than a consequence of hypothermia (Lunze and Hamer 2012).

Another recommended newborn practice is skin-to-skin contact between the baby and mother for the first hour of life after birth. This is a recommendation for any newborns without complications or who are low birthweight; it can help prevent hypothermia as well as encourage breastfeeding (Singh et al. 2017). This intervention is low cost with great benefit in keeping the newborn warm, and has been significantly associated with exclusive breastfeeding – known to prevent mortality (WHO 2012). Evidence has shown that kangaroo mother care, of which skin-to-skin contact is one of three essential components, considerably reduced neonatal mortality in preterm newborns among facility births, though more study is needed to produce this evidence among home births (Lawn 2010).

1.2.2 Bathing

Early bathing increases an infant's risk of hypothermia, which is associated with increased risk of neonatal morbidity and mortality, as described above. In addition, the vernix coating, the protective film that develops on the skin of the fetus that protects against infections, is washed away with early bathing. WHO recommends that bathing the child be delayed until after 24 hours after birth, or at least for the first six hours (WHO 2017).

Bathing an infant soon after birth is a common practice around the world (Sharma et al. 2016). Common beliefs around bathing include the belief that a newborn smells bad, not bathing immediately will lead to body odor later in life, the baby has a need to be clean or is dirty and bathing will prevent infection, visitors prefer clean babies, and bathing will help to shape the baby's head (Waiswa et al. 2008; Hill et al. 2010). Delaying bathing was found to be unacceptable to a community in Uganda, where women cited odor, appearance (dirty), and infant's comfort as reasons to bathe an infant soon after birth (Waiswa et al. 2008). A study in Tanzania found that most infants were bathed within 24 hours; the difference was that births in health facilities and with government-trained TBAs had delayed bathing, while births with untrained TBAs did not (Dhingra et al. 2014).

1.3 Hygienic Cord Care

1.3.1 Cord cutting

WHO has prioritized hygienic cord care, which includes cutting the cord with a new or sterilized instrument, or using a clean delivery kit as well as appropriate cord care (described below) (Liu et al. 2015; Sitrin et al. 2017) and is a standard measure of newborn care (Moran et al. 2013). Hygienic cord care is recommended

to reduce the risk of sepsis, a major cause of newborn mortality—specifically, infection that enters the body at the cord stump site in the newborn. Premature or low birthweight babies are at an increased risk of all-cause mortality. Their skin barrier function is compromised and their immune systems and sometimes vital organs are underdeveloped; preterm babies may also lack or have reduced amounts of vernix, which is only developed in the later stages of pregnancy (Tielsch et al. 2007; Darmstadt et al. 2005; Marodi 2006).

Although several studies have reported common usage of a clean instrument to cut the cord (e.g., Dhingra et al. 2014; Waiswa et al. 2015; Coffey and Brown 2017; Sitrin et al. 2017), traditional practices of cutting with unclean objects are still found. For example, in Nepal the umbilical cord is sometimes cut against a (typically unclean) rupee, called a "good luck coin"; with this entrenched traditional practice in mind, birth kits in Nepal now include a sterile, plastic coin (PATH 2002; Sharma et al. 2016). Other reports indicate that in Nepal and Bangladesh traditional practices include cutting the cord with household tools such a knife or a sickle; the instrument may be placed on a dirty mat, floor, or even a banana leaf next to the woman (Darmstadt et al. 2006; Sharma et al. 2016). Nonetheless, a recent review of coverage of newborn care practices from several household surveys reported that using a clean instrument to cut the cord had the highest coverage among the practices in almost all of the countries reviewed (Sitrin et al. 2017).

1.3.2 Substance placed on the cord

As an alternative to the recommendation for dry cord care, or applying nothing to the cord, in places where home births are common and the neonatal mortality rate exceeds 30 deaths per 1000 live births, the WHO recommends applying chlorhexidine (4%) daily to the cord stump during the first week of life (WHO 2017). This practice reduces risk of sepsis, a major cause of infant mortality. The application of chlorhexidine to the cord is particularly relevant where harmful substances are traditionally placed on the cord, and it can serve as a safe substitute (WHO 2013). Successful trials in South Asia support this practice (Arifeen et al. 2012; Soofi et al. 2012; Mullany et al. 2006). Clean, dry cord care is recommended for infants born in a health facility or born at home in low-mortality settings (WHO 2017).

Around the world, substances are placed on the cord stump to promote healing and separation; a number of related beliefs and practices vary by country, region, or ethnicity (Coffey and Brown 2017; Waiswa 2008). In addition to hastening cord healing, traditional beliefs also include prevention of pain, infection, or bleeding, or to keep out evil spirits or cold air (Coffey and Brown 2017). These substances have included powder, hot compress, herbs, salt, sand, saliva, palm oil, toothpaste, turmeric, boric acid powder, coconut oil, ginger, chewed rice, charcoal, dry coffee, olive oil, butter, mustard oil, clove oil, sandalwood powder, ground seashell, antiseptics, tar, machine or motor oil, breastmilk, petroleum jelly, banana, pounded cassava, burnt nutmeg, animal dung, and others (Coffey and Brown 2017). Substances are placed on the cord regardless of whether the birth occurred at home or in a health facility; if in a facility, a substance would be placed on the cord when the infant was brought home (Coffey and Brown 2017). The potential harm of these substances has not been entirely quantified, but the vulnerability of newborns to infection, especially sepsis, is well documented, and the cord stump provides a route for infection (Coffey and Brown 2017).

1.4 Assessment of Newborn Care Practices in the DHS

The Demographic and Health Surveys (DHS) Program, which administers household-based surveys, adopted and finalized an optional Newborn Care Module in 2014 in order to standardize questions related

to newborn care practices, including thermal care and hygienic cord care.[1] The questions were based on recommendations of the Newborn Indicators Technical Working Group. However, recent surveys have not included the module verbatim as of yet. Surveys were either designed prior to the release of the module, or stakeholders in each country opted to keep the questions similar to previous surveys in order to make comparisons across time. Thus, much of the wording of the questions continues to vary from survey to survey with varying degrees of comparability. Further, in older surveys these questions were typically asked only of mothers who delivered outside of a health facility. More recent surveys have also surveyed mothers who delivered in a health facility as well. Table 1 details the surveys that have assessed these practices, as well as which questions were asked about births according to the place of delivery. While skin-to-skin is an important part of thermal care, this question is now part of the DHS core questionnaire and included in many recent surveys. Table 1 features only those surveys that included additional questions related to drying, wrapping, bathing, cord cutting, or cord care.

1.5 Study Rationale and Questions

Interventions related to thermal care and clean cord care are evidence based and low cost; however, there is scant research using population-based, nationally representative surveys to examine their coverage or how these practices may relate to neonatal mortality in high-mortality, low-income countries. Seeking to fill these gaps, this paper addresses four research questions, each with a unique sample according to survey characteristics, including the questions included in the survey, place of delivery, country, sample size, and time period. These questions are:

1. In the countries that collected data on newborn care, what is the coverage of practices such as thermal care and hygienic cord care, does coverage differ by place of delivery, and has coverage changed over time?

2. Do household-based surveys and population data support evidence of the association between newborn care practices and newborn mortality among home births?

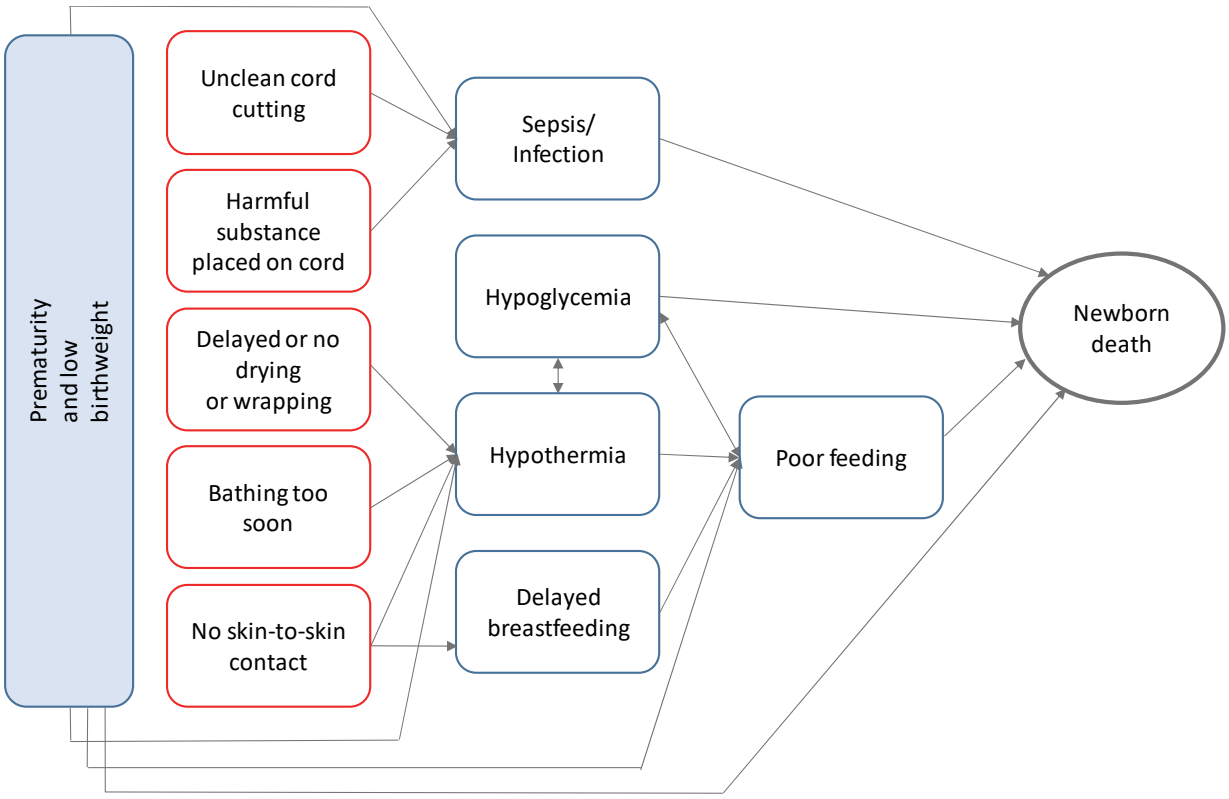
3. How have the associations between newborn care practices and mortality changed over time among home births in Bangladesh, Nepal, and India?

4. What are the key predictors of newborn care practices among home births in South Asia?

Figure 1 depicts the conceptual framework for this analysis. Our analysis examined specific practices related to thermal and cord care that contribute to newborn deaths; the framework does not include all causes of or contributors to newborn mortality. Prematurity is a risk factor for infection, hypoglycemia, hypothermia, and poor feeding, which can cause newborn death, but prematurity can also be a direct cause of death. Cord cutting with unclean instruments or putting substances other than antiseptic on a cord on the day of birth may lead to sepsis and newborn death. Early bathing and delayed or no drying or wrapping on the baby's birth day can cause hypothermia, which can lead to hypoglycemia and poor feeding, also risk factors for newborn death. Hypoglycemia may have a reciprocal relationship with both hypothermia and poor feeding. Finally, skin-to-skin contact affects feeding practices and thermal regulation.

[1] https://dhsprogram.com/publications/publication-DHSQM-DHS-Questionnaires-and-Manuals.cfm.

Figure 1 Conceptual framework of the potential effects of thermal care and cord care practices on neonatal mortality



Boxes in red typically occur in the first day of life, although harmful substances could be placed on cord after the first day of life.

Table 1a Surveys that included an assessment of thermal care practices

	Drying			Wrapping		Bathing		Skin-to-skin	
	Was baby dried before placenta delivered?	Was baby dried or wrapped (without bathing) immedi-ately?	When was baby dried?	Was baby wrapped before placenta delivered?	How long after birth was baby wrapped?	How long after bath was baby wrapped?	How long after delivery was baby bathed?	Immediately after the birth, was baby put directly on the bare skin of your chest?	Immediately after the birth, was baby put on your chest? Was the baby's bare skin touching your bare skin?
Bangladesh 2007 DHS			H		H		H		
Bangladesh 2011 DHS			A		A		A		
Bangladesh 2014 DHS			A				A	A	
Ethiopia 2016 DHS								A	
Ghana 2014 DHS						A	A		
India 2005-06 NFHS		NI							
India 2015-16 NFHS		NI							
Morocco DHS 2003-04									
Nepal 2006 DHS	NI			NI			NI		
Nepal 2011 DHS	NI			NI			NI		
Nepal 2016 DHS	A			A			A	A	
Nigeria 2013 DHS	NI			NI			NI		
Pakistan 2006-07 DHS							A		
Sierra Leone 2013 DHS			F						
Timor-Leste 2009-10 DHS	NI						NI		
Timor-Leste 2017 DHS	A						A		A

Note: Questions are asked of most recent birth in the three (Bangladesh only) or five years preceding the survey, except in Morocco, Ethiopia, and Timor-Leste, where questions are posed for all births in the five years preceding the survey. In the Bangladesh 2011 survey, questions were not administered to mothers of babies born in a health facility delivered by cesarean section. Response options are country-specific and vary by survey.
A = All places of delivery; H = Home; F = Facility; NI = Non-institutional

Table 1b Surveys that included an assessment of cord care practices

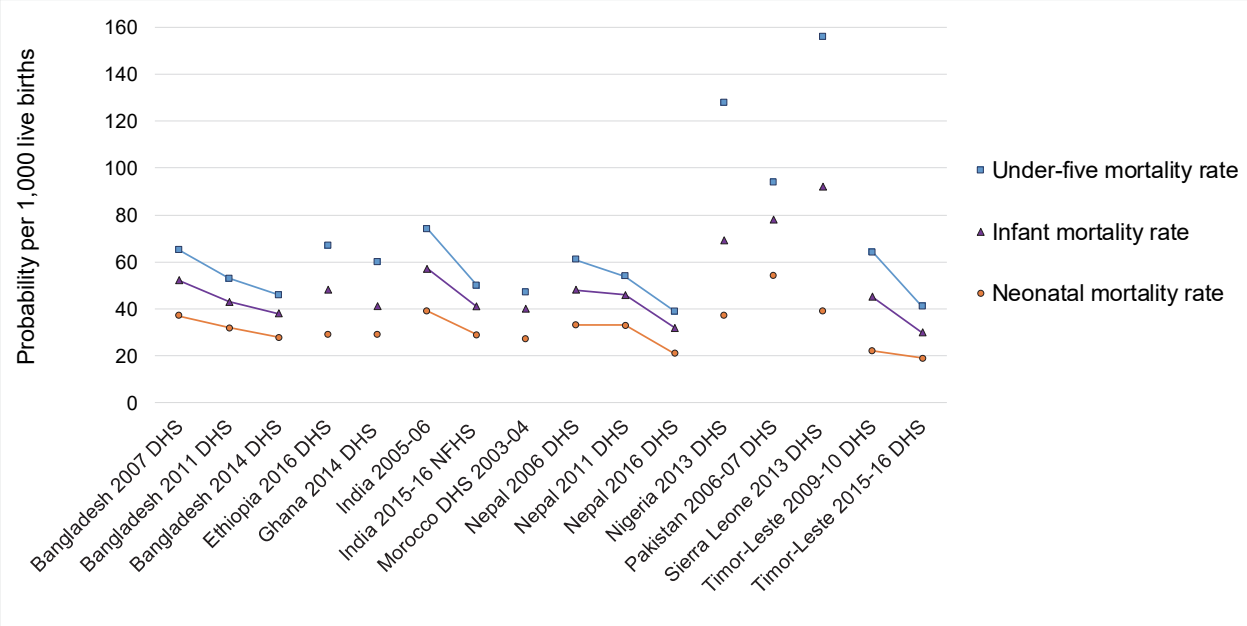
	Cord care					
	Was a clean delivery kit used?	What was used to cut the cord?	Was the instrument boiled?	Was a clean blade used to cut the cord?	What was used to tie the cord?	Was anything applied to the cord after cutting and tying?
Bangladesh 2007 DHS	H	H	H			NI
Bangladesh 2011 DHS	H	H	H			A
Bangladesh 2014 DHS	H	H	H			A
Ethiopia 2016 DHS						A
Ghana 2014 DHS						
India 2005-06 NFHS	NI			NI		
India 2015-16 NFHS	NI			NI		
Morocco DHS 2003-04		A				A
Nepal 2006 DHS	NI	NI				NI
Nepal 2011 DHS	NI	NI				NI
Nepal 2016 DHS	A	A				A
Nigeria 2013 DHS	NI	NI				NI
Pakistan 2006-07 DHS	NI	NI	NI		NI	
Sierra Leone 2013 DHS		F				
Timor-Leste 2009-10 DHS		NI				NI
Timor-Leste 2017 DHS		A				A

Note: Questions are asked of most recent birth in the three (Bangladesh only) or five years preceding the survey, except in Morocco, Ethiopia, and Timor-Leste, where questions are posed for all births in the five years preceding the survey. In the Bangladesh 2011 survey, questions were not administered to mothers of babies born in a health facility delivered by cesarean section. Response options are country-specific and vary by survey;
A = All places of delivery; H = Home; F = Facility; NI = Non-institutional

1.6 Country Context

A brief background of each country context is presented below, with more information available for countries that created a roadmap for newborn survival, modeled on the "Every Newborn" movement. Figure 2 shows the child, infant, and neonatal mortality rates based on data from each survey examined in this analysis. Among all the recent surveys included in the report, the highest level of each type of child mortality (under-five mortality, infant mortality, and neonatal mortality) occur in Nigeria (2013), and Sierra Leone (2013). In countries with multiple surveys (Bangladesh, India, Nepal, and Timor-Leste), all mortality is trending lower, with larger differences for under-five mortality than neonatal mortality rates.

Figure 2 Neonatal, infant, and under-five mortality rates



Source: ICF International, 2015. The DHS Program STATcompiler. Funded by USAID. https://www.statcompiler.com. February 5 2018.

1.6.1 South and South East Asia

Much of this report focuses on countries where we have recent or multiple rounds of surveys, including several countries in South Asia and Southeast Asia: Bangladesh, India, Nepal, and Timor-Leste. In this section we also include country context about Pakistan, although the survey included in this report is now over a decade old. The following section details the neonatal mortality and efforts to improve survival.

Bangladesh

Bangladesh achieved the Millennium Development Goal 4 (MDG) target of two-thirds reduction in under-five mortality. Between 1990 and 2016, neonatal mortality declined from 64 neonatal deaths per 1,000 live births (IGME 2017) to 20 per 1,000 (UNICEF 2018), a drastic reduction. Evaluation has shown the implementation of the Newborn Health Strategy, scale-up of many community-based care programs, increased global funding, and maintained commitment to newborn health despite changes of government have all played key roles (Rubayet et al. 2012). However, the proportion of under-five deaths that are

neonatal increased from 45% to 58% between 1990 and 2015 (IGME 2017). Bangladesh developed an Every Newborn Action Plan in 2014 to guide national efforts to improve newborn survival. Over 30,000 SBAs have been trained to implement practices from Helping Babies Breathe and 85,000 health providers were educated on fundamental newborn care, which included the use of chlorhexidine for cord care. Free maternal and newborn care policies to lower barriers to access are future goals for Bangladesh (WHO and UNICEF 2018).

India

India has the most neonatal deaths of any country (640,000 in 2016) and contributes 24% of all newborn deaths (IGME 2017), with a rate of 25 deaths per 1,000 live births (UNICEF 2018), with wide subnational variation. Neonatal mortality rates range from 7 deaths per 1,000 births in Kerala to more than 30 per 1,000 in Rajasthan and four other states (India Ministry of Health and Family Welfare 2014). India's Newborn Action Plan aims to attain a single-digit neonatal mortality rate by 2030 and emphasizes improving surveillance to track stillbirths and ending preventable newborn deaths, while prioritizing premature births, low birthweight, and sick newborns. The national plan aspires to equity and serves as a reference for state plans.

Nepal

Nepal's neonatal mortality rate is 21 deaths per 1,000 live births (UNICEF Report 2018). The National Newborn Action Plan emphasizes equity, quality, a multisectoral approach, and reform (Nepal Ministry of Health 2016). The plan reports a substantial inequality among wealth quintiles in the annual rate of decrease in the neonatal mortality rate (NMOH 2016). In addition, some ethnic groups (e.g., Dalits) are not represented in national discourse (NMOH 2016). The plan identifies several specific actions: develop and enforce national guidelines for newborn care, develop newborn health care training packages for different health cadres, expand use of chlorhexidine for every newborn and provide it to mothers during visits for antenatal care (ANC), ensure use of partographs and make timely referrals for obstetric danger signs, implement quality improvement strategies, regulate providers and standards, and improve infection prevention.

Pakistan

Pakistan has the highest neonatal mortality rate in the world: 46 per 1000 live births, contributing 10 percent of global neonatal mortality (UNICEF 2018). Although newborn health came into focus in 2000 with several policy changes, including integrating newborn care into community-based services, neonatal mortality declined by less than 1 percent between 2000 and 2010, compared to a global average reduction of 2.1 percent during that decade (Khan et al. 2012). Donor funding mentioning "newborn" increased more for Pakistan than for other countries since 2005, but impacts remain uncertain; the decision in 2012 to decentralize MOH responsibilities to the provincial level was viewed as either a potential opportunity or a threat for newborn health (Khan et al. 2012).

Timor-Leste

Timor-Leste's neonatal mortality rate is 22 deaths per 1,000 live births (UNICEF 2018). UNICEF contends that women living in rural areas cannot get services due to both lack of knowledge and inaccessibility (UNICEF 2018). An assessment in 2015 found that only 50 percent of municipalities had coverage of

Emergency Obstetric and Newborn Care (EmONC) services and there were no Basic Emergency Obstetric and Newborn Care (BEmONC) facilities outside of Dili, the capital city (UNFPA 2015). The RMNCAH Strategy 2015-19 identified differences in postnatal care (PNC) by wealth, women's education, geographic area, and urban residence. The Strategy also acknowledges that a roadmap for newborn survival, modeled on the Every Newborn Action Plan, would be useful, though it has not been adopted (Timor-Leste Ministry of Health 2015).

1.6.2 Africa

Our study also includes several countries in sub-Saharan Africa with recent DHS surveys, and one older survey conducted in northern Africa (Morocco 2003-04). We provide country-specific context for countries with recent surveys assessing newborn care. Among four African countries with recent surveys including an assessment of newborn practices (Ethiopia, Ghana, Nigeria, and Sierra Leone), we found the highest newborn mortality in Sierra Leone and Nigeria.

The National Strategy for Newborn and Child Survival in Ethiopia 2015/16-2019/20 (Government of Ethiopia 2015) acknowledged the need to scale up interventions including PNC, and identifies the most effective interventions for reducing neonatal mortality in Ethiopia as institutional delivery and breastfeeding, with additional plans to introduce new interventions including community case management of neonatal sepsis, chlorhexidine cord care at birth in communities and facilities, and antenatal corticosteroids in hospitals to prevent deaths among preterm births. Ghana's National Newborn Health Strategy and Action Plan 2014-2018 acknowledged that most newborn deaths occur at home. It expressed intentions to increase deliveries with a skilled birth attendant (SBA), PNC, and early initiation of and exclusive breastfeeding. It also noted that newborn health has not been prioritized at any level and newborn indicators are not included in the health management information system. Nigeria's Every Newborn Action Plan (2016) identified priority actions under each of the WHO health system building blocks (WHO 2010), including strengthening the Newborn Subcommittee of the Ministry of Health and ensuring representation from stakeholders, improving health worker skills, upgrading infrastructure, and establishing a monitoring and accountability framework. Likewise, Sierra Leone created the Reproductive, Maternal, Newborn, Child and Adolescent Health (RMNCAH) Strategy 2017-2021, which prioritized neonatal resuscitation, kangaroo mother care, clean delivery practices, immediate essential newborn care, and treatment of infections and sepsis (Sierra Leone Ministry of Health and Sanitation 2017).

More recently, in Morocco, the neonatal mortality rate is 17.8 per 1000 live births (UNICEF 2018). Neonatal mortality accounts for over 70 percent of child mortality in Morocco; the main causes are severe infections, complications of preterm birth, and birth asphyxia (El Hajjaoui 2015). To narrow gaps in access to care, the 2012 – 2016 National Action Plan accelerated the reduction of maternal and neonatal mortality by prioritizing rural areas to receive upgraded services (El Hajjaoui 2015). UNICEF has supported newborn care in Morocco through standardization of essential newborn care, operationalizing a neonatal care network, institutionalizing audits of stillbirth and neonatal deaths, and supportive supervision (UNICEF 2017).

2 DATA AND METHODS

2.1 Data

This study used data from DHS surveys in 10 countries: Bangladesh (2007, 2011, 2014), Ethiopia (2016), Ghana (2014), India (2005-06, 2015-16), Morocco (2003-04), Nepal (2006, 2011, 2016), Nigeria (2013), Pakistan (2006-07), Sierra Leone (2013), and Timor-Leste (2009-10, 2017). These surveys were included because each survey assessed thermal care practices (drying, wrapping or bathing), cord care practices, or both. The DHS Program conducted nationally representative, population-based household surveys in collaboration with the host countries.

The surveys employed a multistage cluster sampling strategy. All women age 15-49 were eligible for interview in selected households. Mothers with a live birth in the five years preceding each survey (or three years in surveys conducted in Bangladesh) received additional questions on care she received during pregnancy, birth, and in the postnatal period. In this section, some surveys have opted to include the Newborn Care Module or similar questions related to care of the baby immediately after delivery or in the first month of life.

2.2 Methods

2.2.1 Indicator construction

Table 2 shows the indicators of thermal care and cord care used in this analysis and their significance for newborn survival. Questions and response options varied slightly across surveys, particularly in surveys conducted prior to the finalization of the module, although we believe the way in which we constructed the variables allows for comparison across time and surveys. Following guidance on the indicators presented by Sitrin et al. (2017), we standardized the definitions across surveys.

Although drying a baby immediately has the dual benefit of providing thermal care and stimulating breathing, wrapping is also a relevant intervention for thermal care and is recommended for thermal care in instances where the mother is unavailable for skin-to-skin contact (Lunze and Hamer 2012; WHO 1997). Drying was not assessed in all surveys, and wrapping may serve as a proxy indicator for thermal care. Further, the two practices of drying and wrapping are highly correlated (Sitrin et al. 2017). Therefore, we combined drying and wrapping into one indicator where both practices were assessed, and wrapping was used as a proxy for drying where drying was not assessed. It should be noted that questions on wrapping are not included in the Newborn Care Module; thus, combining the two questions in future studies may not be possible. However, wrapping has continued to be included in recent surveys, which made combining the responses for drying and wrapping possible for this study.

Another component of thermal care, skin-to-skin care, was only assessed in four recent surveys. Prior to Phase 7 of the DHS, skin-to-skin care was not routinely assessed, and if it was, it was typically assessed with one question, phrased as “Immediately after birth, was the baby placed on the bare skin of your chest?” However, a recent validation study found responses to this question to have low validity and high bias (Blanc et. 2016). The study recommended a two-part question, which notably lessened women’s over-reporting of skin-to-skin, and has been incorporated into the DHS Phase 7 core questionnaire. Only one of

the four surveys assessed in this study included this two-part question, thus results should be interpreted with caution. However, given the evidence around skin-to-skin care, future studies should seek to include it, particularly with use of more recent DHS survey data that includes the two-part question.

We coded each variable into three categories: "yes" if the baby received the intervention as defined, "no" if the baby did not receive the intervention, or "don't know" or missing. For drying and bathing, a "yes" was given if the practice occurred at the appropriate time and "no" if at an inappropriate time, as defined in Table 2 below. In Bangladesh and Ghana, the surveys also included "not dried" and "not bathed" as response options. We cannot know if the respondent interpreted this question as "not bathed (or dried) immediately after birth" or if she responded this way because the baby died before being bathed or dried. Therefore, we included this response in the missing or "don't know" category.

While chlorhexidine is the recommended antiseptic to apply to the umbilical cord after it is cut, chlorhexidine use is only assessed in three surveys (Bangladesh 2014, Nepal 2011, and Nepal 2016). Further, as chlorhexidine use has only recently been promoted for use in high-mortality settings, implementation is still uncommon. Therefore, we grouped chlorhexidine with other antiseptics to create an "antiseptic" application category.

We created composite indicators of thermal care and hygienic cord care in order to assess whether the newborn received the "full" suite of recommended interventions, as defined in Table 2. These variables were coded as: whether the newborn received both practices, whether they received some or none, or whether the mother had any "don't know" or missing response. While some thermal or clean cord care would undoubtedly be better than no recommended practice, we coded these composite indicators in as few categories as possible given the limited number of expected neonatal mortality events reported by surveyed women. Skin-to-skin was also not included in the composite thermal care indicator as so few surveys included an assessment of this practice.

We harmonized these indicators to the extent possible; however, there are a few exceptions to note. As mentioned, the Bangladesh surveys include an assessment of care practices only for births in the preceding three years; for the 2007 survey these questions only applied to children born from January 2004 to the time of the survey (slightly longer than a three-year history depending on survey month). Additionally, in this survey, babies delivered by cesarean section were excluded.

Table 2 Definitions of newborn care practices

Intervention	Indicator	WHO Recommendation[1]	Harmonized Response Categories	Notes
Thermal care	Immediate drying or wrapping	Dried or wrapped immediately[2]	(1) Dried or wrapped within five minutes of birth or before delivery of the placenta (2) Dried or wrapped after five minutes of birth or after delivery of the placenta (3) Not dried, don't know, or missing	Only Bangladesh and Sierra Leone included options for not being dried or wrapped
	Delayed bathing	Bathed after 24 hours; however, after 6 hours may be appropriate in certain contexts	(1) Bathed six hours or more after birth (2) Bathed within the first six hours of birth (3) Not bathed, don't know, or missing	Only surveys in Bangladesh and Ghana included an option for "Not bathed"
	Immediate skin-to-skin contact	Skin-to-skin contact between babies and mothers during the first hour after birth	(1) Skin-to-skin contact immediately after birth (2) No skin-to-skin immediately after birth (3) Don't know, or missing	Only included in 4 surveys
	Composite thermal care	Thermal care for all children	(1) Both recommended thermal care practices including immediate drying or wrapping and delayed bathing (2) No thermal care or partial thermal care (neither or only one recommended practice) (3) Don't know or missing to either recommended thermal care practice	Does not include skin to skin due to lack of availability
Hygienic cord care	Clean instrument used to cut the cord	A new or boiled instrument should be used to cut the cord	(1) A new or boiled instrument was used to cut the umbilical cord, or a clean delivery kit was used (2) A used or non-boiled instrument (3) Don't know or missing	Clean instruments could include (boiled or new) blade, scissors, or knife. Other instruments included bamboo, sickle, fodder cutter, or other.
	Nothing applied to the cord	Dry cord care is recommended; however, in high-mortality settings chlorhexidine is recommended	(1) Nothing was put on the umbilical cord stump (2) Only an antiseptic and no other substance (3) Any other substance applied (4) Don't know or missing	Antiseptics: chlorhexidine, betadine, methylated spirits, gentian violet, Dettol, antibiotic. Other substances: mustard oil, ghee, turmeric, chewed rice, ginger juice, powder, oil, ash, vermillion, dung, local herbs, toothpaste, henna, mud, coffee, flour.
	Composite hygienic cord care	Hygienic cord care for all children	(1) Both recommended cord care practices (including a clean instrument used to cut the cord and antiseptic or dry cord care) (2) No or partial hygienic cord care (neither or only one recommended cord care practice) (3) Don't know or missing to either recommended cord care practice	

[1] WHO 2017
[2] WHO 1997

2.2.2 Coverage of newborn care practices

We examined data among different subpopulations of women interviewed in these surveys to address our research questions. To address our first question on the coverage of newborn care practices, differences by place of delivery, and changes over time, we examined most recent births to women with a live birth in the preceding five years by birth location (at home or in a health facility) and over time, if applicable. The majority of surveys assessed all non-institutional births, including births delivered at home or in other, unspecified places (see Table 1); however, we chose to not examine births that were delivered in other, unspecified places and focus on home deliveries and facility-based deliveries since the circumstances around those "other" locations are unknown and could vary widely—from a roadside delivery to a health facility in another country. Note that among surveys that assessed newborn care practices for births delivered in a health facility, the Bangladesh 2011 survey sample was limited to non-cesarean section births.

Table 3 presents the number and percentage of births delivered in a health facility or at home (respondent's home or other home) but excludes births born in unspecified places, labelled as "other", or with a missing response for place of delivery, which are typically fewer than 2% of births in each survey. Where applicable, we then tested the differences in the proportion of births receiving the recommended practice, not receiving the practice, and the "don't know" or missing response category by place of delivery (home or facility) using chi square tests of independence. The results of the tests of significance (p-values) are included in the appendix tables. We only tested the significance of the difference in coverage by place of delivery within each survey. To assess changes in coverage over time, we compared estimates and confidence intervals. Non-overlapping confidence intervals indicate significant differences, while overlapping confidence intervals indicate non-significant or marginally significant differences.

2.2.3 Newborn care practices and newborn mortality

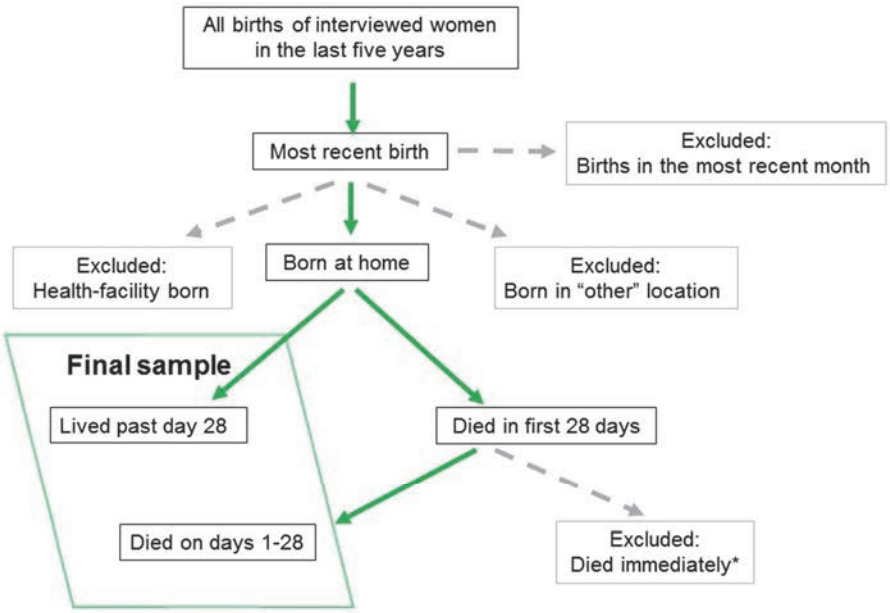
To address our second question, do our data show evidence of an association between newborn care practices and newborn mortality, we restricted the analysis to a more limited sample, as Figure 3 illustrates. We limited our sample in three ways: only included home births; excluded infants who died immediately (on the first day of life), which ranged from 20% of newborn deaths in the 2014 Ghana survey to 73% in the 2016 Timor-Leste survey; and excluded all babies born in the month before the survey. We analyzed only home births because only a small subset of surveys collected data on newborn care practices for births delivered in a health facility, and there may be important confounders between mortality, facility delivery, and newborn practices for which this analysis cannot account. Although excluding neonates who died on the first day of life may underestimate the effects of the practices on mortality, structuring the analysis in this way avoids including cases where the death preceded these care practices. Because the health care systems and care-seeking behaviors have changed over time, this portion of the analysis only includes countries with recent surveys, or surveys conducted in the last 5 years (since 2013).

Ensuring that the exposure to newborn care practices precedes the outcome (newborn mortality) was not possible for all of our indicators. Drying/wrapping immediately, delayed bathing for at least 6 hours, and object used to cut the cord are events that occur in the first day, but the custom of putting a substance on the cord could occur later; the question on this indicator does not specify the exact timing—a limitation in examining this practice as it is associated with mortality.[2] Finally, we excluded babies born in the most recent month before the survey to prevent censoring of data, or to ensure that all births included in the sample had the potential to live through the entire newborn period. Numbers of deaths before and after these exclusions are shown by survey in Table 3.

Similar to methods presented in Section 2.2.2, we conducted tests of the significance of the difference using chi square tests of independence, with p-values presented in the appendices. These tests included the differences in mortality by whether the mother reported that the baby did receive the intervention, did not receive the intervention, or had a don't know or missing response. In the main text of the report, we compare differences in mortality excluding the don't know category. We compare the differences using the confidence intervals.

[2] The DHS Newborn Care Module assessment of application of chlorhexidine includes a question about timing of first application; however, only one survey to date (Nepal 2016) has included this question in their survey.

Figure 3 Sample selection for analysis of newborn care practices and mortality



*Death likely due to pregnancy or birth-related complications, despite receipt or consequence of newborn care practices under study

Table 3 shows the total number of births occurring at home and in a health facility, as well as the total number of deaths in the first month, excluding births in the month before the survey and deaths on the first day of life. As the table shows, there were very few deaths reported in most surveys—fewer than 50 (unweighted) deaths in 9 of the 16 surveys—suggesting that results should be interpreted with caution. We conduct chi square tests of independence again to test the significance of the difference in deaths by receipt of the intervention, although we expect that this analysis lacked adequate power when examining most surveys individually. For instance, in the 2014 Bangladesh survey, 67% of 2,836 home births were dried within five minutes after birth; Bangladesh has an NMR of 28 deaths per 1,000 live births (National Institute of Population Research and Training (NIPORT), Mitra and Associates, and ICF International 2014). If, for example, we found that among those 67% births who were immediately dried, 2.2% of newborns died but, in contrast, 3.2% of newborns died among those who were dried later, we would only have 34% power to detect a significant difference at $\alpha < 0.05$.

Since newborn mortality is a relatively rare event and our sample of deaths is greatly reduced by the necessary exclusions detailed above, we pooled data from the most recent surveys conducted in the last five years for evaluating associations between thermal and cord care practices and newborn mortality: Bangladesh 2014, Ethiopia 2016, Ghana 2014, India 2015-16, Nepal 2016, Nigeria 2013, and Timor-Leste 2015-16. When pooling these data, the individual weights, which adjust for sample design and non-response, were either scaled up for smaller surveys or scaled down for larger surveys. In weighting this way, each survey held equal weight in the pooled analysis—or an equal share of weighted cases in the total. This method also accounts for the differences by country context without overemphasizing larger samples.

In this part of the analysis, we pooled 65,938 home births from the seven most recent surveys assessing newborn practices. Before applying equal weighting, India's survey was the largest and contributed to over half of the total number of cases; data from respondents in Ghana and Nepal only contributed to less than 3% of the total share each. After applying equal weights, each survey contributed to 14% of the total, or 9,420 cases. See Table 4.

Table 3 Numbers of births and deaths analyzed by survey

		Most recent live births				Deaths in the first month among most recent live births			
	Women with a live birth	Born in a health facility		Born at home		All deaths	Excluding deaths of children born in the month preceding the survey	Excluding deaths of children born in the month preceding the survey and deaths on day 1	Births included in the mortality analysis
	N	N	%	N	%	N	N	N (un-weighted N)	N
Bangladesh 2007	3,352	588	17.5	2,752	82.1	52	52	34 (24)	2,707
Bangladesh 2011*	4,652	1,352	29.1	3,291	70.8	50	50	33 (38)	3,206
Bangladesh 2014	4,627	1,784	38.6	2,836	61.3	53	53	30 (29)	2,765
Ethiopia 2016	7,590	2,409	31.7	5,066	66.8	102	101	73 (57)	4,898
Ghana 2014	4,142	3,116	75.2	1,011	24.4	9	9	9 (10)	995
India 2005-06	39,677	16,457	41.5	23,135	58.3	597	588	419 (317)	22,691
India 2015-16	184,641	149,768	81.1	34,325	18.6	871	863	555 (619)	33,733
Morocco 2003-04	4,695	2,986	63.6	1,689	36.0	31	30	24 (24)	1,663
Nepal 2006	4,066	790	19.4	3,221	79.2	56	54	34 (42)	3,160
Nepal 2011	4,148	1,598	38.5	2,480	59.8	46	44	29 (27)	2,440
Nepal 2016	3,998	2,298	57.5	1,521	38.1	20	20	9 (10)	1,488
Nigeria 2013	20,467	7,649	37.4	12,755	62.3	334	328	262 (268)	12,505
Pakistan 2006-07	5,677	2,101	37.0	3,545	62.4	147	145	90 (87)	3,425
Sierra Leone 2013	8,647	4,913	56.8	3,687	42.6	110	106	82 (72)	3,599
Timor-Leste 2009-10	6,015	1,512	25.1	4,500	74.8	73	72	49 (51)	4,410
Timor-Leste 2016	5,000	2,533	50.7	2,458	49.2	48	46	10 (6)	2,364

Note: Ns and % based on most recent births born in the 5 years preceding each survey except Bangladesh, where all analyses are based on births in the preceding 3 years. In the Bangladesh 2011 survey, questions were not administered to mothers of the 799 babies born in a health facility delivered by cesarean section. Births born in other locations are excluded. All numbers and percentages are weighted according to the survey sample weights, except in the column indicating the number of deaths excluding births in the month preceding the survey and deaths on day 1, where both weighted and unweighted numbers of deaths are shown.

In addition to the exclusions described above, the analysis of the association between mortality and practices among recent surveys also excluded "don't know" or missing responses in order to isolate the relationship between each indicator and newborn mortality. In the pooled analysis we analyzed only surveys that included questions for that particular indicator. Thus, the total number of cases varies at this stage depending on the number of surveys that included questions on the indicator and the number of missing cases for each indicator. For drying and wrapping, the total included 54,089 births; bathing, 46,134; both thermal care interventions, 44,966; instrument used to cut the cord, 44,739; substance placed on the cord, 44,793; and both hygienic cord care interventions, 34,163 births.

Table 4 Pooled sample sizes before and after application of equal weights

	Country weighted		Equally weighted	
	N	%	N	%
Bangladesh 2014	2,765	4.7	9,419.7	14.3
Ethiopia 2016	4,898	8.4	9,419.7	14.3
Ghana 2014	995	1.7	9,419.7	14.3
India 2015-16	33,733	57.4	9,419.7	14.3
Nepal 2016	1,488	2.5	9,419.7	14.3
Nigeria 2013	12,505	21.3	9,419.7	14.3
Timor-Leste 2016	2,364	4.0	9,419.7	14.3
Total	**65,938**	**100**	**65,938**	**100**

2.2.4 Newborn care practices and newborn mortality in South Asia

To address our third question, how have the associations between newborn care practices and mortality changed over time in Bangladesh, Nepal, and India, we examined India separately from two pooled samples in Bangladesh and Nepal—the most recent surveys (Bangladesh 2014 and Nepal 2016) and the second most recent surveys (Bangladesh 2011 and Nepal 2011). We deemed this appropriate given the discrepancies in the questions asked: Bangladesh and Nepal both included questions on bathing and substance applied to the cord, whereas India did not. By pooling Bangladesh and Nepal and keeping India separate, we could examine the practices separately as well as by the composite thermal care or hygienic cord care indicators. One important difference to note between the Bangladesh and Nepal surveys is that the survey in Nepal included births in the five years preceding the survey, versus the preceding three years in Bangladesh.

Again, pooled samples in the two rounds of Bangladesh and Nepal were weighted equally, included most recent home births, and adhered to the same exclusion described above. Applying these equal weights, the adjusted sample for Bangladesh and Nepal 2011 surveys included 5,464 births, equally weighted between the two surveys (2,732 in each) and 4,214 births in the two more recent surveys, also with equal weights ensuring that each survey only accounted for half of the cases (2,107) in the pooled sample. The sample for India included 23,135 births in 2005-06 and 34,325 births in 2015-16.

We evaluated the change in the association between independent variables of newborn care practices and our dependent variable, newborn mortality, by comparing the magnitude and strength of the associations over time. We conducted unadjusted and adjusted logistic regression, where again we excluded births in the month preceding the survey and deaths on the first day of life. Adjusted models controlled for known predictors of newborn mortality, including mother's sociodemographic characteristics, care-related and care-seeking behaviors, and birth characteristics. Sociodemographic characteristics of the mother that have been found to be associated with newborn mortality are: place of residence, wealth, education, religion (Titaley et al. 2008), maternal age at birth (Kumar et al. 2013; Lawn et al. 2005), preceding birth interval (Conde-Agudelo et al. 2006), previous child under age 5 died (Winter et al.), receipt of ANC (Arunda et al. 2017), tetanus toxoid vaccine coverage (Lawn et al. 2012), size at birth as a proxy for premature birth (Lawn et al. 2005), gender of child, skilled attendance at birth, and PNC (WHO and UNICEF 2009). Tetanus was only included in the adjusted models in India since it was not assessed in the Bangladesh 2014 survey. We did not include birth order because of its correlation with maternal age. We did not control for additional country-specific variables such as caste, region, or state. Each of these controls comprise many categories; given the rarity of neonatal mortality, including these in an adjusted model would result in empty cells that

would invalidate the model; regrouping these variables into fewer categories could otherwise negate their meaningfulness.

2.2.5 Predictors of newborn care practices in South Asia

Finally, to address our fourth question on what are the key predictors of newborn care practices among home births in South Asia, we examined data from the most recent surveys in India, Bangladesh, and Nepal. As the questions included in India were different from those in Bangladesh and Nepal, we examined the composite thermal care and hygienic cord care practices in Bangladesh and Nepal, but in India examined only drying or wrapping and the instrument used to cut the cord. In one study on clean delivery practices using data from randomized control trial studies conducted in these three countries, maternal age, education, attendance at ANC, skilled attendance at birth, and gestational age of the baby were associated with clean practices in at least one of the three countries (Seward et al. 2012). We included these variables to the extent possible and explored additional covariates of interest. A study by Mullany et al. (2010) found an association between hypothermia and sex of the baby, thus warranting further study on newborn care practices by gender. Our adjusted models control for country (for the pooled Bangladesh and Nepal sample), place of residence, wealth, education, religion, maternal age at birth, birth interval, previous child death, ANC, size at birth (as a proxy for gestational age), sex of the child, and delivery with an SBA. We also included the other newborn care intervention (thermal care or hygienic cord care, depending on which one was the outcome in each model) to test the association between the practices. As these practices are understudied, these models were for exploratory purposes.

3 RESULTS

3.1 Coverage of Newborn Care Practices

3.1.1 Thermal care

Drying and wrapping

Among the most recent surveys conducted in any study country since 2013, the practice of drying or wrapping an infant immediately after a home birth was common in Ghana, India, and Nepal, occurring in four out of five births. This practice was slightly less common among home births in the most recent survey in Bangladesh, occurring in three out of five births, and not common in the recent Nigeria and Timor-Leste surveys, occurring in two out of five births (Figure 4).

In countries with multiple surveys assessing the practice of immediate drying or wrapping, Bangladesh, Nepal, and India show significant increases over time among home births. In Bangladesh, the rapid increase in these practices among home births occurred largely between 2007 and 2011, where it rose from 7% to 54%. Nepal's increases over time were consistent gaining over 15 percentage points in each successive survey, and India nearly doubled over the 10-year interval between surveys, rising from 45% to 81%. In Timor-Leste, a large and significant decrease occurred between the 2009-10 and 2016 surveys. Timor-Leste is the only country to show a decline in the practice of drying or wrapping over time among home births.

All surveys reporting this practice for births in a health facility showed a higher prevalence of drying or wrapping in health facility births compared with home births, except the 2014 Ghana DHS. Among the most recent surveys, difference between drying and wrapping among home births and facility births was significant in Nepal 2016 and Timor-Leste 2016.

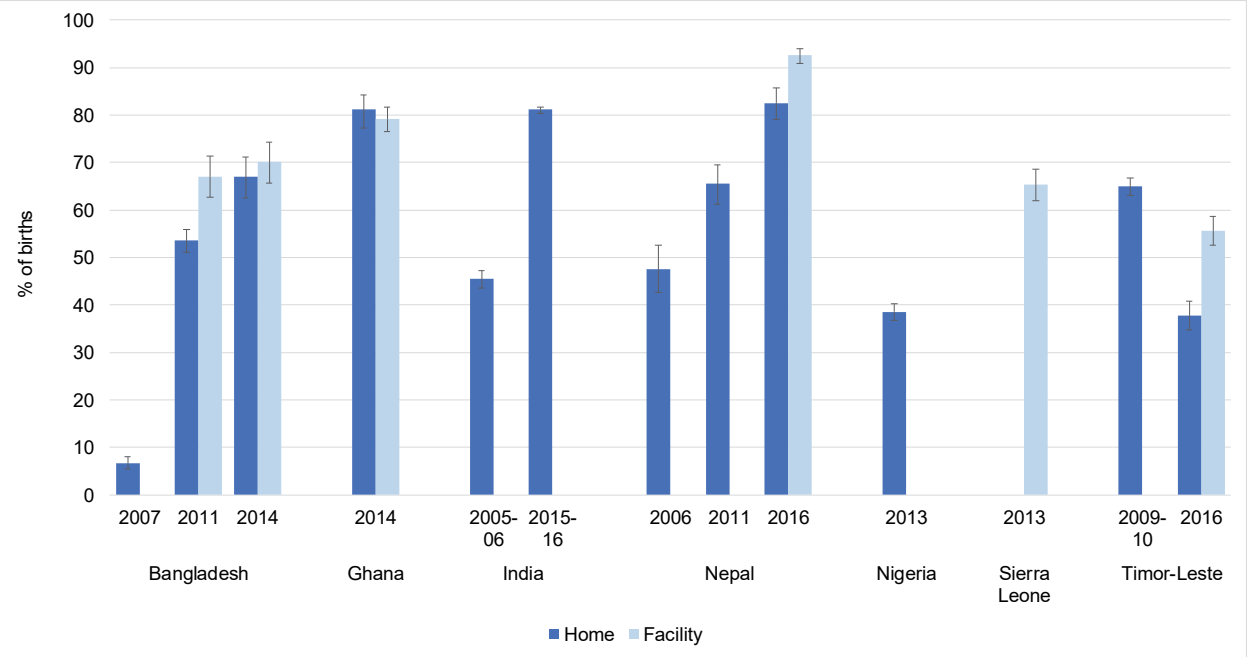
Appendix Table 1a includes supporting estimates, confidence intervals, and p-values of the significance of the difference between home and facility-based births where applicable, as well as estimates for the proportion of mothers with missing or "don't know" responses pertaining to whether or not a baby was dried or wrapped. Among the most recent surveys, Bangladesh and Timor-Leste show that nearly one in ten women who delivered at home reported "don't know" when asked about the drying or wrapping of their newborn. Among facility births, the same proportion of women reported "don't know" in the recent Timor-Leste, and in Sierra Leone 21% of women also reported not knowing if their newborn was dried or wrapped.

In these surveys, one response option allowed a mother to report that the baby was "not dried." Additional tabulations revealed that large proportions of babies were not dried; however, 85% of these babies in the Bangladesh 2007 survey were bathed immediately or bathed less than two hours after birth (results not shown). In Sierra Leone the survey first asked whether the baby was wiped dry after birth. If the response was yes, the survey then asked about the length of time after birth the baby was wiped. If the response was no or "don't know", the respondent was not probed further. These slight differences in wording may have account for some of the discrepancies in the findings between countries.

Appendix Table 1b presents the estimates and confidence intervals among home and facility births for responses related to whether a baby was dried immediately, apart from wrapping. Comparing Appendix

Table 1a and 1b, for most surveys, the percentage of babies who were either dried or wrapped immediately is only slightly higher than the percentage who were immediately dried without consideration of wrapping.

Figure 4 Percentage of babies who were dried or wrapped immediately after birth by place of delivery



Delayed bathing

Figure 5 shows that coverage of the recommended practice of delayed bathing (at least six hours after birth) differed substantially by country and by place of delivery. In the most recent surveys, some countries report that delayed bathing among home births is somewhat common, such as in Bangladesh (66%) and Nepal (57%), yet the practice in facility births is significantly higher in both countries, occurring in over nine out of ten births. In Timor-Leste's most recent survey, delayed bathing among home births is not common at only 23%, though the practice occurs at a significant threefold among facility births. The practice is rare among home births in Nigeria (6%) and Ghana (9%), and though still rare among facility births in Ghana, occurring in one in five births, the difference is significant. Further information is provided in Appendix Table 2.

In countries where bathing was examined in multiple surveys, the practice significantly increased over time among home births. In Bangladesh—the only country where we can examine changes over time in delayed bathing among facility births—there was no significant change in the practice, which has been prevalent in Bangladesh since at least 2011, occurring for at least 90% of facility births.

Skin-to-skin

Only four surveys that included additional questions on newborn thermal care and cord care practices also assessed skin-to-skin contact between the baby and mother immediately after birth (Figure 6, Appendix Table 3). This practice is more often implemented for facility births compared with home births, and this difference is significant in Ethiopia, Nepal, and Timor-Leste. The coverage of skin-to-skin for home births

ranges from 9% in Ethiopia 2016 to 38% in Nepal 2016. For facility-based deliveries, the practice ranged from 28% in Bangladesh to 90% in Timor-Leste.

Figure 5 Percentage of babies with delayed bathing by place of delivery

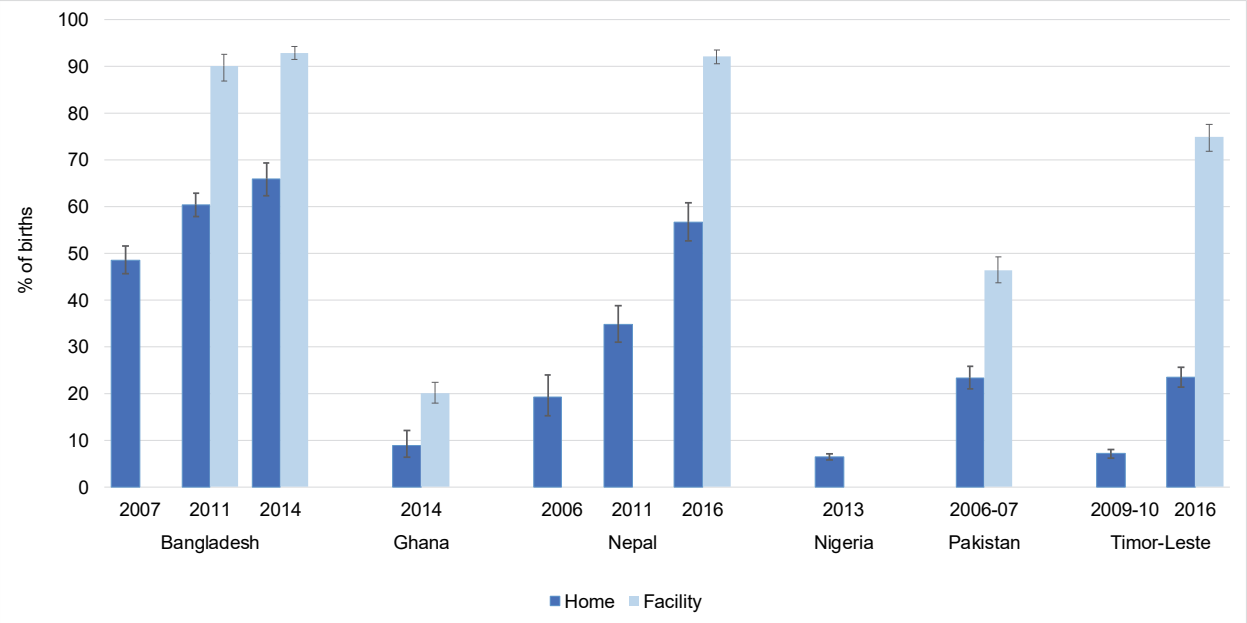
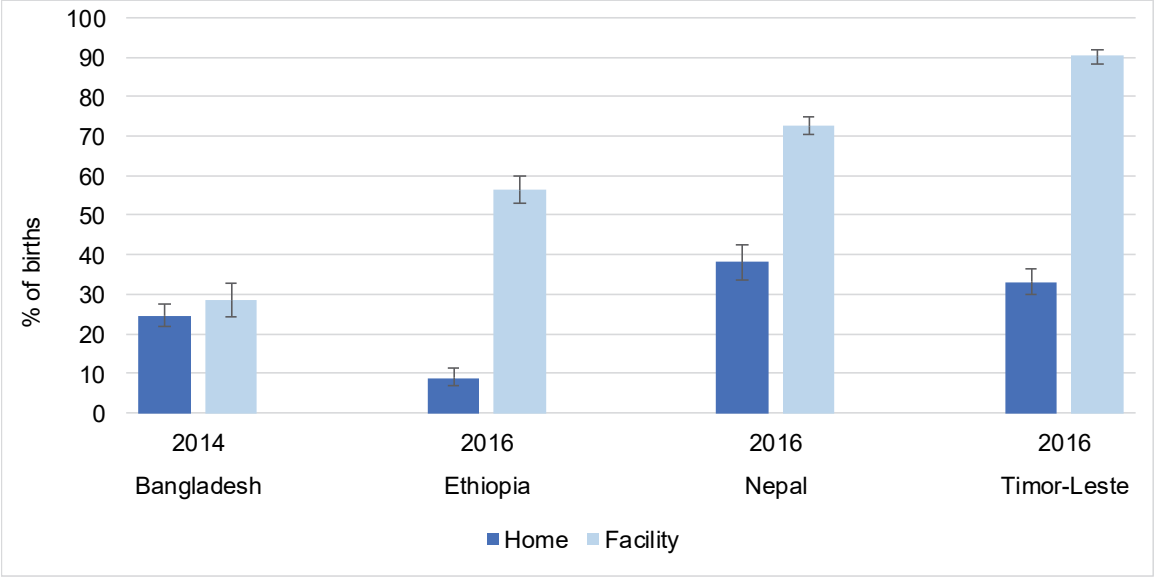


Figure 6 Percentage of babies with immediate skin-to-skin contact by place of delivery

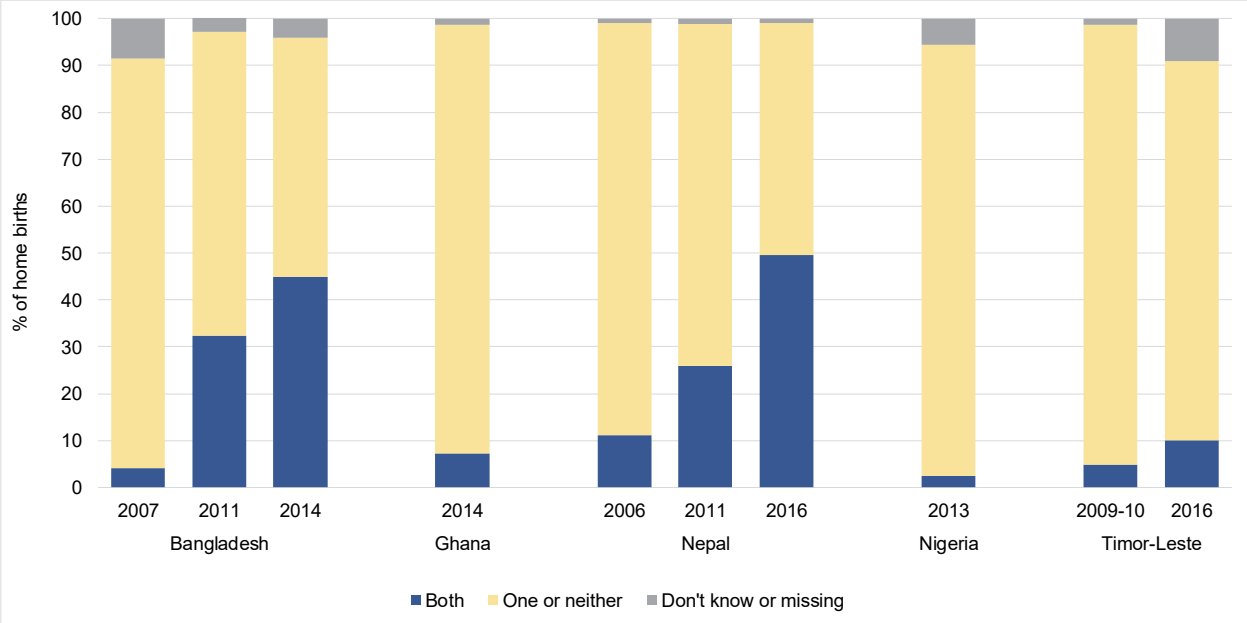


Composite thermal care

We combined both components of thermal care—drying or wrapping immediately and delayed bathing—to create a composite indicator of thermal care. Composite thermal care estimates were examined by whether a newborn had incomplete/partial or no thermal care (0 or 1 components), both thermal care

components, or “don’t know” or missing responses. Incomplete thermal care was the most common type of care in any survey studied, though there were significant decreases in incomplete thermal care over time, and significant increases in both thermal care practices. Figure 7 shows these findings, with additional statistics reported in Appendix Table 4.

Figure 7 Thermal care practices among home births



3.1.2 Hygienic cord care

Clean instrument

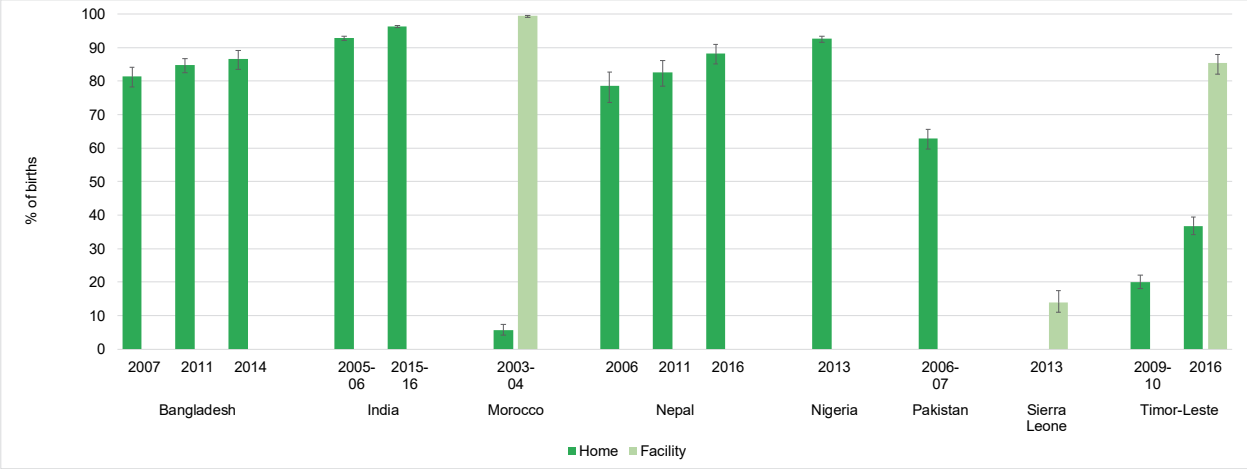
Clean instruments were very commonly used for cord care in four of the eight study countries—Bangladesh, India, Nepal, and Nigeria (Figure 8, Appendix Table 5). In these four countries, the most recent estimates show that nearly nine in ten births at home were accompanied by cord cutting with a clean instrument. It was uncommon in the most recent survey in Timor-Leste, at 37%, although this represents a significant increase from 20% in the earlier survey in 2009-10. In Bangladesh and Nepal, the practice of cord cutting with a clean instrument increased slightly over time, though not significantly, according to confidence interval estimations (Figure 7, Appendix Table 4). India, where births at home commonly follow clean cord cutting practices, had a small but significant increase, from 93% in 2005-06 to 96% in 2015-16. In Morocco clean cord cutting for home births was rarely practiced, at 7%, although this survey was conducted in 2003-04 and may not reflect more current practices.

Only a few countries measured clean cord cutting for births in a health facility—Timor-Leste 2016, Sierra Leone 2013, and Morocco 2003-04. In Timor-Leste, 75% of all births occurred in a facility and clean cord cutting was common in health facilities (85%), a significantly different estimate of home births with clean cord cutting practices. The 2013 Sierra Leone DHS measured clean cord cutting only among facility births. While 42% of births occurred in a health facility (Table 3), only 14% of these births had cord cutting with a clean instrument. In Morocco clean cord cutting was almost universal among births delivered in a health

facility (99%). This is 20 times the prevalence of clean cord cutting among home births, though health facilities delivered only 36% of births in Morocco (Table 3).

Among home births surveyed, if a respondent did not specify that a new or boiled blade was used, the most common instrument used to cut the cord was either scissors (Timor-Leste), or a razor blade, scissors, or knife (Morocco) (results not shown). The questionnaire did not include additional probes as to whether these instruments were new, clean, or boiled. In Pakistan, among the third of babies whose cord was cut with an unclean instrument, the most common instrument was non-boiled scissors, knife, or blade.

Figure 8 Clean instrument used to cut the umbilical cord by place of delivery



Substance placed on cord

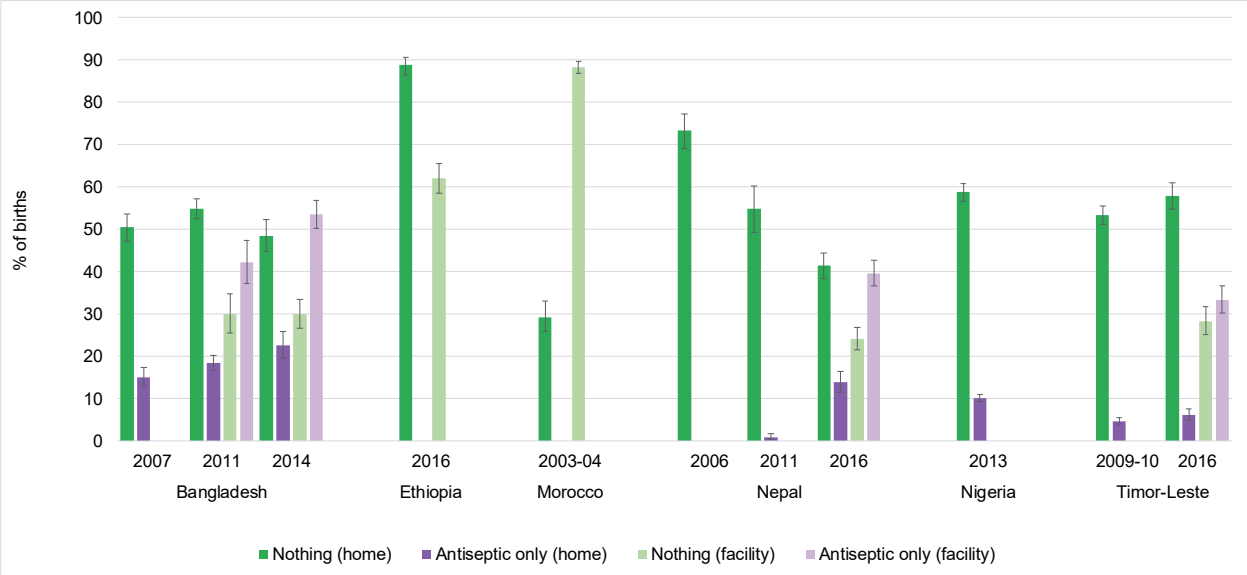
After a newborn's umbilical cord is cut, the recommended practice is to put nothing on the stump of the cord (dry cord care). In high-newborn-mortality settings, the use of chlorhexidine is also recommended by WHO for application to the umbilical stump for babies delivered at home. Figure 9 shows estimates for cord care practices in the six study countries with available data, with supporting information provided in Appendix Table 6. Four countries reported whether an antiseptic was applied to the cord for home births, and Appendix Table 7a shows the specific type of antiseptic used among home births in these four countries; unspecified antiseptics or antibiotics are the most common across surveys. Appendix Table 7b includes the estimates for the two most common types of other or harmful substances placed on the cord in each country; overall, oil was the most common and powder (either boric powder, non-specified powder, or powder and/or ointment) was the second most common substance.

Among the most recent surveys, Ethiopia reports very high prevalence (90%) of dry cord care among home births, while in Nigeria and Timor-Leste just under 60% of home births receive dry cord care. In Nigeria and Timor-Leste around one in ten home births received antiseptic instead of dry cord care. In the most recent survey in Nepal, 41% of home births received dry cord care and 14% received antiseptic. More facility births in Nepal received antiseptic and less dry cord care than home births. These differences were significant when comparing confidence interval estimates. In Bangladesh's recent survey, 48% of home births received dry cord care and 23% received antiseptic. Significantly different were the facility births, where more newborns received antiseptic and fewer newborns received dry cord care than newborns delivered at home.

In comparing confidence intervals around the estimates, Bangladesh shows no significant changes among home births receiving dry cord care or antiseptic over time, though there is a small but significant increase in facility births receiving antiseptic. Combining dry cord care and antiseptic care in each survey year reveals that the percentage of children with "safe cord care" only increased from 65% to 70% from 2007 to 2014.

In Nepal, home births receiving dry cord care has significantly decreased over the three successive surveys, from 73% to 41%. Antiseptic cord care was not measured in Nepal's 2006 DHS. In 2011, however, it was rare, at just 1%, and then increased significantly to 14% in 2016 among home births. As seen in Appendix Table 6, the percentage of babies with a harmful substance applied to their cord actually increased from 26% in 2006 to 43% in 2016, indicating a reduction in the proportion of births with safe cord substance application. There are no significant changes in antiseptic or dry cord care in Timor-Leste's two surveys. Application of harmful substances significantly decreased between the two surveys by 13 percentage points (Appendix Table 6).

Figure 9 Dry or antiseptic cord care by place of delivery



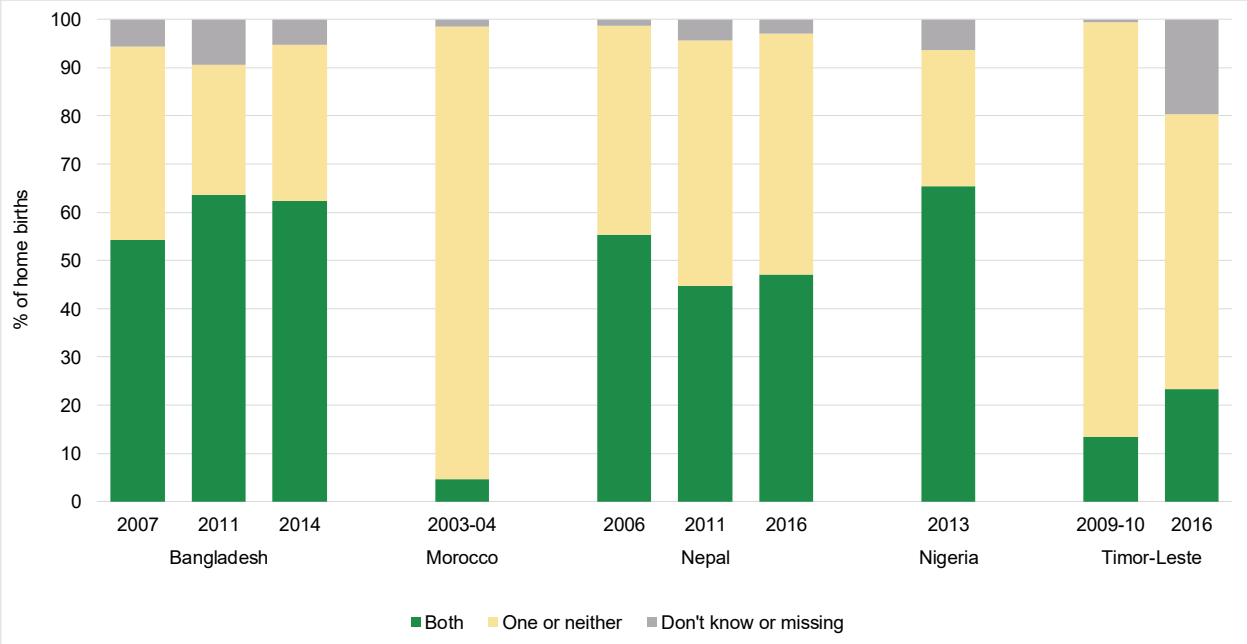
Composite hygienic cord care

Both cord care components—cutting with a clean instrument and safe cord application (dry or antiseptic cord care)—were combined to create a composite hygienic cord care indicator. Figure 10 and Appendix Table 8 present estimates of cord care by whether a newborn had both cord care components, incomplete cord care (0 or 1 components), and "don't know" or missing data. Having both hygienic cord practices was most common in the recent surveys in Bangladesh (62%) and Nigeria (65%). In the 2016 Nepal survey, incomplete cord care occurred at a similar prevalence as having both hygienic cord practices. In the recent Timor-Leste survey, the country had the largest portion of newborns in the "don't know" or missing categories of any survey.

In Bangladesh, although using a clean instrument improved over time, use of the recommended cord care practices did not improve, and thus the combination of both cord care practices remained unchanged over

the last two surveys, after an increase from 2007 to 2011. Similarly, in Nepal coverage of composite hygienic cord care decreased between 2006 and 2011 and then remained unchanged over the last two surveys. Timor-Leste had a significant increase in newborns receiving both practices, from 13% in 2009-10 to 23% in 2016.

Figure 10 Hygienic cord care practices among home births



3.2 Newborn Care Practices and Newborn Mortality

In this section, we compare newborn mortality among babies who did or did not receive recommended newborn care practices. The numbers of deaths examined in this section are reported in Table 3, and aside from larger samples collected in India and Nigeria, constitute very few cases; the results of this section should be interpreted with caution. We examine mortality by each practice, by composite practices, and then summarize these differences for recent surveys. Examining each survey alone is limited by a small sample, thus we pooled data from recent surveys in order to assess the relationship between mortality and newborn care practices in a larger sample.

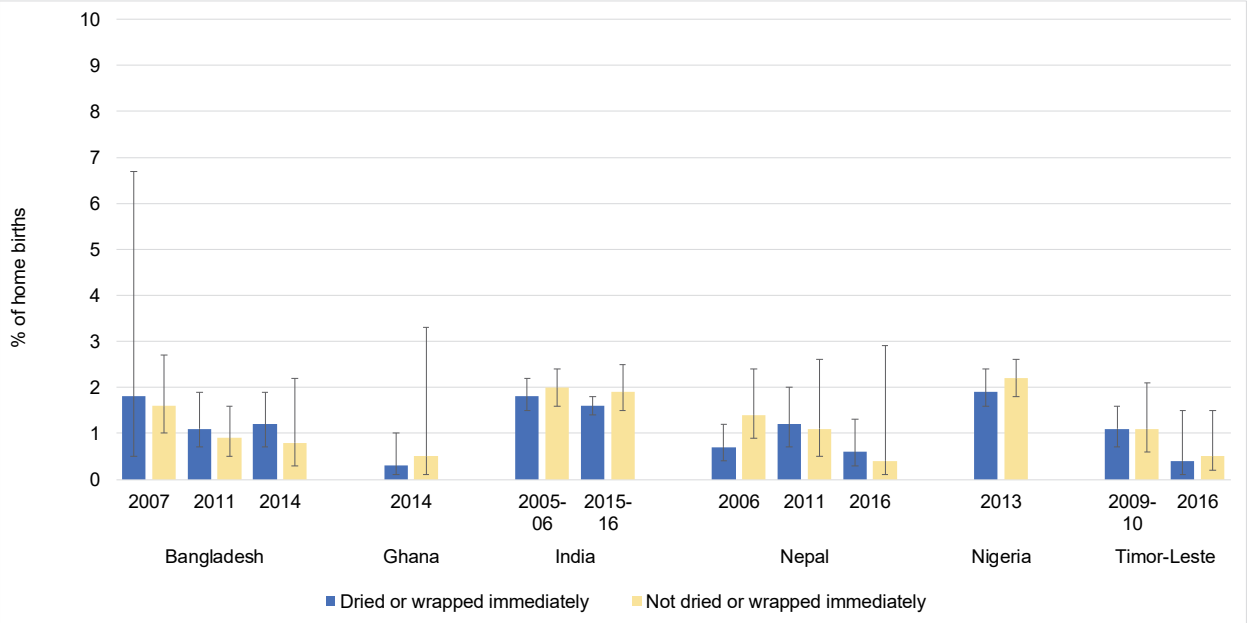
3.2.1 Thermal care

As Figure 11 shows, with additional information provided in Appendix Table 9, there were no significant differences in the percentage of children born at home who died on days 1-28 after birth according to whether they were dried or wrapped immediately after birth. Given the rarity of newborn mortality and the likely lack of power for most samples, this result was not unexpected. Despite a lack of statistical significance, we tried to understand if there were any trends by newborn care practice among the few early deaths, but found no clear trend for deaths on days 1-28 among those who were or were not dried or wrapped. Even within the countries with the largest samples and, incidentally, the highest neonatal mortality rates, we did not find statistically significant differences in the proportion of newborn deaths by drying or wrapping when comparing only those whose mothers reported definitive answers.

Appendix Table 9 shows the significance of the difference in mortality by drying or wrapping as well as among births with "don't know" or missing responses. In the 2014 Ghana DHS, only 1% (n = 9) of mothers responded with "don't know" or had missing responses; however, five of those births (55%) died on days 1-28 (p-value < 0.001). In this survey, only nine births total were recorded to have died in the first month (excluding deaths on the first day); therefore, over half of all newborn deaths had "don't know" or missing responses to the question about drying.

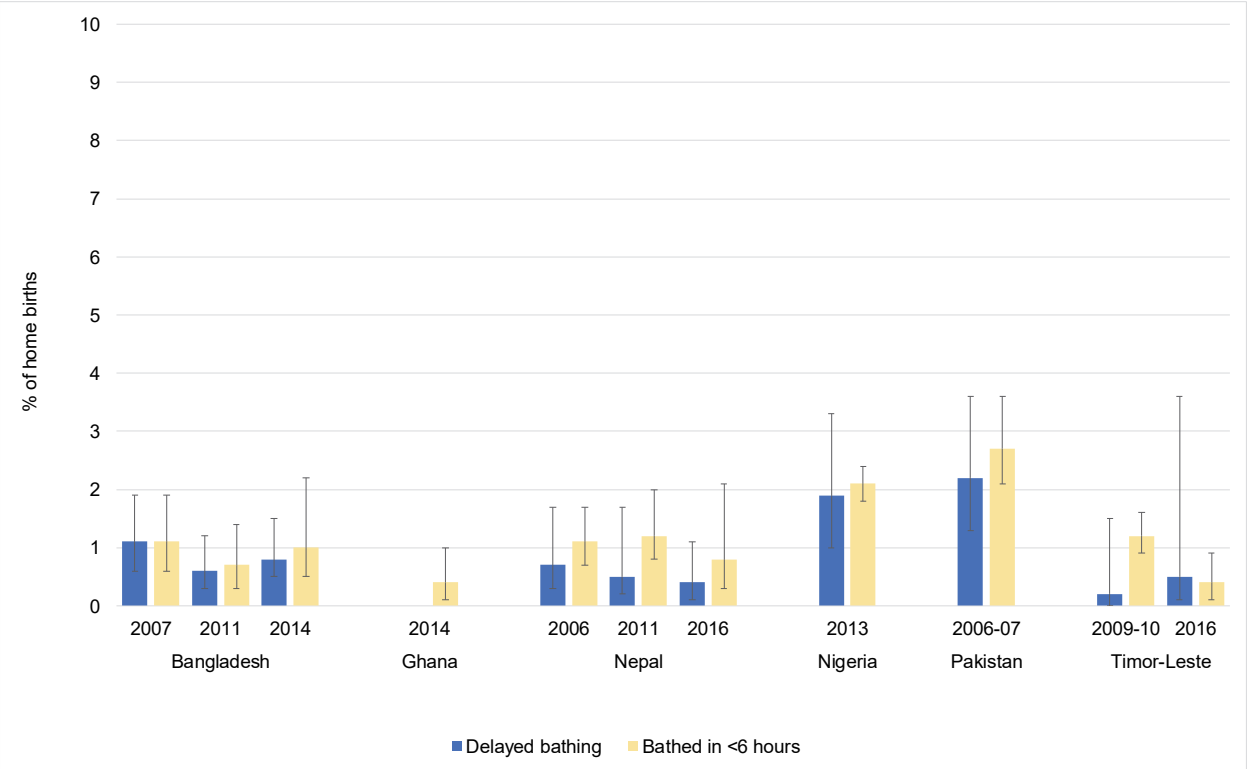
While drying and wrapping are both components of thermal care, drying alone has the additional benefit of providing stimulation to help the child breathe and may help to avert death due to asphyxia. Therefore, we also examined the differences in mortality among babies who were dried and not dried, without consideration of wrapping. We found no significant differences in mortality according to whether the baby was dried or not dried (results not shown).

Figure 11 Percentage of newborn deaths among home births by drying and wrapping practices



There were no significant differences in neonatal deaths (excluding deaths that occurred on the first day) among infants who had delayed bathing and those who did not, which was not unexpected due to the lack of power in the data. Almost every survey showed higher mortality among infants who were bathed before six hours after birth than those with delayed bathing (see Figure 12). Appendix Table 10 shows the proportion of newborns who died on days 1-28 by bathing practice and among those with "don't know" or missing responses, including a p-value indicating the significance of the differences. Relatively few mothers reported that they did not know when their baby was bathed, gave no response, or reported that the baby was not bathed (an option in Bangladesh and Ghana only). However, a large proportion of these "don't know" or missing cases pertained to newborns who died, with the proportion of deaths ranging from 17% to 52%. The discussion chapter of this report presents an in-depth discourse of this particular finding.

Figure 12 Percentage of newborn deaths among home births by timing of first bath



For the four surveys that collected data on skin-to-skin contact between the mother and baby immediately after birth, Figure 13 shows the percentage of babies who died on days 1-28 by whether or not they received skin-to-skin. There were no significant differences and no trend when comparing the four countries. Appendix Table 11 includes supplemental information and shows that for all four countries, there were no deaths in the category for "don't know" or missing responses related to skin-to-skin contact.

Figure 14 shows the proportion of neonatal deaths (days 1-28) by whether a newborn received both thermal care interventions (drying or wrapping and bathing) or partial or no thermal care (one or no interventions). No significant differences were found for deaths among newborns with both or incomplete thermal care, and there were no observable patterns between the two groups. Although only 4% or less of births fell into the category of not dried or bathed, "don't know", or missing, in Bangladesh 2011 and 2014, Ghana 2014, and Nepal 2006 and 2011, a significantly higher proportion of cases of newborn mortality occurred among these babies compared with those with either both, one, or no thermal care interventions (Appendix Table 12).

Figure 13 Percentage of newborn deaths among home births by receipt of immediate skin-to-skin

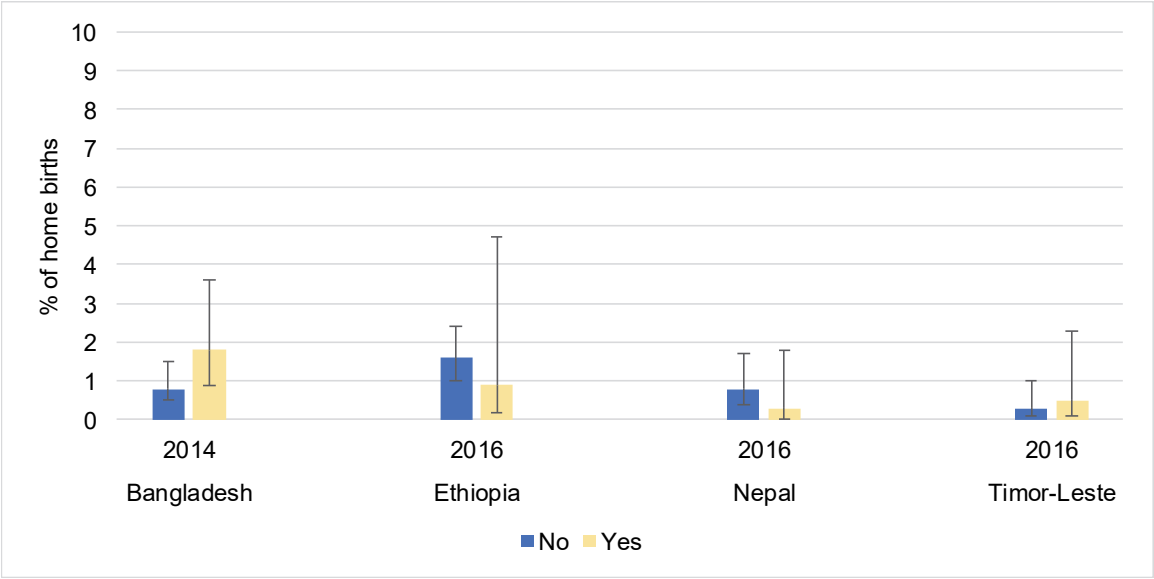
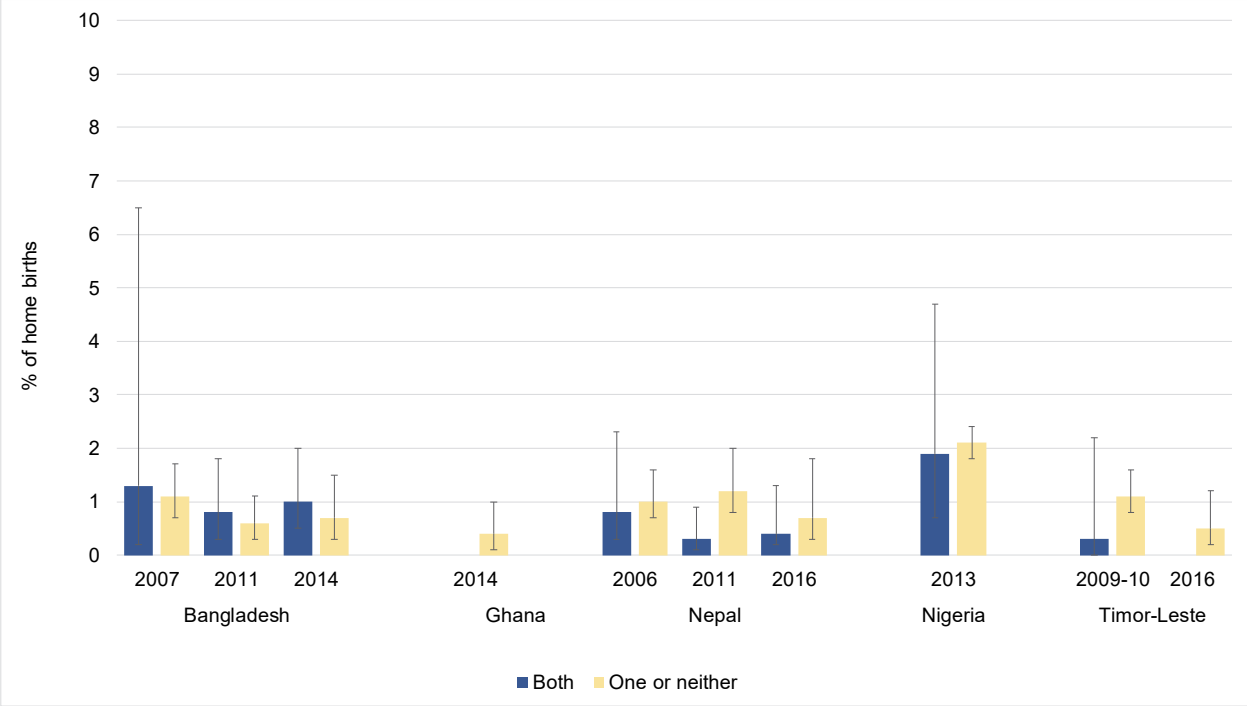


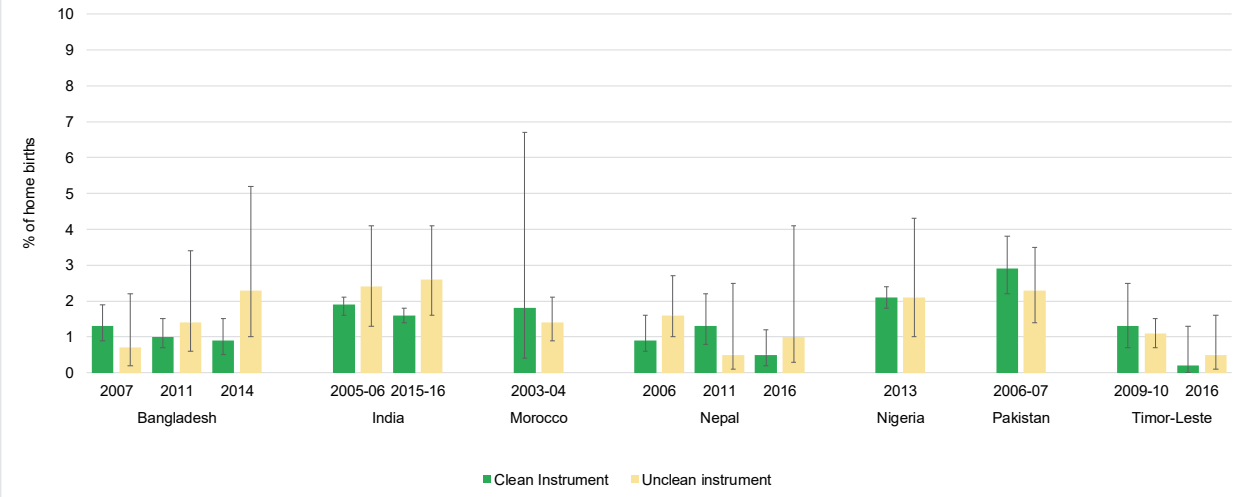
Figure 14 Percentage of newborn deaths among home births by thermal care practices



3.2.2 Hygienic cord care

Neonatal deaths (excluding deaths on the first day of birth) were examined by the means of cutting the cord—clean versus unclean. In no country was the difference in the percentage of births that resulted in a death during days 1-28 significant when stratified by cord-cutting object (Figure 15, Appendix Table 13), nor was there a consistent pattern across surveys. However, in four of the five surveys conducted in the last five years before the survey, deaths were more common where unclean instruments were used. In Bangladesh, India, and Nepal (since 2011), successive surveys showed a trend of decreasing proportion of births resulting in newborn death among home births when a clean cord-cutting instrument was used, and showed an increase in the proportion of births resulting in death when an unclean instrument was used.

Figure 15 Percentage of newborn deaths among home births by type of instrument used to cut the cord



Neonatal deaths among home births (excluding deaths on the first day of birth) were examined by substance put on the cord—whether nothing, antiseptic cord care, or other substance (Figure 16, Appendix Table 14). We observed notable differences in newborn mortality by cord care. In Nepal 2011 and 2016, no deaths occurred among babies who had an antiseptic placed on their cord; we observed no apparent significant difference in mortality between babies with dry cord care and babies with another substance placed on the cord in each of the three Nepal DHS surveys. In Bangladesh 2014, only 0.2% of babies died if they had an antiseptic placed on their cord compared with 1.3% of babies with dry cord care, and 1.1% of babies with another substance placed on the cord. In nearly every survey, the proportion of deaths among newborns with any non-antiseptic substance put on the cord was lower than for dry cord care, with the exception of Morocco (2003-04). Bivariate significance testing including the "don't know" or missing responses yields significant differences in Bangladesh 2011 and 2014, Morocco 2003-04, and Nepal 2011 and 2016 (Appendix Table 14).

Figure 17 and Appendix Table 15 show neonatal deaths by whether a newborn had incomplete cord care or both hygienic cord care interventions. No significant differences in deaths were found between the two groups. In nearly every survey, more deaths occurred among newborns with both cord care practices than incomplete cord care. In Timor-Leste 2016, no deaths occurred among infants who received both cord care

practices. Even when the comparison included the "don't know" and missing responses (Appendix Table 15), we observed no significant differences.

Figure 16 Percentage of newborn deaths among home births by substance placed on the cord

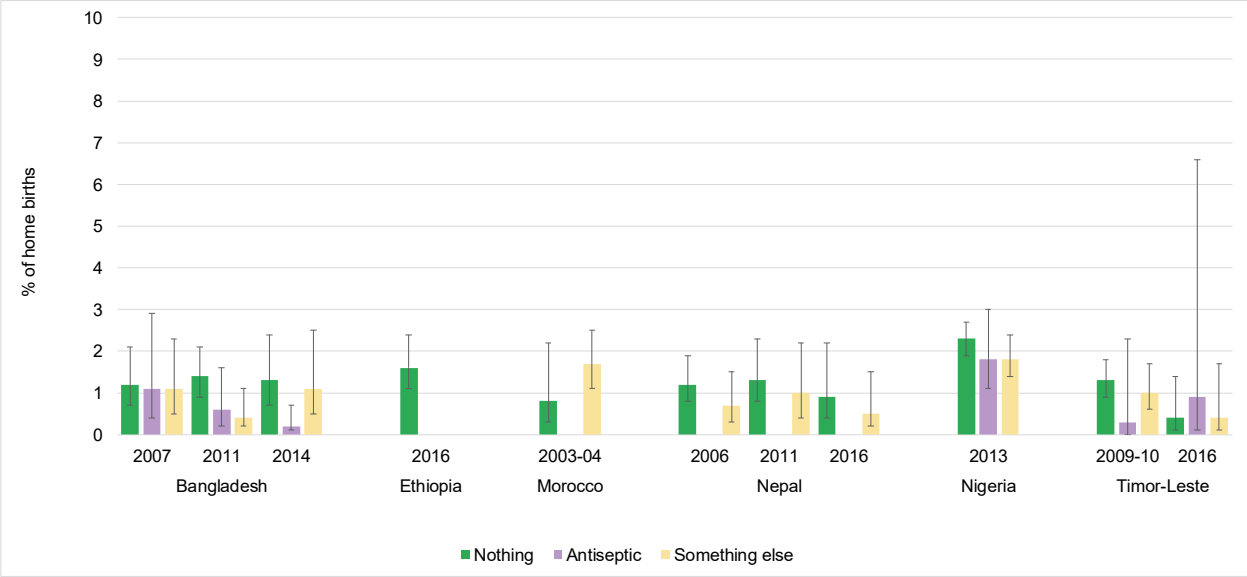
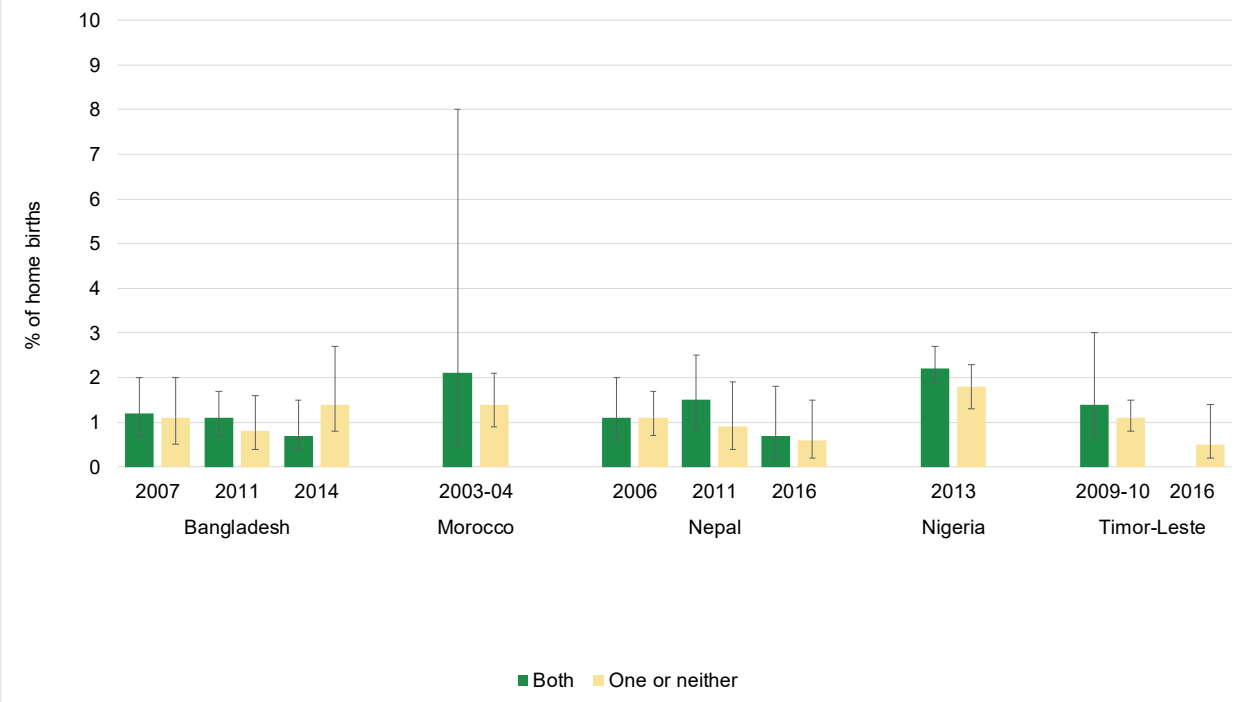


Figure 17 Percentage of newborn deaths among home births by hygienic cord care practices



3.2.3 Newborn care practices and newborn mortality in recent surveys

Tables 5a and 5b summarize the findings above with a side-by-side presentation of the proportion of newborns who died on days 1-28 after birth according to each newborn care practice among home births reported in recent surveys conducted in the last five years (since 2013). Table 5a includes thermal care indicators and Table 5b includes cord care indicators. Additionally, we tested the differences in proportions in each survey individually and in a pooled data set using chi square tests of independence, excluding missing or "don't know" responses in order to isolate the strength of the associations between practice and mortality. In the tables, the darker the red, the higher the mortality; outlined proportions indicate instances of significant differences in death by newborn care practice. The total column in each table shows that among the countries, the highest proportions of deaths occurred in Nigeria and India, while Timor-Leste, Nepal, and Ghana had the lowest proportions.

Both among individual surveys and in the pooled dataset, the percentage of babies who died in the first month was generally slightly higher, but not significantly so, among those who did not receive the recommended thermal care interventions compared with those who were immediately dried or wrapped, had delayed bathing, or both, respectively. As mentioned in Section 3.2.1, there was no overall trend or significant differences in newborn mortality by whether or not a baby received skin-to-skin contact; the pooled dataset yielded no significant differences in a larger sample as well. However, we observed significant differences by cord care practices. In Bangladesh and India, significantly higher proportions of babies died if the cord was cut with an unclean instrument compared with a clean one—at 0.9% among babies with a clean instrument and 2.3% among babies with an unclean instrument (p-value <0.05). In India, 1.6% of babies whose cord was cut with a clean instrument died compared with 2.6% with unclean cord cutting (p-value <0.05). Although the pooled sample did not convey statistically significant difference, in every survey more babies died if the instrument used was not clean, except for Nigeria, where the proportions were similar.

Calculating an average of these estimates would show that across the countries neonatal death is higher among births with an unclean instrument; however, that method assumes the frequency of the practice is equal across all countries. Our method, while weighting surveys equally, accounts for the variation in the coverage of practices across the pooled surveys. While using a clean instrument was common in South Asia and Nigeria, a clean instrument was used only for just over a third of home births in Timor-Leste. When we removed Timor-Leste, the pooled estimates of newborn mortality became 1% among those with a clean instrument versus 1.7% among those with an unclean instrument, though the difference was still non-significant (data not shown). For each of the surveys that included questions on substance applied to the cord, there were no significant differences, though a significant difference emerged when the survey data were pooled. Only 0.6% of babies with only an antiseptic placed on the cord died compared with 1.4% of babies whose mothers reported dry cord care (p-value <0.01).

Significant relationships at the bivariate level were only identified in South Asia, warranting further analysis in these countries. In this Section 3.2.2, we utilized chi square tests of independence, which do not allow for adjustment of other potential contributing factors of newborn mortality. In the next section, Section 3.2.3, we explore the relationship between these practices and mortality using multivariable logistic regression. Further, in South Asia, we have multiple surveys with comparable questions, allowing for the exploration of the change in these relationships over time. As mentioned, sample size was a limitation to

this analysis. The next section draws from the larger samples collected in India, and pools data from two cohorts in Bangladesh and Nepal to increase sample size.

Table 5a Heat map of percentage of newborn deaths among home births by thermal care practices

	Dried or wrapped		Timing of bathing		Skin-to-skin		Composite thermal care		
Survey	Imme-diately	Not imme-diately	6hrs+	<6hrs	Yes	No	Both	Partial/ none	Total
Bangladesh 2014	1.2	0.8	0.8	1.0	1.8	0.8	1.0	0.7	1.1
Ethiopia 2016					0.9	1.6			1.5
Ghana 2014	0.3	0.5	0.0	0.4			0.0	0.4	0.9
India 2015-16	1.6	1.9							1.6
Nepal 2016	0.6	0.4	0.4	0.8	0.3	0.8	0.4	0.7	0.6
Nigeria 2013	1.9	2.2	1.9	2.1			1.9	2.1	2.1
Timor-Leste 2015-16	0.4	0.5	0.5	0.4	0.5	0.3	0.0	0.5	0.4
Pooled	**1.0**	**1.2**	**0.6**	**1.0**	**0.8**	**0.9**	**0.6**	**0.9**	**1.2**

Note: Composite thermal care includes only two indicators of thermal care: drying or wrapping and bathing. The darker the red, the higher the mortality; outlined proportions indicate instances of significant differences in death by newborn care practice.

Table 5b Heat map of percentage of newborn deaths among home births by cord care practices

	Instrument to cut cord		Substance placed on stump			Composite hygienic cord care		
Survey	Clean	Unclean	Nothing	Anti-septic	Other	Both	One or neither	Total
Bangladesh 2014	0.9	2.3	1.3	0.2	1.1	0.7	1.4	1.1
Ethiopia 2016			1.4	n/a	0.0			1.5
Ghana 2014								0.9
India 2015-16	1.6	2.6						1.6
Nepal 2016	0.5	1.0	0.9	0.0	0.5	0.7	0.6	0.6
Nigeria 2013	2.1	2.1	2.3	1.8	1.8	2.2	1.8	2.1
Timor-Leste 2015-16	0.2	0.5	0.4	0.9	0.4	0.0	0.5	0.4
Pooled	**1.2**	**1.0**	**1.4**	**0.6**	**0.8**	**1.1**	**0.9**	**1.2**

Note: The darker the red, the higher the mortality; outlined proportions indicate instances of significant differences in death by newborn care practice.

3.3 Newborn Care Practices and Newborn Mortality in South Asia

Table 6 presents the background characteristics of the three countries in South Asia where we conducted a more in-depth analysis of newborn care practices and their association with newborn mortality. By examining two cohorts of respondent data, we also assessed the changes in the relationships over time. We examined India independently, but to increase our sample sizes pooled the Nepal and Bangladesh surveys. Using multivariable logistic regression, we then tested the associations between newborn mortality and newborn care practices and how the association might have changed over time (10 years between the two India surveys and 3-5 years between the Bangladesh and Nepal surveys); we included controls for other known predictors of neonatal mortality (Tables 7 and 8). Finally, we explored potential predictors of receipt of recommended newborn care practices (Tables 9 and 10).

3.3.1 Background characteristics

Table 6 shows the distribution of these characteristics, revealing many socioeconomic and health care access-related disadvantages among home births. In each country, and in both older and newer surveys, the majority of home births occurred among mothers in rural residence, in the poorest two wealth quintiles, between 18 and 34 years old, with fewer than four or more ANC visits, who did not have a skilled attendant present at birth and did not receive PNC. In the two India surveys, the majority of mothers who delivered at home had no education, though the distribution of level of education was more even in the two Bangladesh and Nepal surveys. The majority of home births in both India surveys, the 2011 Bangladesh and Nepal surveys, and in Nepal in 2016 were fully protected against tetanus. The percentage of home births born to mothers who experienced a death of a previous child under age 5 decreased between successive rounds of surveys in India and in the pooled datasets of Bangladesh and Nepal. Notably, in India, this proportion decreased from almost one-quarter of births (24%) in 2005-06 to 16% in 2015-16; however, this changed occurred over a 10-year period from 2005-06 to 2015-16.

Care-seeking before, during, and after birth, indicated by receipt of four or more ANC visits, having a skilled attendant at birth, and PNC in 2 days, was uncommon but increased between earlier and more recent surveys. In India 2015-16, just over one-fifth of births (22%) were delivered by an SBA, a 7 percentage point increase from 2005-06 (15%); however, only 8% of home births assessed by recent Bangladesh and Nepal surveys were born with assistance from a health professional, only a slight increase from 4% in the combined 2011 surveys. Only 2% of babies received a postnatal check in 2 days after birth, according to the India 2005-06 survey; although still uncommon, 10 years later the percentage increased to 17% by 2015-16. In Bangladesh and Nepal, although the surveys were only 3-5 years apart, the percentage of babies receiving a postnatal check doubled, from 13% to 26%.

Table 6 Distribution of background characteristics among children born at home

	India 2005-06		India 2015-16		Bangladesh and Nepal, 2011		Bangladesh 2014 and Nepal 2016	
	%	N	%	N	%	N	%	N
Place of residence								
Urban	13.5	3,127	15.2	5,230	10.3	562	29.1	1,226
Rural	86.5	20,008	84.8	29,095	89.7	4,902	70.9	2,988
Wealth quintile								
Lowest and second lowest	63.8	14,770	74.4	25,538	56.1	3,068	56.6	2,384
Middle	19.7	4,562	14.0	4,812	21.3	1,165	20.8	877
Second highest and highest	16.4	3,803	11.6	3,974	22.5	1,231	22.6	954
Education								
None	65.1	15,067	53.7	18,448	39.5	2,159	34.5	1,453
Primary	14.6	3,378	17.6	6,038	28.1	1,534	28.5	1,200
Secondary or higher	20.3	4,689	28.7	9,838	32.4	1,771	37.0	1,561
Religion								
Hindu	78.2	18,089	71.3	24,484	44.0	2,402	45.2	1,904
Muslim, other	21.8	5,046	28.7	9,841	56.0	3,063	54.8	2,310
Maternal age at birth								
<18	6.1	1,410	2.2	772	10.2	559	10.6	445
18-34	87.1	20,146	89.2	30,601	82.7	4,521	84.0	3,541
35 and older	6.8	1,578	8.6	2,952	7.0	384	5.4	228
Preceding birth interval								
First birth	17.5	4,050	16.0	5,499	25.2	1,377	26.3	1,110
Less than two years	20.5	4,736	22.3	7,644	12.6	688	13.0	549
Two years or more	62.0	14,349	61.7	21,182	62.2	3,399	60.7	2,556
Previous child under 5 die								
No	76.2	17,632	84.4	28,978	83.7	4,573	87.1	3,672
Yes	23.8	5,503	15.6	5,347	16.3	892	12.9	542
Antenatal care								
Less than 4 visits	84.4	19,528	76.2	26,166	75.0	4,098	65.4	2,754
4 or more visits	15.6	3,607	23.8	8,159	25.0	1,366	34.6	1,460
Tetanus[1]								
Not fully protected	33.2	7,682	18.9	6,476	18.6	1,017	17.1	361
Fully protected	66.8	15,453	81.1	27,849	81.4	4,447	82.9	1,746
Size at birth								
Normal or large	76.7	17,754	82.3	28,234	81.8	4,470	80.8	3,403
Small or very small	23.3	5,381	17.7	6,090	18.2	994	19.2	811
Gender of child								
Male	47.4	10,956	46.5	15,956	48.4	2,643	46.8	1,972
Female	52.6	12,179	53.5	18,369	51.6	2,821	53.2	2,242
Skilled attendant at birth								
No	85.4	19,761	78.3	26,873	96.3	5,264	92.4	3,895
Yes	14.6	3,374	21.7	7,451	3.7	200	7.6	319
PNC in 2 days								
No	97.9	22,653	83.3	28,578	86.6	4,733	74.3	3,131
Yes	2.1	482	16.7	5,747	13.4	731	25.7	1,083
Total	100.0	23,135	100.0	34,325	100.0	5,464	100.0	4,214

[1] Tetanus was not assessed in the Bangladesh 2014 survey; the percentages reflect coverage in Nepal in 2016 only.

3.3.2 Changes in associations between newborn care practices and mortality

Tables 7 and 8 present the unadjusted and adjusted odds ratios of newborn death on days 1-28 after birth by newborn care practices for India and Bangladesh and Nepal, respectively. We excluded "don't know" or missing cases from the dependent variable. The adjusted models control for place of residence, wealth, education, religion, maternal age at birth, birth interval, previous child death, receipt of antenatal care, tetanus protection (India only as full tetanus protection was not assessed in the Bangladesh 2014 survey), size at birth, sex of the child, skilled birth attendance, and PNC. In the pooled Bangladesh and Nepal samples, country was included as an independent variable; additionally, as described earlier, these pooled samples weighted data from Bangladesh and Nepal equally. For each independent variable, we selected the reference category as the category with the largest proportion. Appendix Tables 16 and 17 contain the full results as well as model fit statistics. We present the area under the receiver operating characteristic curve (AUC), which reflects the predictive ability or discriminatory ability of the model, ranging from 0 to 1, where values closer to 1 indicate the best predictive ability and values closer to 0.5 indicate the modeling is no better than random chance. We also present the Pseudo R squared, interpreted as the proportion of the total deviance or variation in the dependent variable (mortality) that can be explained by the covariates in the model.

Table 7 includes the results based the two surveys conducted in India. Despite the large sample sizes, we found no significant associations after controlling for other predictors of mortality among newborns. In the 2015-16 survey, babies whose cord was cut with an unclean instrument had 1.6 times greater odds of dying compared with babies whose cord was cut with a clean instrument or a blade from a kit (p-value <0.05); however, in the adjusted model, the odds were reduced to 1.4 and the association became non-significant. However, it should be noted that "don't know" was not a response option in this survey, which may have affected these findings. Drying and wrapping the baby before the placenta was delivered was not significantly associated in either the unadjusted or adjusted regression analyses. The associations were similar between the 2005-06 and 2015-16 surveys as well.

Table 7 Unadjusted and adjusted odds of newborn mortality among home births in India

	India 2005-06				India 2015-16			
	UOR	95% CI	AOR	95% CI	UOR	95% CI	AOR	95% CI
Drying or wrapping (ref = immediately)								
Delayed drying or wrapping	1.1	[0.8,1.4]	1.0	[0.8,1.3]	1.2	[0.9,1.6]	1.1	[0.8,1.5]
Not dried or wrapped, don't know, missing	0.4	[0.2,1.1]	0.5	[0.2,1.6]	n/a			
Instrument used to cut cord (ref = clean)								
Unclean	1.3	[0.7,2.3]	1.1	[0.6,2.0]	**1.6***	[1.0,2.7]	1.4	[0.8,2.4]
Don't know, missing	0.5	[0.2,1.0]	0.6	[0.2,1.5]	n/a			

Note: Unadjusted odds ratios (UOR); Adjusted odds ratios (AOR); Adjusted models control for place of residence, wealth, education, religion, maternal age at birth, birth interval, previous child death, mother's receipt of ANC, tetanus protection, size at birth, sex of the child, skilled birth attendance, and PNC for the baby. P-values *<0.05, **<0.01, ***<0.001.

In addition to questions on drying or wrapping and the instrument used to cut the cord, Bangladesh and Nepal also included questions on bathing and substances applied to the cord, allowing additional models to explore mortality as it relates to composite indicators of both thermal care and hygienic cord care. Therefore, we conducted two adjusted logistic regression models for each pooled sample: one with each

indicator of thermal care and cord care entered in the model separately, and other substituting these indicators with our composite indicators.

In both the older and more recent pooled samples of births in Bangladesh and Nepal, the adjusted logistic regression results indicated significant associations with cord care practices and newborn death; in the pooled 2011 surveys, however, having a harmful substance placed on the cord significantly predicted mortality in an unexpected way (Table 8). In the older surveys, having any substance (excluding antiseptics) placed on the cord was significantly associated with 50% reduced odds of dying compared with dry cord care (p-value < 0.05), even when holding all other covariates constant. We observed similar odds in the newest Bangladesh and Nepal surveys; however, the association was not significant. As we saw in Appendix Table 7b, in both Nepal and Bangladesh, the most common substances applied to the cord apart from antiseptics were oil (specifically mustard oil and garlic in Bangladesh), and powder or ointment (specifically boric powder in Bangladesh). Additionally, babies who had an antiseptic were less likely to die than babies with dry cord care. In the most recent Bangladesh and Nepal surveys, having an antiseptic placed on the cord significantly reduced the odds of dying by 80% versus dry cord care (Adjusted Odds Ratio (AOR) = 0.2, p-value < 0.01), but the association did not quite reach significance in the older surveys (AOR = 0.4, p-value = 0.10). If we were to predict survival instead of mortality, this would translate into a six-fold increase in the odds of surviving if an antiseptic were used instead of using nothing (AOR = 6.4, p-value < 0.01, 95% Confidence Interval (CI): 1.8 – 23.3, results not shown).

Also, in the Bangladesh and Nepal pooled sample for the more recent surveys, in the unadjusted model results showed that babies whose cord was cut with an unclean instrument had almost two and a half times the odds of dying compared with babies with a clean instrument used (Unadjusted Odds Ratio (UOR) = 2.4, p-value <0.05); when controlling for other important predictors of mortality in the adjusted model, however, the odds were reduced to less than two and the association became non-significant (AOR = 1.9, p-value = 0.11). In both the older and more recent surveys, the combined indicator for hygienic cord care revealed no significant differences between neonatal death when comparing receipt of both hygienic cord care practices to either partial cord care or no hygienic cord care. However, babies whose mothers reported that they did not know or did not provide information for either of the two interventions had over three times the odds of dying compared with babies who received both hygienic cord care interventions (AOR = 3.1, p-value < 0.05).

In both pooled samples in Bangladesh and Nepal, the regression analysis revealed alarmingly high associations between newborn death and the “don’t know” or missing responses to questions on bathing. In the recent surveys, babies whose mothers did not provide a valid response about bathing had over 50 times the odds of dying compared with mothers who said their baby was bathed at least six hours after birth (UOR = 52.4, p-value <0.001). In these most recent surveys our analytic sample contained only 39 unweighted deaths, eight of which were in the “don’t know” or missing response category of bathing (out of 32 total cases with missing or “don’t know” responses). For the combined thermal care variable, the odds were still exceptionally high (UOR = 11.5, p-value <0.001). In the 2011 surveys the odds were higher still for both bathing (UOR = 90.1, p-value < 0.001) and thermal care (UOR = 42.5, p-value < 0.001) for the “don’t know” or missing response category compared with the respective recommended interventions. While of course the absence of a response to the survey does not cause mortality, mortality could cause the absence of a response, a phenomenon we discuss in Section 4.3 of this report. Thus, given the nature of the relationship, we did not include the bathing or combined thermal care variables in our adjusted models.

Table 8 Unadjusted and adjusted odds of newborn mortality among home births in Nepal and Bangladesh

	Bangladesh and Nepal, 2011						Bangladesh 2014 and Nepal 2016					
	UOR	95% CI	AOR	95% CI	AOR	95% CI	UOR	95% CI	AOR	95% CI	AOR	95% CI
Drying or wrapping (ref = immediately)												
Delayed drying or wrapping	0.8	[0.4,1.5]	0.8	[0.4,1.6]	0.8	[0.4,1.6]	0.7	[0.3,2.0]	0.6	[0.2,1.7]	0.7	[0.2,1.9]
Not dried or wrapped, don't know, missing	0.7	[0.2,2.5]	0.8	[0.2,2.8]	0.8	[0.2,2.8]	1.3	[0.3,6.0]	0.9	[0.2,4.3]	0.9	[0.2,4.2]
Bathing (ref = 6 hours or more)												
<6 hours	1.8	[0.8,3.7]					1.4	[0.6,3.3]				
Not bathed, don't know, missing	**90.1*** **	[41.0,197.8]					**52.4*** **	[18.2,150.6]				
Thermal care (ref = both)												
One or neither	1.7	[0.7,3.9]					1.0	[0.4,2.2]				
Don't know or missing	**42.5*** **	[16.8,107.0]					**11.5*** **	[4.1,32.1]				
Instrument used to cut cord (ref = clean)												
Unclean	0.8	[0.3,2.0]	0.7	[0.3,1.8]			**2.4***	[1.1,5.4]	1.9	[0.9,4.2]		
Don't know, missing	0.6	[0.1,4.7]	0.6	[0.1,5.2]			1.4	[0.2,10.5]	1.7	[0.2,16.8]		
Substance placed on cord (ref = nothing)												
Antiseptic	0.4	[0.1,1.2]	0.4	[0.1,1.2]			**0.1****	[0.0,0.4]	**0.2****	[0.0,0.6]		
Other substance	0.6	[0.3,1.2]	**0.5***	[0.3,0.9]			0.6	[0.3,1.5]	0.7	[0.3,1.7]		
Don't know, missing	0.8	[0.3,2.6]	0.9	[0.3,2.9]			1.7	[0.5,5.3]	1.9	[0.5,6.7]		
Hygienic cord care (ref = both)												
One or neither	0.7	[0.4,1.3]			0.6	[0.3,1.1]	1.3	[0.6,2.8]			1.3	[0.6,2.9]
Don't know or missing	0.9	[0.3,2.7]			0.9	[0.3,2.8]	2.5	[0.8,7.5]			**3.1***	[1.0,9.6]

Note: Unadjusted odds ratios (UOR); Adjusted odds ratios (AOR); Adjusted models control for country, place of residence, wealth, education, religion, maternal age at birth, birth interval, previous child death, mother's receipt of antenatal care, size at birth, sex of the child, skilled birth attendance, and PNC for the baby.
P-values *<0.05, **<0.01, ***<0.001.

Appendix Tables 16 and 17 include the complete results of the unadjusted and adjusted multivariable logistic regressions, including all of the covariates we modeled. In India, as Appendix Table 16 shows, we observed some similarities and some changes in the way a number of key sociodemographic and care-seeking factors related to newborn mortality between the two survey periods. Across both surveys, firstborn children and children born fewer than two years after their mother's last child had increased odds of dying compared with babies born to mothers with a longer birth interval (two or more years). However, the magnitude of these effects decreased in the most recent survey. We found greater magnitude and strength of the association between newborn mortality and children born to mothers over age 35 (compared with age 18-34), babies born to mothers who had a previous child die before age 5 (compared with no previous child death), and no PNC checkup (compared to those babies with a checkup within 2 days). Babies who did not receive a PNC checkup had a twofold increase in the odds of dying compared with those who were checked. In the 2005-06 survey but not in the 2015-16 survey, babies of mothers with secondary or higher education were less likely to die in the first month compared with babies of mothers with no education. Babies who were not protected from tetanus and who were small at birth were more likely to die in the first month, across both survey periods.

In contrast, in Bangladesh and Nepal (Appendix Table 17) very few covariates significantly predicted newborn mortality, likely due to the small sample sizes even with pooled data. In the earlier surveys the only covariate to predict death after the first day of life was related to the substance placed on the cord, as discussed above. In the more recent surveys babies born to mothers in the middle wealth quintile (compared with the lower two quintiles), mothers attending four or more ANC visits (compared with fewer than four visits), and mothers delivering with a skilled birth attendant (compared with a TBA or no attendant) were significantly less likely to die on days 1-28.

When comparing model fit statistics among all the models in India and Bangladesh and Nepal, we found the model with the best discriminatory ability, or ability to predict mortality, was the adjusted models for the recent Bangladesh and Nepal surveys (AUC = 0.77 and 0.76); however, this is considered only fair discrimination. The other models assessing newborn mortality fell within a range of 0.60-0.69, which indicate poor discrimination. The Pseudo R^2 estimates were also highest for models conducted with recent Bangladesh and Nepal survey data, and indicate 8% and 9% of the deviance in mortality is explained by the covariates in the model, while the remaining models predicted only 3% - 4% of the deviance in mortality.

3.4 Predictors of Newborn Care Practices in South Asia

Finally, we examined the predictors of newborn care interventions in the most recent surveys in India, Bangladesh, and Nepal. Tables 9 and 10 present the results of the unadjusted and adjusted logistic regressions. We conducted separate models for the composite indicators of thermal care and cord care. The adjusted models controlled for country (in the Bangladesh and Nepal samples), place of residence, wealth, education, religion, maternal age at birth, birth interval, previous child death, receipt of antenatal care, size at birth (as a proxy for gestational age), sex of the child, and skilled birth attendance. For the model examining predictors of thermal care, we included a covariate for hygienic cord care, and for the model testing predictors of hygienic cord care, we included a covariate for thermal care. The models in each sample used slightly different outcome indicators for the practices—drying and wrapping in India and the composite thermal care variable of drying, wrapping, and bathing in Bangladesh and Nepal—and included

slightly different controls related to hygienic cord care—instrument used to cut the cord in India versus composite hygienic cord care in Bangladesh and Nepal.

Table 9 includes the results of the analysis of predictors of thermal care for the three South Asian countries. We considered a baby to have both thermal care practices if they were both immediately dried and bathing was delayed for over six hours after birth; partial or no care included babies who received only one of those interventions, or neither. In both India and in the pooled sample of births in Bangladesh and Nepal, we found that having a skilled birth attendant was positively and significantly associated with a baby's receipt of the recommended thermal care interventions. In both samples, holding all other sociodemographic and care-seeking covariates constant, babies delivered by a skilled attendant had at least one and one-half times the odds receiving both thermal care practices compared with those delivered without a skilled birth attendant (India: AOR = 1.5, p-value < 0.001; Bangladesh and Nepal: AOR = 1.6, p-value < 0.01). In Bangladesh and Nepal, babies born to mothers in wealthier quintiles are more likely to receive both thermal practices compared with lower wealth quintiles (AOR = 1.7, p-value < 0.001), whereas in India, babies in the middle wealth quintile were less likely to be immediately dried compared with lower wealth quintiles (AOR = 0.8, p-value < 0.001). In India (but not in Bangladesh or Nepal), mother attending at least four ANC visits increased the odds of the baby receiving thermal care interventions (AOR = 1.3, p-value < 0.001).

We also saw significant positive associations between receipt of recommended thermal care interventions and hygienic cord care practices in both samples. In India babies whose cord was cut with a clean instrument had a ninefold increase in the odds of receiving thermal care compared with babies whose cord was cut with an unclean object (AOR = 9.3, p-value < 0.001). In Bangladesh and Nepal, babies had a 30% increase in the odds of receiving both thermal care practices if they received both hygienic cord care practices compared with only partial or unhygienic cord care (AOR = 1.3, p-value < 0.05). The models in both samples had quite poor ability to discriminate between those babies who did and did not receive thermal care outcomes (Pseudo R2 = 0.63 in India and 0.59 in Nepal and Bangladesh), and the models only accounted for 6% of the variation in the outcome.

Table 10 presents the findings of the unadjusted and adjusted regression analysis that modeled the associations between hygienic cord care practices and selected covariates of interest. In the adjusted models in Bangladesh and Nepal (but not in India), care before and during birth was associated with receipt of both recommended cord care practices. Mothers' attendance at four or more ANC visits increased the odds of hygienic cord care by 40% compared with no ANC (AOR = 1.4, p-value < 0.01), and having an SBA at delivery increased the odds by 70% compared with having no skilled birth attendant (AOR = 1.7, p-value < 0.01). Additionally, in this pooled sample female babies were less likely to receive both hygienic cord care practices compared with male babies (AOR = 0.8, p-value < 0.05), and babies born in Bangladesh were more likely to receive both of these cord care interventions (AOR = 2.5, p-value < 0.001). In both samples, maternal secondary or higher education was associated with an increased likelihood of babies receiving hygienic cord care. Despite the fact that preterm or low birthweight babies are most in need of these interventions, we did not find any associations between birthweight and the newborn care practices examined in either country. The model in India had fair discriminatory ability (Pseudo R2 = 0.79) and the model explained 15% of the deviance whether or not a baby's cord was cut with a clean instrument. The model for Nepal and Bangladesh, however, had poor discrimination (Pseudo R2 = 0.63) and the model explained 4% of the deviance in hygienic cord care.

Table 9 Unadjusted Odds Ratios and Adjusted Odds Ratios of receiving thermal care interventions among home births in India, Nepal, and Bangladesh

	India 2015-16				Bangladesh 2014 and Nepal 2016			
	UOR	95% CI	AOR	95% CI	UOR	95% CI	AOR	95% CI
Country (ref = Nepal)								
Bangladesh					0.9	[0.7,1.1]	0.7	[0.5,1.1]
Place of residence (ref = rural)								
Urban	**0.9***	[0.8,1.0]	**0.8***	[0.7,1.0]	0.9	[0.7,1.2]	**0.8***	[0.6,1.0]
Wealth quintile (ref = lowest and second)								
Middle	**0.8****	[0.7,0.9]	**0.8*****	[0.7,0.9]	1.2	[0.9,1.7]	1.2	[0.9,1.6]
Second highest and highest	1.1	[1.0,1.2]	1.0	[0.9,1.1]	**1.7*****	[1.4,2.0]	**1.7*****	[1.4,2.1]
Education (ref = none)								
Primary	**1.2****	[1.1,1.3]	**1.1***	[1.0,1.3]	1.0	[0.8,1.2]	1.0	[0.8,1.3]
Secondary or higher	**1.2*****	[1.1,1.3]	**1.1***	[1.0,1.2]	1.2	[0.9,1.5]	1.1	[0.9,1.4]
Religion (ref = Hindu)								
Muslim, other	**0.9***	[0.8,1.0]	0.9	[0.8,1.0]	0.9	[0.7,1.2]	1.0	[0.7,1.4]
Maternal age at birth (ref = 20-34)								
<18	1.0	[0.7,1.3]	1.0	[0.7,1.3]	1.0	[0.8,1.2]	1.0	[0.8,1.3]
18-34								
35 and older	**0.9***	[0.8,1.0]	1.0	[0.9,1.1]	0.8	[0.5,1.1]	0.8	[0.6,1.2]
Preceding birth interval (ref = 2+)								
First birth	1.0	[0.9,1.1]	1.0	[0.9,1.1]	1.1	[0.8,1.3]	1.0	[0.8,1.3]
Less than two years	1.0	[0.9,1.1]	1.0	[0.9,1.1]	1.1	[0.8,1.4]	1.0	[0.7,1.3]
Previous child under 5 die (ref = no)								
Yes	**0.9***	[0.8,1.0]	0.9	[0.8,1.0]	1.0	[0.8,1.2]	1.1	[0.9,1.3]
Antenatal care (ref = less than 4)								
4 or more visits	**1.4*****	[1.3,1.6]	**1.3*****	[1.2,1.5]	1.1	[0.9,1.3]	1.0	[0.8,1.2]
Size at birth (ref = normal or large)								
Small or very small	0.9	[0.9,1.0]	0.9	[0.8,1.0]	1.0	[0.8,1.3]	1.1	[0.9,1.4]
Gender of child (ref = male)								
Female	1.0	[0.9,1.0]	1.0	[0.9,1.1]	1.1	[0.9,1.2]	1.1	[0.9,1.2]
Skilled attendant at birth (ref = no)								
Yes	**1.5*****	[1.4,1.7]	**1.5*****	[1.3,1.6]	**1.8*****	[1.3,2.5]	**1.6****	[1.2,2.2]
Instrument used to cut the cord (ref = unclean)								
Clean	**9.0*****	[7.6,10.6]	**9.3*****	[7.9,11.0]				
Don't know	**0.5*****	[0.5,0.6]	**0.5*****	[0.4,0.6]				
Hygienic cord care (ref = One or neither)								
Both					**1.3***	[1.0,1.5]	**1.3***	[1.1,1.6]
Don't know or missing					**1.8****	[1.2,2.6]	**1.7****	[1.1,2.5]
AUC			**0.63**				**0.59**	
Pseudo R2			**0.06**				**0.02**	

Note: Unadjusted odds ratios (UOR); Adjusted odds ratios (AOR);
P-values *<0.05, **<0.01, ***<0.001

Table 10 Unadjusted Odds Ratios and Adjusted Odds Ratios of receiving hygienic cord care interventions among home births in India, Nepal, and Bangladesh

	India 2015-16				Bangladesh 2014 and Nepal 2016			
	UOR	**95% CI**	**AOR**	**95% CI**	**UOR**	**95% CI**	**AOR**	**95% CI**
Country (ref = Nepal)								
Bangladesh					**2.1*** **	[1.7,2.5]	**2.5*** **	[1.8,3.4]
Place of residence (ref = rural)								
Urban	1.2	[0.9,1.6]	1.2	[0.9,1.6]	0.9	[0.7,1.1]	1.2	[0.9,1.4]
Wealth quintile (ref = lowest and second)								
Middle	1.0	[0.8,1.3]	1.0	[0.8,1.2]	0.9	[0.7,1.2]	0.8	[0.6,1.1]
Second highest and highest	**1.4***	[1.0,1.9]	1.2	[0.8,1.6]	1.1	[0.9,1.4]	0.8	[0.7,1.1]
Education (ref = none)								
Primary	1.1	[0.9,1.3]	1.0	[0.8,1.2]	**1.3***	[1.1,1.6]	1.1	[0.9,1.3]
Secondary or higher	**1.3****	[1.1,1.6]	**1.3***	[1.0,1.5]	**1.9*** **	[1.4,2.4]	**1.5*** **	[1.2,1.9]
Religion (ref = Hindu)								
Muslim, other	0.9	[0.8,1.1]	1.0	[0.8,1.2]	**1.7*** **	[1.4,2.1]	0.9	[0.7,1.2]
Maternal age at birth (ref = 20-34)								
<18	0.7	[0.5,1.0]	0.8	[0.5,1.2]	1.1	[0.8,1.4]	1.0	[0.8,1.4]
35 and older	**0.7*** **	[0.6,0.8]	**0.7****	[0.6,0.9]	0.8	[0.6,1.1]	1.0	[0.7,1.5]
Preceding birth interval (ref = 2+)								
First birth	0.8	[0.7,1.0]	**0.8***	[0.6,0.9]	1.0	[0.7,1.4]	0.8	[0.5,1.1]
Less than two years	0.9	[0.8,1.1]	0.9	[0.8,1.1]	1.1	[0.8,1.4]	1.2	[0.9,1.5]
Previous child under 5 die (ref = no)								
Yes	1.1	[0.9,1.3]	1.1	[0.9,1.4]	1.0	[0.8,1.3]	1.0	[0.8,1.3]
Antenatal care (ref = less than 4)								
4 or more visits	**1.3****	[1.1,1.6]	1.1	[0.9,1.4]	1.1	[0.9,1.4]	**1.4****	[1.1,1.7]
Size at birth (ref = normal or large)								
Small or very small	1.1	[0.9,1.3]	1.1	[0.9,1.3]	0.9	[0.7,1.1]	0.9	[0.7,1.1]
Gender of child (ref = male)								
Female	1.0	[0.9,1.1]	1.0	[0.8,1.1]	**0.8***	[0.7,1.0]	**0.8***	[0.7,1.0]
Skilled attendant at birth (ref = no)								
Yes	1.1	[0.9,1.3]	0.8	[0.7,1.0]	**1.9*** **	[1.4,2.6]	**1.7****	[1.3,2.4]
Dry or wrapping (ref = delayed)								
Immediately	**9.0*** **	[7.6,10.6]	**9.3*** **	[7.9,11]				
Not dried, don't know, missing	**6.8*** **	[6.1,7.6]	**6.7*** **	[5.6,8]				
Thermal care (ref = one or neither)								
Both					**1.3***	[1.0,1.5]	**1.3***	[1.0,1.6]
Don't know or missing					1.5	[0.7,3.2]	1.2	[0.6,2.6]
AUC			**0.79**				**0.63**	
Pseudo R2			**0.15**				**0.04**	

Note: Unadjusted odds ratios (UOR); Adjusted odds ratios (AOR);
P-values *<0.05, **<0.01, ***<0.001

4 DISCUSSION

4.1 Overview of Findings

This study reviewed coverage of recommended newborn practices, including immediate drying, delayed bathing, skin-to-skin contact, clean instruments for cutting the umbilical cord, and clean cord care, both over time and by place of delivery where applicable. We further explored associations between recommended newborn care practices and neonatal mortality in 10 countries and examined trends where possible. Given the small sample size in most countries, we pooled countries to explore the associations between these practices and mortality. With our larger sample sizes in two surveys conducted in India and two pooled samples of recent and preceding surveys in Bangladesh and Nepal, we examined the change in the association between newborn mortality and newborn care practices. Finally, we examined predictors of newborn care practices in three South Asian countries.

We found that newborn care practices varied by place of delivery, country, and over time. Births delivered in a health facility generally received the recommended practices more often than births at home. Immediate drying, delayed bathing and immediate skin-to-skin contact were generally more common practices for births in a health facility than at home. Use of clean instruments to cut the cord was also more prevalent in health facilities in the two surveys that measured this practice among facility births. Use of antiseptic for cord care was more prevalent among facility births, while dry cord care tended to be more common among home births. Drying, bathing, and the composite indictor of both thermal care practices showed more substantial increases in use between the earlier and later survey periods compared with the composite hygienic cord care indicator (clean instrument used to cut the cord and either dry or antiseptic cord care). While Timor-Leste showed a decrease in the practice of immediate drying, there was a slight increase in delayed bathing and having both thermal care practices. For home births, clean cord-cutting instruments were most common in South Asia and Nigeria, with the most recent surveys showing the highest country prevalence. Use of clean instruments increased in South Asia and in Timor-Leste over the survey periods, and use of antiseptics increased in Nepal and Bangladesh.

Using chi-square tests of independence, we found that in recent surveys conducted in India and Bangladesh, the instrument used to cut the cord (clean or unclean) significantly predicted neonatal mortality; there were no significant associations between neonatal mortality and any indicators of thermal care in any country. These findings should be read with the caveat that the analysis likely lacked power to draw strong conclusions at the country level for most surveys. When pooling the five recent surveys that included questions on newborn care, we found no association between thermal care practices and mortality, but a significantly decreased likelihood of neonatal death among babies with either an antiseptic placed on their cord or another substance compared with dry cord care only. The finding that deaths in the first month after birth were less common among babies who had potentially harmful products put on their cord compared with dry cord care was unexpected, although perhaps misleading, and we discuss this further below. However, our study was not the first to reveal such associations. Seward et al. (2012) found higher odds of dying among babies with dry cord care in Bangladesh, but lower odds in Nepal.

After controlling for a number of known predictors of newborn mortality using survey data from South Asia, we found significant associations between neonatal mortality and cord care, but not thermal care. In

India in the multivariable models, immediate drying or cutting the cord with a clean instrument did not predict newborn survival, and in our multivariable analysis using pooled data from recent surveys in Bangladesh and Nepal, we found that application of antiseptics (compared with dry cord care) revealed a large reduction in the odds of dying on days 1-28 after birth. The significance of the association between antiseptic use and mortality also increased between surveys in the Bangladesh and Nepal pooled sample, likely in relation to the increased use of antiseptics; the larger proportion of babies receiving this intervention allowed for a larger sample and higher likelihood of detecting a significant difference. Randomized, controlled trials have indicated the effectiveness of chlorhexidine in reducing mortality (Mullany et al. 2006; El Ariefeen et al. 2012); one study found an effect among low birthweight infants, though not among all infants (Tielsch et al. 2007). In a pooled analysis of three randomized control trials examining the relationship between newborn mortality due to sepsis and clean newborn care practices in Bangladesh, India, and Nepal, there was a significant reduction in mortality among births where a clean birth kit was used, in addition to handwashing, use of a boiled blade, boiled thread, and antiseptic cord care (Seward et al. 2012). In an article about their randomized control trials of using chlorhexidine on the cord stump, Tielsch et al. (2007) stated that pathogens found in newborn infections in South Asia suggested environmental organisms as the likely cause (as opposed to maternal infection transmission more common in other regions). Thus, the use of topical cleansing agents is a particularly salient intervention.

In addition to newborn care practices, we examined the role other covariates may play in newborn mortality, and how these associations have changed over time. In India the magnitude of the association between first birth and mortality decreased. This may be due to fewer children being born to women under age 18 in the 2015-16 survey compared with the 2005-06 survey. As age at first birth in India rises,[3] consequences such as prematurity and low birthweight, which are associated with young age at birth (Kumar et al. 2013), are also likely to decrease. First births may be less risky (Kumar 2013; Lawn et al. 2005). We also found that use of PNC increased over time, and its role in reducing mortality also strengthened. In the pooled Bangladesh and Nepal surveys, babies delivered by a skilled birth attendant and babies delivered to mothers who attended four or more ANC visits had lower odds of dying, though these associations were only in the more recent surveys.

In addition to predicting mortality, we found that in India and in the pooled sample of births in Bangladesh and Nepal, skilled attendance at birth also positively predicted receipt of recommended thermal and hygienic cord care practices. Although less consistent across practice and country, we also saw an association between mother's attendance at ANC visits with recommended newborn care practices. ANC provides an opportunity to counsel mothers about recommended newborn care practices and to encourage skilled attendance at birth. In addition, there are likely mediating links between ANC, use of an SBA, newborn care practices, and newborn survival. This requires further investigation. Using logistic regression, we also found an association between thermal and cord care practices, although Sitrin et al. (2017) did not find the variables to be highly correlated, using Pearson correlations. This study, however, predated the release of recent surveys in Nepal and India and did not examine composite measures. We also found some evidence of gender bias in the pooled sample of Bangladesh and Nepal: female infants were less likely than male infants to receive hygienic cord care. Another study found implications of potential gender bias in newborn care practices in Nepal, where female infants were more likely than males to suffer from

[3] The DHS Program STATcompiler: https://statcompiler.com/en/

hypothermia (Mullany et al. 2010). This evidence of gender bias demands further investigation, and possibly targeted behavior change and counseling interventions.

Given the link between ANC and SBA with increased implementation of recommended practices, and that both health care services and recommended practices can prevent newborn mortality, promotion of both use of maternal health services and the recommended newborn practices may have synergistic effects on newborn survival. The results of this study suggest that as use of maternal health services and implementation of recommended newborn care practices have increased, neonatal mortality has decreased. We found that skilled care during birth leads to better health practices, and that babies who receive recommended newborn care practices—specifically, hygienic cord care—along with antenatal, intrapartum, and PNC have lower odds of dying in the first month after birth. Increases in recommended newborn care practices may have occurred during or after efforts were underway to create an Every Newborn Action Plan in most of the countries in this study, possibly indicating the effects of high-level and systemic engagement in the newborn health agenda. Research in the coming years could elucidate the role of policy shifts and examine how they have changed different elements of care throughout a health system. We see a clear role for ANC in promoting birth preparedness to include newborn care and for knowledgeable SBAs to assist with home deliveries in remote areas; these interventions have also been widely recommended to promote better newborn care practices (Hill 2010; Kumar et al. 2008; Baqui et al. 2008a, b; Bhutta et al. 2008; Bang et al. 2005).

4.2 Strengths, Limitations, and Recommendations

This study supports current literature examining newborn care practices and adds to the body of knowledge about trends in practices and the differences in implementation by place of delivery. By harmonizing responses across surveys in a way that represents whether or not babies are receiving recommended thermal and cord care practices, we were able to show that the recommended practices have mostly increased, and that while health facilities follow recommended practices more often than among home births, there is still room for improvement. While low birthweight or premature babies may be most susceptible to the consequences of lack of thermal regulation or unhygienic cord practices, our study showed that these babies do not receive the interventions either more or less often than normal or larger birthweight babies.

By excluding deaths on the first day of birth and examining newborn mortality only on days 1–28, we can say with some confidence that at least some of the newborn care interventions (immediate drying, delayed bathing for six hours, and using a clean instrument on the cord) occurred prior to death. Although chi square and logistic regressions do not indicate the causality of a relationship, structuring our outcome variable in this way at least eliminates the potential finding of a relationship that only indicates a potential reverse causation effect. Indeed, the strong association between "not bathed, don't know, or missing" likely reflects that the baby died before the mother was able to bathe the baby. Our study highlights the importance of considering the timing of death in relationship to these critical interventions, and using caution when interpreting results. Further, as drying a baby immediately may also help a baby breathe in addition to thermal support, by excluding deaths on the day of birth, we may underestimate the relationship between drying and survival.

One key strength of this study was in the ability to gain more power by pooling data from two geographically proximate countries—Nepal and Bangladesh—where surveys were conducted within the

same time period and contained similar questions. In doing so, and while also examining data from India where the samples were larger, we were able to provide new insight on the role newborn care practices have played in neonatal mortality over time. We found that hygienic cord care appeared to play an increasingly important role in preventing newborn mortality between the two survey periods, at least in South Asia, and this trend deserves continued focus. Our study also highlighted the importance of the role of antenatal care and skilled birth attendance in ensuring newborn survival, even among women who are unable to deliver in a health facility.

This study is limited by the statistical rarity of newborn mortality and the likely lack of power for most samples; it was not unexpected that our results revealed mainly non-significant associations, particularly for the within-country analyses. Although neonatal mortality accounts for nearly half of all under-five mortality (Liu et al. 2015), limiting our sample to home births, excluding deaths in the first day (when most newborn deaths occur (PMNCH 2011)), and excluding births in the most recent month preceding each survey further restricted our sample size. Even when pooling data from two countries in South Asia, cases of newborn death were still few. The two most recent surveys of Bangladesh and Nepal included only a total of 39 deaths, and only 67 deaths in the earlier combined surveys conducted in 2011. Given these limitations, we were unable to control for potential important confounders including caste, region, or state, which could affect the precision of our estimates.

There are many causes of newborn mortality that the newborn care practices examined in this study are not expected to prevent; for example, thermal care and cord care practices would not prevent deaths due to congenital factors or some intrapartum birth complications. Nor does our analysis control for all potential contributing factors. Our adjusted models also failed to include another key indicator related to newborn mortality: immediate breastfeeding. Support for immediate (within one hour) and exclusive breastfeeding is also a main tenet of newborn care, providing newborns with nutritional, immunologic, and thermal support through skin-to-skin holding (Jones et al. 2003; Lawn et al. 2009a; Moore et al. 2013). We did not include immediate breastfeeding in this study because of the misleading association between “never breastfed” and “don’t know” or missing responses and newborn death; for example, in the pooled Bangladesh and Nepal sample, 32 of the 39 deaths had “don’t know” or missing responses to the question on immediate breastfeeding.

Further, because our indicators, specifically hygienic cord care, may lack critical information, they may at times be misleading. In 1994, WHO first identified the “six cleans” that are essential for infection prevention during and after delivery: clean hands, clean birth surface, clean perineum, clean instrument used to cut the cord, clean cord tie, and a clean cloth for drying (WHO 1994). In order to ensure clean cord care, not only must a clean object be used to cut the cord, but any other object that comes in contact with the cord must also be clean, including hands, clamps, towels, or the surface on which the cord is cut. While a woman may have said she boiled her instrument before cutting the cord, we cannot know if it was done properly and if it remained clean until use. Aside from the instrument used, we have no information on the five other “cleans” practices recommended by WHO, so we cannot be sure that our indicator captures hygienic conditions that affect the risk of infection via the cord stump. We recommend that future hygienic cord care promote all areas of sanitary concern. For example, PATH has a well-documented example of including a plastic “good luck” coin in birth kits to replace the practice of using a dirty coin as a surface against which the cord can be cut (PATH 2002). Programs providing clean delivery kits are a highly cost-effective means of preventing mortality, particularly in areas where rates of home delivery are high, as in

South Asia; kits can include clean instruments, soap, a clean sheet on which a mother can deliver, clean string to tie the cord, and even instructions for the birth attendant or mother (Seward et al. 2012).

Regarding the substance placed on the cord, the finding that mortality was highest among babies with dry cord care compared with antiseptics or other substances placed on the cord requires further investigation. It could indicate higher mortality due to a general lack of care for or attention to a newborn who had nothing placed on the cord, rather than a deliberate choice to employ the recommended dry cord care. Coffey et al. (2017) acknowledged the importance of cultural practices in people's lives regarding care for newborn cords, that the desire to care for the cord with topical application of substances persists across cultural contexts, and that there is a paucity of research demonstrating that all traditional substances used around the world are harmful. For example, boric powder as commonly applied in Bangladesh can be harmful if ingested, but little is known about its risk when applied to open wounds; oils, as commonly applied in most countries studied in this report, may be particularly harmful if they are contaminated (Coffey and Brown 2017; Raza et al. 2004). Recommendations are that behavior-change efforts should not necessarily discount the importance of traditional practices, but work with them, and continue to incorporate emerging evidence on these topics. Additionally, given the cultural importance of cord care practices, we speculate that applying something on the cord may indicate that the child may be receiving more care than a child with nothing on the cord; that is, what appears to be dry cord care may actually indicate neglect.

While we were able to isolate our responses so that "antiseptic use" included only births that did not have anything else placed on the cord, these surveys did not universally collect information on the timing of the practice of placing a substance on the cord. Further, our definition was expanded to include antiseptics in addition to chlorhexidine, such as methylated spirits, gentian violet, dettol, betadine, or other antibiotics, the efficacy of which have not all been studied (Coffey et al. 2017). Other products could be placed on the cord immediately after cutting it, at a later time, or even multiple times over the course of the newborn period; the survey questions do not specify those responses. However, we do know that most newborn deaths occur within the first week of life (Lawn et al. 2009b). Thus, it is plausible that our finding that more babies died if they had nothing placed on the cord could reflect not that dry cord care is harmful, but that babies died before anything was placed on the stump. On the other hand, if mothers know that placing any substance on the cord may be harmful, it is possible that this question is susceptible to social desirability bias in that mothers do not report the practice (Liu et al. 2013). Given these potential biases, the conclusion that both other substances and antiseptics are protective against death compared with dry cord care should be regarded with due caution. We recommend research to determine if this is a measurement issue, a timing issue, or a question of intervention effectiveness. An immediate next step could be to check associations between dry cord care and other hygienic practices to see if there is a pattern indicating negligence of infant care.

4.3 Validity and Recall of Newborn Care Practices

Death of a newborn child is traumatic. Women who have lost a child are at risk of psychiatric disorders including depression, anxiety, or even posttraumatic stress disorder (PTSD) (Gold 2016). These psychological consequences can persist for years (Murphy, Shevlin, and Elkit 2014; Christiansen et al. 2013). A large body of evidence shows that memory of details around a traumatic event is compromised, and those who suffer from PTSD or related disorders are prone to reduced recall of specific details; further, individuals who have experienced trauma may avoid discussing the event in detail as a means of emotional

protection, known as "functional avoidance" (Williams et al. 2007; Barry et al. 2018). In some cultures, talking about a stillbirth or neonatal death may be discouraged (Haws et al. 2010; Sisay et al. 2014), which in turn may lead to worse recall. The more often an event is recalled, the more likely it is to be remembered, but memories around the saddest events are least likely to be retained (Bernsten and Rubin 2002).

This notion of reduced recall around traumatic events has important implications for our study. First, it affirms our finding of an increased likelihood of reporting a child death among those women who respond to survey questions that they don't know or who have missing responses. That we found the clearly closest association between the "don't know" and missing responses and newborn death regarding the practice of bathing the newborn suggests that the survey question might be particularly sensitive to functional avoidance or recall errors. In these cases, a newborn's first bath might have been given after the child's death, in customary preparation for the cremation or burial, which may remind the mother of the death itself and thus be extremely difficult to recall or report. Second, we found that the dataset for the most recent survey in India contained no missing or "don't know" responses from mothers reporting on births at home regarding newborn practices such as drying and bathing and the instrument used to cut the cord. Although the questionnaire included a response option for "don't know", the Computer-Assisted Personal Interviewing (CAPI) program erroneously omitted this option in this survey. Finally, our findings elicit concerns about the validity of other responses related to newborn care by bereaved mothers.

Even among mothers whose most recent child survived the first month, the validity of the responses to these questions is still uncertain. "Facility reporting bias" may produce inaccurate estimates because women who deliver in facilities may assume they receive a high level of care and therefore receipt of care practices (Blanc et al. 2016b). It may be impossible for a woman who delivered in a health facility to know if the cord was cut with a clean instrument; she may assume and report a clean instrument was used because of her place of delivery. Studies have shown that women who delivered in facilities or via cesarean section were also more likely to respond with "don't know" to many postnatal newborn care practices (Blanc et al. 2016b). Stanton et al. (2013) compared women's reports of newborn care with their health records from the time of delivery at health facilities in Mozambique and found that questions related to thermal care practices of drying and wrapping met only some acceptability criteria of validity. Yoder et al. (2010) conducted a qualitative study among women in Bangladesh and Malawi and found that, while women definitively stated that their babies received these interventions, they had difficulty relaying and recalling precise timing estimates—which introduces challenges and the potential for interviewer error when coding responses. That is, women tend to report on these activities more generally, using adverbial terms like "soon after", or "a little while" after birth, which leaves to the discretion of the interviewer the interpretation of the precise length of time. This was supported by a study conducted in Mexico, where women who delivered in a health facility were likely to respond "don't know" when asked about newborn practices where timing or sequence of the intervention was important – such as order of thermal care practices – or other postnatal indicators (Blanc et al. 2016a). Although the researchers recommended not using the delivery of the placenta as a reference point for timing, the most recent India survey still used this phrasing. Some confusion around the interpretation of language or meaning of the questions, particularly when translated from English to the host-country languages, is also likely (Yoder et al. 2010).

Similar findings among facility births in Kenya were found by Blanc et al. (2016b) and show that accuracy of reporting on newborn care practices when comparing mother's report to direct observation were affected by wording of the question, type of birth, and context of the indicator. A two-part question that explained

skin-to-skin care notably lessened women over-reporting their receipt of this practice; however, of the four surveys with skin-to-skin questions examined in this report, this two-part question was only incorporated into one of the four surveys. This indicator of skin-to-skin had low validity along with other newborn practices related to timing of events; women who had experienced a cesarean section were less inclined to report on newborn practices that occur right after birth (Blanc et al. 2016b). A qualitative study that interviewed women at the time of their delivery and followed-up 13-15 months after delivery found that postnatal indicators were difficult for women to reliably report over time. Moreover, many women had varying interpretations of the term "immediate" when used in some questions ("*Did someone place the baby on your chest, against your skin immediately after delivery of the baby*?"), and this may cause difficulty in accurate reporting of many postnatal indicators where timing is essential (McCarthy et al. 2016).

4.4 Conclusion

Our study addressed several gaps in the literature, including documenting trends in newborn care practices, demonstrating the way practices differ by place of delivery, and examining how these practices predict newborn mortality, both recently and historically. As expected, we found that births delivered in a health facility received recommended thermal care and hygienic cord care practices more often than births delivered at home. The findings from this study also demonstrated changes over time in newborn care practices in ways that align with current recommendations, even among home births. We found substantial gains in thermal care practices in Bangladesh, India, and Nepal. There were less clear and consistent trends with hygienic cord care. We found that, although using a clean instrument was common in South Asia, the traditions of placing potentially harmful substances on the umbilical cord stump after birth persist, leading to faltering improvement of complete hygienic cord care practices. In Timor-Leste we found only minimal improvement in the combined thermal care or hygienic cord care practices over time.

We further examined the associations of newborn thermal care and cord care practices with newborn mortality by survey and in pooled samples. In many instances, our study likely lacked adequate power to detect significant differences in mortality by newborn care practices. In some settings, however, we found that babies whose cord was cut with an unclean object had an increased likelihood of dying in the first month. In pooled samples of recent surveys, we found that babies who had an antiseptic placed on their cord after it was cut had lower odds of dying compared with those who had nothing placed on their cord. Finally, we found an increase over time in the magnitude and the strength of the association between hygienic cord care practices and newborn survival in South Asia. However, these findings should be interpreted with caution given the potential interference of bias and relatively few cases of deaths even in pooled samples. Further, our study does not control for or examine all potential causes or predictors of newborn mortality, nor are these interventions the sole interventions necessary for preventing the death of a newborn. This study does not indicate that there is or is not a causal relationship between the interventions and death, and should not a substitute for a randomized control study.

One notable but ancillary finding of this study was the significant association found between newborn mortality and missing or "don't know" survey responses by the mother. These findings suggest that a mother's recall of details surrounding the traumatic event of a loss of a child is unreliable. While some women may opt out of responding to the question, the validity of the responses of bereaved mothers is called into question. Thus, additional caveats should be considered in this analysis. Based on these results,

we also recommend a review of compassionate ways to collect data, particularly around sensitive issues such as the loss of a baby.

Finally, our report examined predictors of recommended newborn care practices among home births in South Asia and found that some interventions related to thermal care and hygienic cord care may be provided together, and that skilled care before and during birth increases these recommended practices. Other predictors of care before, during, and after birth may confound the relationship between newborn care practices and mortality within the first year after birth. UNICEF's Every Child Alive report (2018) calls for both an expansion of access and improvements to the quality of newborn care; studies still reveal major gaps in the quality of PNC provided (Marchant 2015). While the newborn care practices examined in this study have generally been increasing, there is still need for improvement and for investigations of the quality of care, which will require new efforts in data collection and analysis.

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APPENDIX

Appendix Table 1a Timing of drying or wrapping by place of delivery

	Home						Facility						
	Immediately		Not immediately		Not dried, don't know, missing		Immediately		Not immediately		Not dried, don't know, missing		
Survey	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2007	6.6	[5.4,8.1]	53.7	[50.6,56.7]	39.7	[36.8,42.8]							
Bangladesh 2011	53.5	[51.1,55.9]	41.1	[38.7,43.5]	5.4	[4.4,6.6]	67.1	[62.7,71.3]	28.1	[24.0,32.7]	4.7	[3.1,7.2]	<0.001
Bangladesh 2014	67.0	[62.5,71.1]	24.8	[20.9,29.1]	8.2	[6.8,9.9]	70.1	[65.6,74.2]	19.3	[16.2,22.9]	10.6	[8.8,12.7]	0.002
Ghana 2014	81.1	[77.3,84.3]	18.0	[14.8,21.7]	0.9	[0.4,1.9]	79.1	[76.4,81.6]	17.7	[15.4,20.3]	3.2	[2.4,4.2]	0.013
India 2005-06	45.4	[43.6,47.2]	51.4	[49.6,53.1]	3.2	[2.9,3.7]							
India 2015-16	81.1	[80.4,81.7]	18.9	[18.3,19.6]	0.0								
Nepal 2006	47.5	[42.6,52.5]	52.1	[47.2,57.0]	0.3	[0.1,0.8]							
Nepal 2011	65.5	[61.2,69.5]	34.0	[29.9,38.3]	0.5	[0.2,1.1]							
Nepal 2016	82.5	[79.0,85.6]	17.2	[14.2,20.6]	0.3	[0.1,0.8]	92.6	[90.9,94.0]	2.8	[2.0,3.9]	4.5	[3.5,5.8]	<0.001
Nigeria 2013	38.5	[36.8,40.3]	58.0	[56.1,59.8]	3.5	[3.0,4.1]							
Sierra Leone 2013							65.3	[61.9,68.6]	14.0	[11.7,16.6]	20.7	[18.5,23.2]	
Timor-Leste 2009-10	65.0	[63.1,66.8]	34.2	[32.4,36.0]	0.9	[0.6,1.2]							
Timor-Leste 2016	37.8	[34.8,40.8]	53.4	[50.5,56.3]	8.8	[7.3,10.7]	55.6	[52.5,58.7]	36.9	[33.9,40.1]	7.5	[6.3,8.8]	<0.001

Appendix Table 1b Timing of drying by place of delivery

	Home						Facility						
	Immediately		Not immediately		Not dried, don't know, missing		Immediately		Not immediately		Not dried, don't know, missing		
Survey	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2007	6.2	[5.1,7.7]	49.4	[46.5,52.2]	44.4	[41.6,47.3]							
Bangladesh 2011	51.4	[48.9,53.9]	41.0	[38.6,43.4]	7.6	[6.5,8.9]	65.5	[60.8,69.9]	29.3	[24.9,34.1]	5.2	[3.5,7.7]	<0.001
Bangladesh 2014	67.0	[62.5,71.1]	24.8	[20.9,29.1]	8.2	[6.8,9.9]	70.1	[65.6,74.2]	19.3	[16.2,22.9]	10.6	[8.8,12.7]	0.002
India 2005-06	45.4	[43.6,47.2]	51.4	[49.6,53.1]	3.2	[2.9,3.7]							
India 2015-16	81.1	[80.4,81.7]	18.9	[18.3,19.6]									
Nepal 2006	42.8	[37.8,48.0]	56.6	[51.4,61.6]	0.6	[0.3,1.1]							
Nepal 2011	57.5	[53.5,61.4]	41.3	[37.4,45.3]	1.2	[0.6,2.3]							
Nepal 2016	78.9	[75.2,82.2]	20.6	[17.4,24.3]	0.5	[0.2,1.0]	90.6	[88.7,92.2]	3.3	[2.4,4.4]	6.1	[4.9,7.6]	<0.001
Nigeria 2013	28.0	[26.5,29.6]	67.7	[66.0,69.4]	4.2	[3.6,4.9]							
Sierra Leone 2013							65.3	[61.9,68.6]	14.0	[11.7,16.6]	20.7	[18.5,23.2]	
Timor-Leste 2009-10	65.0	[63.1,66.8]	34.2	[32.4,36.0]	0.9	[0.6,1.2]							
Timor-Leste 2016	37.8	[34.8,40.8]	53.4	[50.5,56.3]	8.8	[7.3,10.7]	55.6	[52.5,58.7]	36.9	[33.9,40.1]	7.5	[6.3,8.8]	<0.001

Appendix Table 2 Timing of first bath by place of delivery

	Home						Facility						
	Delayed		<6 hours		Not bathed, don't know, missing		Delayed		<6 hours		Not bathed, don't know, missing		
Survey	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2007	48.5	[45.6,51.5]	49.8	[46.9,52.7]	1.7	[1.2,2.3]							
Bangladesh 2011	60.4	[57.8,62.9]	37.6	[35.0,40.2]	2.0	[1.5,2.7]	90.1	[86.9,92.5]	6.3	[4.4,8.9]	3.7	[2.3, 5.7]	<0.001
Bangladesh 2014	65.9	[62.3,69.3]	32.3	[28.9,35.9]	1.8	[1.3,2.5]	92.9	[91.5,94.2]	3.4	[2.6,4.5]	3.6	[2.8,4.7]	<0.001
Ghana 2014	8.8	[6.4,12.0]	90.0	[86.8,92.6]	1.2	[0.6,2.1]	20.1	[18.0,22.4]	68.5	[65.6,71.2]	11.4	[9.6,13.4]	<0.001
Nepal 2006	19.2	[15.2,23.9]	80.1	[75.3,84.1]	0.7	[0.4,1.2]							
Nepal 2011	34.8	[30.9,38.8]	64.5	[60.4,68.5]	0.7	[0.4,1.4]							
Nepal 2016	56.7	[52.7,60.7]	42.7	[38.8,46.8]	0.6	[0.2,1.4]	92.1	[90.6,93.4]	6.3	[5.2,7.7]	1.6	[1.0,2.4]	<0.001
Nigeria 2013	6.4	[5.8,7.1]	89.0	[88.1,89.8]	4.7	[4.1,5.3]							
Pakistan 2006-07	23.3	[20.9,25.8]	75.1	[72.6,77.6]	1.6	[1.1,2.2]	46.4	[43.7,49.2]	49.1	[46.4,51.8]	4.5	[3.4,5.8]	<0.001
Timor-Leste 2009-10	7.1	[6.1,8.1]	92.3	[91.2,93.3]	0.6	[0.4,0.9]							
Timor-Leste 2016	23.4	[21.3,25.6]	76.4	[74.1,78.5]	0.3	[0.1,0.8]	74.8	[71.9,77.6]	24.9	[22.2,27.8]	0.3	[0.1,0.6]	<0.001

Appendix Table 3 Percentage of babies receiving skin-to-skin after birth by place of delivery

	Home						Facility						
	Yes		No		Don't know, missing		Yes		No		Don't know, missing		
Survey	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2014	24.7	[22.0,27.7]	74.8	[71.8,77.6]	0.5	[0.3,0.9]	28.4	[24.3,32.9]	70.1	[65.6,74.2]	1.5	[1.0,2.3]	0.003
Ethiopia 2016	8.9	[7.1,11.2]	90.9	[88.6,92.7]	0.2	[0.1,0.5]	56.4	[52.9,59.9]	39.8	[36.3,43.3]	3.8	[2.9,5.0]	<0.001
Nepal 2016	56.7	[52.7,60.7]	42.7	[38.8,46.8]	0.6	[0.2,1.4]	92.1	[90.6,93.4]	6.3	[5.2,7.7]	1.6	[1.0,2.4]	<0.001
Timor-Leste 2016	23.4	[21.3,25.6]	76.4	[74.1,78.5]	0.3	[0.1,0.8]	74.8	[71.9,77.6]	24.9	[22.2,27.8]	0.3	[0.1,0.6]	<0.001

Appendix Table 4 Thermal care among home births

	Both		One or neither		Don't know, missing	
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**
Bangladesh 2007	4.1	[3.3,5.3]	87.4	[85.8,88.9]	8.4	[7.2,9.8]
Bangladesh 2011	32.4	[30.2,34.7]	64.8	[62.3,67.1]	2.9	[2.2,3.7]
Bangladesh 2014	45.0	[40.8,49.3]	50.9	[47.0,54.8]	4.1	[3.1,5.3]
Ghana 2014	7.2	[5.0,10.4]	91.4	[88.2,93.8]	1.4	[0.8,2.4]
Nepal 2006	11.2	[8.5,14.5]	87.8	[84.4,90.6]	1.0	[0.6,1.5]
Nepal 2011	26.0	[22.7,29.6]	72.8	[68.9,76.3]	1.2	[0.7,2.2]
Nepal 2016	49.5	[45.1,53.9]	49.6	[45.2,54.0]	0.9	[0.4,1.7]
Nigeria 2013	2.5	[2.2,3.0]	91.9	[91.1,92.7]	5.5	[4.9,6.2]
Timor-Leste 2009-10	4.8	[4.0,5.7]	93.8	[92.8,94.6]	1.4	[1.1,1.8]
Timor-Leste 2016	10.0	[8.4,11.9]	80.9	[78.6,83.0]	9.1	[7.5,11.0]

Appendix Table 5 Type of instrument used to cut the cord by place of delivery

	Home						Facility						
	Clean		Unclean		Don't know, missing		Clean		Unclean		Don't know, missing		
Survey	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2007	81.3	[78.3,84.0]	17.7	[15.1,20.7]	0.9	[0.6,1.4]							
Bangladesh 2011	84.7	[82.5,86.6]	14.0	[12.1,16.2]	1.3	[0.9,1.9]							
Bangladesh 2014	86.6	[83.5,89.1]	12.6	[10.1,15.7]	0.8	[0.5,1.3]							
India 2005-06	92.8	[92.1,93.4]	4.2	[3.7,4.7]	3.0	[2.7,3.4]							
India 2015-16	96.2	[95.9,96.5]	3.8	[3.5,4.1]									
Morocco 2003-04	5.6	[4.2,7.3]	93.3	[91.6,94.7]	1.1	[0.7,1.8]	99.4	[99.0,99.6]	0.3		0.3	[0.2,0.7]	<0.001
Nepal 2006	78.5	[73.7,82.7]	21.0	[16.9,25.9]	0.5	[0.3,0.8]							
Nepal 2011	82.5	[78.4,86.1]	16.7	[13.2,20.8]	0.8	[0.4,1.6]							
Nepal 2016	88.3	[85.0,90.9]	10.8	[8.3,14.0]	0.9	[0.5,1.6]							
Nigeria 2013	92.6	[91.6,93.4]	4.1	[3.4,4.9]	3.3	[2.9,3.8]							
Pakistan 2006-07	62.8	[59.8,65.6]	35.2	[32.4,38.2]	2.0	[1.5,2.6]							
Sierra Leone 2013							13.9	[11.0,17.4]	63.8	[60.3,67.2]	22.3	[19.4,25.6]	
Timor-Leste 2009-10	20.0	[18.1,22.1]	79.5	[77.4,81.5]	0.4	[0.3,0.7]							
Timor-Leste 2016	36.7	[34.1,39.4]	47.4	[44.5,50.4]	15.9	[13.5,18.6]	85.3	[82.0,88.0]	2.9	[2.1,3.8]	11.9	[9.2,15.2]	<0.001

Appendix Table 6 Substance placed on the umbilical cord by place of delivery

	Home								Facility								
	Nothing		Antiseptic		Other substance		Don't know, missing		Nothing		Antiseptic		Other substance		Don't know, missing		
Survey	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2007	50.4	[47.2,53.6]	15.0	[13.0,17.3]	28.9	[26.3,31.7]	5.7	[4.8,6.7]									
Bangladesh 2011	54.8	[52.5,57.1]	18.3	[16.6,20.1]	18.2	[16.3,20.3]	8.7	[7.6,10.0]	29.8	[25.5,34.6]	42.2	[37.2,47.4]	5.5	[2.3,6.7]	23.6	[19.7,27.8]	<0.001
Bangladesh 2014	48.4	[44.7,52.2]	22.5	[19.5,25.8]	24.3	[21.9,26.9]	4.7	[3.8,5.9]	24.3	[21.1,27.9]	53.5	[50.2,56.8]	4.0	[3.1,5.2]	18.2	[15.6,21.0]	<0.001
Ethiopia 2016	88.7	[86.4,90.6]	0.0		10.3	[8.6,12.5]	1.0	[0.6,1.5]	62.0	[58.4,65.5]	0.0		22.8	[20.0,25.9]	15.1	[12.9,17.6]	<0.001
Morocco 2003-04	29.2	[25.8,32.9]	0.0		70.2	[66.5,73.7]	0.6	[0.3,1.1]	88.2	[86.7,89.6]	0.0		11.3	[9.9,12.8]	0.5	[0.3,0.9]	<0.001
Nepal 2006	73.3	[69.1,77.2]	0.0		25.7	[22.0,29.9]	0.9	[0.6,1.5]									
Nepal 2011	54.8	[49.3,60.1]	0.8	[0.4,1.6]	40.6	[35.5,45.8]	3.9	[2.9,5.3]									
Nepal 2016	41.3	[38.2,44.4]	13.8	[11.5,16.3]	42.8	[39.4,46.2]	2.2	[1.4,3.2]	24.0	[21.4,26.8]	39.5	[36.5,42.6]	16.6	[14.1,19.3]	19.9	[16.6,23.7]	<0.001
Nigeria 2013	58.7	[56.6,60.7]	10.0	[9.1,10.9]	25.6	[23.7,27.5]	5.8	[5.1,6.5]									
Timor-Leste 2009-10	53.3	[51.1,55.4]	4.6	[3.9,5.4]	41.8	[39.7,43.9]	0.3	[0.2,0.5]									
Timor-Leste 2016	57.8	[54.7,61.0]	6.0	[4.9,7.4]	29.2	[26.4,32.0]	7.0	[5.7,8.6]	28.2	[25.1,31.6]	33.3	[30.1,36.6]	21.1	[18.5,24.1]	17.4	[14.8,20.3]	<0.001

Appendix Table 7a Antiseptic placed on the umbilical cord among home births

	Chlorhexidine		Antibiotic		Antiseptic		Spirit		Gentian Violet		Dettol		Betadine	
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**
Bangladesh 2007	na		8.4	[7.0,10.0]	7.6	[6.2,9.3]	0.5	[0.3,0.8]	1	[0.6,1.5]	na		na	
Bangladesh 2011	na		10.6	[9.4,12.0]	8.4	[7.2,9.7]	0.4	[0.2,0.7]	0.5	[0.2,0.9]	na		na	
Bangladesh 2014	0.0		16.7	[14.5,19.1]	9.0	[7.4,11.0]	0.3	[0.1,0.8]	1.2	[0.7,1.9]	na		na	
Nepal 2011	0.8	[0.4,1.6]	na		na				na		na		na	
Nepal 2016	13.4	[11.2,15.9]	na		na		1.1	[0.5,2.4]	na		na		na	
Nigeria 2013	na		na		na		10.9	[10.0,12.0]	na		1.3	[1.0,1.6]	na	
Timor-Leste 2009-10	na		na		na				na		na		5.3	[4.5,6.3]
Timor-Leste 2016	na		na		na				na		na		6.3	[5.1,7.7]

Note: Response options allow for more than one choice.

Appendix Table 7b Most common harmful substance placed the umbilical cord among home births

Survey	Substance	%	95% CI	Substance	%	95% CI
Bangladesh 2007	Mustard oil with garlic	11.6	[9.7,13.7]	Boric powder	7.7	[6.4,9.3]
Bangladesh 2011	Mustard oil with garlic	11.2	[9.5,13.2]	Boric powder	3.7	[2.9,4.8]
Bangladesh 2014	Mustard oil with garlic	18.8	[16.8,21.0]	Boric powder	3.5	[2.4,5.0]
Ethiopia 2016	Oil	8.7	[7.1,10.7]	Ash	0.4	[0.2,0.7]
Nepal 2011	Oil	23.5	[19.9,27.5]	Ointment/powder	7.9	[5.7, 11.0]
Nepal 2016	Oil	20.0	[17.3,23.1]	Ointment/powder	17.7	[14.6,21.2]
Nigeria 2013	Oil	11.4	[10.3,12.7]	Toothpaste	4.8	[4.0,5.7]
Timor-Leste 2009-10	Ointment/powder	19.2	[17.6,20.9]	Oil	9.5	[8.4,10.8]
Timor-Leste 2016	Oil	12.2	[10.1,14.5]	Traditional medicine	7.3	[6.0,8.9]

Note: Response options allow for more than one choice; non-specified, "other" responses are not included.

Appendix Table 8 Hygienic cord care among home births

	Both		One or neither		Don't know, missing	
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**
Bangladesh 2007	54.3	[51.0,57.5]	40.0	[36.9,43.2]	5.7	[4.8,6.7]
Bangladesh 2011	63.7	[60.9,66.3]	26.9	[24.5,29.5]	9.4	[8.2,10.8]
Bangladesh 2014	62.3	[59.3,65.1]	32.4	[29.4,35.5]	5.3	[4.3,6.6]
Morocco 2003-04	4.6	[3.4,6.2]	93.8	[92.1,95.2]	1.6	[1.1,2.4]
Nepal 2006	55.4	[50.8,60.0]	43.3	[38.7,47.9]	1.3	[0.9,1.9]
Nepal 2011	44.7	[40.5,48.9]	51.0	[46.7,55.3]	4.3	[3.2,5.7]
Nepal 2016	47.1	[43.7,50.5]	50.0	[46.5,53.5]	2.9	[2.1,4.1]
Nigeria 2013	65.4	[63.3,67.4]	28.3	[26.4,30.3]	6.3	[5.6,7.1]
Timor-Leste 2009-10	13.4	[11.9,15.1]	85.9	[84.2,87.5]	0.7	[0.5,1.0]
Timor-Leste 2016	23.3	[21.1,25.8]	57.0	[53.9,60.0]	19.7	[17.1,22.5]

Appendix Table 9 Percentage of newborn deaths among home births by drying practices

	Dried or wrapped immediately		Not dried immediately		Don't know or missing		
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**p-value**
Bangladesh 2007	1.8	[0.5,6.7]	1.6	[1.0,2.7]	0.6	[0.3,1.4]	0.120
Bangladesh 2011	1.1	[0.7,1.9]	0.9	[0.5,1.6]	1.0	[0.3,3.0]	0.773
Bangladesh 2014	1.2	[0.7,1.9]	0.8	[0.3,2.2]	1.2	[0.3,4.9]	0.786
Ghana 2014	0.3	[0.1,1.0]	0.5	[0.1,3.3]	55.0	[22.9,83.5]	<0.001
India 2005-06	1.8	[1.5,2.2]	2.0	[1.6,2.4]	0.8	[0.3,1.9]	0.188
India 2015-16	1.6	[1.4,1.8]	1.9	[1.5,2.5]			0.195
Nepal 2006	0.7	[0.4,1.2]	1.4	[0.9,2.4]	0.0		0.215
Nepal 2011	1.2	[0.7,2.0]	1.1	[0.5,2.6]	0.0		0.923
Nepal 2016	0.6	[0.3,1.3]	0.4	[0.1,2.9]	0.0		0.915
Nigeria 2013	1.9	[1.6,2.4]	2.2	[1.8,2.6]	2.3	[1.2,4.3]	0.674
Timor-Leste 2009-10	1.1	[0.7,1.6]	1.1	[0.6,2.1]	4.0	[0.9,15.3]	0.284
Timor-Leste 2016	0.4	[0.1,1.5]	0.5	[0.2,1.5]	0.0		0.730

Appendix Table 10 Percentage of newborn deaths among home births by timing of first bath

	Delayed		<6 hours		Not bathed, don't know, missing		
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**p-value**
Bangladesh 2007	1.1	[0.6,1.9]	1.1	[0.6,1.9]	16.6	[6.4,36.7]	<0.001
Bangladesh 2011	0.6	[0.3,1.2]	0.7	[0.3,1.4]	30.0	[17.4,46.7]	<0.001
Bangladesh 2014	0.8	[0.5,1.5]	1.0	[0.5,2.2]	25.5	[11.5,47.4]	<0.001
Ghana 2014	0.0		0.4	[0.1,1.0]	43.5	[16.5,75.1]	<0.001
Nepal 2006	0.7	[0.3,1.7]	1.1	[0.7,1.7]	28.6	[8.9,62.3]	<0.001
Nepal 2011	0.5	[0.2,1.7]	1.2	[0.8,2.0]	52.0	[15.5,86.5]	<0.001
Nepal 2016	0.4	[0.1,1.1]	0.8	[0.3,2.1]	20.6	[1.6,80.8]	0.003
Nigeria 2013	1.9	[1.0,3.3]	2.1	[1.8,2.4]	3.0	[1.9,4.7]	0.370
Pakistan 2006-07	2.2	[1.3,3.6]	2.7	[2.1,3.6]	7.0	[2.5,17.9]	0.173
Timor-Leste 2009-10	0.2	[0.0,1.5]	1.2	[0.9,1.6]	0.0		0.220
Timor-Leste 2016	0.5	[0.1,3.6]	0.4	[0.1,0.9]	0.0		0.739

Appendix Table 11 Percentage of newborn deaths among home births by receipt of skin-to-skin care

	Yes		No		Don't know or missing		
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**p-value**
Bangladesh 2014	1.8	[0.9,3.6]	0.8	[0.5,1.5]	0.0		0.256
Ethiopia 2016	0.9	[0.2,4.7]	1.6	[1.0,2.4]	0.0		0.774
Nepal 2016	0.3	[0.0,1.8]	0.8	[0.4,1.7]	0.0		0.532
Timor-Leste 2016	0.5	[0.1,2.3]	0.3	[0.1,1.0]	0.0		0.842

Appendix Table 12 Percentage of newborn deaths among home births by composite thermal care practices

	Both		One or neither		Don't know or missing		
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**p-value**
Bangladesh 2007	1.3	[0.2,6.5]	1.1	[0.7,1.7]	2.8	[1.2,6.3]	0.101
Bangladesh 2011	0.8	[0.3,1.8]	0.6	[0.3,1.1]	18.3	[10.3,30.2]	<0.001
Bangladesh 2014	1.0	[0.5,2.0]	0.7	[0.3,1.5]	8.2	[3.5,18.1]	<0.001
Ghana 2014	0.0		0.4	[0.1,1.0]	37.1	[13.5,68.9]	<0.001
Nepal 2006	0.8	[0.3,2.3]	1.0	[0.7,1.6]	13.4	[3.9,36.9]	<0.001
Nepal 2011	0.3	[0.1,0.9]	1.2	[0.8,2.0]	21.4	[8.0,45.8]	<0.001
Nepal 2016	0.4	[0.2,1.3]	0.7	[0.3,1.8]	4.6	[0.6,29.6]	0.236
Nigeria 2013	1.9	[0.7,4.7]	2.1	[1.8,2.4]	2.9	[1.8,4.5]	0.391
Timor-Leste 2009-10	0.3	[0.0,2.2]	1.1	[0.8,1.6]	2.5	[0.6,9.9]	0.216
Timor-Leste 2016	0.0		0.5	[0.2,1.2]	0.0		0.581

Appendix Table 13 Percentage of newborns who died by type of instrument used to cut the cord

	Clean		Unclean		Don't know or missing		
Survey	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**p-value**
Bangladesh 2007	1.3	[0.9,1.9]	0.7	[0.2,2.2]	6.3	[0.9,33.9]	0.091
Bangladesh 2011	1.0	[0.7,1.5]	1.4	[0.6,3.4]	0.0		0.659
Bangladesh 2014	0.9	[0.5,1.5]	2.3	[1.0,5.2]	2.1	[0.3,13.9]	0.053
India 2005-06	1.9	[1.6,2.1]	2.4	[1.3,4.1]	0.9	[0.4,1.8]	0.170
India 2015-16	1.6	[1.4,1.8]	2.6	[1.6,4.1]	0.0		0.043
Morocco 2003-04	1.8	[0.4,6.7]	1.4	[0.9,2.1]	2.4	[0.3,15.9]	0.831
Nepal 2006	0.9	[0.6,1.6]	1.6	[1.0,2.7]	0.0		0.329
Nepal 2011	1.3	[0.8,2.2]	0.5	[0.1,2.5]	1.8	[0.2,13.1]	0.345
Nepal 2016	0.5	[0.2,1.2]	1.0	[0.3,4.1]	0.0		0.710
Nigeria 2013	2.1	[1.8,2.4]	2.1	[1.0,4.3]	2.2	[1.2,4.3]	0.979
Pakistan 2006-07	2.9	[2.2,3.8]	2.3	[1.4,3.5]	1.1	[0.2,5.1]	0.336
Timor-Leste 2009-10	1.3	[0.7,2.5]	1.1	[0.7,1.5]	4.0	[0.9,15.3]	0.759
Timor-Leste 2016	0.2	[0.0,1.3]	0.5	[0.1,1.6]	0.7	[0.2,2.8]	0.497

Appendix Table 14 Percentage of newborns who died by substance placed on the umbilical cord

	Nothing		Antiseptic		Something else		Don't know, missing		
Survey	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2007	1.2	[0.7,2.1]	1.1	[0.4,2.9]	1.1	[0.5,2.3]	2.9	[0.8,9.4]	0.471
Bangladesh 2011	1.4	[0.9,2.1]	0.6	[0.2,1.6]	0.4	[0.2,1.1]	1.1	[0.3,4.2]	0.015
Bangladesh 2014	1.3	[0.7,2.4]	0.2	[0.1,0.7]	1.1	[0.5,2.5]	2.7	[0.9,7.5]	<0.001
Ethiopia 2016	1.6	[1.1,2.4]	n/a		0.0		6.0	[0.8,34.1]	0.051
Morocco 2003-04	0.8	[0.3,2.2]	n/a		1.7	[1.1,2.5]	0.0		0.020
Nepal 2006	1.2	[0.8,1.9]	n/a		0.7	[0.3,1.5]	0.0		0.021
Nepal 2011	1.3	[0.8,2.3]	0.0		1.0	[0.4,2.2]	1.1	[0.1,7.8]	0.970
Nepal 2016	0.9	[0.4,2.2]	0.0		0.5	[0.2,1.5]	0.0		0.046
Nigeria 2013	2.3	[1.9,2.7]	1.8	[1.1,3.0]	1.8	[1.4,2.4]	1.9	[1.1,3.3]	0.178
Timor-Leste 2009-10	1.3	[0.9,1.8]	0.3	[0.0,2.3]	1.0	[0.6,1.7]	0.0		0.556
Timor-Leste 2016	0.4	[0.1,1.4]	0.9	[0.1,6.6]	0.4	[0.1,1.7]	0.0		0.442

Appendix Table 15 Percentage of newborns who died by hygienic cord care practices

	Both		One or neither		Don't know or missing		
Survey	%	95% CI	%	95% CI	%	95% CI	p-value
Bangladesh 2007	1.2	[0.7,2.0]	1.1	[0.5,2.0]	2.9	[0.9,9.2]	0.287
Bangladesh 2011	1.1	[0.7,1.7]	0.8	[0.4,1.6]	1.1	[0.3,3.9]	0.771
Bangladesh 2014	0.7	[0.4,1.5]	1.4	[0.8,2.7]	2.7	[1.1,6.7]	0.058
Nepal 2006	1.1	[0.6,2.0]	1.1	[0.7,1.7]	0.0	[0.0,0.0]	0.840
Nepal 2011	1.5	[0.8,2.5]	0.9	[0.4,1.9]	1.3	[0.3,6.1]	0.503
Nepal 2016	0.7	[0.2,1.8]	0.6	[0.2,1.5]	0.0	[0.0,0.0]	0.857
Nigeria 2013	2.2	[1.9,2.7]	1.8	[1.3,2.3]	2.0	[1.2,3.3]	0.300
Timor-Leste 2009-10	1.4	[0.7,3.0]	1.1	[0.8,1.5]	0.0		0.686
Timor-Leste 2016	0.0		0.5	[0.2,1.4]	0.6	[0.2,2.3]	0.406

Appendix Table 16 Unadjusted Odds Ratios and Adjusted Odds Ratios of newborn mortality among home births in India

	India 2005-06				India 2015-16			
	UOR	95% CI	AOR	95% CI	UOR	95% CI	AOR	95% CI
Place of residence (ref = rural)								
Urban	0.8	[0.5,1.2]	0.9	[0.6,1.3]	1.1	[0.7,1.5]	1.3	[0.9,1.8]
Wealth quintile (ref = lowest and second)								
Middle	0.9	[0.6,1.2]	1.0	[0.7,1.5]	1.2	[0.9,1.7]	1.3	[1.0,1.8]
Second highest and highest	**0.6***	[0.4,0.9]	1.0	[0.6,1.5]	0.7	[0.4,1.0]	0.8	[0.5,1.3]
Education (ref = none)								
Primary	1.0	[0.7,1.4]	1.0	[0.7,1.5]	1.2	[0.9,1.6]	**1.4***	[1.1,1.8]
Secondary or higher	**0.5****	[0.4,0.8]	**0.5****	[0.3,0.8]	0.9	[0.7,1.2]	1.0	[0.7,1.4]
Religion (ref = Hindu)								
Muslim, other	1.0	[0.7,1.3]	0.9	[0.7,1.3]	**0.7***	[0.6,0.9]	**0.7****	[0.5,0.9]
Maternal age at birth (ref = 18-34)								
<18	**1.8***	[1.1,2.8]	1.0	[0.6,1.7]	1.5	[0.8,2.6]	1.0	[0.5,1.8]
35 and older	**1.6***	[1.0,2.6]	1.6	[1.0,2.7]	**1.9*****	[1.4,2.4]	**1.8*****	[1.4,2.5]
Preceding birth interval (ref = 2+)								
First birth	**2.6*****	[1.8,3.7]	**3.5*****	[2.3,5.3]	**1.8*****	[1.4,2.4]	**2.6*****	[1.9,3.5]
Less than two years	**1.8****	[1.3,2.6]	**1.9*****	[1.3,2.7]	**1.4****	[1.1,1.9]	**1.4***	[1.1,1.9]
Previous child under 5 die (ref = no)								
Yes	1.2	[0.9,1.7]	1.3	[1.0,1.9]	**2.3*****	[1.8,2.8]	**2.4*****	[1.9,3.1]
Antenatal care (ref = less than 4)								
4 or more visits	0.9	[0.6,1.3]	1.2	[0.8,1.7]	0.9	[0.6,1.2]	1.0	[0.8,1.4]
Tetanus (ref = fully protected)								
Not fully protected	**1.7*****	[1.3,2.3]	**1.7*****	[1.3,2.2]	**1.5****	[1.2,1.9]	**1.3***	[1.0,1.7]
Size at birth (ref = normal or large)								
Small or very small	**1.6*****	[1.2,2.1]	**1.6****	[1.2,2.1]	**1.9*****	[1.5,2.5]	**1.9*****	[1.4,2.5]
Gender of child (ref = male)								
Female	1.1	[0.8,1.4]	1.1	[0.9,1.5]	1.1	[0.9,1.3]	1.1	[0.9,1.4]
Skilled attendant at birth (ref = no)								
Yes	0.7	[0.5,1.2]	0.8	[0.5,1.3]	**0.7***	[0.5,1.0]	0.8	[0.6,1.1]
PNC in 2 days (ref = yes)								
No	0.9	[0.4,2.3]	0.8	[0.3,2.1]	**2.2*****	[1.5,3.2]	**2.1*****	[1.5,3.1]
Dry or wrapping (ref = immediately)								
Delayed	1.1	[0.8,1.4]	1.0	[0.8,1.3]	1.2	[0.9,1.6]	1.1	[0.8,1.5]
Not dried, don't know, missing	0.4	[0.2,1.1]	0.5	[0.2,1.6]	n/a			
Instrument used to cut the cord (ref = clean)								
Unclean	1.3	[0.7,2.3]	1.1	[0.6,2.0]	**1.6***	[1.0,2.7]	1.4	[0.8,2.4]
Don't know	0.5	[0.2,1.0]	0.6	[0.2,1.5]	n/a			
AUC			**0.66**				**0.68**	
Pseudo R2			**0.03**				**0.04**	

Note: Unadjusted odds ratios (UOR); Adjusted odds ratios (AOR);
P-values *<0.05, **<0.01, ***<0.001.

Appendix Table 17 Unadjusted Odds Ratios and Adjusted Odds Ratios of newborn mortality among home births in Bangladesh and Nepal

	Bangladesh and Nepal, 2011						Bangladesh 2014 and Nepal 2016					
	UOR	95% CI	AOR	95% CI	AOR	95% CI	UOR	95% CI	AOR	95% CI	AOR	95% CI
Country (ref = Nepal)												
Bangladesh	0.9	[0.5,1.6]	0.7	[0.3,2.0]	0.7	[0.2,1.8]	1.8	[0.8,4.1]	2.1	[1.0,4.7]	2.0	[0.9,4.3]
Place of residence (ref = rural)												
Urban	0.7	[0.3,1.6]	0.7	[0.3,1.7]	0.7	[0.3,1.6]	0.6	[0.2,1.4]	0.7	[0.3,1.7]	0.6	[0.2,1.6]
Wealth quintile (ref = lowest and second)												
Middle	1.2	[0.5,3.2]	1.5	[0.5,4.1]	1.4	[0.5,4.0]	**0.1****	[0.0,0.4]	**0.1****	[0.0,0.5]	**0.1****	[0.0,0.5]
Second highest and highest	1.2	[0.6,2.6]	1.7	[0.6,4.8]	1.7	[0.6,4.8]	0.9	[0.4,2.4]	1.4	[0.4,4.2]	1.2	[0.4,3.7]
Education (ref = none)												
Primary	0.6	[0.3,1.3]	0.5	[0.2,1.3]	0.5	[0.2,1.3]	1.5	[0.5,4.1]	1.4	[0.5,4.0]	1.4	[0.5,3.9]
Secondary or higher	0.8	[0.4,1.5]	0.6	[0.3,1.4]	0.6	[0.3,1.5]	1.4	[0.5,3.7]	1.8	[0.6,5.5]	1.7	[0.6,5.1]
Religion (ref = Hindu)												
Muslim, other	1.0	[0.5,2.0]	1.4	[0.5,3.8]	1.4	[0.5,3.8]	1.3	[0.6,2.8]	0.5	[0.2,1.0]	0.5	[0.2,1.1]
Maternal age at birth (ref= 18-34)												
<18	1.4	[0.6,3.3]	1.4	[0.5,4.2]	1.4	[0.5,4.1]	2.1	[0.9,5.2]	2.6	[1.0,6.9]	2.4	[1.0,6.1]
35 and older	1.2	[0.5,2.8]	1.1	[0.4,2.6]	1.1	[0.4,2.6]	1.7	[0.3,8.5]	1.5	[0.4,6.4]	1.5	[0.4,6.4]
Preceding birth interval (ref = 2+)												
First birth	1.3	[0.6,2.6]	1.3	[0.5,3.0]	1.3	[0.5,3.1]	1.0	[0.5,2.2]	0.6	[0.3,1.3]	0.6	[0.3,1.4]
Less than two years	1.5	[0.6,3.9]	1.5	[0.5,4.0]	1.5	[0.5,3.9]	0.5	[0.1,2.3]	0.5	[0.1,2.4]	0.5	[0.1,2.3]
Previous child under 5 die (ref = no)												
Yes	1.0	[0.5,2.1]	1.1	[0.5,2.3]	1.1	[0.5,2.3]	1.1	[0.4,3.2]	1.1	[0.4,2.9]	1.1	[0.4,2.9]
Antenatal care (ref = less than 4)												
4 or more visits	0.7	[0.3,1.4]	0.6	[0.3,1.4]	0.6	[0.3,1.4]	**0.2***	[0.0,0.9]	**0.2***	[0.1,0.9]	**0.2***	[0.0,0.8]
Size at birth (ref = normal or large)												
Small or very small	1.5	[0.7,3.0]	1.5	[0.7,3.3]	1.5	[0.7,3.3]	1.7	[0.7,3.8]	1.3	[0.5,3.1]	1.4	[0.6,3.3]
Gender of child (ref = male)												
Female	1.3	[0.7,2.2]	1.3	[0.8,2.3]	1.3	[0.8,2.3]	0.6	[0.3,1.4]	0.7	[0.3,1.5]	0.6	[0.3,1.4]

(Continued…)

Appendix Table 17—*Continued*

	Bangladesh and Nepal, 2011						Bangladesh 2014 and Nepal 2016					
	UOR	**95% CI**	**AOR**	**95% CI**	**AOR**	**95% CI**	**UOR**	**95% CI**	**AOR**	**95% CI**	**AOR**	**95% CI**
Skilled attendant at birth (ref = no)												
Yes	0.2	[0.0,1.7]	0.2	[0.0,1.6]	0.2	[0.0,1.4]	**0.1***	[0.0,0.9]	**0.1***	[0.0,1.0]	**0.1***	[0.0,1.0]
PNC in 2 days (ref = yes)												
No	0.7	[0.3,1.4]	0.5	[0.3,1.2]	0.6	[0.3,1.2]	1.5	[0.6,3.9]	1.5	[0.6,3.9]	1.7	[0.6,4.4]
Dry or wrapping (ref = immediately)												
Delayed	0.8	[0.4,1.5]	0.8	[0.4,1.6]	0.8	[0.4,1.6]	0.7	[0.3,2.0]	0.6	[0.2,1.7]	0.7	[0.2,1.9]
Not dried, don't know, missing	0.7	[0.2,2.5]	0.8	[0.2,2.8]	0.8	[0.2,2.8]	1.3	[0.3,6.0]	0.9	[0.2,4.3]	0.9	[0.2,4.2]
Bathing (ref = delayed)												
Immediately	1.8	[0.8,3.7]					1.4	[0.6,3.3]				
Not bathed, don't know, missing	**90.1*****	[41.0,197.8]					**52.4*****	[18.2,150.6]				
Thermal care (ref = both)												
One or neither	1.7	[0.7,3.9]					1.0	[0.4,2.2]				
Don't know or missing	**42.5*****	[16.8,107.0]					**11.5*****	[4.1,32.1]				
Instrument used to cut the cord (ref = clean)												
Unclean	0.8	[0.3,2.0]	0.7	[0.3,1.8]			**2.4***	[1.1,5.4]	1.9	[0.9,4.2]		
Don't know	0.6	[0.1,4.7]	0.6	[0.1,5.2]			1.4	[0.2,10.5]	1.7	[0.2,16.8]		
Substance put on the stump (ref = nothing)												
Antiseptic only	0.4	[0.1,1.2]	0.4	[0.1,1.2]			**0.1****	[0.0,0.4]	**0.2****	[0.0,0.6]		
Other	0.6	[0.3,1.2]	**0.5***	[0.3,0.9]			0.6	[0.3,1.5]	0.7	[0.3,1.7]		
Don't know or missing	0.8	[0.3,2.6]	0.9	[0.3,2.9]			1.7	[0.5,5.3]	1.9	[0.5,6.7]		
Hygienic cord care (ref = both)												
One or neither	0.7	[0.4,1.3]			0.6	[0.3,1.1]	1.3	[0.6,2.8]			1.3	[0.6,2.9]
Don't know or missing	0.9	[0.3,2.7]			0.9	[0.3,2.8]	2.5	[0.8,7.5]			**3.1***	[1.0,9.6]
AUC			**0.65**		**0.63**				**0.77**		**0.76**	
Pseudo R2			**0.03**		**0.03**				**0.09**		**0.08**	

Note: Unadjusted odds ratios (UOR); Adjusted odds ratios (AOR);
P-values *<0.05, **<0.01, ***<0.001