BETTERBIRTH REPORT ADDENDUM

January 2021

SPECIAL TOPICS ON COMPLICATION MANAGEMENT

ARIADNE LABS

ACKNOWLEDGMENTS

This report drew on the expertise of the many partners and stakeholders involved in the BetterBirth Study and the primary Report. It was authored by Megan Marx Delaney, Lauren Bobanski, Rachel Ketchum, Rebecca Bennett, and Katherine Semrau and visually designed by Courtney Staples.

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EXECUTIVE SUMMARY

Complication recognition and management during childbirth is a critical requirement for reducing maternal and perinatal mortality to meet the UN's Sustainable Development Goals.

Building successful and sustainable solutions requires an understanding of the complexity across different layers of the health care ecosystem, including patient preferences, birth attendant behaviors, the context at a given health facility, and the accountability and responsiveness of a larger health system.

This short report unpacks the complexity of five life-saving, facility-based interventions observed during the BetterBirth trial: Referral, cesarean deliveries, antibiotic use, neonatal resuscitation, and oxytocin administration. We highlight process-related findings, such as which groups received the intervention, and health outcomes related findings, such as which groups who received the intervention had the great risk of mortality. The following are our main findings:

REFERRAL

LOW REFERRAL RATES

Referral rates for newborns were concerningly low: only 1.6% of newborns were referred to higher-level facilities. The majority of newborns who ultimately died were never referred to higher-level care. Twins and older women were more likely to be referred (either in utero or after birth), while only ~4% of other high-risk groups such as preterm babies and low birth weight babies were ever referred.

PREVENTABLE MORTALITY

Asphyxia was the predominant cause of death both among those referred and not referred in our sub-study population. Obstructed labor was a major cause of stillbirth among women who were never referred, which may be indicative of a too-low referral and cesarean rate. Non-referred, neonatal deaths that occurred at home were mainly caused by sepsis.

CESAREAN DELIVERIES

LOW CESAREAN RATES

Cesarean rates in the study were 1.8%. Almost all cases requiring cesarean were referred (91%), despite over half of the study facilities reporting to have cesarean capability. Among the 247 cases where a cesarean occurred at a primary-level facility, almost all took place between the hours of 8 a.m. and 2 p.m. Those that arrived in the evening or night had to wait up to 13 hours to deliver.

CESAREAN RARELY PERFORMED ON STILLBIRTHS

Only five stillbirths were reported among the 2,481 cesarean deliveries in the study.

ANTIBIOTICS

VARIED ANTIBIOTIC USE

Antibiotics were given to 14.9% of women and 3.6% of newborns in our direct observation study. Maternal mortality (within seven days) was similar for women who received antibiotics versus those who did not. Among newborns who died within seven days of birth and who did not receive antibiotics around the time of birth, ~25% died of infection, which indicates that recognition and treatment of infection may be insufficient.

NEONATAL RESUSCITATION

RATES OF NEONATAL RESUSCITATION WERE SIMILAR FOR HIGH RISK GROUPS

In our directly observed cohort, we found that 6.4% of newborns received ventilation with a bag and mask. High risk groups, such as preterm newborns, received resuscitation at only slightly higher rates (6.9%).

NEONATAL SURVIVAL FOLLOWING RESUSCITATION

We found that 80% of newborns who received bag and mask resuscitation survived at least the first week of life. Among those who were resuscitated but died, the primary causes of death were asphyxia and complications of prematurity (e.g., lung underdevelopment). Among those who did not receive resuscitation (n=62) but died within seven days of birth, the primary causes of death were asphyxia (39%), complications of prematurity (21%), and sepsis (19%).

OXYTOCIN

INTRAPARTUM OXYTOCIN USED DURING MOST DELIVERIES, DESPITE THE DANGER

Intrapartum oxytocin can shorten labor, but careful monitoring is needed to avoid fetal distress. At baseline, intrapartum oxytocin was administered to 79% of women to augment labor despite <1% use of partograph, which is used to monitor and document fetal heart rate and contraction patterns.

UNMONITORED USE OF INTRAPARTUM OXYTOCIN INCREASES THE NEED FOR NEONATAL RESUSCITATION

In this setting, intrapartum oxytocin use is associated with increased neonatal resuscitation.

Overall, we documented significant gaps in the treatment of complications during the BetterBirth study. These gaps give us direction in where to invest future research and intervention in complications management moving forward.

BACKGROUND

Ariadne Labs released the BetterBirth Report, a comprehensive review of the actionable findings of the BetterBirth Study, in 2019.

In 2020, Ariadne Labs undertook a secondary analysis of the study data to analyze it through the lens of maternal and newborn complications management and develop this addendum to the BetterBirth Report. The addendum includes additional findings and actionable recommendations based on the experience of the more than 157,000 mother-newborn pairs who participated in the BetterBirth study.

BETTERBIRTH STUDY SUMMARY

Ariadne Labs and global partners conducted the BetterBirth Study from 2014 to 2017 in Uttar Pradesh, India to assess the effect of a peer-coaching intervention paired with the WHO Safe Childbirth Checklist on maternal and perinatal mortality. The study was conducted in primary health centers, community health centers, and first referral units; participating women and newborns were followed up to seven days postpartum.

Ultimately BetterBirth interventions resulted in improved adherence to essential birth practices among birth attendants but did not change maternal or perinatal mortality. The study found that there is no magic bullet—no individual clinical practice correlated with better outcomes. Rather, lower mortality correlated with an increased number of completed essential birth practices, regardless of which practices were done.

Improving individual birth attendant performance was insufficient to drive the change required to save lives at scale. To deliver the comprehensive bundle of essential birth practices and achieve sustained outcomes, birth attendants should be supported by a health system that is integrated, cohesive, and seamless.

BetterBirth Data Summary

DATA TYPES	NUMBER OF PARTICIPANTS	NUMBER OF FACILITIES
Seven-day maternal mortality, perinatal mortality, and self-reported severe maternal morbidity outcomes (primary outcomes)	Mother-infant pairs: 157,689 enrolled 157,145 with final seven-day outcomes	120 facilities: 60 intervention 60 control
Direct observation of childbirth care	Births observed at one or more pause points: 603 at baseline 2,563 after two months of coaching 897 after six months of coaching 2,325 four months after the end of the intervention	All half intervention, half control: 10 facilities at baseline 30 after two months of coaching 10 after six months of coaching 30 four months after the end of the intervention
Perinatal verbal autopsy	Of the 7,445 perinatal deaths, we identified 161 perinatal deaths (106 early neonatal deaths, 55 stillbirths) where the delivery was observed. Due to twins, the total number of interviews with mothers was 158.	N/A

A team of birth attendants walk through their facility in Uttar Pradesh.

PURPOSE OF THIS REPORT

The WHO Safe Childbirth Checklist helps birth attendants to systematically assess women and newborns for early signs of complications. Early complication identification is a critical strategy for mortality reduction, particularly in primary health settings with basic resources.

In this addendum, we look at five medical interventions—Referrals, Cesarean sections, Antibiotic use, Resuscitation, and Oxytocin administration—that offer insights into patterns of complication identification and management. We also examine the correlations between these process interventions, the characteristics of those who most commonly receive each intervention, and mortality. We hope that this report can help to identify potential areas for improvement in intrapartum and neonatal care at primary-level facilities and across the health system. ■

Table 1. BetterBirth Study Population

FACILITY CHARACTERISTICS	
Number of facilities	120
Annual delivery load (mean, 95%CI)	1641 (1531-1751)
Functional classification (n, %)	
Primary Health center	46 (38%)
Community Health Center	56 (47%)
First referral unit	18 (15%)
Average distance to district hospital (km) (mean, 95%CI)	30 (27-33)
Average skilled birth attendants per facility (mean, 95%CI)	4.4 (4.1-4.7)
MATERNAL CHARACTERISTICS	
Number of women	157,128
Maternal age	
<=20	2.7%
21-34	95.2%
35-39	2%
40+	0.1%
Number of offspring	
Singleton	99.3%
Multiples	0.7%
Parity	
0	30%
1-3	64%
4+	6%
NEWBORN CHARACTERISTICS	
Sex	
Male	51.8%
Female	47.5%
Unknown	0.7%
Low Birth Weight (2500g or less)	30%
Preterm (Less than 37 weeks gestation)	28%

REFERRAL

Appropriate health care referrals—for example, from a primary facility to a secondary or tertiary facility with specific providers, services, or equipment—and a functional referral system are essential to the quality and continuity of patient care in any health system.

The BetterBirth study was conducted in primary and community health centers, which are designed to handle basic care and to identify complications that require more specialized care.

Primary and community health centers provide care for ~25% of all births across India, therefore what we learn about referral needs and patterns here has critical applications across the country.[1] There is no "right" level of referral, but in the Indian context referral rates range from 2% to 37%.[2,3,4]

Many challenges facing India's referral system are already well known. Gaps in birth attendant knowledge and behavior in treatment of high-risk pregnancies contribute to low-quality care and poor outcomes.[5] At the patient and community level, there are many disincentives for referrals; for example, patients may lack transportation, time, or funds to travel to a facility beyond their community.[6,7] Indeed, in BetterBirth interviews and verbal autopsies, both birth attendants and patients reported hesitancy around referral.

FINDINGS

LEARNINGS ABOUT PROCESS

The BetterBirth Study found that referral patterns for women and newborns were quite different. As described in the BetterBirth report, a majority of women who died in the study were referred at least once. Therefore, we infer that providers are recognizing danger signs for women with the most severe complications and referring these women; the challenge women faced was in the process of referral itself.

REFERRAL OF WOMEN IN THE BETTERBIRTH STUDY

In the BetterBirth Study, 6.3% of women were referred; most of those referrals occurred before delivery.

Among women who died with seven days of childbirth, 83% of these women were referred at least once. Families of these women reported being referred up to five times in an odyssey to find adequate emergency care.

The referral experience for newborns, however, was very different. We found that only 1.6% of newborns in BetterBirth were ever referred. In a subset of newborns whose deliveries were observed by BetterBirth, only 35% of newborns who died within seven days were ever referred. The low rate of referral, particularly among those newborns who ultimately died, is problematic due to a lack of resources to treat the sickest newborns at primary-level facilities.

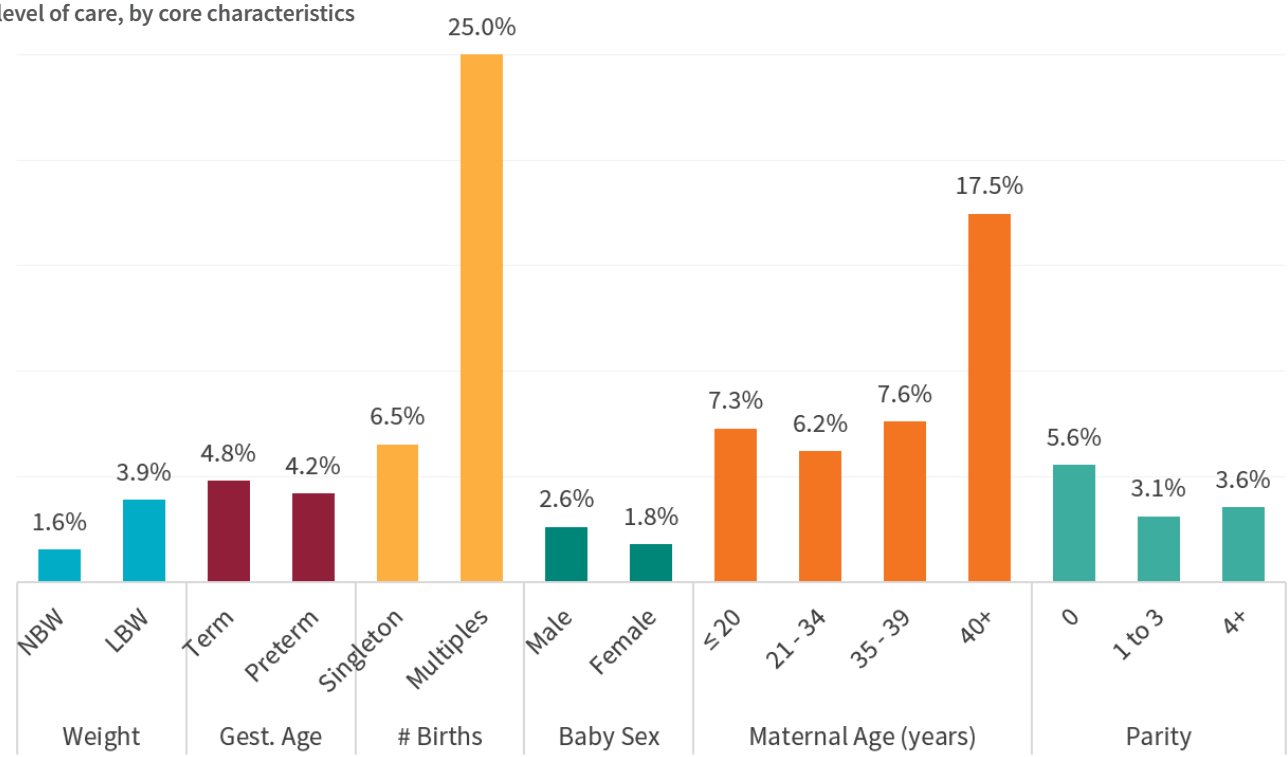
In looking at the characteristics of patients who were referred (including both women and newborns), we find that one-quarter of all twins were referred and a high proportion of women over 40 years of age were also referred.

INTERPRETATION GUIDANCE

This graph shows the percentage of patients who received an intervention within a given group. For example, 1.6% of normal birthweight infants were referred to a higher level of care, whereby 3.9% of all low birthweight infants were referred. Typically, a larger percentage of high-risk groups, such as low birthweight infants, are referred to higher-level care due to higher rates of complications in those populations.

See Table 1 (BetterBirth Study Population) for the distribution across core variable groups.

Figure 1. Percentage of women and newborns who were referred to a higher level of care, by core characteristics



LEARNINGS ABOUT HEALTH OUTCOMES

In Figure 2, we have traced a subset of newborn deaths linking referral status, location of death, and cause of death. Most of the referred newborns died in a health facility (primary-level or referral) and their leading cause of death was asphyxia. In contrast, a substantive proportion of those newborns who were not referred died at home. Leading causes of neonatal death among those not referred varied and included sepsis, in addition to asphyxia. Deaths from sepsis predominantly occurred outside of health facilities, among newborns at home. Antibiotics can prevent and treat newborn sepsis and appear to be underutilized—likely contributing overall to newborn deaths from sepsis (see discussion of antibiotic use later in this addendum). A primary cause of stillbirth at frontline facilities is obstructed labor, which indicates that increased referral and access to cesarean deliveries could potentially reduce mortality.

The plot shown in Figure 3 includes the perinatal risk of death stratified by other characteristics. Among normal weight babies (>2,500g), those who were referred had between 18 and 19 times higher risk of mortality than other normal weight babies in the study. This reflects that the referred newborns were very sick, that the care at the referral facility was suboptimal, or that while referred, the family did not ultimately receive further care.

Figure 2. Sankey diagram showing referral patterns and cause of death among stillbirths and infants who died within seven days of birth

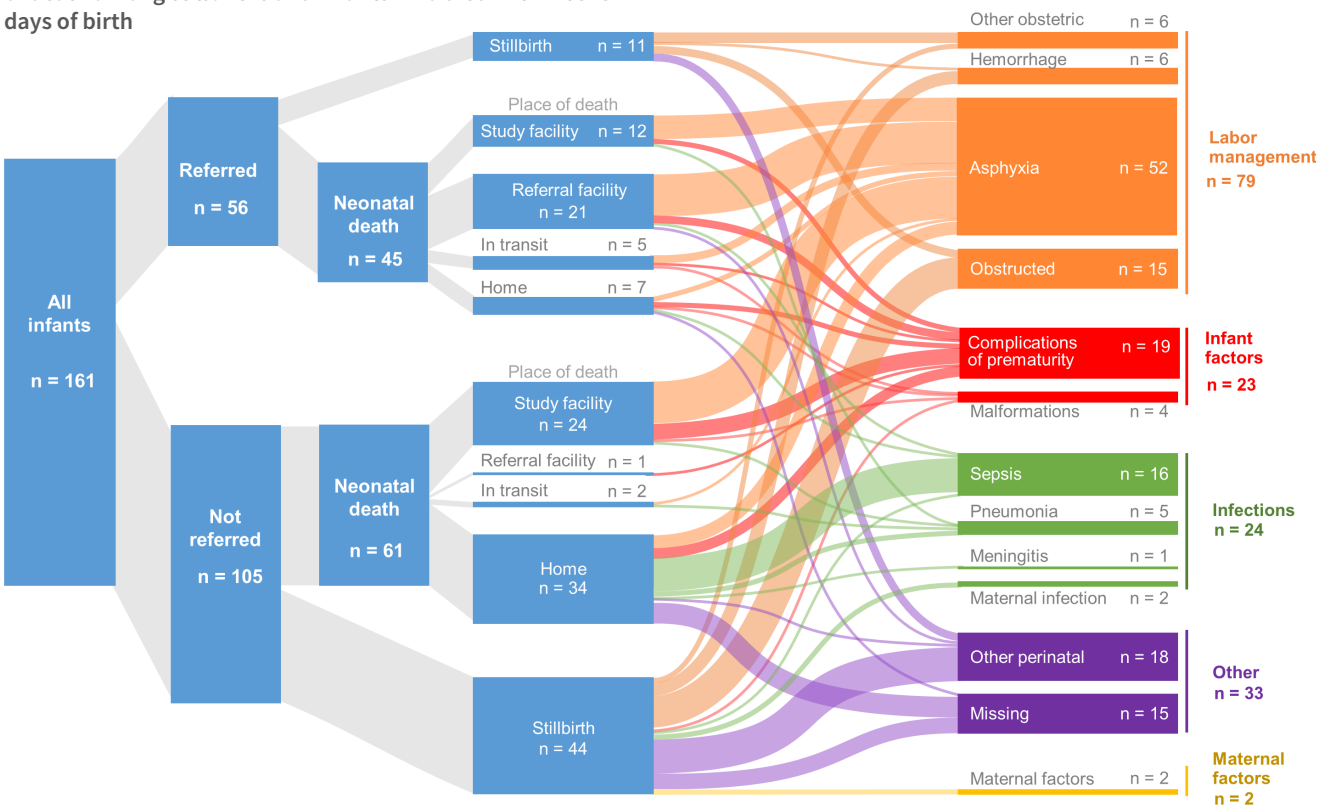
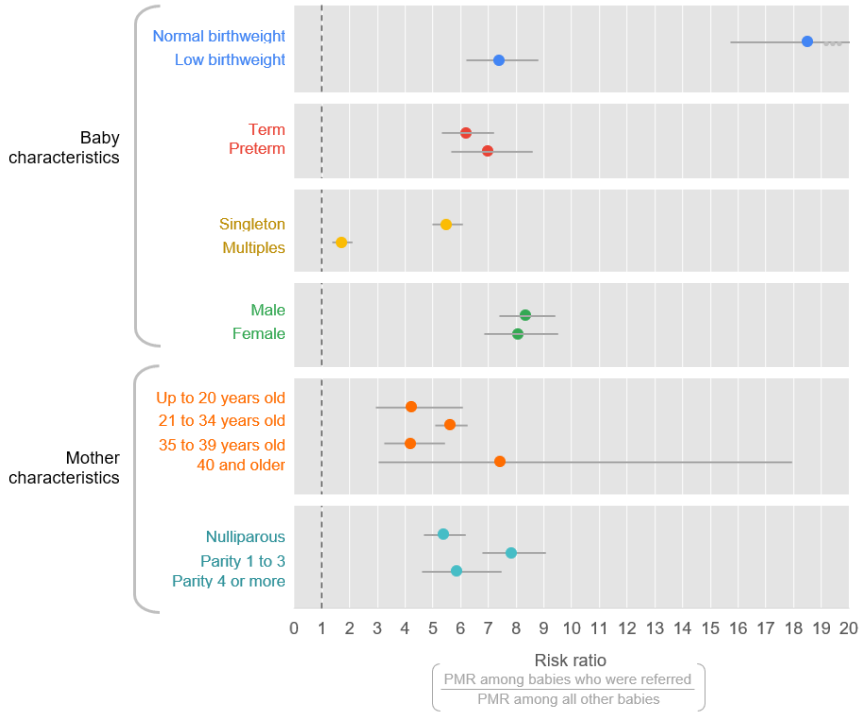


Figure 3. Risk of perinatal mortality among referred cases compared with non-referred cases, by core characteristics



INTERPRETATION GUIDANCE

This Forest plot shows the risk of perinatal mortality among patients who received an intervention versus those who did not. For example, normal birthweight infants who were referred (PMR = 23 per 1,000 births) had an 18.5 times increased risk of death compared with normal birthweight infants who were not referred (PMR = 1.2 per 1,000 births).

In comparison, low birthweight babies (≤2,500g) who are referred have less than eight times higher risk of mortality. This may indicate that health care workers feel more empowered to refer low birthweight babies to higher care earlier, or that referral facilities are better equipped to support low birthweight related complications as opposed to other potentially less common complications that drive the mortality of normal weight babies. In a similar pattern, singleton babies who were referred have more than five times higher risk of mortality compared with singleton babies who were not referred. Referral for twins seems to be protective against increased mortality.

Overall, it appears that the system is more effectively targeting referral and care for known at-risk groups, including low birthweight newborns and multiple births, than for normal weight, singleton newborns.

In looking at the other characteristics in our dataset, we can see an overall elevated risk of mortality for babies who are referred versus those who are not referred, but no other characteristic stands out as driving vulnerability for poor outcomes.

While provider recognition of risk among low birthweight newborns and multiples is critical to neonatal survival and should remain a priority, appropriate referrals for normal weight, singleton newborns offer another opportunity to improve neonatal health outcomes. Implementers may consider strengthening provider knowledge of common complications faced by normal birthweight newborns, while further research should examine any barriers to referral or gaps in care for sick, normal birthweight newborns. ■

CESAREAN BIRTHS

Like referral, the availability of cesarean deliveries ("c-sections") are a critical part of the continuum of care for women and newborns with complications.

A handful of facilities participating in the BetterBirth Study had c-section capability, while most relied on referral for those women who needed c-sections. In all study facilities, care was technically available 24 hours a day, seven days a week, including the capability for c-sections at designated Community Health Centers and First Referral Units.

There is debate within medical and public health communities on the optimal frequency of c-section within a given population, but an average of 19 c-sections per 100 live births is viewed as ideal to reduce maternal and neonatal mortality.[8] In reality, India's c-section rates vary from 3% to 70% depending on region and socioeconomic status. The average c-section rate from 2016 was 17.2%.[9]

Beyond the overall c-section rate, we looked at two additional factors around c-section: timing of delivery and c-sections performed on stillbirths. We wanted to understand patterns of c-sections at different times of day to better understand if this intervention was consistently available 24 hours per day. For all deliveries in the study, we found that the median time from admission to delivery was 105 minutes.

C-sections are not recommended in the case of stillbirth due to the increased risk for the woman, and stillbirth rates remain high in India (23 per 1,000 births in 2015).[2,10,11] Analyzing trends of stillbirth within c-section in the BetterBirth study will help in understanding the trends in this population.

FINDINGS

LEARNINGS ABOUT PROCESS

In general, the BetterBirth study took place in a low c-section environment: C-section deliveries comprised only 1.8% of births studied (~2,800 out of ~160,000). Moreover, 91% of cases requiring c-section in the trial were referred.

A delivery room with the WHO Safe Childbirth Checklist posted on the wall.

To further explore this insight, we analyzed c-section timing—that is, the time of day the deliveries occurred and the median length of time between admission and delivery at different times of day. The analyses (see Figures 4 and 5) revealed that the overwhelming majority of c-sections occurred between 8 a.m. and 2 p.m. at study facilities—a time that facilities are typically better staffed. The median length of time between admission and delivery was also very similar for vaginal deliveries and c-sections during this shift.

Conversely, the median length of time between admission and delivery was dramatically longer for c-sections compared with vaginal deliveries during overnight shifts: Between 8 p.m. and 2 a.m., the median time from admission to delivery for vaginal deliveries was 109 minutes (~2 hours) whereas it was 820 minutes (~14 hours) for cesarean deliveries. The wait time for the 8 p.m. to 2 a.m. shift was roughly 13 hours, and the wait time during the 2 a.m. to 8 a.m. shift was roughly 8 hours, meaning those deliveries ultimately happened during the morning shift.

Finally, we looked at the characteristics of patients who had a cesarean delivery and found that twins and women over 40 had the highest proportions of c-section deliveries.

Figure 4. Patterns of referral and cesarean deliveries by time of day

Shift Name	Total (N)	Referral Status (N (%))	C-Section (N/D)	C-Section (%)
8 am - 2pm	46,899	Referred: 2317 (4.9%)	890/2317	38.4%
		Delivered: 44,582 (95.1%)	182/44,582	0.4%
2 pm - 8 pm	33,450	Referred: 1,686 (5.0%)	606/1,686	35.9%
		Delivered: 31,764 (95.0%)	43/31,764	0.1%
8 pm - 2 am	39,126	Referred: 1,665 (4.3%)	553/1665	33.2%
		Delivered: 37,461 (95.7%)	17/37,461	0.05%
2 am - 8 am	36,510	Referred: 1246 (3.4%)	464/1246	37.2%
		Delivered: 35,264 (96.6%)	10/35,264	0.03%

Delivered = Delivered at study facility

Figure 5. C-section rates by time of arrival (excluding referrals)

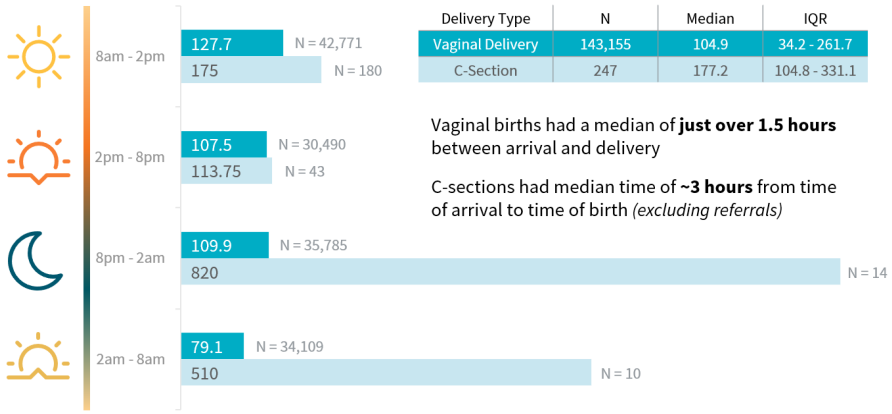


Figure 6. Percentage of women who had a cesarean delivery, by core characteristics

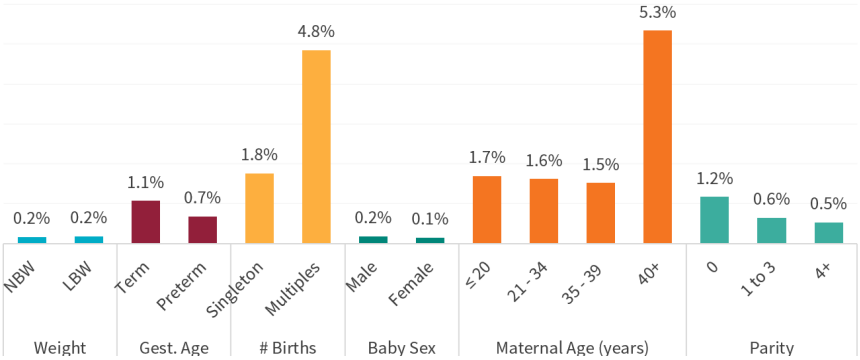


Table 2. C-section and stillbirth

DELIVERY TYPE	TOTAL (N)	STILLBIRTH (N)	STILLBIRTH (%)	95% CI	P-VALUE
Vaginal Delivery	153,176	2,912	1.9%	1.8% - 2.0%	<0.0001
C-section	2,481	5	0.2%	0.02% - 0.4%	

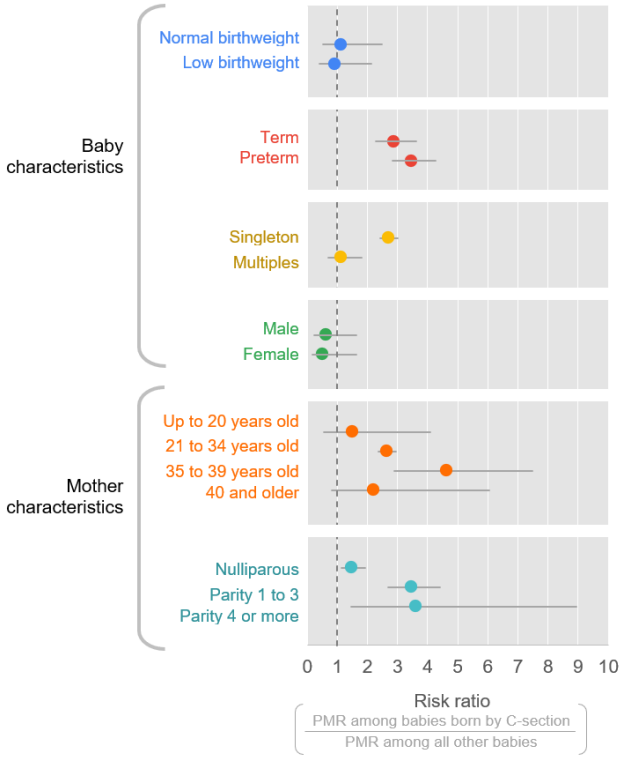
LEARNINGS ABOUT HEALTH OUTCOMES

We found that c-section on a confirmed stillbirth was rare (Table 2); as is consistent with recommendations.

In looking at the relative risk of perinatal mortality among women who had a c-section delivery versus not, similar to the findings on referral, we could discern a reduced risk of perinatal mortality for c-section delivery of twins, but an *increased* risk of perinatal mortality for singleton birth. There is not, however, the same pattern related to birth weight.

Viewed in combination (Figure 3 on referral and Figure 7 on c-section), it may be that patients who are referred, but ultimately do not receive a c-section, may be at the highest risk of perinatal mortality. The risk of perinatal mortality may be higher for women undergoing c-section who have previously delivered children, although the overlapping 95% confidence intervals suggest that further exploration is needed to understand this relationship. ■

Figure 7. Risk of perinatal mortality among infants delivered via cesarean compared with vaginal births, by core characteristics



ANTIBIOTIC USE

When appropriately used, antibiotics are an essential intervention for both women and newborns during both labor and the postnatal period.

For women, antibiotics have been found to prolong gestation and lead to better baby outcomes.[12] In newborns, antibiotics should be used for serious bacterial infections.[13] These infections (including sepsis) make up 33% of neonatal deaths in India.[14] Conversely, while antibiotics can be life-saving in these cases, longer duration of antibiotic use in low birthweight babies has been associated with worse outcomes.[15]

FINDINGS

LEARNINGS ABOUT PROCESS

Antibiotic use was measured through direct observation of care at the primary facility. Care at referral facilities was not observed. In this population, 14.9% of women received antibiotics and 3.6% of newborns received antibiotics. We analyzed the characteristics of the women and newborns who received antibiotics at the study facilities (excluding referrals) to understand if there were any notable differences.

Figure 8 shows maternal antibiotics at slightly higher rates to women with low birthweight, preterm, or twin pregnancies, as well as for women in their first delivery. Newborn antibiotics were comparatively less common. Newborns of older women were less commonly administered antibiotics, and newborns who are a woman's first child were more commonly given antibiotics.

Higher risk groups such as low birthweight or preterm babies did not receive antibiotics at a higher proportion than normal risk newborns.

Figure 8. Percentage of patients who received antibiotics, by core characteristics

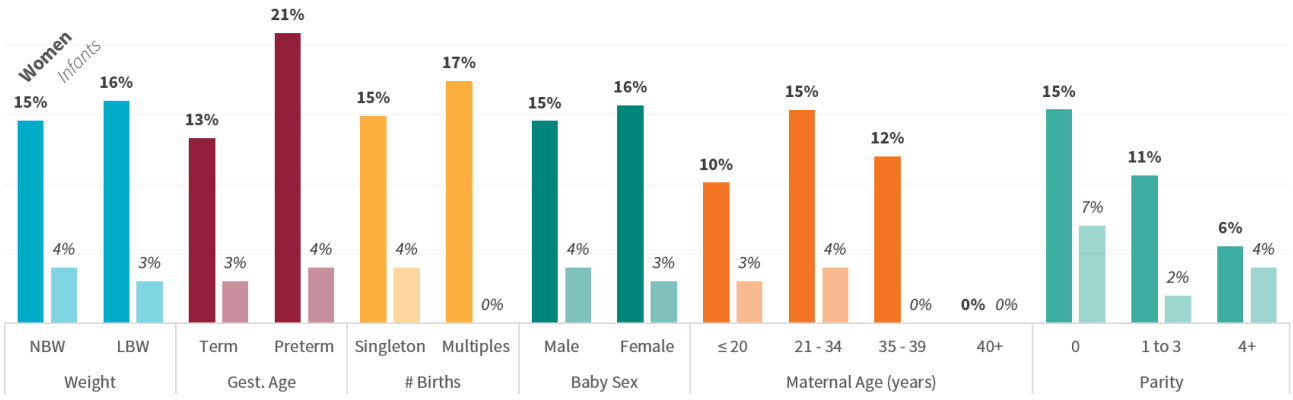
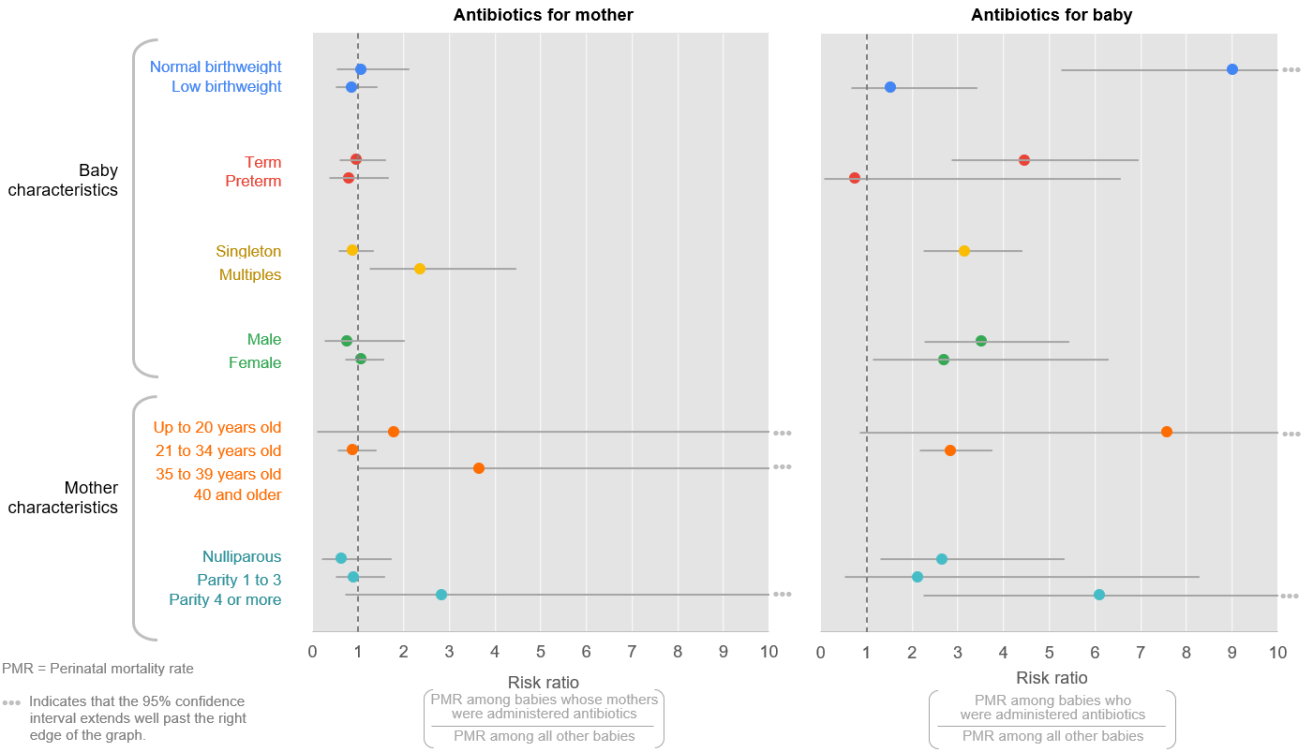


Figure 9. Risk of perinatal mortality among patients who received antibiotics versus no antibiotics, by core characteristics



LEARNINGS ABOUT HEALTH OUTCOMES

Survival among women who received antibiotics and ones who did not was nearly identical, which suggests effective antibiotic use in women at the time of childbirth. There was a larger percentage of stillbirths in the women who received antibiotics than in those who did not (2.2% compared to 1.6%), but fewer early neonatal deaths (3.4% compared to 2.4%). Obstructed labor and hemorrhage were the primary causes of stillbirth for women taking antibiotics. These data do not include causes of neonatal mortality, so we are unable to determine a potentially causal relationship between maternal antibiotic use and lower neonatal mortality.

Through the perinatal verbal autopsy, we found that among newborns who received antibiotics, infection was not a major cause of death (0% sepsis; 11% neonatal pneumonia). Among those newborns who died and did not receive antibiotics, 19% died from sepsis and 5% died from neonatal pneumonia. Because antibiotics are important interventions for both sepsis and neonatal pneumonia, these findings indicate that antibiotics are not used frequently enough or are not used correctly with sick neonates in the first week of life.

In looking at the relative risk of perinatal mortality among women who received antibiotics versus those who did not, there is a slightly increased risk for twins/multiples, although this may be more indicative of the increased risk of mortality related to having a twin delivery at a primary facility (since most twins were referred, and antibiotic use was not documented at referral facilities). Antibiotic use in newborns was uncommon, and patterns in perinatal mortality rate (PMR) reveal a significantly increased risk of death for normal birthweight babies who received antibiotics. Again, this may reflect that only the sickest normal birthweight babies are given antibiotics, compared with low birthweight babies. Other characteristics show trends of the disparate impact of antibiotic use on newborn mortality. ■

RESUSCITATION

Worldwide, it is estimated that about 85% of babies spontaneously initiate breathing at the time of birth, while 10% respond to drying and stimulation, 3% respond to supportive ventilation with a bag and mask, and 2% require additional support such as intubation.

These numbers are higher for groups such as premature newborns.[16] Any facility offering childbirth services must be able to provide resuscitation; it is an emergent complication that cannot wait for a referral.

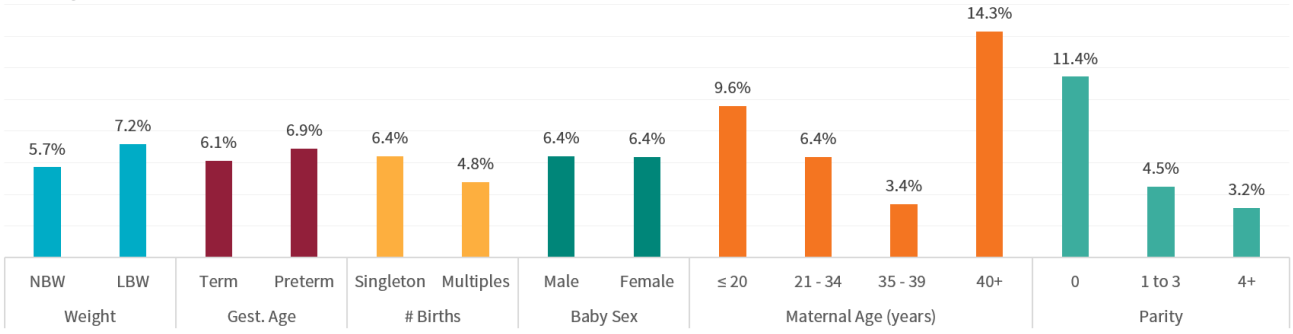
FINDINGS

LEARNINGS ABOUT PROCESS

In BetterBirth facilities, 6.4% of newborns whose birth was observed (184/2,869) were resuscitated with a neonatal bag and mask. We analyzed the characteristics of the women and newborns who received resuscitation at the study facilities (excluding referrals) to understand if there were any notable differences.

We found that only a slightly higher percentage of low birthweight and preterm newborns received resuscitation compared with normal weight, term newborns. The rate is surprisingly low, as particularly preterm newborns are more likely to require respiratory support. Other trends showed that a higher percentage of first children received resuscitation (11.4%) versus 3.2% of babies from women with 4+ parity, which may reflect a social bias against these women.

Figure 10. Percentage of infants who received resuscitation with bag and mask, by core characteristics

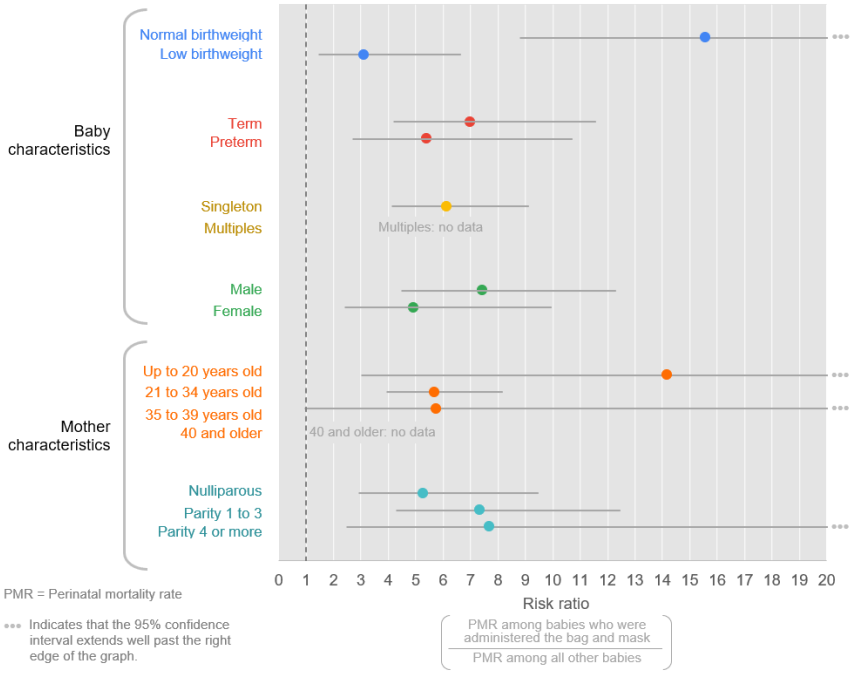


LEARNING ABOUT HEALTH OUTCOMES

Within seven days of birth, 20% of the newborns followed in our primary outcomes who received resuscitation died—primarily from asphyxia and complications of prematurity (e.g., lung underdevelopment). Within the subset of newborns studied in our verbal autopsy work, among those who died within seven days of birth and did not receive resuscitation (n=62), the primary causes of death were asphyxia (39%), complications of prematurity (21%), and sepsis (19%).

In looking closer at the risk ratio across various groups (Figure 11), we can see that the risk of perinatal mortality among normal birth weight babies who received resuscitation care was more than 15 times higher, while the risk was 3 times higher for low birthweight newborns who were resuscitated. This may indicate that resuscitation efforts by birth attendants are less effective among normal birth weight newborns, or potentially that the PMR for low birthweight newborns is so high overall that resuscitation does not greatly impact mortality.

Figure 11. Risk of perinatal mortality among patients who received resuscitation with a bag and mask versus not, by core characteristics



An area for newborn care equipped with medical supplies and a sign with steps for resuscitation.

OXYTOCIN ADMINISTRATION

Oxytocin is a well-established postpartum intervention to prevent and manage hemorrhage, a leading cause of maternal mortality.

Routine use of oxytocin before delivery is increasingly common worldwide to augment labor and has been shown to reduce the need for c-section deliveries.[17,18,19] The WHO recommends that the augmentation of labor be carried out in facilities where there is capacity to manage its potential outcomes, including adverse effects and failure to achieve vaginal birth (i.e., maternal and fetal monitoring, and emergency c-section access).

Without adequate monitoring and surgical capacity, intrapartum oxytocin can cause harm, including higher levels of stillbirths, neonatal deaths, neonatal morbidity (most often related to fetal asphyxia), and maternal postpartum hemorrhage.[20]

FINDINGS

During direct observation, at baseline, oxytocin use was documented during 5,484 deliveries. Oxytocin was used to augment labor in 79% of deliveries even while less than 1% of observed cases had a partograph (documenting fetal heart rate and contraction patterns).

Among cases with health outcomes (n=2,862), we found that perinatal mortality rates were higher for women given oxytocin before delivery than for those who did not receive the drug (p = 0.055). In terms of newborn outcomes, when providers administered oxytocin before delivery, bag-and-mask use for babies was 7.7%, as opposed to 2.1% among babies born without maternal oxytocin.

These findings suggest that antepartum oxytocin may have a harmful effect on newborn health in this context, very likely because of the lack of monitoring, lack of readily available c-sections, and the oxytocin administration method (i.e., single intramuscular dose rather than an intravenous "titrate to effect" dose that can be adjusted and optimized throughout a woman's labor).

OXYTOCIN USE AT BETTERBIRTH INTERVENTION FACILITIES

At BetterBirth intervention facilities, use of oxytocin for labor augmentation was ~30% after two months of coaching, and remained lower even after the completion of the intervention.

Additionally, postpartum use of oxytocin for prevention of maternal hemorrhage was higher in intervention sites (2 months: I=80%,C=21%, p=<0.0001; post-intervention: I=54%,C=15%, p=0.0001). This experience demonstrates that this clinical practice can be adapted in a relatively short period of time.

Critically, we need to curtail harmful practices like unmonitored intrapartum use of oxytocin. Given the potential benefits of oxytocin's intrapartum use, in the medium-term, it is important to consider building monitoring capacity and increasing access to c-section deliveries at frontline facilities to facilitate the safe use of this medication. ■

CONCLUSION

LIMITATIONS OF THESE DATA AND ANALYSES

The analysis presented here is post-hoc and narrowly focused. The available BetterBirth data do not allow us to compare normal and excess mortality—that is, deaths among otherwise similar newborns who did and did not receive an intervention. Such a comparison would allow us to better discern if an intervention has protective or otherwise positive effect. Similarly, comprehensive data was unavailable for sick newborns who do not receive a referral, therefore this data set does not allow for us to compare mortality outcomes between sick newborns who are referred and those who are cared for at home or at the primary care facility.

Due to small sample size, we were unable to analyze the relationship between oxytocin use and c-section, postpartum hemorrhage, or maternal mortality. A broader description of the BetterBirth dataset and its limitations is available.

ACTIONABLE FINDINGS AND FURTHER AREAS FOR EXPLORATION

So how do we apply the findings above into future programming and research?

REFERRAL AND C-SECTION RATES

Pursue further investigation and intervention into the low rates of referral and c-section.

PRIORITY QUESTIONS

> Are the low referral and c-section rates linked to a lack of recognition of complications, or is it related to wider health system factors that discourage these interventions?

> What are the gaps in our knowledge on the patient experience and hesitancy around referral?

> What are the barriers to referral or gaps in care for sick, normal birthweight newborns?

BRINGING IT ALL TOGETHER: MEDICAL INTERVENTIONS AND NEWBORN HEALTH OUTCOMES

PROCESS

Overall, intervention is made more frequently for women than it is for newborns. At-risk women seem to be appropriately identified and referred, with challenges in the implementation of the referral. While we don't have a benchmark for rates of referral or antibiotic administration for newborns in this setting, the rates observed in the BetterBirth study were critically low.

In reality, few c-sections are occurring during the night.

C-sections are largely, and appropriately, not being conducted on stillbirths.

HEALTH OUTCOMES

When broken out by intervention received, the primary causes of death for newborns in the BetterBirth trial were similar to those for all newborns regardless of intervention. Asphyxia was the most common cause of death across the interventions, followed by sepsis, complications of prematurity and pneumonia.

"Normal" groups who receive a medical intervention have the greatest relative risk of perinatal mortality, which may signal that early danger signs in "normal" infants are more likely to be overlooked or dismissed compared to those in traditional at-risk groups (for example referred singletons have an increased relative risk of mortality compared with referred twins).

RECOMMENDATIONS

Delineate referral guidance and intervention for women and newborns. For referrals for women, work is needed on ensuring the referral process is functional, timely, and ensures the continuity of care. In the case of newborns, increased focus is needed on ensuring recognition of newborn complications and issuing a referral.

COMPLICATION MANAGEMENT

Target complication recognition and management at the primary-level for increased investment.

PRIORITY QUESTIONS

What is causing the higher relative risk of perinatal mortality in normal birthweight newborns who receive neonatal resuscitation, particularly compared with the relative risk in low birthweight newborns? Are resuscitation efforts less effective among normal birthweight newborns? Are there other factors for low birthweight newborns that increase the relative impact of resuscitation efforts?

What are the expected or recommended rates of referral, c-section, antibiotic use, resuscitation and oxytocin in a primary-level, low resource setting?

RECOMMENDATIONS

Pursue targeted solutions to improve the timely and high-quality treatment and referral of asphyxia, sepsis and complications of prematurity, including a way to track, treat, and refer newborns after they have left the facility.

Provide additional resources and support regarding the treatment and referral of women and newborns not from at-risk sub-groups.

Prioritize ongoing intervention in provider knowledge and behavior around the proper administration of oxytocin. In the longer term, build towards improved oxytocin monitoring capacity and access to c-section deliveries at frontline facilities.

Ensuring quality complications management at frontline facilities is a complex issue and worthy of careful intervention and research. Moving forward and creating reductions in perinatal mortality are possible by acting with existing evidence and proven interventions in existing systems. ■

NOTES

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