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Newborn Care Training and Perinatal Mortality in Communities in Developing Countries

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Abstract

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Background—Ninety-eight percent of the 3.7 million neonatal deaths and 3.3 million stillbirths per year occur in developing countries, and evaluation of community-based interventions is needed.

Methods—Using a train-the-trainer model, local instructors trained birth attendants from rural communities in six countries (Argentina, Democratic Republic of Congo, Guatemala, India, Pakistan, and Zambia) in the World Health Organization Essential Newborn Care course (routine neonatal care, resuscitation, thermoregulation, breastfeeding, kangaroo care, care of the small baby, and common illnesses), and in a modified version of the American Academy of Pediatrics Neonatal Resuscitation Program (in depth basic resuscitation), except in Argentina.

The Essential Newborn Care intervention was assessed with a before and after design (N=57, 643). The Neonatal Resuscitation Program intervention was assessed as a cluster randomized controlled trial (N=62,366). The primary outcome was 7-day neonatal mortality.

Results—The 7-day follow-up rate was 99.2%. Following Essential Newborn Care training, there was no significant reduction from baseline in all-cause 7-day neonatal (RR 0.99; CI 0.81, 1.22) or perinatal mortality; there was a significant reduction in the stillbirth rate (RR 0.69; CI 0.54, 0.88; $p<0.01$). Seven-day neonatal mortality, stillbirth, and perinatal mortality were not reduced in clusters randomized to Neonatal Resuscitation Program training as compared with control clusters.

Conclusions—Seven-day neonatal mortality did not decrease following the introduction of Essential Newborn Care training of community-based birth attendants, although the rate of stillbirths was reduced following this intervention. Subsequent training in the Neonatal Resuscitation Program did not significantly reduce the mortality rates. (clinicaltrials.gov number, NCT00136708).

Keywords

neonatal mortality; perinatal mortality; developing countries; health systems; effectiveness

INTRODUCTION

Annually, there are approximately 3.7 million neonatal deaths and 3.3 million stillbirths worldwide.¹ Approximately 38% of deaths before age 5 occur during the first 28 days of life, and 75% of the neonatal deaths occur within the first 7 days.^{1,2,3} Without a major reduction in 7-day neonatal deaths, the United Nations' Millennium Declaration Development Goal 3 (i.e. A reduction in mortality under age 5 years by two-thirds²), is unlikely.

In areas of the world with high home delivery rates, stillbirths are prevalent but difficult to distinguish from early neonatal deaths.^{4,5} Thus, examining both stillbirths and early neonatal deaths is important when evaluating perinatal programs designed to reduce mortality.⁴

Major global causes of perinatal mortality are birth asphyxia, low-birth-weight, and prematurity. Low-cost interventions, including neonatal resuscitation training⁶ and kangaroo (skin-to-skin) care⁷, may effectively reduce deaths due to these causes; it has been estimated that introducing these interventions as a “package” might decrease perinatal deaths by up to 50% or more.^{8,9} A recent study showed that training in the World Health Organization Essential Newborn Care course¹⁰ using a “before and after” implementation design improved midwives' skill and knowledge¹¹ and reduced early (7-day) neonatal mortality among low-risk women delivering in Zambian first level clinics.¹² A systematic review of the literature suggests that perinatal mortality may be decreased by training birth attendants.¹³ Thus, wide-scale implementation and evaluation of evidence-based

interventions are needed to improve perinatal outcomes, particularly in rural settings where over 50% of neonatal deaths occur. The current study was designed to test the primary hypotheses that training birth attendants in the World Health Organization Essential Newborn Care course, followed by training in a modified version of the American Academy of Pediatrics Neonatal Resuscitation Program, would each reduce all-cause 7-day (early) neonatal mortality in infants with birth weights of at least 1500 grams in rural communities in developing countries.

METHODS

Study sites and population

The Essential Newborn Care pre-post study was conducted in rural communities in seven sites of the Global Network for Women's and Children's Health Research in six countries (Argentina, Democratic Republic of Congo, Guatemala, India, Pakistan, and Zambia) between March 2005 and February 2007 (Figure 1) using an active baseline design.¹⁴ Active baseline is a design that requires the protocol to be initiated before the prospective controlled data collection is started, followed by the intervention and continuation of data collection. The cluster randomized trial of Neonatal Resuscitation Program training was conducted in 88 communities (none in Argentina) from July 2006 to August 2008. The communities were selected to represent rural areas, to be geographically distinct, and to have at least 300 births per year. Most communities had poor health systems with a high rate of home births assisted by traditional birth attendants.

Government officials and community leaders facilitated the training of all birth attendants in the data collection and the two courses. The studies were approved by the institutional review boards of participating sites in the developing countries and in the United States. An independent Data Monitoring Committee reviewed recruitment, outcomes, and adverse events. Additional monitoring included site visits by local and central personnel and monthly recruitment reports.

Maternal and neonatal data were collected on all births considered to be 1500 grams or more including stillbirths. Because advanced medical care for very-low-birth-weight infants was not available in most communities, the hypotheses and analyses were limited to the fetuses/neonates with birth weights 1500 grams or more.

Procedures

A train-the-trainer educational program utilized various teaching methods for participant learning, including clinical practice sessions and demonstrations to train all birth attendants in the study procedures and in the two courses. These courses were first tested in a clinic-based study in Zambia^{12, 15} and modified for the current study for community-based birth attendants, including the development of materials for illiterate participants. Before baseline data collection, experienced trainers (WAC, EMC, and Monica Collins, RN, MaEd) trained two master trainers per site in data collection, the differentiation of stillbirth and early neonatal death, clinical assessments (fetal heart rate monitoring, signs of life at delivery, and Apgar scores), and adult education/training techniques during a three-day course. The master trainers subsequently trained one or more Community Coordinators (trained research staff, either a physician or nurse) per community. The Community Coordinators trained the birth attendants within each community before the initiation of the baseline period. Birth attendants included traditional birth attendants, nurses, midwives, and physicians. Bags and masks, UNICEF Spring Salter Scales, and clean delivery kits were distributed after training. Following the baseline data collection period, an experienced World Health Organization trainer (Ornella Lincetto, MD), taught master trainers a three-day Essential Newborn Care

course (2004 Edition); these trainers subsequently taught Community Coordinators and birth attendants. The Essential Newborn Care course contents included routine neonatal care, initiation of breathing and resuscitation (including bag and mask ventilation), thermoregulation, early and exclusive breastfeeding, kangaroo (skin-to-skin) care, small baby care, recognition of danger signs, and recognition and initial management of complications. The birth attendants taught the mothers to implement the Essential Newborn Care practices. Following completion of the post-Essential Newborn Care data collection period, a three-day Neonatal Resuscitation Program course (2000 Edition) led by an experienced trainer (Susan Niermeyer MD), was conducted only for intervention clusters, with a refresher course six months later. The Neonatal Resuscitation Program course contents included an in-depth hands-on training in basic knowledge and skills, including initial resuscitation steps, bag and mask ventilation, but not chest compressions, endotracheal intubation, or medications.

The birth attendants and/or Community Coordinators obtained consent and collected all data on standardized data forms. Data were reviewed by the Community Coordinators during weekly visits before local data entry and transmission to the data center.

Study outcomes

The primary outcome for both studies was all-cause 7-day mortality. Pre-specified secondary outcomes for both studies included 7-day mortality specifically attributed to birth asphyxia (defined as failure to initiate and/or sustain normal breathing at birth¹⁷ as determined by the birth attendant), overall stillbirth and fresh stillbirth (defined as absence of maceration); perinatal mortality (stillbirths plus 7-day neonatal mortality), 24 hour mortality, mortality rates stratified by sex, birth weight, birth location, and birth attendant, prespecified dichotomized 1 and 5 minute Apgar scores, the use of resuscitation techniques, and neurological outcome at 7 days assessed with the Ellis examination¹⁸ performed by the Community Coordinators.

Sample size

Based on data collected during the post-Essential Newborn care period, it was determined that for the Neonatal Resuscitation Program intervention, randomization of 88 clusters of at least 300–500 births would be required to have a power of more than 80% with a 5% level of significance using a two-tailed test to detect a 20% relative risk reduction (absolute risk reduction of 5/1000 live births based on data collection after Essential Newborn Care training) of all-cause 7-day neonatal mortality, using an estimated intra-cluster coefficient determined by simulation and confirmed with baseline data.¹⁶

Data management and study monitoring

Data edits, including consistency checks, were performed. The Data Monitoring Committee reviewed the data for safety and efficacy. There were no formal stopping rules during the Essential Newborn Care study. The O'Brien-Fleming boundary method was used for the stopping boundary for efficacy at the planned interim three and six month reviews during the cluster trial assessing the Neonatal Resuscitation Program. The variances were adjusted for the primary outcome variable to account for the intra-cluster correlation (design effect).¹⁹ Chi-square tests and t-tests tested the differences in maternal and neonatal characteristics before and after the Essential Newborn Care intervention, and between the Neonatal Resuscitation Program intervention and control groups.¹⁹ Generalized estimating equations for multivariate logistic regression models accounting for cluster effect were used to test for differences in 7-day neonatal mortality, stillbirths, and perinatal mortality, between the pre- and post-Essential Newborn Care phases and to assess interactions with birth attendant and location of birth. Adjustments were made for significant variables in the

models among the following explanatory variables: trial site, the maternal age at delivery, maternal education, gestational age, parity, birth weight, sex, birth location, and birth attendant category. Adjustments to P values were not made for multiple comparisons. A “difference of differences” analysis tested whether there were time trend effects. Differences were calculated by dividing each intervention period into equal time periods and using the Wilcoxon rank-sum to evaluate the difference between two differences. The data were analyzed using SAS.^{20, 21}

RESULTS

Essential Newborn Care Study

At study baseline, the largest proportion of births was attended by traditional birth attendants; and this proportion increased after implementation of the Essential Newborn Care intervention (33.2% to 39.2%, Table 1). The majority of births were at the mother's home. The proportion of Apgar scores < 4 at 1 and 5 minutes decreased and the use of bag and mask ventilation increased after the Essential Newborn Care intervention.

Outcome data at 7-days were available for 99.2% of births. The 7-day neonatal mortality rate did not decrease significantly following Essential Newborn Care training (Table 2) nor did it decrease significantly in any prespecified subgroup (Appendix Table 1). The overall stillbirth rate decreased (Table 2) mostly due to a lower rate of fresh stillbirths (Appendix Table 2). Subgroup analyses based on significant interactions indicated that the rate of stillbirths by delivery attendant decreased significantly for nurses/midwives (RR 0.50; CI 0.35, 0.72) and traditional birth attendants (RR 0.63; CI 0.45, 0.88) but not for physicians (Appendix Table 2). The stillbirth rate among home deliveries decreased. Perinatal mortality did not significantly decrease (Table 2, Appendix Table 3).

Adjusted generalized estimating equations for multivariate logistic regression models showed that there were no significant differences before and after the Essential Newborn Care intervention in 7-day neonatal mortality ($p=0.60$) or perinatal mortality ($p=0.10$) but stillbirth rates were still significantly different (0.04). Interaction analysis using generalized estimating equations for multivariate logistic regression models showed that there was no significant interaction by birth attendant type for 7-day neonatal mortality ($p=0.13$) or perinatal mortality ($p=0.08$), but there was a significant interaction for stillbirth ($p=0.04$). Difference of differences analysis showed that there was a significant difference in 7-day neonatal mortality ($p=0.03$) between the pre- and post-Essential Newborn Care differences and no significant differences in stillbirth ($p=0.60$) or perinatal mortality ($p=0.32$). Assessment of temporal changes within each intervention period suggested that the observed effects were not explained simply by changes over time (Figure 2).

The rate of moderately/severely abnormal¹⁸ neurological examinations at 7 days decreased from 8.0 to 6.4% after ($p=0.01$). Rates of death within 24 hours after birth were not significantly different before and after Essential Newborn Care training (Appendix Table 4).

Neonatal Resuscitation Program Cluster Randomized Trial

Despite increased use of bag and mask ventilation in the intervention clusters, there were no significant differences in all-cause 7-day neonatal mortality, stillbirth or perinatal mortality rates in the Neonatal Resuscitation Program clusters compared to the control clusters (Table 2). There were no significant differences in mortality between clusters in any of the subgroups (Appendix Tables 1–4). The difference of differences analyses showed no changes in mortality between the intervention and control clusters.

DISCUSSION

This large multicenter study conducted in rural communities in developing countries demonstrated that Essential Newborn Care training and implementation was not associated with a decrease in the primary outcome of neonatal mortality. In secondary analyses, implementation of this program was associated with a significant decrease in stillbirths but not with a decrease in perinatal mortality. Although the pre-post study design precludes a conclusion of causality, it is plausible that the observed reduction in stillbirths may be due to Essential Newborn Care training.^{22, 23, 24} Liveborn infants without obvious signs of life may have been misidentified as stillbirths before this training; such misclassification has been previously reported.^{4,5,22–24} After training, resuscitation was more likely, with a reduction in births classified as stillbirths. The decrease in fresh stillbirths, but not in macerated stillbirths, after Essential Newborn Care training supports this hypothesis. Furthermore, recent studies reported that neonatal resuscitation training, which was part of Essential Newborn Care training, decreased the stillbirth rate.^{23, 24} The decrease in stillbirths was not associated with an increase in neonatal deaths, suggesting that the decrease in deaths was real and not only due to classification bias. The reduction in the stillbirth rate occurred despite a 5% increase in unattended deliveries or deliveries attended by family members in the post-Essential Newborn Care period. The reduction in stillbirths following Essential Newborn Care training appears to be most pronounced in deliveries by nurses/midwives and traditional birth attendants who would likely not have previously been trained in the knowledge and techniques taught. Among these birth attendants, perinatal mortality rates and/or stillbirth rates decreased to levels comparable to those associated with deliveries performed by physicians. In addition to the increased survival, there was a decrease in moderately/severely abnormal¹⁸ neurological examination at 7-day follow-up.

Neonatal mortality, stillbirth, and perinatal mortality rates were not decreased further with Neonatal Resuscitation Program training. Neonatal Resuscitation Program training has been shown to be effective in studies of lower level of evidence.

The studies' strengths are the multi-country population-based design, the large sample sizes, the rigorous training using master instructors, the exclusive use of local trainers to train birth attendants, the use of pregnancy/birth registries to capture all births, the inclusion of all birth attendants, and the high consent and 7-day follow-up rates. A limitation of the study of the Essential Newborn Care course was the pre-post-design. We used an active baseline design, in which all training except Essential Newborn Care training was conducted before initiation of data collection. This approach decreased the likelihood that other concurrent changes in practice influenced the outcomes,¹⁴ although we cannot rule out this possibility. Because of ethical concerns about withholding a basic World Health Organization course and resource constraints, this intervention was not introduced with a randomization design. With high-quality design and data collection, pre-post analyses can provide meaningful results and supplement studies using random allocation.²⁵ Another limitation was that data collection was performed by the birth attendants who implemented the intervention. However, they were closely supervised by the Community Coordinators to promote reliable data collection.

The Essential Newborn Care course has been used previously^{26,27} but the assessment of its impact on patient outcomes has been limited. Training doctors, nurses, and midwives in community hospitals in Sri Lanka in the Essential Newborn Care course reported improved care practices in a group of 1186 newborns but major outcomes were not reported.^{28,29} We recently reported that the current Essential Newborn Care course reduced all-cause 7-day and perinatal mortality in low-risk health care urban health clinics in Zambia.¹² Evaluations of other neonatal care packages have been reported.¹³ Reductions in early neonatal mortality by about 50% in that report and the reduction in stillbirths by over 30% in the current study

would have a major impact worldwide. However, none of the studies were randomized, and most used historic controls. A recently published pilot study of implementation of community-based perinatal care in four intervention clusters and four control clusters, with almost 11,000 births demonstrated the potential impact of training existing health care workers on reducing perinatal mortality.²⁵ In contrast, the Integrated Management of Childhood Illness, a package of interventions to be started with children a week after birth, improved intermediate care indicators, but did not decrease mortality.³⁰

Many studies evaluating the impact of the Neonatal Resuscitation Program in developing countries suggest that neonatal mortality may be decreased. Large non randomized studies of resuscitation training in facilities^{6,31,34}, and communities^{32,33}, in developing countries have reduced neonatal mortality when compared to historic controls. One small facility-based trial in which birth attendants were randomized to early or late neonatal resuscitation training revealed no effect on neonatal mortality.³⁵ To our knowledge, the current trial of neonatal resuscitation is the largest randomized trial of this intervention. The lack of an effect of this training on perinatal mortality could be due to the fact that Essential Newborn Care training, which includes very basic resuscitation training, was already in place.

In summary, training birth attendants in Essential Newborn Care was not associated with a reduction in neonatal mortality, but was associated with reduced stillbirth rates; further training in neonatal resuscitation did not have a significant impact on neonatal outcomes. These data suggest that training in basic neonatal care may have a role in improving perinatal outcomes in the developing world, although more work is needed to further reduce perinatal mortality.

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Appendix

Appendix Table 1

7-Day Neonatal Mortality Rates According to Characteristics of the Infant or Delivery*

	Pre-ENC n (Rate/1000)	Post-ENC n (Rate/1000)	RR (95% CI) Post-vs. Pre- ENC	Post-NRP Intervention n (Rate/1000)	Post-NRP Control n (Rate/1000)	RR(95%CI) Post-NRP Intervention vs. Control
7-day neonatal mortality	513 (23.4)	793 (23.2)	0.99 (0.81, 1.22)	543 (18.6)	685 (21.4)	0.87 (0.65, 1.16)
Male	287 (25.0)	469 (26.4)	1.05 (0.84, 1.32)	297 (20.2)	401 (23.5)	0.86 (0.64, 1.15)
Female	225 (21.5)	323 (19.8)	0.92 (0.74, 1.14)	246 (17.5)	282 (18.8)	0.93 (0.67, 1.29)
Birth attendant						
All birth attendants	391 (21.3)	531 (19.7)	0.93 (0.74, 1.16)	429 (19.0)	547 (20.5)	0.93 (0.67, 1.29)
Physician	75 (19.2)	81 (16.1)	0.84 (0.52, 1.34)	24 (13.2)	83 (20.7)	0.64 (0.35, 1.16)
Nurse/midwife	176 (24.8)	158 (19.0)	0.77 (0.56, 1.04)	246 (24.2)	177 (18.5)	1.31 (0.85, 2.03)
Traditional birth attendants	140 (19.1)	292 (21.6)	1.13 (0.86, 1.49)	159 (15.0)	287 (21.9)	0.68 (0.45, 1.03)

	Pre-ENC n (Rate/1000)	Post-ENC n (Rate/1000)	RR (95% CI) Post-vs. Pre- ENC	Post-NRP Intervention n (Rate/1000)	Post-NRP Control n (Rate/1000)	RR(95%CI) Post-NRP Intervention vs. Control
Family/unattended/other	122 (34.0)	261 (36.1)	1.06 (0.74, 1.52)	113 (17.2)	138 (25.7)	0.67 (0.45, 1.00)
Location of birth						
Home/birth attendant home	374 (25.8)	581 (25.8)	1.00 (0.82, 1.22)	402 (20.3)	498 (23.0)	0.88 (0.64, 1.21)
Clinic	39 (23.3)	100 (27.6)	1.18 (0.80, 1.75)	73 (14.1)	82 (15.1)	0.94 (0.55, 1.61)
Hospital	100 (17.3)	111 (13.9)	0.80 (0.51, 1.27)	67 (15.9)	105 (21.1)	0.76 (0.35, 1.01)
Birth weight						
1500–1999 grams	80 (198.0)	138 (194.1)	0.98 (0.67, 1.44)	103 (113.9)	115 (190.7)	0.60 (0.35, 1.01)
2000–2499 grams	128 (59.7)	191 (53.7)	0.90 (0.63, 1.28)	162 (43.4)	191 (47.4)	0.92 (0.65, 1.28)
2500 grams	194 (12.0)	366 (12.7)	1.06 (0.77, 1.45)	236 (9.9)	310 (11.4)	0.87 (0.60, 1.25)

ENC=Essential Newborn Care; NRP=Neonatal Resuscitation Program

* May reflect missing value; birth weight available for 87.4% of infants with 7-day mortality

Appendix Table 2

Stillbirth Rates According to Characteristics of the Infant or Delivery*

	Pre-ENC n (Rate/1000)	Post-ENC n (Rate/1000)	RR (95% CI) Post-vs. Pre- ENC	Post-NRP Intervention n (Rate/1000)	Post-NRP Control n (Rate/1000)	RR(95%CI) Post-NRP Intervention vs. Control
Stillbirth	520 (23.0)	557 (15.9)	0.69 (0.54, 0.88)	468 (15.7)	491 (15.0)	1.05 (0.82, 1.33)
Fresh stillbirth	440 (19.4)	445 (12.7)	0.65 (0.49, 0.87)	336 (11.3)	347 (10.6)	1.06 (0.82, 1.37)
Macerated stillbirth	80 (3.5)	112 (3.2)	0.90 (0.55, 1.50)	132 (4.4)	144 (4.4)	1.01 (0.65, 1.57)
Male	279 (23.7)	317 (17.4)	0.73 (0.57, 0.94)	252 (16.8)	274 (15.8)	1.07 (0.80, 1.42)
Female	240 (22.2)	237 (14.2)	0.64 (0.47, 0.86)	213 (14.9)	216 (14.2)	1.05 (0.80, 1.37)
Birth attendant						
All birth attendants	411 (21.7)	376 (13.6)	0.63 (0.49, 0.81)	359 (15.6)	419 (15.4)	1.01 (0.79, 1.30)
Physician	62 (15.3)	89 (16.8)	1.10 (0.57, 2.11)	37 (19.8)	65 (15.9)	1.25 (0.80, 1.95)
Nurse/midwife	203 (27.7)	119 (13.9)	0.50 (0.35, 0.72)	175 (16.9)	165 (16.9)	1.00 (0.67, 1.48)
Traditional birth attendants	146 (19.4)	168 (12.2)	0.63 (0.45, 0.88)	147 (13.6)	189 (14.2)	0.96 (0.71, 1.30)
Family/unattended/other	109 (29.3)	181 (24.4)	0.83 (0.57, 1.22)	109 (16.2)	72 (13.2)	1.23 (0.76, 2.01)
Location of birth						
Home/birth attendant home	392 (26.3)	376 (16.4)	0.63 (0.49, 0.80)	326 (16.2)	326 (14.8)	1.09 (0.86, 1.39)
Clinic	32 (18.7)	67 (18.1)	0.97 (0.55, 1.70)	65 (12.4)	93 (16.7)	0.74 (0.41, 1.33)
Hospital	96 (16.1)	114 (13.6)	0.85 (0.49, 1.45)	77 (17.9)	72 (14.2)	1.26 (0.66, 2.39)
Birth weight (grams) *						
1500–1999 grams	49 (106.3)	89 (110.1)	1.04 (0.63, 1.71)	63 (65.1)	45 (69.3)	0.94 (0.46, 1.90)
2000–2499 grams	67 (30.2)	107 (29.1)	0.96 (0.62, 1.50)	76 (19.9)	75 (18.3)	1.09 (0.59, 2.03)
2500 grams	149 (9.1)	172 (5.9)	0.65 (0.43, 0.97) †	162 (6.7)	144 (5.3)	1.28 (0.82, 2.00)

ENC=Essential Newborn Care; NRP=Neonatal Resuscitation Program

* May reflect missing values; birth weight available for 58.9% of stillbirths

Appendix Table 3

Perinatal Mortality Rates According to Characteristics of the Infant or Delivery *

	Pre-ENC n (Rate/1000)	Post-ENC n (Rate/1000)	RR (95% CI) Post-vs. Pre- ENC	Post-NRP Intervention n (Rate/1000)	Post-NRP Control n (Rate/1000)	RR(95%CI) Intervention vs. Control
Perinatal mortality	1,033 (45.9)	1,350 (38.9)	0.85 (0.70, 1.02)	1,011 (34.1)	1,176 (36.1)	0.94 (0.76, 1.17)
Male	566 (48.2)	786 (43.4)	0.90 (0.74, 1.09)	549 (36.7)	675 (38.9)	0.94 (0.76, 1.17)
Female	465 (43.4)	560 (33.8)	0.78 (0.63,0.96)	459 (32.1)	498 (32.8)	0.98 (0.77, 1.24)
Birth attendant						
All birth attendants	802 (42.7)	907 (33.3)	0.78 (0.64, 0.94)	788 (34.4)	966 (35.6)	0.96 (0.77, 1.21)
Physician	137 (34.3)	170 (33.1)	0.97 (0.62, 1.50)	61 (32.8)	148 (36.3)	0.90 (0.62, 1.33)
Nurse/midwife	379 (51.9)	277 (32.8)	0.63 (0.48, 0.83)	421 (40.8)	342 (35.1)	1.16 (0.82, 1.65)
Traditional birth attendants	286 (38.2)	460 (33.6)	0.88 (0.71, 1.10)	306 (28.5)	476 (35.8)	0.79 (0.61, 1.03)
Family/unattended/other	231 (62.6)	442 (59.6)	0.95 (0.72, 1.26)	222 (33.2)	210 (38.6)	0.86 (0.62, 1.19)
Location of birth						
Home/birth attendant home	766 (51.5)	957 (41.8)	0.81 (0.68, 0.97)	728 (36.2)	824 (37.5)	0.97 (0.77, 1.21)
Clinic	71 (41.7)	167 (45.2)	1.08 (0.73, 1.60)	138 (26.4)	175 (31.6)	0.83 (0.52, 1.34)
Hospital	196 (33.2)	225 (27.7)	0.83 (0.55, 1.26)	144 (33.6)	177 (35.0)	0.96 (0.56, 1.64)
Birth weight *						
1500–1999 grams	129 (283.8)	227 (283.8)	1.00 (0.74, 1.35)	166 (171.7)	160 (246.9)	0.70 (0.45, 1.08)
2000–2499 grams	195 (88.2)	298 (81.3)	0.92 (0.69, 1.24)	238 (62.5)	266 (64.9)	0.96 (0.72, 1.30)
2500 grams	343 (21.0)	538 (18.5)	0.88 (0.67, 1.17)	398 (16.5)	454 (16.6)	1.00 (0.76, 1.31)

ENC=Essential Newborn Care; NRP=Neonatal Resuscitation Program

* May reflect missing values; birth weight available for 74.7% of infants with perinatal mortality

Appendix Table 4

Mortality within 24 Hours of Birth *

	Pre-ENC n (Rate/1000)	Post-ENC n (Rate/1000)	RR (95% CI) Post- vs. Pre- ENC	Post-NRP Intervention n (Rate/1000)	Post-NRP Control n (Rate/1000)	RR (95% CI)
24 hour neonatal mortality	196 (8.9)	340 (9.9)	1.11 (0.74, 1.68)	152 (5.2)	203 (6.3)	0.82 (0.52, 1.30)
Male	100 (8.7)	194 (10.8)	1.24 (0.78, 1.99)	92 (6.2)	123 (7.2)	0.87 (0.52, 1.45)
Female	95 (9.0)	145 (8.8)	0.98 (0.65, 1.47)	60 (4.3)	78 (5.2)	0.82 (0.52, 1.28)
Birth attendant						
All birth attendants	156 (8.4)	276 (10.2)	1.20 (0.77, 1.88)	123 (5.4)	158 (5.9)	0.92 (0.57, 1.50)
Physician	23 (5.8)	32 (6.1)	1.07 (0.56, 2.04)	7 (3.8)	24 (6.0)	0.64 (0.13, 3.15)
Nurse/midwife	55 (7.7)	90 (10.7)	1.39 (0.71, 2.69)	58 (5.7)	38 (4.0)	1.44 (0.52, 3.95)
Traditional birth attendants	78 (10.6)	154 (11.4)	1.07 (0.69, 1.68)	58 (5.5)	96 (7.3)	0.75 (0.44, 1.27)
Family/unattended/other	40 (11.1)	63 (8.7)	0.78 (0.29, 2.11)	28 (4.2)	45 (8.3)	0.51 (0.23, 1.11)
Location of birth						
Home/birth attendant home	133 (9.1)	217 (9.6)	1.05 (0.68, 1.64)	79 (4.0)	144 (6.6)	0.60 (0.36, 1.01)
Clinic	24 (14.3)	78 (21.4)	1.50 (0.83, 2.73)	43 (8.3)	38 (7.0)	1.19 (0.52, 2.71)
Hospital	39 (6.6)	44 (5.3)	0.80 (0.44, 1.46)	29 (6.9)	21 (4.2)	1.63 (0.53, 5.05)
Birth weight						

	Pre-ENC n (Rate/1000)	Post-ENC n (Rate/1000)	RR (95% CI) Post- vs. Pre- ENC	Post-NRP Intervention n (Rate/1000)	Post-NRP Control n (Rate/1000)	RR (95% CI)
1500–1999 grams	34 (82.5)	64 (89.0)	1.08 (0.53, 2.19)	27 (29.8)	27 (44.7)	0.67 (0.22, 2.04)
2000–2199 grams	41 (19.1)	68 (19.0)	1.00 (0.54, 1.83)	32 (8.6)	34 (8.4)	1.02 (0.46, 2.25)
2500 grams	81 (5.0)	171 (5.9)	1.18 (0.66, 2.11)	67 (2.8)	81 (3.0)	0.94 (0.47, 1.87)

ENC=Essential Newborn Care; NRP=Neonatal Resuscitation Program

* May reflect missing values

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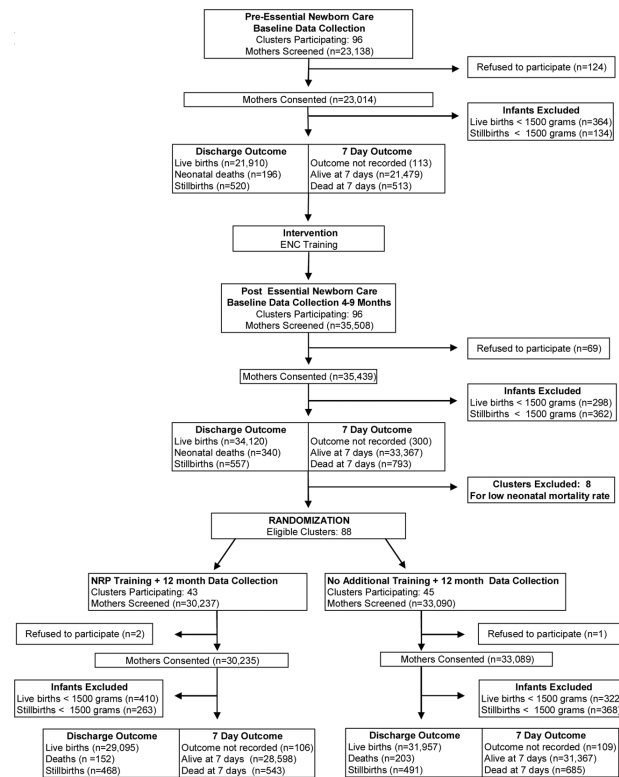


Figure 1.
Flow chart of the study.

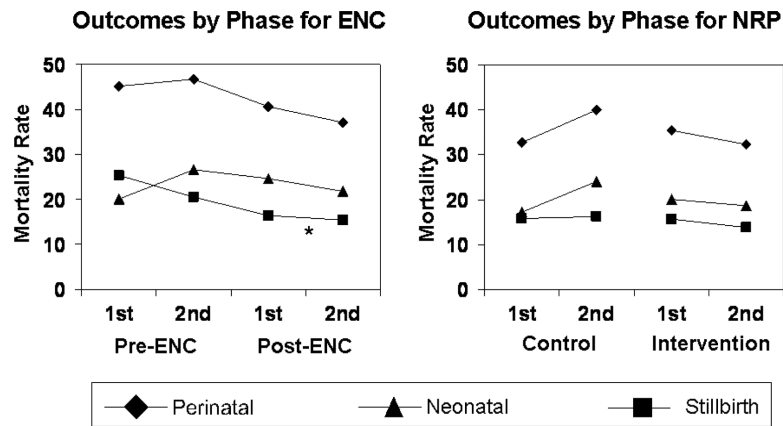


Figure 2.

All-cause early (7-day) neonatal mortality rate, stillbirth rate, and perinatal mortality rate before and after Essential Newborn Care (ENC) training and for the control and intervention clusters in the Neonatal Resuscitation Program (NRP) trial. Data are divided into two consecutive phases (1st and 2nd) for each study period. Following Essential Newborn Care, the stillbirth rate decreased significantly ($p < 0.01$). However, all-cause 7-day neonatal mortality did not change. With Neonatal Resuscitation Program training, the stillbirth rate, the perinatal rate and the 7-day neonatal mortality rate were not significantly different between the intervention versus the control groups.

Table 1

Demographic Characteristics of Subjects Before and After Implementation of the Essential Newborn Care Intervention and in Intervention and Control Groups in the Cluster Randomized Trial of the Neonatal Resuscitation Program *

	Pre-ENC (N=22,626) n (%)	Post-ENC (N=35,017) n (%)	P-value Post- vs. Pre-ENC	Post-NRP Intervention (N=29,715) n (%)	Post-NRP Control (N=32,651) n (%)	P value Post- NRP Intervention vs. Control
Birth attendant						
Physician [†]	4,061 (18.0)	5,311 (15.2)	<0.001	1,864 (6.3)	4,092 (12.5)	< 0.001
Nurse/midwife	7,326 (32.4)	8,531 (24.4)		10,353 (34.9)	9,764 (29.9)	
Traditional birth attendants	7,521 (33.2)	13,718 (39.2)		10,770 (36.3)	13,327 (40.8)	
Family/unattended/other	3,715 (16.4)	7,418 (21.2)		6,720 (22.6)	5,468 (16.7)	
Location of birth						
Hospital [†]	5,980 (26.4)	8,381 (23.9)	<0.001	4,304 (14.5)	5,068 (15.5)	< 0.001
Clinic	1,712 (7.6)	3,704 (10.6)		5,253 (17.7)	5,556 (17.0)	
Birth attendant home	1,524 (6.7)	4,224 (12.1)		2,176 (7.3)	2,464 (7.5)	
Home	13,365 (59.1)	18,640 (53.3)		17,932 (60.4)	19,470 (59.6)	
Other	44 (0.2)	51 (0.1)		42 (0.1)	93 (0.3)	
Multiple birth	604 (2.7)	977 (2.8)	0.39	617 (2.1)	583 (1.8)	0.008
Male [‡]	11,781 (52.2)	18,262 (52.3)	0.87	14,995 (51.1)	17,371 (53.3)	< 0.001
1500–1999 grams ^{‡‡}	460 (2.4)	808 (2.4)	0.04	968 (3.3)	649 (2.0)	< 0.001
2000–2499 grams	2,216 (11.6)	3,681 (10.9)		3,810 (13.2)	4,106 (12.8)	
2500 grams	16,409 (86.0)	29,311 (86.7)		24,126 (83.5)	27,389 (85.2)	
Apgar 1 min < 4	806 (3.9)	983 (2.9)	< 0.001	891 (3.1)	847 (2.7)	0.003
Apgar 5 min < 4	618 (3.0)	697 (2.1)	< 0.001	540 (1.9)	551 (1.8)	0.26
Apneic at birth	2,071 (9.2)	2,153 (6.2)	< 0.001	1,470 (5.0)	1,680 (5.2)	0.41
Bag and mask ventilation	251 (1.1)	613 (1.8)	< 0.001	1,256 (4.2)	1,174 (3.6)	< 0.001

ENC=Essential Newborn Care; NRP=Neonatal Resuscitation Program

* May reflect missing values

[†] P value for subgroups are given for birth attendants (physician row), location of birth (hospital row), gender (male row), and birth weight (1500–1999 grams row)

[‡] Birth weight was available for 94.9% of infants

Table 2

Mortality Rates Before and After Implementation of the Essential Newborn Care Intervention and in Intervention and Control Groups in Cluster Randomized Trial of the Neonatal Resuscitation Program *

	Pre-ENC n (Rate/1000)	Post-ENC n (Rate/1000)	RR (95% CI) Post-vs. Pre- ENC	Post-NRP Intervention n (Rate/ 1000)	Post-NRP Control n (Rate/ 1000)	RR(95%CI) Intervention vs. Control
7-day neonatal mortality	513 (23.4)	793 (23.2)	0.99 (0.81, 1.22)	543 (18.6)	685 (21.4)	0.87 (0.65, 1.16)
Stillbirth	520 (23.0)	557 (15.9)	0.69 (0.54, 0.88) [†]	468 (15.7)	491 (15.0)	1.05 (0.82, 1.33)
Perinatal mortality	1,033 (45.9)	1,350 (38.9)	0.85 (0.70, 1.02)	1,011 (34.1)	1,176 (36.1)	0.94 (0.76, 1.17)

ENC=Essential Newborn Care; NRP=Neonatal Resuscitation Program

* May reflect missing values

[†] <0.003