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CLINICAL ARTICLE

One-year evaluation of the impact of an emergency obstetric and neonatal care training program in Western Kenya

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ABSTRACT

Objective: To determine the impact of introducing an emergency obstetric and neonatal care training program on maternal and perinatal morbidity and mortality at Moi Teaching and Referral Hospital, Eldoret, Kenya. *Methods:* A prospective chart review was conducted of all deliveries during the 3-month period (November 2009 to January 2010) before the introduction of the Advances in Labor and Risk Management International Program (AIP), and in the 3-month period (August–November 2011) 1 year after the introduction of the AIP. All women who were admitted and delivered after 28 weeks of pregnancy were included. The primary outcome was the direct obstetric case fatality rate. *Results:* A total of 1741 deliveries occurred during the baseline period and 1812 in the post-intervention period. Only one mother died in each period. However, postpartum hemorrhage rates decreased, affecting 59 (3.5%) of 1669 patients before implementation and 40 (2.3%) of 1751 afterwards ($P = 0.029$). The number of patients who received oxytocin increased from 829 (47.6%) to 1669 (92.1%; $P < 0.001$). Additionally, the number of neonates with 5-minute Apgar scores of less than 5 reduced from 133 (7.7%) of 1717 to 95 (5.4%) of 1745 ($P = 0.006$). *Conclusion:* The introduction of the AIP improved maternal outcomes. There were significant differences related to use of oxytocin and postpartum hemorrhage.

1. Introduction

Maternal morbidity and mortality are of paramount concern in most resource-poor settings. The aim of the fifth Millennium Development Goal is to reduce maternal mortality [1]. Overall, 33.9% of maternal deaths in the African region are caused by hemorrhage [2].

The most recent estimate of the maternal mortality ratio in Kenya was 488 maternal deaths per 100 000 live births, which accounts for 15% of all deaths of women aged 15–49 years [3]. Although 92% of pregnant women in this country attend at least one prenatal clinic, only 43% deliver in a health facility [3]. Overall, only 44% of births are attended by a skilled attendant, most often a nurse or midwife. This lack of skilled care at delivery has been acknowledged as a key contributor to poor maternal health outcomes [4]. In addition, the adequacy of existing skills has at times been called into question, further underlining the need for consistent teaching and retraining of key provider skills [5,6].

Previous efforts to improve the safety of motherhood in resource-limited settings in the past few decades have focused on improving the skills of traditional birth attendants; however, to date, the efficacy of these efforts has not been clearly demonstrated [7]. Current initiatives are focused on improving the skills of healthcare professionals involved in obstetrics and care of the neonate (e.g. nurse-midwives and physicians) to improve the safety and outcomes of obstetric services as well as increasing the proportion of deliveries performed by a skilled attendant, which has been associated with improved outcomes [8]. To date, tests to evaluate knowledge before and after a training intervention have shown that performance improved after training [9], staff who received training reported improved comfort in dealing with acute scenarios [10], and there was some short-term improvement in the rates of postpartum hemorrhage [11], which is a major contributor to maternal mortality. Despite the availability of numerous training courses on emergency obstetric and neonatal care (EmONC), there is an overall lack of adequate evaluation of existing programs in terms of their clinical performance, and a paucity of evidence of any long-term benefit with regard to maternal and neonatal outcomes [6]. A recent cluster-randomized large-scale trial performed in West Africa [12] showed a significant reduction in maternal mortality ($P = 0.0299$) after the introduction of a

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multifaceted strategy of EmONC training, outreach visits, and maternal death review committees at district and capital hospitals; however, this effect was not seen at hospitals outside the capital.

The Advances in Labor and Risk Management International Program (AIP) is a product developed, owned, and implemented by the Society of Obstetricians and Gynecologists of Canada. The AIP is a capacity-building 5-day course for all health professionals (i.e. physicians, physicians in training, nurses, and midwives) responsible for the delivery of emergency obstetric and newborn care, addressing the five main causes of maternal mortality and morbidity (obstructed labor, hemorrhage, sepsis, hypertensive disorders, and complications owing to unsafe abortion). Newborn health outcomes are addressed in a component on newborn resuscitation and care. The AIP further sensitizes participants to the social, economic, cultural, and legal factors that may impede women from accessing reproductive health services and information, and it advocates for the improvement of women's reproductive and sexual health as a matter of social justice. Finally, it also exposes health professionals and administrators to the monitoring and evaluation methodologies necessary in all initiatives aimed at increasing access and quality of maternal and newborn health services. The AIP is taught within a framework of sexual and reproductive rights [13].

The AIP has become a well-studied measure of EmONC training: for example, Dumont et al. have previously reported the findings of a QUARITE (quality of care, risk management and technology in obstetrics) cluster-randomized trial conducted in Senegal and Mali that used the AIP [12,14]. To address the lack of existing evaluation of EmONC training courses, the aim of the present study was perform a before-and-after prospective chart review evaluation of the program to determine whether introducing the AIP improved the safety of obstetric and neonatal care provided at a low-resource tertiary care center in Kenya.

2. Materials and methods

A prospective study was undertaken involving chart review of all deliveries at Moi Teaching and Referral Hospital (MTRH), Eldoret, Kenya, in the 3-month period (November 1, 2009, to January 31, 2010) prior to introducing the AIP, and in the 3-month period (August 1–November 30, 2011) 1 year after 80% of the maternity ward staff had completed AIP training. The threshold of 80% was agreed upon in the study design as representing most of the labor and delivery staff; staffing atrition and hiring meant that maintaining a level of 100% trained staff for the duration of the study was not possible. All women who were admitted and delivered at MTRH and all neonates who were born at MTRH during the study periods were included in the study. Pregnancies of less than 28 weeks and mothers or neonates transferred to MTRH after delivery elsewhere were excluded from the study. Ethics approval for the study was obtained from both the Research Ethics Board at the University of Toronto and the Institutional Research Ethics Board at Moi University School of Medicine (protocol numbers 24371 and 000435, respectively).

Moi University School of Medicine and MTRH have been partnered with the Department of Obstetrics and Gynecology at the University of Toronto, Canada, since 2007. MTRH is a 700-bed hospital serving over 11 million people in Western Kenya and is the clinical site of Kenya's second-largest medical school. Between 2009 and 2011, approximately 7000 deliveries per year were performed at MTRH. To consolidate the training and experience of the labor ward staff at MTRH, staff were not transferred to other wards or facilities to maintain the impact of training interventions and the team environment.

Research assistants were present on the labor ward 24 hours per day, 7 days per week during the study data collection periods. Delivery information was collected from charts immediately following the delivery on a data collection sheet and later entered into an electronic database. Although research assistants could approach staff for clarification of chart information there was no direct patient contact and therefore informed consent was not required. Data were collected for a month prior to the initiation of the study to pilot the use of the forms and to train the research assistants in data collection.

The primary outcome was the direct obstetric case fatality rate (direct obstetric deaths or women with direct obstetric complications). Secondary outcomes were maternal and neonatal morbidity, including rates of admission to intensive care units and neonatal intensive care units, hemorrhage, transfusions, neonatal mortality rate, and an Apgar score of less than five at 5 minutes.

All chart abstraction data were entered into Microsoft Access 2007 software (Microsoft Enterprise, Redmond, WA, USA) and checked for consistency using SPSS version 19 (IBM, Armonk, NY, USA). Any discrepancies in data were checked against hard-copy data collection forms to ensure accurate data entry. Data from the baseline period prior to the AIP training intervention were merged with the post-AIP training intervention period to allow for before-and-after cross-sectional comparison of the AIP.

Data were collected on the demographic characteristics of the participating mothers (i.e. age, marital status, occupation, and maternal education) and clinical parameters (i.e. height, weight, and gravidity). The mean was calculated for continuous variables. Clinical and delivery characteristics of participants were also dichotomized to reflect the number of women above or below a threshold clinical value. The gestational age of the neonate was characterized as preterm, at term, or post-term if gestation at delivery was less than 37 weeks, 37–41 weeks, or more than 41 weeks, respectively.

Data were collected on the labor characteristics of participants, including method of induction, labor augmentation, and type and duration of labor, for the baseline and post-AIP training intervention periods. Delivery and pregnancy complications, such as episiotomy, tearing, and lacerations, were measured by dichotomous variables with yes or no responses. Data were also collected on neonate characteristics at birth, sex, and Apgar score at 5 minutes.

All statistical analyses were conducted using SPSS version 19. Categorical variables were compared using a χ^2 test and continuous variables were compared using a Student t test to determine whether there were any significant differences between the baseline and post-AIP training intervention periods. When appropriate, the Fisher exact test was used to compare proportions for expected cell counts less than five. $P < 0.05$ was considered statistically significant.

3. Results

The demographic and obstetric characteristics of the study population are shown in Supplementary Material S1 and S2. A similar number of deliveries occurred during the two periods of data collection: 1741 in the baseline period and 1812 after the training intervention. The mean maternal age of the participants was similar for both data collection periods: 26.4 ± 5.8 years and 26.7 ± 5.9 years ($P = 0.137$). The only significant differences between the two study populations were for occupation, how many had completed secondary education, and weight. A higher proportion of students and businesswomen were admitted during the postintervention period ($P < 0.01$), perhaps reflecting the higher proportion with secondary education; however, significantly fewer participants were self-employed ($P = 0.015$). The weight of participants admitted during the postintervention period (68.4 ± 12.1 kg) was significantly greater than that of those admitted before the intervention (65.5 ± 11.9 kg; $P = 0.001$). In total, 748 (43.1%) of 1735 patients in the preintervention period and 725 (40.2%) of 1804 patients in the postintervention period were primigravidas ($P = 0.078$). The two groups of patients were not significantly different in terms of their previous obstetric history, including prior live births and prior preterm births.

Clinical characteristics of the patients are shown in Table 1 and labor characteristics are shown in Table 2. Mean length of pregnancy and proportion of twins delivered were similar before and after the intervention (Table 1). In total, 83 (5.0%) of 1676 and 113 (6.5%) of 1750 patients were HIV positive before and after the intervention period, respectively.

Table 1
Clinical characteristics of participants.[a]

Characteristic	Baseline (n = 1741)	Postintervention (n = 1812)	*P* value[b]
Maternal hemoglobin before delivery[c]	11.5 ± 2.1	11.8 ± 2.0	0.019
≤10 g/dL	258 (26.6)	248 (23.8)	0.138
>10 g/dL	711 (73.4)	796 (76.2)	
Maternal hemoglobin after delivery[d]	8.9 ± 3.8	10.4 ± 3.1	0.228
≤10 g/dL	9 (56.3)	7 (36.8)	0.251
>10 g/dL	7 (43.8)	12 (63.2)	
Maternal HIV serology[e]			
Negative	1593 (95.0)	1637 (93.5)	0.058
Positive	83 (5.0)	113 (6.5)	
HIV treatment[f]			
Antiretroviral treatment (3 drugs)	48 (64.9)	46 (78.0)	0.216
Single-dose nevirapine	15 (20.3)	3 (5.1)	0.009
None	11 (14.9)	10 (16.9)	0.819
Length of pregnancy, wk[g]	38.7 ± 3.1	38.6 ± 3.2	0.591
Term at delivery			
Preterm (<37 weeks)	270 (16.4)	279 (17.6)	0.352
At term (37–41 weeks)	1207 (73.2)	1136 (71.7)	0.332
Post-term (>41 weeks)	171 (10.4)	169 (10.7)	0.786
Number of fetuses[h]			
Median	1.0	1.0	–
Interquartile range (range)	6 (1–2)	3 (1–4)	–
Multiple pregnancy (2 fetuses)	39 (2.3)	31 (1.8)	0.392
Delivered by[i]			
Consultant	17 (1.1)	12 (0.7)	0.292
Medical officer	215 (13.3)	294 (17.4)	0.001
Nurse or midwife	1385 (85.7)	1385 (81.9)	0.003
Transferred to MTRH[j]	294 (17.4)[k]	170 (10.0)[k]	<0.001
Transferred from[l]			
Dispensary	17 (6.0)	8 (6.0)	0.996
District hospital	54 (19.1)	19 (14.3)	0.225
Health center	93 (33.0)	36 (27.1)	0.225
Subdistrict hospital	47 (16.7)	35 (26.3)	0.021
Private clinic	63 (22.3)	31 (23.3)	0.826
Other	8 (2.8)	4 (3.0)	0.923

Abbreviation: MTRH, Moi Teaching and Referral Hospital.
[a] Values are given as mean ± SD or number (percentage), unless otherwise indicated.
[b] Mean values compared with *t* test, and numbers compared with χ^2 test.
[c] Missing data for hemoglobin before delivery for 1540: 772 at baseline and 768 postintervention.
[d] Data for 35 participants: 16 at baseline and 19 postintervention.
[e] Missing data for HIV serology for 127 women: 65 at baseline and 62 postintervention.
[f] Among women who tested positive, HIV treatment data missing for 9 at baseline and 54 postintervention.
[g] Missing data for length of pregnancy for 321 women: 93 at baseline and 228 postintervention.
[h] Missing number of fetuses data for 144 deliveries: 43 at baseline and 101 postintervention.
[i] Missing data for delivery assistance for 245 women: 124 at baseline and 121 postintervention.
[j] Missing transfer data for 163: 51 at baseline and 112 postintervention.
[k] Baseline and postintervention proportions were significantly different when compared using a *Z* test for proportions.
[l] Effective sample size of 415: 282 at baseline and 133 postintervention.

Table 2
Labor characteristics of participants.[a]

Characteristic	Baseline (n = 1741)	Postintervention (n = 1812)	*P* value[b]
Oxytocin augmentation[c]	569 (33.8)	440 (27.4)	<0.001
Duration of labor, h[d]			
1st stage	7.2 ± 6.2	11.8 ± 7.6	<0.001
2nd stage	0.4 ± 1.2	2.2 ± 3.9	0.001
3rd stage	0.2 ± 0.7	3.0 ± 3.9	0.098
Type of labor[e]			
Spontaneous	1564 (92.5)[f]	1460 (87.0)[f]	<0.001
Induced	127 (7.5)[f]	219 (13.0)[f]	<0.001
Method of induction[g]			
Prostaglandin	14 (16.5)	9 (8.3)	0.116
Oxytocin	51 (60)	74 (67.9)	0.291
Artificial membrane rupture	16 (18.8)	0	<0.001
Misoprostol	2 (2.4)	26 (23.9)	<0.001
Dinoprostone (Cerviprime; AstraZeneca, Bangalore, India) or other	2 (2.4)	0 (0.0)	0.191
Method of membrane rupture[h]			
Spontaneous	1214 (79.2)[f]	1079 (85.5)[f]	<0.001
Artificial	319 (20.8)[f]	183 (14.5)[f]	<0.001
Duration of ruptured membranes, h[i]			<0.001
Presence of meconium[j]	144 (8.8)[f]	185 (11.7)[f]	0.007
Abnormal fetal heart auscultation[k]	35 (2.1)[f]	16 (1.0)[f]	0.011

[a] Values are given as mean ± SD or number (percentage), unless otherwise indicated.
[b] Mean values compared with *t* test, and numbers compared with χ^2 test.
[c] Missing oxytocin use data for 262 participants: 56 at baseline and 206 postintervention.
[d] Data for 2579 participants: 1587 at baseline and 992 postintervention.
[e] Missing data for labor type for 183 participants: 50 at baseline and 133 postintervention.
[f] Baseline and postintervention proportions were significantly different when compared using a *Z* test for proportions.
[g] Data for 194 participants: 85 at baseline and 109 postintervention.
[h] Missing data for method of membrane rupture for 758 participants: 208 at baseline and 550 postintervention.
[i] Data for 1529 participants: 1374 at baseline and 155 postintervention.
[j] Missing data for presence of meconium for 325 participants: 98 at baseline and 227 postintervention.
[k] Missing data for fetal heart auscultation for 329 participants: 113 at baseline and 216 postintervention.

Oxytocin was used to augment the labor of significantly more patients in the baseline period than during the post-AIP period ($P < 0.001$), and the first and second stages of labor in the baseline period were also significantly shorter than during the postintervention period ($P \leq 0.001$) (Table 2).

Postpartum hemorrhage rates had decreased significantly in the postintervention period ($P < 0.029$) (Table 3). Significantly more patients received oxytocin after implementation than before (1669 [92.1%] vs 829 [47.6%]; $P < 0.001$) (Table 4). The number of women who received oxytocin before placental delivery increased from 1427 (91.7%) of 1556 before implementation to 1500 (99.7%) of 1505 patients afterwards ($P < 0.001$), and the proportion who received oxytocin after placental delivery (for the active management of the third stage of labor) increased from 98 (6.5%) of 1500 to 123 (98.4%) of 125 ($P < 0.001$). Estimated blood loss increased from 257.7 ± 202.5 mL before implementation to 338.9 ± 244.0 mL afterwards ($P < 0.001$). The number of episiotomies performed was significantly reduced ($P < 0.001$), but the number of women who experienced lacerations increased significantly ($P < 0.001$) (Table 5).

The number of neonates with Apgar scores of less than 5 at 5 minutes was significantly reduced from 133 (7.7%) of 1717 before implementation to 95 (5.4%) of 1745 afterwards ($P = 0.006$) (Table 6). Some outcome measures did not occur at a sufficient frequency to note a difference: for example, there was only one peripartum maternal death in each of the two periods.

4. Discussion

Only two maternal deaths occurred during the present study—one before the AIP training intervention was implemented and one after the training intervention—meaning that there was insufficient power to determine a difference in the direct obstetric case fatality rate, the primary outcome. Nonetheless, there were significant differences in postpartum hemorrhage, administration of oxytocin, administration of oxytocin after delivery of the placenta, and management of postpartum hemorrhage, which were topics addressed in the AIP training curriculum. Significantly more women received oxytocin augmentation in the baseline period than in the postintervention period, which may be related to the significantly shorter first and second stages of labor before implementation of the intervention. Although estimated blood loss increased, this might have been because estimated blood loss was assessed more carefully following AIP training.

The maternal weight of participants admitted during the postintervention period was significantly greater than that of women who

Table 3
Complications of pregnancy and delivery.[a]

Complications present	Baseline (n = 1741)	Postintervention (n = 1812)	*P* value[b]
Pre-eclampsia[c]	91 (5.3)	106 (6.0)	0.352
Maternal seizures or eclampsia[d]	12 (0.7)	9 (0.5)	0.485
Prelabor rupture of membrane[e]	81 (4.7)	75 (4.2)	0.467
Chorioamnionitis[f]	10 (0.6)	7 (0.4)	0.419
Sepsis[g]	3 (0.2)	3 (0.2)	>0.99
Deep vein thrombosis or pulmonary embolism[h]	13 (0.8)[i]	3 (0.2)[i]	0.011
Placental abruption[j]	12 (0.7)	8 (0.4)	0.330
Anemia[k]	246 (15.3)	184 (13.4)	0.154
Prepartum hemorrhage[l]	26 (1.5)	19 (1.1)	0.236
Postpartum hemorrhage[m]	59 (3.5)[i]	40 (2.3)[i]	0.029
Ruptured uterus[n]	5 (0.3)	7 (0.4)	0.775
Maternal death[o]	1 (0.1)	1 (0.1)	>0.99

[a] Values are given as a number (percentage) unless otherwise indicated.
[b] χ^2 test or Fisher exact test (when cell counts <5).
[c] Missing data for pre-eclampsia for 70 participants: 20 at baseline and 50 postintervention.
[d] Missing data for eclampsia for 81 participants: 20 at baseline and 60 postintervention.
[e] Missing data for prelabor rupture of membrane for 28 participants: 11 at baseline and 17 postintervention.
[f] Missing chorioamnionitis data for 30 participants: 13 at baseline and 17 postintervention.
[g] Missing sepsis data for 26 participants: 11 at baseline and 15 postintervention.
[h] Missing data for deep vein thrombosis and pulmonary embolism for 19 participants: 8 at baseline and 11 postintervention.
[i] Baseline and postintervention proportions were significantly different when compared using a *Z* test for proportions.
[j] Missing data for placental abruption for 20 participants: 5 at baseline and 16 postintervention.
[k] Missing data for anemia status for 570 participants: 132 at baseline and 438 postintervention.
[l] Missing data for prepartum hemorrhage for 64 participants: 31 at baseline and 33 postintervention.
[m] Missing data for postpartum hemorrhage for 133 participants: 72 at baseline and 61 postintervention.
[n] Missing data for ruptured uterus for 41 participants: 25 at baseline and 16 postintervention.
[o] Missing data for maternal death for 101 participants: 55 at baseline and 46 postintervention.

were admitted before the intervention, but, this finding was not thought to have clinical relevance.

There was a significant difference in the number of episiotomies performed in the two periods. Reducing the number of episiotomies performed is not an intervention that will save lives; however, avoiding routine episiotomy and performing it only as a matter of best practice in a mother-friendly environment is part of the AIP training and was the only intervention during the study that addressed episiotomy.

Table 4
Medications administered to the mother.[a]

Characteristic	Baseline (n = 1741)	Postintervention (n = 1812)	*P* value[b]
Oxytocin use	829 (47.6)	1669 (92.1)	<0.001
1 dose[c]	671 (88.2)	1277 (77.3)	<0.001
>1 dose	89 (11.7)	369 (22.3)	<0.001
Total dose, μg	11.0 ± 15.5	16.5 ± 19.4	<0.001
Oxytocin use before placental delivery[d]	1427 (91.7)	1500 (99.7)	<0.001
Total dose, units	18.9 ± 31.9	13.53 ± 14.6	<0.001
Oxytocin use after placental delivery[e]	98 (6.5)	123 (98.4)	<0.001
Total dose, units [f]	36.9 ± 50.8	35.2 ± 61.4	0.824
Magnesium sulfate[g]	36 (2.1)[h]	76 (4.8)[h]	<0.001

[a] Values are given as mean ± SD or number (percentage), unless otherwise indicated.
[b] Mean values compared with *t* test, and numbers compared with χ^2 test.
[c] Data for 2413 participants: 761 at baseline and 1652 postintervention.
[d] Missing data for oxytocin use before placental delivery for 492 participants: 185 at baseline and 307 postintervention.
[e] Data for 1625 participants: 1500 at baseline and 125 postintervention.
[f] Data for 205 participants: 97 at baseline and 108 postintervention.
[g] Missing data for magnesium sulfate for 302 participants: 62 at baseline and 240 postintervention.
[h] Baseline and postintervention proportions were significantly different when compared using a *Z* test for proportions.

Table 5
Delivery characteristics of participants.[a]

Characteristic	Baseline (n = 1741)	Postintervention (n = 1812)	*P* value[b]
Mode of delivery[c]			
Spontaneous vaginal	1403 (82.0)	1437 (84.7)	0.043
Assisted vaginal (vacuum, forceps)	19 (1.1)	18 (1.1)	0.993
Vaginal breech	26 (1.5)	19 (1.1)	0.368
Elective cesarean delivery	30 (1.8)	17 (1.0)	0.060
Emergency cesarean delivery	232 (13.6)	205 (12.1)	0.200
Reason for cesarean delivery[d]			
Repeat cesarean elective, not in labor	44 (22.8)	39 (31.0)	0.105
Failed to progress or prolonged labor	56 (29.0)	15 (11.9)	<0.001
Not reassuring fetal status	24 (12.4)	22 (17.5)	0.212
Noncephalic presentation	9 (4.7)	8 (6.3)	0.512
Other	60 (31.1)	42 (33.3)	0.674
Episiotomy[e]	192 (11.2)[f]	84 (4.7)[f]	<0.001
Tearing[g]			
1st degree	330 (19.3)	296 (16.9)	0.070
2nd degree	36 (2.1)	54 (3.1)	0.070
3rd–4th degree	9 (0.5)	9 (0.5)	0.962
Lacerations	50 (2.9)	130 (7.4)	<0.001
Estimated blood loss, mL[h]	257.7 ± 202.5	338.9 ± 244.0	<0.001
Received blood transfusion[i]	43 (2.6)	39 (2.4)	0.755

[a] Values are given as mean ± SD or number (percentage), unless otherwise indicated.
[b] Mean values compared with *t* test, and numbers compared with χ^2 test.
[c] Missing data for mode of delivery for 147 participants: 31 at baseline and 116 postintervention.
[d] Data for 319 participants: 193 at baseline and 126 postintervention.
[e] Missing episiotomy data for 59 participants: 30 at baseline and 29 postintervention.
[f] Baseline and postintervention proportions were significantly different when compared using a *Z* test for proportions.
[g] Missing tearing data for 88 participants: 28 at baseline and 60 postintervention.
[h] Missing data for blood loss for 281 participants: 196 at baseline and 85 postintervention.
[i] Missing data for blood transfusion for 305 participants: 93 at baseline and 212 postintervention.

Audits of maternal deaths at MTRH were performed following the baseline and postintervention periods to determine whether the one recorded maternal death in each time frame was accurate. These audits revealed a few additional maternal deaths, but these deaths were not included in the analysis because they did not occur on the maternity ward: they were due to septic abortions on the gynecology ward, deaths of mothers transferred to MTRH after delivery at another facility, or deaths of pregnant prepartum mothers on the prepartum ward before labor. Interventions are needed to reduce the number of these preventable maternal deaths; however, the focus of the AIP is peripartum morbidity and mortality. Further studies are needed to evaluate the effectiveness of EmONC courses in community and population-wide settings and to assess referral practices and the impact on prepartum deaths.

A limitation of the present study was that it was not a randomized controlled trial. A randomized controlled trial—as was used to evaluate the AIP in the QUARITE trial [12,14]—is considered the gold standard to determine cause and effect. However, they can be challenging to implement for large-scale training programs in real-world environments because environments do not stay static over time. Taking into account the time involved in program implementation and follow-up, the present study was conducted over a period of more than 2 years. During the study period, the mother/baby ward moved to a new location, a separate intervention was introduced to increase availability of emergency medications on the labor ward [15], and an increasing number of protocols were introduced on the maternity ward. However, the AIP was the only training intervention carried out during the study.

Training is a realistic and feasible means of knowledge translation in resource-limited settings, and evidence-based programs such as AIP are available internationally. The AIP specifically allows all health

Table 6
Neonate characteristics at baseline and postintervention.[a]

Characteristic	Baseline (n = 1735)	Post-intervention (n = 1789)	*P* value[b]
Sex[c]			
Male	897 (52.6)	964 (54.6)	0.229
Female	808 (47.4)	800 (45.4)	
Birth weight, g[d]	3007.1 ± 584.9	2901.3 ± 625.3	<0.001
Apgar score, 5 min[e]			
<5	133 (7.7)	95 (5.4)	0.006
5–7	62 (3.6)	57 (3.3)	0.578
>7	1522 (88.6)	1593 (91.3)	0.010
Fetal injuries[f]	8 (0.5)	21 (1.4)	0.009
Neonatal seizures[g]	3 (0.2)	2 (0.1)	>0.99
Neonatal resuscitation[h]	117 (6.9)	50 (2.9)	<0.001
Neonatal ventilation required[i]	108 (6.4)	9 (0.5)	<0.001
Admission to NICU[j]	92 (5.5)	72 (4.2)	0.087

Abbreviation: NICU, neonatal intensive care unit.
[a] Values are given as mean ± SD or number (percentage), unless otherwise indicated.
[b] Mean values compared with *t* test, and numbers compared with χ^2 test (Fisher exact test conducted for variables with cell counts <5).
[c] Missing sex data for 55 neonates: 30 at baseline and 25 postintervention.
[d] Missing birth weight for 111 neonates: 41 at baseline and 70 postintervention.
[e] Missing Apgar score at 5 minutes for 62 neonates: 18 at baseline and 44 postintervention.
[f] Missing data regarding fetal injuries for 393 neonates: 117 at baseline and 276 postintervention. Fetal injuries were categorized as brachial plexus nerve injury, fracture, bruising, laceration, and other.
[g] Missing seizure data for 209 neonates: 35 at baseline and 170 postintervention.
[h] Missing resuscitation data for 121 neonates: 39 at baseline and 82 postintervention.
[i] Missing ventilation data for 193 neonates: 41 at baseline and 152 postintervention.
[j] Missing data for admission to NICU for 121 neonates: 48 at baseline and 73 postintervention.

professionals who work in obstetric care to train together in a multidisciplinary fashion and to be trained by a diverse, multidisciplinary group of trainers, fostering collegiality. Further studies are warranted to evaluate the effectiveness of training in other areas of healthcare provision, and prospective studies, with randomized methodology when possible, are needed to further evaluate the benefit of emergency obstetric training.

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Conflict of interest

The authors have no conflicts of interest.

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