Early detection and bundled treatment of postpartum haemorrhage with the E-MOTIVE intervention: a prospective pre–post intervention study in Pakistan

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Summary

Background Delays in identifying and treating postpartum haemorrhage can result in serious maternal morbidity and mortality. In Africa, objective measurement of blood using a calibrated blood-collection drape (to diagnose postpartum haemorrhage) and use of the E-MOTIVE treatment bundle (comprising early detection of postpartum haemorrhage, massage of uterus, oxytocics, tranexamic acid, intravenous fluids, and examination and escalation of care) improved the consistency and speed of response to postpartum haemorrhage. The aim of this study was to evaluate the implementation and effectiveness of the E-MOTIVE intervention in a south Asian setting.

Methods A prospective pre–post intervention study was conducted at eight secondary-level care hospitals in the Sindh and Punjab provinces of Pakistan. Hospitals were included if they were geographically and administratively distinct from each other, had between 1000 and 5000 vaginal births annually, and provided comprehensive obstetric care with the ability to perform surgery for postpartum haemorrhage, if needed. Usual care was observed at all participating hospitals for 6 months (from Sept 28, 2022 to March 30, 2023); next, a 2-month transition period took place for training and set-up of the E-MOTIVE intervention (Oct 10, 2023 to Dec 10, 2023); then, the E-MOTIVE intervention was implemented for 3 months (Dec 11, 2023 to March 10, 2024). The E-MOTIVE intervention consisted of a calibrated blood collection drape for early detection of postpartum haemorrhage (E) and a bundle of first-response treatments (MOTIVE) comprising uterine massage, oxytocic drugs, tranexamic acid, intravenous fluids, examination, and escalation. The primary composite outcome comprised severe postpartum haemorrhage (≥1000 mL blood loss), laparotomy for bleeding, or death from bleeding. Implementation outcomes were the postpartum haemorrhage detection rate and bundle use rate. Blood loss was measured by collecting and weighing drapes. The study retained the same primary clinical and implementation outcomes as the main trial (NCT04341662).

Findings 18 hospitals were assessed for eligibility, ten were excluded for not meeting the inclusion criteria (four with fewer than 1000 births per year, three with no operating theatre available, one with bundle treatment already implemented, one with more than 5000 births per year, and one with a security hazard), and eight hospitals in the Punjab and Sindh provinces of Pakistan were deemed eligible for inclusion and participated in the study. 5089 women were included in the E-MOTIVE group and 9033 women were included in the usual care group. The median age of women in the E-MOTIVE group was 30 years (IQR 26–32) and in the usual care group was 30 years (IQR 25–30). The primary composite outcome of severe postpartum haemorrhage (blood loss of ≥1000 mL), laparotomy for bleeding, or maternal death from bleeding occurred in less than 0·1% of women in the E-MOTIVE group (two of 5089) versus 2·0% (183 of 9033) in the usual care group (risk ratio 0·03 [95% CI 0·01–0·13]; p=0·0015). Postpartum haemorrhage detection was 100·0% (109 of 109) in the E-MOTIVE group versus 50·9% (534 of 1050) in the usual care group (rate ratio 1·99 [95% CI 1·01–3·92]), and bundle use was 100% (109 of 109) in the E-MOTIVE group versus 40·7% (428 of 1050) in the usual care group (rate ratio 2·50 [95% CI 1·19–5·26]).

Interpretation Implementation of the E-MOTIVE intervention in Pakistan was associated with improvements in clinical outcomes and increased rates of postpartum haemorrhage detection and treatment bundle use. The E-MOTIVE intervention could be generalisable to south Asian settings.

Funding Gates Foundation.

Research in context

Evidence before this study

We searched CENTRAL, MEDLINE, Embase, ClinicalTrials.gov, and the World Health Organization International Clinical Trials Registry Platform from database inception to Oct 18, 2024, without language restrictions for studies. Search terms included variations of "postpartum haemorrhage", "uterotonics", "quantification of blood loss", and "care bundles". Before the E-MOTIVE trial, we identified two studies that incorporated a calibrated blood collection drape to support the diagnosis of postpartum haemorrhage. However, neither study included clear trigger criteria for intervention, nor did they incorporate a standardised treatment bundle. Additionally, the nature of usual care in those settings was not described, limiting the ability to interpret the comparative effectiveness of the interventions tested. The E-MOTIVE trial was conducted in Africa and was the first to test the early detection of postpartum haemorrhage with a calibrated drape and a standardised treatment bundle with clear trigger criteria. This demonstrated significantly reduced rates of severe postpartum haemorrhage and bleeding-related maternal morbidity compared with usual care. No previous studies had assessed the implementation or effectiveness of the E-MOTIVE approach outside the African context.

Added value of this study

To our knowledge, this is the first study to evaluate the implementation and clinical effectiveness of the E-MOTIVE intervention in a south Asian setting. Conducted across eight secondary-care hospitals in Pakistan, this large-scale prospective pre–post study included more than 14 000 women. The study demonstrated a substantial reduction in the composite clinical outcome (severe postpartum haemorrhage, laparotomy for bleeding, or maternal death due to bleeding) and improved adherence to timely bundled treatment for postpartum haemorrhage. The findings are notable not only for the large effect size (risk ratio 0·03 [95% CI 0·01–0·13]), but also for the high fidelity of the implementation achieved. This study adds important evidence that the E-MOTIVE intervention is feasible beyond Africa.

Implications of all the available evidence

The findings from the multi-country E-MOTIVE cluster-randomised trial in Africa and the current pre–post implementation study in Pakistan suggest that early detection of blood loss with a calibrated drape, followed by a use of a bundled treatment response for postpartum haemorrhage, substantially reduces the incidence and severity of postpartum haemorrhage. The E-MOTIVE intervention can be integrated into routine care, with appropriate health-care provider training and system readiness, and adapted for use in diverse health-care settings. The evidence supports the widespread adoption of the E-MOTIVE model as a standard of care for managing postpartum haemorrhage.

Introduction

Postpartum haemorrhage, defined as blood loss of 500 mL or more after birth,[1] is a major cause of maternal mortality and morbidity.[2] Every year, there are an estimated 14 million women who experience postpartum haemorrhage worldwide, resulting in more than 70 000 maternal deaths.[3]

The landmark E-MOTIVE trial, conducted in Africa, demonstrated that accurate and early diagnosis of postpartum haemorrhage with a calibrated drape and prompt management with a treatment bundle resulted in improved outcomes for mothers giving birth vaginally.[4] The E-MOTIVE cluster-randomised trial was conducted at 78 hospitals in Kenya, Nigeria, South Africa, and Tanzania.[4] The E-MOTIVE intervention included a calibrated blood-collection drape with alert lines at 300 mL and 500 mL for early detection of postpartum haemorrhage (designated as E), and a bundle of first-response treatments (uterine massage, oxytocic drugs, tranexamic acid, intravenous fluids, examination, and escalation, designated as MOTIVE). The E-MOTIVE intervention was supported by an implementation strategy. Hospitals in the control group provided usual care, with visual estimation of blood loss and treatment of postpartum haemorrhage in accordance with local or national guidelines. The primary outcome was a composite of severe postpartum haemorrhage (blood loss ≥1000 mL), laparotomy for bleeding, or maternal death from bleeding. There was a 60% reduction in the primary outcome, with a 1·6% event rate in the intervention group, compared with a 4·3% event rate in the usual care group (risk ratio 0·40 [95% CI 0·32–0·50]; p<0·001).[4]

Because the primary E-MOTIVE trial was conducted in four African countries, the generalisability of the findings outside of Africa remains unknown and could be affected by contextual factors including the health-care system, staffing, resources, and patient factors (eg, rates of anaemia and comorbidities). The aim of this study was to evaluate the implementation and effectiveness of E-MOTIVE in a south Asian health-care setting.

Methods

Study design and participants

Pakistan was originally scheduled to be part of the multi-country, cluster-randomised E-MOTIVE trial.[4] However, the start of the trial in Pakistan was delayed by catastrophic floods in 2022. Baseline data were collected, but due to the delays, the other African participating countries progressed to complete the trial before the hospitals in Pakistan could be randomised. As the required sample size for the E-MOTIVE trial had been achieved from the African countries, the Independent Data Monitoring Committee advised completing and analysing the trial without the participation of Pakistan.

The definitive effects found by the E-MOTIVE trial made it unethical to conduct further randomised trials of the intervention. As all countries that contributed to the E-MOTIVE trial were from Africa, an outstanding question on generalisability of the findings outside of Africa remained. In May, 2023, the independent Data Monitoring Committee made a clear recommendation to change the study in Pakistan into a pre–post intervention design and pivot all sites to the intervention. The E-MOTIVE study in Pakistan was conducted to assess the implementation and generalisability of E-MOTIVE in a south Asian health-care setting. The amended protocol was approved by the sponsor (University of Birmingham, UK; RG_19-231) and the Pakistan ethics and regulatory review committee (2023-7120-26699). The study retained the same primary clinical and implementation outcomes as the main trial (NCT04341662).

This prospective pre–post intervention study of the E-MOTIVE intervention took place between October, 2022 and March, 2024 at secondary-level care district headquarter hospitals in the Sindh and Punjab provinces of Pakistan. Hospitals were eligible for inclusion if they were geographically and administratively distinct from each other, had admitted between 1000 and 5000 women per year who had given birth vaginally, and were able to provide comprehensive obstetric care with the ability to perform surgery for postpartum haemorrhage, if needed. We excluded hospitals that already implemented a bundle for treatment of postpartum haemorrhage. The research participants for this study were the health-care providers, including midwives, attending vaginal births in the participating hospitals. Approval was obtained from each participating hospital, allowing staff to collect anonymised clinical outcome data for every vaginal birth. All women who gave birth vaginally in the participating hospitals during the study periods were included.

All the participating hospitals underwent a 6-month control (baseline) period, during which they provided usual care for postpartum haemorrhage (from Sept 28, 2022, to March 30, 2023). Once the approvals were in place for the pre–post intervention design, staff at the same hospitals were trained on the use of E-MOTIVE for the early detection and treatment of postpartum haemorrhage. A 2-month period was allowed for transition to conduct training and to implement and embed the E-MOTIVE intervention in practice (from Oct 10, 2023, to Dec 10, 2023). The E-MOTIVE intervention period lasted 3 months (from Dec 11, 2023, to March 10, 2024; appendix p 2).

See Online for appendix

The E-MOTIVE bundle reflects WHO-recommended, evidence-based practices for the management of postpartum haemorrhage and was implemented as part of standard care. The study intervention targeted health-care providers and not patients. There was no deviation from routine patient care provided, no direct patient interaction, and no collection of identifiable data beyond routinely recorded, anonymised clinical information. Therefore, as outlined in the Ottawa Statement[5] and Council for International Organizations of Medical Sciences guidelines,[6] individual patient consent was not required for our study. This approach was approved by the sponsor (University of Birmingham) and the Pakistan ethics committee.

Procedures

The E-MOTIVE intervention consisted of a calibrated blood collection drape for early detection of postpartum haemorrhage (E) and a bundle of first-response treatments (MOTIVE) comprising uterine massage, oxytocic drugs, tranexamic acid, intravenous fluids, examination, and escalation (appendix p 3). The calibrated drape had an alert line marked in yellow (indicating blood loss reaching 300 mL) and an action line marked in red (indicating blood loss reaching 500 mL) on the calibrated scale (appendix p 4). Implementation was supported by several components, including the use of trolleys or carry cases for postpartum haemorrhage; simulation-based, on-site training (low-dose, high frequency); local champions (midwives and doctors who lead and support change in participating hospitals); and audit and feedback of actionable data to providers (appendix pp 8–13). The implementation strategy was informed by the findings from our previous formative research,[7,8] and refined during multidisciplinary workshops. The intervention was piloted, and implementation strategies were refined in two hospitals (adaptive cycle sites) in Pakistan that did not participate in the main study.

During the control period when usual care was given, blood loss was estimated visually by the health-care provider, and interventions to treat postpartum haemorrhage were used in accordance with local or national guidelines. These interventions were often administered sequentially, with oxytocic drugs given as first-line treatment and tranexamic acid reserved for refractory bleeding. During the control period, uncalibrated drapes without alert lines were used.

During the control and intervention periods, the drape (calibrated or uncalibrated) was placed under the woman's buttocks immediately following vaginal birth of the baby. The blood was collected for 1 h, or 2 h if the bleeding continued beyond 1 h. The drape with the blood was then weighed using a digital weighing scale and photographed for source data verification. The drape weight recorded in grams was converted to volume (mL) at the analysis stage (with dry drape weight being deducted). Essential drugs and treatments for postpartum haemorrhage (oxytocin, tranexamic acid, and intravenous fluids) were available at all times for both the control and intervention groups.

Staffing levels and the provision of commodities, including tranexamic acid and high-quality oxytocin with an intact cold chain, remained consistent between the control and intervention phases. However, calibrated blood

collection drapes, and either postpartum haemorrhage trolleys or carry cases, were introduced during the intervention phase.

Data on blood loss were source-verified by research staff by weighing the drape with the collected blood on the digital weighing scale and taking a photograph (in both the E-MOTIVE and usual care groups). Only source-verified data were used in the analysis.

Outcomes

The primary clinical outcome was a composite of (1) severe postpartum haemorrhage, defined as blood loss of 1000 mL or more after vaginal birth, measured at 1 h and, if there was continued bleeding, for up to 2 h postpartum; (2) postpartum laparotomy for bleeding at any time up to discharge from the hospital; or (3) maternal death from bleeding at any time up to discharge from the hospital. Other clinical outcomes were individual components of the composite clinical outcome, postpartum haemorrhage (defined as blood loss of ≥500 mL), death from any cause, blood transfusion for any cause, blood transfusion for postpartum haemorrhage, blood loss as a continuous variable, uterine tamponade use, intensive care unit admission or higher-level hospital transfer, and newborn death.

The primary implementation outcomes were the detection of postpartum haemorrhage (assessed in women with a diagnosis of postpartum haemorrhage recorded by the health-care providers, out of the total number of women who had postpartum haemorrhage as objectively measured in the blood-collection drape), and adherence to the treatment bundle or bundle usage rate (assessed in women treated with the bundle after a diagnosis of postpartum haemorrhage recorded by the health-care providers, out of the total number of women in whom postpartum haemorrhage was objectively measured). Adherence to the treatment bundle was defined as adherence to at least three core bundle elements: administration of oxytocic drugs, tranexamic acid, and intravenous fluids.

Other implementation outcomes included postpartum haemorrhage detection rate (the number of women diagnosed with postpartum haemorrhage [blood loss of ≥500 mL] by the health-care providers out of the total number of women having a vaginal birth in the health facility); bundle usage rate (the number of women treated with the postpartum haemorrhage bundle following a diagnosis of postpartum haemorrhage by the health-care providers out of the total number of women having a vaginal birth in the health facility); uterine massage; oxytocin use; misoprostol use; tranexamic acid use; intravenous fluids use; examination of the genital tract; number of women receiving any treatment uterotonic; and the number of women requiring additional treatment interventions (ie, not responding to the MOTIVE bundle).

Statistical analysis

We summarised characteristics of the hospital and women by care received (E-MOTIVE and usual care). Binary and categorical variables were summarised with numbers and percentages, and continuous outcomes with mean and SD, or median and IQR, depending on the distribution. Testing for differences in baseline characteristics between E-MOTIVE and usual care was done, allowing for clustering by using mixed-effects models (linear or logistic) with random effects for cluster. A between-within small sample correction was included to account for the small number of clusters.[9] For skewed variables, a clustered Wilcoxon rank sum test was performed. To do this, the variable was ranked within each cluster, and a linear regression model was fitted with rank as the outcome, a fixed effect for group, and cluster robust SEs included. This did not include a small sample correction. To compare binary outcomes

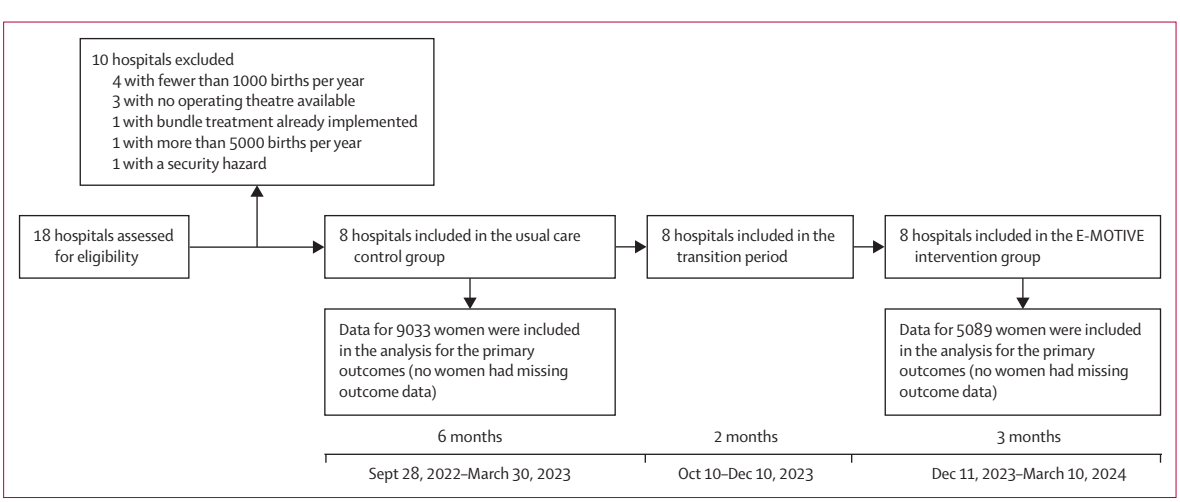

Figure 1: **Study profile and inclusion of hospitals**

	E-MOTIVE group (eight hospitals; 5089 women)	Usual care (eight hospitals; 9033 women)	p value
Median age, years	30 (26–32)	30 (25–30)	0·023*
Median number of previous births†	1 (0–3)	1 (0–3)	0·70*
Distribution of previous births†			
0	2179/5088 (42·8%)	3125/9013 (34·7%)	..
1–4	2263/5088 (44·5%)	4688/9013 (52·0%)	..
≥5	646/5088 (12·7%)	1200/9013 (13·3%)	..
Previous caesarean births	60 (1·2%)	156 (1·7%)	0·054
Postpartum haemorrhage (blood loss ≥500 mL) in previous pregnancy	80 (1·6%)	191 (2·1%)	0·051
Number of women with multiple pregnancies	56 (1·1%)	97 (1·1%)	0·83
Type of birth‡			
Unassisted vaginal births	5114/5145 (99·4%)	9012/9132 (98·7%)	0·011§
Delivery with forceps or vacuum	31/5145 (0·6%)	120/9132 (1·3%)	..
Mean birthweight, g	2852 (431)	2776 (543)	<0·0001
Median gestational age, weeks	37 (36–38)	37 (36–38)	..
Gestational age <37 weeks	1426 (28·0%)	3504 (38·8%)	<0·0001
Antepartum haemorrhage	5 (0·1%)	51 (0·6%)	0·0092
Pre-eclampsia	19 (0·4%)	189 (2·1%)	0·0004
Labour augmented or induced	1442 (28·3%)	2055 (22·7%)	0·0003
Retained placenta or manual removal of placenta	32 (0·6%)	458 (5·1%)	<0·0001

Data are n (%), median (IQR), or mean (SD), unless otherwise indicated. *p values have been calculated with an allowance for clustering by using mixed-effects models (linear or logistic) with random effects for cluster or using a clustered Wilcoxon rank sum test. †Missing data for one woman in the E-MOTIVE group and 20 women in the usual care group. ‡Includes multiple pregnancies. §p value is combined for unassisted vaginal births and delivery with forceps or vaccum.

Table 1: **Clinical characteristics of the women during the usual care (control) and E-MOTIVE (intervention) phases**

between E-MOTIVE and usual care, we present relative risks, which were obtained by fitting a Poisson model with a log link and robust SEs to allow for model misspecification. Random cluster effects for hospitals were included to account for clustering of observations within hospitals. A between-within small sample correction was included to account for the small number of clusters.[9]

Individual and cluster-level covariates were accounted for in the analysis by including a propensity score in the model. The propensity score was derived from a multivariable logistic model with treatment allocation (receiving E-MOTIVE or not) as the outcome and individual-level variables (age; parity; multiple pregnancy; mode of birth; birthweight; previous caesarean section; previous postpartum haemorrhage; gestational age <37 weeks; antepartum haemorrhage diagnosis; pre-eclampsia; augmented labour; and manual removal of the placenta) and a cluster-level variable (number of births) as predictors. The propensity score represents the probability of receiving E-MOTIVE given these observed confounders. Clustering is accounted for in the estimation of the propensity score using cluster robust SEs. For continuous covariates, we assessed whether a non-linear relationship provided a better fit than a linear one, using fractional polynomials. A threshold of $p<0·05$ was used to determine whether to include fractional polynomials.

The continuous outcome (blood loss) was skewed and, therefore, was transformed using a log transformation, before being analysed using a mixed-effects model. A random effect for cluster was included to account for clustering. This approach enabled us to report treatment effect estimates and 95% CIs. Non-parametric alternatives would only present p values, and other approaches that use permutation tests to calculate 95% CIs have not been fully evaluated in the context of studies with clustered data. A propensity score was used to account for individual-level and cluster-level covariates in the same manner as for the binary outcomes. We present effect measures that have been back-transformed and, therefore, represent the ratio of the geometric mean of blood loss in the E-MOTIVE group compared with usual care.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

18 hospitals were assessed for eligibility and ten were excluded for reasons including number of births less than 1000 per year or unavailable operating theatres. Data for analysis were available from eight hospitals in the Punjab and Sindh provinces of Pakistan that participated in the study (figure 1). Usual care (control) data were collected between Sept 28, 2022, and March 30, 2023, and E-MOTIVE intervention data were collected between Dec 11, 2023, and March 10, 2024. 5089 women were included in the E-MOTIVE group and 9033 women in the usual care group (table 1). The median age of women in the E-MOTIVE group was 30 years (IQR 26–32) and in the usual care group was 30 years (25–30). The median number of vaginal births per hospital per month was 200 (IQR 108–287) in the E-MOTIVE group and 143 (107–269) in the usual care group.

The composite clinical outcome of severe postpartum haemorrhage (blood loss of ≥1000 mL), laparotomy due to bleeding, or maternal death due to bleeding occurred in two (<0·1%) of 5084 women in the E-MOTIVE group and in 183 (2·0%) of 9011 in the usual care group (risk ratio 0·03 [95% CI 0·01–0·13]; p=0·0015; table 2). This composite outcome decreased with time following the implementation of the E-MOTIVE intervention for both the transition and intervention periods, compared with the control period (figure 2).

	E-MOTIVE group (eight hospitals; 5089 women)	Usual care (eight hospitals; 9033 women)	Risk ratio* (95% CI)	p value
Composite of severe postpartum haemorrhage (blood loss ≥1000 mL), laparotomy for bleeding, or maternal death from bleeding	2/5084 (<0·1%)	183/9011 (2·0%)	0·03 (0·01–0·13)	0·0015
Postpartum haemorrhage (blood loss ≥500 mL)	109/5084 (2·1%)	1050/9011 (11·7%)	0·20 (0·14–0·30)	<0·0001
Severe postpartum haemorrhage (blood loss ≥1000 mL)	2/5084 (<0·1%)	182/9011 (2·0%)	0·03 (0·01–0·13)	0·0015
Laparotomy†				
For bleeding	0	1/9033 (<0·1%)	..	..
For any cause	0	2/9033 (<0·1%)	..	..
Maternal death†				
From bleeding	0	3/9033 (<0·1%)	..	..
From any cause	0	3/9033 (<0·1%)	..	..
Blood transfusion				
For bleeding	37/5089 (0·7%)	204/9033 (2·3%)	0·38 (0·23–0·62)	0·0030
For any cause	187/5089 (3·7%)	389/9033 (4·3%)	0·99 (0·60–1·63)	0·96
Median blood loss at ≤2 h postpartum, mL	120 (80–160); n=5084	180 (100–300); n=9011	0·59 (0·57–0·61)‡	<0·0001
Implementation outcomes (in women with ≥500 mL blood loss [n=109 in the E-MOTIVE group and n=1050 in the usual care group])				
Detection of postpartum haemorrhage§	109/109 (100·0%)	534/1050 (50·9%)	1·99 (1·01–3·92)	0·047
Adherence to treatment bundle¶	109/109 (100·0%)	428/1050 (40·8%)	2·50 (1·19–5·26)	0·023

Data are n/N (%) or median (IQR) unless otherwise indicated. *Risk ratios are calculated with adjustment for clustering and propensity score (includes cluster-level and individual-level prognostic factors). †No risk ratio is presented as the model failed to converge. ‡Result presented is a ratio of geometric means due to the skewed nature of the variable. §Diagnosis of postpartum haemorrhage made by the birth attendant. ¶Defined as adherence to three core elements of the bundle: administration of oxytocic drugs, tranexamic acid, and intravenous fluids.

Table 2: **Clinical and implementation outcomes**

With reference to implementation outcomes, postpartum haemorrhage (blood loss of ≥500 mL) was detected in 100·0% (109 of 109) of the women in the E-MOTIVE group and in 50·9% (534 of 1050) of those in the usual care group (rate ratio 1·99 [95% CI 1·01–3·92]), and adherence to the treatment bundle was 100·0% (109 of 109) and 40·7% (428 of 1050), respectively (rate ratio 2·50 [95% CI 1·19–5·26]; table 2). The rates of detection of postpartum haemorrhage and adherence to treatment bundle in all women in the intervention phase were similar to those of all women in the control phase (appendix p 15).

The median blood loss 2 h after birth was 120 mL (IQR 80–160) in the E-MOTIVE group and 180 mL (100–300) in the usual care group (table 2). Postpartum haemorrhage (defined as blood loss of ≥500 mL) was diagnosed in 2·1% (109 of 5084) of women in the E-MOTIVE group and in 11·7% (1050 of 9011) of those in the usual care group (risk ratio 0·20 [95% CI 0·14–0·30]), and severe postpartum haemorrhage (defined as blood loss of ≥1000 mL) was diagnosed in two (<0·1%) of 5084 women in the E-MOTIVE group and 182 (2·0%) of 9011 women in the usual care group (risk ratio 0·03 [95% CI 0·01–0·13]). Postpartum blood transfusion for bleeding was given in 37 (0·7%) of 5089 women in the E-MOTIVE group and in 204 (2·3%) of 9033 in the usual care group (risk ratio 0·38 [95% CI 0·23–0·62]).

There were few cases of laparotomy, compression sutures, uterine artery ligation, or hysterectomy (data for compression sutures and uterine artery ligation are not shown; data for hysterectomy are presented in the appendix p 15), which limits meaningful comparison between the intervention and control groups. There were no maternal deaths in the E-MOTIVE group and three deaths in the usual care group. All three deaths in the usual care group were attributed to postpartum haemorrhage. The results for all the secondary outcomes are shown in table 2 and the appendix (p 15).

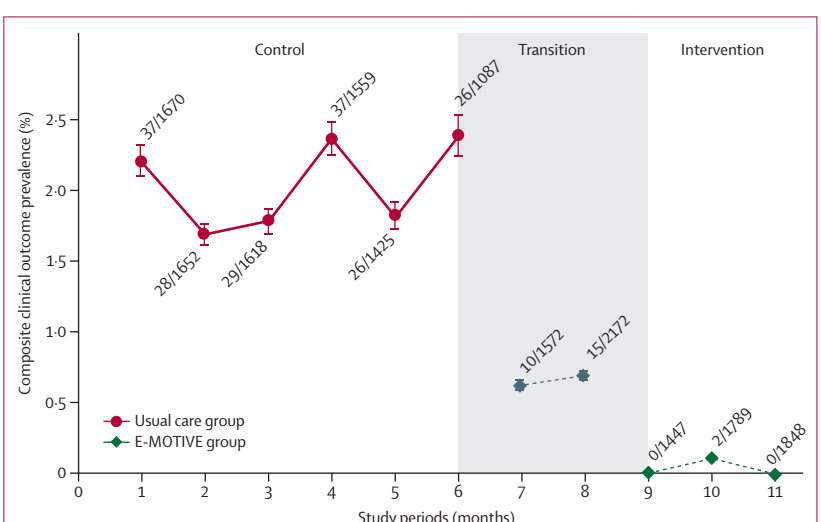

Figure 2: **Composite clinical outcome in the usual care, transition, and E-MOTIVE groups**
The number above each prevalence point indicates the number of women with the composite clinical outcome over the total number of women with vaginal births for the month.

Discussion

Our study showed that the E-MOTIVE intervention in Pakistan was associated with a lower rate of the adverse composite clinical outcome compared with usual care. It was also associated with an improved rate of detection of postpartum haemorrhage and a high rate of treatment bundle usage when postpartum haemorrhage was diagnosed.

The marked difference in the effect size for the primary outcome observed between Pakistan (risk ratio 0·03 [95% CI 0·01–0·13]) and the African settings (risk ratio 0·40 [0·32–0·50])[4] warrants consideration. Although the E-MOTIVE intervention was evaluated as part of a pragmatic implementation study across all sites, the context in which it was introduced in Pakistan differed notably. By the time the implementation study commenced in Pakistan, E-MOTIVE had already been established as a highly effective intervention. We postulate that previous awareness of its demonstrated effect led to greater confidence among clinical teams and a correspondingly high level of implementation fidelity. In the original E-MOTIVE trial, the proportion of women with postpartum haemorrhage who were not diagnosed at the time of blood loss decreased from 50% at baseline to 7% with the intervention.[4] However, in Pakistan, this rate decreased even further, from 50% at baseline to 0% with the intervention, suggesting that the blood collection drape—a key diagnostic component of the intervention—was used with exceptional consistency. The profound risk reduction observed in Pakistan might, therefore, reflect the synergistic effect of proven efficacy combined with high-fidelity implementation.

The improved detection rate of postpartum haemorrhage in the intervention group compared with the control group is probably due to the use of objective blood loss measurement to diagnose postpartum haemorrhage rather than visual estimation, which has been shown to be inaccurate and not detect approximately half of cases.[10] The early detection of excessive blood loss with a calibrated drape and prompt treatment with the MOTIVE bundle also reduced the rate of postpartum haemorrhage in Pakistan, indicating that prompt action had a preventive effect for postpartum haemorrhage. This provides a rationale for the greater treatment benefit observed in this study than in the original E-MOTIVE cluster-randomised trial.[4] Several other complications, including preterm birth, pre-eclampsia, and retained placenta, were lower in the intervention group compared with the control group. Given the non-randomised study design, the lower prevalence of certain complications (such as preterm birth and pre-eclampsia) in the intervention group could reflect differences in the underlying population baseline characteristics. Future analyses could use reverse propensity score matching or restrict to individuals at similar risk in the control group to create more comparable groups and better isolate the effect of the E-MOTIVE intervention.

The E-MOTIVE trial is the first study to evaluate an intervention that explicitly combines objective measurement of blood loss with predefined clinical thresholds for action and a bundled response comprising evidence-based treatments for postpartum haemorrhage. A recent systematic review[11] identified two studies that were conducted before E-MOTIVE.[12,13] Both of these studies incorporated a calibrated blood collection drape to support the diagnosis of postpartum haemorrhage; however, neither study included clear trigger criteria for intervention, nor did they incorporate a standardised treatment bundle. Additionally, the nature of usual care in those settings was not described, limiting the ability to interpret the comparative effectiveness of the interventions tested.

A strength of this study is the source-verification of blood loss data, achieved by photographing the drape containing collected blood on a digital weighing scale with the weight clearly visible. Other strengths include the inclusion of all women who gave birth vaginally in the participating hospitals, which reduced identification and recruitment bias. Access to all bundle components and quality-checked medicines was made available throughout the study. The E-MOTIVE intervention is simple, cost-effective,[14] and can be administered by midwives.

A limitation of this study is the absence of randomised allocation of sites. However, this would have been unethical as clear improvements in clinical outcomes had already been established with the E-MOTIVE intervention in the E-MOTIVE trial.[4] We therefore adopted a prospective pre–post intervention design. The larger sample size in the usual care group reflects the longer baseline period, rather than any change in recruitment practices. Due to the lack of randomisation, propensity score adjustments were used to adjust for observed confounders. However, the possibility of residual confounding due to unmeasured variables remains. Because this was a pre–post intervention study without a concurrent control group, the substantial reduction in the composite clinical outcome might also reflect other contributing factors, including other improvements in care, heightened awareness due to the study itself (Hawthorne effect), or regression to the mean. Another limitation was that health-care providers would have been able to see blood collecting in the transparent, uncalibrated drapes used in the usual care group. This might have attenuated the observed effect in the E-MOTIVE group. Furthermore, there were outcomes such as postnatal anaemia and the women's experience that were not assessed.

Ensuring the widespread availability of affordable calibrated blood collection drapes is essential for implementation across all maternity health-care settings, including public and private facilities. Hospitals that adopt the E-MOTIVE intervention should also ensure the necessary resources, quality-checked

medicines, and postpartum haemorrhage trolleys or carry cases are available to facilitate adoption and generate similar levels of effect as found in the E-MOTIVE trial. Standardised training for E-MOTIVE through regular drills should be developed to ensure staff preparedness. Future research should assess the effectiveness of E-MOTIVE in a high-income country setting to determine global generalisability. Additionally, implementation research should be conducted to adapt and assess E-MOTIVE in non-hospital and rural settings. The acceptability of the intervention to women should also be assessed.

In conclusion, our study showed that the E-MOTIVE intervention can enable early detection and prompt and effective treatment of postpartum haemorrhage in a south Asian setting. The E-MOTIVE intervention has been integrated into routine care in Africa and Pakistan, with appropriate health-care provider training and system readiness. Evidence supports the widespread adoption of the E-MOTIVE model as a standard of care for managing postpartum haemorrhage.

Contributors

AJD, JTM, LJM, OTO, IDG, KH, and AC contributed to the study design and methodology. CE designed the training approach with input from all clinical authors. LEB, KNS, MP, IH and AASw were responsible for study management and had oversight of data collection. LS was the principal investigator for the study in Pakistan. LS, SN, and SM were responsible for the oversight of the study at the hospitals in Pakistan that contributed to the overall study conduct. Additional supervision was provided by SS, RK and AL. KS, IA, AR, AAsh, NS, KM, SW, and RL were responsible for site-specific project administration and data management. JTM, LJM, and KH were responsible for data analysis. AASw assisted with data curation. All authors contributed to data interpretation. AJD wrote the first draft of the manuscript. All authors contributed to critical revision of the manuscript for important intellectual content and gave final approval. The manuscript represents the views of the named authors only and not necessarily the views of their affiliations, the World Health Organization or Human Reproduction Programme. AJD, SN, LS, and AC vouch for the accuracy of the data and analyses. AJD, JTM, LJM, KH, and AC directly accessed and verified the data reported in the paper. All authors had full access to all the data in the study and accept final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

After publication, study data will be made available on reasonable request to the corresponding author. A proposal with a detailed description of study objectives and statistical analysis plan will be needed for assessment of requests. Additional materials might also be required during the process of assessment. De-identified study data will be provided after approval by the principal investigator (AC) and study management group. E-mail: emotive@trials.bham.ac.uk

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