

BMJ Open Assessing the changes in childbirth care practices and neonatal outcomes in Western China: pre-comparison and post-comparison study on early essential newborn care interventions

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ABSTRACT

Objective To explore the changes in childbirth care practices and health outcomes of newborns after the introduction of early essential newborn care (EENC).

Design A pre-comparison and post-comparison study.

Setting The study was conducted in December 2016 and December 2018 in 18 counties in four western provinces of China.

Participants 46 hospitals that provide delivery services participated in the study.

Interventions EENC practices were introduced and implemented in the 46 hospitals.

Outcome measures The changes of hospital indicators such as incidence of birth asphyxia and neonatal mortality were compared in 2016 and 2018. EENC coverage indicators, such as skin-to-skin (STS) contact, and time of first breast feeding were also compared before and after the intervention via interview with 524 randomly selected postpartum mothers (320 in 2016 and 204 in 2018).

Results 54 335 newborns were delivered in the pre-EENC period (2016) and 58 057 delivered in the post-EENC period (2018). According to hospital records, the proportion of newborns receiving immediate STS contact increased from 32.6% to 51.2% (Risk Ratio (RR)=1.57, 95% CI 1.55 to 1.59) and the percentage of newborns receiving prolonged STS contact for more than 90 min increased from 8.1% to 26.8% (RR=3.31, 95% CI 3.21 to 3.41). No statistically significant changes were found in neonatal mortality, although slight decreases in birth asphyxiate and neonatal intensive care unit admission rates were detected. Among the mothers interviewed, the proportion of newborns receiving immediate STS contact increased from 34.6% to 80.0% (RR=2.31, 95% CI 1.69 to 3.17). The exclusive breastfeeding rate increased from 43% to 73.4% (RR=1.71, 95% CI 1.43 to 2.04). The average length of the first breast feeding increased from 15.8 min to 17.1 min.

Conclusions The introduction of EENC has yielded significant improvements in newborn care services at the pilot hospitals, including enhanced maternal and newborn care practices, improved STS contact quality and early breastfeeding performance. Further studies are needed to evaluate the long-term impact of EENC on newborn health outcomes.

Strengths and limitations of this study

- This is the first study to explore the changes in childbirth practices and health outcomes of newborns after the introduction of early essential newborn care (EENC) in China.
- For some primary indicators such as rate of skin-to-skin contact and breast feeding, both the hospital-reported data and patient-reported data were presented for mutual authentication.
- This research was a pre–post design so the results may be biased due to the possible introduction of other interventions unrelated to EENC during this time that may have affected newborn care practices.

INTRODUCTION

In China, over 99.9% of births take place in hospitals and are attended by skilled birth attendants, including certified midwives and obstetricians.^{1 2} In Western China, the hospital delivery rate has significantly increased from 44.8% in 1996 to 99.7% in 2018.³ The newborn, infant and under-five mortality ratios in China have decreased steadily over the last two decades, dropping to 3.9 per 1000, 6.1 per 1000 and 8.4 per 1000 in 2018, respectively.³ Despite the significant improvements, neonatal deaths account for around 50% of all under-five deaths in China, thus China remains one of the WHO's high-priority countries for advancement in neonatal health.⁴ Newborns still face significant risks throughout their perinatal period, which includes pregnancy, delivery and postpartum, as well as during the neonatal stage. Therefore, in conjunction with a key aim of the Sustainable Development Goals, China must focus on further reducing neonatal mortality in order to guarantee child survival



and optimal physical and mental development for all children.

To improve newborn survival and ensure a healthy start for every infant, WHO Member States in the Western Pacific Region endorsed the *Action Plan for Healthy Newborn Infants in the Western Pacific Region (2014–2020)* in 2013.⁵ This action plan aims to improve the quality of facility-based maternal and newborn care services, recognising that over 95% of deliveries in the region are in health facilities and that outdated and harmful health worker practices are widespread.⁶ The focus of this action plan is on the implementation of early essential newborn care (EENC), a package of evidence-based interventions shown to prevent and treat the leading causes of newborn illness and death.^{4 7} EENC includes a simple, yet vital, sequence of steps during and immediately after birth: thoroughly drying a newborn immediately after birth to prevent hypothermia and stimulate breathing, delaying cord clamping to reduce risk of anaemia in babies and complications in preterm infants, immediate and sustained skin-to-skin (STS) contact with the mother after delivery to prevent hypothermia, early (within 15–90 min of birth) and exclusive breast feeding, newborn eye care to prevent eye infection and Vitamin K₁ administration to prevent intracranial haemorrhage.⁷

Since 2013, the eight priority countries with the highest burdens of neonatal mortality in the Western Pacific Region—Cambodia, China, Laos, Mongolia, Papua New Guinea, Philippines, Solomon Islands and Vietnam—have been supported by WHO to introduce, sustain and scale-up EENC. Annual reviews on EENC implementation among these eight priority countries have shown the improvement in newborn care practices. By the end of 2017, 87% of term babies were receiving immediate STS contact and 57% remained in contact until completion of the first breast feed; 85% of term babies were exclusively breast fed in the immediate postpartum period and 90% received delayed cord clamping.⁸ The enhanced newborn care is showing an impact on health outcomes. A tertiary referral hospital in Vietnam reported statistically significant decreases in admission to the neonatal intensive care unit (NICU) (RR=0.68), hypothermia (RR=0.72) and cases of sepsis (RR=0.28) following EENC introduction.⁹

In 2016, EENC was introduced in China, starting with six hospitals.¹⁰ This early pilot produced meaningful results. A preliminary evaluation of the six hospitals showed that, after 3 months, 87% of infants born at term received immediate STS contact after delivery and 47% remained in contact until completion of the first breast feed. The breastfeeding rate and exclusive breastfeeding rate before discharge increased to 77% and 48%, respectively.¹¹ While these initial findings were quite promising, there are more than 25 000 health facilities for maternity and delivery services across China, with a large number of health providers who still need to be trained and equipped to implement EENC.

In 2017, the National Health Commission of China and UNICEF jointly launched the 3-year Safe Neonatal

Project (SNP) in 18 counties of four western provinces to further expand EENC. The aim of SNP is to optimise the EENC recommendations adapted to China's context and explore feasible implementation strategies for EENC with robust monitoring,¹² particularly in the disadvantage areas of China. While this project is ongoing, this study provides interim results analysing the EENC implementation rate and comparing the hospital impact indicators before and after EENC introduction in SNP counties. This analysis will help provide policymakers, health professionals and researchers with a comprehensive picture related to the usefulness of EENC in county-level hospitals. This is the first multicentre observational study concerning the effect of EENC in China.

METHODS

Study participants

This is a pre-comparison and post-comparison study, comparing data before and after the implementation of the intervention. This study involved 18 counties in four provinces in Western China: Qinghai, Ningxia, Sichuan and Guizhou. Over 83% of these counties were national-level poverty-stricken counties. In 2016, the population of 15–49 years old women and 0–5 years old children in these counties was 2.44 million and 0.52 million, respectively. The number of pregnant women was 95 430 and the number of live births was 91 125. These counties were selected to participate in this study because of their relatively high neonatal mortality rates, strong project management capacity and the government's desire to improve healthcare quality. EENC was introduced to 46 hospitals that provide maternity and delivery services.

EENC introduction

In the first quarter of 2017, EENC was introduced using the standardised training course and approach developed by WHO—the EENC Module 2—*Coaching for the First Embrace*, used for breathing and non-breathing babies. Coaching was conducted by national facilitators over 2 days in a delivery-room setting through a practice-based approach, without lectures or presentations. In China, midwives are the main medical personnel present at vaginal deliveries and caesarean sections, and obstetricians and paediatricians are present for high-risk deliveries. Thus, EENC coaching was provided to midwives, obstetricians and paediatricians. Participants reviewed current hand hygiene, delivery and newborn care practices and identified how these can be improved. Facilitators assisted them to practice sequential steps in the delivery of breathing and non-breathing babies until fully mastered. Post-coaching evaluations of hand hygiene, simulated clinical practice performance and EENC knowledge quiz were administered. Participants that passed these evaluations were certified as hospital EENC facilitators.

Once an initial cohort of hospital facilitators had been coached, hospitals established multidisciplinary EENC teams responsible for overseeing the cascading training of all staff and the routine EENC implementation. EENC

Module 3—*Introducing and Sustaining EENC in Hospitals: Routine Childbirth and Newborn Care*¹³—was used as the quality improvement model. This quality improvement approach involved quarterly assessments of childbirth and newborn care practices, hospital policies, environmental hygiene and availability of medicines and supplies.¹³ Data collected were summarised and used to inform development of short-term hospital action plans to improve care and to facilitate regular monitoring and evaluation. In the fourth quarter of 2017, a quality control assessment was conducted by national facilitators to oversee the implementation of EENC and ensure that all trained staff had mastered the skills. All hospitals demonstrated continued adherence to the EENC intervention before the collection of post-intervention data.

Intervention exposures

EENC practices were the primary exposures in this study. After introducing EENC Module 2 and Module 3, each hospital started EENC implementation by using the EENC Clinical Practice Pocket Guide,⁷ which provided detailed recommendations related to the following key practices: (1) accompanied during delivery by husband or other family member; (2) drying the baby immediately after birth and starting STS contact with mother (within 1 min) and lasting for at least 90 min; (3) delayed umbilical cord clamping and proper care of the cord stump (no application of any sterilising substances); (4) neonatal resuscitation; (5) early initiating of and exclusive breast feeding; (6) newborn eye care (application of erythromycin ointment within 90 min of birth) and (7) Vitamin K₁ administration for newborns.¹³ All vaginal deliveries should follow the above EENC practices and procedures. Hospitals also were encouraged to implement EENC in caesarean deliveries, but this was a voluntary choice based on the situation and resources of the hospital.

Data collection

The pre-data and post-data collection were conducted using the same methods by trained hospital staff in December 2016 and December 2018, respectively. Electronic statistic records at the 46 pilot hospitals were collected related to hospital deliveries, newborn diseases and other administrative information. Data was extracted from hospitals' routine information system. Postnatal mother face-to-face questionnaire interviews were conducted to collect data on personal experience of delivery health care. According to the standard method in the EENC Module 1—*Annual Implementing Review and Planning Guide*—hospitals with more than ten postpartum mothers at the time of data collection randomly selected ten patients to participate; whereas those with less than ten postpartum mothers selected all of them. As a result, we interviewed 320 mothers before EENC implementation and 204 after EENC implementation. The content of the interviews focused on the mothers' experiences of childbirth and newborn care practices. The medical records of these mothers were also reviewed to collect relevant information.

Study indicators

The variables collected in this study consisted of two entities: hospital indicators and key EENC practice coverage indicators. The hospital indicators included the rates for STS contact, early initiation of breast feeding (within 60 min of birth), exclusive breast feeding before hospital discharge, birth asphyxia, NICU admission, newborn sepsis and neonatal mortality. The key EENC practice coverage indicators included the rates for: (1) accompanied delivery by a family member; (2) STS contact (its initiation time and duration); (3) no wrapping of the umbilical cord directly after birth; (4) newborn eye care; (5) newborn Vitamin K₁ administration; (6) newborn hepatitis B vaccine within 24 hours of birth; (7) newborn BCG vaccine within 24 hours of birth; (8) newborn baths delayed until 24 hours after birth; (9) rooming-in of mother and newborn; (10) no bottle feeding of a newborns and (11) breastfeeding performances (initiation time, duration and exclusivity). Most of the study indicators were calculated based on information collected in the binary form (yes/no). The duration of the first breast feeding was a continuous variable. Since some indicators, such as rate of STS contact and breast feeding, could be obtained from both the hospital administrative data set and the postnatal mother interview, both the hospital-reported data and patient-reported data were presented for mutual authentication.

Statistical analysis

All data were entered into EpiData and stored in a password-protected SPSS file, accessible only by members of the research team. The Student's t-test for continuous variables and Pearson's χ^2 test for categorical variables were used to compare outcomes of interest before and after EENC implementation. Relative risk and CIs were calculated for each categorical variable. Multiple factor binary logistic regression was used to examine the effect of the exposures after controlling for the confounding variables. Statistical analysis was conducted by using SPSS Statistics software V.22.0.

Patient and public involvement

Neither patients nor the public were involved in the design, conduct, reporting or dissemination plans for our research. Because this was a pilot study focusing on the clinical practice within hospitals, the patients' involvement in the study design and implementation might cause research bias. In addition, this pilot project might need to be localised before receiving public attention.

RESULTS

Change of hospital indicators according to hospital reporting

A total of 54 335 live births in the pre-EENC period (2016) and 58 057 in the post-EENC period (2018) were registered. According to hospital records, the proportion of newborns receiving immediate STS contact (within 1 min) increased from 32.6% to 51.2% (RR=1.57, 95% CI 1.55 to 1.59) and prolonged STS contact (≥ 90 min) increased from 8.1% to 26.8% (RR=3.31, 95% CI 3.21 to 3.41). Pre-EENC data on umbilical cord care, early initiation of breast feeding and exclusive breast feeding were not available because hospitals

**Table 1** Change of key hospital indicators before and after EENC intervention according to hospital medical records, n (%)*

Hospital indicators	Pre-EENC	Post-EENC	RR (95% CI)	SE	P value
Number of live births	54 335	58 057	/	/	/
Caesarean	18 155 (33.4)	19 275 (33.2)	0.99 (0.98 to 1.01)	0.10	0.264
EENC key practice					
Any STS contact	13 475 (24.8)	37 214 (64.1)	2.58 (2.54 to 2.63)	0.02	<0.001
STS started early (within 1 min of live)	17 713 (32.6)	29 725 (51.2)	1.57 (1.55 to 1.59)	0.01	<0.001
STS duration \geq 90 min	4401 (8.1)	15 559 (26.8)	3.31 (3.21 to 3.41)	0.02	<0.001
Hospital impact indicators					
Early initiation of breast feeding*	/	47 288 (73.7)	/	/	/
Exclusive breast feeding*	/	49 987 (86.1)	/	/	/
Birth asphyxia	2414 (4.4)	1787 (3.0)	0.68 (0.69 to 0.77)	0.03	0.036
NICU admission	7777 (14.3)	6091 (10.5)	0.73 (0.71 to 0.76)	0.02	0.011
Newborn sepsis	57 (0.10)	81 (0.14)	1.33 (0.95 to 1.87)	0.17	0.510
Newborn death	42 (0.08)	53 (0.09)	1.18 (0.79 to 1.77)	0.21	0.109

*There were missing data for the pre-EENC group because hospitals did not routinely collect these indicators before EENC introduction. EENC, early essential newborn care; NICU, neonatal intensive care unit; STS, skin to skin.

did not report these indicators before EENC introduction, and these data were not able to be obtained from routine medical documents either. Comparing data before and after the intervention, no statistically significant changes were found related to neonatal mortality, although slight decreases in the birth asphyxiate and NICU admission rates were observed (table 1).

Demographic characteristics of postpartum mothers

A total of 320 mother–infant pairs were observed before the EENC implementation and 204 pairs were observed afterwards. There were no statistically significant differences between the two groups in terms of demographic characteristics (table 2).

Change of EENC key interventions according to patient reporting

The proportion of newborns receiving immediate STS contact (within 1 min) increased from 34.6% to 80.0%, and prolonged STS contact (\geq 90 min) increased from 9.5% to 63.1%. The rate of umbilical wrapping dropped from 97.8% to 15.3%, according to medical records. Significant increases were also observed in newborn eye care (from 12.5% to 58.4%) and the BCG vaccine (from 49.0% to 75.8%). Fewer newborns used bottle feeding after the intervention implementation (from 40.9% to 21.5%) (table 3).

Changes in breastfeeding practices according to patient reporting

Breastfeeding performances improved significantly, with the breastfeeding rate increasing from 79.4% to 96.1%, the time between birth and the initiation of breast feeding becoming significantly shorter, the length of breastfeeding time becoming longer and the rate of exclusive breast feeding rising from 43.0% to 73.4% (table 3). Results of the multiple logistic regression showed that STS contact (OR=8.46, 95%

CI 1.30 to 55.17), STS contact starting within 1 min of birth (OR=5.83, 95% CI 1.42 to 23.95) and STS contact duration \geq 90 min (OR=6.15, 95% CI 1.68 to 22.57) were associated factors for successful early breast feeding (table 4).

DISCUSSION

This study provided analyses of primary data related to EENC pilot programmes implemented in resource limited areas in Western China. The study results show that the introduction of EENC significantly promotes the newborn care service

Table 2 Mother's demographic characteristics before and after EENC implementation

Demographic characteristics	Pre-EENC (n=320)	Post-EENC (n=204)	P value
Mother's age (mean \pm SD)	26.6 \pm 5.3	26.7 \pm 5.7	0.510
Mother's ethnicity, n (%)			0.052
Han	168 (52.5)	78 (38.4)	
Hui	53 (16.6)	41 (20.2)	
Other	99 (31.0)	84 (41.4)	
Mother's education level, n (%)			0.183
Elementary school or lower	69 (21.7)	51 (25.1)	
Junior high school	137 (43.1)	87 (42.9)	
Senior high school	58 (18.2)	20 (9.9)	
University or higher	54 (17.0)	45 (22.2)	

EENC, early essential newborn care.

Table 3 Change in EENC key interventions before and after EENC intervention according to postnatal mothers interview, n (%)

EENC key interventions	Pre-EENC (n=320)	Post-EENC (n=204)	RR (95% CI)	SE	P value
Accompany delivery	68/320 (21.3)	34/204 (16.7)	0.78 (0.54 to 1.14)	0.19	0.251
STS contact					
Any STS contact	79/320 (24.7)	155/204 (76.0)	3.08 (2.50 to 3.78)	0.11	<0.001
STS started early (within 1 min)	27/78 (34.6)	120/150 (80.0)	2.31 (1.69 to 3.17)	0.16	<0.001
STS duration <10 min	46/74 (62.2)	11/130 (8.5)	0.14 (0.08 to 0.25)	0.30	<0.001
STS duration ≥90 min	7/74 (9.5)	82/130 (63.1)	6.67 (3.26 to 13.67)	0.37	<0.001
Applied medicine/wrapped the umbilical cord	308/315 (97.8)	30/196 (15.3)	0.16 (0.11 to 0.22)	0.17	<0.001
Newborn eye care performed	39/312 (12.5)	115/197 (58.4)	4.67 (3.40 to 6.41)	0.16	<0.001
Newborn Vitamin K ₁ administered	229/314 (72.9)	149/187 (79.7)	1.09 (0.99 to 1.21)	0.05	0.090
Hepatitis B vaccine given within 24 hours	297/314 (94.6)	192/194 (99.0)	1.05 (1.02 to 1.08)	0.02	0.011
BCG vaccine given within 24 hours	153/312 (49.0)	147/194 (75.8)	1.55 (1.35 to 1.77)	0.07	<0.001
Baby bathed after 24 hours	188/254 (74.0)	160/197 (81.2)	1.10 (0.99 to 1.21)	0.05	<0.071
Bottle-fed newborns	101/247 (40.9)	42/199 (21.1)	0.52 (0.38 to 0.70)	0.16	<0.001
Rooming-in with mother	181/257 (70.4)	182/202 (90.1)	1.28 (1.17 to 1.40)	0.05	<0.001
Breastfeeding performance					
Any breast feeding	204/257 (79.4)	196/204 (96.1)	1.21 (1.13 to 1.30)	0.04	<0.001
Breastfeeding initiation (<15 min)	10/198 (5.1)	35/184 (19.0)	3.77 (1.92 to 7.39)	0.34	<0.001
Breastfeeding initiation (15–90 min)	78/198 (39.4)	84/184 (45.7)	1.16 (0.92 to 1.46)	0.12	0.235
Breastfeeding initiation (>90 min)	110/198 (55.6)	65/184 (35.3)	0.63 (0.50 to 0.80)	0.12	<0.001
Breastfeeding duration (min)	15.8 ± 16.9	17.1 ± 10.6	/	/	0.002
Exclusive breast feeding	95/221 (43.0)	127/173 (73.4)	1.71 (1.43 to 2.04)	0.09	<0.001

EENC, early essential newborn care; STS, skin to skin.

improvements, including enhanced maternal and newborn care practices, improved STS contact quality and early breastfeeding performance. This study contributes valuable findings to advocate for the promotion and implementation of EENC across China, as well as in other regions around the world with similar circumstances to Western China.

The low exclusive breastfeeding rate is a worldwide public health issue both in developed and developing countries.^{14–16} Enhanced breastfeeding performance has been proven to

reduce mortality rate and provide better health outcomes among newborns.^{17–20} Previous studies have mentioned the correlation between early STS contact and successful breastfeeding practices.²¹ Moore's systematic review showed STS contact within 10 min of birth could improve the chances of successful breast feeding.²¹ Our study also noted that the prolonged STS contact was strongly associated with breast feeding within 90 min of birth. The Chinese government started to emphasise breast feeding in the 1990s and joined

Table 4 Association between EENC-recommended practices and early breast feeding using multiple factor logistics regression (n=204)

Independent variable	β	SE	OR (95% CI)	P value
Constant	−8.588	3.419	/	0.012
Mother's age	0.048	0.046	1.05 (0.96 to 1.15)	0.291
Mother's education	0.310	0.337	1.36 (0.70 to 2.64)	0.358
Accompanied delivery	−0.103	0.938	0.90 (0.14 to 5.67)	0.912
Baby bathed after 24 hours	0.325	1.133	1.38 (0.15 to 12.76)	0.774
Whether STS with mother	2.135	0.957	8.46 (1.30 to 55.17)	0.026
STS started within 1 min	1.763	0.721	5.83 (1.42 to 23.95)	0.014
STS duration ≥90 min	1.817	0.663	6.15 (1.68 to 22.57)	0.006
Rooming-in with mother	−1.001	0.838	0.37 (0.07 to 1.90)	0.232

EENC, early essential newborn care; STS, skin to skin.



the baby-friendly hospital initiative²² in 1992.²³ Currently, there are over 7300 baby-friendly hospitals in China and the government is planning on revising this criteria according to the new guidance on baby-friendly hospital initiatives issued by WHO and UNICEF.^{24 25} Despite the great progress and promotion of baby-friendly hospitals, delayed initiation of STS contact, insufficient contact between mothers and babies, and insufficient duration of STS contact to satisfy early breast feeding in hospitals have been observed.²⁶ Considering the significant effect of EENC on breastfeeding practices as seen in these pilot hospitals, China's baby-friendly hospitals could benefit from the implementation of EENC components to reinforce important aspects of newborn care, like successful breast feeding.

This study also showed the improvement of other recommended practices after EENC implementation, such as the decreased rate of applying medicine and wrapping an infant's umbilical cord. Currently, health workers in China usually use iodine tincture for sterilisation and then gauze-containing disinfectant powder for wrapping.²⁶ Our study, along with others,²⁷ showed that no increased risk of umbilical infection was observed after recommending sterilisation and wrapping of the umbilical cord be withheld, as long as strict procedures during the operation were followed. In this study, hospital-reported data and patient-reported data were both presented for mutual authentication. For EENC key practice indicators, such as any STS contact, STS starting time, STS duration, the hospital-reported rates were lower than patient-reported rates. One possible reason for this is the reporting bias, and another reason could be because around one-third of deliveries in the study hospitals included in this study were caesarean deliveries and pilot hospitals were unable to fully implement EENC recommendations with such deliveries.

Hospital impact factors were also compared before and after EENC implementation. Throughout the study, the incidence of newborn sepsis and newborn deaths stayed relatively the same, and birth asphyxia and NICU admission rates decreased slightly. These data are less impressive than those from one hospital in Vietnam that implemented EENC and showed a significant drop in the number of NICU admissions and case of newborn sepsis.⁹ One possible reason is that, the newborn health status has been greatly improved in China during the past decade, leaving fewer room for improvements. The time period of our intervention was only 2 years. It is difficult to decrease newborn mortality in such a short period of time. In addition, other factors might have influenced the survival of newborns. Previous studies have shown that, due to the shortages of obstetricians, midwives/nurses and paediatricians in hospitals across Western China, daily work has become more demanding and work efficiency is limited.²⁸ Also, a lack of basic equipment, medicine and supplies was seen in some pilot hospitals.²⁹ Although basic life-saving newborn care services were emphasised in the pilot hospitals, newborn health workers still need further improve their skills in diagnoses and treatment of newborn diseases.³⁰ EENC coaching should therefore be expanded to meet the needs of local health workers and provide additional training related to obstetric and paediatric topics. Despite these

inadequacies, EENC has indeed improved health workers' awareness of early newborn care.¹⁵ The introduction of EENC broke stereotypes and allowed health workers in pilot hospitals to emphasise baby-friendly practices. This type of shift will have a long-lasting effect; therefore, follow-up studies are needed to evaluate the long-term impact of EENC on healthcare indicators.

While this study revealed important findings, limitations to this study exist. This research was a pre-post design. The results might be biased due to secular trends or the introduction of other interventions unrelated to EENC during the time frame of this study. Also, the Hawthorne effect may have influenced the results since mothers were aware they were being observed and asked for their input. To minimise observer bias, exit interviews of postpartum mothers were conducted.

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Contributors WQ completed the statistical analyses and drafted the initial manuscript; QY, YW, JLY and XT assisted with the data collection, on-site quality control and statistical analyses; TX and XH contributed to the conceptualisation and design of the study, supervised the data collection and reviewed and revised the manuscript; KM and AN contributed to the review and revision of the manuscript and XJ contributed to the design of the study. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval The study was reviewed and approved by the Institutional Review Board at the National Center for Women and Children's Health, Chinese Center for Disease Control and Prevention. The approval for direct observation was obtained from hospital management at each location. All interviews and record checks were done with the written approval from each postpartum mother.

Data availability statement The data sets used during the present study are available from the corresponding author on reasonable request.

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