Effectiveness of Early Essential Newborn Care Implementation In Four Provinces of Western China

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Abstract

Introduction: Neonatal survival remains a public health concern globally. Early Essential Newborn Care (EENC) recommended by World Health Organization is a package of cost-effective interventions to improve neonatal health and development outcomes. In this study we aimed to explore the effectiveness of EENC implementation in four provinces of western China.

Methods: A pre- and post-intervention investigations were conducted in 4 selected EENC intervention counties and 4 control counties of four western provinces of China, during June to August 2017 and December 2020 to April 2021 respectively. A mixed quantitative and qualitative approach was used for data collection and analysis. Data on the coverage of EENC practices were collected through post-intervention face-to-face questionnaire interview with postpartum mothers before hospital discharge. Hospital-reported data on neonatal health outcomes were obtained through mail surveys in both investigations. We also performed semi-structured interviews with stakeholders of policymakers, health staff, and postpartum mothers to learn their perceived usefulness of EENC implementation.

Results: 599 mother-newborn pairs in the intervention group and 699 pairs in the control group participated in the post-intervention survey. With the confounding factor of province being controlled for, proportions of newborns receiving any skin to skin contact (99.50% vs. 49.07%), exclusive breastfeeding before discharge (92.57% vs. 63.80%), no applied medicine to the umbilical cord (98.50% vs. 9.73%), routine eye care (93.16% vs. 8.73%), and vitamin K₁ administration (98.33% vs. 88.98%) were higher in the intervention group compared with the control group (P<0.05). Lower incidences of neonatal diarrhea (0.07% vs. 0.22%) and eye infection (0.04% vs. 0.29%) were reported in the intervention group than the control group (P<0.05). The enhanced satisfaction of stakeholders primarily manifests in belief acknowledgement, policy promotion, emotional support, health improvement, widely-acknowledged sustainability, and work support.

Conclusion: EEEC-recommended core practices have been successfully introduced in pilot hospitals. The efficacy of EENC implementation should be highly recognized to accelerate the progress towards its national rolling out.

1 Introduction

Neonatal health care is critical to child short- and long-term survival and early development; ensuring a healthy start for all newborns will accelerate progress towards the target “ending preventable deaths of newborns by 2030” proposed by United Nations’ Sustainable Development Goals (SDG) in 2015. While a significant progress has been made in addressing children survival situation, neonatal death remains a serious concern globally, accounting for approximately 48% of all deaths among children under 5 years. Over 2/3 of neonatal deaths occurred in the first 3 days, especially in 24 hours after birth. China has reduced neonatal mortality rate from 33.1‰ in 1991 to 3.5‰ in 2019, however, newborn death is still the
leading contributor to death of children under 5 year-old\textsuperscript{5}. Adopting effective interventions to turn the tide should be national high priority.

Early Essential Newborn Care (EENC) is a package of evidence-based interventions for mothers and newborns around birth. It was recommended by World Health Organization (WHO) \textit{Action Plan for Healthy Newborn Infants in the Western Pacific Region (2014–2020)} in 2013, to reduce the preventable newborn death\textsuperscript{6}. EENC emphasizes the minimization of unnecessary practices such as routine suctioning and early physical examination for newborns, while promotes core cost-effective practices including immediate and uninterrupted mother-baby skin to skin contact (SSC) for 90 min, delayed umbilical cord clamping, early breastfeeding initiation, and kangaroo mother care (KMC) for premature infants\textsuperscript{7–8}. All priority countries in the Western Pacific Region continued scale-up of EENC and the applicability of EENC has been substantiated in other countries\textsuperscript{11}. To sustain the practice improvements, more actions are needed to support incorporation of EENC into routine clinical practices.

Understanding the health effects of EENC implementation is necessary to scale up EENC nationally. Evidence has indicated that EENC-recommended interventions are practical and cost-effective to improve neonatal health outcomes in western China\textsuperscript{9–10}, However, previous studies regarding EENC implementation were restricted to pre- and post-intervention design within groups\textsuperscript{10,12}, cross-sectional observational investigation of service capacity\textsuperscript{13}, incomprehensive research scope with small sample size\textsuperscript{14–15}, and limited qualitative researches lacking a combination of perspectives from multiple stakeholders\textsuperscript{16–17}. Moreover, most studies lack controls and a multi-centre design\textsuperscript{10,12,14}. Our large sample, multi-center study, is such an attempt to address the above noted gaps in researches to date.

With the aim to achieve equitable and high-quality coverage of health care for all newborns, the National Health Commission (NHC) of China and United Nations Children’s Fund jointly launched the 3-year Safe Neonatal Project (SNP) in western China. From September 2017 to December 2020, SNP was implemented in 18 counties of four western provinces including Qinghai, Sichuan, Guizhou, and Ningxia Hui Autonomous Region, setting out a vision of a nation where every newborn reaches full potential. SNP aims to help (mothers and) newborns in pilot areas increasingly benefit from equitable policies, guidelines, and high impact and quality interventions for survival and development. Based on data obtained from SNP, we aim to comprehensively explore the positive impacts of EENC implementation. Our findings will provide empirical references on clinical practice of EENC to China and other countries with similar demands, which will help inform health authorities of tailored EENC promotion strategies to enhance neonatal health and well-beings.

\section*{2 Methods}

\subsection*{2.1 Study design}

This was a pre- and post-intervention study. Data were collected from baseline and endline investigations which were conducted from June to August 2017, and December 2020 to April 2021, respectively. We
conducted mixed quantitative and qualitative analyses to assess the positive impacts of EENC implementation.

2.2 Study settings

Out of the 18 SNP counties, one SNP county was randomly selected as the intervention county in each province in our study, with a control county being selected from the same province. In each intervention/control county, 1–2 county-level hospitals providing midwifery services with over 5000 live births annually, were selected as sample health facilities. A total of 15 health facilities were enrolled in this study, with 7 in the intervention group and 8 in the control group, respectively. The province-stratified group allocation and on-site survey time are shown in supplementary table 1. The two groups were homogeneous in socioeconomic development, demography, and maternal and child health care levels.

2.3 EENC implementation

2.3.1 EENC practices

EENC contains a package of evidence-based interventions for maternal and neonatal health improvement. The 7 key practices are as following:

(1) 1 min after birth:

a. Neonatal resuscitation for newborns if without spontaneous breathing.

(2) 1–3 min after birth:

b. Immediate and prolonged SSC: The thoroughly dried neonate is in direct skin contact with mother’s bare breast and abdomen for ≥90 min. Cover (do not wrap) the newborn’s skin with clean warm cloth and the head with a hat.

c. KMC for preterm newborns: Baby is placed in continuous SSC between his/her mother, father, or other family members.

d. Delayed umbilical cord clamping and proper care: Umbilical cord clamping is delayed until there is no umbilical pulsation. No substances are applied to the cord stump.

(3) 90 min after birth:

e. Early breastfeeding initiation: Initiating early breastfeeding when baby presents the feeding cues including rooting, tonguing or biting hands. Baby latches on and stays fixed to the nipple, opening mouth widely to attach to mother’s breast and sucking successfully.

(4) 90 min–24 h after birth:

f. An intramuscular administration of 1 mg Vitamin K₁ to prevent neonatal hemorrhagic diseases.
g. Routine eye care with erythromycin to prevent neonatal eye infection.

Out of the core interventions, sustained SSC for \( \geq 90 \) min, early breastfeeding initiation within 60 min after birth, no medicine applied to umbilical cord, routine eye care, and Vitamin K\(_1\) administration were selected as key indicators to assess the general coverage of EENC practices in this study.

### 2.3.2 Intervention group

EENC was introduced to the intervention counties through cascading coaching carried out through certified national and provincial facilitators. The coaching process strictly adhered to WHO *Early Essential Newborn Care Module 2 - Coaching for the First Embrace - Facilitator's Guide*. Subsequently, the trained multidisciplinary team composed of obstetricians, midwives, pediatricians/ neonatologists, nurses, and infection control, quality assessment, and hospital administration staff, implemented EENC-recommended practices following the publicly-published national expert consensus.

The quality assessment of EENC implementation was carried out quarterly by national and provincial facilitators, in order to oversee the execution of EENC and ensure that all trained staffs grasped the skills.

### 2.3.3 Control group

As to the control group, routine newborn health care practices, including immediate mother-newborn separation and umbilical cord clamping, cord wrapping, and application of disinfectant to the cord, were implemented in the control hospitals. Of note, EENC will be introduced to the control group when the study end.

### 2.4 Data collection

#### 2.4.1 Mail survey for health facilities

Mail surveys were conducted in all enrolled 15 health facilities to review the impact of EENC on newborn health indicators before and after implementation. The data collection tool was designed based on WHO *Early Essential Newborn Care Module 1: Annual implementation review and planning guide*. It focused on the information of deliveries and neonatal health outcome indicators in the past 12 months, which were collected from routine monitoring records of the recruited health facilities. The same electronic questionnaires were issued by NHC at both baseline and endline phases, while data submission was overseen and verified by hospital quality control teams. Health outcomes of interest included neonatal diarrhea, umbilical infection, eye infection, and mortality.

#### 2.4.2 Questionnaire survey for mother-newborn pairs

In the post-EENC phase, we conducted the questionnaire survey with postpartum mothers and their newborns before hospital discharge. The questionnaire was designed referring to WHO *Early Essential Newborn Care Module 3 - Introducing and sustaining EECN in hospitals: routine childbirth and newborn...*
care\textsuperscript{19}, and focused on coverage indicators of EENC key practices. Specifically, data on SSC and breastfeeding practices were obtained from face-to-face questionnaire interviews with postpartum mothers, while coverage on practices of umbilical cord and routine eye care, and Vitamin K\textsubscript{1} administration were extracted from neonatal medical records.

Postpartum mothers and their newborns were selected based on the following criteria: 1) Postpartum mothers agreed to participate this study with written informed consent; 2) Mothers were vaginally delivered at least 2 hours prior to questionnaire interviews; 3) Mothers were in good conditions, not having a stillbirth or newborn death. Postpartum mothers who were multiparous were excluded to avoid the duplication of data collection. The sample size of mother-newborn pairs was calculated using the following formula:

$$n = \left[ \frac{Z_{1-\alpha/2}^2 P(1-P) + Z_{\beta}^2 P(1-P) + P(1-P)}{(P_1 - P_2)^2} \right]^2$$

Early breastfeeding initiation rate was selected as the core indicator to estimate the sample size, where $P_1$ is early breastfeeding initiation (within 1 hour after birth) rate before EENC implementation, and $P_2$ is early breastfeeding initiation rate after EENC implementation, and $P$ is $\frac{P_1 + P_2}{2}$, and $Z_{1-\alpha/2}/Z_{\beta}$ is standard normal deviance at the significance level of $\alpha/1-\beta$.

We assumed $P_1$ at baseline of 40\% based on previous literatures\textsuperscript{21}. EENC implementation was expected to increase $P_1$ by 20\% and thus $P_2$ was estimated as 60\%. A minimum sample of 148 ($\alpha=0.05$; $\beta=0.10$) mother-child pairs per group was therefore calculated with allowance for 15\% invalid samples. The theoretical sample size of mother-newborn pairs was 1184 (group\*stratified province=148*2*4).

Considering that the recruited hospitals from the geographically dispersed and health resources-limited western counties, commonly had low delivery volume annually, we enrolled all mother-newborn pairs fulfilling the enrollment criteria during the investigation, with the aim to ensure enough sample size. Informed written consents were obtained from all postpartum mothers.

\textbf{2.4.3 Qualitative survey with interested stakeholders}

During the endline investigation, we conducted semi-structured focus group discussions with policymakers and health staff, and individual in-depth interviews with postpartum mothers in each group of the 8 counties, as they represented different roles of stakeholders regarding the EENC intervention. National policies, WHO EENC modules, and relevant literature were reviewed to develop synthesis of interviews. The qualitative survey focused on the knowledge of EENC, fidelity to the EENC-recommended practices, and target populations’ satisfaction of EENC implementation.
We used purposive sampling to recruit participants and the sample size was determined as per data saturation. All interviews were conducted in quiet and private rooms, to enable stakeholders to provide subjective assessments of EENC implementation according to their experiences. Every focus group discussion and in-depth interview lasted for approximately 90 min and 30 min, respectively. All participants involved in interviews provided written informed consents.

2.5 Outcomes of interest

The effectiveness of EENC implementation was evaluated by the quantification of differences in core practices coverage and neonatal health outcome indicators between intervention and control groups, and perceived usefulness obtained from interested stakeholders. Detailed qualitative findings regarding potential barriers that affect EENC implementation, effects and contextual factors of EENC coaching, and experiences of postpartum mothers will be published separately.

2.6 Data Analysis

As our study was conducted in four provinces, stratification by province was performed to control the potential regional variation. We did descriptive analyses of demographic characteristics of postpartum mothers and babies with frequency (proportion) and mean ± standard deviation (SD). Cochran-Mantel-Haenszel (CMH) test/Fisher exact probability method for categorical variables and t-test for quantitative data, with the confounding factor being controlled for, were carried out to test the significance of differences between intervention and control groups. We used 95% confidence intervals (CI) to estimate the uncertainty in differences of EENC practices coverage between the two groups. Participants with missing data for key variables were removed. Data were put into EpiData 3.1 with double-entry method, and SAS 9.4 (SAS Institute Inc., Cary, NC, USA) was used to conduct statistic analyses. The significance level of $\alpha$ was 0.05.

All interviews were audio-taped and the recordings were transcribed into textual materials. Thematic framework approach was used to analyse qualitative data. Perspectives of multiple stakeholders (ie, policymakers, health staff, and postpartum mothers) on each thematic category were generalized and presented for mutual authentication. The four stages of data analysis were: (1) familiarization of transcripts; (2) identification of a thematic framework; (3) data coding; (4) interpretation of main findings. QSR Nvivo 12.0 was used for data generalization and numerical coding.

3 Results

3.1 Demographic characteristics of mother-newborn pairs

We enrolled a total of 1298 mother-newborn pairs from 8 counties in the four provinces, with 599 pairs in the intervention group and 699 pairs in the control group. Pregnant women in the intervention group had an average age of 26.11±5.44 years, and 383 (63.94%) had an education level of junior high school or lower; postpartum mothers in the control group were aged 26.33±5.18 years and 423 (60.52%) were with
junior high school or lower education. Newborns enrolled in the intervention and control groups had mean birth lengths of 49.59±1.76 cm and 50.33±1.71 cm, with 570 (95.16%) and 653 (93.42%) being weighted 2500~4000g, respectively. Demographic characteristics of recruited mother-newborn pairs were shown in Table 1.

3.2 Coverage of EENC core interventions

Before EENC introduction, except that Vitamin K$_1$ administration had been implemented in part of the enrolled health facilities, other key clinical practices were not performed in both intervention and control groups. All practices except for KMC, were implemented in intervention counties after EENC implementation. SSC and routine eye care were partly implemented in control groups (Figure 1).

With the confounding variable of province being controlled for, compared with the control group, significant improvements were noted in the intervention group for proportions of neonates receiving all EENC core practices at endline ($P<0.05$). The disparities in practice coverage between the two groups were homogeneous in four provinces. Intervention groups in four provinces had higher coverage of immediate SSC (within 1 min), prolonged SSC for at least 90 min, early breastfeeding initiation (within 60 min), and exclusive breastfeeding rate before discharge, particularly for Guizhou Province (92.62%, 90.60%, 97.98%, and 95.30%, respectively). No applied medicine to the umbilical cord, routine eye care, and intramuscular injection of vitamin K$_1$ were common (>90%) in intervention groups (except for routine eye care in Ningxia Hui Autonomous Region) (Table 2).

More babies in the intervention group versus control group received five EENC practices post intervention, with the difference in coverage between the two groups being 67.45% (95% CI: 63.69%–71.20%). The differences in proportion of newborns receiving all five practices between two groups in Guizhou, Qinghai, Sichuan, and Ningxia were 85.33% (79.67%–90.99%), 72.99% (65.56%–80.43%), 74.34% (67.40%–81.29%), and 39.38% (31.80%–46.95%), respectively (Figure 2).

The differences in coverage of EENC practices between the two groups in detail were shown in supplementary Figures 1~11, and supplementary Table 2.

3.3 Neonatal health outcomes

Based on hospital records, a total of 9266 and 11786 live births were delivered in the intervention and control groups in 2016, respectively, while 6909 live births in the intervention group and 9496 in the control group were registered in 2020. After controlling for the confounding factor of province, statistically significant differences in the neonatal diarrhea (0.07% vs. 0.22%) and eye infection (0.04% vs. 0.29%) incidences between intervention and control groups were observed in the post-EENC phase. The study was not powered to detect differences in neonatal mortality between the two groups (Table 3).

3.4 EENC Satisfaction of interested parties
183 participants recruited from 8 counties were interviewed, consisting of 52 (25 in the intervention group and 27 in the control group) policymakers, 94 (45 and 49) health staff, and 37 (15 and 22) postpartum mothers. The sample size of interviewees recruited in each group stratified by province was reported in supplementary Table 3.

The theme regarding satisfaction of interested parties were summarized into six sub-themes: recognition, policy, emotion, work support, health outcomes, and sustainability (supplementary Figure 12). Most stakeholders stated that EENC had been widely recognized. The positive health effects of EENC practices promoted the implementation of policies relevant to newborn health care at the county and hospital levels. SSC brought great happiness to mothers and strengthened the bonding with their newborns. Health staff stated that the EENC coaching improved their professional skills, and promoted the normalization and standardization of clinical practices. Notably, some participants perceived EENC implementation was associated with reduced incidence rates of neonatal hypothermia and umbilical cord infection, and neonatal mortality. As EENC brought direct health benefits to health workers, mothers, and neonates, most policymakers clearly expressed their commitment to continue to implement EENC-recommended interventions. Some selected quotations of stakeholders regarding satisfaction were reported in Table 4.

4 Discussion

To the best of our knowledge, this is the first and largest study that investigated the coverage and health effects of EENC practices in western China. According to our present study, the considerably better coverage of EENC key practices including immediate and prolonged SSC, exclusive breastfeeding before discharge, no applied medicine to the umbilical cord, eye care, and Vitamin K₁ administration, was observed in intervention hospitals in the post-EENC phase. Furthermore, we found that compared with the previous investigation¹, the proportions of newborns receiving EENC key practices increased as a whole, which indicated the successful EENC promotion in pilot counties. However, KMC for preterm newborns had not been implemented in intervention hospitals due to limited technical support in western counties. These findings provide important information for optimizing EENC practices further in poverty-stricken areas of western China, and potentially in other high-demand areas of the world.

Our study showed that mother-newborn SSC was associated with increased early initiation breastfeeding rate and first-breastfeeding duration, which were highly consistent with previous studies²³–²⁴. SSC may activate the oxytocinergic system, and the elevated concentration of oxytocin in postpartum mother in turn promotes the lactation and prolonged breastfeeding duration²⁵. In response to “Facilitate immediate and uninterrupted skin-to-skin contact and support mothers to initiate breastfeeding as soon as possible after birth” advocated in WHO Baby-Friendly Hospital Initiative (BFHI)²⁶, SSC should be steadily facilitated to provide optimal breastfeeding supports and high-quality services for mothers and newborns. Additionally, we found SSC brought positive experience to most postpartum mothers, by which mothers’ satisfaction, breastfeeding confidence, and mother-child bonding were strengthened. As WHO indicated,
high-quality health care can activate mothers to adopt pro-health behaviors\textsuperscript{27}. In Viet Nam, some private hospitals regarded EENC as a special service which attracted pregnant women to gain high-quality antenatal and childbirth care\textsuperscript{16}. To optimize the experience of postpartum mothers and improve the quality of health services, efforts should be taken to make SSC available to all mothers and neonates.

The usual practices of clamping the umbilical cord immediately after birth and applying disinfectant to the cord can increase the risk of bacterial infection\textsuperscript{18}. The guideline released by WHO in 2014 indicated that the umbilical cord clamping should be delayed until there is no cord pulsation for improved maternal and infant health outcomes\textsuperscript{28}. A quasi-experimental study in China did find newborns receiving EENC interventions experienced lower umbilical cord infection rate compared to those in control groups (0.3% vs. 0.9\%)\textsuperscript{29}. However, no significant effect was found in our study. Even though the proportion of newborns receiving no applied medicine to the umbilical cord was high in pilot hospitals, the lower umbilical infection rate (0.43\% vs. 0.00\%) was observed merely in pilot hospitals of Sichuan Province. The undetected health effects in other centers may be partly explained by the imperfect quality of hospital-reported data, which supports more stringent quality control measures and routine health management in pilot health facilities.

WHO-recommended routine eye care and vitamin K\textsubscript{1} administration should be applied to prevent neonatal ophthalmia and haemorrhage\textsuperscript{30–31}, and the health benefits have been reported in previous publications\textsuperscript{31–33}. Even though the overall eye infection rate in the intervention group was found lower compared to the counterpart (0.04\% vs. 0.29\%), further studies with longer observation period and more rigorous quality supervision are worthy of conduction to strengthen the evidence base.

The Normalization Process Theory (NPT) provides a theoretical framework to assess the probability of the routine embedding of complex interventions: when practitioners acknowledge the importance and benefits of new interventions, the new routine is expected to be sustainable\textsuperscript{34}. Consistent with NPT, we observed that the positive feedback from postpartum mothers and improved neonatal outcomes convinced health staff of the value of EENC, which in turn motivated them to routinely implement EENC-recommended practices. Our findings contribute to the growing evidence suggesting applying the effective services to primary health facilities.

Nevertheless, previous studies showed lacking national technical guidelines, which caused inconsistencies in childbirth and early newborn care practices across regions\textsuperscript{35}, is anticipated to be an uphill battle for the national scale-up of EENC in China. Moreover, health staff shortage was also perceived a challenge to implement EENC practices in our pilot hospitals, for which reason the sustained SSC might be interrupted when health workers were in pressing work demand\textsuperscript{16,36}. Since regional disparities between western rural counties and urban areas in economically developed provinces in China remain high, the allocations in equipment supply, such as maternity wards, radiant warmers, and neonatal resuscitation equipment to western health facilities should be increased\textsuperscript{37–38}. In our present study, most postpartum mothers were with junior high school or lower education. Current evidence suggests that
education level can be one of the most important socioeconomic factor to gain accessibility of EENC practices. Better access to education may be associated with the increased availability of high-quality health services, while health behaviors of poorly educated mothers were easily affected by their surroundings\textsuperscript{39–40}. Therefore, increased investment in timely and effective propaganda of EENC, such as the provision of accessible health educational materials, should be positioned as a priority for poorly educated pregnant women and their family members in poverty-stricken or geographically distant areas.

Our results can be regarded as valuable references on further promotion of EENC in China and other countries with similar context. Compared with previous studies with pre- and post-intervention design\textsuperscript{10, 12}, the control group was set in our study to better assess the improvement of EENC core intervention coverage and health outcomes. Considering the potential regional variation across four western provinces, we conducted a stratification analysis with the confounding variable of province being controlled for. Moreover, as part of EENC key coverage indicators, were extracted from neonatal medical records, the potential observation bias of Hawthorne effect can be eliminated. Notably, we collected assessments of multiple stakeholders including policymakers, health staff, and postpartum mothers on each thematic category, which provided mutual authentication across different roles. In our study, the quantitative and qualitative results validated and complemented each other, which enhanced the validity of our findings.

This study also has some limitations. Firstly, we collected questionnaire data on postpartum mothers and newborns from county-level hospitals with relatively large delivery volumes, thus the findings might not be generalized to health facilities of other levels and provinces. Secondly, as data on SSC and breastfeeding practices were reported by postpartum mothers, the recall bias may affect the precision of coverage indicators. Thirdly, the efficacy of EENC interventions may be underestimated if obstetrical health staff in control groups attended EENC-relevant technical training during the EENC implementation period. Finally, due to the unavailability of individual cases on health indicators, we could not link reported EENC practices with neonatal health outcomes, and fail to eliminate the non-equivalence of baseline difference in health outcomes between intervention and control groups. The casual association between EENC practices and neonatal health impacts was worthy of further exploration.

5 Conclusion

EEEC practices are feasible and have been successfully introduced to intervention hospitals of western China. EENC core interventions (except for KMC) are routinely implemented in pilot health facilities, and the implementation is associated with reduced incidence rates of neonatal diarrhea and eye infection. The perceived usefulness gained from multiple stakeholders manifested in concept recognition, policy promotion, positive emotional experience, work support etc. The potential obstacles of EENC implementation mean concerted efforts should be made in China to meet the WHO target “at least 80% of facilities providing childbirth services implementing EENC”.

Declarations
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Author’s contributions

The research was designed by TX and XBT. The data analysis and draft of the manuscript were completed by CRW. The on-site data were collected by CRW, YL, HXYZ, and GY. The data supervision and quality control were done by TX, YL, XBT, and CRW. TX, XNH, and XBT helped with the draft revision. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Availability of data and materials

The datasets supporting the conclusions of this article are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethics approval of this study was received from the Institutional Review Boards of National Center for Women and Children Health, Chinese Center for Disease Control and Prevention (FY2019-09). All participants involved in this study provided written informed consents. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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**Tables**

Due to technical limitations, tables 1,2,3 and 4 are available as a download in the Supplemental Files section.

**Figures**

**Figure 1**

Clinical practices of EENC core interventions A. Clinical practices of EENC core interventions from baseline survey B. Clinical practices of EENC core interventions from endline survey

**Figure 2**

Difference in general coverage of EENC core interventions between intervention and control groups according to endline survey

**Supplementary Files**

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- Supplementarymaterial.docx
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