Effectiveness of early essential newborn care implementation in four counties of western China

Chenran Wang1, Yun Lin1, Hanxiyue Zhang2, Ge Yang2,3, Kun Tang2, Xiaobo Tian4, Xiaona Huang4 and Tao Xu1*

Abstract
Background: Neonatal survival is a public health concern globally. However, the regional disparity in neonatal mortality between rural counties of western China and urban areas of eastern provinces remains high. Early essential newborn care (EENC), recommended by World Health Organization, refers to a set 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 counties of western China.

Methods: Pre- and post-intervention investigations were conducted in four selected EENC intervention counties and four control counties of four western provinces of China, from June to August 2017 and from 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 via a post-intervention face-to-face questionnaire survey with postpartum mothers before hospital discharge. Hospital-reported data on neonatal health indicators were obtained through mail surveys in both investigations. We also performed semi-structured interviews with policymakers, health staff and postpartum mothers to understand their perceptions about the usefulness of EENC implementation.

Results: Overall, 599 mother-newborn pairs in the intervention group and 699 pairs in the control group participated in the post-intervention survey. Controlling for the confounding factor of province, the proportion of newborns receiving EENC interventions was higher in the intervention group than in the control group (P < 0.05). Intervention groups in four provinces had higher coverage of: any skin-to-skin contact (99.50% vs. 49.07%); early breastfeeding initiation (within 60 min of birth) (90.84% vs. 80.35%); no medicine applied 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%). EENC implementation was associated with decreased risk of neonatal diarrhea (OR: 0.326, 95% CI: 0.123, 0.865) and eye infection (OR: 0.147, 95% CI: 0.045, 0.483). Policymakers, health staff and postpartum mothers expressed satisfaction with the EENC interventions, noting a willingness among staff and policymakers to implement and sustain these interventions; the promotion of these interventions within hospital policy; the positive emotions experienced by postpartum mothers; perceived improvements in health; and improvements in support for health workers.

© The Author(s) 2022. Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated in a credit line to the data.
Conclusion: EENC-recommended core practices (except kangaroo mother care) have been successfully introduced in pilot hospitals. The efficacy of EENC implementation should be highly recognized to accelerate the progress towards its national roll out.

Keywords: Early essential newborn care, Clinical practice, Western China

Introduction
Neonatal health care is critical to child short- and long-term survival and development; ensuring a healthy start for all newborns will accelerate progress towards the Sustainable Development Goal (SDG) target of “ending preventable deaths of newborns by 2030” [1, 2]. While significant progress has been made in addressing child survival, neonatal death remains a serious concern globally, accounting for approximately 48% of all deaths among children under 5 years of age. More than two-thirds of neonatal deaths occur in the first three days after birth, especially in first 24 h after birth [3, 4]. China has reduced the rate of neonatal mortality from 33.1‰ in 1991 to 3.4‰ in 2020, however, newborn death is still the leading contributor to under-5 mortality [5]. Furthermore, the regional disparity in neonatal mortality between rural counties of western China and urban areas of eastern provinces remains high. The national report of China Maternal and Child Health Surveillance in 2020 showed that the neonatal mortality rates in western (4.8‰) and rural (3.9‰) regions were notably higher in comparison to eastern (1.8‰) and urban (2.1‰) areas [5]. The regional discrepancy in the burden of newborn deaths can be partly explained by the coverage inequality of high-quality newborn interventions across regions [6, 7]. Therefore, adopting effective interventions to address these discrepancies should be a high national priority.

Early Essential Newborn Care (EENC) is a package of evidence-based interventions for mothers and newborns delivered around birth. It was recommended by World Health Organization (WHO) Action Plan for Healthy Newborn Infants in the Western Pacific Region (2014–2020) to reduce preventable newborn deaths [8]. EENC emphasizes the minimization of unnecessary practices, such as routine suctioning and early physical examination for newborns, while promoting core cost-effective practices, including: immediate and uninterrupted mother-baby skin-to-skin contact (SSC) for at least 90 min, delayed umbilical cord clamping, early breastfeeding initiation, and kangaroo mother care for premature infants [9, 10]. All priority countries in the Western Pacific Region have continued to scale up EENC and the applicability of EENC has been substantiated in other countries [11]. To sustain these advancements, additional efforts are needed to integrate EENC into routine clinical practice.

With the aim of achieving equitable and high-quality coverage of health care for all newborns, the National Health Commission of China and the United Nations Children’s Fund (UNICEF) jointly launched the three-year Safe Neonatal Project in western China. From September 2017 to December 2020, the project was implemented in 18 counties of four western provinces with the highest burden of neonatal and under-5 deaths, including Qinghai, Sichuan, Guizhou, and Ningxia Hui Autonomous Region [7], setting out a vision of a nation where every newborn reaches his or her full potential. The purpose of the Safe Neonatal Project is to scale up EENC interventions in pilot counties; it aims to ensure that mothers and newborns in pilot areas increasingly benefit from equitable policies, guidelines, and quality, high-impact EENC practices for survival and development.

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 for improving neonatal health outcomes in western China [12, 13]. However, previous studies on EENC implementation were restricted to pre- and post-intervention design within groups [13, 14]; used only cross-sectional observational investigation of service capacity [15]; employed a narrow research scope with small sample size [16, 17]; and conducted limited qualitative research that lacked the perspectives of multiple stakeholders [18, 19]. Moreover, most studies lacked controls and a multi-centre design [13, 14, 16]. Our large sample, multi-centre study, is an attempt to address the above noted gaps in research to date. Based on data obtained from the Safe Neonatal Project, we aim to comprehensively explore the positive impacts of EENC implementation. Our findings will provide empirical references on the clinical practice of EENC to China and other countries with similar demands, with the goal of informing health authorities how tailored EENC promotion strategies can enhance neonatal health and well-being.

Methods
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 from
December 2020 to April 2021, respectively. We conducted mixed quantitative and qualitative analyses to assess the positive impacts of EENC implementation.

**Study settings**

Out of the 18 Safe Neonatal Project counties, one 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, one to two county-level hospitals providing midwifery services with over 1000 live births annually were selected as sample health facilities. A total of 15 health facilities were enrolled in this study, with seven in the intervention group and eight 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 [20, 21].

**EENC implementation**

**EENC practices**

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

1. Within 1 min after birth:
   a. Neonatal resuscitation for newborns if without spontaneous breathing.
   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.

2. Within 1–3 min of birth:
   iii. Delayed umbilical cord clamping and proper care: Umbilical cord clamping is delayed until there is no umbilical pulsation. No sterilization medicines are applied to the cord stump.

3. Within 90 min of birth:
   iv. Early breastfeeding initiation: Initiating early breastfeeding when baby presents 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.
   v. Kangaroo mother care for premature and low birthweight infants: Preterm newborns with gestational age ≤ 34 weeks or low birthweight newborns with birth weight ≤ 2000 g is placed in continuous SSC between his/her mother, father or other family members.

4. 90 min to 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 ≥ 90 min, early breastfeeding initiation within 60 min after birth, no medicine applied to umbilical cord, routine eye care, and vitamin K₁ administration were selected as key indicators to assess the general coverage of EENC practices in this study. Before EENC introduction in pilot counties, vitamin K₁ administration had already been implemented in some of the enrolled health facilities.

**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* [22]. Subsequently, the trained multidisciplinary team that was composed of obstetricians, midwives, pediatricians/ Neonatologists, nurses, and hospital administration (including infection control and quality assessment) staff implemented EENC-recommended practices following the publicly-published national expert consensus [23, 24].

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 staff grasped the skills. Self-assessments of routine newborn care practices were recorded periodically by quality control teams of health facilities, and the assessment tools were formulated based on WHO *Early Essential Newborn Care Module 3—Introducing and sustaining EENC in hospitals: routine childbirth and newborn care* [23].

**Control group**

Non-recommended 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 ends.
Sample size estimation

**Postpartum mother-newborn pairs**

In the post-EENC phase, we conducted the question-naire survey with postpartum mothers and their newborns before hospital discharge. 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 delivered vaginally at least two hours prior to questionnaire interviews; 3) mothers had not experienced a stillbirth or newborn death. Postpartum mothers who were multiparous were excluded to avoid duplication in data collection. The sample size of mother-newborn pairs was calculated using the following formula:

\[
\begin{align*}
 n &= \left[ \frac{Z_{1-\alpha/2}^2 \sqrt{2P(1-P) + Z_{\beta}^2 (P_1(1-P_1) + P_2(1-P_2))}}{(P_1 - P_2)^2} \right]^2
\end{align*}
\]

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

We assumed \(P\) at baseline of 40% based on previous literature [25]. 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 minimum 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 resource-limited western counties tended to have a low delivery volume annually, we enrolled all mother-newborn pairs fulfilling the enrollment criteria during the investigation, with the aim of ensuring an adequate sample size.

**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 eight counties, as they represented different roles of stakeholders regarding the EENC intervention. National policies, WHO EENC modules, and relevant literature were reviewed to help synthesize interviews. We performed purposive sampling to recruit participants and the sample size was determined as per data saturation.

Data collection

**Mail survey for health facilities**

Mail surveys were conducted in all 15 enrolled health facilities to review the impact of EENC on newborn health indicators before and after implementation. The mail survey questionnaire was designed based on WHO *Early Essential Newborn Care Module 1 - Annual implementation review and planning guide*. It collected neonatal health indicators in the past 12 months, which were recorded by directors of obstetrics or neonatology/pediatrics based on routine monitoring records of the recruited health facilities. The same electronic questionnaires were issued by the National Health Commission of China at both baseline and endline phases, while data submission was overseen and verified by hospital quality control teams. Health indicators of interest included neonatal diarrhea, umbilical infection, eye infection, and mortality during the neonatal period (0 ~ 28 days).

**Questionnaire survey for mother-newborn pairs**

The questionnaire for postpartum mothers and newborns was designed in reference to the WHO *Early Essential Newborn Care Module 3* [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 K1 administration were extracted from neonatal medical records. The contents of questionnaire survey were documented by midwives, obstetric nurses and doctors.

**Qualitative survey with interested stakeholders**

The qualitative survey focused on the knowledge of EENC, adherence to the EENC-recommended practices, and target populations’ satisfaction of EENC implementation. 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 consent.

**Neonatal health indicators of interest**

The effectiveness of EENC implementation was evaluated by the quantification of differences in core practices coverage and neonatal health indicators (neonatal diarrhea, umbilical infection, eye infection, and mortality during the neonatal period) between intervention and control
groups, and perceived usefulness of the interventions obtained from interested stakeholders.

Data analysis
Data obtained from mail surveys and questionnaire surveys were in institutional and individual level forms, respectively. 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. Unconditional logistic model was used to examine the association between EENC implementation and neonatal health indicators. 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 statistical analyses. The significance level of α was 0.05.

All interviews were audio-taped and the recordings were transcribed into textual materials. The thematic framework approach was used to analyse qualitative data. Perspectives of multiple stakeholders (i.e., 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 with transcripts; (2) identification of a thematic framework; (3) data coding; and (4) interpretation of main findings. QSR Nvivo 12.0 was used for data generalization and numerical coding.

Results
Demographic characteristics of mother-newborn pairs
A total of 1373 questionnaires of mother-newborn pairs were collected in the endline survey, of which 75 were invalid due to inappropriate subjects, and excessive missing items or logic errors. Finally, we enrolled 1298 mother-newborn pairs from eight counties in the four provinces, with 599 pairs in the intervention group and 699 pairs in the control group. With the confounding factor of province being controlled for, no statistically significant differences were found in the distribution of maternal age and neonatal birthweight (P > 0.05). Pregnant women in the intervention group had an average age of 26.11 ± 5.44 years, and 383 (63.94%) had an educational attainment of junior high school or lower; postpartum mothers in the control group were aged 26.33 ± 5.18 years and 423 (60.52%) had junior high school level education or lower. 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%) weighing 2500 ~ 4000 g, respectively. Demographic characteristics of recruited mother-newborn pairs were shown in Table 1.

Coverage of EENC core interventions
Before the introduction of EENC, other key clinical practices were not performed in both intervention and control groups (with the exception of vitamin K₁ administration, which had been implemented in some of the enrolled health facilities). All practices, except for kangaroo mother care, were implemented in intervention counties after EENC implementation. SSC and routine eye care were partly implemented in control groups (Fig. 1).

With the confounding variable of province being controlled for, compared with the control group, significant improvements in proportions of neonates receiving all selected EENC core practices were noted in the intervention group at end line (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) (85.07% vs. 21.87%); prolonged SSC for at least 90 min (78.02% vs. 0.58%); early breastfeeding initiation (within 60 min) (90.84% vs. 80.35%); and exclusive breastfeeding before discharge (92.57% vs. 63.80%). Coverage was particularly high in Guizhou Province: 92.62% for immediate SSC; 90.60% for prolonged SSC; 97.98% for early breastfeeding initiation; and 95.30% for exclusive breastfeeding. In the intervention groups, no applied medicine to the umbilical cord (98.50% vs. 9.73%), routine eye care (93.16% vs. 8.73%), and intramuscular injection of vitamin K₁ (98.33% vs. 88.98%) were common (> 90%), 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%). Differences in the 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 (Fig. 2).

The differences in coverage of EENC practices between the two groups in detail were shown in supplementary Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and supplementary Table 2.
Table 1  Demographic characteristics of postpartum mothers and newborns according to endline survey (N=1298)

|                          | Total (N=1298) | Guizhou Province (n = 421) | Qinghai Province (n = 280) |
|--------------------------|----------------|-----------------------------|-----------------------------|
|                          | Intervention  (n = 599) | Control (n = 699) | Intervention  (n = 150) | Control (n = 271) | t/χ² | P | Intervention  (n = 137) | Control (n = 143) | t/χ² | P |
| Maternal                 |                |                            |                            |                    |                  |    |                        |                        |                  |    |
| Age (x±SD)               | 26.11±5.44     | 26.33±5.18                 | 0.766*                     | 0.444              | 24.16±6.10       | 25.73±5.84     | 2.596 | 0.010                   | 26.37±5.12       | 26.14±5.20     | 0.005 |
| Education level          |                |                            | 14.096*                    | 0.003              | 37 (24.67)        | 33 (12.18)     | 13.028 | 0.005                   | 77 (56.20)       | 85 (59.44)     |        |
| Primary school or below  |                |                            |                            |                    | 85 (56.67)        | 164 (60.52)     | 22 (16.06) | 21 (14.69)              | 10 (7.30)        | 20 (13.99)     |        |
| Junior high school       |                |                            |                            |                    | 18 (12.00)        | 40 (14.76)      | 10 (7.30) | 20 (13.99)              | 10 (7.30)        | 20 (13.99)     |        |
| Senior high school       |                |                            |                            |                    | 10 (6.67)         | 34 (12.55)      | 28 (20.44) | 17 (11.89)              | 28 (20.44)       | 17 (11.89)     |        |
| College or higher        |                |                            |                            |                    | 298 (49.75)       | 284 (40.63)     | 42.334 | <0.001                  | 136 (99.27)      | 128 (89.51)    |        |
| Nationality              |                |                            |                            |                    | 90 (60.00)        | 75 (27.68)      | 4.339  | 0.038                   | 1 (0.73)         | 15 (10.49)     |        |
| Minorities               |                |                            |                            |                    | 60 (40.00)        | 196 (72.32)     | 0.537  | 0.954                   | 61 (44.53)       | 48 (33.57)     |        |
| Han nationality          |                |                            |                            |                    | 39 (26.00)        | 73 (26.94)      | 1 (0.73) | 15 (10.49)              | 42 (30.66)       | 60 (41.96)     |        |
| Parity                   |                |                            |                            |                    | 194 (32.39)       | 265 (37.91)     | 6 (4.20) | 25 (17.68)              | 33 (23.47)       | 50 (35.38)     |        |
| First birth              |                |                            |                            |                    | 216 (36.06)       | 228 (32.62)     | 34 (24.82) | 35 (24.82)              | 34 (24.82)       | 35 (24.82)     |        |
| Second birth             |                |                            |                            |                    | 228 (32.62)       | 273 (39.47)     | 42 (30.66) | 60 (41.96)              | 42 (30.66)       | 60 (41.96)     |        |
| Third birth or above     |                |                            |                            |                    | 189 (31.55)       | 206 (29.47)     | 7 (5.45)  | 10 (7.26)               | 7 (5.45)         | 10 (7.26)      |        |
| Infants                  |                |                            |                            |                    | 69 (46.00)        | 115 (42.44)     | 34 (24.82) | 35 (24.82)              | 34 (24.82)       | 35 (24.82)     |        |
| Birthweight (g)          |                |                            |                            |                    | 26 (17.17)        | 50 (38.76)      | 1 (0.73)  | 25 (17.68)              | 5 (3.65)         | 25 (17.68)     |        |
| < 2500                   |                |                            |                            |                    | 570 (95.42)       | 653 (93.42)     | 5 (3.65)  | 4 (2.80)                | 5 (3.65)         | 4 (2.80)       |        |
| 2500 – 4000              |                |                            |                            |                    | 16 (2.67)         | 20 (2.86)       | 2 (1.33)  | 9 (6.32)                | 2 (1.33)         | 9 (6.32)       |        |
| > 4000                   |                |                            |                            |                    | 49.59±1.76        | 50.33±1.71      | 7.699   | <0.001                  | 50.41±1.90       | 50.01±0.69     | 3.086  |
| Birth length (cm)        |                |                            |                            |                    | 49.59±1.76        | 50.33±1.71      | 7.699   | <0.001                  | 50.41±1.90       | 50.01±0.69     | 3.086  |
| Gestational age          |                |                            |                            |                    | 6.443*            | 0.011           | 5.689   | 0.017                   | 6.443*           | 0.011          |        |
| Full-term birth          |                |                            |                            |                    | 589 (98.33)       | 670 (95.85)     | 143 (97.80) | 140 (97.90)             | 133 (97.08)      | 140 (97.90)    |        |
| Premature/low birth weight |            |                            |                            |                    | 10 (1.67)         | 29 (4.15)       | 1 (0.67)  | 14 (5.17)               | 4 (2.92)         | 3 (2.10)       |        |

* indicates p<0.05; ** indicates p<0.01
### Table 1 (continued)

|                                | Qinghai Province (n = 280) | Sichuan Province (n = 282) | Ningsia Hui Autonomous Region (n = 315) |
|--------------------------------|-----------------------------|-----------------------------|-----------------------------------------|
|                                | t/\chi^2        | P               | Intervention  | t/\chi^2        | P               | Intervention  | Control (n = 155) | t/\chi^2        | P               | Intervention  | Control (n = 155) | t/\chi^2        | P               |
| Maternal                       |                |                 | (n = 152)       |                |                 | (n = 160)       |                |                 |                 |                | (n = 155)       |                |                 |
| Age (x±SD)                     | -0.377         | 0.707           | 26.57±4.40     | 0.202          | 0.840           | 27.37±5.51     | 0.021          | 0.984*          | 7.939          | 0.047           |
| Education level                | 6.315          | 0.007           | 50(3.29)       | 0.002*         | 50(31.25)       | 29(18.71)      |                |                 |                |                |                |                 |
| Primary school or below        |                |                 | 2(1.54)        |                |                | 49(30.63)       | 64(41.29)      |                |                |                |                |                 |
| Junior high school             |                |                 | 25(19.23)      |                |                | 49(30.63)       | 64(41.29)      |                |                |                |                |                 |
| Senior high school             |                |                 | 67(51.54)      |                |                | 23(14.38)       | 27(17.42)      |                |                |                |                |                 |
| College or higher              |                |                 | 36(27.69)      |                |                | 38(23.75)       | 35(22.58)      |                |                |                |                |                 |
| Nationality                    | 12.370         | <0.001          |                | 0.461*         |                | 1.379          | 0.240          |                |                |                |                |                 |
| Minorities                     | 0.000          |                 | 1(0.77)        |                |                | 72(45.00)       | 80(51.61)      |                |                |                |                |                 |
| Han nationality                | 15210.000      | 0.993           | 129(99.23)     |                |                | 88(55.00)       | 75(48.39)      |                |                |                |                |                 |
| Parity                         | 4.615          | 0.000           | 19.408         | <0.001         |                |                |                |                |                |                |                |                 |
| First birth                    | 61(40.13)      |                 | 61(46.92)      |                |                | 55(34.38)       | 46(29.68)      |                |                |                |                |                 |
| Second birth                   | 54(35.53)      |                 | 62(47.69)      |                |                | 56(35.00)       | 60(38.71)      |                |                |                |                |                 |
| Third birth or above           | 37(24.34)      |                 | 7(5.38)        |                |                | 49(30.63)       | 49(31.61)      |                |                |                |                |                 |
| Infants                        |                |                 |                |                |                |                |                |                |                |                |                |                 |
| Birthweight (g)                | 50(3.85)       |                 | 50.14±1.48     | 50.14±1.48     | 49.85±0.91      | 49.85±0.91     | 49.65±1.98     | 49.97±1.32     | 6986           | 0.001*          |                |                 |
| < 2500                         | 3(1.97)        |                 | 143(94.08)     | 143(94.62)     | 155(96.88)      | 145(93.55)     |                |                |                |                |                |                 |
| 2500 ~ 4000                    | 143(94.08)     |                 | 123(94.62)     | 123(94.62)     | 155(96.88)      | 145(93.55)     |                |                |                |                |                |                 |
| > 4000                         | 6(3.95)        |                 | 2(1.54)        | 2(1.54)        | 3(1.88)         | 5(3.23)        |                |                |                |                |                |                 |
| Birth length (cm)              | 5.635          | <0.001*         | 0.003†         | 0.0954         | 2.553†          | 0.110          | 5086†          | 0.444          | 150(98.68)     | 123(94.62)     | 157(98.13)     | 150(96.77)     |
| (x±SD)                         | 0.003†         | 0.0954          | 2.553†         | 0.110          |                |                |                |                |                |                |                |                 |
| Gestational age                | 0.003†         |                 | 150 (98.68)    | 123(94.62)     | 157(98.13)      | 150(96.77)     |                |                |                |                |                |                 |
| Full-term birth                |                |                 |                |                |                |                |                |                |                |                |                |                 |

* Fisher exact probability
** Satterthwaite t’ test (heterogeneous variance)
† Cochran-Mantel–Haenszel (CMH) with controlled variable as province
Neonatal health indicators

The univariate logistic regression model showed that EENC implementation was associated with decreased risk of neonatal diarrhea (OR: 0.327, 95% CI: 0.123, 0.867) and eye infection (OR: 0.147, 95% CI: 0.045, 0.483). After controlling for the confounding factor of province, similar results were found in association between EENC and decreased risk of neonatal diarrhea (OR: 0.326, 95% CI: 0.123, 0.865) and eye infection (OR: 0.147, 95% CI: 0.045, 0.483). The result was not powered enough to detect the potential association between EENC implementation and neonatal mortality and umbilical infection (Table 3).

EENC satisfaction of stakeholders

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

The satisfaction level of interested parties was summarized into six sub-themes: recognition, policy, emotion, work support, health outcomes, and sustainability (see supplementary Fig. 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 helped them bond 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 believed that EENC implementation was associated with reduced incidence risk of neonatal hypothermia, umbilical cord infection and neonatal mortality. Because EENC brought direct health benefits to health workers, mothers, and neonates, most policymakers clearly expressed their commitment to continue to implement EENC-recommended interventions. Selected quotes from stakeholders regarding satisfaction with EENC interventions are reported in Table 4.

Discussion

To the best of our knowledge, this is the first and largest study to investigate the coverage and health effects of EENC practices in western China. According to our present study, a considerably higher coverage of EENC key practices, including immediate and prolonged SSC, early breastfeeding initiation, no medicine applied 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 our interim evaluation in the same provinces [13], the proportions of newborns receiving EENC key practices...
Table 2  Coverage of EENC core interventions in four provinces according to endline survey (N = 1298)

|                        | Total (N = 1298) | Guizhou Province (n = 421) | Qinghai Province (n = 280) |
|------------------------|------------------|-----------------------------|----------------------------|
|                        | Intervention     | Control         | t/χ²   | P       | Intervention | Control         | t/χ²   | P       |
| **SSC**                |                  |                 |       |         |             |                 |       |         |
|                        | (n = 599)        | (n = 699)       |       |         | (n = 150)   | (n = 271)       |       |         |
| Any SSC                | 596 (99.50)      | 343 (49.07)     | 463.344* | < 0.001 | 149 (99.33) | 12 (4.43)       | 368.234 | < 0.001 |
| Time of SSC initiation |                  |                 | 331.742* | < 0.001 | —           | —               | < 0.001* |         |
| post birth (min)       |                  |                 |       |         |             |                 |       |         |
| < 1                    | 507 (85.07)      | 75 (21.87)      | 311.742* | < 0.001 | 138 (92.62) | 0 (0.00)       | —       | < 0.001* |
| 1 ~ 10                 | 89 (14.93)       | 211 (61.52)     | —       | < 0.001 | 11 (7.38)   | 5 (41.67)      | 49 (35.77) | 0 (0.00) |
| 11 ~ 59                | 0 (0.00)         | 36 (10.50)      | —       | < 0.001 | 0 (0.00)   | 5 (41.67)      | 0 (0.00) | 1 (1.64) |
| ≥ 60                   | 0 (0.00)         | 21 (6.12)       | —       | < 0.001 | 0 (0.00)   | 2 (16.67)      | 0 (0.00) | 0 (0.00) |
| **SSC duration (min)** |                  |                 | 535.143* | < 0.001 | —           | < 0.001*       |         |         |
| < 10                   | 15 (2.52)        | 136 (39.65)     | —       | < 0.001 | 2 (1.34)   | 7 (58.33)      | 3 (2.19) | 24 (39.34) |
| 10 ~ 30                | 51 (8.56)        | 132 (38.48)     | —       | < 0.001 | 0 (0.00)   | 2 (16.67)      | 23 (16.79) | 29 (47.54) |
| 30 ~ 60                | 40 (6.71)        | 70 (20.41)      | —       | < 0.001 | 9 (6.04)   | 3 (25.00)      | 2 (1.46) | 7 (11.48) |
| 60 ~ 90                | 25 (4.19)        | 3 (0.87)        | —       | < 0.001 | 3 (2.01)   | 0 (0.00)       | 1 (0.73) | 0 (0.00) |
| ≥ 90                   | 465 (78.02)      | 2 (0.58)        | —       | < 0.001 | 135 (90.60) | 0 (0.00)     | 108 (78.83) | 1 (1.64) |
| **Breastfeeding**       |                  |                 | 523 (87.75) | 270 (78.72) | 2.381* | 0.123 | 147 (98.66) | 5 (41.67) | — | < 0.001* | 133 (97.08) | 61 (100.00) |
| Successful first-time  |                  |                 |       |         |             |                 |       |         |
| breastfeeding with     |                  |                 |       |         |             |                 |       |         |
| provision of SSC       |                  |                 |       |         |             |                 |       |         |
| Any breastfeeding      | 579 (96.66)      | 641 (91.70)     | 12.823* | < 0.001 | 149 (99.33) | 238 (87.82)    | 17.232 | < 0.001 |
| Initiation (min)       |                  |                 | 25.898* | < 0.001 | 34.615     | < 0.001        |         |         |
| ≤ 60                   | 526 (90.84)      | 515 (80.35)     | —       | < 0.001 | 146 (97.99) | 180 (75.63)    | 134 (99.26) | 105 (75.00) |
| 61 ~ 90                | 32 (5.53)        | 67 (10.45)      | —       | < 0.001 | 0 (0.00)   | 10 (4.20)      | 1 (0.74) | 30 (21.43) |
| > 90                   | 21 (3.63)        | 59 (9.20)       | —       | < 0.001 | 3 (2.01)   | 48 (20.17)     | 0 (0.00) | 5 (3.57) |
| **Duration (min)**     |                  |                 | 47.046* | < 0.001 | 47.243     | < 0.001        |         |         |
| < 10                   | 80 (13.82)       | 62 (9.67)       | —       | < 0.001 | 6 (4.03)   | 27 (11.34)     | 62 (45.93) | 17 (12.14) |
| 10 ~ 30                | 178 (30.74)      | 221 (34.48)     | —       | < 0.001 | 47 (31.54) | 79 (33.19)     | 71 (52.59) | 32 (22.86) |
| 30 ~ 60                | 73 (12.61)       | 172 (26.83)     | —       | < 0.001 | 19 (12.75) | 81 (34.03)     | 0 (0.00) | 55 (39.29) |
| 61 ~ 90                | 248 (42.83)      | 186 (29.02)     | —       | < 0.001 | 77 (51.68) | 51 (21.43)     | 2 (1.48) | 36 (25.71) |
Table 2 (continued)

|                                | Total \((N = 1298)\) | Guizhou Province \((n = 421)\) | Qinghai Province \((n = 280)\) |
|--------------------------------|----------------------|--------------------------------|----------------------|
|                                | Intervention \((n = 599)\) | Control \((n = 699)\) | \(t/\chi^2\) | \(P\) | Intervention \((n = 150)\) | Control \((n = 271)\) | \(t/\chi^2\) | \(P\) | Intervention \((n = 137)\) | Control \((n = 143)\) | \(t/\chi^2\) | \(P\) |
| **Exclusive breastfeeding**     | 536 (2.57)          | 409 (63.80)        | 131.476<sup>9</sup> | < 0.001 | 142 (95.30) | 96 (40.34)  | 116.922 | < 0.001 | 133 (98.52) | 112 (80.00) | 153.012 | < 0.001 |
| **No applied medicine to the umbilical cord** | 590 (98.50) | 68 (9.73) | 1042.438<sup>9</sup> | < 0.001 | 147 (98.00) | 1 (0.37) | 403.733 | < 0.001 | 134 (97.81) | 65 (45.45) | 403.733 | < 0.001 |
| **Routine eye care**           | 558 (93.16) | 61 (8.73) | 965.278<sup>9</sup> | < 0.001 | 150 (100.00) | 0 (0.00) | 421.000 | < 0.001 | 135 (98.54) | 59 (41.26) | 421.000 | < 0.001 |
| **Intramuscular injection of vitamin K<sub>1</sub>** | 589 (98.33) | 62 (8.73) | 71.015<sup>9</sup> | < 0.001 | 149 (99.33) | 2 (0.67) | 1.000 | 1.000 | 137 (97.81) | 142 (99.30) | 1.000 | 1.000 |

**Qinghai Province \((n = 280)\)**

|                                | Sichuan Province \((n = 282)\) | Ningxia Hui Autonomous Region \((n = 315)\) |
|--------------------------------|--------------------------------|--------------------------------|
|                                | Intervention \((n = 152)\) | Control \((n = 130)\) | \(t/\chi^2\) | \(P\) | Intervention \((n = 160)\) | Control \((n = 155)\) | \(t/\chi^2\) | \(P\) |
| **SSC**                        | 111.094 | < 0.001 | 895<sup>3</sup> | 0.003 | 4.208<sup>3</sup> | 0.040 |
| Any SSC                        | 151 (99.34) | 121 (93.08) | 159 (99.38) | 149 (96.13) | 244.389<sup>3</sup> | < 0.001 |
| Time of SSC initiation post birth (min) | — | — | < 0.001* | — | 167.786 | < 0.001 |
| < 1                            | 132 (87.42) | 8 (6.61) | 149 (93.71) | 7 (4.70) |
| 1 – 10                         | 19 (12.58) | 91 (75.21) | 10 (6.29) | 115 (77.18) |
| 11 – 59                        | 0 (0.00) | 17 (14.05) | 0 (0.00) | 13 (8.72) |
| ≥ 60                           | 0 (0.00) | 5 (4.13) | 0 (0.00) | 14 (9.40) |
| **SSC duration (min)**         | 113.372 | < 0.001 | 233.929 | < 0.001 | 167.786 | < 0.001 |
| < 10                           | 2 (1.32) | 44 (36.36) | 8 (5.03) | 61 (40.94) |
| 10 –                           | 2 (1.32) | 25 (20.66) | 26 (16.35) | 76 (51.01) |
| 30 –                           | 4 (2.65) | 50 (41.32) | 25 (15.72) | 10 (6.71) |
| 60 –                           | 16 (10.60) | 1 (0.83) | 5 (3.14) | 2 (1.34) |
| ≥ 90                           | 127 (84.11) | 1 (0.83) | 95 (59.75) | 0 (0.00) |
Table 2 (continued)

|                                | Qinghai Province (n = 280) | Sichuan Province (n = 282) | Ningxia Hui Autonomous Region (n = 315) |
|--------------------------------|-----------------------------|----------------------------|----------------------------------------|
|                                | t/χ²                         | P                          | t/χ²                                   | P                          |
| Success-                       | 0.642 § 0.423               | 148 (98.01)                 | 103 (85.12)                            | 15.664 < 0.001             |
| Any breastfeeding              | 0.000 § 1.000                | 143 (94.08)                 | 119 (91.54)                            | 0.686 0.407                |
| Initiation (min)               | 0.642 § 0.423               | 143 (94.08)                 | 119 (91.54)                            | 0.686 0.407                |
| ≤ 60                           | 35.569 < 0.001 *            | 134 (93.71)                 | 106 (89.08)                            | 112 (73.68) 124 (86.11)   |
| 61–90                          | 3 (2.10)                    | 7 (5.88)                    | 28 (18.42)                             | 20 (13.89)                |
| > 90                           | 6 (4.20)                    | 6 (5.04)                    | 12 (7.89)                              | 0 (0.00)                  |
| Duration (min)                 | 125.772 < 0.001             | —                           | < 0.001                                | 6.432 0.092               |
| < 10                           | 0 (0.00)                    | 9 (7.56)                    | 12 (7.89)                              | 9 (6.25)                  |
| 10–19                          | 10 (6.99)                   | 42 (35.29)                  | 50 (32.89)                             | 68 (47.22)                |
| 20–29                          | 16 (11.19)                  | 6 (5.04)                    | 38 (25.00)                             | 30 (20.83)                |
| 30–39                          | 117 (81.82)                 | 62 (52.10)                  | 52 (34.21)                             | 37 (25.69)                |
| Exclusive breastfeeding        | 24.250 < 0.001              | 127 (88.81)                 | 96 (80.67)                             | 3.396 0.065               |
| No applied                     | 93.283 < 0.001              | 150 (98.68)                 | 2 (1.54)                               | 266.132 < 0.001           |
| medicine to the umbilical      | Routine eye                 | 107.880 < 0.001             | 152 (100.00)                           | 159 (99.38) 311.025 < 0.001 |
| cord                           | Intramuscular injection of  | Intramuscular injection of  | Intramuscular injection of           |
| vitamin K₁                     | vitamin K₁                  | vitamin K₁                  | vitamin K₁                              |
|                                 | 0.000 § 1.000               | 1.000                       | 1.000                                  | 0.000                     |

* : Fisher exact probability
§ : Cochran-Mantel-Haenszel (CMH) with controlled variable of province
# : Corrected chi-squared test
increased (SSC duration ≥ 90 min: 63.1% vs. 78.0%; any breastfeeding: 96.1% vs. 96.7%; vitamin K₁ administration: 79.7% vs. 98.3%; newborn eye care: 58.4% vs. 93.2%), which indicates the successful EENC promotion in pilot counties. However, kangaroo mother care for preterm newborns was not 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 proportions of early initiation breastfeeding and a longer duration of first-breastfeeding – findings that are highly consistent with previous studies [27, 28]. SSC may activate the oxytocinergic system, and the elevated concentration of oxytocin in postpartum mothers in turn promotes lactation and prolonged breastfeeding duration [29]. In response to the WHO recommendation to “facilitate immediate and uninterrupted skin-to-skin contact and support mothers to initiate breastfeeding as soon as possible after birth”, advocated as part of the Baby-Friendly Hospital Initiative [30], SSC should be steadily facilitated to provide optimal breastfeeding support and high-quality services for mothers and newborns. Additionally, we found that SSC was a positive experience for most postpartum mothers’
Table 4 Examples of stakeholder attitudes regarding satisfaction of EENC implementation

| Theme category | Main findings | Quotations |
|----------------|---------------|------------|
| **Satisfaction** |               |            |
| Recognition     | EENC-recommended practices gained wide acceptance of policymakers and health staff | "Positive feedback from the newborn's family members means that EENC is acceptable and applicable." (a policymaker in the intervention group of Sichuan Province) |
|                 |               | "We are highly willing to implement EENC practices. After the EENC implementation, we are delighted to observe the health benefits, and our traditional conceptions have changed. Particularly, SSC, umbilical cord care, as well as eye care, bring benefits not merely to us, but also to mothers and newborns." (a health staff in the intervention group of Sichuan Province) |
| Policy          | The positive effects of EENC implementation promoted the establishment of principles on neonatal health at both county and hospital levels | "We issued some health policies to promote EENC. For example, the ‘Safe Neonatal Project’ has been listed to our 13th Five-Year Plan. In the next five years, we will continuously incorporate this project into the 14th Five-Year Plan, as the focus of newborn health improvement." (a policymaker in the intervention group of Guizhou Province) |
| Emotion         | EENC practices, particularly SSC, improved mothers' happiness | "One mother said: it is really such a great feeling! I am so happy!" (a health staff in the intervention group of Sichuan Province) |
|                 | SSC strengthened parent–child bonding | "My baby was put on my breast immediately after birth, and there was a good sense of intimate attachment between by little baby and me. I felt so excited and happy. (Interviewer: Is this feeling different from your previous two babies? Mother: I feel more intimate with this one)." (a postpartum mother receiving SSC in the control group of Qinghai Province) |
| Health outcomes | EENC implementation was perceived to be associated with reduced incidence risk of neonatal hypothermia and umbilical cord infection, and neonatal mortality | "Before EENC introduction, newborns were separated from their mothers after delivery, and the incidence risk of hypothermia was quite high. However, hypothermia incidents have decreased considerably since EENC practices were implemented among pregnant women who delivered vaginally in 2018." (a health staff in the intervention group of Ningxia Hui Autonomous Region) |
|                 |               | "I notice that after EENC implementation, the incidence risk of umbilical infection has been reduced distinctly, and the occurrence is scarcely observed." (a health staff in the intervention group of Qinghai Province) |
| Sustainability  | Most interviewees expressed their determination to continue to implement EENC-recommended practices | "EENC-recommended practices should be further scaled up in our poverty-stricken areas." (a health staff in the intervention group of Ningxia Hui Autonomous Region) |
| Work support    | The implementation of EENC provides support for health workers, including improvement of professional skills, standardization of vital clinical practices, and conservation of medical consumables | "Some practices, including eye care, and vitamin K1 administration, are simple and easy to operate, which may partly explain the reason for the successful scale-up in our pilot hospital." (a health staff in the intervention group of Ningxia Hui Autonomous Region) |
|                 |               | "EENC promotes exclusive breastfeeding, which reduces neonatal diarrhea and allergies induced by breastfeeding substitutes. The health effects in turn alleviate our routine workload." (a health staff in the intervention group of Guizhou Province) |
satisfaction, breastfeeding confidence, and mother–child bonding. As WHO indicates, high-quality health care can encourage mothers to adopt pro-health behaviours [31]. Further, in Viet Nam, some private hospitals regarded EENC as a special service that attracted pregnant women seeking high-quality antenatal and childbirth care [18]. 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 [22]. The guideline released by WHO in 2014 indicated that, for improved maternal and child health outcomes, umbilical cord clamping should be delayed until there is no cord pulsation [32]. Indeed, a quasi-experimental study in China found that newborns receiving EENC interventions experienced lower umbilical cord infection rate compared to those in control groups (0.3% vs. 0.9%) [33]; however, no significant health effect was found in our study. Even though the proportion of newborns receiving no 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 centres may be partly explained by the imperfect quality of hospital-reported data, which highlights the need for more stringent quality control measures and routine health management in pilot health facilities.

WHO-recommended routine eye care and vitamin K administration should be applied to prevent neonatal ophthalmia and haemorrhage [34, 35], and the health benefits of this practice have been reported in previous publications [35–37]. Although the overall eye infection rate in the intervention group was found lower than the control counterpart (0.04% vs. 0.29%), further studies with longer observation period and more rigorous quality supervision are needed to strengthen the evidence base.

Normalization Process Theory provides a theoretical framework for assessing the probability of routine embedding of complex interventions: when practitioners acknowledge the importance and benefits of new interventions, the new routine is expected to be sustainable [38]. Consistent with Normalization Process Theory, we observed that the positive feedback from postpartum mothers and improved neonatal health indicators 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 for introducing these effective practices into primary health facilities.

Nevertheless, previous studies have noted the lack of national technical guidelines for newborn care in China, which have caused inconsistencies in childbirth and early newborn care practices across regions [39]. As such, it is anticipated to be an uphill battle to scale up EENC nationwide in China. Moreover, Frederick AC et al. revealed that health staff shortages were also perceived as a challenge to the implementation of EENC practices in our pilot hospitals, leading to interruptions in health worker support for sustained SSC. [18, 40] Since regional disparities between western rural counties and urban areas in economically developed provinces in China remain high, the allocations in equipment supplied to western health facilities should be increased (e.g., maternity wards, radiant warmers, and neonatal resuscitation equipment) [41, 42]. In our present study, most postpartum mothers had junior high school or lower education. Current evidence suggests that education level can be one of the most important socioeconomic factors in gaining access to EENC practices. Better access to education may be associated with the increased availability of high-quality health services, while the health behaviours of poorly educated mothers were easily affected by their surroundings [43, 44]. Therefore, increased investment in timely and effective promotion 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.

This is the first study to evaluate the effectiveness of EENC implementation through various data sources and mixed quantitative and qualitative methods. By introducing the control group, our findings indicate that EENC implementation is associated with improved health status of neonates, and the differences in core practice coverage between groups needed to be considered in the further scale-up of EENC. Our results can be regarded as a valuable reference on further promotion of EENC in China and other countries with a similar context. Compared with previous studies with pre- and post-intervention design, the control group was set in our study to better assess the improvement of EENC core intervention coverage and health indicators. Considering the potential regional variation across four western provinces, we conducted stratification analyses, controlling for the confounding variable of province. Moreover, the extraction of some EENC key coverage indicators from neonatal medical records helps to alleviate observation bias (i.e., the Hawthorne effect). 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 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 generalizable to health facilities of other levels and provinces. Secondly, as data on SSC and breastfeeding practices were reported by postpartum mothers, 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 impacts. The casual association between EENC practices and neonatal health impacts is worthy of further exploration.

Conclusion

EENC practices are feasible and have been successfully introduced to intervention hospitals of western China. EENC core interventions (except for kangaroo mother care) are routinely implemented in pilot health facilities, and the implementation is associated with reduced incidence risk of neonatal diarrhea and eye infection. The perceived usefulness of EENC interventions was identified by multiple stakeholders, who noted the willingness of staff to implement these interventions, the promotion of these interventions within hospital policy, the positive emotions experienced by postpartum mothers, and improvements in work-related support for health workers. The potential obstacles to EENC implementation mean concerted efforts should be made in China to meet the WHO target “at least 80% of facilities providing child-birth services implementing EENC”.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-022-08570-6.

Acknowledgements

We are truly grateful to all mothers, newborns, policymakers, and health staff participating in this study.

Authors’ 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 GV. 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.

Funding

The present study was supported by Safe Neonatal Project of the UNICEF Office for China.

Availability of data and materials

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

Declarations

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 interest.

Author details

1 National Center for Women and Children’s Health, Chinese Center for Disease Control and Prevention, Haidian District, Room 601, No. 12 Da Huisi Rd, Beijing 100081, People’s Republic of China. 2 Vanke School of Public Health, Tsinghua University, Beijing, China. 3 Division of Neonatology and Center for Newborn Care, Guangzhou Women and Children’s Medical Center, Guangzhou, China. 4 United Nations Children’s Fund Office for China, Beijing, China.

Received: 15 April 2022 Accepted: 14 September 2022

Published online: 21 September 2022

References

1. Tao X. Early essential newborn care (EENC): The prioritized intervention to end preventable newborn deaths. Chin J Prev Med. 2020;54(5):498–502.
2. GBD 2017 SDG Collaborators. Measuring progress from 1990 to 2017 and projecting attainment to 2030 of the health-related Sustainable Development Goals for 195 countries and territories: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):2091–138.
3. Vos T, Abbasi M, Abbasifard M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet (British edition). 2020;396(10258):1204–22.
4. World Health Organization. Special Tabulation of Demographic and Health Survey in 43 countries (Data Year 2005–2011). Geneva: World Health Organization; 2012.
5. Office of National Maternal and Child Health Surveillance. Report of maternal and child health surveillance based on three national networks. 2019.
6. Wang C, Xu T. The Trend and Cause of Mortality Burden in Infancy - China, 1990–2019. China CDC Weekly. 2021;3(16):340–5.
7. Wang Y, Li X, Zhou M, et al. Under-5 mortality in 2851 Chinese counties, 1996–2012: a subnational assessment of achieving MDG 4 goals in China. Lancet. 2016;387(10015):273–83.
8. World Health Organization. Action Plan for Healthy Newborn Infants in the Western Pacific Region (2014–2020). Manila: World Health Organization Regional Office for the Western Pacific, 2014.
9. Obara H, Sobel H. Quality maternal and newborn care to ensure a healthy start for every newborn in the World Health Organization Western Pacific Region. BJOG. 2014;121:154–9.
10. World Health Organization. Early essential newborn care: clinical practice pocket guide: Manila: World Health Organization Regional Office for the Western Pacific, 2014.
11. World Health Organization. Meeting report: Third biennial meeting on accelerating progress in early essential newborn care(EENC): synergies
with hospital quality and safety. Manila, Philippines: Regional Office for the Western Pacific; 2021.

12. Qu W, Yue Q, Wang Y, et al. Implementation of the early essential newborn care (EENC) on neonatal outcomes in western China: an observational study. The Lancet. 2018;92:554.

13. Qu W, Yue Q, Wang Y, et al. 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. BMJ Open. 2020;10(12):e18289.

14. Tran HT, Manna P, Murray JCS, et al. Early essential newborn care is associated with reduced adverse neonatal outcomes in a tertiary hospital in Da Nang. Viet Nam: a pre-post-study intervention study. EClinicalMedicine. 2018;6:51–8.

15. Xu T, Qu W, Wang Y, Yue Q, Huang X, Tian X. Analysis of early essential newborn care capacities of rural health facilities - four provinces in western China. 2016. China CDC Weekly. 2020;2(1):8–12.

16. Duan X, Li N, Li S, Qu Y, Sun C, Liu Q. Effects of early essential newborn care on hypothermia and short-term outcomes in vaginally born preterm infants. Chin J Perinat Med. 2019;22(8):565–9.

17. Cui M, Liu Z, Wang A, Zhang X, Zhang Y, Wang X. Effects of early essential newborn care on the onset of lactogenesis among primiparous. Chinese Journal of Child Health Care. 2019;27(10):1136–9.

18. Morseth MS, Nguyen TT, Sku M, et al. Health staff experiences with the implementation of early essential newborn care guidelines in Da Nang municipality and Quang Nam province in Viet Nam. BMC Health Serv Res. 2020;20(1):585.

19. Xu J, Liu J, Shen Q. Qualitative study on maternal experience of early essential newborn care. Chin J Nurs. 2019;54(12):1830–4.

20. Zhang Ju, Fangyin Wu, Yingjia J, et al. Trend analysis on mortality and the mortal causes among children under 5 in Sichuan province, from 2001 to 2013. Chinese Journal of Epidemiology. 2014;35(9):1049–52.

21. Zhang XL, Huang XC, Yang CX, et al. Analysis on newborn cause of death from 1998 to 2017. J Guizhou Med Univ. 2019;44(12):1466–71.

22. World Health Organization. Coaching for the first embrace: facilitator’s guide (Early Essential Newborn Care). Module 2. Manila: World Health Organization Regional Office for the Western Pacific; 2016.

23. World Health Organization. Introducing and sustaining EENC in hospitals: routine childbirth and newborn care (Early Essential Newborn Care): Module 3. Manila: World Health Organization Regional Office for the Western Pacific; 2016.

24. Society of Perinatal Medicine of Chinese Medical Association, Obstetric Subgroup of Society of Obstetrics and Gynecology, Obstetric Nursing Committee of Chinese Nursing Association, et al. Expert consensus on Early Essential Newborn Care (China, 2020). Chin J Perinat Med. 2020;23(7):433–40.

25. Qu W, Wang Y, Yue Q, et al. Investigation on early essential newborn care in county and township health facilities in four provinces of western China. Chinese Journal of Child Health Care. 2020;28(7):830–3.

26. Pope C, Ziebland S, Mays N. Qualitative research in health care: analysing complex interventions in health care: the normalization process model. BMC HEALTH SERV RES. 2007;7:148.

27. May C, Finch T, Mair F, et al. Understanding the implementation of complex interventions in health care: the normalization process model. BMC HEALTH SERV RES. 2007;7:148.

28. Xu T, Yue Q, Wang Y, Murray J, Sobel H. Childbirth and early newborn care practices in 4 provinces in China: a comparison with WHO recommendations. Glob Health Sci Pract. 2018;6(3):565–73.

29. Shen Q. Qualitative study on maternal experience of early essential newborn care on hypothermia and short-term outcomes in vaginally born preterm infants. Chin J Perinat Med. 2019;22(8):565–9.

30. Jullien S. Vitamin K prophylaxis in newborns. BMC PEDIATR. 2021;21(Suppl 1):350.

31. Mei J, Lin C, Zhang L, Zhang Y, Dong Y. Pediatric resources and medical service delivery capability in primary healthcare institutions in China. Chinese General Practice. 2019;22(13):1511–5.

32. Yang Z, Hu X, Chen R, Ren X. Research on the equity of the primary medical and health resource allocation in China. Chinese Health Resource. 2017;20(2):106–9. 122.

33. Pagel C, Prost A, Hossen M, et al. Is essential newborn care provided by institutions and after home births? Analysis of prospective data from community trials in rural South Asia. BMC Pregnancy Childb. 2014;14(1):99.

34. WHO. Guidelines for the Treatment of Chlamydia trachomatis. Geneva: World Health Organization; 2016.

35. Sanokar MJ, Chandrasekaran A, Kumar P, Thukral A, Agarwal R, Paul VK. Vitamin K prophylaxis for prevention of vitamin K deficiency bleeding: a systematic review. J Perinatol. 2016;36 Suppl 1(Suppl 1):S29–35.

36. Immunization CPSI, Committee. Recommendations for the prevention of neonatal opthalmia. Paediatr Child Health. 2002;7(7):480–8.

37. May C, Finch T, Mair F, et al. Understanding the implementation of complex interventions in health care: the normalization process model. BMC HEALTH SERV RES. 2007;7:148.

38. Xu T, Yue Q, Wang Y, Murray J, Sobel H. Childbirth and early newborn care practices in 4 provinces in China: a comparison with WHO recommendations. Glob Health Sci Pract. 2018;6(3):565–73.

39. Frederick AC, Buxen NH, Engebretson JC, Hurst NM, Schneider KM. Exploring the skin-to-skin contact experience during cesarean section. J Am Assoc Nurse Pract. 2016;28(1):31–8.

40. Xu T, Yue Q, Wang Y, Murray J, Sobel H. Childbirth and early newborn care practices in 4 provinces in China: a comparison with WHO recommendations. Glob Health Sci Pract. 2018;6(3):565–73.

41. Mei J, Lin C, Zhang L, Zhang Y, Dong Y. Pediatric resources and medical service delivery capability in primary healthcare institutions in China. Chinese General Practice. 2019;22(13):1511–5.

42. Yang Z, Hu X, Chen R, Ren X. Research on the equity of the primary medical and health resource allocation in China. Chinese Health Resource. 2017;20(2):106–9. 122.

43. Page C, Prost A, Hossen M, et al. Is essential newborn care provided by institutions and after home births? Analysis of prospective data from community trials in rural South Asia. BMC Pregnancy Childb. 2014;14(1):99.

44. Upadhyay RP, Rai SK, Anand K. Neonatal neonatal practice and its association with skilled birth attendance in rural Haryana. India Acta Paediatr. 2012;101(12):e535–9.

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more: biomedcentral.com/submissions