



# Introducing evidence-based practice improvement in Chinese neonatal intensive care units

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**Abstract:** China has the largest population in the world. With rapid economic growth, the incidence of premature birth has shown an increasing trend and more neonatal intensive care units (NICUs) are being established across the country. However, there is substantial variability in clinical practice and variations in short- and long-term outcomes among patients in different NICUs. There remains a big gap between China and developed countries in terms of infant outcomes. The Evidence-based Practice for Improving Quality (EPIQ) is a successful model that has been implemented in NICUs across Canada to improve infant outcomes. We applied EPIQ in a single NICU in China and successfully reduced the incidence of ventilator-associated pneumonia, central line (CL) associated bloodstream infection (CLABSIs), and improved the breastmilk use in NICU. In the next phase, we are extending EPIQ to another 24 centers in China and have established the Chinese Neonatal Network for national collaboration, to improve infant outcomes across China.

**Keywords:** neonatal intensive care units (NICUs); quality improvement (QI)

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## Introduction

China has a large population of about 1.4 billion people in 2015, accounting for around a fifth of the world population (1). According to the governmental 2010 population census, there were about 15.9 million live births in China, with a crude birth rate of 11.9 births per 1,000 population (2). With the rapid economic growth and development of China, the incidence of premature birth has shown an increasing trend, and the number of preterm infants cared for in Chinese neonatal intensive care units (NICUs) has increased (3). More NICUs are being established across the country (4). The advancement of perinatal-neonatal medicine has resulted in an increasing survival rate of preterm infants in China. However, the development of neonatology as a subspecialty is uneven among different districts and there is

high variability in under-5 mortality rates, with more than 10-fold difference in infant mortality rates between under-developed areas in west China and the relatively more developed areas in east China (5,6).

In the last two decades several reports have suggested that there has been little or only marginal further improvement in preterm outcomes (7,8). This issue may stem from problems with the quality of neonatal care provided, including practice variations (9). As such, as in North America, there has been a significant focus on using quality improvement (QI) methods to improve neonatal care.

The Evidence-based Practice for Improving Quality (EPIQ) method of QI was developed in Canada by Dr. Shoo Lee, and has been implemented in NICUs across Canada. EPIQ combines the use of evidence from the

published literature and outcomes data from participating hospitals with consideration of site-specific contextual factors affecting QI implementation to facilitate change (10). The method uses a network approach where sites share information and support each other through collaborative learning. In this manner, knowledge is effectively disseminated across a large number of sites, sites remain motivated, and a culture for change is created. A cluster randomized controlled trial of the EPIQ method targeting hospital acquired infection (HAI) and bronchopulmonary dysplasia (BPD) in Canadian NICUs resulted in a 32% decrease in HAI and 15% decrease in BPD among the participating sites (10). In a subsequent study targeting mortality and all five major neonatal morbidities [BPD, severe intraventricular haemorrhage (IVH), retinopathy of prematurity (ROP), HAI, and necrotising enterocolitis (NEC)], EPIQ resulted in a 25% decrease in HAI, a 24% decrease in ROP, a 20% decrease in NEC, and a 7% increase in neonatal survival without major morbidity (11). Thus, the EPIQ method offers a comprehensive and effective approach to improving neonatal outcomes with the flexibility to be adapted to different NICU environments.

Preterm birth is the leading cause of childhood mortality in China (12,13). The mortality in very low birth weight (VLBW, birth weight <1,500 g) infants with infection is threefold higher when compared with VLBW infants without infection (14). In addition to the worsening of short-term outcomes, HAIs are associated with long-term neurodevelopmental problems that develop after discharge as a result of neurological changes caused by the infection (15).

While the immature immunity of preterm infants put them at high risk to develop infection after birth, patients admitted to a NICU with a high rate of HAI because of sub-optimal practices are at a significant disadvantage to those who have access to a NICU that implements best practices. HAIs can be reduced by seemingly simple practice changes, such as increased hand hygiene compliance, removal of ventilation devices as soon as appropriate, use of practice guidelines for the insertion and maintenance of CLs, removing vascular access when infants reach a total fluid intake of 120 mL/kg/day via nasogastric or oral feeds, and promoting breast milk feeding (16). However, the effective implementation of even simple practice changes can be difficult to achieve without a rigorous QI method. In China, very few studies have been conducted to reduce HAI in the NICU through QI methods.

The International Training Program in Neonatal-Perinatal Medicine was established in April 2004 in

Shanghai. It is a joint venture of the Canadian Neonatal Network™ and the Children's Hospital of Fudan University (FUCH) in Shanghai and endorsed by the Canadian Pediatric Society. This program upgraded standards of care and training at the FUCH in Shanghai, and also created unprecedented new opportunities for collaboration between Canadian and Chinese doctors and hospitals on a wide range of issues, including research (17).

With the objective of improving neonatal outcomes, we have adopted the EPIQ method and started systemic practice changes in a single center in China since 2008. Following this, we collaborated with 24 NICUs across China to reduce HAI through evidence-based practice improvement from 2015 to 2018.

### Examples of QI in a single NICU

The pilot QI project was conducted in the NICU of FUCH, which is a 693-bed academic tertiary care center affiliated with Fudan University, Shanghai, China. The NICU had 30 beds, which was increased to 50 beds after moving to its new location in June 2008. All the staff neonatologists in the NICU have had 1 or 2 years of clinical training in Canadian Neonatal Network Hospitals and received standardized training about the EPIQ program before our NICU QI program started.

#### *Ventilator associated pneumonia (VAP)*

As increasing numbers of very premature babies are surviving, many of them require mechanical ventilation (MV), and VAP has become a major challenge in China. As reported previously, VAP was the most frequent nosocomial infection (NI) in our NICU, accounting for 41.3% of NI cases (18). In June 2008, relocation of our hospital to a new site prompted the implementation of a comprehensive infection control program to reduce VAP in the NICU.

A bundle of comprehensive preventive measures against VAP was gradually implemented over a 1-year period from August 1, 2008, to July 31, 2009 in our NICU following relocation to a new facility. Several measures were implemented including reinforcement of hand hygiene practices, rational waste disposal, enhancement of patient isolation and ventilator disinfection, periodic educational activities on VAP prevention, shortened duration of MV, enhanced respiratory management of patients, and rational use of antibiotics.

Of 491 patients receiving MV during the study period,

92 (18.7%) developed VAP corresponding to 27.33 per 1,000 ventilator-days in total. The VAP rate decreased from 48.84 per 1,000 ventilator-days in pre-intervention phase to 18.50 per 1,000 ventilator-days in the post-intervention phase ( $P < 0.001$ ). Overall mortality rate of admitted neonates significantly decreased from 14.0% to 2.7% ( $P < 0.001$ ).

The study (19) demonstrates that a bundle of infection control practices can effectively reduce the occurrence of VAP among neonatal patients in China.

### **CLABSIs**

CLABSI has been emerged as the dominant nosocomial infection among premature infants during the last decade as CLs have become routine practice in Chinese NICUs. Hence, we conducted a 3-year study to characterize CLABSIs among neonates in the NICU of FUCH and to evaluate the impact of a multifaceted evidence-based practice for improving quality program to decrease CLABSI.

The intervention measures were developed in accordance with the EPIQ method, which including enhanced hand hygiene practices, dedicated PICC teams and monitor groups, use of an all-inclusive CL cart and prepackaged kits, evaluating CLs daily and removal of non-essential CLs, and providing education and simulation training.

A total of 171 patients with CLs were observed; 29 of them developed CLABSI corresponding to 7.35 per 1,000 catheter days, with a CL utilization ratio of 37.9%. Overall CLABSI rate decreased gradually from 16.7 per 1,000 CL days in pre-intervention phase to 5.2 per 1,000 CL days in post-intervention phase ( $P < 0.01$ ) although the CL utilization rate increased.

This study (20) showed that a bundle of preventive measures can have a significant positive impact on CLABSI rates in Chinese NICUs. These simple, inexpensive measures can potentially be generalized to other NICUS in developing countries.

### ***Mother's own milk feeding (not published data)***

The nutritional benefits of human milk are well-established, especially for infants born preterm. Previous research from developed countries has shown that mother's milk feeding rates can be significantly improved by implementing structured evidence-based practices to promote mother's milk use in the NICU (21). However, there has been a lack of QI initiatives to improve mother's milk feeding in

NICUs in China. We carried out a multi-disciplinary QI initiative aimed at increasing the prevalence of mother's own milk feeding in infants born at  $< 1,500$  grams, and evaluated the impact of our mother's milk promotion program by comparing the mother's milk consumption rates and neonatal outcomes of infants before and during the initiative.

Preliminary results were positive and resulted in the establishment of a hospital-based human milk bank in the NICU at FUCH.

### **Implement EPIQ in Chinese NICUs through collaborative study**

Based on the success of the study at a single site in FUCH, we proceeded to broaden the scope and apply the EPIQ methodology to improve outcomes in other centers across China, incorporating the lessons learned from our previous study.

Population-based data on the incidence of HAIs in Chinese NICUs are not available and the reported incidence of HAI varies greatly between different units and regions. Reported rates of HAI in the general NICU patient population (all admissions) range from 3.1% (22) to 17.2% (18,22-25). In preterm or VLBW infants the incidence of HAI is higher than in the general NICU population with reported rates ranging from 16.7% to 61.2% (24-26).

By building on our work in the FUCH NICU and the existing collaborations between the CNN and FUCH (International Training Program in Neonatal-Perinatal Medicine based in FUCH since 2004), a cluster randomized controlled trial (clinical trials ID: NCT0260015) was conducted targeting all types of HAI in 24 NICUs across China (Reduction of infection in neonatal intensive care units using the Evidence-based Practice for Improving Quality, REIN-EPIQ) with collaboration between FUCH and CNN and Maternal-Infant Care (MICare). The overall goal of the project was to evaluate the impact of the EPIQ method on HAI in Chinese NICUs using a cluster randomized controlled trial.

The baseline data from REIN-EPIQ in 2015–2016 showed that mortality and morbidity (including BPD, HAIs, IVH/PVL) of preterm infants remain high in China with significant variations among NICUs (27). The incidence of VAP in Chinese NICUs is similar to that in developed countries. However, there is substantial variability in different NICUs (28).

We anticipate that a direct result of this project will be

the reduction of HAI in participating NICUs, which has the potential to have an impact on the long-term outcomes of enrolled infants including improved neurodevelopmental outcomes. A reduction in HAI will also decrease resource utilization associated with neonatal care.

### Established Chinese Neonatal Network (CHNN) for national collaboration

CHNN was launched in 2018, which includes 53 NICUs in China. CHNN is a group of multi-disciplinary researchers who collaborate on research issues related to neonatal care. The Network established and maintains a high quality neonatal-perinatal database with sustainable infrastructure necessary to facilitate collaborative research.

As described above, the outcomes of patients in NICUs varied significantly. Wide variations in mortality and serious morbidities of preterm infants between NICUs exist even though the participating NICUs were all tertiary units in metropolitan cities. In China there is a great need to bring NICUs together to share knowledge and establish a formal QI process to improve neonatal outcomes and quality of care. The EPIQ method has already been tested in a single center and offers a comprehensive solution to the problem of implementing collaborative coordinated QI in China. By building on a foundation of collaborative learning and targeted practice change, implementing EPIQ in China will improve the quality of care, identify novel approaches to neonatal care and knowledge translation, and reduce the inequity that exists due to differing standards of care. The results from REIN-EPIQ showed that the incidences of severe IVH among VLBWI and ELBWI was still significantly higher than those of developed countries. The incidences of severe IVH in ELBWI and in preterm infants with gestational age  $\leq 28$  weeks were 13.5% (160/1,185) and 13.1% (368/2,800), respectively (29). Currently collaborative QI initiatives have been initiated to reduce infections in Chinese NICUs. Further QI initiatives are needed to ensure infants receive appropriate care and reduce adverse neonatal outcomes in China. Knowledge gained from this initiative will be valuable in the future for targeting other neonatal morbidities, such as NEC, BPD, ROP and IVH.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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