Impact of a nationwide training program for neonatal resuscitation in China

XU Tao, WANG Hui-shan, YE Hong-mao, YU Ren-jie, HUANG Xing-hua, WANG Dan-hua, Wang Li-xin, FENG Qi, GONG Li-min, MA Yi, William Keenan and Susan Niermeyer

Keywords: resuscitation; infant, newborn; asphyxia neonatorum; neonatal mortality; in-service training; China

Background Seventeen million births occur in China each year. Neonatal mortality is the leading cause of under 5-year-old child deaths, and intrapartum-related injury accounts for much of mental retardation in young children. The Chinese Ministry of Health sought to improve infant and child survival through a nationwide initiative to have at least one person trained in neonatal resuscitation at every birth. The aim of the current study was to evaluate the impact of China Neonatal Resuscitation Program (NRP) on policy and infrastructure changes and its effectiveness in decreasing the incidence of mortality among newborn infants.

Methods The Chinese NRP incorporated policy change, professional education, and creation of a sustainable health system infrastructure for resuscitation. Multidisciplinary teams from all 31 provinces and municipal states disseminated NRP in a train-the-trainer cascade. The intervention targeted 20 provinces with high neonatal mortality and programs to reduce maternal mortality. Program evaluation data came from 322 representative hospitals in those provinces.

Results Changes in policy permitted midwives to initiate resuscitation and required resuscitation training for licensure. From 2004 through 2009 more than 116,659 professionals received NRP training in the 20 target provinces, with 94% of delivery facilities and 99% of counties reached. Intrapartum-related deaths in the delivery room decreased from 7.5 to 3.4 per 10,000 from 2003 to 2008, and the incidence of Apgar ≤7 at 1 minute decreased from 6.3% to 2.9%.

Conclusions The Chinese NRP achieved policy changes promoting resuscitation, trained large numbers of professionals, and contributed to reduction in delivery room mortality. Improved adherence to the resuscitation algorithm, extension of training to the township level, and coverage of births now occurring outside health facilities can further increase the number of lives saved.

Birth asphyxia is one of the leading causes of infant mortality, cerebral palsy and mental disabilities worldwide. The People’s Republic of China is the world’s most populous country and the third largest in terms of territory. Approximately 17 million babies are born in China each year. The infant mortality rate (IMR) averaged 21.5 deaths per 1000 live births in 2004; however, disparity existed between urbanized areas, with an average IMR as low as 10.1 per 1000 live births and rural areas with an average IMR of 24.5 per 1000 live births. Of all infant deaths, 20.5% or more than 73,000 deaths per year, resulted from intrapartum hypoxic-ischemic events (asphyxia). Furthermore, intrapartum-related neonatal mortality ranked as the second leading cause of death among children under 5-year-old in China, and neonatal deaths from all causes...
accounted for 63.9% of total under 5-year-old deaths.\textsuperscript{4,5}

Following the drafting of the Millennium Development Goals, attention of the global health community focused on neonatal survival as a key to achieving child survival goals.\textsuperscript{6,7} As one of the 60 child survival priority countries affirmed by United Nations International Children’s Emergency Fund (UNICEF), China adopted the goal of reducing under 5-year-old child mortality by two-thirds from 1990 levels before the year 2015. The Chinese Ministry of Health (MOH) identified perinatal asphyxia as a health priority for the country.\textsuperscript{8} Because family planning is a fundamental national policy in China, prevention of child mortality and disability is essential to family and population health.\textsuperscript{4} Parents and health professionals in China added their voices to the call for significant change in resuscitation care at birth.

The Chinese healthcare system follows the administrative hierarchy of the PRC (province, prefecture, county in descending order) for the organization of services. Provincial maternal-child health centers, usually in the capital cities, receive referrals of complex cases as well as routine births. Prefecture and university-affiliated hospitals in larger cities provide subspecialty intensive care. Municipal hospitals offer variable subspeciality services, and county (or urban district) hospitals focus on routine and intermediate care, including comprehensive emergency obstetric care. Township health centers perform uncomplicated births and offer basic emergency obstetric care. Village and urban community clinics focus on prenatal and postnatal care.\textsuperscript{4}

Neonatal resuscitation varied widely in its content and availability across China before 2004. Universities, non-governmental organizations, and faith-based groups had introduced the Neonatal Resuscitation Program (NRP) in several provinces, but the coverage and sustainability of these trainings were limited.\textsuperscript{8,10} Other areas received equipment and supplies through international agencies, but lacked resuscitation training for professionals. Many areas lacked both equipment and training and relied on older systems of pharmaceutical-based resuscitation. Midwives attend the majority of deliveries in China; however, resuscitation did not fall within their scope of practice.

In 2002, the Chinese MOH identified perinatal asphyxia as a health priority for the country, and sought partners in the development of an educational program to reduce intrapartum-related neonatal mortality.\textsuperscript{8} The NRP of the American Academy of Pediatrics (AAP) and the American Heart Association had gained usage in over 120 countries, including China, and recognition as an effective intervention to improve infant outcomes.\textsuperscript{11-13} Johnson and Johnson Pediatric Institute (JJPI) had collaborated with the AAP on previous programs and brought together the partnership in 2003. The aim of the current study was to evaluate the impact of China NRP on policy and infrastructure changes and its effectiveness in decreasing the incidence of mortality among newborn infants from 2004 through 2008.

METHODS

Participants and responsibilities

The MOH convened a Neonatal Resuscitation Program Task Force in 2003 to direct the China NRP intervention under the leadership of the Director of Maternal Child Health and Community Health.\textsuperscript{10} Nationally recognized experts in neonatal resuscitation represented the Chinese Society of Perinatal Medicine (CSPM), the Chinese Pediatrics Society, and the Chinese Nursing Association (CNA). The National Center for Women and Children’s Health (NCWCH), part of the Chinese Center for Disease Control and Prevention (CDC), served as the implementing agency, providing technical support, program monitoring and evaluation, and coordination with the international collaborators. JJPI contributed outside funding and also participated in strategic planning and management of the intervention program, external communication, and partner relationships. The AAP provided current editions of the Textbook of Neonatal Resuscitation,\textsuperscript{10,13} which served as the core of the educational intervention, as well as technical advice on program structure, educational methods, and resuscitation science. The China NRP Task Force sought to create a sustainable infrastructure for resuscitation training and practice within the 5-year term of the original agreement.

Policy

The NRP Task Force identified two changes in national policy crucial to supporting the neonatal resuscitation intervention. First, the professional role of all medical personnel providing care at delivery should include resuscitation of the newly born infant. Second, neonatal resuscitation training should be part of the requirements for licensure of facilities providing obstetric services and professionals providing care at delivery. These policy requirements were embodied in the administrative documents issued by MOH to each program province. The health authorities from program provinces carried out these policies to encourage infrastructure changes and raise extra funding for training workshops and equipment.

Programmatic intervention

Training model

The nationwide training, Freedom of Breath, Fountain of Life, pursued 2 major objectives to achieve the goal of reducing neonatal mortality: (1) to extend training so that at least one person is present at every delivery who is capable of initiating resuscitation, (2) to create a sustainable infrastructure for resuscitation training. The cascade of training began in July 2004 with preparation of the national faculty, 20 obstetricians, perinatologists, pediatricians, neonatologists, midwives, and obstetrical nurses experienced in their professions and in teaching. Four expert nurse and physician faculty from the AAP
taught the national faculty, who later the same week, trained 90 provincial instructors representing 20 target provinces. Each provincial instructor team included an obstetrician, a pediatrician, a midwife/nurse, and an administrator of the provincial MOH (usually also a physician). The MOH identified the 20 target provinces on the basis of relatively higher IMR, presence of the Chinese Society of Perinatal Medicine in the province, participation in the governmental Program to Reduce Maternal Mortality and Eliminate Neonatal Tetanus (R&E), and need for healthcare capacity-building. The R&E program provided training in lifesaving obstetric skills, incentives for in-hospital deliveries of poor families, public health education, and equipment including clean delivery kits, warmers, resuscitation bags, masks, and laryngoscopes. Each NRP provincial team was charged with setting up a provincial training center and beginning instructor training in provincial, prefecture, and municipal hospitals within 6 months. Instructor training in 10 remaining non-targeted provinces and autonomous regions of China occurred in April 2005, with 8 national faculty training 39 additional provincial/regional instructors. A third training August 2006 concluded dissemination to all 31 provinces and autonomous regions of the country. Each health authority of the 20 targeted provinces extended training according to the model that best fit local specifications. Every year instructors provided either centralized provincial trainings or dispersed courses at the prefecture, municipal, and county level.

Training content
Topics covered in the NRP training included the physiology of normal transition at birth and asphyxia, the initial steps of resuscitation (drying, warmth, clearing the airway, stimulation), positive-pressure ventilation, chest compressions, intubation, and medication administration. The International Liaison Committee on Resuscitation Consensus on Science and Treatment Recommendations form the evidence base for NRP. Training emphasizes development of skills as well cognitive knowledge and integrates these aspects in performance exercises. Participants complete both a performance evaluation (Megacode) and a written evaluation.

Materials and equipment
Each national and provincial instructor received a complete set of training equipment and materials at the completion of the instructor course. All target provinces received additional training equipment for use and loan by the provincial training center. Training equipment included an infant CPR mannequin, bag and mask ventilation device, meconium aspirator and bulb suction device, laryngoscope, stethoscope, and other supplies as called for in the Textbook of Neonatal Resuscitation. NCWCH also distributed textbooks and supplemental print and digital educational media in Mandarin as part of the intervention in the 20 target provinces; institutions and individuals in the non-target areas purchased training materials from the Second Military Medical University Publishing House.

Although the neonatal resuscitation training program did not distribute clinical equipment for health facilities, it took advantage of clinical supplies provided under the R&E program in target provinces. In addition, government directives obligated health facilities in target provinces to purchase neonatal resuscitation equipment.

Communications
Each of the organizations represented on the NRP Task Force used its communication infrastructure to provide program updates and introduce new phases of implementation. NCWCH created a website for Freedom of Breath, Fountain of Life in 2005 (http://nrp.chinawch.org.cn). Periodic update conferences for instructors in the 20 target provinces introduced revisions in the international resuscitation guidelines and permitted sharing of province-specific research findings and regional/local initiatives.

Supervision and instructor certification
Provincial and national supervision of implementation and training started in 2005 and continued throughout the intervention. Each province established a supervision team, overseen by NCWCH, to ensure implementation and evaluation of NRP. Provincial supervision teams submitted an annual report to NCWCH. In addition, NCWCH organized and led teams of professionals from CSPM and CNA (members of the NRP Task Force or national instructors) on supervisory visits to hospitals in target provinces each year. The supervisory teams specified to the provincial health bureau the criteria for selection of hospitals to be evaluated, i.e. level of the hospital, number of births, and proportion of staff trained. The MOH initiated provincial-level instructor certification in early 2008 to ensure high quality throughout the training cascade and establish a foundation for long-term training. Certification included evaluation of knowledge, teaching ability, and practical skills.

Definition of birth asphyxia
In this study, birth asphyxia, also called asphyxia neonatorum, was defined as a failure to start regular respiration within a minute of birth. Apgar score continues to provide a convenient shorthand for reporting the status of the newborn infant. Although it was not strictly comparable to international standards, Apgar score ≤7 at 1 minute had been widely used in China to diagnose birth asphyxia.

Evaluation methods and measurements
Near the end of the intervention in 2008–2009, NCWCH conducted a final evaluation in 18 hospitals representing 3 levels of facilities (provincial, prefecture, county) from each of the 20 target provinces (360 hospitals). The hospitals were selected using a stratified random
sampling method. Hospitals with annual average live births over 1000 were eligible for sampling. Six provincial hospitals were selected in each province. Three prefectures from each province were selected and in each prefecture, 3 prefecture hospitals and 1 county hospital were selected. After notification of the health authority of each program province, the evaluation team enrolled 322 hospitals willing to provide self-reported evaluation data. For each hospital, evaluators confirmed self-reported data on numbers of professionals trained, number and proportion of staff trained within hospitals, availability of equipment for resuscitation in the clinical setting, and infant outcomes including intrapartum-related morbidity (asphyxia defined as Apgar ≤7 at 1 minute) and death in the delivery room secondary to intrapartum-related events (asphyxia-specific mortality). In order to verify the reliability of self-reported data, evaluators randomly selected one hospital in each province to double-check the data accuracy by looking through the training documents, delivery records, medical records and so on.

In addition, evaluators randomly selected 4 hospitals (1 provincial hospital, 2 prefecture hospitals and 1 county hospital) among the 18 hospitals in each province for on-site evaluation. The Task Force members reviewed mortality records and training documents; interviewed nursing, obstetric, and pediatric department heads; observed Megacode performance (an objective, structured evaluation of skills and decision making) of 240 randomly selected hospital staff; and conducted questionnaire interviews on training quality (level of training received, number of training courses attended, length of skill practice during training and sharing of training equipments during training) of another 130 randomly selected hospital staff. The proportion of facilities covered by professionals trained in neonatal resuscitation, combined with estimated effect of the intervention in the Lives Saved Tool (LiST), generated projections of the number of lives saved through neonatal resuscitation.\(^\text{13}\)

**Statistical analysis**

For categorical variables (e.g. training coverage), data were compiled as frequency and percentage; differences between groups were compared by chi-square test. Changes in asphyxia incidence and mortality over time were explored using Cochran-Armitage Trend test. For continuous variables (e.g. Megacode performance score), data were reported as mean ± standard deviation (SD) and analysis was performed with independent \(t\)-test or one-way analysis of variances (ANOVA) in SPSS 13.0 (SPSS Inc., Chicago, IL, USA). \(P\) value less than 0.05 was considered statistically significant. Child survival projections utilized methods developed by the Child Health Epidemiology Reference Group, The Bellagio Child Survival Study Group, and the International Child Development Steering Group (LiST module, Spectrum 3.40, Futures Institute, Glastonbury, CT, UK).\(^\text{16}\)

**Human subjects review**

The Colorado Multiple Institution Review Board classified the research as exempt. The MOH of the People’s Republic of China approved the study.

**Role of the funding source**

JJPI, a non-profit entity, provided 5-year funding for instructor training and update conferences, educational materials, and evaluation. The Chinese MOH contributed funding at the national and provincial level in 20 target provinces. Both the MOH and JJPI participated in design and management of the intervention and reviewed the evaluation plan. The National Center for Women and Children’s Health, China CDC performed data collection, analysis, and interpretation; wrote the report with members of the NRP Task Force, and made the decision to submit the paper for publication. The sponsor had no role in data collection, analysis, interpretation, writing, or the decision to submit for publication.

**RESULTS**

**Policy**

The MOH promoted adoption of neonatal resuscitation through several policy changes. In 2004 a Red Letter included resuscitation in the scope of practice for midwives. Midwives must be capable of initiating resuscitation and assisting physicians with intubation and medication administration. Provincial MOH regulations in the target provinces made successful completion of NRP mandatory for licensure of midwives and obstetricians. Provincial licensure of delivery facilities requires obstetric and pediatric staff trained in NRP and resuscitation equipment in delivery suites and operating rooms. Over three-quarters of target provinces incorporated NRP into their continuing education system. At the province level, 80% of provinces incorporated NRP into the obstetric department management system and 65% into the pediatric department management system.

**Professionals trained and educational materials delivered**

Confirmed self-report data from 20 provinces showed that from 2004 through 2009, 110,659 health providers in the target provinces participated in training, and 191 of 234 provincial instructor candidates earned certification. NRP reached 223 large to medium cities (100.0%) and 1368 counties (98.8%) in the 20 target provinces, accounting for 94.3% (20,574/21,823) of institutions that provide delivery services. The program delivered 21,000 textbooks, 799 training mannequin and equipment sets, 70,000 NRP guidelines, and 21,000 delivery room wall charts to the 20 target provinces.

The quality of training was illustrated through questionnaire interview with health staffs. Nine of the 130 selected providers were tacking care of patients and did not participate in the interview. The results showed that 40.5% of providers received training at hospital level, 38.0% at above county level and 21.5% at above
province level. The 73.6% of providers received training for more than 3 times in previous 12 months, 18.2% for 2 times and 8.2% for 1 time. In terms of training quality, 43.8% of providers performed skill practice for 1 day in the last training workshop, 36.4% performed skill practice for half a day and 19.8% for less than 2 hours. The 44.6% of providers shared one set of training equipment with less than 8 trainees during the last training workshop, 31.4% sharing with 9–12 trainees and 24.0% sharing with over 13 trainees.

Impact of training

Coverage among hospital staff

Over 90% of perinatal staff in the facilities evaluated received training in their hospital. Approximately 60% received training from instructors at or above the county level (Table 1). Obstetricians and midwives in provincial level hospitals received trainings from higher-level instructors than those in prefecture and county hospitals. Pediatricians and midwives in county level hospitals received more in-hospital trainings than those in provincial level hospitals.

Practical skills

Two of the 240 selected providers were performing surgery and were not evaluated of the Megacode performance. Among the 238 health providers evaluated, 173 passed the Megacode performance test (73%) by correctly demonstrating 85% of items. Midwives demonstrated the highest pass rates for practical skills ($\chi^2=8.323$, $P=0.016$), followed by pediatricians and obstetricians (Table 2). Of a total possible score of 40, the average score for obstetricians was 33.8±3.9 and the average score for pediatricians was 34.4±3.6. Of a total possible score of 32 for midwives, the average score was 27.3±4.0. Among providers of different post levels, junior providers demonstrated higher pass rates ($\chi^2=13.21$, $P<0.001$) than senior and intermediate providers (Table 2).

Availability of equipment and supplies

Over 90% of delivery rooms in target provinces were equipped with resuscitation bags, infant masks, laryngoscopes and radiant warmers. A higher proportion of provincial-level hospitals had supplies for intubation and suction compared to prefecture and county hospitals. Availability of resuscitation equipment was more complete in delivery than operating rooms. Only 71.4% and 57.3% of provincial-level hospitals had meconium aspirators in delivery and operating rooms respectively and even lower proportions of prefecture and county hospitals had the recommended device (Table 3).

Clinical outcomes

The incidence of Apgar score ≤7 at 1 minute decreased from 6.32% in 2003 to 2.94% in 2008 ($\chi^2=4396.77$, $P<0.001$). The mortality from asphyxia in the delivery room decreased from 7.55 per 10000 live births in 2003 to 3.41 per 10 000 live births in 2008 ($\chi^2=53.56$, $P<0.001$) (Table 4). Trend test for the differences from 2003 to 2008 indicated a decrease trend in asphyxia incidence ($Z=77.67$, $P<0.001$) and in mortality from asphyxia in the delivery room ($Z=7.78$, $P<0.001$).

Analysis by hospital level also showed a decline of asphyxia incidence and mortality among hospitals of different levels. From 2003 to 2008, the asphyxia incidence decreased by 56.5% in provincial-level hospitals, 33.4% in prefecture hospitals and 80.1% in county hospitals. Mortality from asphyxia in the delivery room decreased by 50.7% in provincial-level hospitals, 37.6% in prefecture level hospitals, and 55.5% in county level hospitals (Table 5).

Project of lives saved

Projecting 95% coverage of delivery facilities with neonatal resuscitation training throughout China yields an estimate of over 15 000 newborn lives saved per year as a result of the intervention (Table 6). The proportion of facility births (83%), effectiveness factor for neonatal resuscitation (0.3), and the baseline coverage for neonatal resuscitation before the intervention (41.5%) are defaults in LiST estimated from the best available data and expert consensus. When applied to demographic projections

### Table 1. Numbers of professionals and proportion of perinatal staff trained by hospital level

<table>
<thead>
<tr>
<th>Groups</th>
<th>Total number</th>
<th>Number receiving training at county and above level (n (%)</th>
<th>Number receiving training at hospital level (n (%)</th>
<th>Total Number</th>
<th>Number receiving training at county and above level (n (%)</th>
<th>Number receiving training at hospital level (n (%)</th>
<th>Total number</th>
<th>Number receiving training at county and above level (n (%)</th>
<th>Number receiving training at hospital level (n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provincial</td>
<td>1843</td>
<td>1760 (95.5)</td>
<td>1599</td>
<td>1599</td>
<td>925 (57.8)</td>
<td>1388 (86.8)</td>
<td>1637</td>
<td>1033 (63.1)</td>
<td>1525 (93.2)</td>
</tr>
<tr>
<td>Prefecture</td>
<td>1622</td>
<td>1543 (95.1)</td>
<td>1101</td>
<td>1101</td>
<td>647 (58.7)</td>
<td>1008 (91.6)</td>
<td>1324</td>
<td>674 (50.9)</td>
<td>1256 (94.9)</td>
</tr>
<tr>
<td>County</td>
<td>393</td>
<td>380 (96.7)</td>
<td>190</td>
<td>190</td>
<td>103 (54.2)</td>
<td>177 (93.2)</td>
<td>196</td>
<td>76 (38.8)</td>
<td>194 (99.0)</td>
</tr>
<tr>
<td>Total</td>
<td>3858</td>
<td>3683 (95.5)</td>
<td>2890</td>
<td>2890</td>
<td>1675 (58.0)</td>
<td>2573 (89.0)</td>
<td>3157</td>
<td>1783 (56.5)</td>
<td>2975 (94.2)</td>
</tr>
</tbody>
</table>

\[ \chi^2 \text{ values} \] = 91.367, 1.793, 1.397, 18.604, 70.942, 12.580

\[ P \text{ values} \] = 0.001, 0.408, 0.497, <0.001, <0.001, 0.002

### Table 2. Pass rate of Megacode performance among perinatal providers by specialty and post level

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number (n)</th>
<th>Pass (n)</th>
<th>Pass rate (%)</th>
<th>( \chi^2 ) values</th>
<th>( P \text{ values} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obstetricians</td>
<td>81</td>
<td>51</td>
<td>63.0</td>
<td>8.323</td>
<td>0.016</td>
</tr>
<tr>
<td>Pediatricians</td>
<td>79</td>
<td>57</td>
<td>72.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwives</td>
<td>78</td>
<td>65</td>
<td>83.3</td>
<td>13.21</td>
<td>0.001</td>
</tr>
<tr>
<td>Post level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior</td>
<td>33</td>
<td>21</td>
<td>63.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>72</td>
<td>43</td>
<td>59.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junior</td>
<td>133</td>
<td>109</td>
<td>82.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
for China’s population and birth rate, increasing coverage of facility births to 95% results in an estimated 103,000 additional lives saved from 2010–2015, with the true value falling between ±50% of this estimate.

**DISCUSSION**

Freedom of Breath, Fountain of Life created a sustainable educational infrastructure for neonatal resuscitation in China and contributed to the reduction of neonatal asphyxia and asphyxia-related neonatal mortality. In a midterm evaluation of the China NRP program, the incidence of asphyxia decreased from 3.83% to 2.76%. The mortality from asphyxia in these delivery sites decreased from 3.08 to 2.06 per 10,000 live births. Findings of this final evaluation have indicated more significant improvement. For example, the key change in policy, permitting midwives to initiate resuscitation, enabled timely response by those in attendance at birth, as reflected in a lower proportion of depressed Apgar scores at 1 minute. Provincial regulations promoted the dissemination of NRP by making resuscitation training a requirement for licensure of perinatal professionals and delivery facilities. Provincial instructor teams accomplished the training of a large number of professionals with a focus on areas of high neonatal and infant mortality.19,20 Training reached provincial, prefecture, and county hospitals in the target areas and achieved high levels of coverage of perinatal staff, including midwives, obstetricians, and pediatricians. Furthermore, training proved effective in equipping learners from all professional groups with the practical skills of resuscitation and improved interdisciplinary collaboration.21,22 As part of a package of perinatal interventions designed to decrease not only infant mortality but also maternal mortality (R&E), neonatal resuscitation training was associated with a significant decline in the incidence of asphyxia and death in the delivery room secondary to intrapartum-related events.23

The NRP guideline states that “Apgar score should not be

---

**Table 3. Availability of equipment and supplies in delivery and operating room by hospital level (%)**

<table>
<thead>
<tr>
<th>Items</th>
<th>Delivery room</th>
<th></th>
<th>Operating room</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Provincial (n=119)</td>
<td>Prefecture (n=145)</td>
<td>County (n=38)</td>
<td>Provincial (n=117)</td>
</tr>
<tr>
<td>Resuscitation bag</td>
<td>118 (99.2)</td>
<td>144 (99.3)</td>
<td>36 (94.7)</td>
<td>5.171</td>
</tr>
<tr>
<td>Infant mask</td>
<td>117 (98.3)</td>
<td>141 (97.2)</td>
<td>34 (89.5)</td>
<td>7.305</td>
</tr>
<tr>
<td>Radiant warmer</td>
<td>116 (97.5)</td>
<td>137 (94.5)</td>
<td>38 (100)</td>
<td>3.315</td>
</tr>
<tr>
<td>Laryngoscope</td>
<td>114 (95.8)</td>
<td>131 (90.3)</td>
<td>33 (86.8)</td>
<td>4.271</td>
</tr>
<tr>
<td>Endotracheal tube</td>
<td>112 (94.1)</td>
<td>116 (80.0)</td>
<td>30 (78.9)</td>
<td>11.934</td>
</tr>
<tr>
<td>Suction catheters</td>
<td>116 (97.5)</td>
<td>123 (84.8)</td>
<td>30 (78.9)</td>
<td>15.327 &lt;0.001</td>
</tr>
<tr>
<td>Oropharyngeal tube</td>
<td>104 (87.4)</td>
<td>97 (66.9)</td>
<td>28 (73.7)</td>
<td>15.092</td>
</tr>
<tr>
<td>Prophylactic aspirator</td>
<td>85 (71.4)</td>
<td>77 (53.1)</td>
<td>21 (55.3)</td>
<td>9.710</td>
</tr>
<tr>
<td>Meconium aspirator</td>
<td>111 (94.1)</td>
<td>126 (86.9)</td>
<td>32 (84.2)</td>
<td>3.790</td>
</tr>
<tr>
<td>Umbilical catheters</td>
<td>16 (13.4)</td>
<td>7 (4.8)</td>
<td>1 (2.6)</td>
<td>8.314</td>
</tr>
</tbody>
</table>

**Table 4. Change in asphyxia incidence and mortality from asphyxia for 2003 to 2008 in selected hospitals of the 20 target provinces**

<table>
<thead>
<tr>
<th>Years</th>
<th>Delivery room</th>
<th>Number of deaths due to asphyxia at delivery</th>
<th>Asphyxia incidence (%)</th>
<th>Mortality from asphyxia in delivery room (/10,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>1015</td>
<td>1261.552</td>
<td>6.32</td>
<td>7.55</td>
</tr>
<tr>
<td>2004</td>
<td>1015</td>
<td>1324.85</td>
<td>6.09</td>
<td>7.52</td>
</tr>
<tr>
<td>2005</td>
<td>1015</td>
<td>1340.04</td>
<td>5.95</td>
<td>7.24</td>
</tr>
<tr>
<td>2006</td>
<td>1015</td>
<td>1430.75</td>
<td>5.85</td>
<td>7.18</td>
</tr>
<tr>
<td>2007</td>
<td>1015</td>
<td>1480.00</td>
<td>5.73</td>
<td>7.10</td>
</tr>
<tr>
<td>2008</td>
<td>1015</td>
<td>1491.25</td>
<td>5.61</td>
<td>7.04</td>
</tr>
</tbody>
</table>

**Table 5. Asphyxia incidence and mortality from asphyxia in 2003 and 2008 by hospital level in selected hospitals of the 20 target provinces**

<table>
<thead>
<tr>
<th>Hospital level</th>
<th>Live births</th>
<th>Number with birth asphyxia</th>
<th>Number of deaths due to asphyxia at delivery</th>
<th>Asphyxia incidence (%)</th>
<th>Mortality from asphyxia in delivery room (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provincial (n=91)</td>
<td>83,230</td>
<td>5,454</td>
<td>57</td>
<td>6.550</td>
<td>6.850</td>
</tr>
<tr>
<td>2003</td>
<td>144,935</td>
<td>4,131</td>
<td>49</td>
<td>2,850</td>
<td>3.380</td>
</tr>
<tr>
<td>2008</td>
<td>134,479</td>
<td>7,219</td>
<td>101</td>
<td>6,310</td>
<td>8.820</td>
</tr>
<tr>
<td>Prefecture (n=122)</td>
<td>194,521</td>
<td>7,768</td>
<td>107</td>
<td>3,990</td>
<td>5.500</td>
</tr>
<tr>
<td>2003</td>
<td>194,521</td>
<td>7,768</td>
<td>107</td>
<td>3,990</td>
<td>5.500</td>
</tr>
<tr>
<td>County (n=36)</td>
<td>39,441</td>
<td>2,325</td>
<td>21</td>
<td>5,890</td>
<td>5.320</td>
</tr>
<tr>
<td>2003</td>
<td>59,124</td>
<td>1,015</td>
<td>14</td>
<td>1,170</td>
<td>2.370</td>
</tr>
<tr>
<td>2008</td>
<td>121,552</td>
<td>5,826</td>
<td>121,552</td>
<td>5,826</td>
<td>5.320</td>
</tr>
</tbody>
</table>

*Number of hospitals in which data were collected: 2003, 249; 2004, 254; 2005, 259; 2006, 264; 2007, 266; 2008, 267.*


should interventions for depressed infants be delayed until the 1-minute assessment.” According to the guideline, all newly born (an infant at the time of birth) should be identified by a rapid assessment of 4 characteristics (term gestation? Crying or breathing? Good muscle tone? Heart rate ≥100 per minute?) to see whether or not it requires resuscitation. If the answer to any of these 4 assessment is “no”, the infant should receive initial steps in stabilization or more following resuscitation actions. Approximately 60 seconds, also called the “Golden Minute” are allotted for completing the initial steps and reevaluating. At this time point, many of the elements contributing the Apgar score at 1 minute are altered and most depressed infants may get a higher score and are not diagnosed as birth asphyxia. Less than 1% of infants require extensive resuscitative measures. From this aspect we could conclude that NRP training prevent those depressed newly born from becoming asphyxia and thus decreased the asphyxia incidence.

Despite considerable reach and effectiveness of the intervention, the quality of instruction varied among the facilities surveyed. Very high demand for training resulted in large numbers of learners per course and limited the opportunities for skill practice. While over 90% of perinatal staff in the target provinces received training at the hospital level, only about 60% received training at higher levels in the training cascade, where instructors more consistently used case-based methods to practice skills. Most hospital-level trainings consisted of lectures, and learners had fewer opportunities for skill-building. A previous study showed that whether participate in neonatal resuscitation, time of practice skill-building. A previous study showed that major factors influencing the Megacode performance lectures, and learners had fewer opportunities for teaching no more than 5 learners, yields significantly limited the opportunities for skill practice. While over 90% of delivery rooms in target provinces were equipped with resuscitation bags, infant masks, laryngoscopes and radiant warmers; however, the availability of certain resuscitation equipment (i.e. meconium aspirators and intubation supplies) was still low, especially at the county level. Availability of resuscitation equipment also was more complete in delivery than operating rooms. In unanticipated cases needing resuscitation in the operating room, pediatricians often had to bring resuscitation equipment with them when responding to a call. This resulted in delay and decreased the success of resuscitation.

Achieving the goal of at least one person trained in neonatal resuscitation at every delivery requires continuation of the initiative. Challenges include not only the quality of instruction and availability of equipment, but also adherence to the resuscitation algorithm by learners. Turnover in staff and changes in resuscitation science both call for periodic renewal of training. Above all, achieving the goal of one skilled person present at every delivery necessitates extension of neonatal resuscitation to births occurring at the township clinic level as well as those occurring outside medical facilities. The impact of resuscitation training may be greater in those settings with higher mortality and fewer obstetrical resources for primary prevention.

Limitations of the evaluation centered on the generalizability of the sites evaluated and the international comparability of measures of clinical outcome. Selection of the sample for evaluation sought to obtain representation of the levels and geographic distribution of hospitals within the target area; however, bias in their selection cannot be excluded. The target area was not representative of large urban, coastal areas where sophisticated medical services exist, but many migrant populations have limited access to care. Definitions of asphyxia and measures of early neonatal mortality were not strictly comparable to international standards; for example, limited access to neonatal specialty care and ability to obtain follow-up through the first week or month of life prevented calculation of early neonatal mortality (7 days) or 28-day neonatal mortality. Improvements in obstetrical care might have also contributed to the reduction in Apgar scores≤7 at one minute.

In the future, programs should give priority to counties and townships, especially in rural areas and urban poor populations in order to reduce disparities in mortality between rural and urban areas and among regions. Essential resuscitation equipment and supplies should be available in all delivery settings. Care in grassroots health facilities should be improved to ensure that neonatal resuscitation reaches all births occurring within facilities and to attract women who still deliver outside health facilities.

Certification of instructors should continue at the provincial and prefecture levels. Renewal of instructor certification and updating of resuscitation guidelines/algorithm should coincide with the 5-year cycle for updating international resuscitation guidelines. Future trainings should focus on improving the practice opportunities of learners and promoting their practical skills rather than knowledge only. Effective mechanisms

Table 6. Application of the lives saved tool

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility births (%)</td>
<td>83</td>
</tr>
<tr>
<td>Effectiveness factor for neonatal resuscitation</td>
<td>0.3</td>
</tr>
<tr>
<td>Coverage for neonatal resuscitation (%)</td>
<td>Baseline 41.5</td>
</tr>
<tr>
<td></td>
<td>Projected 95</td>
</tr>
</tbody>
</table>

for monitoring and evaluation, including monitoring and technical support of resuscitation performance, timely documentation, and more feasible indicators for intrapartum-related health outcomes would aid in more comparably and accurately reflecting trends and causes of maternal and neonatal mortality. Therapeutic interventions for neonatal encephalopathy and follow-up of survivors of resuscitation for long-term morbidity will assume importance for improving not only survival, but the quality of survival.

The responsibilities of hospital-based instructors should include establishment of an NRP supervision team to provide quality training to hospital staff, utilization of the NRP algorithm, technical support, and perinatal/neonatal mortality audit. With a locus of training in each delivery facility, resuscitation becomes a focal point and a model for quality improvement. These measures are essential to strengthen and ensure equal access to technical support of resuscitation performance, timely documentation, and more feasible indicators for monitoring and evaluation, including monitoring and technical support of resuscitation performance, timely documentation, and more feasible indicators for intrapartum-related health outcomes would aid in more comparably and accurately reflecting trends and causes of maternal and neonatal mortality. Therapeutic interventions for neonatal encephalopathy and follow-up of survivors of resuscitation for long-term morbidity will assume importance for improving not only survival, but the quality of survival.

The responsibilities of hospital-based instructors should include establishment of an NRP supervision team to provide quality training to hospital staff, utilization of the NRP algorithm, technical support, and perinatal/neonatal mortality audit. With a locus of training in each delivery facility, resuscitation becomes a focal point and a model for quality improvement. These measures are essential to strengthen and ensure equal access to resuscitation at birth, which is a key component in operationalizing the government’s aim of building a “new socialist countryside” and promoting balanced development among regions in order to build a harmonious society.

REFERENCES


(Received November 23, 2011)

Edited by CHEN Li-min