



# Regionalization of neonatal intensive care in Korea

Yun Sil Chang, MD, PhD

Department of Pediatrics, Samsung Medical Center,  
Sungkyunkwan University School of Medicine, Seoul,  
Korea

Received: 2 November 2011, Accepted: 25 November 2011  
Corresponding author: Yun Sil Chang, MD, PhD  
Department of Pediatrics, Samsung Medical Center, Sung-  
kyunkwan University School of Medicine, 50 Irwon-dong,  
Gangnam-gu, Seoul 135-710, Korea  
Tel: +82-2-3410-3528, Fax: 02-3410-0049,  
E-mail: yschang@skku.edu

Copyright © 2011 by The Korean Pediatric Society

In the current era of low-birth rate in Korea, it is important to improve our neonatal intensive care and to establish an integrative system including a regional care network adequate for both high-risk pregnancies and high-risk newborn infants. Therefore, official discussion for nation-wide augmentation, proper leveling, networking, and regionalization of neonatal and perinatal care is urgently needed. In this report, I describe the status of neonatal intensive care in Korea, as well as nationwide flow of transfer of high-risk newborn infants and pregnant women, and present a short review of the regionalization of neonatal and perinatal care in the United States and Japan. It is necessary not only to increase the number of neonatal intensive care unit (NICU) beds, medical resources and manpower, but also to create a strong network system with appropriate leveling of NICUs and regionalization. A systematic approach toward perinatal care, that includes both high-risk pregnancies and newborns with continuous support from the government, is also needed, which can be spearheaded through the establishment of an integrative advisory board to propel systematic care forward.

**Key words:** High-risk newborns, High-risk pregnancy, Perinatal center, Transport, Transfer, Korea

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

## Introduction

The fertility rate in Korea has reduced to 1.149 per woman of child-bearing age in 2009, which is one of the lowest in the world<sup>1)</sup>. This low birth rate is emerging as one of the nation's most serious problems in Korea. Recently, the average age of mothers giving birth has significantly increased due to social and economic changes, and the fertility rate is dropping with this increasing maternal age<sup>2)</sup>. In addition, the increased use of recently developed assisted reproductive technologies has led to a simultaneous increase in multiple and preterm births<sup>3)</sup>. Providing adequate neonatal intensive care for high-risk newborns is essential for decreasing their mortality and morbidity, which ultimately reduces the future costs for their morbidity of whole nation.

Therefore, in the current period of low birth rate, absolute increases in the number of high-risk newborns, including premature and low-birth weight infants, requiring neonatal intensive care, has to be considered as the nation's most urgent health problem. Solving this problem requires a systematic national health plan, which needs to be established and followed as soon as possible. Most developed countries, including the United States (US) and Japan, despite having higher fertility rates compared to Korea, have already recognized the importance of improvement and regionalization of neonatal intensive care. Governments in many developed countries systemically support and manage the neonatal intensive care and the linked perinatal centers, and provide a health care system in which high-risk pregnancies and high-risk newborns can be treated adequately

and efficiently, in a timely manner. To deliver efficient perinatal and neonatal intensive care, the governments have built a network through nationwide regionalization.

The neonatal intensive care unit (NICU) in Korea has been developed since the 1980s and there has been much progress until now. However, there is still a lack of a large number of NICU beds. Moreover, sufficient official investment and discussion for achieving a well-distributed nationwide network and regionalization has not been undertaken yet.

Recently, the Committee for Data Collection and Statistics in the Society of Korean Neonatology has undertaken the survey for the nationwide status of NICU in 2010 with the support of the Management Center for Health Promotion<sup>4)</sup>. Here, a short review of the status of neonatal care in developed countries, including the US and Japan, and the current condition for networking and regionalization of neonatal intensive care in Korea are described.

### Status and regionalization of neonatal intensive care in the US

In the US, more than 30 years earlier than in Korea, in 1970s, management and regionalization of not only neonatal intensive care, but also perinatal care, including high-risk pregnancies, was systemized and established<sup>5)</sup>. The system focused on decreasing perinatal morbidity and mortality, along with providing high quality of care for high-risk pregnancies and high-risk newborns by the most efficient use of facilities and equipment, as well as highly trained personnel, and maximizing the effect of medical resource investments<sup>6)</sup>. In 1975, the perinatal and neonatal management was classified into 3 levels under the motto “Toward Improving Outcome of Pregnancy (TIOP)” (Committee on Perinatal Health, 1975)<sup>5,7)</sup> as follows.

<Level I: Primary medical center>

1. Pregnancies without complications
2. Nursery for normal newborns and newborns with minor medical problems

<Level II: Secondary medical center>

1. Pregnancies with mild complications
2. Neonatal intensive care unit for newborns with moderate medical problems

<Level III: Tertiary medical center>

1. Pregnancies with severe complications
2. Neonatal intensive care unit for newborns with severe medical problems.

Quantitative and qualitative improvement in NICUs, as well as NICU regionalization, resulted in integrative improvement of neonatal intensive care around the nation. In 1993, TIOPII (Toward Improving Outcome

of Pregnancy II, The 90s and Beyond) was launched to emphasize the importance of integrated and regionalized care system and classify the previous classification in more detail (Committee on Perinatal Health, 1993)<sup>8,9)</sup>. The levels of perinatal (Table 1)<sup>9)</sup> and intensive neonatal care treatment recently used in US are as following (Table 2)<sup>10)</sup>. Newborn transfer system holds a great value in the regionalized medical system. Transfer between levels I, II and III neonatal care centers is an important tool used to effectively distribute medical resources around the region. Transfer team is composed of nurses, respiratory treatment personnel, neonatal care doctors, residents or by other personnel, and ambulances, helicopters and fixed-wing aircrafts were being used as transport vehicles<sup>11)</sup>. Following the introduction of a centralized neonatal transfer service, response times improved significantly<sup>12)</sup>.

### Status and regionalization of neonatal intensive care in Japan

Neonatal care in Japan was supported by the government early on. Medical support for premature infants and reporting system for low-birth weight infants were introduced in 1958. In 1979, parts of obstetric and pediatric departments were combined as perinatal care system and operated regionalized perinatal medical centers based on the “Regionalization of neonatal care to improve newborn death rate” project. In 1984, Maternal Fetal Intensive Care Unit was set up as perinatal care units. In 1991, “Doctor Car” was first introduced to operate ambulances that focus on transfer of high-risk newborns between the medical centers. In 1995, Maternal and Child Health Law was revised and from the following year, one general perinatal care medical center per 1 million began to be built around the nation. These medical centers have been maintained and supported until today. A total of 242 regional perinatal care centers and 77 integrated general maternal-fetal medical centers now serve as the backbone of Japan’s perinatal care. Three central (super) perinatal care units were established in the most populated regions of Tokyo to deal with the highest-risk pregnancies and neonates from the entire nation<sup>13)</sup>. A total of 80 million Yens (Japanese currency) (1 billion KRW [Korean currency]) for regional centers, 140 million Yens (1.8 billion KRW) for integrated general centers, and 190 million Yens (2.5 billion KRW) for central centers are being supported by the government<sup>14)</sup>.

According to the Ministry of Health and Welfare in Japan, the Japanese government allocated 1.7 billion Yens (17.9 billion KRW) for the care of premature infants and 2.3 billion Yens (24.4 billion KRW) for perinatal care. The support and network for perinatal care is still increasing in Japan<sup>15)</sup>.

The death rate of low-birth weight newborns has been decreasing for the past 30 years in Japan due to continuous and systemic efforts driven

**Table 1. Definitions of Care at Perinatal Centers in the United States**

Service	Basic	Specialty	Subspecialty
Care provided			
Basic inpatient care for women and newborns without complications	×	×	×
High-risk pregnancies with moderate complications		×	×
Neonatal intensive care including ventilation			×
Inpatient care for critically ill neonates			×
Follow-up medical care of infants released from NICU			×
Follow-up developmental assessment			×
Consultation and referral arrangements			×
Transport service			×
Personnel			
Physician and nursing staff to care for uncomplicated pregnancy	×	×	×
Obstetrician		×	×
Pediatrician		×	×
Obstetric anesthesia			×
Neonatologist			×
Perinatal social worker			×
Genetic counselor			×
Pediatric subspecialists			
Pediatric surgery, subspecialties, and support services			×
Laboratories to assess fetal well-being and maturity		×	×
Level III ultrasound capability			×
Laboratories with microspecimen capability		×	×
Blood gases available on 24-hr basis			×

NICU, neonatal intensive care unit.

**Table 2. Proposed Uniform Definition of Levels of Neonatal Intensive Care in United States**

Level	Capabilities associated with highest level
I	Basic neonatal care: well-newborn nursery Neonatal resuscitation at every delivery Postnatal care to healthy newborns Stabilize and provide care for stable infants born at 35 to 37 wk gestation Stabilize newborns who are ill and infants born at <35 wk gestation until transfer to NICU
II	Specialty neonatal care: special care nursery
IIA	Resuscitate and stabilize preterm or ill infants before transfer to level III Provide care for infants born at >32 wk GA and weighing $\geq 1,500$ g without need for assisted ventilation Provide care for infants who are convalescing after intensive care
IIB	Mechanical ventilation for brief durations (<24 hr) or continuous positive airway pressure
III	Subspecialty NICU
IIIA	Care for infants born at >28 wk gestation and weighing >1,000 g Provide sustained life support limited to conventional mechanical ventilation Perform minor surgical procedures such as placement of central venous catheter or inguinal hernia repair
IIIB	Comprehensive care for extremely low birth weight infants ( $\leq 1,000$ g and $\leq 28$ wk GA) High-frequency ventilation and inhaled nitric oxide Prompt and on-site access to a full range of pediatric medical subspecialists Advanced imaging including CT, MRI, echocardiography Pediatric surgical specialists and pediatric anesthesiologists to perform major surgery such as ligation of PDA and repair of abdominal wall defects, NEC with bowel perforation, TEF or esophageal atresia, and myelomeningocele
IIIC	Provide ECMO and surgical repair of complex congenital cardiac malformations that require cardiopulmonary bypass

NICU, neonatal intensive care unit; GA, gestational age; CT, computed tomography; MRI, magnetic resonance imaging; PDA, patent ductus arteriosus; NEC, necrotizing enterocolitis; TEF, tracheoesophageal fistula; ECMO, extracorporeal membrane oxygenation.

by the government. The survival rate of extremely-low-birth weight newborn infants (<1,000 g) that requires the highest intensive care was improved from 44.7 in 1980<sup>16)</sup> to 83.0% in 2005<sup>17)</sup>. Currently, 80% of newborns survive regardless of their birth weight and finally, Japan currently has the lowest premature infant death rate in the world.

## Status and regionalization of neonatal intensive care in Korea

### 1. Changes in the number of total and regional NICU beds

From the national survey of the Committee for Data Collection and Statistics in the Society of Korean Neonatology for NICU status reported at October, 2010<sup>4)</sup>, number of real operating NICUs was 93 hospitals and operating NICU beds were 1,252. Compared to previous reports in 2006<sup>18)</sup>, the 2010 survey showed markedly decreased operating NICUs and NICU beds throughout the nation. Although a few NICUs and NICU beds were added or expanded due to regional demands, with or without support from the government, such as the project of “Regional NICU expansion” and “Regional Children’s Hospital” of the Ministry of Health and Welfare, a considerable number of NICUs have been closed or cut in size over the last 5 years (Table 3). The reasons behind this reduction were manifold. First, the inability of the hospital running the NICU to meet the requirement of legal NICU classification and standards for the facility and manpower enacted in 2006, thereby closing their NICU or reducing the number of beds. Secondly, a reduction in the number of obstetrical staff, which led to a decrease in deliveries, and a lack of medical staff available to treat high-risk newborns in NICU also led to the decrease in of functioning NICU beds.

**Table 3.** Changes in Number of Regional Operating NICUs and NICU Beds

Region	2005 <sup>18)</sup>	2009 <sup>19)</sup>	2010.10 <sup>4)</sup>
Seoul	586 (44)	480 (31)	476 (30)
Incheon	80 (4)	46 (4)	42 (4)
Gyeonggido	308 (23)	216 (20)	211 (17)
Gangwondo	55 (3)	31 (2)	37 (3)
Chungcheongdo	74 (5)	60 (5)	60 (3)
Daejeon	98 (5)	41 (3)	51 (3)
Jollado	57 (11)	47 (9)	37 (5)
Gwangju	64 (6)	62 (4)	48 (3)
Gyeongsangdo	58 (14)	122 (10)	105 (8)
Busan	169 (14)	90 (11)	97 (7)
Daegu	152 (7)	47 (6)	46 (5)
Ulsan	15 (4)	29 (3)	29 (3)
Jejudo	15 (3)	13 (2)	13 (2)
Total	1,731 (143)	1,284 (110)	1,252 (93)

Values are presented as no. of NICUs (no. of NICU Beds).  
NICU, neonatal intensive care unit.

All of the regional operating NICU and NICU beds were reduced, except in the Gyeongsangdo and Ulsan areas, as shown in Table 3.

### 2. Shortage of regional beds and medical resources of NICU

There were 444,849 total live births in 2009, in Korea<sup>1)</sup>. Comparison of the number of regional NICU beds to the total number of regional live births is shown in Table 4. Number of NICU beds are 0.3 to 5.3 per 1,000 live births, depending on the region, with large variability. Seoul has the highest number of beds and Jollanamdo has the lowest number of beds. Large cities such as Seoul, Daejeon, Busan, and Gwangju have more than 3.2 beds per 1,000 live births. However, the number of beds is very small in regions neighboring the 4 areas Gyeonggido, Chungcheongnamdo, Gyeongsangnamdo, and Jollanamdo. When the regions are classified based on larger geographical features, or areas (Table 5), variability in the number of NICU beds are slightly decreased, to 1.8 to 3.2 per 1,000 live births, depending on the area. It can be expected that high-risk newborns are being transferred to neighboring regions. For instance, Seoul may be used to compensate for the required beds in the Gyeonggido region.

On the scope of medical resources, Gyeongsangbukdo, Ulsan, and Jollanamdo, still have less than 0.3 mechanical ventilators per NICU bed (Table 5), and only 1 or 0 neonatologists (Table 6), as well as the lowest number of NICU beds per 1000 live births amongst all the national regions. Therefore, those regions do not have enough medical resources to provide adequate emergency neonatal intensive care.

According to the national survey report for 2006<sup>18)</sup> and 2010<sup>4)</sup>, 3.2

**Table 4.** Regional NICU Beds per 1,000 Live-Births

Region	2009 Korean Statistics Total live-births <sup>1)</sup>	NICU beds	NICU beds per 1,000 live-births
Seoul	89,595	476	5.3
Incheon	24,379	42	1.7
Gyeonggido	113,691	211	1.9
Gangwondo	12,112	37	3.1
Chungcheongbukdo	13,903	25	1.8
Daejeon	13,915	51	3.7
Chungcheongnamdo	19,257	35	1.8
Daegu	19,399	46	2.4
Gyeongsangbukdo	22,373	49	2.2
Busan	25,110	97	3.9
Ulsan	11,033	25	2.3
Gyeongsangnamdo	30,320	60	2.0
Jollabukdo	15,233	27	1.8
Gwangju	13,101	48	3.7
Jollanamdo	15,995	10	0.6
Jejudo	5,433	13	2.4
Total	444,849	1,252	2.8

NICU, neonatal intensive care unit.

**Table 5.** Areal NICU Beds per 1,000 Live-Births

Area (Integrative Region)	2009 Korean Statistics Total live-births <sup>1)</sup>	NICU beds	NICU beds per 1,000 live-births
Seoul, Incheon, Gyeonggido	227,665	729	3.2
Gangwondo	12,112	37	3.1
Chungcheongdo, Daejeon	47,075	111	2.4
Daegu, Gyeongsangbukdo	41,772	95	2.3
Busan, Ulsan, Gyeongsangnamdo	66,463	182	2.7
Jollabukdo	15,233	27	1.8
Gwangju, Jollanamdo	29,096	58	2.0
Jejudo	5,433	13	2.4
Total	444,849	1,252	2.8

NICU, neonatal intensive care unit.

**Table 6.** Regional Medical Resources of Neonatal Intensive Care

	No. of NICU	NICU beds	Ventilator	Ventilator per NICU beds	No. of doctors on call	No. of neonatologists
Seoul	30	476	228	0.48	50	40
Incheon	4	42	26	0.62	6	3
Gyeonggido	17	211	103	0.49	19	14
Gangwondo	3	37	16	0.43	4	3
Chungcheongbukdo	1	25	10	0.40	1	1
Daejeon	3	51	28	0.55	6	4
Chungcheongnamdo	2	35	14	0.40	3	2
Daegu	5	46	29	0.63	7	6
Gyeongsangbukdo	3	49	10	0.20	6	1
Busan	7	97	56	0.58	14	9
Ulsan	2	25	7	0.28	3	1
Gyeongsangnamdo	4	60	26	0.43	6	3
Jollabukdo	3	27	15	0.56	4	3
Gwangju	3	48	25	0.52	4	3
Jollanamdo	2	10	3	0.30	8	0
Jejudo	2	13	6	0.46	2	2
Total	91*	1,252	596	0.48	142	95

NICU, neonatal intensive care unit.

\*Hospital surveyed.

to 3.4 neonatal intensive care beds are needed per 1,000 live births, and 4.1 to 4.5 beds per 1,000 live births are needed, including the operation of supplementary beds. Therefore, more than 1.0 bed per 1,000 live births is needed in all of the regions, and even more in larger areas. Therefore, it is required to increase the number of beds and medical resources, including medical equipment and manpower, nationwide with proper allocation for the establishment of regionalization and network for neonatal care.

### 3. Transfer flow of high-risk newborn

Table 7 shows the flow of 929 neonatal patients in July 2010, reported in the 2010 survey<sup>4)</sup>. When the nation is divided into 16 regions by cities and provinces, 749 newborns (80.6%) were transferred

within the region and 180 newborns (19.4%) were transferred out of region. Therefore, approximately 20% of the high-risk newborns were transferred out of the region. If the nation was divided into 8 integral areas by grouping: Seoul, Incheon, and Gyeonggido as Region 1; Gangwondo as region 2; Chungcheongbukdo, Chungcheongnamdo, and Daejeon as Region 3; Daegu and Gyeongsangbukdo as Region 4; Jollabukdo as Region 5; Gwangju and Jollanamdo as Region 6; Gyeongsangnamdo, Busan, and Ulsan as Region 7; and Jejudo as Region 8. Except the transfer to Seoul from all other integral regions, all of the transfers were made within each integral area. Therefore, in the future, regionalization of neonatal intensive care has to be set up by establishment of integral area NICU centers with careful consideration of proximity of neighboring regions, availability of

**Table 7. Regional Transfer of High-Risk Newborn Infant during July, 2010<sup>4)</sup>**

Transfer to	Seoul	Incheon	Gyeonggido	Gangwondo	Chungcheongbukdo	Daejeon	Chungcheongnamdo	Daegu	Gyeongsangbukdo	Busan	Ulsan	Gyeongsangnamdo	Jollabukdo	Guangzhou	Jollanamdo	Jejudo	Transfer Within region	Transfer out of region	Total
Seoul	216	8	49	0	0	1	3	0	0	1	0	0	1	0	0	1	216	64	280
Incheon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyeonggido	13	0	151	0	0	0	0	0	0	0	0	0	0	0	0	0	151	13	164
Gangwondo	1	0	16	27	3	0	0	0	1	0	0	0	0	0	0	0	27	21	48
Chungcheongbukdo	0	0	0	0	38	1	0	0	0	0	0	0	0	0	0	0	38	1	39
Daejeon	0	0	0	0	0	43	2	0	0	0	0	0	0	0	0	0	43	2	45
Chungcheongnamdo	0	0	8	0	0	1	34	0	0	0	0	0	0	0	0	0	34	9	43
Daegu	0	0	0	0	1	0	0	49	12	0	0	0	0	0	0	0	49	13	62
Gyeongsangbukdo	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	5	1	6
Busan	0	0	0	0	0	0	0	0	0	88	1	10	0	0	0	0	88	11	99
Ulsan	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	9	0	9
Gyeongsangnamdo	0	0	1	0	0	0	0	0	1	13	4	24	0	0	1	0	24	20	44
Jollabukdo	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	13	0	13
Gwangju	0	0	0	0	0	0	0	0	0	0	0	0	1	49	24	0	49	25	74
Jollanamdo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
Jejudo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2
Transfer out of region	14	8	74	0	4	3	5	1	14	14	5	10	2	0	25	1			180
Total	230	8	225	27	42	46	39	50	19	102	14	34	15	49	26	3	749	180	929

**Table 8. Regional Transfer of High-Risk Pregnant Women during Two Weeks of July, 2010<sup>4)</sup>**

Transfer to	Seoul	Incheon, Gyeonggido	Kangwondo	Chungcheongbukdo	Daejeon, Chungcheongnamdo	Daegu, Gyeongsangbukdo	Busan, Ulsan, Gyeongsangnamdo	Jollabukdo	Guangzhou, Jollanamdo	Jejudo	Transfer within region	Transfer out of region	Total
Seoul	95		1			1	1				95	3	98
Incheon, Gyeonggido	42	47		12	3			1			47	58	105
Kangwondo	5		14					1			14	6	20
Chungcheongbukdo			2	10	1						10	3	13
Daejeon, Chungcheongnamdo	5	1			36			1			36	7	43
Daegu, Gyeongsangbukdo	3					24					24	3	27
Busan, Ulsan, Gyeongsangnamdo							33				33	0	33
Jollabukdo	1	1			1			10			10	3	13
Gwangju, Jollanamdo								47			47	0	47
Jejudo										1	1	0	1
Transfer within region	56	2	3	12	5	1	1	0	3	0			
Total	151	49	17	22	41	25	34	10	50	1	317	83	400

traffic routes, and effective use of available beds. It is also evident that there are special needs for transfer of high-risk newborns, because of the need for highly-selective specialized surgery or high-end specialized care, or of lack of availability of regional NICU beds for super-emergent cases. Like super perinatal care centers in Tokyo, Japan, we need to create national integrative care centers to serve the purpose of high-end and super-emergency neonatal care, and a final referral center. Since very large NICUs that handle more than 100 very-low birth weight newborn infants are located in Seoul, rather than to expand NICU beds in the Seoul area, it is advisable to set up or use big centers in Seoul as the final referral super center for the entire nation. Moreover, it is important to create a network with other regional and more integrative area NICUs around the nation. There is a need to classify the level of neonatal intensive care units in Korea, like in the US. Therefore, it is needed to effectively distribute the medical resources for neonatal care through proper leveling, regionalization and networking of neonatal care in Korea.

#### 4. Transfer flow of high-risk pregnancies

Table 8 shows the transfer flow of high-risk pregnancies during 2 weeks of July 2010, reported in the 2010 survey<sup>4)</sup>. A total of 400 high-risk pregnant women were transferred to other hospitals and 83 patients (21%) were transferred out of region. Among 447 transfer contacts, 311 patients (69.6%) were actually accepted in the first hospital/medical center to which they were requested for being transferred; however, 127 patients were denied their transfer in the first contact to transfer. The reason for denying the transfer was, 50% due to lack of NICU beds, 29.3% due to unavailability of mechanical ventilator in the NICU, 7.1% due to difficulties in surgery and special care, and 5.0% due to lack of medical personnel resources in NICU and delivery room. The transfer flow of high-risk pregnant women was very similar to transfer flow of high-risk newborns. Approximately 20% of the patients were transferred out of region and 70% of the patients were accepted on the first hospital/medical center to which

they were requested for being transferred whereas the remaining 30% were wandering to find a hospital for their care. Since most of the denials for transfer were due to lack of medical resources in the NICU, management of high-risk pregnancies and high-risk newborns cannot be separated from one another. A perinatal approach, that includes both high-risk pregnancies and newborns, is needed when establishing the policies for their care.

## Conclusion

Neonatal intensive care for high-risk newborns is a major health issue that should be supported by the government, as discussed in the cases of the US and Japan. Neonatal intensive care policies of advanced countries may be summarized as follows. First, the policies accommodate perinatal care and transport systems, including high-risk pregnant women and high-risk newborns. Second, the policies level and regionalize the high-risk newborn infant care system using expert groups and instating clear legislation. Third, there is continuous support from the government for systematically constructing high-risk neonatal and perinatal care systems. Fourth, there is an effective distribution and use of medical resources, by establishment of a clear transfer system and regionalization.

In Korea, it is evident that there is a shortage of NICU beds and medical resources nationwide, with varying degrees across regions, and a lack of systemic perinatal and neonatal regional networking. In the recent analysis on transferred high-risk newborns and pregnant women, about 20% were transferred beyond their location, while most of them were transferred in the vicinity of their original location. Seoul tended to have patients transferred from all the parts of the country. As most high-risk newborn infants are transferred within the neighboring region, regional care centers should be upgraded, and there seems to be a need to bolster a few national central centers in Seoul for taking care of patients transferred from other regional medical centers, to provide challenging high-end treatments. The main cause for the transfer of high-risk pregnant women was the deficits of beds and medical resources of NICU, which were the same deficits that applied to high-risk newborn transfers. The success rate of transfers was only about 70%. Ultimately, to complete the health care system of high-risk newborns in the era of low-birth rates, an absolute increase in the number of NICU beds, along with proper equipment, facilities, and manpower, and the completion of proper transfer system through regionalization and leveling of NICUs are needed. Further, a systematic approach toward perinatal care that includes both high-risk pregnancies and newborns is needed, as well as the establishment of an integrative advisory board to drive the momentum of systematic approach. Establishment of regionalized perinatal centers, including

those that can accommodate high-risk pregnancies and neonatal intensive care through a nationwide network will result in improving the outcome of high-risk newborns. Such a system will help improve the health and save the lives of thousands of newborns and provide an effective solution for low-birth rate issues in Korea.

## Acknowledgement

This study was supported by the Health Promotion Fund, Ministry for Health, Welfare and Family Affairs, Republic of Korea (Policy 10-11).

## References

1. Statistic Korea, Korean Statistical Information Service. Birth [Internet]. Daejeon: Statistics Korea; c1996 [cited 2011 Nov 11]. Available from <http://www.kosis.kr>.
2. Moon JY, Hahn WH, Shim KS, Chang JY, Bae CW. Changes of maternal age distribution in live births and incidence of low birth weight infants in advanced maternal age group in Korea. *Korean J Perinatol* 2011;22:30-6.
3. Park YS, Choi SH, Shim KS, Chang JY, Hahn WH, Choi YS, et al. Multiple births conceived by assisted reproductive technology in Korea. *Korean J Pediatr* 2010;53:880-5.
4. Chang YS (The Committee on Data Collection and Statistics of the Korean Society of Neonatology). The survey on the actual conditions of neonatal intensive care units and analysis of survival rate of high-risk newborn infants. 2010 Report of Management Center for Health Promotion 2010. Seoul: The Korean Society of Neonatology, 2010.
5. Committee on Perinatal Health. Toward improving the outcome of pregnancy: recommendations for the regional development of maternal and perinatal health services. New York: National Foundation-March of Dimes, 1976.
6. Bode MM, O'shea TM, Metzguer KR, Stiles AD. Perinatal regionalization and neonatal mortality in North Carolina, 1968-1994. *Am J Obstet Gynecol* 2001;184:1302-7.
7. Ryan GM Jr. Toward improving the outcome of pregnancy recommendations for the regional development of perinatal health services. *Obstet Gynecol* 1975;46:375-84.
8. Little GA, Merenstein GB. Toward improving the outcome of pregnancy, 1993: perinatal regionalization revisited. *Pediatrics* 1993;92:611-2.
9. Committee on Perinatal Health; March of Dimes Birth Defects Foundation. Toward improving the outcome of pregnancy: the 90s and beyond. New York: March of Dimes Birth Defects Foundation, 1993.
10. Stark AR; American Academy of Pediatrics Committee on Fetus and Newborn. Levels of neonatal care. *Pediatrics* 2004;114:1341-7.
11. Thompson TR. Neonatal transport nurses: an analysis of their role in the transport of newborn infants. *Pediatrics* 1980;65:887-92.
12. Kempley ST, Baki Y, Hayter G, Ratnavel N, Cavazzoni E, Reyes T, et al. Effect of a centralised transfer service on characteristics of inter-hospital neonatal transfers. *Arch Dis Child Fetal Neonatal Ed* 2007;92:F185-8.
13. Bae CW. Bench-marking of Japanese perinatal center system for improving maternal and neonatal outcome in Korea. *Korean J Perinatol* 2010;21:129-39.

14. Japan Association of Obstetrics and Gynecologists. Perinatal maternal and child health center [Internet]. Tokyo: Japan Association of Obstetrics and Gynecologists, c2008 [cited 2011 Nov 11]. Available from: <http://www.jaog.or.jp/JAPANESE/jigyō/JYOSEI/center.htm>.
15. Japan Ministry of Health Labor and Welfare [Internet]. Tokyo: Japan Ministry of Health Labor and Welfare, [c2011] [cited 2011 Nov 11]. Available from: <http://www.mhlw.go.jp/english/>.
16. Hahn WH, Chang JY, Chang YS, Shim KS, Bae CW. Recent trends in neonatal mortality in very low birth weight Korean infants: in comparison with Japan and the USA. *J Korean Med Sci* 2011;26:467-73.
17. Itabashi K, Horiuchi T, Kusuda S, Kabe K, Itani Y, Nakamura T, et al. Mortality rates for extremely low birth weight infants born in Japan in 2005. *Pediatrics* 2009;123:445-50.
18. Shin SM (The Committee on Data Collection and Statistics of the Korean Society of Neonatology). Establishment of and effective health care system for high risk newborn infants. 2006 Report of Management Center for Health Promotion 2006. Seoul: The Korean Society of Neonatology, 2006.
19. Kang BH, Jung KA, Hahn WH, Shim KS, Chang JY, Bae CW. Regional analysis on the incidence of preterm and low birth weight infant and the current situation on the neonatal intensive care units in Korea, 2009. *J Korean Soc Neonatol* 2011;18:70-5.