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Improved Outcomes of Very Low Birth Weight Infants in Korea: 2015–2016 vs. 2021–2022 From the Korean Neonatal Network

In Gyu Song,[1] **Jae Woo Lim**,[2] **Yun Sil Chang**,[3,4] **and the Korean Neonatal Network**

[1]Department of Pediatrics, Yonsei University College of Medicine, Seoul, Korea
[2]Department of Pediatrics, Konyang University College of Medicine, Daejeon, Korea
[3]Department of Pediatrics, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea
[4]Department of Health Sciences and Technology, Samsung Advanced Institute for Health Sciences & Technology, Sungkyunkwan University, Seoul, Korea

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Address for Correspondence:
Yun Sil Chang, MD, PhD
Department of Pediatrics, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Korea.
Email: yschang@skku.edu

ORCID iDs
In Gyu Song
https://orcid.org/0000-0002-3205-9942
Jae Woo Lim
https://orcid.org/0000-0003-2001-0727
Yun Sil Chang
https://orcid.org/0000-0001-9201-2938

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ABSTRACT

Background: This study aimed to analyze improvements in the survival rates and morbidities of very low birth weight infants (VLBWIs) in the Republic of Korea from 2015 to 2022.
Methods: Data from the Korean Neonatal Network were used to assess survival and morbidity trends among VLBWIs, particularly focusing on changes across different gestational ages. The analysis included a comparison with data from other neonatal networks, such as the Australian and New Zealand Neonatal Network, Canadian Neonatal Network, Swedish Neonatal Quality Register, Neonatal Research Network Database Japan, and United States National Vital Statistics Reports, to understand differences in survival and morbidity outcomes.
Results: The survival rate of VLBWIs in Korea rose from 86% in 2015–2016 to 91% in 2021–2022. This increase was most notable in infants born before 28 gestational weeks, with significant gains observed among those born at 24 (67% in 2021–2022 compared with 51% in 2015–2016, $P < 0.001$), 25 (80% in 2021–2022 versus 66% in 2015–2016, $P < 0.001$), and 26 (89% in 2021–2022 compared to 79% in 2015–2016, $P < 0.001$) gestational weeks. Compared with other networks, the survival rates of Korean VLBWIs, except for infants born before 24 gestational weeks whose survival rates remain significantly lower, have largely caught up with those of high-income countries. The incidence of major morbidities such as severe intraventricular hemorrhage, necrotizing enterocolitis, and sepsis also showed a decreasing trend. However, incidence rates of bronchopulmonary dysplasia and periventricular leukomalacia remained relatively high, especially for infants born before 24 gestational weeks.
Conclusion: Although outcomes have improved significantly in Korea, further efforts are needed to enhance survival rates of infants born before 24 gestational weeks. Focused interventions and improvements in clinical practices are essential to achieve better outcomes for these vulnerable infants.

Keywords: Infant; Very Low Birth Weight; Intensive Care Units, Neonatal; Survival Rate; Morbidity; Korea

Author Contributions

Conceptualization: Song IG, Lim JW, Chang YS. Data curation: Song IG, Lim JW. Formal analysis: Song IG. Investigation: Song IG, Lim JW, Chang YS. Methodology: Song IG, Lim JW, Chang YS. Validation: Song IG. Visualization: Song IG, Chang YS. Writing - original draft: Song IG. Writing - review and editing: Lim JW, Chang YS.

INTRODUCTION

Globally, birth rates are decreasing[1]; however, the proportion of preterm and low birth weight infants has been increasing, reaching approximately 10%.[2] The Republic of Korea, a representative low-birth-rate country, recorded a reduction in its total fertility rate to 0.72 in 2023, with 9.8% of births being preterm.[3] Among premature infants, very preterm infants, that is, those born before 32 gestational weeks or weighing less than 1,500 g (very low birth weight infants, VLBWIs), face significant risks of early morbidity and mortality, necessitating long-term follow-up care.[4-6] Accordingly, many countries have established neonatal networks to register and monitor the data of these high-risk infants.[7-10] Cross-network collaborations, such as the International Network for Evaluation of Outcomes of Neonates (iNEO) and Asian Neonatal Network Collaboration (AsianNeo), allow for comparative studies of neonatal outcomes and facilitate research that supports each network's quality improvement initiatives.[11-13] The Korean Neonatal Network (KNN) was established in 2013 by the Korean Society of Neonatology and Korea Centers for Disease Control and Prevention to improve outcomes for VLBWIs in Korea.[14]

The KNN, a prospective nationwide registry, now collects data from 78 neonatal intensive care units (NICUs) and had registered over 24,000 infants as of October 2024. In 2022, 1,826 out of 2,018 (90.5%) VLBWIs born in Korea were registered.[15] Initially focused on VLBWIs, the KNN expanded in 2022 to include all infants born at less than 32 gestational weeks, regardless of birth weight, significantly broadening its scope. In addition to supporting neonatal care improvements, the KNN has facilitated research, with 187 submitted proposals and 107 published papers to date. Through its annual reports on survival rates and morbidities, as well as quality improvement initiatives, the KNN remains instrumental in enhancing the care of high-risk infants in Korea.[14,16-19]

This study aimed to examine changes in major morbidities and survival among infants registered in the KNN from 2015 to 2022 and compare these outcomes with data from other neonatal networks worldwide, particularly in high-income countries.

METHODS

Data collection

This research utilized data from the annual KNN reports covering the years 2015 to 2022. A total of 16,967 VLBWIs born at the gestational age of 22 weeks or more between January 1, 2015 and December 31, 2022 are included in the KNN registry. The number of VLBWIs enrolled each year was 2,392, 2,358, 2,136, 2,125, 2,000, 1,825, 1,803, and 2,328, respectively (the increase in 2022 reflects the inclusion of infants born at less than 32 gestational weeks).

To compare the outcomes in Korea with those of other countries, publicly available data from international neonatal networks were utilized. These data were annual reports published in 2015 and 2022 by the Australian and New Zealand Neonatal Network (ANZNN), Canadian Neonatal Network (CNN), and Swedish Neonatal Quality Register (SNQ) were used.[7-9] Regarding the SNQ data, information for 2015 did not include infants born at 28 gestational weeks. Additionally, as specific data for 2022 were not available, aggregated data from 2018 to 2022 were used for the analysis. For Japan, data from the Neonatal Research Network Database Japan was not easily accessible through public sources, so information was

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requested via email. Data from the Period/Cohort Linked Birth-Infant Death Data Files provided by the National Center for Health Statistics were utilized to analyze infant mortality rates in the United States.[20]

Variables

Definitions of variables are outlined as follows. Bronchopulmonary dysplasia (BPD) was evaluated at 36 weeks of postmenstrual age in patients who needed oxygen with an FiO_2 greater than 0.21 or who required positive pressure ventilation, which aligns with the moderate to severe BPD classification as per the 2001 criteria established by the National Institute of Child Health and Human Development.[21] The incidence of BPD by grade was calculated based on the number of infants who survived to a postmenstrual age of 36 weeks and were evaluated for BPD grade. Other conditions assessed included patent ductus arteriosus (PDA), necrotizing enterocolitis (NEC, stage ≥ 2),[22] retinopathy of prematurity (ROP),[23] intraventricular hemorrhage (IVH, grade ≥ 3),[24] cystic periventricular leukomalacia (PVL), and culture-confirmed sepsis. The proportion of infants who underwent PDA surgery was calculated as the ratio of infants with symptomatic PDA to those who underwent PDA surgery. Additionally, the rate of ROP that required surgery was assessed only among infants diagnosed with ROP, rather than all infants. The incidence of other diseases was calculated by dividing the number of affected infants by the evaluated number of infants. Among the above-mentioned morbidities, only the condition for which calculations could be made using the same criteria were compared with the ANZNN data. Survival rate was defined as and calculated based on infants who were alive at the time of NICU admission and discharged alive, excluding those who died in the delivery room. This definition has been applied consistently across networks in other countries. However, in the United States, survival is defined as infants who survive up to 1 year of age, according to the Period/Cohort Linked Birth-Infant Death Data.

Statistical analysis

We analyzed survival rates and neonatal complications in VLBWIs across different gestational ages and time periods. Data were grouped in 2-year intervals from 2015 to 2022, and gestational age was categorized into four groups: 22–25, 26–27, 28–31, and ≥ 32 weeks. To examine differences in survival rates by country, we compared the KNN data with that of international neonatal networks. Changes in neonatal outcomes and survival rates over time were assessed using linear regression, while comparisons between two groups, such as different time periods, were conducted using the chi-square test. Categorical variables are presented as percentages with their respective ranges of probability (95% confidence intervals). Statistical analysis was performed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA), and a *P* value of less than 0.05 was considered statistically significant.

Ethics statement

This study utilized data from published annual reports and therefore did not require Institutional Review Board approval, as all data were anonymized and publicly available.

RESULTS

Maternal and neonatal characteristics

Table 1 summarizes the maternal and neonatal characteristics of VLBWIs in Korea from 2015 to 2022. A trend analysis was conducted to observe changes over time. Regarding maternal

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Table 1. Maternal and neonatal characteristics of very low birth weight infants in Korea (2015–2022)

Characteristics	2015–2016	2017–2018	2019–2020	2021–2022	*P* value
Maternal characteristics					
Multiple gestation					0.166
Singleton	64 (63 to 64)	64 (58 to 71)	59 (56 to 63)	60 (60 to 60)	
Twin	32 (31 to 32)	31 (25 to 38)	35 (33 to 38)	35 (32 to 38)	
≥ Triplet	5 (3 to 6)	4 (4 to 5)	5 (5 to 6)	5 (2 to 8)	
Method of pregnancy					0.040
Natural	76 (75 to 77)	75 (71 to 79)	67 (66 to 69)	64 (63 to 66)	
Assisted reproductive technology	24 (23 to 25)	25 (21 to 29)	33 (31 to 34)	36 (34 to 37)	
Cesarean section	79 (78 to 81)	81 (79 to 83)	82 (82 to 83)	85 (84 to 86)	0.019
Gestational diabetes mellitus	8 (6 to 9)	9 (7 to 11)	11 (10 to 12)	14 (12 to 16)	0.024
Pregnancy induced hypertension	19 (18 to 19)	20 (18 to 22)	21 (20 to 22)	22 (18 to 26)	< 0.001
Histologic chorioamnionitis	29 (27 to 32)	30 (30 to 30)	28 (27 to 29)	26 (25 to 27)	0.168
Premature rupture of membrane	35 (34 to 35)	33 (31 to 35)	35 (33 to 37)	34 (28 to 39)	0.865
Antenatal steroid therapy	78 (73 to 84)	84 (83 to 85)	87 (87 to 87)	89 (89 to 89)	0.031
Neonatal characteristics					
Intubation at delivery	62 (56 to 68)	56 (55 to 58)	53 (53 to 54)	47 (44 to 52)	0.008
Cardiac compression at delivery	5 (4 to 6)	5 (5 to 5)	3 (3 to 4)	3 (3 to 4)	0.106
Respiratory distress syndrome	78 (75 to 81)	77 (77 to 77)	74 (74 to 75)	73 (71 to 75)	0.024
Air leak	5 (5 to 6)	6 (5 to 6)	4 (4 to 5)	4 (4 to 4)	0.326
Massive pulmonary hemorrhage	6 (6 to 6)	6 (5 to 7)	5 (5 to 5)	4 (2 to 5)	0.056
Postnatal steroid therapy	21 (18 to 25)	24 (22 to 26)	24 (20 to 28)	23 (22 to 24)	0.452

Each cell shows the percentage for the corresponding period, with the range of probability (95% confidence interval) indicated in parentheses.
P values are based on trend analysis.

characteristics, the rate of cesarean sections significantly increased ($P = 0.019$), as did the use of assisted reproductive technology (ART) ($P = 0.040$). Additionally, the prevalence of gestational diabetes mellitus ($P = 0.024$) and pregnancy-induced hypertension ($P < 0.001$) showed significant increases. Similarly, antenatal steroid use also showed a significant upward trend ($P = 0.031$). Regarding neonatal characteristics, the need for intubation at delivery significantly decreased over time ($P = 0.008$), while respiratory distress syndrome incidence also declined slightly ($P = 0.024$).

Neonatal morbidities according to gestational age and in comparing to the ANZNN data

Table 2 presents the major morbidities among VLBWIs in Korea from 2015 to 2022. BPD incidence increased significantly, particularly among infants born before 28 gestational weeks, when comparing 2015–2016 with 2021–2022. The proportion of infants with PDA who underwent surgery significantly declined, especially in infants born at 26–27 weeks, reducing from 40% in 2015–2016 to 23% in 2021–22. NEC incidence decreased for infants born at 26–27 weeks, from 11% to 6%, but remained high (16%) for those born at 22–25 weeks. ROP requiring surgery showed a decline in incidence, particularly for 22–25 weeks, from 45% in 2015–2016 to 37% in 2021–2022. IVH (grade ≥3) incidence reduced from 9% to 6%, with a notable decline from 30% to 22% for those born at 22–25 weeks. PVL incidence remained high, particularly at 11–15% for infants born at 22–25 weeks. Sepsis incidence significantly declined from 20% to 12%, especially in infants born before 32 gestational weeks.

The comparison between the KNN and ANZNN revealed differences in major morbidities among VLBWIs. The incidence of BPD was similar, but it was higher in ANZNN for most gestational ages. NEC was more prevalent in the KNN, particularly in infants born at 22–27 weeks (13% vs. 9%). IVH incidence was notably higher in the KNN cohort for infants born at 22–25 weeks (22% vs. 19%). PVL incidence was generally higher across all gestational ages

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Table 2. Major morbidities of very low birth weight infants by gestational age in Korea (2015–2022)

Major morbidities by gestational age groups, wk	2015–2016 (n = 4,748)	2017–2018 (n = 4,260)	2019–2020 (n = 3,824)	2021–2022 (n = 4,134)	*P* value	*P'* value
BPD, moderate to severe	29 (17 to 51)	33 (21 to 55)	34 (19 to 53)	31 (18 to 53)	0.592	0.039
22–25	69 (63 to 99)	83 (81 to 90)	79 (74 to 97)	81 (77 to 98)	0.336	< 0.001
26–27	46 (34 to 60)	53 (39 to 68)	54 (44 to 65)	53 (40 to 67)	0.232	0.020
28–31	21 (12 to 28)	25 (15 to 32)	26 (17 to 34)	22 (13 to 32)	0.783	0.460
≥ 32	5 (1 to 6)	8 (3 to 10)	4 (1 to 6)	7 (2 to 7)	0.859	0.195
PDA, underwent surgery	34 (15 to 35)	36 (17 to 34)	33 (23 to 41)	22 (13 to 36)	0.200	< 0.001
22–25	44 (36 to 47)	43 (35 to 47)	39 (30 to 42)	34 (27 to 38)	0.034	0.005
26–27	40 (28 to 52)	43 (41 to 45)	37 (28 to 45)	23 (19 to 28)	0.168	< 0.001
28–31	23 (14 to 28)	26 (20 to 30)	24 (21 to 28)	10 (7 to 13)	0.272	< 0.001
≥ 32	18 (2 to 24)	20 (0 to 22)	27 (11 to 54)	20 (−1 to 58)	0.575	0.727
NEC, stage ≥ 2	7 (3 to 9)	7 (3 to 10)	6 (4 to 7)	5 (2 to 8)	0.056	0.002
22–25	15 (13 to 19)	17 (13 to 19)	14 (11 to 18)	16 (13 to 18)	1.000	0.679
26–27	9 (7 to 11)	11 (10 to 13)	8 (7 to 9)	6 (5 to 6)	0.256	0.006
28–31	4 (3 to 5)	4 (2 to 5)	4 (2 to 6)	3 (2 to 4)	0.225	0.187
≥ 32	2 (0 to 2)	1 (0 to 2)	1 (0 to 1)	1 (0 to 1)	0.225	0.061
ROP, underwent surgery	26 (10 to 24)	25 (8 to 24)	23 (5 to 22)	22 (8 to 31)	0.010	0.065
22–25	45 (40 to 62)	44 (28 to 65)	37 (24 to 51)	37 (27 to 67)	0.080	0.029
26–27	23 (17 to 29)	24 (16 to 31)	23 (9 to 36)	21 (20 to 21)	0.282	0.490
28–31	10 (4 to 12)	10 (3 to 12)	10 (2 to 14)	8 (6 to 11)	0.225	0.566
≥ 32	0 (0 to 0)	3 (−1 to 2)	0 (0 to 0)	5 (−3 to 8)	0.368	0.159
IVH, grade ≥ 3	9 (8 to 14)	9 (7 to 14)	8 (5 to 13)	6 (3 to 15)	0.087	< 0.001
22–25	30 (26 to 46)	29 (23 to 43)	27 (21 to 38)	22 (18 to 35)	0.057	0.001
26–27	10 (10 to 13)	11 (9 to 12)	10 (7 to 14)	10 (6 to 14)	0.742	0.569
28–31	4 (2 to 6)	4 (1 to 6)	3 (1 to 5)	2 (1 to 4)	0.056	< 0.001
≥ 32	1 (0 to 1)	1 (0 to 1)	0 (0 to 1)	1 (0 to 1)	0.742	0.175
PVL	7 (4 to 6)	8 (5 to 8)	7 (5 to 7)	6 (4 to 8)	0.368	0.588
22–25	11 (5 to 15)	15 (10 to 19)	14 (7 to 17)	11 (9 to 13)	0.937	0.940
26–27	8 (7 to 10)	10 (8 to 13)	9 (9 to 9)	8 (8 to 9)	0.865	0.927
28–31	7 (5 to 8)	7 (4 to 9)	6 (5 to 8)	6 (5 to 7)	0.106	0.367
≥ 32	1 (0 to 2)	2 (0 to 2)	2 (0 to 2)	2 (0 to 3)	0.225	0.220
Sepsis	20 (9 to 25)	20 (13 to 26)	17 (8 to 23)	12 (7 to 19)	0.077	< 0.001
22–25	36 (28 to 42)	39 (37 to 44)	32 (29 to 38)	29 (26 to 33)	0.178	0.007
26–27	30 (25 to 36)	29 (24 to 34)	26 (21 to 31)	21 (13 to 29)	0.042	< 0.001
28–31	15 (9 to 19)	15 (9 to 19)	11 (5 to 15)	7 (3 to 12)	0.056	< 0.001
≥ 32	6 (1 to 6)	7 (1 to 15)	5 (2 to 7)	4 (2 to 5)	0.200	0.116

Each cell shows the percentage for the corresponding period, with the range of probability (95% confidence interval) indicated in parentheses.
P values are based on trend analysis, while *P'* values represent comparisons between 2015–2016 and 2021–2022.
BPD = bronchopulmonary dysplasia, PDA = patent ductus arteriosus, NEC = necrotizing enterocolitis, ROP = retinopathy of prematurity, IVH = intraventricular hemorrhage, PVL = cystic periventricular leukomalacia, Sepsis = culture proven sepsis.

in the KNN. Although the overall incidence rate of sepsis was higher in the KNN, for infants born at 22–25 weeks, the ANZNN showed a higher rate (35% vs. 29%) (**Table 3**).

Survival rates according to gestational age from 2015 to 2022

The survival rate of VLBWIs in Korea increased from 86% in 2015–2016 to 91% in 2021–2022, showing a positive trend ($P = 0.071$), with a statistically significant increase when comparing 2021–22 to 2015–16 ($P' < 0.001$). The increase was particularly pronounced among infants born before 28 gestational weeks, with significant improvements for infants born at 24 (67% in 2021–2022 vs. 51% in 2015–2016, $P' < 0.001$), 25 (80% in 2021–2022 vs. 66% in 2015–2016, $P' < 0.001$), and 26 (89% in 2021–22 vs. 79% in 2015–16, $P' < 0.001$) gestational weeks (**Table 4**).

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Comparing survival rates of extremely preterm infants with other neonatal networks

In 2015, the survival rate of extremely preterm infants born at or before 28 gestational weeks in Korea was significantly lower across most gestational ages compared with the data reported in other countries including the United States, Australia, New Zealand, Canada, Sweden, and Japan. By 2022, Korea's survival rates had improved, reaching levels similar to those of other neonatal networks, with lower survival in only infants born before 24 gestational weeks ($P < 0.05$). However, survival rates in Japan remained significantly higher than those in Korea across most gestational ages in 2022, indicating a notable disparity (**Fig. 1** and **Supplementary Table 1**).

Table 3. Comparison of major morbidities between the KNN and ANZNN

Major morbidities by gestational age groups, wk	2021–2022 KNN (n = 4,134)	2022 ANZNN (n = 3,406)
BPD, moderate to severe	35	38
22–25	81	85
26–27	53	61
28–31	22	24
NEC, stage ≥ 2	6	4
22–27	13	9
28–31	3	1
IVH, grade ≥ 3	7	5
22–25	22	19
26–27	10	12
28–31	2	2
PVL	7	3
22–25	11	8
26–27	8	5
28–31	6	2
Sepsis	13	10
22–25	29	35
26–27	21	17
28–31	7	2

Each cell shows the percentage for the corresponding network.
KNN = Korean Neonatal Network, ANZNN = Australian and New Zealand Neonatal Network, BPD = bronchopulmonary dysplasia, NEC = necrotizing enterocolitis, IVH = intraventricular hemorrhage, PVL = cystic periventricular leukomalacia, Sepsis = culture-proven sepsis.

Table 4. Survival rate of very low birth weight infants by gestational age in Korea (2015–2022)

Gestational ages, wk	2015–2016 (n = 4,748)	2017–2018 (n = 4,260)	2019–2020 (n = 3,824)	2021–2022 (n = 4,134)	*P* value	*P*' value
22	11 (4 to 19)	17 (16 to 18)	15 (2 to 37)	29 (12 to 45)	0.133	0.033
23	37 (31 to 42)	35 (21 to 50)	39 (31 to 48)	44 (27 to 62)	0.164	0.195
24	51 (47 to 56)	56 (52 to 60)	56 (47 to 64)	67 (54 to 81)	0.083	< 0.001
25	66 (51 to 79)	64 (55 to 73)	75 (62 to 88)	80 (77 to 83)	0.093	< 0.001
26	79 (73 to 84)	82 (82 to 82)	88 (83 to 94)	89 (88 to 90)	0.031	< 0.001
27	87 (86 to 87)	88 (86 to 90)	87 (85 to 90)	91 (90 to 93)	0.250	0.044
28	93 (92 to 94)	93 (92 to 93)	95 (93 to 97)	94 (94 to 95)	0.326	0.406
29	95 (93 to 98)	95 (94 to 96)	96 (94 to 98)	97 (94 to 100)	0.056	0.125
30	98 (98 to 99)	96 (94 to 98)	97 (97 to 97)	98 (97 to 100)	0.865	0.997
31	97 (95 to 99)	97 (96 to 98)	98 (98 to 98)	98 (97 to 99)	0.106	0.370
≥ 32	98 (94 to 100)	97 (96 to 99)	98 (93 to 99)	97 (90 to 100)	0.553	0.288
Total	86 (72 to 90)	86 (73 to 90)	88 (80 to 86)	91 (75 to 95)	0.071	< 0.001

Each cell shows the percentage for the corresponding period, with the range of probability (95% confidence interval) indicated in parentheses.
P values are based on trend analysis, while *P*' values represent comparisons between 2015–2016 and 2021–2022.

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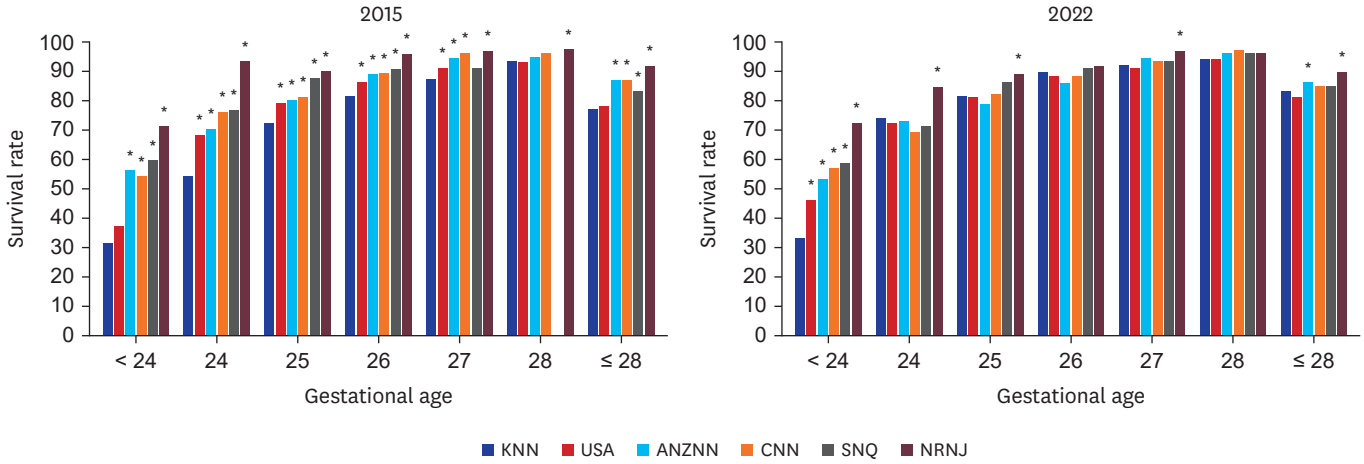

Fig. 1. International comparison of the survival rate of preterm infants based on gestational age.
KNN = Korean Neonatal Network, USA = United States National Center for Health Statistics, ANZNN = Australian and New Zealand Neonatal Network, CNN = Canadian Neonatal Network, SNQ = Swedish Neonatal Quality Register (SNQ data for 2015 does not include data for those born at 28 weeks. The values shown for 2022 represent data from 2018 to 2022.), NRNJ = Neonatal Research Network Database Japan.
*$P < 0.05$, compared with the KNN data.

DISCUSSION

This study demonstrated significant improvements in the survival rates of VLBWIs in Korea, particularly extremely preterm infants, from 2015–2016 to 2021–2022, with survival at ≥ 24 weeks reaching levels comparable to those of other advanced countries, except Japan. The incidences of PDA, NEC, IVH, and sepsis decreased significantly. However, survival rates of infants born at < 24 weeks remained lower than those in other advanced countries, while increasing BPD rates and unchanged PVL rates highlight the need for further advancements in neonatal intensive care.

During the study period, the proportion of multiple gestations increased from 37% to 40%, likely due to the increase in ART use from 24% to 36%. ART use in the ANZNN and CNN in 2022 was approximately 8%, highlighting Korea's higher rate of 36%. Similarly, the rate of multiple gestations was higher in Korea than in the ANZNN (15.5%) and CNN (17.4%), reflecting a distinctive feature of the KNN.[25,26] This may be due to Korea's practice of multiple-embryo transfers in ART, unlike countries where single-embryo transfer is common.[27] Additionally, the rates of gestational diabetes and pregnancy-induced hypertension have increased, possibly linked to the increase in the proportion of mothers aged 35 years and older, from 33.2% in 2015 to 46.8% in 2022. The use of antenatal steroids increased throughout the study period, likely reflecting their role in improving preterm survival.[28] The focus on non-invasive ventilation for BPD prevention also led to a significant decrease in intubation at delivery.[29]

Moderate to severe BPD increased in 2021–2022 compared to 2015–2016, particularly among infants born at less than 27 weeks, likely due to improved survival rates. This highlights the need for additional preventive measures and long-term follow-up for these patients.[30] Among infants with symptomatic PDA, the proportion undergoing surgery decreased. This rate was nearly halved among those born at 26–31 weeks when comparing 2015–2016 to 2021–2022. There is an ongoing debate regarding PDA management, and a similar decreasing trend has been observed in large-scale data studies in Korea.[31,32] NEC, which

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has high complication and mortality rates, significantly declined, with the incidence among infants born at 26–27 weeks reducing from 11% in 2017–2018 to 6% in 2021–2022, while it remained high at 16% for those born at 22–25 weeks. This underscores the importance of preventive measures like promoting breastmilk feeding.[33] The proportion of infants with ROP requiring surgery also decreased, from 45% in 2015–2016 to 37% in 2021–2022, likely due to improvements in neonatal care and the use of anti-vascular endothelial growth factor therapy.[34] Grade 3 or higher IVH decreased from 9% in 2015–2016 to 6% in 2021–2022, particularly among infants born at 22–25 weeks, where the incidence decreased from 30% to 22%. These improvements may positively impact both survival rates and long-term outcomes. However, no notable decrease in PVL was observed, indicating the need for continued efforts. Sepsis incidence also declined significantly, particularly among infants born at less than 32 weeks, likely reflecting improvements in care and infection control, with coronavirus disease 2019 (COVID-19) measures possibly contributing to this decline.[35,36] The decline in sepsis may have helped reduce other morbidity and mortality rates.

The comparison between the KNN and ANZNN data highlights both encouraging progress and persistent challenges in neonatal care for VLBWIs in Korea. The incidence of major morbidities, such as NEC and IVH, was higher in the KNN compared than in the ANZNN, particularly among the extremely premature infants (22–25 gestational weeks). Conversely, some morbidities, such as sepsis, were observed to be lower in the KNN for infants born at 22–25 weeks, which may reflect effective infection control measures implemented in Korean NICUs.[35] The disparities in outcomes underscore the need for continued quality improvement efforts in Korea, with a focus on adopting best practices observed in the ANZNN. Additionally, collaboration between networks, such as through the AsianNeo and iNEO, can facilitate the exchange of knowledge and practices that have proven successful, ultimately contributing to the reduction of morbidity and mortality for these vulnerable populations.

The decrease in morbidities may have contributed to the improvement in survival rates. A comparison between 2015–2016 and 2021–2022 shows particularly marked improvement in infants born at less than 28 gestational weeks. For infants in the periviable period (22–24 gestational weeks), the most recent period (2021–2022) showed significant gains compared to 2019–2020, with survival rates increasing from 15% to 29% at 22 weeks, 39% to 44% at 23 weeks, and 56% to 67% at 24 weeks. Gestational ages of 25 and 26 weeks saw similar improvements, with survival rates increasing by 14% and 10%, respectively, from 2015–2016 to 2021–2022. These improvements likely reflect the cumulative effects of enhanced neonatal care quality and active infection control measures during the COVID-19 pandemic.[36] Additionally, the shift from a resident-dependent to a specialist-led care model has increased the involvement of skilled pediatricians directly caring for VLBWIs, which may also have contributed to the observed improvements.[37,38]

The survival rate of extremely preterm infants in Korea has now improved to levels comparable to those of other high-income countries. In 2015, survival rates for all gestational ages below 28 weeks were significantly lower than those in the United States, Australia, New Zealand, Canada, Sweden, and Japan. By 2022, these differences had largely decreased, although significant disparities remained for infants born before 24 gestational weeks, underscoring an ongoing disparity at the earliest gestational ages. Additionally, across most gestational ages, the survival rate in Korea was still lower than that in Japan. To improve the survival rates of infants born during this critical period, coordinated efforts are needed,

starting with prenatal planning involving obstetricians and families. Enhanced antenatal corticosteroid administration, antenatal counseling, and targeted perinatal interventions have been shown to contribute positively to survival outcomes in extremely preterm infants.[39,40] Postnatal care must also be optimized to enhance outcomes for these high-risk infants, including strategies such as improved respiratory and circulatory management, optimal nutritional support, and minimal handling.[40,41] Above all, improvements in the clinical environment are essential to ensure that skilled personnel can provide intensive care to patients with the highest risk.[42]

This study has some limitations. First, as this research used data from published annual reports, establishing causal relationships or determining direct associations between variables was challenging. However, given that numerous studies have been published annually from the KNN and research collaborations with other neonatal networks worldwide have been conducted, we anticipate that these gaps could be addressed through future research efforts.[14] Additionally, the use of different data sources could affect consistency as data from the United States were obtained from the National Vital Statistics Reports and Japanese data were obtained through specific requests, potentially reducing uniformity. Despite this limitation, we strived to use consistent definitions for mortality and morbidities to ensure comparability across datasets. Second, the cohort composition changed, starting in 2022. As mentioned earlier, while only preterm infants with a birth weight of less than 1,500 g were included in the registry up until 2021, starting in 2022, the inclusion criteria were expanded to include all infants born at less than 32 gestational weeks, which might have influenced the primary outcomes. Nevertheless, most of the improvements were observed among extremely preterm infants born before 28 gestational weeks, suggesting that the cohort change likely had minimal effect. Despite these limitations, this study has notable strengths. It utilized a large-scale prospective cohort from the KNN, which allows for comprehensive and reliable data collection. This large-scale dataset provides a robust assessment of VLBWIs outcomes in Korea over several years, demonstrating significant improvements in survival and morbidity. Moreover, by comparing outcomes with other international neonatal networks, this study offers valuable insights into Korea's progress in neonatal care relative to that in other high-income countries, highlighting both areas of success and opportunities for further improvement.

In summary, substantial improvements occurred in survival rates and major morbidities, including PDA, NEC, IVH, and sepsis, among VLBWIs in Korea from 2015–2016 to 2021–2022. Survival rates for extremely preterm infants born at gestational ages greater than 24 weeks reached levels comparable to those of other advanced countries, except Japan. However, the survival rates of infants born before 24 gestational weeks remained lower than those in other advanced countries, highlighting the need for further advancements in the care of periviable infants. Additionally, reducing the incidence of morbidities, particularly BPD and PVL, is crucial to further improve both survival and long-term outcomes in this high-risk population.

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SUPPLEMENTARY MATERIAL

Supplementary Table 1

Survival rates (%) of extremely preterm infants by gestational age: comparison across neonatal networks

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