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Association between NICU intensivist staffing and neonatal outcomes

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We aimed to evaluate whether neonatal intensive care unit (NICU) intensivist staffing is associated with improved survival outcomes among neonates admitted to NICUs in South Korea. This nationwide retrospective cohort study included all neonates hospitalized in NICUs between January 1, 2019, and December 31, 2021. Patients were categorized into two groups based on intensivist staffing: the intensivist group, comprising neonates admitted to hospitals with full-time NICU intensivists, and the non-intensivist group, comprising those treated in hospitals without dedicated NICU intensivist coverage. A total of 79,306 neonates were included in the final analysis; among them, 44,330 (56.1%) were admitted to NICUs with registered NICU intensivists. In multivariable logistic regression analysis, the intensivist group had a significantly lower odds of 30-day mortality (odds ratio [OR]: 0.73; 95% confidence interval [CI] 0.58–0.92; $P = 0.007$) compared to the non-intensivist group. Similarly, in Cox regression analysis, the intensivist group showed a lower risk of 1-year all-cause mortality (hazard ratio: 0.79; 95% CI 0.69–0.91; $P = 0.001$). These findings suggest that the presence of dedicated NICU intensivists is associated with improved short- and long-term survival outcomes among neonates, supporting policies to enhance specialized staffing in neonatal intensive care settings.

Keywords Critical care, Neonates, Neonatal intensive care units, Neonatologist

A critically ill newborns requiring round-the-clock care are admitted to the neonatal intensive care unit (NICU)[1]. Neonates are admitted to the NICU owing to preterm birth, low birth weight, and/or serious medical illness[1]. During the first four weeks of life, when infants are most vulnerable to serious illness and death[2], neonatal morbidity and mortality are recognized as global public health challenges[3].

Several factors, including hospital volume and NICU staffing levels, are associated with mortality and morbidity. Increased staffing levels did not demonstrate a clear benefit for neonates in the NICU[4]. This differs from previous research, which found that having a intensivist in the adult intensive care unit (ICU) improved the survival outcomes of critically ill adult patients[5,6]. Neonatologist staffing is crucial in modern neonatal intensive care owing to the changing needs of the neonatology workforce as patient volume and acuity grows[7,8]. However, no evident advantage of neonatologist staffing has been reported in the literature regarding neonatal clinical outcomes in the NICU. Investigations into the clinical efficacy are critical to justify allocating additional medical resources, such as neonatologists, to the NICU.

Therefore, this study aimed to determine whether NICU intensivist staffing was associated with improved neonatal survival outcomes in the NICU. We hypothesized that NICU intensivist staffing was associated with increase neonatal NICU survival rates.

Methods

Study design, setting, and ethical declarations

This retrospective population-based cohort study was approved by the Institutional Review Board (IRB) of Seoul National University Bundang Hospital (IRB approval number: X-2304-825-901). The National Health Insurance Service (NHIS) Big Data Center granted permission to share the data for this project (NHIS-2023-1-566). Using deidentified data from the South Korean NHIS database allowed data analysis without the need for informed consent. This study followed the ethical standards of the responsible committee on human experimentation

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(institutional) and with the Helsinki Declaration of 1975. Due to the retrospective nature of the study, IRB of Seoul National University Bundang Hospital waived the need of obtaining informed consent.

NHIS database

The NHIS, South Korea's public insurance program, provided the data for this study. All disease diagnoses and prescription information were fully captured by the NHIS database. Registration with the NHIS enables access to government-sponsored health insurance programs. Diagnoses were coded using the 10th edition of the International Classification of Diseases (ICD-10). Foreign residents must register with the NHIS if their stay in South Korea exceeds 6 months. The NHIS database offers additional information of socioeconomic status and date of death for each individual[9].

Neonatal intensivist system

In South Korea, NICU intensivist must hold board certification in pediatrics and are typically required to have substantial clinical experience in neonatal care. According to national guidelines, the role of an NICU intensivist is ideally fulfilled by neonatologists—pediatricians who have completed an additional 1–2 years of fellowship training in neonatology and passed the subspecialty board examination. However, pediatricians without subspecialty certification may also be designated as NICU attendings if they possess at least three years of clinical experience in neonatal intensive care.

For the purpose of this study, "intensivists" were defined as physicians who were officially registered as full-time NICU attendings with the Ministry of Health and Welfare and were assigned exclusively to NICU care without concurrent responsibilities in other clinical areas. According to a 2024 national report[10], 67.9% of these NICU intensivists were neonatologists. Hospitals with a single registered intensivist were eligible for government reimbursement under the NICU intensivist incentive program, and additional financial support was provided to facilities employing two or more intensivists to maintain a neonate-to-intensivist ratio of less than 10:1.

In hospitals without registered intensivists, neonatal care was typically provided by general pediatricians without subspecialty training in neonatology. These physicians often concurrently managed general pediatric inpatients, outpatients, and nursery care. In some cases, pediatric residents or faculty without formal neonatal training supervised care, particularly in teaching hospitals. In rare instances, adult intensivists, anesthesiologists, or obstetricians were consulted when pediatric specialists were unavailable. These hospitals were classified as non-intensivist institutions in this study.

Study population (neonate in NICU)

From January 1, 2019, to December 31, 2021, this study included all neonates admitted to NICUs throughout South Korea. As all neonates admitted to the NICU in South Korea must register a prescription code, this code for NICU admission during hospitalization was used to extract the data. To increase homogeneity of the research population (neonates), we only included initial NICU admissions for neonates admitted two or more times during the study period. As a result, only all first NICU admissions of a neonate were included in the analysis, i.e., if a neonatal critical illness occurred at Hospital A NICU (non-intensivist hospital) and was transferred to Hospital B NICU (intensivist hospital), only cases from Hospital A were included in the analysis.

Neonates were classified into two groups based on NICU staffing: the intensivist group included neonates admitted to NICUs with at least one full-time NICU intensivist, while the non-intensivist group comprised those admitted to NICUs without such staffing. Among the intensivist group, NICUs that employed two or more intensivists to maintain a neonate-to-intensivist ratio of less than 10:1 were further categorized as Type II intensivist units. NICUs with only one full-time intensivist were classified as Type I intensivist units.

Endpoints

Thirty-day and 1-year all-cause mortality were established as the endpoints of the study following NICU admission. The 30-day and 1-year mortality rates were defined as any death within 30 d or 1 year of NICU admission, respectively. By using these endpoints, we aimed to assess the short- and long-term effects of intensivist staffing on neonates in the NICU.

Collected variables

Data on the sex of neonates were collected. Residence and household income levels were included as variables to represent the socioeconomic status of the parents of neonates. Residential areas were divided into rural (all other regions) and urban (Seoul and other metropolitan cities). Household income data from the NHIS database categorized the parents of the neonates into income quartiles using, determining their annual insurance premiums[11]. Medical aid programs support financially disadvantaged individuals or those unable to afford insurance premiums, with over 67% of medical expenses subsidized by the government. This program covered nearly all medical costs, alleviating financial burdens. Patients were divided into five groups, including the Medical Assistance Program group, using quartile ratios.

Neonates were categorized into three groups based on the hospitals where they were admitted to the NICU: general hospitals, tertiary general hospitals, and other hospital groups. Eleven underlying conditions may impact the prognosis of neonates in the NICU: (1) congenital malformations, deformations, and chromosomal abnormalities, (2) disorders related to fetal growth, (3) birth trauma, (4) complications of intrapartum events, (5) convulsions and disorders of cerebral status, (6) infection, (7) respiratory and cardiovascular disorders, (8) other neonatal conditions, (9) low birth weight and prematurity, (10) acute kidney injury or acute renal failure, and (11) inborn errors of metabolism. The ICD-10 codes used to derive the 11 underlying illnesses are listed in Table S1. Furthermore, data were gathered on the use of continuous renal replacement treatment, mechanical ventilation, extracorporeal membrane oxygenation support, and cardiac resuscitation during NICU stays.

Statistical analyses

Clinicopathological features were presented as mean values and continuous variables with standard deviations. Numerical and percentage forms of categorical variables were used. The t-test assessed differences in clinicopathological characteristics between intensivist and non-intensivist groups for continuous data, whereas the chi-square test was used for categorical variables.

Multivariable logistic regression modeling was used for 30-day mortality, including all covariates in the model for adjustment. The Hosmer–Lemeshow statistic confirmed that the model's goodness of fit was appropriate. The results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). For 1-year all-cause mortality, multivariable Cox regression modeling was used for time-to-event analysis. Deaths within a 1-year timeframe were classified as events, with survival duration measured from the date of NICU admission designated as the time. In addition, we performed subgroup analysis after excluding neonates with congenital malformations, deformations, and chromosomal abnormalities because the main causes of neonatal death in NICU in developed countries are congenital anomaly[12]. The central assumption of the Cox proportional hazards model was validated using log–log graphs. Results of Cox regression analysis included hazard ratios (HRs) with 95% CIs. Sensitivity analyses using multivariable Cox regression models to assess the intensivist staffing type on the main results. All analyses were performed using R software (R Utilities, version 4.0.3). Statistical significance was set at $P < 0.05$.

Results

Neonates in the NICU

The selection procedure for neonates admitted to the NICU is illustrated in Fig. 1. Between January 1, 2019, and December 31, 2021, 92,643 neonates were admitted to the NICUs in South Korea. The final study included 79,306 neonates admitted to the NICU with 13,607 multiple admission cases excluded to focus slowly on initial NICU admission cases. Of the neonates, 44, 330 (56.1%) were admitted to the NICU in 52 hospitals (30 tertiary general hospital, 14 general hospital, and 8 other hospitals) where intensivists worked, forming the intensivist group. Meanwhile, 34,736 (43.9%) neonates were admitted to NICUs in 34 hospitals (15 tertiary general hospital, 11 general hospital, and 8 other hospitals) without intensivist staffing, constituting the non-intensivist group. Among the neonates in the intensivist group, 15,807 (20.0%) and 28,493 (36.1%) in the NICU were classified into the type I and type II intensivist groups, respectively. The clinicopathological features of the intensivist and non-intensivist treatment groups are compared in Table 1. Mean duration of survival time among neonates who died within a year was 25.5 days.

Survival analyses

Thirty-day mortality

Table 2 presents the results of the multivariable logistic regression model for 30-day mortality following NICU admission. After NICU admission, the intensivist group exhibited 27% lower odds of 30-day mortality (OR: 0.73, 95% CI 0.58–0.92; $P = 0.007$; model 1) compared to the non-intensivist group. In the sensitivity analysis, the

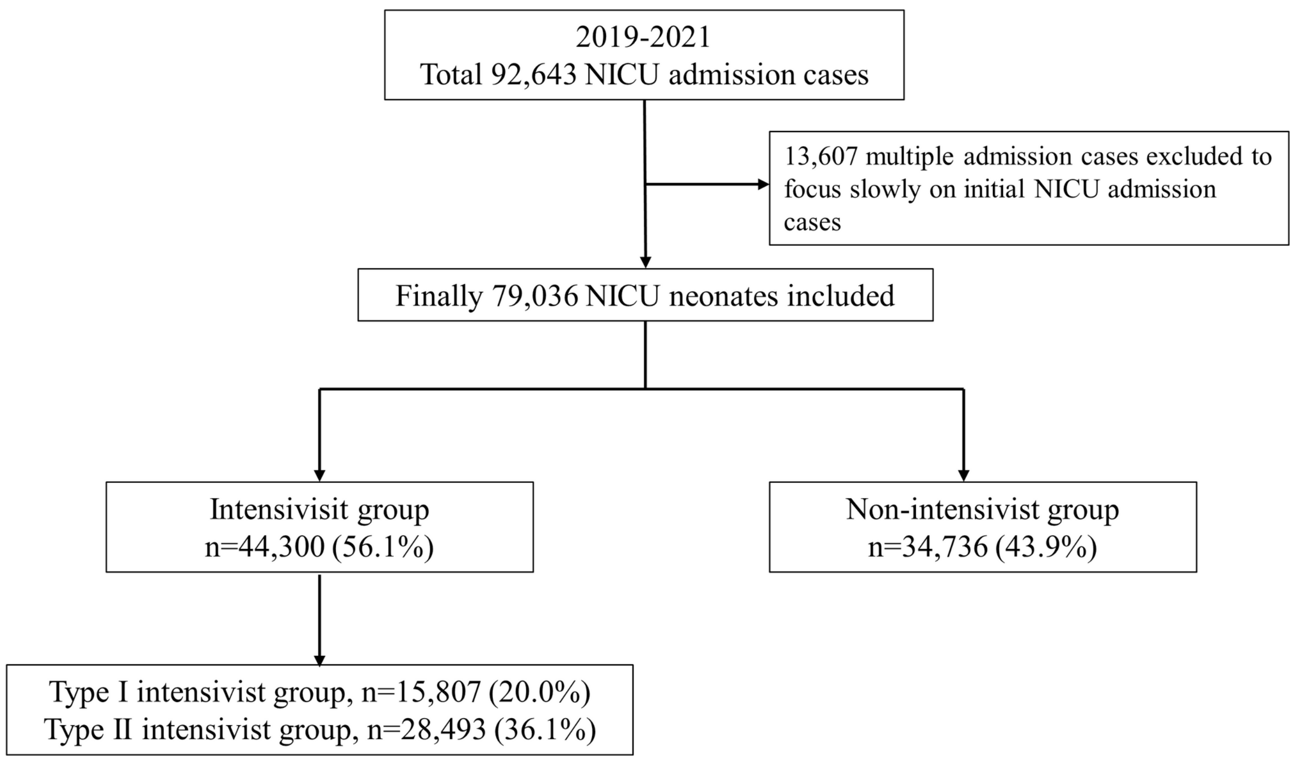

Fig. 1. Flow chart depicting the selection process of neonates.

Variable	Intensivist group n = 44,300	Non-intensivist group n = 34,736	*P*-value
Female sex	19,717 (44.5)	15,113 (43.5)	0.005
Household income level			< 0.001
Q1 (lowest)	4,674 (10.6)	4,275 (12.3)	
Q2	7,522 (17.0)	6,476 (18.6)	
Q3	15,881 (35.8)	12,547 (36.1)	
Q4 (highest)	14,313 (32.3)	9,550 (27.5)	
Medical aid program group	195 (0.4)	244 (0.7)	
Unknown	1,715 (3.9)	1,644 (4.7)	
Residence			< 0.001
Urban area	19,478 (44.0)	12,995 (37.4)	
Rural area	24,822 (56.0)	21,741 (62.6)	
Type of hospital			< 0.001
Tertiary general hospital	30,110 (68.0)	16,727 (48.2)	
General hospital	11,214 (25.3)	16,732 (48.2)	
Other hospital	2,976 (6.7)	1,277 (3.7)	
Underlying condition			
Congenital malformations, deformations, and chromosomal abnormalities	21,385 (48.3)	15,752 (45.3)	< 0.001
Disorder related to fetal growth	3,453 (7.8)	2,252 (6.5)	< 0.001
Birth trauma	1,571 (3.5)	1,169 (3.4)	0.168
Complications of intrapartum events	2,069 (4.7)	1,264 (3.6)	< 0.001
Convulsions and disorders of cerebral status	4,136 (9.3)	2,988 (8.6)	< 0.001
Infection	16,336 (36.9)	15,747 (45.3)	< 0.001
Respiratory and cardiovascular disorders	23,910 (54.0)	17,647 (50.8)	< 0.001
Other neonatal conditions	35,010 (79.0)	27,928 (80.4)	< 0.001
Low birth weight and prematurity	20,789 (46.9)	13,832 (39.8)	< 0.001
AKI or ARF	223 (0.5)	958 (2.8)	< 0.001
Inborn error of metabolism	408 (0.9)	543 (1.6)	< 0.001
Treatment during NICU stay			
Duration of mechanical ventilation in day	0.4 (1.2)	0.3 (1.1)	< 0.001
ECMO support	236 (0.5)	64 (0.2)	< 0.001
CRRT use	10 (0.0)	2 (0.0)	0.057
Experience of CPR	394 (0.9)	224 (0.6)	< 0.001
LOS, day	15.8 (15.4)	13.9 (13.5)	< 0.001
NICU stay, day	10.1 (12.0)	8.4 (10.5)	< 0.001
Year of NICU admission			< 0.001
2019	10,672 (24.1)	17,769 (51.2)	
2020	14,711 (33.2)	10,107 (29.1)	
2021	18,917 (42.7)	6,860 (19.7)	
30-day mortality	283 (0.6)	204 (0.6)	< 0.001
1-year all-cause mortality	577 (1.3)	402 (1.2)	0.067

Table 1. Clinicopathological features of the intensivist and non-intensivist treatment groups. AKI, acute kidney injury; ARF, acute renal failure; NICU, neonatal intensive care unit; ECMO, extracorporeal membrane oxygenation; CRRT, continuous renal replacement therapy; CPR, cardiopulmonary resuscitation; LOS, length of hospital stays.

type I intensivist group showed a 31% reduction in odds of 30-day mortality after NICU admission (OR: 0.69, 95% CI 0.50–0.94; $P = 0.018$; model 2), whereas the type II intensivist groups exhibited a 25% reduction (OR: 0.75, 95% CI 0.58–0.96; $P = 0.020$; model 2) compared with the non-intensivist group. All ORs with 95% CIs for multivariable model 1 are presented in Table S2. Although both Type I and Type II NICU intensivist groups were associated with significantly lower odds of 30-day mortality compared to the non-intensivist group, there was no statistically significant difference in 30-day mortality between the Type I and Type II groups.

One-year all-cause mortality

Table 3 shows the results of the multivariable Cox regression model for 1-year all-cause mortality following NICU admission. After NICU admission, the intensivist group had a 21% lower risk of 1-year all-cause mortality (HR: 0.79, 95% CI 0.69, 0.91; $P = 0.001$; model 3) than the non-intensivist group. In the sensitivity analysis, the

Variable	OR (95% CI)	*P*-value
30-day mortality (model 1)		
Non-intensivist group	1	
Intensivist group	0.73 (0.58, 0.92)	0.007
30-day mortality (model 2)		
Non-intensivist group	1	
Type I Intensivist group	0.69 (0.50, 0.94)	0.018
Type II Intensivist group	0.75 (0.58, 0.96)	0.020

Table 2. Multivariable logistic regression model for 30-day mortality after NICU admission. NICU, neonatal intensive care unit; OR, odds ratio; CI, confidence interval.

Variable	HR (95% CI)	*P*-value
1-year all-cause mortality (model 3)		
Non-intensivist group	1	
Intensivist group	0.79 (0.69, 0.91)	0.001
1-year all-cause mortality (model 4)		
Non-intensivist group	1	
Type I Intensivist group	0.81 (0.68, 0.97)	0.022
Type II Intensivist group	0.78 (0.67, 0.91)	0.002

Table 3. Multivariable cox regression model for 1-year all-cause mortality after NICU admission. NICU, neonatal intensive care unit; HR, hazard ratio; CI, confidence interval.

Variable	OR or HR (95% CI)	*P*-value
30-day mortality		
Non-intensivist group	1	
Intensivist group	0.70 (0.56, 0.82)	< 0.001
1-year all-cause mortality		
Non-intensivist group	1	
Intensivist group	0.77 (0.65, 0.91)	< 0.001

Table 4. Subgroup analysis after excluding neonates with congenital malformations, deformations, and chromosomal abnormalities. NICU, neonatal intensive care unit; OR, odds ratio; HR, hazard ratio; CI, confidence interval.

type I intensivist group showed a 19% reduced risk of 1-year all-cause mortality after NICU admission (HR: 0.81, 95% CI 0.68–0.97; $P = 0.022$; model 4), whereas the type II intensivist group exhibited a 22% reduction (HR: 0.78, 95% CI 0.67–0.91; $P = 0.002$; model 4) compared with the non-intensivist group. All HRs with 95% CIs for multivariable model 3 are presented in Table S3. Although both Type I and Type II NICU intensivist groups were associated with significantly lower 1-year all-cause mortality compared to the non-intensivist group, there was no statistically significant difference in 1-year mortality between the two intensivist subgroups.

Subgroup analysis

Table 4 shows the results of subgroup analysis after excluding neonates with congenital malformations, deformations, and chromosomal abnormalities. The intensivist group exhibited 30% lower odds of 30-day mortality (OR: 0.70, 95% CI: 0.56–0.82; $P < 0.001$) compared to the non-intensivist group. Additionally, the intensivist group had a 23% lower risk of 1-year all-cause mortality (HR: 0.77, 95% CI 0.65, 0.91; $P < 0.001$) than the non-intensivist group.

Discussion

This population based cohort study showed that NICU intensivist staffing was associated with improved both 30-day and 1-year all-cause survival outcomes in neonates after NICU admission. These results were similar regardless of the neonate-to-intensivist ratio. Our results are the first to report that NICU intensivist staff may improve the clinical outcomes among neonates in the NICU. This highlights the substantial costs and assistance required for hiring intensive care specialists, such as neonatologists, in the NICU.

High-intensity staffing in the ICU (requiring intensivist consultation or a closed ICU) reduces mortality and the length of stay in both adult settings[13–15]. Clinical outcomes may differ depending on ICU admission timing. ICU admission times with intensivist coverage in surgical ICUs considerably reduce 30-day mortality compared to non-intensivist coverage[16]. Consequently, the American College of Vital Care Medicine task group proposed the establishment of an intensivist-led, high-performing, multidisciplinary ICU-focused team as a crucial component of effective care delivery. Standardized procedures such as care packages and institutional support can be used to generate high-quality ICU results for overall quality improvement[17].

Treating preterm neonates in the NICU involves intricate and sophisticated procedures. Growth and developmental delays in preterm infants may result from numerous stress factors, including exposure to light and noise, high infection risk from routine invasive procedures, discomfort from invasive and surgical treatments, and reduced mother-infant connection[18,19]. Prematurity, low birth weight, respiratory distress syndrome, sepsis, intraventricular hemorrhage and chronic lung disease are key contributors to neonatal mortality. Treating these conditions requires a professional team capable of providing precise and specific treatments[2]. Additionally, neonates require specialized care and expertise in airway management and intubation and various procedures, surpassing that needed for adults, necessitating the involvement of trained professionals in this procedure[20]. In communication with parents of neonates in the ICU, neonatologists facilitate family participation, with parents actively involved in decision-making during medical rounds[21]. The findings of our study showed that intensive care specialists have a significant impact on the management of difficult neonatal critical care, resulting in reduced fatality rates in the NICU.

Another advantage of our study is that we examined both short- and long-term survival rates up to 30 days and one year following NICU admission. In a recent report from the United States, the 30-day mortality for NICU neonates from January 1, 2010, to December 31 was 0.28%[22], whereas the corresponding rate in our study was approximately 0.6%. The 30-day mortality rate is widely used as a short-term outcome measure for neonates and serves as a proxy for immediate clinical effectiveness in NICU settings[22,23]. The 1-year all-cause mortality rate—often referred to as the newborn mortality rate—is an important indicator of population health[24]. Prior studies have focused on preterm neonates, emphasizing 1-year survival as a key endpoint, and several countries prioritize improving 1-year neonatal survival in healthcare policy agendas[25,26]. The finding that NICU intensivist staffing was associated with improved 1-year survival is thus meaningful from both clinical and public health perspectives.

Although the mean survival duration among neonates who died within one year was relatively short (25.5 days), evaluating 1-year all-cause mortality remains clinically relevant. Many critically ill neonates, particularly those born preterm or with low birth weight, remain vulnerable to delayed complications such as bronchopulmonary dysplasia, necrotizing enterocolitis, sepsis, or neurologic injury, which may lead to mortality beyond the early postnatal period[27]. Therefore, 1-year mortality allows for a more comprehensive assessment of both in-hospital and post-discharge risks in this population.

Although overall NICU intensivist staffing was associated with improved neonatal outcomes, no statistically significant difference was observed between Type I and Type II intensivist hospitals. This finding suggests that the presence of at least one full-time NICU intensivist, rather than the number of intensivists alone, may be the critical factor contributing to improved outcomes. It is also possible that the benefit of additional intensivists is diminished in hospitals where other essential resources—such as adequate nurse-to-patient ratios, advanced equipment, or standardized protocols—are not concurrently optimized. Further research is needed to explore the threshold effect of intensivist staffing and the contextual factors that influence its effectiveness in neonatal intensive care settings.

Although this study had several advantages, it had some limitations. First, due to incomplete data in the NHIS database, it was impossible to accurately determine gestational age and birth weight, which are crucial factors for neonatal mortality. Second, some maternal conditions that could affect the prognosis of neonates in the NICU could not be evaluated owing to insufficient information in the NHIS database. For example, it has been established that maternal hypertension contributes to the higher mortality rate of premature infants.[28] Third, apart from the presence of a NICU intensivist, detailed inclusion of other staffing information and level of NICU such as neonate-to-nurse ratios, the experience level of the nurses, and the availability of respiratory therapists was not feasible. Fourth, as described in the methodology, not all NICU intensivists in our study were also neonatologists; only about 67.9% were neonatologists, and it could affect on results in this study. Moreover, it was reported that variations in the number of neonatologists were linked to differences in mortality rates among very-low-birth-weight infants across various centers in Korea, even after accounting for patient risks and hospital-related factors[10]. Finally, we did not evaluate the level of the NICU in addition to the hospital's capacity, and more research is needed to address these limitations.

In conclusion, this population-based cohort analysis revealed that NICU intensivist staff was associated with improved 30-day and 1-year all-cause survival outcomes in neonates after NICU admission. These findings highlight the importance of neonatologists in the NICU. Furthermore, national policy support is necessary to ensure continuous training of neonatal intensivists and availability of medical resources in this crucial area of healthcare.

Data availability

Data will be available upon reasonable request to the corresponding author.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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