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Association Between Hospital Recognition for Nursing Excellence and Outcomes of Very Low-Birth-Weight Infants

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Context Infants born at very low birth weight (VLBW) require high levels of nursing intensity. The role of nursing in outcomes for these infants in the United States is not known.

Objective To examine the relationships between hospital recognition for nursing excellence (RNE) and VLBW infant outcomes.

Design, Setting, and Patients Cohort study of 72 235 inborn VLBW infants weighing 501 to 1500 g born in 558 Vermont Oxford Network hospital neonatal intensive care units between January 1, 2007, and December 31, 2008. Hospital RNE was determined from the American Nurses Credentialing Center. The RNE designation is awarded when nursing care achieves exemplary practice or leadership in 5 areas.

Main Outcome Measures Seven-day, 28-day, and hospital stay mortality; nosocomial infection, defined as an infection in blood or cerebrospinal fluid culture occurring more than 3 days after birth; and severe (grade 3 or 4) intraventricular hemorrhage.

Results Overall, the outcome rates were as follows: for 7-day mortality, 7.3% (5258/71 955); 28-day mortality, 10.4% (7450/71 953); hospital stay mortality, 12.9% (9278/71 936); severe intraventricular hemorrhage, 7.6% (4842/63 525); and infection, 17.9% (11 915/66 496). The 7-day mortality was 7.0% in RNE hospitals and 7.4% in non-RNE hospitals (adjusted odds ratio [OR], 0.87; 95% CI, 0.76-0.99; $P=.04$). The 28-day mortality was 10.0% in RNE hospitals and 10.5% in non-RNE hospitals (adjusted OR, 0.90; 95% CI, 0.80-1.01; $P=.08$). Hospital stay mortality was 12.4% in RNE hospitals and 13.1% in non-RNE hospitals (adjusted OR, 0.90; 95% CI, 0.81-1.01; $P=.06$). Severe intraventricular hemorrhage was 7.2% in RNE hospitals and 7.8% in non-RNE hospitals (adjusted OR, 0.88; 95% CI, 0.77-1.00; $P=.045$). Infection was 16.7% in RNE hospitals and 18.3% in non-RNE hospitals (adjusted OR, 0.86; 95% CI, 0.75-0.99; $P=.04$). Compared with RNE hospitals, the adjusted absolute decrease in risk of outcomes in RNE hospitals ranged from 0.9% to 2.1%. All 5 outcomes were jointly significant ($P<.001$). The mean effect across all 5 outcomes was OR, 0.88 (95% CI, 0.83-0.94; $P<.001$). In a subgroup of 68 253 infants with gestational age of 24 weeks or older, the ORs for RNE for all 3 mortality outcomes and infection were statistically significant.

Conclusion Among VLBW infants born in RNE hospitals compared with non-RNE hospitals, there was a significantly lower risk-adjusted rate of 7-day mortality, nosocomial infection, and severe intraventricular hemorrhage but not of 28-day mortality or hospital stay mortality.

JAMA. 2012;307(16):1709-1716 www.jama.com

One in 4 very low-birth-weight (VLBW) infants (<1500 g) dies in the first year of life; nearly all deaths (87%) occur in the first month.[1] Infant mortality in the United States is concentrated in this population. Although they account for only 1.5% of births, these infants account for more than half of infant deaths.[1] Very low-birth-weight infants who survive have higher rates of morbidity and disability, including developmental delays and cognitive impairment, than infants with normal birth weights.[2-5]

Neonatal intensive care unit (NICU) infants are among the most nurse-intensive patients, with recommended patient-nurse ratios of at most 2 to 1 for neonates needing intensive care.[6,7] To intervene before the onset of life-threatening problems, nurses must make complex assessments, implement highly intensive therapies, and make immediate adjustments dependent on infant response.[8] Maintaining optimal respiratory, cardiac, and feeding status may result in improved de-

For editorial comment see p 1750.

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velopment and behavior, lower levels of morbidity, and shorter hospitalization.[9] Nurse handling of an infant and recognition and response to subtle cues that an infant is distressed may support infant hemodynamic stability and reduce the likelihood of intraventricular hemorrhage.[10] Aseptic technique and scrupulous hand hygiene by nurses during infant care, especially in the maintenance of central lines, decrease the risk of infants acquiring a nosocomial infection.[11,12]

The American Nurses Credentialing Center developed the Magnet Recognition Program to recognize health care organizations for quality patient care, nursing excellence, and innovations in professional nursing practice.[13] Organizations are evaluated for evidence of achieving 5 program elements: transformational leadership; structural empowerment; exemplary professional practice; new knowledge, innovations, and improvements; and empirical outcomes. Exemplary professional practice is achieved when "nurses have significant [professional] control . . . and work in collaboration with interdisciplinary partners to achieve high-quality patient outcomes."[14(p28)] The other 4 elements support and maintain nursing excellence. For instance, structural empowerment means "the flow of information and decision-making is bi-directional and horizontal . . . among professional nurses at the bedside, the leadership team, and the chief nursing officer (CNO).[14(p44)] New knowledge includes "establishing new ways of achieving high-quality, effective, and efficient care."[14(p32)] Transformational leadership requires that "the CNO in a Magnet organization . . . develops a strong vision and well-articulated philosophy, professional practice model, and strategic and quality plans in leading nursing services."[14(p42)] Empirical outcomes document achievement in all of these areas. These criteria are expected to assist health care organizations in achieving high-quality nursing care for all patients. The route to recognition is an extensive and rigorous process that generally takes 2 years. Recognition is at the hospital level but all units must meet criteria. The hospital pays a sliding-scale application fee, conducts an extensive self-evaluation followed by an analysis to identify the gaps in achieving standards, works with a consultant to implement organizational changes to fulfill numerous recognition of nursing excellence (RNE) standards, and is evaluated by outside appraisers through a site visit of several days.[15] Hospitals are required to undergo a redesignation process every 4 years. Interim reporting is also required.

Recognition for nursing excellence is uncommon. Only 7% of US hospitals achieve this. Very few lose it (<10 since the program's inception in 1994); however, approximately 20% of hospitals with a NICU have this recognition (authors' tabulations of American Hospital Association Annual Survey data and American Nurses Credentialing Center public listing).

Patient outcomes in RNE hospitals have been understudied.[16,17] The objective of this study was to examine the association of hospital RNE status with VLBW infant outcomes. We analyzed mortality, severe intraventricular hemorrhage (SIVH), and nosocomial infection because we hypothesized these outcomes would be influenced by nursing care and prior research has indicated that they may be affected.[18-21] In addition to hospital stay mortality, 2 other mortality time frames were predefined: within the critical first week of life and within 28 days of birth. Death in the first week of life accounts for the majority of neonatal (71%) and in-hospital (57%) mortality in VLBW infants. Death within 28 days, or neonatal mortality, is a commonly reported statistic.

METHODS

Sites and Patient Sample

The Vermont Oxford Network (VON) is a voluntary collaborative network of hospitals with a NICU dedicated to improving the quality and safety of medical care for newborn infants and their families. VON hospitals are located in 47 states, Washington, DC, and 22 foreign countries. The VON database contains detailed uniform clinical and treatment information on all VLBW infants cared for by network hospitals. By 2008, the US VON database comprised 578 hospitals, which included approximately 65% of NICUs and 80% of all VLBW infants born in the United States. This cross-sectional study included 558 VON hospitals with inborn infants in 2007 and 2008. The remaining 20 were children's hospitals that had only outborn infants.

The study population consisted of 72 235 inborn infants who weighed between 501 and 1500 g. Infants who died in the delivery department or elsewhere in the hospital were included even if they were not admitted to the NICU. Infants who weighed 500 g or less were excluded for consistency with prior studies. Infants with incomplete data on infant characteristics (n=599) were excluded to yield a consistent sample for multivariable models. In analyses of mortality, an additional 299 infants were excluded for missing data on death. Institutional review board approval was obtained from the University of Medicine and Dentistry of New Jersey and the University of Vermont, including a waiver of informed consent. The University of Pennsylvania institutional review board judged the project exempt.

Variables

All patient- and NICU-level measures were obtained or derived from the VON database. VON data are collected using standardized definitions. The data are subjected to extensive range, logic, and consistency checks when submitted and are reviewed and verified annually. Infant characteristics were measured at birth.

The key outcome measures were death (within 7 days, 28 days, and the hospital stay), nosocomial infection, and SIVH. Nosocomial infection was defined as an infection in blood or cerebrospinal fluid culture occurring more than 3 days after birth. The database includes information on 3 culture-proven infections: coagulase-negative *Staphylococcus*, the most common bacterial infection in the NICU; other bacterial infections; and fungal infections. Severe intraventricular hemorrhage was defined as the presence of grade 3 or 4 intraventricular hemorrhage on a cranial ultrasound performed within the first 28 days.[22] Grades 3 and 4 hemorrhages are the most severe and are more likely to be associated with long-term neurodevelopmental sequelae. Of the sample, 14.6% of the infants were transferred and 3.7% were readmitted to the birth hospital. The final disposition (discharge alive or dead) is tracked for all infants and attributed to the birth hospital regardless of transfer status. If an infant was readmitted to the birth hospital after a transfer, SIVH and infection were collected for the entire stay, including at the transfer hospital, and attributed to the birth hospital. These data were not collected on infants transferred out and not readmitted. However, since SIVH occurs principally in the first few days of life, the 23-day median age of transfer implies that SIVH is unlikely to occur in a transfer hospital. In 2009, VON data were collected on infection location and indicated that among readmitted infants, 4% of infections were contracted at the transfer hospital; in this analysis, those would be attributed to the hospital of birth.

The independent variable, hospital RNE designation in 2008, was obtained from a public website listing designated hospitals' original and most recent year of redesignation.[23] Patient risk adjusters consisted of infant characteristics that were developed for the VON risk-adjustment model.[23] These covariates included gestational age in weeks (and its square); small for gestational age; 1-minute Apgar score; race and ethnicity (non-Hispanic black, non-Hispanic white, or other [including Hispanic]); sex; multiple birth; presence of a major birth defect; vaginal delivery; and whether the mother received prenatal care. Race and ethnicity were classified into standard VON options based on maternal race and ethnicity as recorded in the birth certificate or medical record. Maternal socioeconomic status was not available in the VON database and could not be geocoded. Previous research did not find an effect of maternal socioeconomic status on mortality using earlier years of the VON database.[24] The risk-adjustment model had area under the receiver operating characteristic curves of 0.88 for mortality, 0.82 for SIVH, and 0.75 for infection.

Two NICU-level variables were included consistent with prior research.[24-26] Volume was measured as the mean number of VLBW infants admitted to the hospital in 2007 and 2008. Due to the presence of high-volume NICUs, the data were transformed to the natural log of volume for a more normally distributed measure. NICU level was obtained from the VON's annual survey. The VON classifies NICUs into levels A (restriction on ventilation; no surgery), B (major surgery), and C (cardiac surgery), corresponding to high level II and level III units in the American Academy of Pediatrics NICU classification. The universe of US NICUs was identified from the American Hospital Association survey[27] by nonzero values for neonatal intensive care beds. Two hospital characteristics, hospital ownership (not-for-profit, for-profit, or public) and teaching status (membership in the Council of Teaching Hospitals), were also obtained from the American Hospital Association survey.

Data Analysis

Our focus in this study was on hospital RNE and VLBW infant outcomes. We first examined the bivariate relationship between RNE and each outcome. Tests of bivariate comparisons adjusted for infant clustering within hospitals. We then estimated 3 logistic regressions for each outcome. The first included only RNE status as the independent variable. The second added patient risk adjusters. The third added NICU- and hospital-level covariates. All models controlled for birth year to account for a secular trend. We estimated random-effects models by the maximum likelihood method. This method includes an unobserved hospital-level component (the random effect) that captures any omitted hospital-level factors that systematically increase or decrease the likelihood of each outcome for all infants in that hospital. Inclusion of this random effect corrects the standard errors for the resulting within-hospital correlation (ie, clustering) in patient outcomes. When there are multiple outcomes and all are hypothesized to be important, a joint significance test computes the average effect to summarize the overall pattern. The joint F test accounts for correlation between the 3 mortality measures. To determine whether RNE status was significantly related to all 5 outcomes, we tested the hypothesis that all 5 odds ratios (ORs) were jointly equal to 1 and also tested whether the mean OR across all 5 outcomes was equal to 1. Confidence intervals and *P* values for these tests were based on the bootstrap method to account for correlation between the estimates.[28] To explore the possibility that RNE may have a different association with outcomes for VLBW infant subgroups, such as those above a viability threshold, we repeated our regression analyses in subgroups stratified by gestational age of 24 weeks or older vs younger than 24 weeks and birth weight of 1000 g or more vs less than 1000 g (extremely low birth weight). The analyses were conducted using Stata software, version 10.1.[29] The a priori significance level was $P < .05$ for a 2-sided significance test.

RESULTS

Of the sample, 21% of hospitals had RNE status compared with 19% of US hospitals with a NICU; 16% of sample hospitals provided the highest level of care (level C). Compared with the universe of hospitals with a NICU, our sample contains somewhat more teaching hospitals (33% vs 27%) and larger units (a mean of 28 beds vs 22 beds).

Compared with non-RNE hospitals, the RNE hospitals with a NICU are mostly not-for-profit (87% vs 71%) and have more registered nurse hours (10.5 vs 9.3 hours per patient-day at the hospital level); twice as many are teaching hospitals (55% vs 27%) (TABLE 1). Few RNE hospitals are for-profit compared with non-RNE hospitals (3% vs 13%). The RNE hospitals care for a larger volume of VLBW infants than non-RNE hospitals (93 vs 74 VLBW infants, respectively). Also, RNE hospital NICUs are disproportionately level C (32% vs 12%) rather than level A (23% vs 33%) compared with non-RNEs. These RNE/non-RNE differences mirrored those of US NICUs (eTable 1; available at http://www.jama.com).

Sample infants had a mean birth weight of 1056 g and a gestational age of 28.2 weeks (Table 1). The racial and ethnic composition of the entire sample was 47% non-Hispanic white, 29% non-Hispanic black, and 24% other, while the composition of infants in RNE hospitals was disproportionately non-Hispanic white (54%) ($P < .001$). The risk profile of RNE hospitals was higher than for non-RNE hospitals based on the characteristics of VLBW infants born in those hospitals. The RNE hospitals had disproportionately more infants with higher-risk characteristics such as lower Apgar score, multiple birth, and white race. It is well known in this literature that black infants have a survival advantage, which differs from most other populations.[30] The mean predicted probability of death was 13.0% in RNE hospitals and 12.6% in non-RNE hospitals controlling for infant factors.

The percentage of eligible infants with each outcome was as follows: 7-day mortality, 7.3% (n = 5258/71 955); 28-day mortality, 10.4% (n = 7450/71 953); hospital stay mortality, 12.9% (n = 9278/71 936); SIVH,

Table 1. Hospital, NICU, and Infant Characteristics

Characteristics	Participants[a] Total	RNE Hospitals	Non-RNE Hospitals	*P* Value[b]
Hospital characteristics	N = 558	n = 119	n = 439	
Hospital ownership				
Public	85 (15)	13 (11)	72 (16)	.001
For-profit	60 (11)	3 (3)	57 (13)	
Not-for-profit	413 (74)	103 (87)	310 (71)	
Member, Council of Teaching Hospitals	185 (33)	66 (55)	119 (27)	<.001
Hospital nursing characteristics				
RNE hospital	119 (21)	119 (100)	0	
Registered nurse hours per adjusted patient-day, mean (SD)[c]	9.6 (3.0)	10.5 (2.9)	9.3 (2.9)	<.001
NICU characteristics				
NICU level				
A	171 (31)	27 (23)	144 (33)	<.001
B	296 (53)	54 (45)	242 (55)	
C	91 (16)	38 (32)	53 (12)	
Annual volume of very low-birth-weight admissions, mean (SD)	78 (60.4)	93 (58.9)	74 (60.3)	<.001
Infant characteristics	n = 72 235	n = 17 455	n = 54 780	
Birth weight, mean (SD), g	1056 (287)	1056 (286)	1056 (287)	.89
Gestational age, mean (SD), wk	28.2 (2.9)	28.2 (2.9)	28.2 (2.9)	.96
1-Minute Apgar score, mean (SD)	5.4 (2.5)	5.3 (2.5)	5.5 (2.5)	<.001
Small for gestational age	13 916/72 216 (19)	3345/17 449 (19)	10 571/54 767 (19)	.70
Multiple birth	20 616/72 224 (29)	5284/17 454 (30)	15 332/54 770 (28)	<.001
Congenital malformation	3439/72 194 (5)	840/17 449 (5)	2599/54 745 (5)	.72
Vaginal delivery	19 972/72 230 (28)	4817/17 452 (28)	15 155/54 778 (28)	.87
Had prenatal care	69 124/72 025 (96)	16 817/17 421 (97)	52 307/54 604 (96)	<.001
Male	36 341/72 211 (50)	8869/17 451 (51)	27 472/54 760 (50)	.13
Race/ethnicity	n = 72 040	n = 17 410	n = 54 630	
Non-Hispanic white	33 541 (47)	9426 (54)	24 115 (44)	<.001
Non-Hispanic black	21 164 (29)	4588 (26)	16 576 (30)	
Other[d]	17 335 (24)	3396 (20)	13 939 (26)	
Year of birth 2008	37 116/72 235 (51)	9132/17 455 (52)	27 984/54 780 (51)	<.001

Abbreviations: NICU, neonatal intensive care unit; RNE, recognition for nursing excellence.
[a] Data are expressed as No. (%) of participants unless otherwise indicated.
[b] The χ^2 test was used for comparison of categorical variables and the unpaired 2-tailed *t* test for continuous variables.
[c] Calculated by the authors from the 2008 American Hospital Association Annual Hospital Survey.[27]
[d] All other races/ethnicities, including Hispanic.

Table 2. Very Low-Birth-Weight Infant Outcomes, 2007-2008

Outcomes	Infants, No./Total (%)		
	All Hospitals (N = 558)	RNE Hospitals (n = 119)	Non-RNE Hospitals (n = 439)
No. of infants	72 235	17 455	54 780
Death within 7 d	5258/71 955 (7.3)	1215/17 415 (7.0)	4043/54 540 (7.4)
Death within 28 d	7450/71 953 (10.4)	1740/17 415 (10.0)	5710/54 538 (10.5)
Death before discharge home	9278/71 936 (12.9)	2159/17 414 (12.4)	7119/54 522 (13.1)
Nosocomial infection	11 915/66 496 (17.9)	2706/16 221 (16.7)	9209/50 275 (18.3)
Severe intraventricular hemorrhage	4842/63 525 (7.6)	1109/15 482 (7.2)	3733/48 043 (7.8)

Abbreviation: RNE, recognition for nursing excellence.

7.6% (4842/63 525); and infection, 17.9% (11 915/66 496) (TABLE 2). The 7-day mortality was 7.0% in RNE hospitals vs 7.4% in non-RNE hospitals (difference, 0.4%); 28-day mortality was 10.0% in RNE hospitals vs 10.5% in non-RNE hospitals (difference, 0.5%); and hospital stay mortality was 12.4% in RNE hospitals vs 13.1% in non-RNE hospitals (difference, 0.7%). The incidence of SIVH was 7.2% in RNE hospitals and 7.8% in non-RNE hospitals (difference, 0.6%). Infection occurred in 16.7% of VLBW infants in RNE hospitals and 18.3% in non-RNE hospitals (difference, 1.6%).

TABLE 3 shows the relationships between RNE status and infant outcomes in logistic regression models. The lower rates of adverse outcomes in RNE hospitals observed in Table 2 understate the differences between these hospital types. From the unadjusted OR to the OR adjusted for infant risk, the ORs associated with RNE status decreased on average by 0.07 (range, 0-0.12). This is because somewhat higher-risk infants are born in RNE hospitals, so unadjusted models confound RNE status with patient risk. Adjusting for patient risk, RNE hospitals had statistically significant ORs of 0.84 to 0.87 for mortality and SIVH, but the OR of 0.88 (95% CI, 0.76-1.00) for infection was not statistically significant.

Three infant outcomes exhibited statistically significant associations with RNE status in models that also controlled for NICU and hospital variables: 7-day mortality, infection, and SIVH. Birth in an RNE hospital was associated with odds of death in the first week of life of 0.87 (95% CI, 0.76-0.99), an odds of infection of 0.86 (95% CI, 0.75-0.99), and an odds of SIVH of 0.88 (95% CI, 0.78-1.00). The 28-day and in-hospital mortality had similar ORs (0.90) but were not statistically significant. Compared with non-RNE hospitals, the adjusted absolute decrease in risk of outcomes in RNE hospitals ranged from 0.9% to 2.1%. All 5 outcomes were jointly significant ($P < .001$). The mean effect across all 5 outcomes was an OR of 0.88 (95% CI, 0.83-0.94; $P < .001$). Infants cared for in type A NICUs had an OR for infection of 0.74 (95% CI, 0.60-0.92; $P = .005$) relative to type C NICUs. Infants born in for-profit hospitals had an OR for infection of 1.24 (95% CI, 1.02-1.49; $P = .03$) relative to not-for-profit hospitals. The OR for the log volume of VLBW infants for 7-day mortality was 0.90 (95% CI, 0.82-0.99; $P = .02$).

The 2 gestational age subgroups exhibited marked differences in the ORs for the mortality variables but not for infection and SIVH. In the older gestational age subgroup (≥24 weeks), the ORs for all 3 mortality outcomes were smaller than in the full cohort, ranging from 0.83 to 0.87, and were statistically significant (TABLE 4). In the younger gestational age subgroup (<24 weeks), the ORs for all 3 mortality outcomes were weaker (ie, closer to or exceeding 1.00), with $P > .60$ (eTable 2). The results of analyses in birth-weight subgroups mirrored the overall findings (eTable 3 and eTable 4).

COMMENT

Hospital RNE status was found to be associated with significantly lower rates of 7-day mortality, nosocomial infection, and SIVH in VLBW infants. Rates of 7-day mortality (7%), SIVH (8%), and nosocomial infection (18%) were high in these patients. There was a 12% to 14% difference in the odds of these outcomes between RNE and non-RNE hospitals, with 95% confidence limits close to 1, which translates to relatively small adjusted absolute risk differences of 0.9% to 2.1%. For neonatal and in-hospital mortality, the findings were not significant. Although the significant mortality difference between the 2 hospital groups disappeared by 28 days of life, it remained significant in older-gestational-age infants.

These morbidities have serious consequences. Development of an infection more than doubles the mortality rate among VLBW infants.[31] In our sample, among infants who survived 3 days, 13.8% of those with nosocomial infection died compared with 5.5% without infection. Even more striking are the implications of SIVH for mortality. In our sample, 36.4% of infants with SIVH died compared with 5.9% without SIVH. There are important long-term consequences of SIVH for brain development, including neurocognitive impairment, cerebral palsy, and developmental delays.[32,33]

Among VLBW infants born at 24 weeks of gestational age or more, the ORs for all 3 mortality measures were stronger (0.83 to 0.87) and statistically significant. The exclusion of the extremely premature subgroup (<24 weeks) sharpened the RNE association with mortality in the remaining infants. Infants born before 24 weeks are at the lower limit of viability. Some families and physicians of these infants will choose not to use assisted ventilation and instead provide comfort care. Thus, RNE status was more strongly associated with survival for infants in the gestational age range in which intensive care is usually applied.

Our study identified larger differences in the odds of outcomes than did the few studies that have identified similar associations between hospital RNE and adult outcomes. The earliest study documented a 5% lower Medicare mortality rate in 1988 in 39 hospitals identified by reputation as a good place to practice nursing and for a record of recruiting and retaining professional nurses in a competitive market compared with a matched sample of hospitals.[34] Another study of 2004 data found a 5% lower patient fall rate in RNE vs non-RNE hospitals.[16]

In the decade since *Crossing the Quality Chasm*,[35] there have been numerous calls to improve the quality of the health care system. The Quality Health Outcomes Model links system-level factors to patient outcomes.[36] Recognition of nursing excellence status is a system-level factor encompassing professional control, interdisciplinary collaboration, decision making shared from the bedside to the highest management level, and developing new knowledge about how to achieve high-quality, effective, and efficient care. Improving the quality of care for vulnerable infants was emphasized in the Institute of Medicine report on preterm birth,[37] which pointed to nursing as a promising avenue for developing NICU quality measures, and the focus on infants was reinforced by a March of Dimes report.[38] One way to increase the number of infants that receive high-quality care would be to increase the number of hospitals with RNE. Our results suggest benefit for the VLBW infant population, but other hospitalized patients may also benefit, as suggested by the limited empirical evidence.

Table 3. Odds Ratios Estimating the Association of Hospital RNE Status and NICU and Hospital Variables With Very Low-Birth-Weight Infant Outcomes[a]

	Odds Ratio (95% CI)					
Outcomes	Unadjusted	*P* Value	Adjusted for Patient Characteristics	*P* Value	Adjusted for Patient, NICU, and Hospital Characteristics	*P* Value
Mortality						
Within 7 d	0.96 (0.86-1.06)	.41	0.84 (0.74-0.96)	.01	0.87 (0.76-0.99)	.04
Within 28 d	0.96 (0.87-1.05)	.35	0.87 (0.77-0.98)	.02	0.90 (0.80-1.01)	.08
Before discharge	0.95 (0.87-1.03)	.21	0.87 (0.78-0.97)	.01	0.90 (0.81-1.01)	.06
Morbidity						
Nosocomial infection	0.88 (0.78-1.01)	.06	0.88 (0.76-1.00)	.06	0.86 (0.75-0.99)	.04
Severe intraventricular hemorrhage	0.90 (0.80-1.00)	.05	0.84 (0.75-0.95)	.01	0.88 (0.78-1.00)	.045

Abbreviations: NICU, neonatal intensive care unit; RNE, recognition for nursing excellence.
[a] Odds ratios and 95% CIs were derived from random-effects logistic regression models. All models control for year of birth. Infant risk adjusters were gestational age, gestational age squared, 1-minute Apgar score, small for gestational age, multiple birth, congenital malformation, vaginal delivery, prenatal care, race/ethnicity, and sex. NICU characteristics were adjusted for the natural log of volume of very low-birth-weight infants and level of care. Hospital characteristics were adjusted for hospital ownership and membership in the Council of Teaching Hospitals.

Table 4. Odds Ratios Estimating the Association of Hospital RNE Status and NICU and Hospital Variables With Very Low-Birth-Weight Infant Outcomes Among Infants With Gestational Age of 24 Weeks or More at Birth[a]

	Odds Ratio (95% CI)					
Outcomes	Unadjusted	*P* Value	Adjusted for Patient Characteristics	*P* Value	Adjusted for Patient, NICU, and Hospital Characteristics	*P* Value
Mortality (n = 67 497-67 517)						
Within 7 d	0.91 (0.81-1.02)	.10	0.81 (0.70-0.93)	.004	0.83 (0.72-0.96)	.01
Within 28 d	0.92 (0.83-1.02)	.11	0.85 (0.75-0.95)	.01	0.87 (0.77-0.99)	.03
Before discharge	0.91 (0.83-1.00)	.06	0.85 (0.76-0.96)	.01	0.87 (0.78-0.98)	.02
Morbidity						
Nosocomial infection (n = 64 201)	0.87 (0.77-1.0)	.04	0.87 (0.75-0.99)	.04	0.86 (0.74-0.99)	.03
Severe intraventricular hemorrhage (n = 61 030)	0.89 (0.80-1.00)	.06	0.84 (0.74-0.96)	.01	0.88 (0.77-1.00)	.05

Abbreviations: NICU, neonatal intensive care unit; RNE, recognition for nursing excellence.
[a] Odds ratios and 95% CIs were derived from random-effects logistic regression models. All models control for year of birth. Infant risk adjusters were gestational age, gestational age squared, 1-min Apgar score, small for gestational age, multiple birth, congenital malformation, vaginal delivery, prenatal care, race/ethnicity, and sex. NICU characteristics were adjusted for volume of very low-birth-weight infants and level of care. Hospital characteristics were adjusted for hospital ownership and membership in the Council of Teaching Hospitals.

The better outcomes observed in VLBW infants in RNE hospitals may reflect higher-quality NICU and obstetric care. Perhaps RNE hospitals have a broad, long-standing commitment to quality care that is reflected in other aspects of care, such as excellent physician care, respiratory care, or infection control, that are not directly related to RNE but that may independently contribute to better outcomes for VLBW infants. Thus, RNE status may serve as a marker for an institution-wide commitment to optimizing outcomes. Recognition for nursing excellence status has been included as a criterion for a high-quality institution by the national groups US News & World Report Best Hospitals (since 2004)[39] and Leapfrog (since 2011).[40]

The practical importance of our findings is influenced by the accessibility of existing RNE hospitals to mothers at high risk of preterm birth. Currently, access is limited because only 1 in 5 hospitals with a NICU has RNE. This is a particular source of concern for racial and ethnic minorities because disproportionately few minority infants are born in hospitals with RNE.

Our study has limitations. The VON is not fully representative of US hospitals with a NICU. Our results may underestimate the "true" RNE associations. The comparison hospitals in this sample participate in a network dedicated to improving the quality and safety of neonatal care; therefore, they most likely give greater attention to quality improvements and monitoring. In addition, the VON disproportionately lacks the smallest NICUs, where prior research shows that outcomes are the worst.[25] In addition, we excluded 20 network hospitals without inborn infants. Outborn infants may acquire morbidities before admission, thus confounding the role of RNE status in these outcomes. By restricting to inborn infants, we excluded some freestanding children's hospitals. Infection and SIVH were not recorded for some infants who were transferred out. However, transfer rates were low and did not differ substantially by hospital type (12% for RNE and 15% for non-RNE). Also, the cross-sectional research design prevents causal inferences. There may be unobserved quality-related characteristics of RNE hospitals that are differentially associated with outcomes. Future research should focus on NICU nursing care, including the roles of specific factors (eg, nurse staffing and experience), as well as physicians and other health care professionals.

Our study focused on hospitals that met criteria for organizational excellence in nursing through comprehensive standards that are documented and continuously monitored. Meeting these criteria was associated with better outcomes for high-risk infants.

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Acquisition of data: Lake, Staiger, Horbar, Cheung, Patrick, Rogowski.
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Statistical expertise: Staiger, Kenny.
Obtained funding: Lake, Staiger, Horbar, Patrick, Rogowski.
Administrative, technical, or material support: Lake, Cheung.
Study supervision: Lake.
Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Lake received an honorarium for plenary remarks at the 2010 American Nurses Credentialing Center Research Symposium. Dr Staiger holds an equity interest in ArborMetric Inc, a company that sells efficiency measurement systems and consulting services to insurers and hospitals. Dr Horbar is chief executive and scientific officer for the Vermont Oxford Network. No other disclosures were reported.
Funding/Support: This study was supported by a Robert Wood Johnson Foundation Interdisciplinary Nursing Quality Research Initiative grant (to Dr Lake) and grant R01NR010357 (to Dr Rogowski) from the National Institute of Nursing Research, National Institutes of Health.
Role of the Sponsors: The funding organizations had no role in the design and conduct of the study; in the collection, analysis, and interpretation of the data; or in the preparation, review, or approval of the manuscript.
Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Nursing Research or the National Institutes of Health.
Online-Only Material: eTables 1 through 4 and the Author Audio Interview are available at http://www.jama.com.
Additional Contributions: We thank the 578 institutions that participated in the Vermont Oxford Network database, whose work made this research possible.

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