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RESEARCH ARTICLE

Disparities in Perinatal Quality Outcomes for Very Low Birth Weight Infants in Neonatal Intensive Care

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Objective. To determine if hospital-level disparities in very low birth weight (VLBW) infant outcomes are explained by poorer hospital nursing characteristics.

Data Sources. Nurse survey and VLBW infant registry data.

Study Design. Retrospective study of 8,252 VLBW infants in 98 Vermont Oxford Network hospital neonatal intensive care units (NICUs) nationally. NICUs were classified into three groups based on their percent of infants of black race. Two nurse-sensitive perinatal quality standards were studied: nosocomial infection and breast milk.

Data Collection. Primary nurse survey ($N = 5{,}773$, 77 percent response rate).

Principal Findings. VLBW infants born in high-black concentration hospitals had higher rates of infection and discharge without breast milk than VLBW infants born in low-black concentration hospitals. Nurse understaffing was higher and practice environments were worse in high-black as compared to low-black hospitals. NICU nursing features accounted for one-third to one-half of the hospital-level health disparities.

Conclusions. Poorer nursing characteristics contribute to disparities in VLBW infant outcomes in two nurse-sensitive perinatal quality standards. Improvements in nursing have potential to improve the quality of care for seven out of ten black VLBW infants who are born in high-black hospitals in this country.

Key Words. Health disparities, nurse staffing, nurse practice environment, quality standards, VLBW infants

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Very low birth weight (VLBW) infants are a high-risk patient population, comprising half of US infant deaths. Born weighing less than 1,500 g (3.2 pounds), these infants are disproportionately black (33 percent of VLBW infants vs. 16 percent of infants) (Mathews et al. 2011). Black VLBW newborns are concentrated in relatively few hospitals[1] whose quality of care has disproportionate influence on most black infants' health outcomes. Outcomes of the birth hospitalization have lifetime consequences that may contribute to health disparities.

Given the high concentration of black infants in few hospitals, poorer quality of care can generate population-level health disparities. In this article, we examine a previously unaddressed question: do infants cared for in hospitals with a high concentration of black infants have poorer perinatal quality outcomes as defined by the National Quality Forum? If so, what are the factors that influence observed disparities in the perinatal quality measures?

We studied two National Quality Forum (NQF) nurse-sensitive perinatal care standards: nosocomial infection and breast milk (National Quality Forum 2012a, 2013). The remaining perinatal standards address process measures related to delivery or screening for retinopathy of prematurity (National Quality Forum 2012b). Infection and breast milk have long-term health implications for VLBW infants. The development of an infection doubles the mortality rate, increases hospital costs and length of stay (Stoll et al. 2002; Payne et al. 2004), and is associated with poorer neurodevelopmental and growth outcomes in early childhood among extremely LBW infants (Stoll et al. 2004).

Multiple national authorities, including the Surgeon General, have endorsed exclusive breast milk for all newborns (U. S. Department of Health and Human Services 2011; American Academy of Pediatrics 2012; National Quality Forum 2013). Compared to infant formula, breast milk has unparalleled immunologic, digestive, and nutritional qualities that enhance infants' growth and health trajectories (U. S. Department of Health and Human Services 2011). These qualities are particularly beneficial to VLBW infants. However, the current NQF measure is limited to healthy, term newborns, is not risk-adjusted, and therefore excludes NICU patients (National Quality Forum 2013). We use breast milk in the NICU because it is recommended by the American Academy of Pediatrics as follows: "All preterm infants should receive human milk" (American Academy of Pediatrics Section on Breastfeeding 2012, p. e831, Table 3). For preterm infants, breast milk also

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reduces the likelihood of necrotizing entercolitis (NEC) (i.e., death of the bowel tissue; Ip et al. 2007), which occurs in 6 percent of VLBW infants (Horbar et al. 2012) and is fatal in 30 percent of cases (Fitzgibbons et al. 2009). In evidence from 2002, NEC increased length of stay by 1–2 months and yielded excess hospital charges of $200,000 per survivor (Bisquera, Cooper, and Berseth 2002).

VLBW infants are treated in neonatal intensive care units (NICUs), where they are closely monitored and provided with life support measures and intensive interventions. NICU stays are among the most expensive hospitalizations (Institute of Medicine 2006) due to the care intensity and long stays, which are typically 2 months for VLBW infants. A quarter of these infants stay about 3 months (82 days) or longer.[2]

In the NICU, the registered nurse is the primary care provider 24 hours a day. The nurse handles the infant, makes complex assessments of the infant's status, implements intensive therapies, and makes immediate adjustments based on the infant's response. The nurse monitors the infant's respiratory, cardiac, and nutritional statuses. NICUs are nurse-intensive, averaging two or three infants per nurse (Rogowski et al. 2013). Better nurse staffing and more professional nursing practice environments have been associated with better patient outcomes across hospitalized populations (Aiken et al. 2008, 2012; Friese et al. 2008; Kutney-Lee et al. 2009; Rogowski et al. 2013; Shekelle 2013; Tubbs-Cooley et al. 2013).

The nurse has a prominent role in infection prevention. The common source of infection is an intravenous catheter, which is required for most VLBW babies. The nurse administers intravenous fluids and maintains catheter hygiene. Aseptic technique and scrupulous hand hygiene decrease the risk of infants acquiring a nosocomial infection (Haley and Bregman 1982; Haley et al. 1995).

The challenges of providing breast milk in the NICU are numerous. The nurse is responsible for supporting the mother in developing and maintaining a milk supply. With their knowledge and expertise of effective lactation technique, NICU nurses play an important role in guiding mothers through the process of breastfeeding (Lessen and Crivelli-Kovach 2007; Nelson 2007; Boucher et al. 2011). Nursing staff have been reported to spend more time than other health care professionals assisting parents through direct instruction, positive reinforcement, and encouragement (Nelson 2007). Evidence suggests that breastfeeding mothers require more of a nurse's time and that limits on a nurse's time affect the frequency of breastfeeding support (Nelson 2007; Hallowell et al. 2014).

The only studies that have looked at disparities in this patient population examined mortality. One study showed that both white and black infants had higher mortality rates in hospitals with over 35 percent black infants (Morales et al. 2005). Another estimated that, had black VLBW babies in New York City been born in the same hospitals as white babies, the black/white disparity in VLBW neonatal mortality in New York City would be reduced by 34.5 percent (Howell et al. 2008). The explanation for these results is unknown.

Recent studies documented lower nurse staffing in the top-decile-black hospitals (Ly et al. 2010) and that nurse staffing and the nurse work environment partly explained hospital-level disparities in outcomes for adults (Brooks-Carthon et al. 2011). It is not known how nursing features differ between hospitals with varying concentrations of black infants due to lack of data. These are the first data available to address these objectives. We focus on nursing because of the nursing intensity of this setting and the integrality of nursing care to these quality standards. The purposes of the study were to measure disparities in nurse-sensitive perinatal quality outcomes in hospitals with high, middle, and low concentrations of black VLBW infants and to estimate the associations of nurse staffing and work environment as hospital factors that may influence these disparities. In addition, we explore whether other hospital personnel contribute to outcome disparities.

METHODS

We conducted a national, multihospital, retrospective cohort study in 2008 in which nurse survey data were used to measure NICU nursing features and clinical data from the Vermont Oxford Network database were used to measure infant characteristics and outcomes.

Sites and Patient Sample

The hospital sample comprised 98 Network NICUs recruited to a nurse staffing study involving extensive nurse primary data collection. In 2008, the Network, an international quality and safety consortium, comprised 576 US hospitals, with approximately 65 percent of NICUs and 80 percent of VLBW infants in the US. The Network is broadly representative of US NICUs (Lake et al. 2012). The Network classifies NICUs into Levels A (restriction on ventilation, no surgery), B (major surgery), and C (cardiac surgery), corresponding to levels II, III and IV in the American Academy of Pediatrics's classification

(American Academy of Pediatrics [AAP] Committee on Fetus and Newborn 2012). Hospitals were recruited based on NICU level of care and geographic region to represent the Network. The NICU directors at all US Network hospitals were invited to participate. Midway through recruitment, a second invitation was sent to NICUs in levels and regions with fewer recruits in order to yield a representative sample.

The study population consisted of inborn infants (i.e., born in the hospital) of all racial and ethnic groups who weighed between 501 and 1,500 g and met inclusion criteria for one or both outcomes (N = 8,252). Infants met inclusion criteria for infection after 3 days of life (n = 8,246). Infants met inclusion criteria for breast milk if they were discharged home on enteral feeding (n = 6,964). Very few infants had missing outcome data (n = 7 for infection and 4 for breast milk). Institutional review board approval was obtained from The University of Pennsylvania, the University of Medicine and Dentistry of New Jersey, and the University of Vermont.[3]

Variables

Three terciles of hospitals were identified (<11 percent, 11–31 percent, >31 percent black) from the percentages of all VLBW black infants born in 578 US Network hospitals in 2007–2008. Two years of data provided more stable estimates of the percentages of black infants in smaller NICUs. Non-Hispanic black infants were categorized as black. All other infants were categorized as non-black.

The total percentage of black VLBW infants cared for in each tercile was calculated. The distribution of black infants in the Network nationally across hospital groups was as follows: 70 percent of black VLBW newborns were born in high-black hospitals, compared with 25 percent in the middle-black tercile and 5 percent in the low-black tercile.

NICU nursing features were measured from primary web-based nurse-survey data in March 2008 (N = 5,773; 77 percent response rate). A site coordinator at each NICU distributed invitations to complete the one-time web survey to eligible staff nurses identified by the nurse manager. All staff nurses who worked at least 16 hours per week employed at least 3 months on the nursing unit were eligible. An average of 58 nurses per NICU responded to the survey (range 18–159). The educational and experience composition of the survey respondents was nearly identical to that of the population of eligible nurses employed in the unit. Nurses reported about their last shift infant assignment, including infant acuity, their qualifications, and the NICU nursing practice environment. Nurse managers provided data on nurses' educational preparation. Compliance with minimum staffing thresholds for five infant acuity categories from specialty societies was measured from observed patient-to-nurse ratios (American Academy of Pediatrics and American College of Obstetricians and Gynecologists, Lemons, and Lockwood 2007; Association of Women's Health Obstetric and Neonatal Nurses's 2010; Rogowski et al. 2013). Based on prior work showing that nearly all (93 percent) NICUs understaffed their infants on average, we measured nurse understaffing (Rogowski et al. 2013). Nurse understaffing relative to guidelines was measured at the nurse level and aggregated to the unit level. The variable is the mean fraction of a nurse that a NICU is below national guidelines. Nurse understaffing was measured as the fraction of a nurse per infant needed to meet national guidelines. The nurse-to-infant ratio ranges from 1: 3–4 for the lowest acuity infants ("continuing care") to one or more nurse per infant for the highest acuity infants, "unstable, requiring complex critical care" (American Academy of Pediatrics and American College of Obstetricians and Gynecologists, Lemons, and Lockwood 2007). The percentage of nurses with a bachelor of science or higher degree in nursing was computed. Neonatal intensive care qualifications were calculated as the percentage of nurses with neonatal critical care specialty certification or 2 years of NICU experience (American Academy of Pediatrics and American College of Obstetricians and Gynecologists, Lemons, and Lockwood 2007). The professional practice environment was measured by the Practice Environment Scale of the Nursing Work Index (PES-NWI), an NQF standard, using the composite of five subscales (Lake 2002; National Quality Forum 2004, 2012c). The PES-NWI comprises 31 items in five subscales: Nurse Participation in Hospital Affairs; Staffing and Resource Adequacy; Nursing Foundations for Quality of Care; Nurse Manager Ability, Leadership, and Support of Nurses; and Collegial Nurse/Physician Relations.

Nurse managers provided data on NICU personnel and number of beds in January 2008, including neonatologists, residents, fellows, respiratory therapists, pharmacists, nurse practitioners, social workers, nutritionists, patient care technicians, and lactation consultants. We created three variables: neonatologists, residents and fellows, and other personnel. The frequency of personnel was converted to FTEs as follows: each person that worked the entire shift was considered one full-time equivalent (FTE), while each person that worked for "part of the shift" was considered 0.5 FTE. The FTEs of each provider were calculated per 10 beds overall and for day shift. Total hospital expenditures per admission for all hospitalized patients were calculated from the AHA

Annual Survey of Hospitals (American Hospital Association 2010) and analyzed as a hospital-wide indicator of resource use per admission.

Infant characteristics, infant outcomes, and NICU-level measures were obtained from the Network database using standardized definitions (Vermont Oxford Network 2008). The database contains detailed uniform clinical and treatment information on all VLBW infants. Congenital malformation was defined as a specific birth defect that is considered lethal or life-threatening as detailed in the VON Manual of Operations (Vermont Oxford Network 2008). Nosocomial infection was defined as an infection in blood or cerebrospinal fluid culture occurring more than 3 days after birth for three culture-proven infections: coagulase negative staphylococcus requiring 5 or more days of antibiotic treatment, other bacterial infections, and fungal infections. This definition is virtually identical to NQF #0304: late sepsis or meningitis in VLBW neonates (National Quality Forum 2012a). The only difference is that our measure includes fungal infections, which account for very few infections.

The NQF perinatal standard, #0480 refers to "exclusive breast milk feeding" but is not currently applied to the NICU. The only VON data on breast milk use is from the variable "enteral feeding at discharge." We defined being discharged without breast milk as having no enteral feedings containing breast milk within 24 hours of discharge. Breast milk combined with fortifier or formula was considered breast milk. We chose this approach because fortifier is often used to supplement breast milk in critically ill newborns (Kleinman 2009). Therefore, our measure is a lower bound estimate of infants discharged without *exclusive* breast milk.

Patient risk-adjusters for infection and breast milk consisted of infant gestational age in weeks (and its square); small for gestational age; 1-minute Apgar score; maternal race and ethnicity (non-Hispanic black, non-Hispanic white, or other [including Hispanic]); gender; multiple birth; presence of a major birth defect; vaginal delivery; and whether the mother received prenatal care (Rogowski et al. 2004). The 1-minute Apgar score is considered preferable to the 5-minute Apgar score because it reflects the status of the infant at birth rather than after any interventions that happened in the 5 minutes following birth. Race/ethnicity was included in the breast milk model to account for cultural and biological differences in the rates of using breast milk (U. S. Department of Health and Human Services 2011). The biological differences include higher rates of preeclampsia among black women. This condition and its treatment diminish the production of breast milk (Leeners et al. 2005; Shen, Tymkow, and MacMullen 2005; Cordero et al. 2012). Race/ethnicity was determined for the VON database through maternal self-report, the birth certificate, or the medical record. Prenatal care was defined as any prenatal obstetrical care prior to the admission (Vermont Oxford Network 2008). This risk-adjustment model is well established for mortality in VLBW infants and has been demonstrated to successfully adjust for risk of infection (Lake et al. 2012; Rogowski et al. 2013). There is currently little guidance in the literature for risk adjustment for breast milk. This model had area under the receiver operating characteristic curves of 0.76 for infection and 0.66 for breast milk.

The included NICU-level variables consistent with prior research were volume and NICU level (A, B, C) (Rogowski et al. 2004; Phibbs et al. 2007). Volume was modeled as the log of the mean annual number of VLBW admissions. The log transformation fits the data, particularly from small volume hospitals, better than earlier, threshold-based approaches. The universe of US NICUs was identified from the American Hospital Association (AHA) survey data (American Hospital Association 2010) by nonzero values for neonatal intensive care beds. Expense per admission for all hospitalized patients was measured in $1,000 increments at the hospital level from the AHA data. Hospital ownership and teaching status were obtained from the 2008 AHA data.

Data Analysis

Our study focused on hospital concentration of black infants, nursing factors, and VLBW infant outcomes. Characteristics of hospitals and infants, as well as nursing factors, other personnel in the sample overall, and hospital subgroups were described. Nursing and other personnel factors that differed significantly between high- and low-black hospitals were considered for the main regression analysis. To determine whether potential outcome rate differences were due to differential risk factors of black and non-black infants, the characteristics of black and non-black infants were examined separately across hospital subgroups. For each outcome, we compared the prevalence in hospitals with high and low concentrations of black infants and calculated a z-statistic. For these comparisons to best measure the disparity, we excluded the middle tercile because the contrast of interest was the highly concentrated with the least concentrated. In addition, we compared the prevalence for black and non-black infants separately across hospital groups to determine if outcomes were worse for black infants in low-black hospitals or non-black infants in high-black hospitals. We estimated four random-effects logistic regression models by the method of maximum likelihood for each dependent variable: infection and discharge without breast milk. The random effects applied to the hospital level. The first model included only terciles for concentration of black infants (high, middle, with low as the reference category) as the independent variables. The second added patient risk adjusters. The third added NICU-level covariates. The fourth added nursing variables. The random effect corrects the standard errors for within-hospital correlation (clustering) in patient outcomes. Additional regression models were estimated to examine whether including other NICU personnel staffing or hospital expense per admission reduced the coefficient of the high-black hospital outcome effect.

To examine whether the effect of the hospital concentration of VLBW black infants differed by infant race, models including interaction terms for race (black, non-black) and black concentration tercile were estimated. To examine whether the effect of nursing on outcomes differed by infant race, models including interaction terms for race (black, non-black) and nursing factor were estimated. The analyses were conducted using *Stata* statistical software version 10.1 (Statacorp 2007).

RESULTS

In comparison to all U.S. hospitals with a NICU in 2008 (890 hospitals), the sample contained more teaching hospitals (47 percent vs. 27 percent) and somewhat more not-for-profit hospitals (81 percent vs. 71 percent), as well as larger NICUs (a mean of 41 vs. 28 beds). The sample was disproportionately recognized for nursing excellence through Magnet accreditation (32 percent vs. 19 percent) (American Nurses Credentialing Center 2014). RN staffing for the entire hospital in sample hospitals was higher than in U.S. hospitals with a NICU (10.3 hours per patient day vs. 9.4, $p < .01$). All U.S. geographic regions were represented.

In comparison to all Network hospitals in 2008 (558 hospitals), the sample contained more teaching hospitals (47 percent vs. 33 percent) and somewhat more not-for-profit hospitals (81 percent vs. 74 percent), as well as larger NICUs (a mean of 41 vs. 34 beds). Most sample NICUs were Level B (63 percent), followed by Levels C (26 percent) and A (11 percent). By contrast, the Network had more Level A units (30 percent) than C (18 percent).

In sample hospitals, the high-, medium-, and low-black hospital groups did not differ on hospital characteristics or NICU Level (Table 1). Volume of VLBW infant admissions and the number of NICU beds were higher in high-black than in low-black hospitals (128 vs. 80; $p = .005$ and 47 vs. 33; $p = .02$).

Sample infants had a mean birth weight of 1,078 g and gestational age of 28.4 weeks (Table 1). Infants in high-black hospitals had significantly lower

Table 1: Hospital, NICU, and Infant Characteristics in All Hospitals and by Hospital Concentration of Black VLBW Infants

		*Participants**			
		Concentration of VLBW Black Infants†			
	Total (%)	*Low (< 11%)*	*Medium (11–31%)*	*High (> 31%)*	*p-Value of High versus Low*‡
Number of hospitals	*N* = 98	*N* = 26	*N* = 37	*N* = 35	
Hospital characteristics					
Hospital ownership§					
Public	13 (13.3)	5 (19.2)	4 (10.8)	4 (11.4)	.14
For-profit	6 (6.1)	2 (7.7)	4 (10.8)	0 (0.0)	
Not-for-profit	79 (80.6)	19 (73.1)	29 (78.4)	31 (88.6)	
Member, council of teaching hospitals§	46 (46.9)	9 (34.6)	19 (51.4)	18 (51.4)	.21
Hospital nursing characteristics					
Magnet hospital	31 (31.6)	11 (42.3)	9 (24.3)	11 (31.4)	.43
Hospital-wide RN hours per adjusted patient day, mean (SD)¶	10.4 (2.6)	10.6 (3.0)	10.6 (2.5)	10.1 (2.5)	.51
NICU characteristics					
NICU level					
A	11 (11.2)	5 (19.2)	2 (5.4)	4 (11.4)	.67
B	62 (63.3)	15 (57.7)	26 (70.3)	21 (60.0)	
C	25 (25.5)	6 (23.1)	9 (24.3)	10 (28.6)	
Annual volume of VLBW admissions, mean (SD)	106.4 (64.5)	79.7 (55.8)	104.4 (57.6)	128.3 (70.8)	.005
Number of NICU beds, mean (SD)**	40.6 (22.1)	32.7 (17.2)	40.1 (22.3)	46.8 (23.7)	.02
Number of infants	*N* = 8,252	*N* = 1,642	*N* = 3,051	*N* = 3,559	
Infant characteristics					
Birth weight, mean (SD), g	1,078.0 (277.3)	1,094.2 (273.1)	1,084.0 (279.3)	1,065.5 (277.1)	<.001
Gestational age, mean (SD), weeks	28.4 (2.7)	28.4 (2.7)	28.3 (2.7)	28.3 (2.8)	.15
1-minute Apgar Score, mean (SD)	5.4 (2.4)	5.6 (2.4)	5.6 (2.4)	5.3 (2.5)	<.001

Continued

Table 1. *Continued*

		*Participants**			
		Concentration of VLBW Black Infants†			
	Total (%)	*Low (< 11%)*	*Medium (11–31%)*	*High (> 31%)*	*p-Value of High versus Low*‡
Small for gestational age	1,594 (19.3)	330 (20.1)	574 (18.8)	690 (19.4)	.55
Multiple birth	2,384 (28.9)	503 (30.6)	964 (31.6)	917 (25.8)	<.001
Congenital malformation	296 (3.6)	56 (3.4)	144 (4.7)	96 (2.7)	.14
Vaginal delivery	2,306 (27.9)	470 (28.6)	787 (25.8)	1,049 (29.5)	.53
Had prenatal care	7,925 (96.0)	1,559 (95.0)	2,961 (97.1)	3,405 (95.7)	.24
Gender, male	4,118 (49.9)	834 (50.8)	1,526 (50.0)	1,758 (49.4)	.35
Race/Ethnicity					
Non-Hispanic white	4,088 (49.5)	927 (56.5)	1,815 (59.5)	1,346 (37.8)	<.001
Non-Hispanic black	2,478 (30.0)	100 (6.1)	604 (19.8)	1,774 (49.8)	
Hispanic	1,222 (14.8)	447 (27.2)	443 (14.5)	332 (9.3)	
Asian/Pacific Islander	282 (3.4)	83 (5.1)	119 (3.9)	80 (2.2)	
Native American	43 (0.5)	27 (1.6)	10 (0.3)	6 (0.2)	

*Data are expressed as No. (%) of participants unless otherwise indicated.
†Concentrations were based on national Vermont Oxford Network 2007–2008 data.
‡The chi-square test was used for comparison of categorical variables and the unpaired two-tailed *t*-test for continuous variables for comparison of high- to low-black hospitals.
§Measured from the 2008 American Hospital Association Annual Hospital Survey.
¶Calculated by the authors from the 2008 American Hospital Association Annual Hospital Survey.
**NICU beds is the sum of AHA survey variables neonatal intensive care beds and neonatal intermediate care beds; seven hospitals had missing values.
NICU, neonatal intensive care unit; RN, registered nurse; VLBW, very low birth weight.

birth weights and Apgar scores ($p < .001$) than in low-black hospitals. Fewer infants in high-black hospitals were a multiple birth ($p < .001$). The racial and ethnic composition of the sample was 50 percent non-Hispanic white, 30 percent non-Hispanic black, and 20 percent other. Half of the infants in the 36 high-black hospitals were black, compared to only 6 percent in the 26 low-black hospitals. There was no systematic pattern of differences in infant characteristics for black and non-black infants across hospital groups (Tables S1A and S1B).

Table 2: VLBW Infant Outcomes for All Infants and for Infants of Black and Non-Black Race in All Hospitals and by Hospital Concentration of VLBW Black Infants

	Infants, No./Total (%)					
			Concentration of VLBW Black Patients			*p*-Value of High versus Low
Outcomes	*Race*	*Total*	*Low (< 11%)*	*Medium (11–31%)*	*High (> 31%)*	
Overall						
Nosocomial infection	All infants	1,390/8,246 (16.9)	234/1,641 (14.3)	503/3,051 (16.5)	653/3,554 (18.4)	<.001
Discharge home without breast milk	All infants	3,892/6,964 (55.9)	615/1,429 (43.0)	1,346/2,489 (54.1)	1,931/3,046 (63.4)	<.001
By black and non-black race						
Nosocomial infection	Black	447/2,478 (18.0)	12/100 (12)	99/604 (16.4)	336/1,774 (18.9)	.08
	Non-black	943/5,768 (16.4)	222/1,541 (14.4)	404/2,447 (16.5)	317/1,780 (17.8)	<.01
Discharge home	Black	1,543/2,091 (73.8)	54/92 (58.7)	333/477 (69.8)	1,156/1,522 (76.0)	<.001
without breast milk	Non-black	2,349/4,873 (48.2)	561/1,337 (42.0)	1,013/2,012 (50.4)	775/1,524 (50.9)	<.001

Note. The *p*-value is from a *z*-statistic comparing high- to low-black hospitals.
VLBW, very low birth weight.

Table 3: NICU Nursing Characteristics and Other Provider Staffing in All Hospitals and by Hospital Concentration of VLBW Black Infants

		Concentration of VLBW Black Infants			
	Total	*Low (< 11%)*	*Medium (11–31%)*	*High (> 31%)*	*p-Value of High versus Low*
Number of hospitals	$N = 98$	$N = 26$	$N = 37$	$N = 35$	
Nursing characteristics					
Nurse understaffing: Fraction of a nurse per infant needed to meet guidelines, mean	.18 (.11)	.14 (.08)	.18 (.09)	.22 (.15)	.004
% of staff registered nurses with neonatal intensive care qualifications	.84 (.09)	.83 (.10)	.83 (.10)	.85 (.08)	.44
% of staff registered nurses with BSN or higher nursing degree	.55 (.15)	.55 (.16)	.56 (.14)	.55 (.16)	.88
Practice Environment Score	3.05 (.25)	3.16 (.27)	3.07 (.21)	2.95 (.24)	.004
*Other provider staffing**					
Neonatologists	0.47 (0.22)	0.46 (0.21)	0.50 (0.24)	0.43 (0.23)	.59
Medical fellows and residents	0.42 (0.58)	0.36 (0.55)	0.44 (0.62)	0.45 (0.57)	.53
Non-physicians	0.17 (0.08)	0.19 (0.10)	0.17 (0.07)	0.17 (0.06)	.28

Note. The p-value is from a t-statistic comparing high- to low-black hospitals. Practice Environment Score is the composite score from the Practice Environment Scale of the Nursing Work Index. Higher scores indicate better practice environments.
*Day shift FTEs per 10 beds.
VLBW, very low birth weight.

The observed rate of nosocomial infection was 16.9 percent and discharge home without breast milk was 55.9 percent (Table 2). High-black hospitals had higher rates of infection (18.4 percent vs. 14.3 percent; $p < .001$) and discharge without breast milk (63.4 percent vs. 43.0 percent; $p < .001$) than low-black hospitals. Both black and non-black infants had worse outcome rates in the high-black hospitals.

Relative to national guidelines, sample NICUs were understaffed on average 0.18 of a nurse per NICU infant (Table 3). Understaffing was greater in high-black hospitals (0.22 of a nurse) than in low-black hospitals (0.14), $p = .004$; a difference of .73 SD. About half (55 percent) of the NICU nurses had a bachelor's or higher degree in nursing and most (84 percent) had neonatal qualifications. Nurse education and qualifications did not differ across terciles. The nursing practice environment was rated 3.05 overall, which is considered a favorable rating, reflecting that most nurses agreed (equal to 3 on a scale from 1 to 4) that the 31 characteristics that indicate a professional nursing environment were present in their NICU. The practice environment ratings were lower in high-black hospitals (2.95) than in low-black hospitals (3.16), $p = .004$; a difference of .84 SD. Staffing by neonatologists, residents, fellows, and other providers did not differ significantly between high- and low-black hospitals.

Infants in high-black hospitals had higher odds of both adverse outcomes in models that controlled for infant and NICU variables, including infant race (Table 4). Birth in a high-black hospital (relative to a low-black hospital) was associated with odds of infection of 1.64 ($p = .01$), and odds of no breast milk of 1.61 ($p = .03$). In models that further controlled for nurse understaffing and the nursing practice environment, there was no longer a significant association between high-black hospital status and either outcome. After controlling for nursing factors, the excess risk (the difference between the odds ratio and equivalent risk of 1.00) associated with being born in a high-black hospital declined about one-third for infection (from .64 to .44) and about one half for no breast milk (from 0.61 to 0.32). A 1 SD higher score on the Practice Environment Scale of the Nursing Work Index was associated with 15 percent lower odds of infection (OR = 0.85, $p = .04$). A 1 SD higher level of nurse understaffing was associated with a 20 percent higher odds of no breast milk (OR = 1.21, $p = .02$). With the addition of the nursing variables, the coefficient for high-black hospital status became nonsignificant because the coefficient decreased in magnitude, not because the confidence interval grew. Results did not differ by NICU level. The OR for the log volume of VLBW infants for infection was 0.78 (95 percent CI, 0.60–1.00; $p = .048$). In both models that did and did not control for the nursing variables including the other personnel or expense per admission variables resulted in minimal change (i.e., the second decimal place changed) in the other coefficients. In particular, there was minimal change in the high-black coefficient and it remained highly significant ($p < .01$). Thus, the non-nurse staffing variables and hospital-level expenses did not account for any of the high- black effect.

In models with interaction terms for individual race and hospital category (high black or middle black), the interaction was not significant for infection. Being treated in a high-black hospital had a stronger association ($p = .017$) with being discharged home without breast milk among black infants than among non-black infants. In models with interaction terms for individual race and nursing factors, the interactions were not significant for either outcome.

Table 4: Odds Ratios Estimating the Association of Hospital Concentration of Black Infants, NICU, and Nursing Variables with VLBW Infant Outcomes

	Odds Ratio (95% Confidence Interval)			
VLBW Infant Outcomes	*Adjusted for Patient and NICU Characteristics*	*p-Value*	*Adjusted for Patient, NICU, and Nursing Characteristics*	*p-Value*
Nosocomial infection				
Concentration of black infants				
Low (<11% is reference)	1.00		1.00	
Medium (11–31%)	1.42 (0.99–2.02)	.054	1.36 (0.96–1.92)	.08
High (>31%)	1.64 (1.14–2.36)	.01	1.44 (1.00–2.08)	.052
Nursing characteristics				
Understaffing			1.04 (0.92–1.19)	.52
Practice environment			0.85 (0.72–0.99)	.04
Discharge home without breast milk				
Concentration of black infants				
Low (<11% is reference)	1.00		1.00	1.00
Medium (11–31%)	1.35 (0.89–2.05)	.15	1.25 (0.84–1.85)	.28
High (>31%)	1.61 (1.05–2.46)	.03	1.32 (0.87–2.01)	.19
Understaffing			1.21 (1.04–1.41)	.02
Practice environment			0.92 (0.77–1.10)	.35

Note. Odds ratios and confidence intervals were derived from random-effects logistic regression models. 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 gender. NICU characteristics were adjusted for the natural log of volume of VLBW infants and level of care.
NICU, neonatal intensive care unit; VLBW, very low birth weight.

Comment

Hospitals that disproportionately treat black patients have worse patient outcomes (Morales et al. 2005; Skinner et al. 2005; Lucas et al. 2006; Breslin et al. 2009; Chan et al. 2009; Hausmann et al. 2009; Ly et al. 2010; Brooks-Carthon et al. 2011; Jha, Orav, and Epstein 2011) for unknown reasons. This article examined differences in nursing factors and their contribution to observed outcome disparities in a high-risk pediatric patient population. There has been a lack of data to address this question, which requires a large quantity of multihospital nursing and patient data, including patient race, risk characteristics, and outcomes. We find that high-black hospitals have lower quality of care as measured by two nurse-sensitive perinatal quality standards: infection and discharge home on breast milk. Nurse staffing and practice environments account for a sizable fraction (one-third to one-half) of the hospital-level disparities.

Relative to national guidelines, high-black hospitals understaff NICU babies more than one-fifth of a nurse (.22) per infant, which is .73 SD greater than in low-black hospitals. Furthermore, in high-black hospitals, nurses' practice environments are less supportive of professional nursing practice (differences equate to nearly 1 SD [.84] lower scores) than in low-black hospitals. Numerous studies have linked hospital nurse staffing and practice environments to patient outcomes (Aiken et al. 2008, 2012; Friese et al. 2008; Kutney-Lee et al. 2009; Rogowski et al. 2013; Shekelle 2013; Tubbs-Cooley et al. 2013). In fact, when nursing factors were controlled for instead of being an unobserved factor, the differences in outcomes between high-black and low-black hospitals were no longer statistically significant. Our results underscore the importance of nursing as a factor driving the disparities between these hospital types. The findings are consistent with the only other study showing that nurse staffing and practice environments contribute to disparities in quality of care and patient satisfaction in hospitals with high concentrations of black patients (Brooks-Carthon et al. 2011). No data have previously been available to determine whether nursing resources differ between hospitals with varying concentrations of black infants. The primary data required for this study involved surveys of nearly 6,000 staff nurses in 98 NICUs throughout the country.

There are dramatic distributional differences in where black infants are cared for in the US Vermont Oxford Network. Nearly three-fourths of black VLBW infants are born in a third of hospitals that care for critically ill newborns. Very few black infants, 1 in 20, are born in hospitals with better nursing characteristics. Therefore, these quality differences contribute to population-level health disparities.

Our results shed light on several potential causal bases for institution-level outcome disparities. Perhaps nursing factors are proxies for other hospital resources that may be poorer in high-black hospitals and account for the disparity. We examined measures of NICU physicians and other providers and overall resources dedicated to patient care. These measures did not differ across high and low-black hospitals and did not explain the disparities.

Another potential basis for hospital-level outcome disparities is differential treatment of black and non-black infants. This was not supported in our results, which showed that both black and non-black infants in high-black hospitals had worse outcomes. Furthermore, the nursing factors did not differentially affect infants of different races, suggesting that black infants are not disadvantaged relative to non-black infants by poorer nursing resources. This result differs from evidence from elderly postsurgical patients, for whom nurse staffing had a larger mortality effect for black patients than other patients (Brooks Carthon et al. 2012).

Perhaps high-black hospitals care for higher-risk black and non-black patients than other hospitals. The disparity would derive from differential risk. However, the infant characteristics by racial category were similar across hospital groups.

Nursing is the largest, most expensive component of hospital cost (Kane and Siegrist 2002). To reduce disparities, better nursing factors would be required in high-black hospitals. However, hospital payment policy changes under the Affordable Care Act (ACA) are unlikely to improve the financial situation of these providers. Health insurance expansion under the ACA will largely replace uninsured patients with Medicaid patients. Due to low Medicaid reimbursements, the revenue gained from an insured population may not offset the lost disproportionate share payments beginning in 2014 (Bristol 2012). Targeted policies would be needed for these institutions where augmenting nursing resources would be a powerful instrument of quality improvement. Nurse managers should target nurse staffing and environments as top priorities for improvement efforts.

Infants in disproportionately black hospitals had at least 60 percent higher odds of the adverse outcomes that are nurse-sensitive perinatal quality standards. In this population, the consequences of suffering an infection include a dramatically higher mortality rate, as well as poorer growth into early childhood (Stoll et al. 2002, 2004). Not receiving breast milk deprives these infants of optimal nutrition for the first 6 months of life, as established by the surgeon general. Not receiving breast milk also increases the risk of a frequently fatal morbidity, NEC (Ip et al. 2007). However, the reduction in NEC due to the use of breast milk corresponds to the time an infant is in the NICU, not the use of breast milk at discharge, as was measured in this study. Therefore, the birth hospitalization and related outcomes of these infants begin a lifetime trajectory of health disparities.

Black infants are particularly disadvantaged in high-black hospitals with respect to receiving breast milk. Individual maternal race was controlled for in the analysis. Black infants have the lowest breast feeding rates among racial and ethnic groups nationally (60 percent as compared to 75 percent of white infants and 80 percent of Asian or Hispanic infants) (US Department of Health and Human Services 2011). We find that birth in a high-black hospital compounds this difference.

As noted, the NQF measure for infants eligible for breast milk excludes the NICU setting. Our results document that, in the setting with the neediest population, we are falling far short of the Surgeon General's recommendation. This gap warrants immediate attention. A first step would be to add this setting to the NQF standard.

The clear pattern of poorer outcomes in high-black hospitals raises the question: What are the bases for their lower quality? Two principal institutional factors likely operate: financial constraints and poor management. Our data did not show lower overall expense-per-admission in high-black hospitals. We were not able to look at management, but other research has shown that hospital board chairpersons of high-black hospitals reported less expertise with quality of care issues and were less likely to rate quality as a top priority compared to board chairpersons in other hospitals (Jha and Epstein 2011). Our finding showing inferior nursing practice environments in high-black hospitals supports the premise that these institutions are poorly organized. Our measure of the nursing practice environment was preferable to a hospital-level organization measure because it was developed for the personnel type of interest (registered nurses) and measured in the specific unit where our population is cared for.

Our study has limitations. The cross-sectional design limits causal inference. Compared to the Network and U.S. hospitals with a NICU, the sample comprised somewhat more teaching hospitals, as well as larger and higher level NICUs. The sample hospitals participate in a consortium dedicated to improving the quality and safety of neonatal care; therefore, they may give greater attention to quality monitoring and improvements. The Network disproportionately lacks the smallest NICUs, where outcomes are the worst (Phibbs et al. 2007). Our results derive from a sample of hospitals with better overall staffing than the population of U.S. hospitals with a NICU. Therefore, our results may underestimate the adverse events and overestimate the nursing resources in a typical NICU. Other hospital characteristics that may be related to these outcomes, such as rooms and supplies for pumping milk, or the presence of hand washing stations, were not included due to data limitations. Breast-feeding is a personal choice and may not be medically advisable, for example, if the mother is HIV positive or uses narcotics. Moreover, the data did not contain maternal education, or socioeconomic or health insurance status.

This is the first study to link varying nursing resources across hospitals with high and low fractions of black patients to hospital-level disparities and to demonstrate that nursing contributes to these disparities in a high-risk population. Improvements in nursing resources in high-black hospitals have the potential to improve outcomes for seven of ten black VLBW infants in this country.

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Disclosures: None.

Disclaimers: None.

Notes

1. Authors tabulations from Vermont Oxford Network data.
2. Authors tabulations from Vermont Oxford Network data; median length of stay in 2009 was 62 days.
3. The University of Vermont did not consider the project to be human subjects research.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.
Table S1A: Characteristics of VLBW Black Infants in All Hospitals and by Hospital Concentration of Black VLBW Infants.
Table S1B: Characteristics of VLBW Non-Black Infants in All Hospitals and by Hospital Concentration of Black VLBW Infants.
Data S1. Vermont Oxford Network Participating Hospitals.