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Changes in Hospital Quality at Hospitals Serving Black and Hispanic Newborns Below 30 Weeks' Gestation

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Abstract

OBJECTIVE: Examine whether the quality of Black and Hispanic serving (BHS) compared to not BHS (NBHS) NICUs has changed differentially over time.

STUDY DESIGN: Infants 24-29 weeks' gestation born at U.S. Vermont Oxford Network centers (2006-2018) were studied. We calculated adjusted hospital quality scores as the predicted probabilities of a composite in-hospital mortality and morbidities from a logistic model. We regressed hospital quality scores on birth year to estimate the linear temporal slope by BHS-serving status for hospitals within each Census division.

RESULTS: Hospital quality improved similarly over time for BHS and NBHS hospitals across all divisions except West South Central where mean change in the composite score was −18.8 (95% CI: −24.1, −13.5) for NBHS and −9.3 (95% CI: −14.1, −4.6) for BHS hospitals (p-value= 0.009).

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AUTHOR CONTRIBUTIONS

NB participated in the conception and design of the study, including the analysis plan and in the interpretation of the data, wrote all drafts of the manuscript, and helped to revise it critically for important intellectual content.

MG participated in designing the analysis plan, was responsible for the data management and data analysis, participated in the interpretation of the data, contributed to writing sections of the manuscript, and helped to revise the manuscript critically for important intellectual content.

EE participated in the conception of the study and the interpretation of the data and revised the manuscript critically for important intellectual content.

JH participated in the conception of the study, is the Chief Executive and Scientific Officer of the Vermont Oxford Network, from which the data were drawn, participated in the interpretation of the data, and helped to revise the manuscript critically for important intellectual content.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST

The authors have indicated they have no potential conflicts of interest to disclose.

CONCLUSION: Hospital quality improved similarly for BHS and NBHS hospitals across most divisions. Variation within and between divisions should be a focus for quality improvement.

Keywords

extremely preterm infants; hospital quality; Black serving NICU; Hispanic serving NICU; mortality; morbidity

INTRODUCTION

Major improvements in neonatal outcomes of 501-1500 g infants have been recently reported.[1] Among 756 neonatal intensive care units (NICUs) located in the U.S. and participating in the Vermont Oxford Network (VON) database between 2005 and 2014, rates of in-hospital death and severe morbidities declined.[1] Applying evidence-based perinatal and obstetrical care practices, such as use of antenatal corticosteroids and implementation of less invasive respiratory support techniques, through quality improvement (QI) initiatives was cited as a possible explanation for this improvement.[1] However, little is known on how such improvements in outcomes relate to NICUs that predominantly serve Black and Hispanic infants. Black and Hispanic serving NICUs have been reported to have lower quality, as measured by higher risk-adjusted neonatal mortality rate or a composite of neonatal mortality and severe morbidity rates, than non-Black and non-Hispanic serving NICUs.[2–4]

We reported using data from VON (2006-2017) that the disparity for Black and Hispanic compared to White infants for certain outcomes, such as mortality, has narrowed.[5] However, by 2017, mortality and several morbidities remained elevated, especially for Black infants.[5] To expand on these findings, we examined whether the quality of predominantly Black and Hispanic compared to predominantly non-Black and non-Hispanic serving NICUs has changed differentially over time.

METHODS

Study Sample

We conducted a multicenter retrospective study based on the VON database. VON is a nonprofit voluntary worldwide community dedicated to improving the quality, safety, and value of care for newborns. Members submit data on infants 401-1500 grams or 22-29 weeks' gestation admitted to a reporting hospital within 28 days of birth. NICUs contribute data from medical records using standardized VON forms. All data undergo automated checks for quality and completeness at the time of submission. We included infants without congenital anomalies born between 24-29 weeks' gestation at one of the U.S. VON NICUs between January 1, 2006-December 31, 2018. We excluded infants born <24 weeks as parental and/or NICU preferences might affect whether postnatal life support is provided.[6] The University of Vermont's committee for human research determined that use of VON's de-identified research repository for this analysis was not human subjects research.

Study Variables

Maternal race/ethnicity was obtained by personal interview with the mother, review of the birth certificate, or medical record, in that order. The VON database categories include: non-Hispanic Black (labeled Black), non-Hispanic White (labeled White), Hispanic, Asian, Native American, and Other race.

Our primary outcome was a composite of in-hospital mortality and morbidities (MM). The secondary outcome was in-hospital mortality. The MM outcome for each infant was defined based on 10 indicators: in-hospital mortality, necrotizing enterocolitis (NEC), focal intestinal perforation, late-onset sepsis (LOS), severe intraventricular hemorrhage (sIVH), cystic periventricular leukomalacia (PVL), severe retinopathy of prematurity (sROP), chronic lung disease (CLD), pneumothorax, and ROP surgery. The MM outcome for each infant took value 1 if any of the above 10 indicators was present or 0 otherwise, with the following exceptions: if the death indicator was missing and any of the other 9 indicators was present, the MM outcome was set to 1; if the death indicator was missing and none of the other 9 indicators was present, the MM outcome was defined as missing.

In-hospital mortality was tracked before hospital discharge and after transfer until ultimate disposition. NEC was diagnosed at surgery or postmortem and required ≥1 clinical sign and ≥1 radiographic finding.[7] Focal intestinal perforation, separate from NEC, was defined as a single focal perforation with the remainder of the bowel appearing normal, diagnosed during surgery or postmortem examination.[7] We included focal intestinal perforation in the MM outcome definition, as it is difficult to discern from NEC without review of the bowel. LOS, after day 3 of life, was defined as bacterial pathogen or coagulase negative *Staphylococcus* recovered from blood or cerebrospinal fluid or fungus recovered from blood culture.[7] Coagulase-negative *Staphylococcus* infection also required ≥1 sign of generalized infection and treatment with ≥5 days of intravenous antibiotics.[7] sIVH was defined as grades 3 or 4 using Papile's classification within 28 days of birth.[8] PVL was defined as multiple small periventricular cysts on a cranial ultrasound, CT, or MRI. sROP was defined as stages 3 to 5 based on a retinal examination before hospital discharge.[9] CLD was defined as any supplemental oxygen use at 36 weeks' postmenstrual age or on oxygen at discharge at 34-35 weeks if transferred or discharged <36 weeks.[7]

To classify hospitals into Black and Hispanic serving status categories, we calculated cutoffs for each of the nine U.S. Census divisions (New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific). The division-specific cutoff was calculated as the 70th percentile of the distribution of proportions of infants of a given race among hospitals in each division. We defined hospital Black and Hispanic serving status within each Census division to account for geographic variation which might be responsible for a considerable portion of the disparities in hospital quality given that Black infants reside disproportionately in regions of the country with low-quality hospitals.[10,11] For example, the division-specific cutoff for defining a predominantly Black serving NICU in New England was 22.5% but it was 56.6% in the South Atlantic. Previous studies have used different cut-offs to define predominantly Black serving NICUs (>31%[12] or >35%[4] Black infants) but did not account for the Census division.

A hospital with a proportion of Black infants above its division cutoff was defined as (i) “predominantly Black serving”; a hospital with a proportion of Hispanic infants above its division cutoff was defined as (ii) “predominantly Hispanic serving”; a hospital with a proportion of Black and Hispanic infants above its division cutoff was defined as (iii) “predominantly Black and Hispanic serving”; and a hospital with a proportion of both Black and Hispanic infants below its division cutoff was defined as (iv) “predominantly not Black or Hispanic serving”. We did not classify Asian separately from White serving hospitals since both Asian and White infants experience similar outcomes.[5] Hospitals in the first 3 categories (i-iii) above were subsequently grouped in the combined category “combined predominantly Black and Hispanic serving” (subsequently labeled as BHS) and compared to the reference group “predominantly not Black or Hispanic serving” (subsequently labeled NBHS).

NICU level in the VON Membership Survey includes level A [restriction on ventilation or no surgery], B [major surgery], or C [cardiac surgery requiring bypass].

Inclusion Criteria

The original dataset included 294,424 births in 805 hospitals. Only Black, Hispanic, White, and Asian infants were included. Infants born to Native American mothers and mothers of other races (6,892), infants with no information on race (1,037), infants with missing MM score (699), and infants with missing information on NICU type (405) were excluded, leaving 285,391 births in 801 hospitals for analysis on the primary outcome, MM score. A total of 386 hospitals were classified as “NBHS” and 415 as “BHS” (177 as predominantly Black serving, 175 as predominantly Hispanic serving, and 63 as predominantly Black and Hispanic serving). For the secondary outcome, mortality before discharge, there were 284,546 births in 801 hospitals; 387 hospitals were classified as “NBHS” and 414 as “BHS” (175 as predominantly Black serving, 174 as predominantly Hispanic serving, and 65 as predominantly Black and Hispanic serving).

Statistical Analysis

For each hospital, we calculated the probability of either outcome (MM or in-hospital mortality) being equal to 1 for each infant based on logistic regression. We refer to these probabilities (multiplied by 100) as quality scores (higher scores imply lower quality). We defined two types of scores, one at the country level and one at the Census division level. For the score at the country level, we used logistic regression to obtain the log-odds of the probability of the outcome, adjusted for gestational age (continuous 2nd degree orthogonal polynomial), race/ethnicity (categorical), year of birth (categorical), NICU type (categorical), and a random intercept for hospital. For the score at the division level, we used a logistic model as above and adjusted for division. The random-intercept models were fitted using penalized quasi-likelihood.[13] The scores were obtained by back-transforming the hospital-specific log-odds.

Scores at the country or division level were averaged by hospital and year across infants. We used t-test to examine whether the mean MM in more recent years i.e., the last two years of the study period (2017-2018) were significantly different by BHS status within

each division. We fit linear regression models with quality scores as response variables to estimate the temporal slope for hospitals within a given division. The interpretation of the slope is the mean change in the quality score between 2006 and 2018 for hospitals in a Census division. For example, a slope equal to negative 10 for division "A" means that hospitals in division "A" experienced on average a decrease of 10 percentage points in the quality score between 2006-2018. The decrease would be relative to the national average for hospitals in the same division when using the score at the country level, but it would be relative to the division average when using the score at the division level. Slopes were estimated separately for hospitals classified as "NBHS", "BHS", "predominantly Black serving", and "predominantly Hispanic serving". The interactions between each of BHS, predominantly Black, predominantly Hispanic serving hospitals, and NBHS hospitals were also estimated. Standard errors were calculated using the total variance law to account for the uncertainty in the quality score estimates and the uncertainty in the estimation of the slopes. We present the results comparing NBHS to BHS hospitals as primary and provide the results comparing NBHS hospitals to predominantly Black serving hospitals and to predominantly Hispanic serving hospitals as supplementary.

In summary, we used the probability of adverse outcomes (mortality and morbidity) as a proxy of hospital quality. Probabilities (i.e., scores) for each hospital were estimated using logistic regression models adjusted for confounding and for within-hospital clustering. These scores, which are by definition asymptotically normal, were subsequently analyzed using t-tests and linear regression to assess temporal changes. Significance was set at the 5% level. Analyses were performed using R and SAS (version 9.4; SAS Institute, Cary NC).

Sensitivity Analyses

We assessed the sensitivity of the results by recalculating the MM score after: 1) not adjusting for race/ethnicity, and 2) additionally adjusting for chorioamnionitis and hypertension (restricted to 2008-2018, n=243,052 births in 794 hospitals, as chorioamnionitis and hypertension variables were added in 2008).

RESULTS

The study cohort maternal, newborn, and hospital characteristics are reported by NBHS vs. BHS status and Census division in Table 1. At least a 13% higher difference in any human milk at discharge was observed among NBHS vs. BHS hospitals in two divisions (West North Central and Mountain). The highest discrepancy in antenatal corticosteroid usage by serving status was observed in West South Central (88.0% for NBHS vs. 80.1% for BHS hospitals) whereas the highest discrepancy in admission temperature $<36.5^0$C by serving status was observed in the Middle Atlantic (44% for NBHS vs. 54.4% for BHS hospitals) and the South Atlantic division (35% for NBHS vs. 43.5% for BHS hospitals).

Table 2 shows the mean change in probability percentage points in the MM score between 2006 and 2018 computed at the division level by NBHS vs. BHS status. In West South Central, NBHS hospitals achieved a greater improvement in quality [−18.8% (95% CI: −24.1, −13.5)] than BHS hospitals [−9.3% (95% CI: −14.1, −4.6)], with a statistically significant test for interaction (p=0.009). NBHS hospitals in East South Central also

achieved a greater quality improvement [−20.7% (95% CI: −30.3, −11.0)] than BHS hospitals [−9.7% (95% CI: −17.8, −1.6)], though the test for interaction was not statistically significant (p=0.09). In all other divisions, NBHS hospitals achieved a similar reduction to BHS hospitals in the MM score.

For in-hospital mortality, changes over time were similar among NBHS vs. BHS hospitals across all divisions (Table 3). However, the reduction in mortality among NBHS hospitals in East South Central [−5.3% (95% CI: −10.9, 0.4)] was moderately larger as compared to BHS hospitals [−1.9% (95% CI: −6.2, 2.3)]. Still, the estimates showed substantial uncertainty which weakens the strength of this observation.

Findings at the country level for both the primary and secondary outcomes were very similar and are not reported.

Table 4 shows the mean (SD), minimum, and maximum MM scores by NBHS vs. BHS status and Census division in the last 2 years of the study period (2017-2018). The mean (SD) score ranged from 0.39 (0.18) in the East South Central region to 0.64 (0.16) in the Mountain region among NBHS hospitals, and from 0.42 (0.11) in the New England region to 0.63 (0.20) in the Mountain region among BHS hospitals. Statistically significant differences in the mean MM score were observed in the South Atlantic division where the mean (SD) score among NBHS hospitals was 0.44 (0.13) compared to 0.48 (0.10) among BHS hospitals (p-value=0.04), and the East South Central division where the mean (SD) score among NBHS hospitals was 0.39 (0.18) compared to 0.47 (0.10) among BHS hospitals (p-value=0.01). The mean (SD) MM score in West North Central was higher among NBHS [0.53 (0.11)] than BHS hospitals [0.49 (0.13)], although the difference was not statistically significant (p-value=0.07).

Study results separately comparing NBHS to predominantly Black serving hospitals and predominantly Hispanic serving hospitals are similar to the results reported above. Table 5 (online) shows the mean change between 2006 and 2018 in the MM score for NBHS vs. predominantly Black and predominantly Hispanic serving hospitals. Table 6 (online) shows the mean (SD), minimum, and maximum MM scores by Census division comparing NBHS to predominantly Black and predominantly Hispanic serving hospitals in the last 2 years of the study period.

Sensitivity analyses

The study findings were similar after recalculating the MM score 1) without adjusting for race/ethnicity, and 2) additionally adjusting for chorioamnionitis and hypertension (data not shown).

DISCUSSION

In our study of more than 800 U.S. hospitals serving more than 280,000 infants born at 24-29 weeks' gestation, hospital quality defined by a composite of mortality and severe morbidities, improved between 2006 and 2018 similarly for NBHS and BHS hospitals. This was the case across all Census divisions, except for East and West South Central, where the

mean change in the composite score was respectively, −20.7 (95% CI: −30.3, −11.0) and −18.8 (95% CI: −24.1, −13.5) for NBHS hospitals and −9.7 (95% CI: −17.8, −1.6) and −9.3 (95% CI: −14.1, −4.6) for BHS hospitals, but was statistically different for only West South Central. In the last 2 years of the study period, the mean MM score was similar between NBHS and BHS hospitals except for South Atlantic and East South Central, where hospital quality scores were notably lower for BHS than those for NBHS hospitals.

Utilizing health care quality measurements to accelerate improvements in health care delivery is common.[14] In the neonatal field, hospital quality has largely focused on outcome measures after adjusting for case-mix[2,3] due to the limitations of publicly available data that do not collect data on process measures. Outcome measures have mainly included neonatal mortality rate or a composite of neonatal mortality and severe morbidity rates.[2–4] Another measure that has been increasingly utilized in measuring NICU quality is the Baby-MONITOR score, a composite of 5 process (any human milk at discharge, no admission hypothermia, any antenatal steroid administration, no hospital acquired infection, timely retinal examination) and 4 outcome measures (survival to hospital discharge, no chronic lung disease, no pneumothorax, greater than median growth velocity).[15] However, a study utilizing the Baby-MONITOR score to evaluate NICU quality by race and ethnicity across VON participating hospitals, showed that Black infants had significantly lower process but higher outcome scores than White infants.[16] In the absence of a gold standard quality measure that assesses racial and ethnic disparities and the lack of process measures in publicly available data, it is still important to examine hospital quality as defined by outcome measures to serve as a benchmark for continuous QI.

Previous studies have reported that BHS hospitals have lower quality than NBHS hospitals. In one study using VON data (1995-2000), predominantly Black serving NICUs defined as having >35% of Black very low birth weight (VLBW) infants, had higher risk-adjusted neonatal mortality rates than NICUs that served <15% of Black VLBW infants.[4] In another VON study (2007-2008), VLBW infants born in high-Black concentration hospitals (>31% Black) had higher rates of infection and discharge without breast milk than low-Black concentration hospitals (<11% Black).[12] A study from New York City hospitals (1996-2001) showed that VLBW White infants were more likely to be born in hospitals with the lowest tertile of mortality rates (49%) compared with VLBW Black infants (29%).[2] Another study from New York City hospitals (2010-2014) showed that Black and Hispanic very preterm infants were more likely to be born at hospitals with higher risk-adjusted neonatal mortality and severe morbidity (CLD, NEC, sROP, and sIVH) rates contributing to the disparities among Black and Hispanic compared to White infants.[3] Similarly, a VON study (2014-2016) showed that after accounting for region of residence, Black compared to White infants received care at NICUs with a lower Baby-MONITOR score.[10] However, no study to our knowledge has examined the change in hospital quality by Black and Hispanic serving status over time.

The mean MM score in more recent years (2017-2018) and the mean change in the MM score between 2006 and 2018 were similar by NBHS vs. BHS status across most Census divisions. However, overall improvements on *average* conceal considerable regional and unit level variations among both NBHS and BHS hospitals. For example, the mean change in the

composite MM score ranged from −20.7 (95% CI: −30.3, −11.0) in the East South Central division to −6.0 (95% CI: −15.9, 3.9) in the Mountain division among NBHS hospitals and from −16.3 (95% CI: −24.4, −8.2) in New England to −9.3 (95% CI: −14.1, −4.6) in West South Central among BHS hospitals. Additionally, these changes do not imply that outcomes improved similarly among Black, and Hispanic compared to White infants. In a VON study (2006-2017), we showed that compared to White infants, Black infants had a faster decline for mortality, NEC, and LOS while Hispanic infants had a faster decline for mortality and pneumothorax.[5] However, by the end of the study, mortality, NEC, LOS, and sIVH remained elevated particularly among Black infants.[5]

Hospital quality was lowest in the Mountain division across both NBHS and BHS hospitals. This is similar to a recent VON study that also showed lower NICU quality, defined by the Baby-MONITOR score, in the Mountain division.[10] The lower hospital quality improvement over time for BHS compared to NBHS hospitals in East and West South Central and the lower mean hospital quality scores in the South Atlantic and East South Central divisions point to the importance of examining in more depth opportunities for QI initiatives. The reasons for these disparities by NBHS vs. BHS status are multifactorial and might include financial barriers,[17] lower staff-to-infant ratios,[12] training or experience of healthcare professionals,[17] access to subspecialists,[17] availability of ancillary personnel, and structural racism.[18] However, we cannot make causal claims about what is driving these disparities.

Strengths of our study include a large sample size with over 800 hospitals distributed across all Census divisions. We also defined NBHS vs. BHS status within each Census division to account for geographic variation. Limitations of our study include lack of data on the quality of labor and delivery which might also impact neonatal outcomes. We are uncertain how our findings translate to NICUs not represented in VON. Black and Hispanic serving NICUs might be underrepresented in VON due to being under resourced to participate in collaborative QI efforts.[19] However, the VON database includes over 85% of all U.S. births at 22-29 weeks' gestation.

Between 2006 and 2018, hospital quality as defined by a composite of mortality and severe morbidities improved similarly for NBHS and BHS VON hospitals across most Census divisions. However, extensive variation within and between regions remains, and should be a focus for continued QI.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS:

BHS	combined predominantly Black and Hispanic serving
CI	confidence interval
CLD	chronic lung disease
LOS	late-onset sepsis
MM	mortality and morbidity
NBHS	predominantly not Black or Hispanic serving
NEC	necrotizing enterocolitis
NICU	neonatal intensive care unit
PVL	periventricular leukomalacia
QI	quality improvement
sIVH	severe intraventricular hemorrhage
sROP	severe retinopathy of prematurity
VLBW	very low birth weight
VON	Vermont Oxford Network

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Table 1.

Characteristics of infants born at 24 to 29 weeks' gestation in VON centers 2006-2018 by NBHS vs. BHS status and Census division.

	NBHS	**BHS**	**NBHS**	**BHS**	**NBHS**	**BHS**	**NBHS**	**BHS**
	Northeast				***Midwest***			
	New England N=10872		*Middle Atlantic* N=34320		*East North Central* N=46440		*West North Central* N=20408	
Race/ethnicity								
Black	532 (11.8)	1529 (24.1)	4056 (22.0)	8006 (50.4)	5457 (23.6)	10197 (43.7)	1838 (14.8)	2765 (34.7)
Hispanic	473 (10.5)	1570 (24.7)	2086 (11.3)	3652 (23.0)	1033 (4.5)	3135 (13.4)	612 (4.9)	773 (9.7)
White	3301 (73.1)	2905 (45.7)	11238 (61.0)	3547 (22.3)	16124 (69.8)	9241 (39.6)	9534 (76.7)	4278 (53.7)
Asian	212 (4.7)	350 (5.5)	1038 (5.6)	697 (4.4)	484 (2.1)	769 (3.3)	451 (3.6)	157 (2.0)
Hypertension	969 (26.1)	1366 (25.6)	3916 (25.1)	3388 (25.2)	5468 (28.0)	4966 (25.0)	2884 (27.1)	2000 (29.4)
Chorioamnionitis	630 (17.0)	1349 (25.3)	2447 (15.7)	2168 (16.2)	3823 (19.7)	3447 (17.4)	1037 (9.8)	1699 (25.2)
Antenatal corticosteroids	4284 (94.9)	5845 (92.0)	16342 (88.9)	14045 (88.4)	20969 (90.8)	20591 (88.3)	11122 (89.5)	6947 (87.2)
Gestational age, weeks, mean (SD)	27.0 (1.7)	26.9 (1.7)	27.0 (1.7)	26.8 (1.7)	26.9 (1.7)	26.8 (1.7)	26.9 (1.7)	26.9 (1.7)
Admission temperature <36.5°C	1864 (42.3)	2531 (42.0)	7905 (44.0)	8443 (54.4)	8327 (37.5)	8341 (37.6)	4379 (36.0)	3036 (39.0)
Any human milk at discharge	2186 (48.9)	3161 (50.5)	7915 (43.3)	5874 (37.3)	9243 (40.4)	8358 (36.2)	6036 (49.2)	2789 (35.4)
NICU level								
A	544 (12.0)	733 (11.5)	3211 (17.5)	1833 (11.5)	7169 (31.0)	4353 (18.7)	917 (7.4)	1040 (13.1)
B	3260 (72.2)	2660 (41.9)	10909 (59.3)	10574 (66.5)	11902 (51.5)	12542 (53.9)	6749 (54.3)	3960 (49.8)
C	714 (15.8)	2961 (46.6)	4286 (23.3)	3492 (22.0)	4027 (17.4)	6376 (27.4)	4769 (38.4)	2956 (37.2)
Years in VON database, mean (SD)	12.6 (1.2)	11.3 (3.1)	10.4 (4.1)	9.4 (4.3)	10.7 (3.8)	10.3 (4.0)	11.6 (2.4)	10.2 (4.1)
Years in VON database, range	9-13	4-13	1-13	1-13	2-13	1-13	5-13	1-13
	South						***West***	
	South Atlantic N=60576		*East South Central* N=18316		*West South Central* N=36685		*Mountain* N=15782	
Race/ethnicity								
Black	8515 (38.1)	20588 (53.8)	2346 (32.2)	5485 (49.7)	5098 (28.0)	6990 (37.9)	305 (4.0)	1153 (14.3)
Hispanic	1564 (7.0)	5609 (14.7)	201 (2.8)	593 (5.4)	3505 (19.2)	6683 (36.2)	1416 (18.4)	3514 (43.5)
White	11673 (52.3)	11202 (29.3)	4685 (64.3)	4837 (43.9)	8893 (48.8)	4418 (23.9)	5750 (74.6)	3177 (39.4)
Asian	576 (2.6)	849 (2.2)	55 (0.75)	114 (1.0)	725 (4.0)	373 (2.0)	239 (3.1)	228 (2.8)
Hypertension	6041 (31.1)	9619 (29.4)	2236 (35.0)	3143 (33.8)	4869 (30.6)	4886 (29.9)	1674 (25.7)	1779 (26.5)

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	NBHS	BHS	NBHS	BHS	NBHS	BHS	NBHS	BHS
Chorioamnionitis	3356 (17.3)	5891 (18.0)	1333 (20.8)	1397 (15.0)	2067 (13.0)	1799 (11.1)	1231 (18.9)	1428 (21.3)
Antenatal corticosteroids	19716 (88.4)	33246 (87.1)	6281 (86.2)	9599 (87.2)	16002 (88.0)	14762 (80.1)	6745 (87.6)	6965 (86.5)
Gestational age, weeks, mean (SD)	26.9 (1.7)	26.8 (1.7)	26.9 (1.7)	26.9 (1.7)	26.9 (1.7)	26.9 (1.7)	27.0 (1.6)	26.9 (1.7)
Admission temperature <36.5°C	7681 (35.0)	16135 (43.5)	3267 (45.6)	4710 (43.6)	5924 (34.7)	7572 (42.6)	2317 (30.9)	2949 (37.7)
Any human milk at discharge	8719 (39.4)	13840 (36.7)	2079 (28.7)	3092 (28.3)	7204 (39.9)	5885 (32.1)	3982 (52.2)	3042 (38.0)
NICU level								
A	3472 (15.6)	6476 (16.9)	2638 (36.2)	4280 (38.8)	3288 (18.1)	3514 (19.1)	1572 (20.4)	505 (6.3)
B	15153 (67.9)	16670 (43.6)	2782 (38.2)	4014 (36.4)	11386 (62.5)	10613 (57.5)	4724 (61.3)	3876 (48.0)
C	3703 (16.6)	15102 (39.5)	1863 (25.6)	2735 (24.8)	3532 (19.4)	4320 (23.4)	1414 (18.3)	3691 (45.7)
Years in VON database, mean (SD)	9.1 (4.1)	10.0 (4.1)	9.2 (3.4)	9.8 (3.8)	8.4 (4.4)	7.9 (4.6)	9.3 (4.3)	10.2 (3.5)
Years in VON database, range	1-13	1-13	2-13	2-13	1-13	1-13	1-13	1-13
	West							
	Pacific N=41992							
Race/ethnicity								
Black	1445 (7.3)	3974 (18.0)						
Hispanic	6079 (30.6)	11163 (50.5)						
White	9321 (46.9)	4768 (21.6)						
Asian	3036 (15.3)	2206 (10.0)						
Hypertension	4162 (24.6)	4392 (23.6)						
Chorioamnionitis	2383 (14.1)	1771 (9.5)						
Antenatal corticosteroids	17965 (90.5)	19173 (87.0)						
Gestational age, weeks, mean (SD)	27.0 (1.7)	26.9 (1.7)						
Admission temperature <36.5°C	6196 (32.2)	7048 (33.0)						
Any human milk at discharge	11968 (61.1)	10922 (50.3)						
NICU level								
A	5433 (27.3)	9342 (42.3)						
B	10465 (52.6)	8905 (40.3)						
C	3983 (20.0)	3839 (17.4)						
Years in VON database, mean (SD)	11.1 (3.4)	10.9 (3.5)						

	NBHS	BHS	NBHS	BHS	NBHS	BHS	NBHS	BHS
Years in VON database, range	1-13	1-13						

NBHS—predominantly not Black or Hispanic serving; BHS—combined predominantly Black and Hispanic serving.

Numbers are n (%) unless otherwise indicated.

Unit of analysis is infants.

Hypertension and chorioamnionitis variables were added in 2008.

Maternal hypertension defined as chronic or pregnancy-induced, with or without edema and proteinuria, or as maternal blood pressure above 140 systolic or 90 diastolic prior to or during the present pregnancy.

Infant's body temperature measured by taking a rectal, esophageal, tympanic, or axillary temperature, was recorded within the first hour after admission to the NICU.

Any human milk at discharge denominator includes no enteral feeding, human milk, and formula only.

Data missing on: hypertension for n=373 (0.15%), chorioamnionitis for n=736 (0.30%), antenatal corticosteroids for n=420 (0.15%), admission temperature for n=6665 (2.4%), human milk for n=441 (0.16%), NICU type for n=164 (0.06%).

Number of hospitals in each Census division: New England n=25; Middle Atlantic n=99; East North Central n=115; West North Central n=53; South Atlantic n=126; East South Central n=51; West South Central n=121; Mountain n=49; Pacific n=162.

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Table 2.

Mean change between 2006-2018 in the mortality and morbidity score (probability percentage points) by NBHS vs. BHS status and Census division.

	NBHS		BHS	
Division	**N**	**Slope (95% CI)**	**N**	**Slope (95% CI)**
New England	11	−16.0 (−24.8, −7.3)	14	−16.3 (−24.4, −8.2)
Middle Atlantic	52	−13.5 (−18.4, −8.6)	47	−14.6 (−19.9, −9.4)
East North Central	58	−11.7 (−16.3, −7.2)	57	−12.1 (−16.7, −7.5)
West North Central	26	−10.8 (−16.5, −5.0)	27	−13.6 (−20.8, −6.4)
South Atlantic	57	−13.5 (−18.2, −8.9)	69	−13.7 (−17.5, −9.9)
East South Central	25	−20.7 (−30.3, −11.0)	26	−9.7 (−17.8, −1.6)
West South Central	50	−18.8 (−24.1, −13.5)	71	−9.3 (−14.1, −4.6)*
Mountain	30	−6.0 (−15.9, 3.9)	19	−10.7 (−20.6, −0.8)
Pacific	77	−11.0 (−15.6, −6.4)	85	−10.4 (−14.7, −6.2)
All divisions	386	−12.9 (−14.9, −10.8)	415	−11.8 (−13.7, −9.8)

NBHS—predominantly not Black or Hispanic serving; BHS—combined predominantly Black and Hispanic serving.

* p-value=0.009 for the interaction between NBHS and BHS hospitals.

N shows the number of hospitals.

Table 3.

Mean change between 2006-2018 in mortality (probability percentage points) by NBHS vs. BHS status and Census division.

	NBHS hospitals		BHS hospitals	
Division	**N**	**Slope (95% CI)**	**N**	**Slope (95% CI)**
New England	12	−5.4 (−9.6, −1.3)	13	−4.5 (−8.5, −0.4)
Middle Atlantic	52	−4.2 (−6.9, −1.4)	47	−4.6 (−7.6, −1.6)
East North Central	58	−3.7 (−6.5, −0.8)	57	−4.0 (−6.6, −1.5)
West North Central	26	−2.5 (−5.3, 0.4)	27	−4.3 (−8.1 , −0.4)
South Atlantic	57	−3.6 (−6.2, −0.9)	69	−4.4 (−6.5, −2.3)
East South Central	25	−5.3 (−10.9, 0.4)	26	−1.9 (−6.2, 2.3)
West South Central	50	−4.5 (−7.1, −2.0)	71	−3.0 (−5.5, −0.6)
Mountain	30	−2.7 (−7.3, 1.9)	19	−3.4 (−7.1, 0.2)
Pacific	77	−2.9 (−5.3, −0.4)	85	−3.5 (−5.8, −1.1)
All divisions	387	−3.6 (−4.7, −2.6)	414	−3.7 (−4.7, −2.7)

NBHS—predominantly not Black or Hispanic serving; BHS—combined predominantly Black and Hispanic serving.

N shows the number of hospitals.

Table 4.

Mean and range of the mortality and morbidity score by NBHS vs. BHS status and Census division in 2017 and 2018.

	NBHS hospitals			BHS hospitals			
	N	Mean (SD)	Min-Max	N	Mean (SD)	Min-Max	p-value
Division							
New England	22	0.45 (0.12)	0.19-0.61	27	0.42 (0.11)	0.15-0.58	0.36
Middle Atlantic	89	0.47 (0.10)	0.13-0.70	74	0.45 (0.11)	0.09-0.69	0.35
East North Central	105	0.49 (0.13)	0.13-0.84	99	0.49 (0.11)	0.14-0.81	0.98
West North Central	49	0.53 (0.11)	0.23-0.82	44	0.49 (0.13)	0.16-0.72	0.07
South Atlantic	93	0.44 (0.13)	0.18-0.86	121	0.48 (0.10)	0.14-0.68	0.04
East South Central	43	0.39 (0.18)	0.13-0.78	40	0.47 (0.10)	0.21-0.67	0.01
West South Central	89	0.44 (0.13)	0.10-0.65	124	0.45 (0.13)	0.08-0.72	0.77
Mountain	53	0.64 (0.16)	0.23-0.91	35	0.63 (0.20)	0.21-0.93	0.85
Pacific	144	0.42 (0.14)	0.08-0.82	147	0.43 (0.14)	0.06-0.83	0.66
All divisions	687	0.47 (0.15)	0.08-0.91	711	0.47 (0.13)	0.06-0.93	1.00

NBHS—predominantly not Black or Hispanic serving; BHS—combined predominantly Black and Hispanic serving.

p-value by t-test comparing NBHS and BHS hospitals.

N shows the number of observations contributed by hospitals, i.e., a hospital participating in VON for 2017 and 2018 contributes two observations. A total of 725 hospitals participated in VON during 2017 and 2018.

Table 5.

Mean change between 2006-2018 in the mortality and morbidity score (probability percentage points) for NBHS, BHS, predominantly Black, and predominantly Hispanic serving hospitals, by Census division.

	NBHS hospitals		BHS hospitals		Predominantly Black serving hospitals		Predominantly Hispanic serving hospitals	
Division	**N**	**Slope (95% CI)**	**N**	**Slope (95% CI)**	**N**	**Slope (95% CI)**	**N**	**Slope (95% CI)**
New England	11	−16.0 (−24.8, −7.3)	14	−16.3 (−24.4, −8.2)	6	−16.5 (−28.0, −4.9)	6	−17.0 (−30.4, −3.5)
Middle Atlantic	52	−13.5 (−18.4, −8.6)	47	−14.6 (−19.9, −9.4)	17	−12.5 (−19.4, −5.6)	17	−6.7 (−18.0, 4.7)
East North Central	58	−11.7 (−16.3, −7.2)	57	−12.1 (−16.7, −7.5)	22	−11.5 (−19.3, −3.7)	22	−13.7 (−20.9, −6.5)
West North Central	26	−10.8 (−16.5, −5.0)	27	−13.6 (−20.8, −6.4)	11	−15.3 (−29.1, −1.4)	11	−13.8 (−24.4, −3.3)
South Atlantic	57	−13.5 (−18.2, −8.9)	69	−13.7 (−17.5, −9.9)	32	−15.0 (−20.6, −9.5)	32	−14.6 (−20.1, −9.2)
East South Central	25	−20.7 (−30.3, −11.0)	26	−9.7 (−17.8, −1.6)	13	−11.5 (−22.9, −0.1)	11	−8.8 (−22.1, 4.4)
West South Central	50	−18.8 (−24.1, −13.5)	71	−9.3 (−14.1, −4.6) *	35	−9.1 (−15.9, −2.3) **	35	−9.5 (−16.5, −2.6) ***
Mountain	30	−6.0 (−15.9, 3.9)	19	−10.7 (−20.6, −0.8)	4	−17.6 (−43.2, 8.0)	4	−4.6 (−21.6, 12.4)
Pacific	77	−11.0 (−15.6, −6.4)	85	−10.4 (−14.7, −6.2)	37	−11.1 (−17.5, −4.8)	37	−7.9 (−14.6, −1.2)
All divisions	386	−12.9 (−14.9, −10.8)	415	−11.8 (−13.7, −9.8)	177	−11.8 (−14.8, −8.9)	175	−11.1 (−14.1, −8.1)

NBHS—predominantly not Black or Hispanic serving; BHS—combined predominantly Black and Hispanic serving.

* p-value=0.009 for the interaction between NBHS and BHS hospitals.

** p-value=0.03 for the interaction between NBHS and BHS hospitals.

*** p-value=0.04 for the interaction between NBHS and BHS hospitals.

N shows the number of hospitals.

BHS hospitals include predominantly black serving hospitals (n=177), predominantly Hispanic serving hospitals (n=175), and predominantly black and Hispanic serving hospitals (n=63).

Table 6.

Mean and range of the mortality and morbidity score for NBHS, BHS, predominantly Black, and predominantly Hispanic serving hospitals, by Census division in 2017 and 2018.

	NBHS hospitals			BHS hospitals			Predominantly Black serving hospitals			Predominantly Hispanic serving hospitals		
	N	Mean (SD)	Min-Max	N	Mean (SD)	Min-Max	N	Mean (SD)	Min-Max	N	Mean (SD)	Min-Max
Division												
New England	22	0.45 (0.12)	0.19-0.61	27	0.42 (0.11)	0.15-0.58	12	0.40 (0.13)	0.15-0.58	12	0.45 (0.08)	0.30-0.57
Middle Atlantic	89	0.47 (0.10)	0.13-0.70	74	0.45 (0.11)	0.09-0.69	31	0.48 (0.09)	0.30-0.69	23	0.42 (0.12) *	0.09-0.57
East North Central	105	0.49 (0.13)	0.13-0.84	99	0.49 (0.11)	0.14-0.81	37	0.45 (0.11)	0.14-0.63	41	0.50 (0.10)	0.20-0.68
West North Central	49	0.53 (0.11)	0.23-0.82	44	0.49 (0.13)	0.16-0.72	15	0.42 (0.15) *	0.16-0.65	19	0.51 (0.11)	0.30-0.72
South Atlantic	93	0.44 (0.13)	0.18-0.86	121	0.48 (0.10) *	0.14-0.68	57	0.49 (0.10) *	0.14-0.68	57	0.46 (0.10)	0.17-0.65
East South Central	43	0.39 (0.18)	0.13-0.78	40	0.47 (0.10) *	0.21-0.67	19	0.43 (0.09)	0.21-0.58	19	0.50 (0.08) *	0.34-0.67
West South Central	89	0.44 (0.13)	0.10-0.65	124	0.45 (0.13)	0.08-0.72	58	0.46 (0.11)	0.26-0.67	64	0.43 (0.14)	0.08-0.72
Mountain	53	0.64 (0.16)	0.23-0.91	35	0.63 (0.20)	0.21-0.93	7	0.72 (0.17)	0.38-0.89	8	0.80 (0.09) *	0.70-0.93
Pacific	144	0.42 (0.14)	0.08-0.82	147	0.43 (0.14)	0.06-0.83	63	0.41 (0.15)	0.06-0.83	62	0.44 (0.13)	0.16-0.75
All divisions	687	0.47 (0.15)	0.08-0.91	711	0.47 (0.13)	0.06-0.93	299	0.46 (0.13)	0.06-0.89	305	0.47 (0.13)	0.08-0.93

NBHS—predominantly not Black or Hispanic serving; BHS—combined predominantly Black and Hispanic serving.

* p-value <0.05 by t-test with NBHS hospitals as the comparison group.

N shows the number of observations contributed by hospitals, i.e., a hospital participating in VON for 2017 and 2018 contributes two observations. A total of 725 hospitals participated in VON during 2017 and 2018.