The Correlation Between Neonatal Intensive Care Unit Safety Culture and Quality of Care

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Objectives: Key validated clinical metrics are being used individually and in aggregate (Baby-MONITOR) to monitor the performance of neonatal intensive care units (NICUs). The degree to which percep tions of key components of safety culture, safety climate, and teamwork are related to aspects of NICU quality of care is poorly understood. The objective of this study was to test whether NICU performance on key clinical metrics correlates with caregiver perceptions of safety culture.

Study Design: Cross-sectional study of 6253 very low-birth-weight infants in 44 NICUs. We measured clinical quality via the Baby-MONITOR and its nine risk-adjusted and standardized subcomponents (antenatal corticosteroids, hypothermia, pneumothorax, healthcare-associated infection, chronic lung disease, retinopathy screen, discharge on any human milk, growth velocity, and mortality). A voluntary sample of 2073 of 3294 eligible professional caregivers provided ratings of safety and teamwork climate using the Safety Attitudes Questionnaire. We examined NICU-level variation across clinical and safety culture ratings and conducted correlation analysis of these dimensions.

Results: We found significant variation in clinical and safety culture metrics across NICUs. Neonatal intensive care unit teamwork and safety climate ratings were correlated with absence of healthcare-associated infection ($r = 0.39$ [$P = 0.01$]) and $r = 0.29$ [$P = 0.05$], respectively. None of the other clinical metrics, individual or composite, were significantly correlated with teamwork or safety climate.

Conclusions: Neonatal intensive care unit teamwork and safety climate were correlated with healthcare-associated infections but not with other quality metrics. Linkages to clinical measures of quality require additional research.

Key Words: Baby-MONITOR, composite measure, quality culture, teamwork, neonatal intensive care unit

What This Study Adds: NICU teamwork and safety climate correlated significantly with healthcare-associated infections. However, other metrics of quality of care did not correlate. Caution should be applied in equating establishment of a culture of safety in health care has been a national health policy priority. The Joint Commission includes the establishment of a culture of safety as a critical component for achieving highly reliable and safe care and requires hospitals to measure and monitor safety culture in an ongoing fashion. A culture of safety has been defined as “individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety management.” Maintaining a culture of safety in health care has been a national health policy priority. The Joint Commission includes the establishment of a culture of safety as a critical component for achieving highly reliable and safe care and requires hospitals to measure and monitor safety culture in an ongoing fashion. A culture of safety has been defined as “individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety management.”

What’s Known: Establishing a strong culture of safety is a health policy priority. Teamwork and safety climate, two well-established dimensions of safety culture, vary significantly among NICUs. The contribution of this variation to differences in NICU quality of care delivery is unknown.

What This Study Adds: NICU teamwork and safety climate correlated significantly with healthcare-associated infections. However, other metrics of quality of care did not correlate. Caution should be applied in equating efforts to improve safety culture with expectations for better quality of care delivery.

Supplemental digital contents are available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal’s Web site (www.journalpatientsafety.com).

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culture of safety is a strategy for preventing patient harm. Safety culture surveys assess caregiver perceptions of safety culture, especially its best-studied subdomains, safety climate and teamwork, have been shown to vary widely and are linked to clinical outcomes, including healthcare-associated infections (HAIs) and mortality.4,8

The Safety Attitudes Questionnaire (SAQ) was found to be psychometrically robust9 in the neonatal intensive care unit (NICU) and demonstrated significant variation in safety culture.10 Preterm infants in the NICU setting are fragile and require complex and prolonged intensive care. This makes them vulnerable to lapses in teamwork and patient safety. However, the relationship between NICU safety culture ratings and clinical metrics of quality has not been established. In addition, the evidence from other areas of healthcare demonstrates relatively weak links between safety culture and clinical outcomes,11 along with concerns about reporting bias.12,13

Neonatal intensive care is a complex and multidimensional activity, which the measurement of its quality should reflect. In previous work, we developed the Baby-MONITOR (Measure Of Neonatal Intensive care Outcomes Research), a composite indicator of quality of care provided to very low-birth-weight (VLBW, <1500 g) infants.14 A panel of experts selected 9 of 28 potential metrics in a modified Delphi experiment.15 This selection process was subsequently sanctioned by a sample of clinical neonatologists.16 Both groups identified the same nine clinical metrics. These metrics routinely collected by NICUs that are members of the California Perinatal Quality Care Collaborative (CPQCC) and the Vermont Oxford Network (VON), which collects data on nearly 85% of the VLBW infants born in the United States. Each measure is risk-adjusted, standardized, equally weighted, and averaged. The Baby-MONITOR has face validity,15,16 and has been shown to be robust to variations in methods of construction.14 Several of the measures of the Baby-MONITOR more narrowly represent safety domains, including infections, antenatal steroids, hypothermia on admission, pneumothorax, and retinopathy screening. Others could be defined in more quality domains requiring teamwork for high performance (chronic lung disease, growth velocity, and any human milk feedings at discharge). Overlap exists between safety and quality and several measures require both behaviors for high performance.

Based on the associations of quality of care delivery with health worker assessments of safety and teamwork climate in other areas of medicine, we hypothesized that caregiver assessments of teamwork and safety climate would correlate with clinical metrics of quality for VLBW infants in the NICU setting, using the Baby-MONITOR and its individual subcomponents.

METHODS

Design

This cross-sectional study combined registry data routinely submitted by NICU members of the CPQCC2 with a voluntary sample of healthcare workers, participating in two simultaneous quality improvement initiatives, organized by the CPQCC focused on Delivery Room Management. More than 90% of NICUs in California are members of the CPQCC. We used the CPQCC clinical data to compute risk-adjusted scores for each subcomponent of the Baby-MONITOR. We then correlated these scores against health care worker assessments of teamwork and safety climate. Clinical data were obtained between January 1, 2010, and December 31, 2012, and safety culture survey data were collected between June and September 2011 from 44 participant NICUs.

Thus, we selected the clinical data to cover approximately 1.5 years before and after the timing of the survey, providing a large clinical sample for estimation of quality of care delivery to VLBW infants in California NICUs.

The CPQCC assures high data quality through several mechanisms. It trains local NICU personnel to abstract clinical data. Annual training sessions help promote accuracy and uniformity in data abstraction. In addition, each record has range and logic checks both at the time of data collection and at data closeout, with auditing of records with excessive missing data. Definitions align with those specified for members of the VON.

Sample

Infants

Our goal for this study was to create a relatively homogenous and unbiased sample of VLBW infants for comparison across NICUs.15 To ensure that patient outcomes reflected the quality of care of the NICU under observation, we excluded infants who died before 12 hours after delivery and those with severe congenital anomalies. We also restricted the analysis to infants born after 24 completed weeks of gestation to avoid systematic bias based on decisions to withhold resuscitation at the threshold of viability.18 We used multivariate analyses because of the small number of VLBW infants cared for in some institutions.

Health Care Workers

A cross-sectional anonymous survey of all NICU healthcare worker perceptions of teamwork was performed among a voluntary sample of NICUs participating in a quality improvement collaborative organized by the CPQCC.17 We offered to analyze and provide feedback on a survey of safety culture to all 61 NICUs who participated in the improvement initiative, 44 of which accepted. For all units, we used a paper-based version of the SAQ instrument to investigate safety and teamwork climate. Staff with a 0.5 full time equivalent or greater time commitment to the NICU for at least the four weeks before survey administration were invited to participate. Details of the survey and its administration can be found in the eAppendix, http://links.lww.com/JPS/A193.19 Our response rate was 62.9% (2073/3294), with a range across the 44 hospitals of 21.7% to 100% (mean [SD] = 69.7% [19.8%]).

The study was approved by the institutional review board at Stanford University.

Metrics

Quality of Care

Details of the Baby-MONITOR have been published elsewhere.14,15 In brief, an expert panel selected nine metrics of quality for inclusion in the composite, including the following:1 antenatal corticosteroid use,2 hypothermia (<36°C) during the first hour after delivery,3 nonsurgically induced pneumothorax,4 HAI,5 chronic lung disease (oxygen requirement at 36 weeks gestational age),6 timely eye exam (retinopathy of prematurity screening as recommended by the American Academy of Pediatrics),7 discharge on any human breast milk,8 growth velocity,9 and mortality during the birth hospitalization.9

Each of the metrics is scored so that a higher score indicates a better outcome. All metrics, except for timely eye exam as a process measure, are individually risk adjusted for severity of illness at the time of birth. To further classify NICU performance on each quality measure, we used a method developed by Draper and Gittoes.20 For each NICU and for each subcomponent of the Baby-MONITOR, a z score was computed as the observed rate minus the expected rate divided by its estimated standard error.
These standardized $z$ scores are approximately normally distributed with the mean of 0 and standard deviation of 1 when no quality differences are present.

### Safety Culture

Of the several safety culture survey instruments in the literature, the SAQ is widely used and has good psychometric properties.\textsuperscript{21} The SAQ contains 30 items that load on the following six domains: teamwork climate, safety climate, job satisfaction, perceptions of management, stress recognition, and working conditions. Each item is rated on a five-point Likert scale ranging from 1 (disagree strongly) to 5 (agree strongly). Positions included attending physicians, fellow physicians, neonatal nurse practitioners, registered nurses (RNs), respiratory care practitioners, and others.

Safety culture scale scores were calculated at the NICU level as follows: first, we created for each scale item a binary variable that was 1 if respondents “strongly” or “slightly” agreed with the item.
and 0 otherwise, and then, we computed the means of these dichotomous variables. We call this “percentage agree” or “percentage reporting good ‘safety climate’ or ‘teamwork climate.’”

Analyses
We used summary statistics such as frequencies, percentages, means (standard deviations), and graphs to describe demographics and our three variables: Baby-MONITOR (with subcomponents), safety climate, and teamwork climate. For each NICU, we computed z scores and percentiles for the Baby-MONITOR and its subcomponents, as well as percent positive rates at the scale and item level for the safety climate and teamwork scales. We then used Pearson correlation coefficient to test for correlations between the clinical and safety culture metrics.

Statistical analyses were performed using SAS (Version 9.4; SAS Institute, Inc, Cary, NC).

RESULTS
Table 1 shows the characteristics of survey respondents and the clinical sample. A total of 6253 VLBW infants in 44 NICUs met the inclusion criteria. Of these NICUs, 10 (22.7%) were designated as regional NICUs, 28 (63.6%) as community NICUs, and 5 (11.4%) as intermediate NICUs as defined by the California Department of Healthcare Services. These designations are roughly equivalent with designations by the American Academy of Pediatrics as level 4, 3, and 2, respectively. Most respondents were RNs and female. The distribution of job positions among respondents mirrored the distribution of eligible participants across participating NICUs. Providers were quite experienced, with the largest number of respondents (643 [33%]) having worked more than 20 years in their specialty. Clinical characteristics are slightly better than all California estimates.

Figures 1A and B show the percent of positive responses for the teamwork and safety climate scales, respectively. The mean (SD, range) percent positive response was 77.6% (6.2, 64.9%–89.6%) for teamwork and 77.0% (5.5, 66.2%–86.6%) for safety climate.

Table 2 shows the distribution of responses across all respondents for the teamwork and safety climate scales and items. For all items, the response scores of the top 4 NICUs were significantly different from the bottom 4 NICUs.

The NICU Baby-MONITOR scores ranged from −2.5 to 1.7 standard units, indicating significant and clinically meaningful variation (eFigure 1 in the eAppendix shows NICU-level variation, http://links.lww.com/JPS/A193).

Table 3 shows the Pearson correlation coefficients between teamwork and safety climate with the Baby-MONITOR and its

| Overall | Bottom 4 NICUs | Top 4 NICUs | Difference Between the Top and Bottom 4 NICUs |
|---------|----------------|-------------|---------------------------------------------|
| Teamwork climate | | | |
| It is easy for personnel here to ask questions when there is something they do not understand. | 83.79 (5.35) | 73.43 (1.15) | 91.67 (0.72) | * |
| I have the support I need from others in this NICU to care for patients. | 85.73 (4.88) | 77.91 (1.73) | 95.00 (2.22) | * |
| Nurse input is well received in this NICU. | 77.24 (8.35) | 61.93 (3.89) | 91.11 (4.27) | * |
| In this NICU, it is difficult to speak up if I perceive a problem with patient care. | 28.07 (7.45) | 14.28 (3.64) | 40.48 (0.63) | * |
| Disagreements in this NICU are appropriately received. | 69.07 (8.51) | 55.15 (1.14) | 85.06 (2.22) | * |
| The physicians and nurses here work together as a well-coordinated team. | 77.51 (10.48) | 55.85 (2.16) | 92.84 (1.79) | * |
| Safety climate | | | |
| The culture in this NICU makes it easy to learn from the errors of others. | 67.61 (7.80) | 55.14 (1.84) | 80.65 (1.93) | * |
| Medical errors are handled appropriately in this NICU. | 83.71 (6.97) | 71.16 (2.66) | 95.29 (3.30) | * |
| I know the proper channels to direct questions regarding patient safety in this NICU. | 87.73 (4.15) | 80.93 (1.11) | 94.54 (1.01) | * |
| I am encouraged by others in this NICU, to report any patient safety concerns I may have. | 79.96 (5.68) | 70.03 (0.51) | 89.15 (1.40) | * |
| I receive appropriate feedback about my performance. | 74.32 (7.12) | 62.51 (2.23) | 86.30 (2.61) | * |
| I would feel safe being treated here as a patient. | 80.94 (8.20) | 67.50 (0.58) | 96.32 (1.68) | * |
| In this NICU, it is difficult to discuss errors. | 35.04 (8.75) | 16.32 (7.11) | 49.12 (3.78) | * |

*Scale score for a respondent = ((mean of the item from NICUs − 1) × 25). *
*P < 0.01.
*P < 0.001.
*P < 0.0001.

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subcomponents. Only HAI exhibited a statistically significant relationship (Figs. 2A, B). None of the other components of the Baby-MONITOR score or the composite were significantly correlated with teamwork and safety climate. eTables 2A and B in the eAppendix, http://links.lww.com/JPS/A193, show the correlations between teamwork climate items, safety climate items, and Baby-MONITOR and its subcomponents. Both positive and negative correlations were observed with no predominant pattern.

**DISCUSSION**

This study extends findings from the healthcare literature demonstrating substantial variability in safety culture and clinical metrics of quality and outcomes. Our findings also reinforce results from studies in adult intensive care settings,23 and our own previous work, which revealed links between safety or teamwork climate and infection-related outcomes. Healthcare workers in NICUs who report that “I would feel safe being treated here” work in units with lower infection rates. The reverse of this association is also true, whereby NICUs with high infection rates have fewer healthcare workers who report “It is easy to ask questions when there is something they don’t understand” or “Physicians and nurses work together as a well-coordinated team.” However, we were surprised that none of the other clinical outcomes were significantly correlated with safety or teamwork climate. Overall, our findings reflect a weaker than expected correlation of metrics of quality with teamwork and safety climate.

A priori, we did expect some metrics to yield lower correlations, particularly because some of them may be outside the direct purview of many frontline providers in the NICU (antenatal corticosteroid therapy, pneumothorax, hypothermia on admission, and timely eye exam). For example, obstetricians provide antenatal steroids, specialized delivery room teams may be accountable for pneumothoraces (at least those that occur in the delivery room) or hypothermia on admission, and the ophthalmology team may have a separate system for tracking infants in need for a retinopathy exam, with variable input by frontline NICU staff. Therefore, when frontline staff responded to the survey, the processes associated with these outcomes may not have been at the forefront of their minds. Nevertheless, we wanted to test for correlations with these metrics, given that they had previously been identified as key metrics of NICU quality; knowing how these relate to safety and teamwork metrics is important information for leadership.

We did expect other subcomponents of the Baby-MONITOR to correlate with teamwork and safety climate. Specifically, based on the adult literature and clinical rationale, we expected NICU-level safety culture ratings to be associated with HAI, mortality, chronic lung disease, any human breast milk at discharge, and growth velocity. Each of these metrics requires multidisciplinary

### TABLE 3. Correlations Between Teamwork and Safety Climate and Baby-MONITOR and Its Subcomponents

|                              | Teamwork Climate | Safety Climate |
|------------------------------|------------------|----------------|
|                              | r (95% CI)       | P              | r (95% CI)     | P               |
| No HAI                       | 0.39 (0.10 to 0.61) | 0.01          | 0.29 (−0.01 to 0.55) | 0.05          |
| No chronic lung disease      | 0.17 (−0.13 to 0.45) | 0.27          | 0.18 (−0.13 to 0.45) | 0.25          |
| Any human breast milk at discharge | 0.02 (−0.28 to 0.32) | 0.89          | 0.09 (−0.22 to 0.38) | 0.57          |
| High growth velocity         | −0.05 (−0.35 to 0.25) | 0.74          | −0.20 (−0.47 to 0.10) | 0.19          |
| Survival                     | 0.15 (−0.15 to 0.43) | 0.33          | 0.24 (−0.06 to 0.50) | 0.12          |
| Antenatal steroid use        | −0.05 (−0.36 to 0.27) | 0.78          | 0.01 (−0.30 to 0.33) | 0.93          |
| No hypothermia on admission  | −0.06 (−0.35 to 0.25) | 0.72          | −0.16 (−0.44 to 0.14) | 0.30          |
| No pneumothorax              | 0.25 (−0.05 to 0.51) | 0.11          | 0.07 (−0.23 to 0.36) | 0.63          |
| Timely retinopathy exam      | −0.07 (−0.37 to 0.23) | 0.64          | −0.16 (−0.44 to 0.15) | 0.32          |
| Baby-MONITOR score           | 0.14 (−0.17 to 0.42) | 0.38          | 0.02 (−0.28 to 0.31) | 0.92          |

n = 44 NICUs.
95% CI, 95% confidence interval; r, Pearson correlation coefficient.

![Figure 2](https://example.com/f2.png)

**FIGURE 2.** A, Correlation between HAI and teamwork climate. Each dot represents one NICU. B, Correlation between HAI and safety climate. Each dot represents one NICU. x-axis, HAI in SD units; y-axis, safety climate score.
care teams to work together effectively, with flat hierarchies, good communication, and the freedom to speak up if an unsafe situation is identified.24,25 However, in this sample, the HAI rate was the only metric associated with safety and teamwork climate. It may be that the perceptions of unit teamwork and safety climate are associated with concrete behaviors that help prevent infections. For example, in one study, units with higher teamwork and safety climate ratings exhibited better hand hygiene.5

Potentially, the care processes linked with other outcomes are less concretely defined than with infection and not as readily recognizable to survey respondents. For example, growth velocity requires a more prolonged and complex set of interventions and has no sentinel outcome (e.g., infection). Although teamwork is critical in ensuring optimal nutritional support, providers may not as readily associate distinct behaviors with this outcome. We speculate that connecting actions and outcomes in the minds of providers may potentially be a critical intervention for improvement and one that could be monitored in its success through repeated assessments of safety culture and clinical outcomes. When these connections are not made, efforts to improve teamwork and safety behaviors may not directly result in better quality of care delivery.

The previous safety culture literature may also be subject to publication bias.12,13 Few randomized controlled studies exist to demonstrate causal relationships between safety culture and clinical outcomes. Thus, our findings are important and have practical implications. They add to a growing literature highlighting11 the fact that providers and managers need to be careful not to confuse efforts to improve safety culture with expectations for broad-based quality improvement. It is important to recognize that the evidence for links between safety culture and clinical outcomes is still being developed and that many things may influence clinical outcomes beyond what a safety culture survey can measure. Other studies have shown that interventions to improve teamwork (e.g., TeamSTEPPS) may improve teamwork behaviors without necessarily improving clinical outcomes.26 Although such activities may be necessary to create a favorable contextual environment for effective implementation of standardized evidence-based care delivery, they are not sufficient. Neonatal intensive care units still have to do the hard work of establishing care delivery mechanisms that optimize care outcomes. It they fail to do this, high safety culture ratings may merely reflect nice people providing suboptimal care on a range of outcomes.

Our results must be viewed within the context of the study design. Our cross-sectional study design is hypothesis generating. In addition, because all the analyses are conducted at the NICU level, our sample of 44 NICUs is relatively small to detect statistical significance, making the size and direction of the correlation coefficients more informative in this context. It is also important to understand that the strength of the correlations is not unusual with regard to institutional level variables. In a previous paper, we found just slightly higher correlations when we correlated clinical outcomes with one another.26 Here, we correlated dimensions (teamwork and safety climate), which are more distant in their relation to clinical outcomes. The correlations overall likely indicate that the Baby MONITOR and dimensions of Safety culture measure different aspects of quality of care delivery. By tracking both, institutions may gain insights about different components of service delivery that promote high-quality care and operational excellence.

Neonatal intensive care units participating in this study were not randomly chosen. Rather, they participated by sharing their assessments: Alta Bates Hospital, Berkeley; Antelope Valley Hospital, Lancaster; Arrowhead Regional Medical Center, Colton; California Pacific Medical Center –California, San Francisco; Cedars Sinai Medical Center, Los Angeles; Children’s Hospital Central California, Madera; Children’s Hospital of Orange County, Orange; Community Regional Medical Center - Fresno, Fresno; Doctors Medical Center-Modesto, Modesto; El Camino Hospital-Mountain View, Mountain View; Garfield Medical Center, Monterey Park; Good Samaritan Hospital of Santa Clara Valley–San Jose, San Jose; Harbor UCLA Medical Center, Torrance; Hoag Memorial Presbyterian Hospital, Newport Beach; Hollywood Presbyterian, Los Angeles; Huntington Memorial Hospital, Pasadena; John Muir Medical Center, Walnut Creek; Kaweah Delta District Hospital, Visalia; Mercy Medical Center Redding, Redding; Mercy San Juan Hospital, Carmichael; Methodist Hospital of Southern California, Arcadia; Miller Children’s at Long Beach Memorial Medical Center, Long Beach; Orange County Global Medical Center, Santa Ana; Pomona Valley Regional Medical Center, Pomona; Providence Saint Joseph’s Medical Center, Burbank; Providence Tarzana Medical Center, Tarzana; Rady Children’s Hospital at Palomar, Escondido; Redlands Community Hospital, Redlands; Regional Medical Center of San Jose, San Jose; Riverside County Regional Medical Center, Moreno Valley; Salinas Valley Memorial Healthcare System, Salinas; Scripps Memorial Hospital-La Jolla, La Jolla; Sequoia District Hospital, Redwood City; Sharp Chula Vista Medical Center, Chula Vista; Sharp Mary Birch Hospital for Women, San Diego; St. Bernadine Medical Center, San Bernardino; St. Jude Medical Center, Fullerton; Sutter Medical Center-Sacramento, Sacramento; Tri-City Medical Center, Oceanside; UC Davis Medical Center, Sacramento; UC San Francisco Medical Center, San Francisco; Valley Presbyterian Hospital, Van Nuys. The authors also thank the local leaders and staff of the CPQCC NICUs who contributed their efforts to this study.

CONCLUSIONS

This study reveals significant correlation between HAI rates and NICU teamwork and safety climate. However, other metrics of quality predicted to correlate with teamwork and safety climate did not. Caution is needed in equating efforts to improve safety culture with expectations for broad-based quality improvement.

ACKNOWLEDGMENTS

The authors thank the providers from the following NICUs who participated by sharing their assessments: Alta Bates Hospital, Berkeley; Antelope Valley Hospital, Lancaster; Arrowhead Regional Medical Center, Colton; California Pacific Medical Center –California, San Francisco; Cedars Sinai Medical Center, Los Angeles; Children’s Hospital Central California, Madera; Children’s Hospital of Orange County, Orange; Community Regional Medical Center - Fresno, Fresno; Doctors Medical Center-Modesto, Modesto; El Camino Hospital-Mountain View, Mountain View; Garfield Medical Center, Monterey Park; Good Samaritan Hospital of Santa Clara Valley–San Jose, San Jose; Harbor UCLA Medical Center, Torrance; Hoag Memorial Presbyterian Hospital, Newport Beach; Hollywood Presbyterian, Los Angeles; Huntington Memorial Hospital, Pasadena; John Muir Medical Center, Walnut Creek; Kaweah Delta District Hospital, Visalia; Mercy Medical Center Redding, Redding; Mercy San Juan Hospital, Carmichael; Methodist Hospital of Southern California, Arcadia; Miller Children’s at Long Beach Memorial Medical Center, Long Beach; Orange County Global Medical Center, Santa Ana; Pomona Valley Regional Medical Center, Pomona; Providence Saint Joseph’s Medical Center, Burbank; Providence Tarzana Medical Center, Tarzana; Rady Children’s Hospital at Palomar, Escondido; Redlands Community Hospital, Redlands; Regional Medical Center of San Jose, San Jose; Riverside County Regional Medical Center, Moreno Valley; Salinas Valley Memorial Healthcare System, Salinas; Scripps Memorial Hospital-La Jolla, La Jolla; Sequoia District Hospital, Redwood City; Sharp Chula Vista Medical Center, Chula Vista; Sharp Mary Birch Hospital for Women, San Diego; St. Bernadine Medical Center, San Bernardino; St. Jude Medical Center, Fullerton; Sutter Medical Center-Sacramento, Sacramento; Tri-City Medical Center, Oceanside; UC Davis Medical Center, Sacramento; UC San Francisco Medical Center, San Francisco; Valley Presbyterian Hospital, Van Nuys. The authors also thank the local leaders and staff of the CPQCC NICUs who contributed their efforts to this study.

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