

# Association of Patient Acuity and Missed Nursing Care in U.S. Neonatal Intensive Care Units

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## Abstract

The health outcomes of infants in neonatal intensive care units (NICUs) may be jeopardized when required nursing care is missed. This correlational study of missed care in a U.S. NICU sample adds national scope and an important explanatory variable, patient acuity. Using 2016 NICU registered nurse survey responses ( $N = 5,861$ ) from the National Database of Nursing Quality Indicators, we found that 36% of nurses missed one or more care activities on the past shift. Missed care prevalence varied widely across units. Nurses with higher workloads, higher acuity assignments, or in poor work environments were more likely to miss care. The most common activities missed involved patient comfort and counseling and parent education. Workloads have increased and work environments have deteriorated compared with 8 years ago. Nurses' assignments should account for patient acuity. NICU nurse staffing and work environments warrant attention to reduce missed care and promote optimal infant and family outcomes.

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**Keywords**

neonatal intensive care, missed nursing care, nurse work environment, nurse workload, patient acuity

Critically ill infants are a high-risk population for whom nurses provide continuous care. There is little room for errors of omission for this fragile patient population. Any missed nursing care has the potential to compromise infant health outcomes in the hospital and in the future as infants grow and develop. Missed nursing care is defined as “required nursing care that is omitted or delayed” (Kalisch, Landstrom, & Williams, 2009, p. 4). Examples of missed care for infants include delayed oral feedings and missed counseling of breast-feeding mothers.

Despite multiple studies of missed nursing care in neonatal intensive care, no prior study has examined infant acuity, which varies considerably in this setting and influences nurse workload (Rogowski et al., 2015). Nor has any study documented the prevalence and predominant types of missed care across U.S. neonatal intensive care units (NICUs). These foci are essential to document the bases for and scope of the problem to intervene effectively to decrease missed care.

To address these gaps, our objectives were to estimate the contribution of patient acuity to missed nursing care, in the context of well-acknowledged organizational factors: nurse workload and the nurse work environment, and to document the range of missed nursing care across NICUs. We hypothesized that higher infant acuity, higher workloads, and poorer work environments would increase the probability of missed nursing care. The knowledge gap concerning the mechanisms behind missed care is a critical barrier to progress in improving NICU outcomes. An evidence-based understanding of the factors contributing to missed nursing care in the NICU may contribute to novel, clinically effective strategies to improve the health and life course of critically ill infants.

**Background**

Infants cared for in the NICU, including premature infants, are the most vulnerable hospitalized newborns. The complexity of care required for them, along with their fragile health status due to anatomic, physiologic, and immunologic immaturity, put them at a high risk for adverse outcomes and a low tolerance for poor care processes. Optimal care of these infants depends on individualized, highly skilled nursing care, which may prove difficult, given that the average NICU nurse cares for two or three infants of varying acuity levels each shift (Rogowski et al., 2015).

NICU nurses monitor infants for subtle cues and provide timely and appropriate interventions to prevent morbidity or further decline when morbidity develops. The surveillance role of the NICU registered nurse (RN) includes maintaining the “stability of [the infant’s] cardiopulmonary, neurologic, metabolic and thermal functions” (American Academy of Pediatrics & American College of Obstetricians and Gynecologists, 2007, p. 31). In addition to direct care of the infant, nurses play a key

role in communication with parents and in the initiation and support of the provision of human milk.

Evidence about missed nursing care, its negative consequences for patient outcomes, and related organizational factors has emerged in multiple patient populations internationally (Ausserhofer et al., 2014; Jones, Hamilton, & Murry, 2015; Kalisch, 2015; Papastavrou, Andreou, & Efstathiou, 2014). The evidence on NICU patients is limited to five studies. In nine Quebec NICUs, missed care was less frequent in better work environments (Rocheffort & Clarke, 2010). Survey data from 230 certified neonatal U.S. nurses suggested that system factors contribute to missed nursing care (Tubbs-Cooley, Pickler, Younger, & Mark, 2015). A study in a U.S. medical center linked delayed feeding (a type of missed care) of NICU infants to time required to achieve full oral feedings and length of stay (Tubbs-Cooley, Pickler, & Meinzen-Derr, 2015). In seven Quebec NICUs, missed care was significantly associated with nurse perceptions of parent and infant readiness for discharge and infant pain control (Rocheffort, Rathwell, & Clarke, 2016). In a sample of 134 NICUs in four U.S. states, missed nursing care was significantly more prevalent in NICUs with a high percentage of Black very low birth weight infants (Lake, Staiger, Edwards, Smith, & Rogowski, 2017).

According to Donabedian's framework of quality care assessment, quality outcomes derive from structures and processes. Our conceptualization of missed care is as a care process. The principal organizational structure theorized to influence missed nursing care at the nursing unit level is the work environment. The work environment is defined as the organizational features that facilitate or undermine nurse professional autonomy and includes five domains: nursing foundations for quality of care, nurse participation in hospital affairs, staffing and resource adequacy, nurse-physician collegial relations, and nurse manager leadership (Lake, 2002). These structural features are theorized to affect the provision of essential nursing care. Thus, deficient practice environments likely undermine nurse efficiency and effectiveness.

Another recognized structural feature influencing missed care is nurse staffing (Jones et al., 2015). Pervasive understaffing in U.S. NICUs has been documented (Rogowski et al., 2013). Heavy patient assignments may influence missed nursing care.

Differing infant acuity in the NICU is a structural feature that contributes to nurse workload. Acuity refers to nursing care needs. A recent study of long-standing acuity categories from the American Academy of Pediatrics demonstrated a 1:1 patient-to-nurse ratio for the highest acuity infants compared with 3:1 for the lowest acuity infants (Rogowski et al., 2013). The potential for missed care is high if acuity is not taken into consideration in patient allocation decisions.

### *New Contributions*

Building on the existing studies of missed care in the NICU, our study adds national scope, plus a new and important explanatory variable, patient acuity. Our sample of 303 U.S. NICUs in 41 states and the District of Columbia provides unprecedented

coverage of the U.S. NICU population. This is the first national study to show that nurses in better work environments miss less care, a relationship that has been identified in Quebec NICUs. We introduce patient acuity, which is not captured in standard workload measures but clearly influences workload and likely missed nursing care. Previous research on missed care has not explored patient acuity as a predictor to explain missed care in any population. Examining patient acuity with workload as the basis for missed care advances the field by providing evidence to help guide nurse assignments. The results provide implications for patient assignment, more justification for attention to the work environment, and contribute to the dialogue regarding institutional staffing policies and legislation on critical care nurse staffing ratios.

## **Method**

This was a cross-sectional, correlational study based on a survey of RNs conducted in 2016 for the National Database of Nursing Quality Indicators® (NDNQI). The NDNQI is a voluntary program for hospitals that collects data about nursing-sensitive factors to improve patient care quality (Montalvo, 2007). The independent variables, work environment, nurse workload, and infant acuity, and the dependent variables, prevalence and frequency of missed care, were measured from nurse survey data.

The unit of analysis was the NICU. Some hospitals had multiple NICUs. The sample was derived from hospitals with an eligible NICU. The NICU sample comprised all NICUs that met inclusion criteria: participation in the 2016 NDNQI RN survey and at least 3 staff nurse respondents with complete data on the key variables. The work environment was conceptualized as a nursing unit property; therefore, sufficient agreement among nurses within a unit must be established prior to measure specification at the unit level. The minimum of three staff nurses is based on prior work demonstrating satisfactory aggregate properties of the Practice Environment Scale of the Nursing Work Index (PES-NWI; Lake et al., 2017; Lake, Hallowell, et al., 2016). intraclass coefficient (ICC) (1,k) values greater than 0.60 support the aggregation of the work environment variable to the hospital level (Glick, 1985; Koo & Li, 2016). For our study, the ICC (1,k) was 0.83.

The nurse sample comprised NICU staff nurse survey respondents who had non-missing data on the number of infants' assigned and infant acuity, which were the key variables measured at the nurse level in regression analyses. The RN survey inclusion criteria are employment on the unit at least 3 months and working at least 50% of the time in direct patient care. The NDNQI has been conducting the RN survey for 2 decades and has numerous incentives to encourage participation, which is voluntary. The average unit-level response rate for the sample NICUs was 72.8%.

The data sources for this study include the 2016 NDNQI RN survey and the 2016 annual survey of the American Hospital Association (AHA). The 2011 "NICUs and Neonatologists of the USA and Canada" directory was used to calculate the national distribution of NICU levels.

## *Dependent Variables*

Missed care was measured by self-report, the most common method found in a recent systematic review that included 42 quantitative reports (Jones et al., 2015). The selected measure is a standard in the field (Jones et al., 2015; Lake, Germack, & Viscardi, 2016), comprising 12 care activities considered fundamental to the science and practice of nursing, such as patient surveillance. Two domains of missed care were identified by factor analysis: planning/communication, and clinical care (Bruyneel et al., 2015). This set was augmented by four items designed for this study to address NICU outcomes of breast milk feeding and hospital-acquired infection: breast-feeding support, timely feedings, hand hygiene, and central line maintenance/care. When the missed care measure was incorporated into the NDNQI, the decision was made to include those items, given their relevance to multiple populations. The NDNQI added “ambulation or range of motion” based on clinical rationale and consistency with similar missed care measures. The total number of missed care items was 17 (12 + 4 + 1 = 17).

One NDNQI survey item asks, “On the most recent shift you worked, which of the following nursing activities were necessary but left undone because of time constraints?” Respondents are asked to check all that apply. Variables were created from the missed care responses: (a) a set of binary variables indicating whether any or no care was missed and whether each element was missed and (b) three frequency variables for the number of missed nursing elements overall as well as in each of the two domains.

## *Independent Variables*

The nurse work environment was measured using the PES-NWI (Lake, 2002), which has been endorsed by the National Quality Forum (NQF; 2017) since 2004 as a nursing care performance measure and is used widely by investigators in the United States and abroad (Swiger et al., 2017; Warshawsky & Havens, 2010). The PES-NWI consists of 31 4-point Likert-type items describing selected organizational traits associated with professional practice environments. The survey asks nurses to indicate the degree to which each organizational trait is present in their current job. The 31 items are grouped into five subscales reflecting the work environment domains listed earlier. The composite score was calculated as the mean of the five subscale scores (Lake, 2002).

Two versions of NDNQI survey exist: one contains the PES-NWI, introduced in 2006 following NQF endorsement, and the other contains the Job Satisfaction Scale (JSS), offered beginning in 1998 (Montalvo, 2007). To include all eligible respondents, we developed a facsimile PES-NWI composite measure from 11 items with similar content across the two measures. Two experts confirmed that the JSS items used to create the PES-NWI facsimile were analogous in content to the PES items. An example was the JSS item “RNs on our unit have opportunities for career advancement,” was matched to the PES-NWI item “opportunities for advancement.” We

compared the item distributions in the two subsamples and found they were rather similar. To generate PES-NWI composite facsimile scores, we estimated the PES-NWI composite score from these 11 items in the sample with PES-NWI data and then predicted the facsimile score in the respondents with JSS data. To evaluate PES-NWI composite facsimile performance, regressions were estimated in the two subsamples (the PES-NWI survey respondents and the JSS survey respondents) and the results were quite similar. The coefficient for the PES-NWI variable was  $-0.29$  for the original composite and  $-0.26$  for the facsimile composite. Therefore, equivalence was established and these alternate PES-NWI composite variables were used in a single regression. Details are available from the corresponding author on request. The PES-NWI was used rather than the JSS because it is the NQF endorsed measure, whereas the JSS is oriented toward job satisfaction. Similar items common to both enabled us to exploit all the survey data.

Nurse workload was measured as the number of patients assigned on the last shift worked. The survey question asks, "Over your entire shift, what was the total number of patients assigned to you?" Response options include "shared one patient with another nurse," one patient . . . 24 patients, >24 patients. The responses of the 0.61% of nurses who reported greater than six patients were recoded as missing based on previous work showing that NICU nurses with more than six patients served unconventional roles.

On the survey, each nurse reported the acuity of each infant assigned on the last shift, using established definitions specific to the NICU population (Rogowski et al., 2015). The five acuity levels are Level 1, continuing care; Level 2, intermediate care; Level 3, intensive care; Level 4, multisystem support; and Level 5, unstable/complex critical care (Rogowski et al., 2015). In a national sample, the observed fraction of a nurse assigned to an infant of each acuity level, termed the acuity weight, was calculated as 0.36 for Level 1, 0.41 for Level 2, 0.52 for Level 3, 0.72 for Level 4, and 0.96 for Level 5 (Rogowski et al., 2015). The acuity weights were originally calculated so that an average nurse's acuity-adjusted workload was equal to one (i.e., one nurse) in an earlier sample (Rogowski et al., 2015). For this study, average acuity was calculated as the average acuity weight of a nurse's assigned infants. Acuity-adjusted nurse workload was measured as the number of infants, weighted by their respective acuity weights.

### *Nurse, NICU, and Hospital Characteristics*

We used several nurse, NICU, and hospital characteristics to describe the sample. The nurse survey included questions on nurse gender, age in years, highest degree earned in nursing, years of experience as a RN and on the current unit, and specialty certification.

AHA annual survey data were utilized to measure hospital size (classified as <300 beds, 300 to 500 beds, and >500 bed), ownership (public, for-profit, not-for-profit), teaching status (classified as academic medical center [American Association of Medical Colleges member], other teaching or nonteaching), and geographic region

(Northeast, Midwest, West, and South). Number of NICU beds was measured at the hospital level from AHA variables as the sum of neonatal intensive care and neonatal intermediate care beds. NICU level of care (II, III, IV) was measured from NDNQI data as reported by each NICU. NICU level was included as a statistical control in regression models to account for patient complexity at the unit level. The rates of missing data for all variables were quite low (less than 2%). To evaluate the representativeness of the sample nationally, we described the characteristics of hospitals with a NICU identified in the AHA data by nonzero NICU beds, and compared them with the sample hospitals.

### *Statistical Analysis*

Descriptive statistics were used to describe the hospital, unit, and nurse samples and the distributions of the key variables. Internal consistency scale reliability of the PES-NWI composite was tested with Cronbach's alpha because the composite, a mean of subscale mean values, is a continuous variable. Interrater reliability of the PES-NWI composite aggregated to the NICU-level was assessed by the ICC (1,k) (Koo & Li, 2016). We estimated ordinary least squares models of the relationship between the number of missed care activities and the nurse and NICU-level factors. We estimated logistic regression models of the odds a nurse missed at least one care activity, a binary variable. All models were nurse-level regressions that accounted for clustering at the unit level. In all models, continuous independent variables were standardized to ease interpretation. In addition, we estimated hierarchical linear and logistic models with random intercepts at the unit level. Because the frequency of missed care is a count, we also estimated Poisson and negative binomial models as a robustness check. Due to very similar results, we report estimates from the ordinary least squares and logistic models. Beta coefficients were interpreted as the effect of a 1 *SD* increase in the PES-NWI composite score, nursing workload, average acuity of assigned infants, and acuity-adjusted workload on the number of care activities missed. Odds ratios were interpreted as the effect of a 1 *SD* change in the respective independent variables on the odds of a nurse missing any care. Statistical significance was judged at the .05 level for a two-tailed test.

### **Results**

The hospital sample comprised 280 hospitals in 41 states and the District of Columbia. Most hospitals had fewer than 300 beds, had a teaching mission, were nonprofit, and were located in metropolitan areas (Table 1). The sample was distributed fairly evenly across the four U.S. census regions. Compared with 942 hospitals with a NICU nationally, the sample was similar in the proportion with a teaching mission, had relatively more not-for-profit hospitals (which comprised 72% of such hospitals nationally), and smaller hospitals (42% of hospitals nationally had fewer than 300 beds).

There were 303 NICUs in the sample. Nineteen hospitals had two or more NICUs. Two thirds of the sample's NICUs were Level III, similar to NICUs nationally in 2011,

**Table 1.** Characteristics of Sample Hospitals, NICUs, and Nurses.

Characteristics	%	M	SD
<i>Hospital characteristic (n = 280)</i>			
Bed size			
<300 beds	54.6	—	—
≥300 and <500 beds	31.4	—	—
≥ 500 beds	13.9	—	—
Teaching hospital			
Academic medical center	20.0	—	—
Teaching	35.7	—	—
Nonteaching	44.3	—	—
Hospital ownership <sup>a</sup>			
Public	8.2	—	—
For-profit	7.9	—	—
Not-for-profit	83.9	—	—
Geographic region			
Northeast	21.8	—	—
Midwest	24.3	—	—
West	13.2	—	—
South	40.7	—	—
Metropolitan status			
Nonmetro	3.2	—	—
Metro >50,000	96.8	—	—
<i>NICU characteristic (n = 303)</i>			
NICU beds <sup>b</sup>	—	30.9	21.4
Level			
II	27.4	—	—
III	68.0	—	—
IV	4.6	—	—
<i>Nurse characteristics<sup>c</sup> (N = 5,861)</i>			
Female	98.4	—	—
Age	—	39.7	12.1
Bachelor of science or higher degree in nursing	76.3	—	—
Years of experience			
In practice in United States	—	14.5	11.7
On unit	—	9.3	9.3
Nurse certification for specialty practice	26.1	—	—

Note. NICU = neonatal intensive care unit.

<sup>a</sup>N = 279. <sup>b</sup>N = 253 due to 27 hospitals had missing American Hospital Association data on number of beds. <sup>c</sup>The number of nurses varies from 5,185 to 5,861 due to missing data.

in which 71% were Level III and 16% were Level II. The average number of NICU beds (31) was similar to the national average. The nurse sample consisted of 5,861 nurses. They were nearly all female with an average age of 39.7 years and had 15 years'



**Table 2.** Descriptive Statistics for the Work Environment, Workload, and Acuity Measures.

	<i>n</i>	<i>M</i>	<i>SD</i>	Min	Max
Nurse work environment composite score	303	2.94	0.25	2.07	3.63
Patient acuity	5,861	0.46	0.13	0.34	0.95
Patient load	5,861	2.48	0.78	1.00	6.00
Acuity-adjusted patient load	5,861	1.10	0.30	0.34	4.83

experience as a nurse and 9 years on the current unit. Three quarters held a bachelor's of science degree in nursing (BSN) and one quarter were specialty certified.

NICU-level work environment measure, nurse-level workload, and infant acuity statistics are displayed in Table 2. The PES-NWI composite had high internal consistency (Cronbach's alpha of .87). The PES-NWI composite score nursing-unit-level mean of 2.94 indicates that in a typical nursing unit, nurses tended toward "agree" (3.0) that valued organizational traits were present in their current job. This mean ranged from 2.07 (tend toward "disagree" [2.0]) to 3.63 (tend toward "strongly agree") across units. The mean number of patients per nurse was 2.48 ( $SD = 0.78$ ; range 1 to 6 across nurses). The average acuity of an infant in a nurse's assignment was 0.46 ( $SD = 0.13$ ), equivalent to the midpoint between Levels 2 (corresponding to intermediate care) and 3 (intensive care). The average acuity-adjusted nurse workload was 1.10, equivalent to 10% higher than if the number and acuity of a nurse's assigned infants totaled those observed in an earlier national sample (Rogowski et al., 2015). The adjusted workload ranged from 0.34 to 4.83.

Missed nursing care prevalence and patterns are displayed in Table 3. Whole sample and subsamples defined by whether the nurse's acuity-adjusted workload was below or above the median acuity-adjusted workload in our sample are presented. All but one comparison were statistically significant. The percentage of nurses missing pain management, the activity missed by the fewest nurses, was not significant. On average, nurses missed 0.88 activities ( $SD = 1.59$ ; range 0 to 15 across nurses). The frequency of planning/communication activities missed was triple that of clinical activities missed (0.67 vs. 0.21, respectively). Nurses with high acuity-adjusted workloads had two to three times as much total missed care, as well as missed clinical and planning/communication activities, as nurses with low acuity-adjusted workloads.

The percentage of nurses that missed one or more care activities was 36% overall, 49% among nurses with a high-acuity workload, and 27% among nurses with a low-acuity workload. Specific care activities were missed by 0.4% to 15.0% of nurses. Each activity was missed by double to triple the percentage of nurses with high-acuity loads compared with nurses with low-acuity loads. The most prevalent missed care was for teach/counsel patients and family (15%), comfort/talk with patients (13%), help/counsel breast-feeding mothers (11%), and prepare patients and families for discharge (10%). The lowest prevalence of missed care, at less than 1%, was for central line assessment/care, adequate hand hygiene, and pain management. At the unit-level, the mean percentage of nurses that missed one or more activities was 34.1%, ranging

**Table 3.** Distributions of Missed Nursing Care in Neonatal Intensive Care Nurses, Overall, and by Acuity-Adjusted Patient Load Subgroups.

	Overall (N = 5,861)	Acuity-adjusted patient load <sup>a</sup>	
		Below median	Above median
Average number of care activities missed, Mean			
Total care activities	0.88	0.58	1.36**
Clinical activities	0.21	0.12	0.35**
Planning/communication activities	0.67	0.46	1.02**
Percent of nurses missing care activities, %			
One or more activities	35.7	27.1	49.4**
Teach/counsel patients and family	15.0	10.5	22.3**
Comfort/talk with patients	12.5	8.0	19.6**
Help/counsel breast-feeding mothers	10.6	6.7	16.8**
Prepare patients and families for discharge	9.9	7.5	13.8**
Develop or update care plans	9.8	7.0	14.3**
Adequately document nursing care	7.3	4.9	11.0**
Administer oral feedings on time	5.3	3.3	8.6**
Adequate patient surveillance	4.5	2.4	7.9**
Administer medications on time	3.5	2.0	5.9**
Coordinating patient care	2.1	1.0	3.9**
Oral hygiene	1.9	0.9	3.3**
Ambulation or range of motion	1.8	1.3	2.6**
Skin care	1.3	0.7	2.3**
Treatments and procedures	1.0	0.5	1.7**
Central line assessment/care	0.6	0.2	1.2**
Adequate hand hygiene	0.5	0.3	0.8**
Pain management	0.4	0.4	0.4

<sup>a</sup>All comparisons of missed care prevalence between the high and low acuity-adjusted workload subsamples were statistically significant at \*\* $p < .01$  except pain management, which was statistically significant at \* $p < .05$ .

from 0% to 100% across units. The unit-level mean frequency of activities missed was 0.89 (range 0 to 7.3 across units).

The regression results are displayed in Table 4. These models are nurse-level regressions of two measures of missed nursing care: frequency of total activities missed and the binary measure of whether any activity was missed. These dependent variables were regressed on NICU and nurse-level independent variables. The models controlled for NICU level and number of beds. Missed care frequency, but not missed care odds, was significantly higher in Level II NICUs compared with Level III (results not shown). Number of NICU beds was significantly positively associated with missed care frequency and odds (results not shown).

**Table 4.** Linear (Panel A) and Logistic (Panel B) Regression Models With Results Displaying the Relationships Between Nurse Work Environment, Nurse Workload, Patient Acuity, and Missed Nursing Care.<sup>a,b,c,d</sup>

	Adjusted for NICU nursing characteristics	Adjusted for nursing and nurse characteristics	Adjusted for NICU nursing, nurse and NICU characteristics
<i>Panel A: OLS model of number of care activities missed, regression coefficient and [95% CI]</i>			
Unit-level measures			
Practice environment	-0.29*** [-0.35, -0.22]	-0.26*** [-0.33, -0.20]	-0.26*** [-0.32, -0.20]
Nurse-level measures			
Patient load	0.39*** [0.31, 0.46]	0.56*** [0.47, 0.65]	
Average acuity		0.30*** [0.24, 0.35]	
Acuity-adjusted patient load			0.61*** [0.52, 0.71]
R <sup>2</sup>	.087	.110	.114
<i>Panel B: Logit model of any missed care, OR and [95% CI]</i>			
Unit-level measures			
Practice environment	0.66*** [0.60, 0.73]	0.68*** [0.62, 0.74]	0.68*** [0.62, 0.75]
Nurse-level measures			
Patient load	1.75*** [1.61, 1.91]	2.24*** [2.01, 2.49]	
Average acuity		1.47*** [1.37, 1.57]	
Acuity-adjusted patient load			2.39*** [2.13, 2.68]
Pseudo R <sup>2</sup>	.068	.083	.083

Note. NICU = neonatal intensive care unit; OLS = ordinary least squares; OR = odds ratio; CI = confidence interval. Sample size 5,861. All models control for NICU level and NICU number of beds.

<sup>a</sup>Work environment variables are nursing unit level (n = 303). <sup>b</sup>Nurse workload is nurse-level (N = 5,861 for work environment; 5,861 for workload and joint models). <sup>c</sup>The dependent variable is nurse level. <sup>d</sup>Results were considered statistically significant at p < .05 for a two-tailed test.

\*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 4 Panel A shows results for ordinary linear regression of the frequency of total activities missed on NICU and nurse-level independent variables. All independent variables were standardized so the coefficients could be interpreted as the effect of 1 *SD* change in each variable on the frequency of missed care. In Model 1, the work environment and patient load were statistically significant. A 1 *SD* increase in the PES-NWI composite score was associated with a reduction of 0.29 activities missed, which is one third of the mean missed care frequency of 0.88 ( $0.29/0.88 = 0.33$ ). A 1 *SD* increase in patient load was associated with an increase of 0.39 activities missed, or 44% of the mean frequency. In Model 2, the addition of patient acuity, which was also significant, increased the explained variance from 0.087 to 0.110. Here, a 1 *SD* increase in average acuity was associated with a 0.30 increase in missed care frequency, that is, 33% of the mean frequency. The addition of average acuity increased the coefficient for workload to 0.56, or 64% of the mean frequency. The work environment coefficient reduced slightly from 0.29 to 0.26. In Model 3, which substituted acuity-adjusted workload for separate acuity and workload variables, the single variable did as well as the two by themselves in terms of  $R^2$ , suggesting that acuity-adjusted workload is an appropriate summary of these separate measures. A 1 *SD* increase in acuity-adjusted workload was associated with a 0.61 increase in missed care frequency, that is, 69% of the average frequency.

Panel B of Table 4 shows results for logistic regression of the binary variable, indicating whether one or more care activities was missed on NICU and nurse-level independent variables. For the odds that a nurse missed one or more activities, the results were similar to the missed care frequency variable. A 1 *SD* higher PES composite score was associated with a 34% reduction in the odds of missing any care. For a nurse with an average probability of missing any care of 36%, this reduction in the odds translates to an absolute reduction in the probability of missing any care of 9 percentage points (from 36% to 27%), or one quarter of the average probability. A 1 *SD* increase in patient load was associated with a 75% increase in probability of missed care, equivalent to a 14 percentage point absolute effect, or 39% of the average probability. In Model 2, which added in average patient acuity, a 1 *SD* increase in average acuity was associated with a 47% increase in odds of missed care, equivalent to 9 percentage points absolute effect, which is 25% of the average probability. The addition of average acuity increased the odds for workload to 2.24, equivalent to 20 percentage points absolute effect, or 56% over the average probability. The work environment coefficient changed trivially. In Model 3, which substituted acuity-adjusted workload for separate acuity and workload variables, a 1 *SD* increase in acuity-adjusted workload was associated with a 2.39% increase in missed care odds, equivalent to 21 percentage points absolute effect, or about 58% of the average probability. The pseudo  $R^2$  for Models 2 and 3 were both greater than for Model 1, indicating that accounting for acuity improves the ability to explain the odds of missing care.

## Discussion

This is the first article to document the prevalence of missed nursing care in neonatal intensive care in a large national sample, comprising a third of U.S. NICUs. We found

that NICU staff nurses routinely missed required care and that its prevalence varied widely across units. On their last shift, 36% of sample nurses missed one or more care activities. In some units, none of the nurses missed care and in others, all of the nurses missed some care. While nurses overall missed approximately 1 activity (0.88) on their last shift, this ranged from 0 to 15 across nurses and from 0 to 7 across units. The finding that some hospitals had substantially more missed nursing care than others is both a safety and quality issue for hospitals and a concern for parents. Notably, the most common activities missed involved patient comfort and counseling and education of parents. These levels of missed nursing care are problematic for patient-centered care and optimal infant and family outcomes.

That every care activity was missed implies that some infants are not fed on schedule, may not receive breast milk, do not receive medications on time, have delayed or missed treatment and procedures, and suffer pain. These care gaps likely impact short-term outcomes including comfort, growth, length of stay, and morbidity, for example, necrotizing enterocolitis (i.e., death of a section of bowel), which is less common among infants who receive breastmilk (Ip et al., 2007). A study of missed or delayed oral feedings in the NICU demonstrated significantly delayed time to full oral feedings and longer length of stay (Tubbs-Cooley, Pickler, & Meinzen-Derr, 2015).

Infants are not receiving proper care due to nurses' heavy assignments, including high infant acuity, and poorly organized environments. Patient acuity, a new focus of inquiry on missed care introduced in this article, was a key predictor in this population. Acuity in this population ranges from continuing care to unstable/complex critical care. The average acuity-adjusted workload of 1.10 in this sample indicates that workloads have increased 10% over the past 8 years (Rogowski et al., 2015). Our data show that patient assignments did not fully account for acuity differences as evident in the *SD* of 0.3 for acuity-adjusted patient load. An *SD* of 0.3, given an average of 1.10, shows that substantial variation remains after assignments are determined.

Increasing a nurse's assignment by 1 *SD* (0.78 patients) more than doubles the odds the nurse will miss care and increases the missed care frequency by 0.6 activities, relative to a mean frequency of 0.88. Increasing the acuity of a nurse's assigned infants by 1 *SD* increases the odds that the nurse will miss care by 1.5 times and increases the frequency by 0.3 activities. These large effects demonstrate the sensitivity of missed care to typical differences in patient assignments across nurses.

An acuity-adjusted workload measure accounted for two aspects of a nurse's assignment: acuity and workload. This approach reflects clinical practice as workload and acuity are not mutually exclusive. For each activity, the percentage of nurses with high acuity-adjusted workloads who missed the activity was double to triple the percentage of nurses with low-acuity loads who missed the activity.

These findings signal quality and safety concerns in NICUs. Infants with the highest levels of acuity are the most understaffed (Rogowski et al., 2013). Our findings here show that nurses caring for infants with the highest acuity assignments have the highest levels of missed nursing care. It is therefore imperative for staffing in the units to take into account patient acuity, as these vulnerable infants are at the highest risk for poor patient outcomes.

In addition to adequate staffing, better practice environments have the potential to reduce missed care. Improving the NICU work environment, as measured by the PES-NWI composite score, by 1 *SD*, that is, a typical variation across this sample, reduces the odds a nurse will miss care by 32% and decreases the missed care frequency by 0.3 activities. This mean value reflects that some nurses miss an activity and others do not. A nurse manager may anticipate that improving their environment would result in fewer nurses missing activities, and the mean would decrease. Even if units do not have the resources to increase nurse staffing, improved organization of existing resources and the culture on the unit can reduce rates of missed nursing care. Benchmark data that identifies work environment weaknesses may be useful.

Unfortunately, the work environment in these contemporary data are rated less favorably compared with 8 years ago. In a national sample of 98 NICUs from 2008 (Lake et al., 2017), the PES-NWI composite score was 3.05, compared with the current national sample of 303 NICUs, with the composite score of 2.94, a 0.4 *SD* reduction. This difference supports an intervention to address work environment quality.

Our findings are consistent with the few studies of missed nursing care in the NICU, although no prior studies measured a critical factor, infant acuity. Our missed care prevalence of 40% is similar to the 52% rate from a survey of 230 certified NICU nurses (Tubbs-Cooley, Pickler, Younger, et al., 2015). A Canadian study found a significant association between the practice environment and missed nursing care (Rochefort & Clarke, 2010). Consistent with these smaller studies, the present study found that the patient-centered and care coordination aspects of care were missed most frequently. Although some studies measure missed care frequency from rarely to often, our measure captures a point-in-time prevalence as well as how many different activities were missed.

Our results have implications for infant development, nursing practice, health care organizations, health policy, and health services research. In addition to short-term infant health implications, the care that is missed most often has long-range implications for the baby and family. For example, when teaching and breast-feeding support are missed, the baby and family may continue to have a knowledge deficit that could affect infant development over the longer term. Long-term outcomes may be an unstudied area where missed care has a large impact. The relationships identified here are consistent with evidence that better nurse staffing and work environments in the NICU are associated with higher rates of nurses providing breast-feeding support (Hallowell, Spatz, Hanlon, Rogowski, & Lake, 2014) and infants receiving breast milk (Hallowell et al., 2016). As advocated by the American Academy of Nursing Breast-Feeding Expert Panel, breast-feeding, due to its socioeconomic, behavioral, and biologic buffering effects, has the potential to mitigate childhood toxic stress (Hallowell, Froh, & Spatz, 2017). The long-term implications of missed nursing care may relate to large racial disparities in postneonatal (i.e., first month of life) survival to the first year of life (Mathews, MacDorman, & Thoma, 2015). Part of the survival disparity may be due to insufficient preparation and ability of the parent to care for the baby. The higher rates of missed nursing care in minority-serving NICUs (Lake et al., 2017), may set

the stage for this disparity. Given the types of missed care missed more frequently, acute care goals may be met, but long-term health may be compromised.

The practice implication of these findings is that a large segment of staff nurses in the NICU are unable to provide care that they deem necessary. The professional burden of missed care weighs on nurses' thoughts and contributes to dissatisfaction, burn-out, and potential turnover (Kalisch, Tschannen, & Lee, 2011).

From a policy perspective, our evidence suggests that institutional and legislative policies regarding staffing ratios in critical care settings should account for patient acuity adjustments, permit flexibility in policy compliance, and allow staff nurse input into decisions. Moreover, the expectations of care providers have changed under new payment arrangements that require accountability for assuring postdischarge outcomes. In the past, providers focused primarily on the outcomes for the hospital stay itself, with little effort toward what happened once the baby went home. By contrast, today's payment models emphasize integrated care delivery where providers are responsible for achieving population health goals. In the context of such care delivery changes, the significance of missed nursing care is potentially greater.

Our study had limitations. The sample units were in NDNQI hospitals, which comprise a self-selecting group focused on quality outcomes. NDNQI hospitals are disproportionately nursing Magnet hospitals, recognized for achieving excellent nursing standards. Missed care may be more common in hospitals that do not participate in quality-oriented programs. Notably, some NICUs within our sample had a high missed care prevalence. The results may present a lower prevalence of missed care than the actual prevalence in the U.S. NICU population. The cross-sectional design limits causal inference. Other situational factors reported in the literature such as urgent patient situations, or surges in patient volume or acuity, or interruptions (Tubbs-Cooley, Pickler, Younger et al., 2015), were not available in the data but are likely to be influenced by the work environment and workload. Remedies to missed care that address work environment may be effective by reducing the occurrence or facilitating an effective response to the situational factors, thereby reducing missed care. This sample of nurses has a higher proportion of BSN nurses (75%) than a sample in an earlier multihospital study (49%; Rogowski et al., 2015). However, there are no national estimates of the BSN proportion among NICU nurses.

Future research should explore the relationship between missed nursing care and patient and family outcomes. If missed care is a mediating factor to outcomes, as has been shown in adult populations (Ball et al., 2018), then it could be considered as driving the large outcome differences that have been documented across units that have been seen as unexplainable (Rogowski et al., 2004). Given our results, future research should test interventions that determine workload based on infant acuity, which is not done presently (Rogowski et al., 2013), ideally in a cluster trial design.

NICU infants are among the most vulnerable patients. Many of the tasks missed relate to the patient centeredness of care, including teaching and breast-feeding support. Thus, improving missed nursing care is likely to also improve the patient-centeredness of NICU care for infants and their families. These aspects of care are



particularly important for infant development once the infant is discharged home from the NICU.

### Authors' Note

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