Nurse Staffing Effects on Patient Outcomes

Safety-Net and Non-Safety-Net Hospitals

Mary A. Blegen, PhD, RN, FAAN, Colleen J. Goode, PhD, RN, FAAN,† Joanne Spetz, PhD,* Thomas Vaughn, PhD,‡ and Shin Hye Park, MS, RN, PhD(c)**

Background: Nurse staffing has been linked to hospital patient outcomes; however, previous results were inconsistent because of variations in measures of staffing and were only rarely specific to types of patient care units.

Objective: To determine the relationship between nurse staffing in general and intensive care units and patient outcomes and determine whether safety net status affects this relationship.

Research Design: A cross-sectional design used data from hospitals belonging to the University HealthSystem Consortium.

Subjects: Data were available for approximately 1.1 million adult patient discharges and staffing for 872 patient care units from 54 hospitals.

Measures: Total hours of nursing care [Registered Nurses (RNs), Licensed Practical Nurses, and assistants] determined per inpatient day (TotHPD) and RN skill mix were the measures of staffing; Agency for Healthcare Research and Quality risk-adjusted safety and quality indicators were the outcome measures.

Results: TotHPD in general units was associated with lower rates of congestive heart failure mortality ($P<0.05$), failure to rescue ($P<0.10$), infections ($P<0.01$), and prolonged length of stay ($P<0.01$). RN skill mix in general units was associated with reduced failure to rescue ($P<0.01$) and infections ($P<0.05$). TotHPD in intensive care units was associated with fewer infections ($P<0.05$) and decubitus ulcers ($P<0.10$). RN skill mix was associated with fewer cases of sepsis ($P<0.01$) and failure to rescue ($P<0.05$). Safety-net status was associated with higher rates of congestive heart failure mortality, decubitus ulcers, and failure to rescue.

Conclusions: Higher nurse staffing protected patients from poor outcomes; however, hospital safety-net status introduced complexities in this relationship.

Key Words: nurse staffing, quality of care, patient safety, safety net hospitals

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Research linking nurse staffing to the quality of patient care has increased markedly in the years since an IOM committee concluded that there was little research in this area.[1] Although the overall conclusions from this research are that higher levels of nurse staffing are linked with better quality of care and better patient outcomes, systematic reviews of this work report many inconsistencies.[2–8] More recent work, not yet included in systematic reviews, continues to show mixed results.[9–13] The lack of consistent findings hampers the creation of clear policies for nurse staffing. Existing studies further provide little information on specific staffing levels for general units compared with intensive care units (ICUs).

These inconsistent results stem, in part, from varying sources of staffing data, some of which were shown to be unreliable with attenuation bias from measurement.[7,12,14–16] Previous measures included hospital level counts of nursing staff, across all patient units, that combine registered nurses (RNs) providing direct care with those in administrative and support positions. Furthermore, some of these hospital-level studies only had access to data for RNs and licensed practical nurses (LPNs), whereas 40% to 50% of the care in non-ICUs is delivered by unlicensed nursing assistants (NA). Many studies used large national and state databases to access this information,[14,17,18] whereas others used survey questionnaires asking about nursing workload.[11,19] A smaller set of studies examined this issue at the patient care unit level. These studies, by necessity, used relatively small samples as data on unit-level staffing are not collected in large publicly available US databases and have to be requested from individual hospitals. Some of these studies concentrated on adult ICUs,[10,20,21] some used only adult medical/surgical (non-ICU) units,[22] and some combined the two.[23,24] Two recent studies included separate values for nurse staffing in ICUs and general units in Veterans Administration hospitals[12] and in Belgian hospitals.[25] Given the varying measures of nurse staffing, the varying support for the

From the *Department of Community Health Systems, School of Nursing, University of California, San Francisco, CA; †College of Nursing, University of Colorado at Denver, Denver, CO; and ‡Department of Health Management, College of Public Health, University of Iowa, Iowa city, IA.

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Reprints: Mary A. Blegen, PhD, RN, FAAN, Department of Community Health Systems, School of Nursing, University of California, San Francisco, CA. E-mail: Mary.Blegen@nursing.ucsf.edu.

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relationship between staffing and patient outcomes should not be a surprise. More consistent support specific to different types of units would provide clear direction for policy and administration.

To refine the knowledge in this area, we examined the effect of direct care nurse staffing hours from all nursing care providers using measures recommended by the National Quality Forum[26] and calculated these separately for general units and ICUs. These measures capture actual time spent in providing nursing care, omitting administrative and other types of system support, and adjust for numbers of patients needing care. Staffing was further used to predict patient outcomes as measured by the Agency for Healthcare Research and Quality (AHRQ) in their Inpatient Quality Indicators and Patient Safety Indicators.[27] Given recent study findings about poorer outcomes in safety-net hospitals,[28,29] the study examined the effect of safety-net status while controlling for patient acuity and technology. The objective of the study was to determine the relationship between nurse staffing in general and ICUs and patient outcomes, and to determine whether safety-net status affected the relationships.

METHODS

Design and Data

This cross-sectional, model testing study used 2 data sets created by the University HealthSystem Consortium (UHC). The clinical data set contained discharge diagnosis and procedure codes, and actual and expected length of stay for 1.1 million adult, nonobstetric, nonpsychiatric patients. The operational data set contained the direct caregiver hours at the level of the patient care unit, enabling us to differentiate staffing levels in intensive care from those in non-ICUs. Values for staffing and outcomes were calculated for each of the 4 calendar quarters for 2005, the most recent year for which data were complete when the study was initiated.

The sample consisted of hospitals that were regular or affiliate members of the UHC and contributed data to both their clinical and operational data sets, hi 2005, there were 213 regular and associate members of UHC, of these 54 had contributed data to both operational and clinical data sets. We had staffing data from 872 adult inpatient units (285 ICUs, 587 general).

Hospital Characteristics

To adjust for the aggregate acuity of each hospital's patients, we obtained the Medicare case mix index for each hospital. Technology level of each hospital was determined using the Saiden Index.[30] Safety-net status in this set of UHC hospitals was reported in the data set as "Yes" or "No," according to the Centers for Medicare and Medicaid Services definition of disproportionate share. That is, safety-net hospitals are those receiving adjustment payments to provide care to a significantly disproportionate share of low-income patients who are not paid by other payers, such as Medicare, Medicaid, the Children's Health Insurance Program, or other health insurance (available at: http://www.hhs.gov/recovery/cms/dsh.html). Size, ownership, and location were available but had no systematic effects on the outcomes and were not considered in the multivariate analyses.

Nurse Staffing

The following 2 variables were used for nurse staffing: total hours of care from RNs, LPNs, and NA for each patient day (TotHPD); and the proportion of those hours that were provided by RNs (RN skill mix). The UHC data sets presented the opportunity to use the most informative method of measuring the amount of nursing care provided in inpatient care units, the hours from direct care givers per patient day in each inpatient unit. Measures were focused only on patient care activities by (a) capturing the worked hours exclusive of management and clinical specialist hours, and vacation and sick time; (b) separating unit staffing by the care needs of the patients (intensive or nonintensive care); and (c) including the presence of patients in the units for observation or short stay in addition to those counted in the midnight census. These measures were a distinct improvement over previous studies that had to combine staffing from all units to the hospital level, include administrative and support hours, were not able to select only worked hours from total paid hours, and were not able to adjust patient days for short stay and observation patients. Reliability and validity of staffing data obtained from payroll records have not been specifically studied but is believed to be accurate as it is vital to the hospital's ongoing functioning.

The measures of nurse staffing on adult ICUs and nonintensive care general adult units (including step-down units and excluding obstetric, psychiatric, rehabilitation, skilled care) were then aggregated to the hospital level. This aggregation was necessary as the outcomes were only available at the hospital level; patient discharge outcomes are not linked to their care in specific units, but to the entire hospital stay. Intraclass correlation coefficients demonstrated that the variability of staffing within hospitals was much less than the variability between hospitals [ICC (1) between 0.34 and 0.46; ICC (2) between 0.91 and 0.97].

Patient Outcomes

Outcomes included one measure provided by UHC, proportion of nonobstetric adult patients with longer-than-expected length of stay for their diagnosis, and a set of outcomes computed from patient discharge data using the patient safety indicators and inpatient quality indicators developed by AHRQ. Although the validity of indicators has been questioned, they are widely used to assess the quality of patient care.[31] These outcome rates are calculated only at the hospital level as patient discharges cannot be linked to particular units within hospitals. The outcome indicators were risk adjusted by calculating them, using the AHRQ procedures, as a ratio of observed to expected. If the hospital's performance was as expected for their mix of patients, the value is 1.0. If they have a higher than expected rate of these adverse outcomes, the value is greater than 1.0 and if they have fewer adverse occurrences than expected,

the value is less than 1.0. Indicators were calculated if there were 30 or more patients meeting the inclusion criteria in the quarter; if there were fewer cases, the value was set to missing.

A short list of indicators were selected for this study using the following 2 criteria: first, indicators that had been shown to be sensitive to nursing care in past research or recommended by the National Quality Forum; second, if the indicator appeared to be stable in this data set. For example, postoperative hip fracture has been considered a nurse-sensitive indicator (patient falls); however, it was not used for this study as 52 of the hospitals had at least one-quarter with zero rates, and 142 of the 208 quarters of data were missing or zero.

Data analyses were performed using STATA, version 9 (StataCorp LP, College Station, TX), tested 2 hypotheses, and explored 1 research question.

HI: Controlling for hospital characteristics (eg, Medicare case mix index, technology, safety-net status) and patient risk factors, total hours of direct nursing care per patient day (TotHPD) and the proportion of care provided by RNs (RN skill mix) in adult general units will be associated with better patient outcomes.

H2: Controlling for hospital characteristics (as above) and patient risk factors, total hours of direct nursing care per patient day (TotHPD) and the proportion of care provided by RNs (RN skill mix) in adult ICUs will be associated with better patient outcomes.

Research Question: Does safety-net status affect the staffing levels, outcome rates, or the relationship between these variables?

The same set of hospital characteristics was used in each analysis. After initial analyses showed that safety-net hospitals had poorer patient outcomes, we added terms for interactions between safety-net status and nurse staffing to examine whether the effects of nurse staffing on patient outcomes differed according to safety-net status. When the interaction was statistically significant, a linear combination procedure[32] was used to estimate the regression coefficients for safety-net hospitals; this summed up the staffing slope for non-safety-net hospitals with the estimated slope differences between safety-net and non-safety-net hospitals.

The following 2 sets of analyses were done for each outcome: one with general unit staffing and the other with ICU staffing. This was done to clarify any differences in effects of staffing in each area. Because the 4 quarters of data were nested within each hospital, data were clustered by hospital and robust standard errors were used.

We recognized that nurse staffing may be affected by patient outcomes in previous time periods, thus confounding our interpretation of the coefficient of staffing. To assess the causal relationship between staffing and outcomes, we used instrumental variables regression. The supply of nurses (RNs per 1000 population) in the metropolitan statistical area (MSA) was the instrumental variable predicting nurse staffing.[33] Nurse supply at the MSA was determined by collecting from each state the number of licensed RNs residing in each county and the population of that county, and further aggregating these to the MSA that included the county. Although nurse supply was a good predictor of nurse staffing, the tests for endogeneity were not statistically significant. We concluded that staffing and outcomes were not endogenous and present the ordinary least squares results in this study.

RESULTS

There was a total of 208 quarters of data from the 54 hospitals; 8 quarters of data were missing from hospitals that began submitting their data partway through the year. Of the 54 hospitals, 47 belonged to the Council of Teaching Hospitals, 50 were major and 4 were minor teaching; and 46 were designated as safety-net hospitals. Ownership varied with 8 community, 14 local government, 29 university, and 3 owned by a religious organization; none owned by private investor. Of these hospitals, 12 were members of multi-hospital networks and 19 indicated that they were recognized as a Magnet Hospital. Of these hospitals, 24 were located in inner-cities, 20 in urban locations, 8 in suburban, and 2 in rural areas. Members of the UHC are among the largest hospitals in the country; the average size of UHC hospitals in our sample was 559 acute care operating beds, with a range of 197 to 925 beds. However, the average bed size of all hospitals belonging to the UHC in 2005 was 432, whereas the average size of all members in the American Hospital Association was 164. Safety-net hospitals were similar to non-safety-net in size, case mix, and technology (Table 1). The homogeneity of the sample controlled some of the organizational characteristics that have introduced uncertainty in previous studies.[34] However, this advantage came at the price of having a sample that does not fully represent the broader hospital industry of the United States.

Table 1 also presents summary statistics for the nurse staffing data. The average per hospital, per quarter for total hours of care from all nursing care providers (TotHPD) was 11.13 in adult general units and 20.8 in adult ICUs. The proportion of the total hours delivered by RNs (RN staff mix) averaged 60% in general units and 76% in ICUs. Safety-net and non-safety-net hospitals had similar nurse-staffing levels. Table 2 presents the mean, standard deviation, and range for each of the outcome variables used in this study. In general, outcomes were worse in safety-net hospitals.

Tables 3 and 4 present the results of the multivariate T3-4, analyses. Several of the control variables included in the analysis had significant effects on patient outcomes. Hospitals with a higher Medicare case mix index had higher levels of congestive heart failure (CHF) mortality and lower rates of decubitus ulcers. Technology had no statistically significant effect on the outcomes in this set of hospitals. Safety-net hospitals had higher rates of mortality in CHF patients, decubitus ulcers, and failure to rescue. The interactions between safety-net status and nurse-staffing levels were significant for CHF mortality, failure to rescue (for ICU staffing), infections due to medical care, and excessive length of stay (for general unit nurse staffing). Results for interactions between safety-net status and nurse staffing, with separate coefficients for safety-net and non-safety-net

TABLE 1. Sample Description

	Variable	All Hospital (54) Mean (SD)	Non-Safety-Net Hospitals (8) Mean (SD)	Safety-Net Hospitals (46) Mean (SD)
Hospital characteristics	Acute care operating beds	559.35 (186.99)	599.47 (137.16)	552.05 (194.11)
	Case mix index	1.81 (0.22)	1.86 (0.14)	1.81 (0.23)
	Service/technology mix	26.95 (5.71)	29.40 (2.92)	26.53 (5.99)
Within Hospital Unit Types	**Variable**	**Total Sample Mean (SD)**	**Non-Safety-Net Hospitals Mean (SD)**	**Safety-Net Hospitals Mean (SD)**
Adult general	TotHPD	11.13 (1.86)	11.04 (1.15)	11.15 (1.96)
	RN skill mix	60.11 (7.06)	62.08 (6.50)	59.75 (7.11)
Adult ICU	TotHPD	20.80 (3.07)	21.10 (2.19)	20.75 (3.21)
	RN skill mix	76.36 (5.65)	76.60 (4.04)	76.31 (5.90)

Adult general units included non-intensive medical/surgical and stepdown units (excluding obstetrics, psychiatric, rehabilitation units).
TotHPD: total hours of care per patient day (RN, LPN, unlicensed assistants).
RN staff mix: proportion of total hours of care provided by RNs.
ICU indicates intensive care unit; RN, registered nurses; SD, standard deviation.

hospitals, are presented when the interactions were statistically significant.

Higher total staffing (TotHPD) in general adult units in non-safety-net hospitals was associated with lower CHF mortality rates, lower rates of infection due to medical care, and fewer patients with length of stay greater than expected (Table 3). Safety-net hospitals with higher total staffing had fewer patients with extended length of stay greater than expected and higher rates of CHF mortality. Failure to rescue rates was lower in all hospitals when RN skill mix was higher in general units, and infections due to medical care were lower in non-safety-net hospitals with higher RN mix and higher total staffing.

For ICU staffing, non–safety-net hospitals with higher TotHPD had lower infections due to medical care (Table 4). Higher RN skill mix in ICUs in all hospitals was associated with lower rates of postoperative sepsis. In safety-net hospitals, higher RN staff mix in ICUs was associated with lower failure to rescue rates and higher CHF mortality rates.

DISCUSSION

Using data from 54 teaching hospitals, members, and affiliates of the UHC, we found that nurse staffing in both general adult units and ICUs had beneficial effects on patient outcomes, controlling for Medicare case mix index, technology, and safety-net status. The specific effects on outcomes were different for general unit staffing and ICU staffing. There have been few previous studies that examined staffing in ICUs separately from staffing in general units; those studies found that higher intensive care staffing was associated with lower infection rates[10,20,21] and higher staffing in general units was associated with lower mortality.[12,25]

General unit staffing considering all staffing hours (RN, LPN, NA) was related to lower CHF mortality, lower infections and lower rates of extended stays in non-safety-net hospitals. Only the effects of total hours on length of stay were found in safety-net hospitals. When more of the nursing care hours were provided by RNs, the rates of failure to rescue were lower in all hospitals and hospital-acquired infections were lower in non-safety-net hospitals.

ICU RN skill mix had beneficial effects on postoperative sepsis in all hospitals and on failure to rescue in safety-net hospitals. When non-safety-net hospitals had more total hours of care in the ICU, they had lower rates of hospital-acquired infections. In addition, there was a trend toward lower decubitus ulcers ($P<0.10$) for all hospitals with higher total hours of care in intensive care.

Our findings are in agreement with previous research carried out at the hospital level that found higher nurse staffing to be associated with lower mortality,[3,11,12,19] lower failure to rescue,[18,19] and lower hospital-acquired infections.[3,23] The decrease in proportion of patients who

TABLE 2. Descriptions of Patient Outcomes Observed Over Expected (O/E)

Variable	All Hospitals (54) Mean (SD)	Non-Safety-Net Hospitals (8) Mean (SD)	Safety-Net Hospitals (46) Mean (SD)
In-hospital mortality CHF (O/E)	0.7786 (0.4167)	0.6903 (0.3392)	0.7951 (0.4284)
Decubitus ulcer (O/E)	1.2814 (0.4909)	0.9938 (0.3729)	1.3336 (0.4925)
Failure to rescue (O/E)	0.9435 (0.2081)	0.8399 (0.1828)	0.9626 (0.2073)
Infection due to medical care (O/E)	1.8053 (0.7783)	1.8171 (0.6341)	1.8032 (0.8033)
Postoperative sepsis (O/E)	1.4101 (1.1717)	1.2104 (0.6757)	1.4471 (1.2398)
Proportion of patients with LOS >expected	0.0085 (0.0036)	0.0085 (0.0039)	0.0085 (0.0035)

CHF indicates congestive heart failure; LOS, length of stay; SD, standard deviation.

TABLE 3. Robust Regression Results for Nurse Staffing on Adult General Units, Including Interaction of Safety-Net Status and Staffing

Variable Statistical Significance for Total Model	In-Hospital CHF Mortality (O/E)*	Decubitus Ulcer (O/E)†	Failure to Rescue (O/E)*	Infection Due to Medical Care (O/E)*	Postoperative Sepsis (O/E)	Rate of LOS >Expected*
Medicare CMI	0.345† (0.08 to 0.61)	−0.649* (−1.08 to −0.21)	−0.036 (−0.24 to 0.17)	0.090 (−0.57 to 0.75)	0.162 (−1.03 to 1.36)	−0.0017 (−0.006 to 0.002)
Technology	0.002 (−0.01 to 0.01)	0.010 (−0.01 to 0.03)	−0.004 (−0.01 to 0.003)	−0.004 (−0.04 to 0.03)	0.004 (−0.03 to 0.04)	0.000 (−0.000 to 0.000)
Safety-net (no vs. yes)	0.140† (0.02 to 0.26)	0.335† (0.058 to 0.62)	0.094‡ (−0.01 to 0.19)	−0.036 (−0.29 to 0.22)	0.224 (−0.21 to 0.66)	0.000 (−0.00 to 0.00)
TotHPD	−0.087† (−0.15 to −0.02)	−0.036 (−0.08 to 0.01)	−0.023‡ (−0.05 to 0.000)	−0.233* (−0.37 to −0.09)	−0.058 (−0.17 to 0.05)	−0.002* (−0.002 to −0.001)
RN skill mix	0.003 (−0.01 to 0.02)	−0.005 (−0.02 to 0.01)	−0.008* (−0.01 to −0.004)	−0.027† (−0.05 to −0.005)	−0.015 (−0.05 to 0.02)	0.000 (−0.00 to 0.00)
Interaction terms						
Safety-net × TotHPD	0.1256* (0.05 to 0.20)			0.268* (0.11 to 0.43)		0.001† (0.00 to 0.001)
Safety-net × RN skill mix	−0.001 (−0.02 to 0.02)			0.033‡ (−0.01 to 0.07)		−0.001 (−0.00 to 0.00)
Safety-net hospital coefficients						
TotHPD	0.039† (0.002 to 0.076)			0.035 (−0.043 to 0.003)		−0.001† (−0.001 to −0.000)
RN skill mix	0.002 (−0.008 to 0.012)			0.006 (−0.026 to 0.038)		0.000 (−0.000 to 0.000)

Nonstandardized regression coefficients and 95% confidence intervals.

Analysis done with robust regression, clustering by hospital.

N = 208 hospital/quarters except for CHF mortality n = 204; failure to rescue n = 206, Sepsis n = 205.

When interactions not significant, the coefficient for staffing is for all hospitals. When interactions are significant, the coefficients in lines 4 and 5 are for non-safety-net hospitals and the coefficients in lines 9 and 10 are for safety-net hospitals.

*$P<0.001$.

†$P<0.05$.

‡$P<0.10$.

CHF indicates congestive heart failure; CMI case mix index; LOS, length of stay; O/E, observed over expected; RN, registered nurses; TotHPD, total hours of care per patient day (RN, LPN, unlicensed assistants).

TABLE 4. Robust Regression Results for Nurse Staffing on Adult Intensive Care Units, Including Interaction of Safety-Net Status and Staffing

Variable Statistical Significance for Total Model	In-Hospital CHF Mortality (O/E)*	Decubitus Ulcer (O/E)†	Failure to Rescue (O/E)*	Infection Due to Medical Care (O/E)*	Postoperative Sepsis (O/E)†	Rate of LOS >Expected
Medicare CMI	0.335* (0.09 to 0.58)	−0.655* (−1.12 to −0.19)	−0.062 (−0.27 to 0.15)	0.102 (−0.58 to 0.78)	0.001 (−1.17 to 1.18)	−0.002 (−0.01 to 0.00)
Technology	0.002 (−0.01 to 0.01)	0.009 (−0.01 to 0.03)	−0.007 (−0.02 to 0.00)	−0.002 (−0.03 to 0.03)	0.006 (−0.03 to 0.04)	0.000 (−0.00 to 0.00)
Safety-net (no vs. yes)	0.116‡ (−0.01 to 0.24)	0.331† (0.04 to 0.62)	0.100† (0.01 to 0.19)	−0.037 (−0.35 to 0.28)	0.251 (−0.21 to 0.71)	−0.000 (−0.00 to 0.00)
TotHPD	−0.008 (−0.04 to 0.03)	−0.021‡ (−0.044 to 0.00)	−0.031 (−0.07 to 0.01)	−0.134† (−0.23 to −0.03)	0.038 (−0.08 to 0.15)	−0.000 (−0.00 to 0.00)
RN skill mix	−0.007 (−0.037 to 0.01)	−0.011 (−0.03 to 0.01)	0.009 (−0.01 to 0.03)	0.015 (−0.03 to 0.06)	−0.040* (−0.07 to −0.01)	−0.000 (−0.00 to 0.00)
Interaction terms						
Safety-net × TotHPD	0.0240 (−0.02 to 0.07)		0.022 (−0.02 to 0.06)	0.148† (0.03 to 0.26)		
Safety-net × RN skill mix	0.0241† (0.00 to 0.05)		−0.020† (−0.04 to −0.00)	−0.018 (−0.07 to 0.04)		
Safety-net hospital coefficients						
TotHPD	0.016 (−0.008 to 0.041)		−0.008 (−0.024 to 0.006)	0.015 (−0.042 to 0.071)		
RN skill mix	0.017† (0.006 to 0.028)		−0.011† (−0.018 to −0.003)	−0.002 (−0.038 to 0.033)		

Nonstandardized regression coefficients and 95% confidence intervals.

Analysis done with robust regression, clustering by hospital.

N = 208 hospital/quarters except for CHF mortality n = 204; failure to rescue n = 206, Sepsis n = 205.

When interactions not significant, the coefficient for staffing is for all hospitals. When interactions are significant, the coefficients in lines 4 and 5 are for non-safety-net hospitals and the coefficients in lines 9 and 10 are for safety-net hospitals.

*$P<0.001$.

†$P<0.05$.

‡$P<0.10$.

CHF indicates congestive heart failure; CMI case mix index; LOS, length of stay; O/E, observed over expected; RN, registered nurses; TotHPD, total hours of care per patient day (RN, LPN, unlicensed assistants).

experienced lengths of stay greater than expected with higher staffing is a new finding.

These results raise questions as to how non-RNs affect these outcomes, when the TotHPD shows beneficial effects. Most of the key surveillance and intervention activities for detecting and preventing these complications must be done by RNs; however, sufficient assistance from LPNs and NA providing basic care will free the RN to spend more time monitoring for problems and preparing patients for discharge. In addition, basic patient care activities will also help prevent some of these complications such as decubitus ulcers.

Patients in safety-net hospitals have been shown to have worse outcomes, although the definition of safety-net hospital affects this relationship.[28,29,35] Safety-net hospitals in this sample had higher rates of CHF mortality, decubitus ulcers, and failure to rescue. The average levels of nurse staffing were not very different between safety-net and non-safety-net hospitals, but the relationships between nurse staffing and outcomes did differ. For example, when nurse staffing was higher, CHF mortality was also higher in safety-net hospitals, although the effect coefficients for staffing otherwise were negative. No previous work compared the effects of nurse staffing on patient outcomes in safety-net hospitals with non-safety-net hospitals. Potential explanations include the observations that patients in safety-net hospitals are more likely to be from lower socioeconomic groups, have poorer general health, and have more comorbid conditions; therefore, they are more likely to have negative outcomes regardless of nurse staffing.[36,37] It is also possible that safety-net hospitals maintain their nurse-staffing levels differently than non-safety-net hospitals, perhaps using more contract nurses or more overtime hours. Finally, as Lankshear et al[6] suggested, systematic differences in other aspects, such as medical care quality, may also change the apparent effects of nurse staffing on outcomes. Further research is needed to explain these differences.

Although there has been controversy about failure to rescue,[38,39] it is still used as an indicator of the quality of hospital care and the quality of nursing care. Ghaferi et al[40] reported that it was the response to complications (or failure to respond) rather than the actual occurrence of complications that distinguished hospitals with different surgical mortality rates. Previous work has shown that a higher failure to rescue rate was associated with lower nurse staffing.[11,19] This study indicates that it is RN skill mix in both general and ICUs that is most likely to affect failure to rescue. Professional nurses in those units are in a position to detect early signs of complications, alert the rest of the healthcare team, and begin intervening to rescue the patient.

Decubitus ulcers are considered a primary indicator of the quality of nursing care but, like this study, the results of previous work has been inconsistent.[4] Part of the difficulty can be attributed to the very different ways of outcomes from where data about decubitus ulcers are collected—periodic prevalence studies using direct observations, voluntary incidence reports, and discharge data that primarily records only ulcers at an advanced stage. Decubitus ulcers in previously healthy patients tend to occur when these patients are immobilized for surgery or intensive care procedures. Our study, consistent with another recent study, suggests that the total staffing hours in the ICU are most likely to reduce this rate ($P<0.10$).[10]

Overall mortality has been studied in relation to nurse staffing in many studies with varying success.[11,18,19] This study looked only at mortality from CHF and found that total nursing hours in general units rather than ICUs was more likely to reduce deaths related to heart failure. Previous work reported that mortality rates following acute cardiac conditions such as cardiac surgery and acute myocardial infarction have been shown to be related to nurse staffing, particularly staffing in general units.[13,25,41]

Hospital-acquired infections (infections related primarily to intravenous and urinary catheters) were reduced when the TotHPD in general adult units and in the ICU were higher. In addition, the occurrence of postoperative sepsis was reduced by higher levels of RN skill mix in the ICU. This is in keeping with the bulk of previous research showing the strong links between nurse staffing and reductions in hospital-acquired infections.[16,21]

The proportion of patients with lengths of stay greater than expected was most closely linked to total nursing hours in adult general units. Previous work had linked nurse staffing to overall length of stay.[18,20] Nurses have the central role in preparing patients for discharge and, therefore, this could explain this particular link to lengths of stay greater than expected.

This work improved on previous studies of nurse staffing and patient outcomes by including only hours of direct inpatient care, excluding paid time off, and administrative and support hours. Furthermore, these hours were apportioned across all patients in the unit including those not formally admitted, the short stay, and observation patients. Finally, we separated nursestaffing levels in ICUs from non-ICUs and found that these were linked to different outcomes.

No previous study has examined the effects of nurse staffing in safety-net hospitals in comparison with non-safetynet hospitals. Although the findings of this study are limited by the small number of non-safety-net hospitals, the effects of nurse staffing on patient outcomes do differ according to safetynet status. These results open questions about how staffing is decided and maintained in safety-net hospitals. More study is needed to explore this further.

The results of this study are also limited by the small sample of teaching hospitals. Teaching status has been linked to patient outcomes, sometimes with worse and sometimes with better outcomes.[42,43] The homogeneity of this sample of teaching hospitals allowed better control of potential confounding variables, but does limit the extent to which the results can be applied in nonteaching hospitals.

To the extent the results apply, administrators should consider increasing total hours per patient day in both general and ICU units to reduce infections. Costs per case of hospital acquired infections and other adverse outcomes are high, ranging between $30,000 and $44,300.[44,45] These savings could more than justify the costs of higher nurse staffing. Medicare previously paid for services without regard to quality or outcomes; however, the Centers for

Medicare and Medicaid Services is reducing or eliminating payments for care after adverse events including decubitus ulcers, falls, and hospital-acquired infections. To reduce failure to rescue, administrators should consider increasing the RN skill mix in general units. For hospitals with higher than expected length of stay, administrators should consider increasing the total nursing hours per patient day in general units. To reduce the potential for hospital acquired infections including sepsis, higher levels of nurse staffing in ICUs are recommended. To reduce some adverse events, increase in the hours of care from all nursing care providers would help; for others, it is important to increase the hours from RNs.

Hospital administrators and governmental policy makers need clearer and more consistent results on which decisions and recommendations could be based. The uncertainty of achieving real gains in quality of care—and thus cost savings from fewer patient complications during hospitalization—from greater investment in nursing staff could be reduced with rigorously obtained research evidence. This study provides further evidence, using the best available measures, of the benefit of higher staffing levels in hospital-acquired infections, postoperative sepsis, failure to rescue, and timely discharge.

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