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RESEARCH ARTICLE

Nurse Staffing Levels: Impact of Organizational Characteristics and Registered Nurse Supply

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Objective. To assess the impact of nurse supply in the geographic areas surrounding hospitals on staffing levels in hospital units, while taking into account other factors that influence nurse staffing.
Data Sources. Data regarding 279 patient care units, in 47 randomly selected community hospitals located in 11 clusters in the United States, were obtained directly from the hospitals from the U.S. Census report, National Council of State Boards of Nursing, and The Centers for Medicare and Medicaid Services.
Study Design. Cross-sectional analyses with linear mixed modeling to control for nesting of units in hospitals were conducted. For each patient care unit, the hours of care per patient day from registered nurses (RNs), LPNs, nursing assistants, and the skill-mix levels were calculated. These measures of staffing were then regressed on type of unit (intensive care, medical/surgical, telemetry/stepdown), unit size, hospital complexity, and RN supply.
Principal Findings. RN hours per patient day and RN skill mix were positively related to intensity of patient care, hospital complexity, and the supply of RNs in the geographic area surrounding the hospital. LPN hours, and licensed skill mix were predicted less reliably but appear to be used as substitutes for RNs. Overtime hours increased in areas with a lower RN supply. Vacancy and turnover rates and the use of contract nurses were not affected by nurse supply.
Conclusions. This study is the first to show that hospital RN staffing levels on both intensive care and nonintensive care units decrease as the supply of RNs in the surrounding geographic area decreases. We also show that LPN hours rise in areas where RN supply is lower. Further research to describe the quality of hospital care in relation to the supply of nurses in the area is needed.
Key Words. Nurse staffing, workforce, nurse shortage, hospital complexity

In 2002, the Bureau of Health Professions at the Health Resources and Services Administration released a report on the supply of, demand for, and shortages of registered nurses (RNs) (Biviano et al. 2004). The report, based on data from state licensure boards, census data, labor statistics, National League for Nursing annual surveys, and the National Sample Survey of Registered Nurses, found a 6 percent shortage in the supply of RNs. The report further predicted the shortage would increase to 12 percent by 2010 and to 20 percent by 2020. However, the shortage was not spread evenly across the states; rather, in 2000 no shortage existed in 21 states while the study identified shortages ranging from 3.5 to 17 percent in the other 29 states.

Nurses perceive a shortage in the practice setting and report that the quality of care provided is declining as a result. A majority of the respondents in a national survey of 4,108 randomly selected nurses working in inpatient units reported that the shortage of nurses has been a major problem, affecting the time nurses have to devote to each of their patients (89 percent), the quality of patient care provided by nurses (77 percent), the ability of nurses to maintain patient safety (64 percent), and the early detection of patient complications by nurses (64 percent) (NurseWeek/AONE 2002).

Since Aiken's landmark study published in 1994, evidence has been building that higher nurse staffing levels in hospitals are associated with better quality of patient care (Aiken, Smith, and Lake 1994; Blegen, Goode, and Reed 1998; Blegen and Vaughn 1998; Kovner and Gergen 1998; Aiken et al. 2002; Kovner et al. 2002; Needleman et al. 2002; Unruh 2003a, b; Person et al. 2004; Needleman et al. 2006). Discussions of these research results uniformly include concerns about the impact of the nursing shortage on the quality of care and the safety of patients; however, only one research report in the last 15 years addressed the direct impact of the shortage on hospital staffing (Grumbach et al. 2001).

Decisions about staffing levels in hospitals must balance personnel costs with the intensity of care required by the population of patients served by each hospital. The acuity of the patients, standards for staffing set by experts and professional groups, reimbursement rates, and the orientation of the hospital or hospital corporation (for-profit, not-for-profit) influence this balance. In addition, market and other environmental factors, such as the supply of

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nurses, influence the decisions about staffing and staffing standards. Little study has been done on the actual influence of these factors on staffing levels.

This study is part of a larger project examining staffing and patient outcomes in a national random sample of hospitals. The purpose of this analysis was to assess the impact of nurse supply in the geographic areas surrounding the hospitals on patient care unit staffing levels, while taking into account hospital factors that influence nurse staffing levels. We analyzed several measures of patient care unit staffing in relation to the supply of RNs, the type of unit (intensive care, stepdown/telemetry, medical/surgical), unit size, and hospital complexity (size, technology, teaching status, patient case mix). Nurse staffing measures included RN hours per patient day (Hppd), LPN Hppd, Total Hppd, RN mix (proportion of total hours provided by RNs), and licensed mix (proportion provided by RNs and LPNs).

Two research questions were posed:

1. Controlling for patient care unit type, unit size, and hospital complexity, what is the impact of the supply of RNs in the surrounding geographic area on hospital nurse staffing?
2. What are the relationships between the supply of RNs and hospital RN vacancy rate, turnover rates, overtime hours, and the use of agency or traveler nurses?

While there has been a great deal of interest in the effect of nurse staffing levels on the quality of care in hospitals, there has been much less interest in determining the factors that affect the nurse staffing levels other than documenting the changes during the health care crisis of the past 15 years (Aiken, Sochalski, and Anderson 1996; Anderson and Kohn 1996; Spetz 1998; Buerhaus and Staiger 1999; Bond and Raehl 2000; Unruh 2002). Recent work has established that the supply of nurses is not meeting the demand for nurses and that this shortage will worsen in the decades to come (U.S. DHHS 2002). While the conclusion that a local shortage of nurses will decrease the level of RN staffing in hospitals is logical, there is little evidence actually linking them or estimating the magnitude of the effect.

The determinants of RN staffing levels in hospitals have been examined directly or indirectly while investigating other questions. The type of patient care unit makes the biggest difference, with higher staffing levels on units with more acutely ill patients (Blegen, Goode, and Reed 1998; Blegen and Vaughn 1998; Brewer and Frazier 1998; Hodge et al. 2004). Unit level staffing is high in teaching hospitals (Mark, Salyer, and Wan 2000; Hodge et al. 2004; Seago, Spetz, and Mitchell 2004); hospitals with more acutely ill patients (Brewer and

Frazier 1998; Mark, Salyer, and Wan 2000); and hospitals in rural areas (Brewer and Frazier 1998; Hodge et al. 2004). Not-for-profit hospitals and those located in areas with more competition and higher managed care penetration have higher staffing levels (Mark, Salyer, and Wan 2000; Seago, Spetz, and Mitchell 2004).

Three studies examined hospital-level RN staffing using American Hospital Association (AHA) data from the early 1980s. Hospitals with higher staffing were located in areas with a more competitive market (Robinson 1988); were larger (Becker and Foster 1988; Bloom, Alexander, and Nuchols 1997); were private (Becker and Foster 1988); were located in urban areas (Bloom, Alexander, and Nuchols 1997); and were teaching hospitals (Bloom, Alexander, and Nuchols 1997). Bloom and colleagues added an RN supply factor to their model (ratio of number of RNs in the county to hospital beds in the county) and report that a higher supply of RNs in the county was associated with higher RN skill mix in the hospitals.

Using more recent data from the AHA, Grumbach et al. (2001) examined the associations among hospitals' reports of shortage status, vacancy rate, RN turnover rate, and staffing levels and the relationship of these variables to the RN supply in the county. They defined shortage as a "situation in which hospitals are unable to hire nurses at prevailing wages to achieve the staffing desired" (p. 388). When hospital-reported statistics were aggregated to the health service area, RN supply (nurses in county in relation to population) was correlated with hospital-reported shortage, $r = -0.18$, $p < .05$; RN vacancy rate, $r = -0.21$, $p < .05$; but not with RN turnover rate, $r = -0.30$, not significant; and RN staffing, $r = -0.04$, not significant. Seago et al. (2001) found that the primary predictors of hospital-reported shortage are location in the South, proportion of nonwhite county residents, proportion of Medicaid or Medicare patients, higher patient acuity, and team or functional nursing care delivery model. However, they did not include supply of RNs in these analyses.

METHODS

The analyses conducted for this report used data collected for the Nurse Staffing and Quality of Care study (NINR NR01 04937). The main study used a cross-sectional design with retrospective data collection for the calendar year 2000. Hospitals were randomly selected in a two-stage sampling process. First, a sampling frame of geographic clusters of hospitals with more than 200 beds was created using 1999 AHA data and geographic mapping software. The clusters included hospitals located within a circle, approximately 100 miles in diameter, centered on every metropolitan statistical area centroid in the 48 contiguous states. Clusters were selected as the sampling unit rather than individual hospitals because the investigators planned to visit each hospital and travel would be more efficient if the hospitals were grouped into clusters. A sample of community hospitals was sought; therefore, clusters included in the sampling frame had to have at least 10 nonfederal, non-university affiliated, acute care general hospitals. To ensure that we obtained hospitals from all areas of the country, the clusters were stratified by region (Northeast, Southeast, Midwest, West). Two clusters were selected at random from each of the four regions, and two clusters were randomly selected from all remaining clusters. The two totally random selections were located in the most populated regions of the country, the Northeast and Southeast.

In the second stage, hospitals were randomly sampled from each cluster, and approval for participation sought from the respective Chief Nursing Officer (CNO). With a goal of enrolling five hospitals from each cluster, hospitals were contacted in random order until five had agreed to participate. In one small cluster, only two eligible hospitals agreed to participate. Therefore, we used the cluster geographically closest to it (located in an adjacent state) to enroll others resulting in a total of 11 clusters. Once the selected hospitals agreed to be part of the study, they were further screened to determine their ability to provide the needed data. Of the 290 hospitals included in 11 clusters, we contacted 190 by letter and then with telephone calls to the CNO. Of those, 53 hospitals agreed to participate; although six eventually could not provide the data needed. The most frequent reason for not proceeding beyond the initial contact was no response from the CNO; other frequent reasons were that, while interested, the hospital was involved in other data collection efforts or the hospital corporation or their attorneys would not allow sharing of the data we requested. The final sample comprised hospitals that were willing to participate and share their data; this may have introduced some bias and limited the breadth of applicability of the results. Hospitals were asked to provide data for six units caring for adult patients for this study (up to four medical/surgical and stepdown/telemetry units, and up to two intensive care units [ICUs]).

Staffing data were provided for each participating patient care unit for each quarter of calendar year 2000. Staffing was measured using Hppd from each type of nursing care provider (RN, LPN, CNA) and staff mix, in terms of proportion of total hours delivered by RNs (RN mix) and the proportion of total hours delivered by licensed personnel (licensed mix). Nurse managers and clinical specialist hours were reported separately and were not included in these analyses. Units also reported the number of hours of care provided by agency or traveler nurses, and those that were overtime in each quarter. Units reported the number of patient days of care provided during the quarter, and the hours of care for short stay and observation patients. Hours of care were standardized by dividing the total hours for all providers and the number of hours for each type of provider by the number of days of patient care provided on the unit during the quarter. The number of patient days included both the traditional midnight census days and adjustments for shorter-stay patients (18 hours equaled one patient day). In addition, the data included the number of RN lines budgeted for each unit, vacancies, and the number of RNs leaving in each quarter. For the analyses reported here, we determined, using repeated measures ANOVA and graphic displays, that there were no systematic differences in staffing by quarter and then aggregated the quarterly values to one annual value for each unit. Hospital data and RN supply data were annual values.

Administrative data were collected directly from each hospital and supplemented with data from the AHA Annual Survey and the Federal Register. Data directly reported by the hospital included size (the number of acute care staffed beds), technology, and the number of medical residents. From these we calculated the teaching intensity (ratio of residents to beds), and the technology index (count of 10 specific technologies available: angioplasty, cardiac catheterization, lithotripter, open heart surgery, CT scanner, diagnostic radioisotope facility, MRI, PET scan, SPECT tomography, transplant surgery). Medicare case-mix index from the Federal Register for FY 2000 was used to indicate overall patient acuity.

Definitions of nurse shortage or supply have varied with the source of indicators and the purpose of the study. As noted earlier, some researchers have defined shortage from the hospital's perspective as the inability to hire the nurses desired. In other work, shortage is defined as fewer nurses available for employment (supply) than a forecasting or prediction model indicates are needed (demand). For this study, we use the term "RN supply" to indicate the relative numbers of nurses available in the geographic area surrounding the hospital (licensed RNs per 1,000 population). As noted above, the hospital-specific data were collected in 2000, and the RN supply and shortage information was from the same year. In 2000, the shortage was very apparent although it varied widely across states.

To determine the supply of RNs in the geographic area in which each cluster of hospitals was located, we used state-level data from the 2000 Census (U.S. Census Bureau 2005) and the count of active nurse licensees in each state from the National Council of State Boards of Nursing (Crawford, Marks, and Gawel 2000). The total number of active RN licenses was divided by the population of that state and multiplied by 1,000 (licensed RNs per 1,000 population). Seven of the hospital clusters contained hospitals in one state; each of those clusters were assigned the nurse supply value for that state. Four of the clusters contained hospitals in urban areas that crossed state lines; these clusters were assigned the average value for the two states. Nurses often work in hospitals located in different counties or states from their homes. The RN supply variable is broad enough to encompass this commuting pattern.

Studies of hospital quality and staffing include characteristics such as bed size, patient acuity, use of advanced technology, and teaching status. These characteristics are known to inter-correlate and are thought to represent the complexity of care delivered to the population of patients in the hospital. For this study a single variable was calculated to account for the complexity level of the hospital. Using procedures applied in previous attempts to develop taxonomies of hospitals or health networks (Alexander et al. 1996; Bazzoli et al. 1999; Dubbs et al. 2004), we conducted cluster analysis (SAS PROC Cluster) to determine hospital groupings by the pattern of relationships among four key characteristics: size, technology, patient acuity, and teaching intensity. Four clusters of hospitals were identified and validated using discriminant function analysis. The clusters were ordered by level of care complexity with variable means (size, technology, patient severity, and teaching intensity) increasing across the four levels of complexity. Within the sample of 47 hospitals, 10 were placed at the lowest level, complexity level 1, 15 at level 2, 17 at level 3, and five at level 4.

For the multivariate analyses, we adjusted for the dependencies in our data set using SAS PROC MIXED. Hospital was the nesting factor. Units were characterized by size (unit bedsize) and by patient type (two dummy variables contrasted stepdown and ICUs with medical/surgical units). The other variables in the analyses were hospital complexity and RN supply. Separate analyses were conducted for Total Hppd, RN Hppd, LPN Hppd, RN mix, licensed mix, agency/traveler percent, overtime hours percent, vacancy rate (unfilled budgeted lines), and RN turnover rate (# RNs leaving during year/ (budgeted lines minus vacant lines)).

RESULTS

The final sample for this analysis included 47 hospitals from 11 geographical areas. Sixty percent of the hospitals in this study were located in areas designated as having a nurse shortage, an almost identical proportion to that of states with shortages (29 of 50) (U.S. DHHS 2002). The average size of these hospitals was 320 staffed acute care beds (range 104–870). The number of participating units from the hospitals varied from three to nine. The majority of the hospitals, 38, were private nonprofit institutions; five were local or state government owned, and four were for-profit hospitals. The hospitals were located in urban or suburban areas. The Federal Medicare case-mix index averaged 1.49 (range 1.18–2.01). Of the 47 hospitals, 17 had eight or more of the technologies and procedures about which we inquired, 27 had four to seven, and four had three or fewer. The most common types of technology were CT scanner, MRI, and diagnostic radio-isotopes.

More than half (51 percent) of participating hospitals employed medical residents, while only 15 percent of them were members of the Council of Teaching Hospitals. Teaching intensity (ratio of residents to hospital beds) ranged between 0.00 and 1.7 (median for all hospitals = 0.00, median for the 23 hospitals with residents = 0.09). One of the highly complex hospitals used a large number of residents (the 1.7 ratio) although was not an affiliate with the University Hospital Consortium on which we based our exclusion of academic health centers. Analyses were completed with and without that hospital and there were no differences in direction or significance of the results. The characteristics of the patients treated by these hospitals varied. The proportion of hospital patients with private health insurance or Medicare ranged between 44 and 96 percent with an average of 78 percent. On average, 61 percent of their patients were female. The proportion of patients from non-Caucasian backgrounds varied between 1 and 62 percent, with an average of 33 percent.

Hospitals provided data for 150 medical/surgical units, 51 stepdown/telemetry units, and 78 ICUs. Medical/surgical units had an average of 34 beds, stepdown/telemetry units had an average of 32 beds and ICUs had an average of 15 beds. The nurse staffing levels varied greatly across unit types (see Table 1). Total Hppd averaged 16.20 hours in ICU; 8.34 in stepdown units, and 7.17 in medical/surgical units. RN Hppd averaged 14.86 in intensive care, 5.64 in stepdown, and 4.49 in medical/surgical units. The average RN mix values were 92 percent in intensive care, 68 percent in stepdown, and 63 percent in medical/surgical units. The average licensed mix was 93 percent in intensive care, 71 percent in stepdown, and 68 percent in medical/surgical

Table 1: Nurse Staffing by Type of Unit

	Means (Standard Deviations)				
	Medical/Surgical Units (N= 149)	*Stepdown/Telemetry Units (N= 51)*	*Intensive Care Units (N= 77)*	*ANOVA p-Value*	*ANOVA Post Hoc Difference*
Total Hppd	7.17 (1.52)	8.34 (1.80)	16.20 (3.14)	<.001	1,2;1,3;2,3
RN Hppd	4.49 (1.20)	5.64 (1.61)	14.86 (2.72)	<.001	1,2;1,3;2,3
LPN Hppd	0.38 (0.57)	0.27 (0.43)	0.08 (0.21)	<.001	1,3;2,3
CNA Hppd	2.29 (0.86)	2.35 (0.99)	1.24 (1.26)	<.001	1,3;2,3
Licensed Hppd	4.87 (1.11)	5.91 (1.48)	14.94 (2.69)	<.001	1,2;1,3;2,3
RN mix	0.63 (0.10)	0.68 (0.10)	0.92 (0.06)	<.001	1,2;1,3;2,3
Licensed mix	0.68 (0.08)	0.71 (0.09)	0.93 (0.07)	<.001	1,3;2,3
Overtime proportion	0.051 (0.05)	0.066 (0.00)	0.065 (0.10)	.405	
Agency/traveler proportion	0.015 (0.03)	0.023 (0.04)	0.023 (0.04)	.289	
Vacancy rate	0.12 (0.10)	0.14 (0.09)	0.11 (0.08)	.544	
RN turnover	0.29 (0.20)	0.31 (0.20)	0.28 (0.20)	.817	

ANOVA p-values show significance of differences in means across complexity groups; number pairs show post hoc test results with $p<.10$.

Hppd, hours per patient day; licensed Hppd, hours per patient day from RNs and LPNs; RN mix, proportion of hours delivered by RNs; licensed mix, proportion of hours delivered by licensed personnel (RN and LPN); RN, registered nurse.

units. More hours of care are attributed to overtime (5.8 percent) than to agency/traveler sources (1.9 percent). Medical/surgical units used fewer agency/traveler hours and overtime hours than other types of units, although these differences were not statistically significant. Vacancy and turnover rates did not differ across types of units.

Table 2 presents the specific hospital characteristics and the nurse staffing levels for each of the four complexity groupings (1—low, 4—high). Unit-level staffing data are presented separately for nonintensive care and ICUs. While the hospital characteristic averages increased across the four levels of complexity, the patterns for each of the four characteristics were distinct. The four highest complexity hospitals were distinguished from the other hospitals by three variables, bed size, technology, and teaching status (ratio of residents to beds), while they shared a similar level of patient acuity (case-mix index) with hospitals in complexity level 3. Hospitals in complexity level 1 were distinct from the others in their low-technology level and shared with hospitals in complexity level 2 a low case-mix index.

Non-ICU staffing varied systematically across the complexity groupings, with hospitals in complexity level 4 having higher total hours per day, higher

Table 2: Hospital Characteristics and Unit-Level Nurse Staffing by Hospital Complexity

	Mean (Standard Deviation)					
	Complexity 1 (N= 10)	*Complexity 2 (N= 15)*	*Complexity 3 (N= 17)*	*Complexity 4 (N= 5)*	*ANOVA p-Value*	*ANOVA Post Hoc Difference*
(a) Hospital-level variables						
Bed size	253 (101)	360 (108)	253 (98)	564 (252)	<.001	1,4;2,4;3,4
Technology (range 0–10)	3.8 (1.5)	7.1 (1.0)	7.1 (1.4)	9.4 (.89)	<.001	1,2;1,3;1,4;2,4;3,4
Medicare CMI	1.31 (0.07)	1.40 (0.10)	1.64 (0.16)	1.63 (0.15)	<.001	1,3;1,4;2,3;2,4
Ratio residents to beds	0.04 (0.06)	0.06 (0.07)	0.06 (0.11)	0.67 (0.26)	<.001	1,4;2,4;3,4

	Mean (Standard Deviation)					
	Complexity 1 (N= 35)	*Complexity 2 (N= 66)*	*Complexity 3 (N= 69)*	*Complexity 4 (N= 27)*	*ANOVA p-Value*	*ANOVA Post Hoc Difference*
(b) Unit-level variables—nonintensive care						
Total Hppd	7.45 (2.1)	7.06 (1.44)	7.50 (1.49)	8.39 (1.69)	.006	2,4
RN Hppd	4.41 (1.2)	4.48 (1.3)	4.89 (1.4)	5.70 (1.3)	<.001	1,4;2,4
LPN Hppd	0.30 (0.4)	0.42 (0.60)	0.35 (0.58)	0.27 (0.44)	.569	
RN mix	0.61 (0.07)	0.63 (0.10)	0.65 (0.11)	0.69 (0.09)	.015	1,4
Licensed mix	0.65 (0.08)	0.70 (0.08)	0.70 (0.09)	0.71 (0.07)	.009	1,2;1,3;1,4

	Mean (Standard Deviation)					
	Complexity 1 (N= 13)	*Complexity 2 (N= 31)*	*Complexity 3 (N= 25)*	*Complexity 4 (N= 9)*	*ANOVA p-Value*	*ANOVA Post Hoc Difference*
(c) Unit-level variables—intensive care						
Total Hppd	16.37 (2.37)	15.80 (2.54)	16.13 (4.04)	17.54 (3.14)	.543	
RN Hppd	15.10 (1.84)	14.30 (1.79)	14.88 (3.63)	16.44 (3.06)	.209	
LPN Hppd	0.04 (0.14)	0.08 (0.26)	0.07 (0.14)	0.03 (0.26)	.810	
RN mix	0.93 (0.05)	0.91 (0.08)	0.92 (0.05)	0.94 (0.07)	.718	
Licensed mix	0.93 (0.05)	0.92 (0.08)	0.93 (0.06)	0.95 (0.07)	.713	

ANOVA p-values show significance of differences in means across complexity groups; number pairs show post hoc test results with $p<.10$.

Hppd, hours per patient day; RN, registered nurse.

RN hours per day, and higher RN staff mix. Hospitals in the lowest complexity group had the lowest proportion of licensed nurses (RNs and LPNs). ICU nurse staffing levels did not differ across the four complexity groupings. Intensive care staffing has been set by national professional groups and varies less across hospitals than staffing in other types of units.

Staffing levels and the relationships among staffing and other variables differ between non-ICUs and ICUs. Therefore, bivariate correlations were done using two subsets of units. Table 3 contains the correlations for non-ICUs and Table 4 contains the correlations for ICUs (coefficients discussed here are all statistically significant at $p < .05$ unless otherwise indicated).

RN supply, the average number of licensed RNs per 1,000 population, across the 11 geographic areas in which the sample hospitals were located, ranged from 7.34 to 15.34 and was related to staffing levels on both ICUs and non-ICUs in the bivariate correlations. RN Hppd was higher in areas where the RN supply was higher (nonintensive care $r = 0.123$ [not statistically significant]; intensive care $r = 0.336$). It appears that a shortage of RNs may be offset by the use of LPNs as RN supply was negatively related to LPN Hppd on non-ICUs ($r = -0.298$) and on ICUs ($r = -0.182$ not statistically significant). Overtime may be used to compensate for fewer RNs in both non-ICUs ($r = -0.164$) and ICUs ($r = -0.424$). The bivariate correlations did not show an effect for RN supply on use of agency/traveler nurses, vacancy rates, or turnover rates. As noted above, hospital complexity was not significantly related to staffing levels in the ICUs, nor was unit size (see Table 4). Also notable in the bivariate correlations were the trade-offs that hospitals make in staffing patient care units. Use of LPNs increased when supply and use of RNs was lower. There was also an increase in use of nurse assistants (CNA) when LPN hours decreased. CNAs bolster the total Hppd even in ICUs and were used more when there are fewer LPN hours.

Hospital complexity was positively correlated with total staffing, RN staffing, and licensed staffing on non-ICUs (Total Hppd $r = 0.171$; RN Hppd $r = 0.280$; RN mix $r = 0.231$, licensed Hppd $r = 0.287$, licensed mix $r = 0.205$) but not with LPNs or CNAs. Unit size was negatively related to total staffing and RN staffing on non-ICUs (Total Hppd $r = -0.144$; RN Hppd $r = -0.265$; RN mix $r = -0.285$), while it was positively related to LPN staffing ($r = 0.187$).

The bivariate correlation results might be misleading as the dependencies in the data set cannot be controlled. The multilevel, multivariate analyses, which did control for the nesting of units within hospitals and for the interrelationships among predictors, found similar results. Table 5 presents the results for four of the outcome variables. There were few statistically significant

Table 3: Correlations between Hospital Complexity, RN Shortage, and Staffing on Nonintensive Care Units ($N = 201$ Units)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1. RN: 1,000 population complexity	1													
2. Complexity	– 0.223*	1.0												
3. Unit bedsize	– 0.085	– 0.029	1.0											
4. Total Hppd	– 0.033	0.171*	– 0.144*	1										
5. RN Hppd	0.123	0.280*	– 0.265*	0.818*	1									
6. LPN Hppd	– 0.298*	– 0.028	0.187* *	– 0.051	– 0.350*	1								
7. Licensed Hppd	0.007	0.287*	– 0.205*	0.852	0.920*	0.045	1							
8. CNA Hppd	– 0.081	– 0.063	0.062	0.636*	0.233*	– 0.172*	0.177*	1						
9. RN mix	0.302*	0.231*	– 0.285*	0.077	0.617*	– 0.571*	0.418*	– 0.447*	1					
10. Licensed mix	0.103	0.205*	– 0.173*	– 0.077	0.323*	0.219*	0.436*	– 0.778*	0.654*	1				
11. Agency/traveler (%)	– 0.052	– 0.136	– 0.115	– 0.131	0.035	– 0.062	0.010	– 0.242*	0.193*	0.198*	1			
12. Overtime (%)	– 0.164*	0.048	– 0.080	– 0.080	– 0.129	0.049	– 0.123	0.018	– 0.108	– 0.095	– 0.016	1		
13. Vacancies[†]	– 0.108	0.107	– 0.123	0.051	0.166	– 0.086	0.149	– 0.211*	0.238*	0.246*	0.419*	0.006	1	
14. RN turnover[‡]	0.088	0.166	0.050	0.115	0.204*	0.037	0.238*	– 0.217*	0.214*	0.270*	0.135	0.006	0.420*	1

*$p < .05$.

[†]Vacancies = # vacant lines/budgeted lines.

[‡]RN turnover = # RN leaving during year/(budgeted lines – vacancies).

Hppd, hours per patient day; RN, registered nurse.

Table 4: Correlations between Hospital Complexity, RN Shortage, and Staffing on Intensive Care Units ($N = 78$ U)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. RN: 1,000 population	1													
2. Complexity	−0.128	1.0												
3. Unit bedsize	0.049	0.321*	1											
4. Total Hppd	0.339*	0.099	−0.034	1										
5. RN Hppd	0.336*	0.146	−0.057	0.926*	1									
6. LPN Hppd	−0.182	0.075	0.095	−0.207	−0.179	1								
7. Licensed Hppd	0.326*	0.153	−0.050	0.920*	0.997*	−0.104	1							
8. CNA Hppd	0.148	−0.068	0.026	0.530*	0.177	−0.294*	0.156	1						
9. RN mix	−0.064	0.059	−0.054	−0.353*	0.021	0.099	0.029	−0.954*	1					
10. Licensed mix	−0.107	0.075	−0.029	−0.389*	−0.026	0.310*	−0.003	−0.976*	0.976*	1				
11. Agency/ traveler (%)	−0.013	−0.094	−0.249*	−0.127	−0.061	−0.137	−0.072	−0.161	0.197	0.157	1			
12. Overtime (%)	−0.424*	0.165	−0.081	−0.441*	−0.470*	−0.003	−0.474*	−0.055	−0.088	−0.088	−0.028	1		
13. Vacancies†	−0.071	0.044	−0.255	0.113	0.229	0.029	0.231	−0.178	0.207	0.198	0.466*	−0.259	1	
14. RN turnover‡	0.048	0.377*	0.059	0.264	0.271	0.086	0.277	0.104	−0.126	−0.114	0.056	−0.332	0.412*	1

*$p<.05$.

†Vacancies = # vacant lines/budgeted lines.

‡RN turnover = # RN leaving during year/(budgeted lines − vacancies).

Hppd, hours per patient day; RN, registered nurse.

Table 5: Mixed Linear Model Analyses Predicting Staffing Levels ($N = 279$)

Effect	RN Hppd	LPN Hppd	RN Mix (RN %)	Licensed Mix (RN and LPN%)
Intercept	2.52*	1.016**	0.516***	0.660***
Stepdown versus medical/surgical	1.22***	– 0.165**	0.051***	0.024*
ICU versus medical/surgical	9.92***	– 0.270**	0.268***	0.224***
Hospital complexity	0.454*	– 0.043	0.025***	0.017*
Unit bedsize	– 0.027**	0.005	– 0.002***	– 0.001*
RN: 1,000 population	0.163*	– 0.059**	0.010**	0.002

Unstandardized multivariate coefficients.

*$p < .05$.

**$p < .01$.

***$p < .001$.

Hppd, hours per patient day; RN, registered nurse; ICU, intensive care unit.

results for the impact of hospital complexity or RN supply on Total Hppd, CNA Hppd, agency/traveler percent, overtime percent, vacancy rates, and turnover rate (results not provided here). Most of the nurse staffing variables were not normally distributed. All analyses were repeated using the natural log of the values that assumed approximately normal distributions. Inferential results were unchanged and the results reported here used the nontransformed variables for clarity in interpretation.

The mixed model analyses showed that the RN Hppd (Table 5) was determined by type of patient care unit with ICUs averaging 10 more hours of RN care per patient day than medical/surgical units. The complexity of the hospital affected RN staffing with each increasing complexity level associated with nearly 30 minutes (0.45 hours) more care per patient day. The size of the units affected staffing levels, with each increase of one bed resulting in a few minutes less care (1.6 minutes) for each patient. Finally, the supply of RNs in the surrounding area had a significant impact with each increase of one licensed RN per 1,000 population associated with 0.16 hours (10 minutes) more care per patient day.

The LPN staffing levels, on the other hand (Table 5), were not affected by hospital complexity or by unit size. Compared with medical/surgical units, LPNs were used less on stepdown units and ICUs. There was less use of LPNs in areas with higher RN supply, with 0.06 fewer hours of LPN care for each additional licensed RN per 1,000 population.

Effects similar to RN Hppd were seen for RN mix (Table 5). A richer mix was used on stepdown and ICUs than medical/surgical units. The percent of total hours of care provided by RNs increased in higher complexity hospitals, decreased on larger units, and increased in areas with greater RN supply. That is, in areas with one more licensed RN per 1,000 population, the proportion of hospital care provided by RNs increased 1.0 percent and hospitals increased the RN mix by 2.5 percent for each level of increased complexity. Licensed mix was similarly but not as strongly related to complexity and was not related to RN supply (Table 5).

DISCUSSION

Several factors predict nurse staffing levels on hospital inpatient units. This study examined the total and the net effects on the unit staffing levels of RN supply in the geographic areas surrounding the hospitals, the complexity of care provided in each hospital, the acuity of the patients on each unit, and the size of the patient care unit. Using a randomly selected set of 47 hospitals in 11 distinct geographic areas in the United States, the study shows that each of these factors has a significant net effect. There were no previous studies of this issue with which to compare our results, although the findings are logical and fit the prevailing beliefs. We found that the RN supply in the surrounding geographic area plays a major role in determining the hospital's staffing levels. Controlling for patient care unit type, hospital complexity, and unit bedsize, hospitals located in areas with lower RN supply staff their units with fewer RNs, and more LPNs. This effect was present even on ICUs that usually staff according to national guidelines. The results show clearly the effect of nurse shortages in some areas in 2000 and presage the effect of the predicted deepening shortage on future hospital nurse staffing. Recognizing that this sample of hospitals may not be fully representative of all U.S. community hospitals, it would be useful to replicate the study using other data sets.

Using a newly created categorization of hospitals reflecting the complexity of care provided, this study also showed that the complexity of the hospital impacts the RN staffing levels. Hospitals with more complex care (larger hospitals, with more technology, higher Medicare case mix, and more medical residents) had higher levels of nurse staffing. This difference was apparent in the use of RNs on non-ICUs; however, ICU staffing was similar across hospital complexity levels.

Nurse staffing levels on patient care units in acute care hospitals were most directly influenced by the acuity of the patients cared for on the unit. ICUs had the highest total hours of care and the highest RN staff mix. RN Hppd were more than three times greater on ICUs than on medical/surgical units. Telemetry/stepdown units provide slightly more hours of care and a higher RN staff mix than medical/surgical units, reflecting a level of acuity between patients on medical/surgical units and those on ICUs.

On non-ICUs, unit bedsize also influenced staffing levels. Our results indicated that larger units have lower total Hppd, lower RN Hppd, and lower RN mix. The data also suggested that larger units use more LPNs. It is possible that economies of scale come into play to produce these results. On larger units with more total staff more flexible staffing is possible; that is, more LPNs and unlicensed nursing assistants may be used on larger units, under the supervision of RNs. Smaller units must maintain a higher proportion of RNs due to the restrictions in the care LPNs and unlicensed staff can provide.

While there is evidence supporting the impact of RN staffing levels on the quality of patient care, there has been very little research examining LPN staffing levels. Unruh's (2001, 2002, 2003a, b) work is an exception. Our results indicate that hospitals are using more LPNs when RN supply is low. Based on concerns about the quality and safety of patient care, there has been a movement toward requiring minimal nurse–patient ratios in hospitals and nursing homes. Ratios in California, the first state to institute mandatory ratios, prescribe a patient-to-nurse ratio that varies by type of patient (ICU, pediatric unit, etc.). An interesting facet of these ratios is that all licensed nurses can be counted; that is, both RN and LPNs are included.

Relationships between nurse supply and vacancy rates, turnover and use of agency or traveler nurses were not apparent in this study, in contrast to previous findings (Grumbach et al. 2001; May, Bazzoli, and Gerland 2006). A survey of hospitals for the year 2000, conducted by the HSM Group (2002) revealed an average vacancy rate of 10.2 percent and an RN average turnover rate of 21.3 percent. The hospitals included in the analyses reported here had slightly higher vacancy rates (11–14 percent) and higher turnover rates (28–31 percent). In a shortage situation hospitals often compete for available staff offering bonuses and other enticements to fill their vacant positions, which could lead to higher turnover rates. However, these data suggest that RN supply had little effect on turnover and vacancy rates. If these areas had experienced a chronic short supply of RNs, it is possible that the hospitals shaped their staffing to the supply; i.e., had fewer RN lines budgeted and therefore had fewer lines to be vacant. The use of agency/traveler nurses was not related to the supply of RNs in this study. However, there was more use of overtime in areas with low supply of RNs both in intensive care and non-ICUs. A speculative conclusion about this pattern is that, despite lower staffing levels and possibly high recruitment efforts by other facilities, nurses responded to the patients' needs for care in their own institutions, increased their work (increased overtime), and remained loyal to institution. More research is needed on why nurses remain loyal, especially as the shortage becomes more significant (McNeese-Smith 2001).

This study used data from 279 patient care units in 47 acute care hospitals in the United States. Hours of direct care per patient day provided by RNs, LPNs, and unlicensed nursing assistants were included in the analyses. Staffing varied widely across types of patient care units, in relation to unit size and hospital complexity, and in response to the supply of RNs in the surrounding geographical area. Given the RN shortage that is predicted to both deepen and spread across most of the United States in the next decades, we can expect the RN staffing levels in acute care hospitals to decrease. The quality of patient care will depend first on increasing that supply and distributing the RNs more evenly, secondly on creative use of LPNs and unlicensed care givers, and thirdly on the organization and management of patient care units to make the most effective use of the RNs available. With regard to the latter two issues, future research needs to be conducted to better understand the impact on quality associated with substituting LPNs for RNs, including the number of LPNs and CNAs an RN can effectively supervise. Undoubtedly, this will be related to patient acuity and to organizational practices and resources, such as the availability and use of information technology and the structure and organization of work within the hospital.

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