ORIGINAL CONTRIBUTION

Hospital Nurse Staffing and Patient Mortality, Nurse Burnout, and Job Dissatisfaction

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Context The worsening hospital nurse shortage and recent California legislation mandating minimum hospital patient-to-nurse ratios demand an understanding of how nurse staffing levels affect patient outcomes and nurse retention in hospital practice.

Objective To determine the association between the patient-to-nurse ratio and patient mortality, failure-to-rescue (deaths following complications) among surgical patients, and factors related to nurse retention.

Design, Setting, and Participants Cross-sectional analyses of linked data from 10184 staff nurses surveyed, 232342 general, orthopedic, and vascular surgery patients discharged from the hospital between April 1, 1998, and November 30, 1999, and administrative data from 168 nonfederal adult general hospitals in Pennsylvania.

Main Outcome Measures Risk-adjusted patient mortality and failure-to-rescue within 30 days of admission, and nurse-reported job dissatisfaction and job-related burnout.

Results After adjusting for patient and hospital characteristics (size, teaching status, and technology), each additional patient per nurse was associated with a 7% (odds ratio [OR], 1.07; 95% confidence interval [CI], 1.03-1.12) increase in the likelihood of dying within 30 days of admission and a 7% (OR, 1.07; 95% CI, 1.02-1.11) increase in the odds of failure-to-rescue. After adjusting for nurse and hospital characteristics, each additional patient per nurse was associated with a 23% (OR, 1.23; 95% CI, 1.13-1.34) increase in the odds of burnout and a 15% (OR, 1.15; 95% CI, 1.07-1.25) increase in the odds of job dissatisfaction.

Conclusions In hospitals with high patient-to-nurse ratios, surgical patients experience higher risk-adjusted 30-day mortality and failure-to-rescue rates, and nurses are more likely to experience burnout and job dissatisfaction.

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THE PAST DECADE HAS BEEN A TURbulent time for US hospitals and practicing nurses. News media have trumpeted urgent concerns about hospital understaffing and a growing hospital nurse shortage.[1-3] Nurses nationwide consistently report that hospital nurse staffing levels are inadequate to provide safe and effective care.[4-6] Physicians agree, citing inadequate nurse staffing as a major impediment to the provision of high-quality hospital care.[7] The shortage of hospital nurses may be linked to unrealistic nurse workloads.[8] Forty percent of hospital nurses have burnout levels that exceed the norms for health care workers.[4] Job dissatisfaction among hospital nurses is 4 times greater than the average for all US workers, and 1 in 5 hospital nurses report that they intend to leave their current jobs within a year.[4]

In 1999, California passed legislation mandating patient-to-nurse ratios for its hospitals, which goes into effect in July 2003. The California legislation was motivated by an increasing hospital nursing shortage and the perception that lower nurse retention in hospital practice was related to burdensome workloads and high levels of job-related burnout and job dissatisfaction. Stakeholder groups advocated widely divergent minimum ratios. On medical and surgical units, recommended ratios ranged from 3 to 10 patients for each nurse.[9-11] In early 2002, California's governor announced that hospitals must have at least 1 licensed nurse for every 6 medical and surgical patients by July 2003,

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a ratio that will move to 1 to 5 when the mandates are fully implemented.[12]

This study reports on findings from a comprehensive study of 168 hospitals and clarifies the impact of nurse staffing levels on patient outcomes and factors that influence nurse retention.[13] Specifically, we examined whether risk-adjusted surgical mortality and rates of failure-to-rescue (deaths in surgical patients who develop serious complications) are lower in hospitals where nurses carry smaller patient loads. In addition, we ascertained the extent to which more favorable patient-to-nurse ratios are associated with lower burnout and higher job satisfaction among registered nurses. We also estimated excess surgical deaths associated with the different nurse staffing ratios vigorously debated in California. Finally, we estimated the impact of nurse staffing levels proposed in California on nurse burnout and dissatisfaction, 2 precursors of turnover.[13] Our findings offer insights into how more generous registered nurse staffing might affect patient outcomes and inform current debates in many states regarding the merits of legislative actions to influence staffing levels.

METHODS

Patients, Data Sources, and Variables

Our study combines information about hospital staffing and organization obtained from nurse surveys with patient outcomes derived from hospital discharge abstracts and hospital characteristics drawn from administrative databases.[14] The study protocol for linking anonymized nurse data and handling denominalized patient data was approved by the institutional review board of the University of Pennsylvania.

Hospitals. Data were collected on all 210 adult general hospitals in Pennsylvania. Information about hospital characteristics was derived from the 1999 American Hospital Association (AHA) Annual Survey and the 1999 Pennsylvania Department of Health Hospital Survey.[15,16] Ultimately, 168 of the 210 acute care hospitals had discharge data for surgical patients in the targeted Diagnosis Related Groups (DRGs) during the study period, as well AHA data, and survey data from 10 or more staff nurses. Six of the excluded hospitals were Veterans Affairs hospitals, which do not report discharge data to the state. Twenty-six hospitals were excluded because their administrative or patient outcomes data could not be matched to our surveys because of missing variables, primarily because they reported their characteristics or patient data as aggregate multihospital entities. In 10 additional small hospitals, the majority of which had fewer than 50 beds, fewer than 10 nurses responded to the survey.

A nurse staffing measure was calculated as the mean patient load across all staff registered nurses who reported having responsibility for at least 1 but fewer than 20 patients on the last shift they worked, regardless of the specialty or shift (day, evening, night) worked. This measure of staffing is superior to those derived from administrative databases, which generally include registered nurse positions that do not involve inpatient acute care at the bedside. Staffing was measured across entire hospitals because there is no evidence that specialty-specific staffing offers advantages in the study of patient outcome[17] and to reflect the fact that patients often receive nursing care in multiple specialty areas of a hospital. Direct measurement also avoided problems with missing data common to the AHA's Annual Survey of hospitals, which imputed staffing data in 1999 for 20% of Pennsylvania hospitals.

Three hospital characteristics were used as control variables: size, teaching status, and technology. Hospitals were grouped into 3 size categories: small ($\leq$100 hospital beds), medium (101-250 hospital beds), and large ($\geq$251 hospital beds). Teaching status was measured by the ratio of resident physicians and fellows to hospital beds, which has been suggested as superior to university affiliations and association memberships as an indicator of the intensity of teaching activity.[18] Hospitals with no postgraduate trainees (nonteaching) were contrasted with those that had 1:4 or smaller trainee:bed ratios (minor teaching hospitals) and those with ratios that were higher than 1:4 (major teaching hospitals). Finally, hospitals with facilities for open heart surgery and/or major transplants were classified as high-technology hospitals and contrasted with other hospitals.[19]

Nurses and Nurse Outcomes. Surveys were mailed in the spring of 1999 to a 50% random sample of registered nurses who were on the Pennsylvania Board of Nursing rolls and resided in the state. The response rate was 52%, which compares favorably with rates seen in other voluntary surveys of health professionals.[20] Roughly one third of the nurses who responded worked in hospitals and included the sample of 10 184 nurses described here. No special recruiting methods or inducements were used. Demographic characteristics of the respondents matched the profile for Pennsylvania nurses in the National Sample Survey of Registered Nurses.[21] Nurses employed in hospitals were asked to use a list to identify the hospital in which they worked, and then were queried about their demographic characteristics, work history, workload, job satisfaction, and feelings of job-related burnout. Questionnaires were returned by nurses employed at each of the 210 Pennsylvania hospitals providing adult acute care. To obtain reliable hospital-level estimates of nurse staffing (the ratio of patients to nurses in each hospital), attention was restricted to registered nurses holding staff nurse positions involving direct patient care and to hospitals from which at least 10 such nurses returned questionnaires. In 80% of the 168 hospitals in the final sample, 20 or more nurses provided responses to our questionnaire. There were more than 50 nurse respondents from half of the hospitals. We examined 2 nurse job outcomes in relation to staffing: job satisfaction (rated on a 4-point scale from very dissatisfied to very satisfied) and burnout (measured with the Emotional Exhaustion scale of the Maslach Burnout Inventory, a standardized tool).[22,23]

Patients and Patient Outcomes. Discharge abstracts representing all admis-

sions to nonfederal hospitals in Pennsylvania from 1998 to 1999 were obtained from the Pennsylvania Health Care Cost Containment Council. These discharge abstracts were merged with Pennsylvania vital statistics records to identify patients who died within 30 days of hospital admission to control for timing of discharge as a possible source of variation in hospital outcomes. We examined outcomes for 232342 patients between the ages of 20 and 85 years who underwent general surgical, orthopedic, or vascular procedures in the 168 hospitals from April 1, 1998, to November 30, 1999. Surgical discharges were selected for study because of the availability of well-validated risk adjustment models.[24-29] The number of patients discharged from the study hospitals ranged from 75 to 7746. Only the first hospital admission for any of the DRGs listed in the BOX for any patient during the study period was included in the analyses.

In addition to 30-day mortality, we examined failure-to-rescue (deaths within 30 days of admission among patients who experienced complications).[24-29] Complications were identified by scanning discharge abstracts for *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes in the secondary diagnosis and procedure fields that were suggestive of 39 different clinical events. Distinguishing complications from previously existing comorbidities involved the use of rules developed by expert consensus and previous empirical work, as well as examination of discharge records for each patient's hospitalizations 90 days before the surgery of interest for overlap in secondary diagnosis codes.[27-29] Examples of complications included aspiration pneumonia and hypotension/shock. Patients who died postoperatively were assumed to have developed a complication even if no complication codes were identified in their discharge abstracts.

Risk adjustment of mortality and failure-to-rescue for patient characteristics and comorbidities was accomplished by using 133 variables, including age, sex, surgery types, and dummy variables indicating the presence of chronic preexisting health conditions reflected in the *ICD-9-CM* codes in the discharge abstracts (eg, diabetes mellitus), as well as a series of interaction terms. The final set of control variables was determined by a selection process that paralleled an approach used and reported previously.[27-29] The *C* statistic (area under the receiver operating characteristic curve) for the mortality risk adjustment model was 0.89.[30]

Box. Surgical Patient Diagnosis Related Groups Included in the Analyses of Mortality and Failure-to-Rescue

General Surgery
146-155, 157-162, 164-167, 170, 171, 191-201, 257-268, 285-293, 493, and 494

Orthopedic Surgery
209-211, 213, 216-219, 223-234, 471, 491, and 496-503

Vascular Surgery
110-114, 119, and 120

Data Analysis

Descriptive data show how patients and nurses in our sample were distributed across the various categories of hospitals defined by staffing levels and other characteristics. Logistic regression models were used to estimate the effects of staffing on the nurse outcomes (job dissatisfaction and burnout) and 2 patient outcomes (mortality and failure-to-rescue). We computed the odds of nurses being moderately or very dissatisfied with their current positions and reporting a level of emotional exhaustion (burnout) above published norms for medical workers and of patients experiencing mortality and failure-to-rescue under different levels of registered nurse staffing, before and after control for individual characteristics and hospital variables. For nurse outcomes, we adjusted for sex, years of experience in nursing, education (baccalaureate degree or above vs diploma or associate degree as highest credential in nursing), and nursing specialty. For analyses of patient outcomes, we controlled for the variables in our risk adjustment model, specifically, demographic characteristics of patients, nature of the hospital admission, comorbidities, and relevant interaction terms. For analyses of both patient and nurse outcomes, we adjusted for hospital size, teaching status, and technology.

All logistic regression models were estimated by using Huber-White (robust) procedures to account for the clustering of patients within hospitals and adjust the SEs of the parameter estimates appropriately.[31,32] Model calibration was assessed with the Hosmer-Lemeshow statistic.[33] We used direct standardization to illustrate the magnitude of the effect of staffing by estimating the difference in the numbers of deaths and episodes of failure-to-rescue under different staffing scenarios. Using all patients in the study and using the final fully-adjusted model, we estimated the probability of death and failure-to-rescue for each patient under various patient-to-nurse ratios (ie, 4, 6, and 8 patients per nurse) with all other patient characteristics unchanged. We then calculated the differences in total deaths under the different scenarios.[34] Confidence intervals (CIs) for these direct standardization estimates were derived with the Δ method described by Agresti.[35] All analyses were performed using STATA version 7.0 (STATA Corp, College Station, Tex), and $P<.05$ was considered statistically significant in all analyses.

RESULTS

Characteristics of Hospitals, Nurses, and Patients

Distributions of hospitals with various characteristics, distributions of nurses surveyed, and patients whose outcomes were studied are shown in

Table 1. Study Hospitals, Surgical Patients Studied, and Nurse Respondents in Hospitals*

Characteristic	No. (%) Hospitals (N = 168)	Patients (N = 232 342)	Nurses (N = 10 184)
Staffing, patients per nurse			
≤4	20 (11.9)	41 414 (17.8)	1741 (17.1)
5	64 (38.1)	111 752 (48.1)	4818 (47.3)
6	41 (24.4)	48 120 (20.7)	2114 (20.8)
7	29 (17.3)	21 360 (9.2)	1106 (10.9)
≥8	14 (8.3)	9696 (4.2)	405 (4.0)
Size, No. of beds			
≤100	41 (24.4)	16 123 (6.9)	842 (8.3)
101-250	95 (56.6)	110 510 (47.6)	4927 (48.4)
≥251	32 (19.1)	105 709 (45.5)	4415 (43.4)
Technology			
Not high	121 (72.0)	103 824 (44.7)	4706 (46.2)
High	47 (28.0)	128 518 (55.3)	5478 (53.8)
Teaching status			
None	107 (63.7)	98 937 (42.6)	4553 (44.7)
Minor	44 (26.2)	80 127 (34.5)	3435 (33.7)
Major	17 (10.1)	53 278 (22.9)	2196 (21.6)

*Percentages may not add up to 100 because of rounding.

Table 2. Characteristics of Nurses (N = 10 184) in the Study Hospitals*

Characteristic	No. (%)
Women	9425 (94.1)
BSN degree or higher	3980 (39.6)
Years worked as a nurse, mean (SD)	13.8 (9.8)
Clinical specialty	
Medical and surgical	3158 (31.0)
Intensive care	1992 (19.6)
Operating/recovery room	998 (9.8)
Other	4026 (39.6)
High emotional exhaustion	3926 (43.2)
Dissatisfied with current job	4162 (41.5)

*Sample size for individual characteristics varied because of missing data. BSN indicates bachelor of science in nursing. High emotional exhaustion refers to levels of emotional exhaustion above the published "high" norm for medical workers.[20] Dissatisfied with current job combines nurses who reported being either very dissatisfied or a little dissatisfied.

TABLE 1. Fifty percent of the hospitals had patient-to-nurse ratios that were 5:1 or lower, and those hospitals discharged 65.9% of the patients in the study and employed 64.4% of the nurses we surveyed. Hospitals with more than 250 beds accounted for a disproportionate share of both patients and nurses (45.5% and 43.4%, respectively). Although high-technology hospitals accounted for only 28.0% of the institutions studied, more than half (55.3%) of the patients discharged and 53.8% of nurses surveyed were from high-technology hospitals. A majority of the patients studied and nurses surveyed were drawn from the 61 hospitals (36.3%) that reported postgraduate medical trainees in 1999.

As shown in TABLE 2, 94.1% of the nurses were women and 39.6% held a baccalaureate degree or higher. The mean (SD) work experience in nursing was 13.8 years (9.8). Thirty-one percent of the nurses in the sample worked on medical and surgical general units, while 19.6% and 9.8% worked in intensive care and perioperative settings, respectively. Forty-three percent of the nurses had high burnout scores and a similar proportion were dissatisfied with their current jobs.

Of the 232 342 patients studied, 53 813 (23.2%) experienced a major complication not present on admission and 4535 (2.0%) died within 30 days of admission. The death rate among patients with complications was 8.4%. The surgical case types and clinical characteristics of the patient cohort are shown in TABLE 3. Slightly more than half of patients (51.2%) were classified in an orthopedic surgery DRG, with the next largest group of patients (36.4%) undergoing digestive tract and hepatobiliary surgeries. Chronic medical conditions, with the exception of hypertension, were relatively uncommon among these patients. Patients who experienced complications and were included in our analyses of failure-to-rescue were similar to the broader group of patients in our mortality analyses with respect to their comorbidities, but orthopedic surgery patients were less prominently represented among patients with complications than in the overall sample.

Staffing and Job Satisfaction and Burnout

Higher emotional exhaustion and greater job dissatisfaction in nurses were strongly and significantly associated with patient-to-nurse ratios. TABLE 4 shows odds ratios (ORs) indicating how much more likely nurses in hospitals with higher patient-to-nurse ratios were to exhibit burnout scores above published norms and to be dissatisfied with their jobs. Controlling for nurse and hospital characteristics resulted in a slight increase in these ratios, which in both cases indicated a pronounced effect of staffing. The final adjusted ORs indicated that an increase of 1 patient per nurse to a hospital's staffing level increased burnout and job dissatisfaction by factors of 1.23 (95% CI, 1.13-1.34) and 1.15 (95% CI, 1.07-1.25), respectively, or by 23% and 15%. This implies that nurses in hospitals with 8:1 patient-to-nurse ratios would be 2.29 times as likely as nurses with 4:1 patient-to-nurse ratios to show high emotional exhaustion (ie, 1.23 to the 4th power for 4 additional patients per nurse = 2.29) and 1.75 times as likely to be dissatisfied with their jobs (ie, 1.15 to the 4th power for 4 additional patients per nurse = 1.75). Our data further indicate that, although 43% of nurses who report high burnout and are dissatisfied with their jobs intend to leave their current job within the next 12 months, only 11% of the nurses who are not burned out and who remain satisfied with their jobs intend to leave.

Staffing and Patient Mortality and Failure-to-Rescue

Among the surgical patients studied, there was a pronounced effect of nurse staffing on both mortality and mortality following complications. Table 4 also shows the relationship between nurse staffing and patient mortality and failure-

to-rescue (mortality following complications) when other factors were ignored, after patient characteristics were controlled, and after patient characteristics and other hospital characteristics (size, teaching status, and technology) were controlled. Although the ORs reflecting the nurse staffing effect were somewhat diminished by controlling for patient and hospital characteristics, they remained sizable and significant for both mortality and failure-to-rescue (1.07; 95% CI, 1.03-1.12 and 1.07; 95% CI, 1.02-1.11, respectively). An OR of 1.07 implies that the odds of patient mortality increased by 7% for every additional patient in the average nurse's workload in the hospital and that the difference from 4 to 6 and from 4 to 8 patients per nurse would be accompanied by 14% and 31% increases in mortality, respectively (ie, 1.07 to the 2nd power = 1.14 and 1.07 to the 4th power = 1.31).

These effects imply that, all else being equal, substantial decreases in mortality rates could result from increasing registered nurse staffing, especially for patients who develop complications. Direct standardization techniques were used to predict excess deaths in all patients and in patients with complications that would be expected if the patient-to-nurse ratio for all patients in the study were at various levels that figure prominently in the California staffing mandate debates. If the staffing ratio in all hospitals was 6 patients per nurse rather than 4 patients per nurse, we would expect 2.3 (95% CI, 1.1-3.5) additional deaths per 1000 patients and 8.7 (95% CI, 3.9-13.5) additional deaths per 1000 patients with complications. If the staffing ratio in all hospitals was 8 patients per nurse rather than 6 patients per nurse, we would expect 2.6 (95% CI, 1.2-4.0) additional deaths per 1000 patients and 9.5 (95% CI, 3.8-15.2) additional deaths per 1000

Table 3. Characteristics of the Surgical Patients Included in Analyses of Mortality and Failure-to-Rescue*

Characteristic	No. (%)	
	All Patients (N = 232 342)	Patients With Complications (n = 53 813)
Men	101 624 (43.7)	25 619 (47.6)
Age, mean (SD)	59.3 (16.9)	64.2 (15.7)
Emergency admissions	63 355 (27.3)	21 541 (40.0)
Deaths within 30 days of admission	4535 (2.0)	4535 (8.4)
Major Diagnostic Categories (MDCs)		
General surgery		
Diseases and disorders of the digestive system (MDC 6)	54 919 (23.6)	19 002 (35.3)
Diseases and disorders of the hepatobiliary system (MDC 7)	29 660 (12.8)	6804 (12.6)
Diseases and disorders of the skin, subcutaneous tissue, and breast (MDC 9)	12 771 (5.5)	3010 (5.6)
Endocrine, nutritional, metabolic diseases, and disorders (MDC 10)	4853 (2.1)	1535 (2.9)
Orthopedic surgery		
Diseases and disorders of the musculoskeletal system (MDC 8)	118 945 (51.2)	17 403 (32.3)
Vascular surgery		
Diseases and disorders of the circulatory system (MDC 5)	11 194 (4.8)	6059 (11.3)
Medical history (comorbidities)		
Congestive heart failure	11 795 (5.1)	5735 (10.7)
Arrhythmia	3965 (1.7)	1765 (3.3)
Aortic stenosis	2248 (1.0)	848 (1.6)
Hypertension	79 827 (34.4)	20 648 (38.4)
Cancer	28 558 (12.3)	9074 (16.9)
Chronic obstructive pulmonary disease	19 819 (8.5)	7612 (14.2)
Diabetes mellitus (insulin and noninsulin dependent)	31 385 (13.5)	9597 (17.8)
Insulin-dependent diabetes mellitus	3607 (1.6)	1755 (3.3)

*Patients who died postoperatively were assumed to have developed a complication even if no complication codes were identified in their discharge abstracts.

Table 4. Patient-to-Nurse Ratios With High Emotional Exhaustion and Job Dissatisfaction Among Staff Nurses and With Patient Mortality and Failure-to-Rescue*

	Odds Ratio (95% Confidence Interval)					
	Unadjusted	*P* Value	Adjusted for Nurse or Patient Characteristics	*P* Value	Adjusted for Nurse or Patient and Hospital Characteristics	*P* Value
Nurse outcomes						
High emotional exhaustion	1.17 (1.10-1.26)	<.001	1.17 (1.10-1.26)	<.001	1.23 (1.13-1.34)	<.001
Job dissatisfaction	1.11 (1.03-1.19)	.004	1.12 (1.04-1.19)	.001	1.15 (1.07-1.25)	<.001
Patient outcomes						
Mortality	1.14 (1.08-1.19)	<.001	1.09 (1.04-1.13)	<.001	1.07 (1.03-1.12)	<.001
Failure-to-rescue	1.11 (1.06-1.17)	.004	1.09 (1.04-1.13)	.001	1.07 (1.02-1.11)	<.001

*Odds ratios, indicating the risk associated with an increase of 1 patient per nurse, and confidence intervals were derived from robust logistic regression models that accounted for the clustering (and lack of independence) of observations within hospitals. Nurse characteristics were adjusted for sex, experience (years worked as a nurse), type of degree, and type of unit. Patient characteristics were adjusted for the patient's Diagnosis Related Groups, comorbidities, and significant interactions between them. Hospital characteristics were adjusted for high technology, teaching status, and size (number of beds).

patients with complications. Staffing hospitals uniformly at 8 vs 4 patients per nurse would be expected to entail 5.0 (95% CI, 2.4-7.6) excess deaths per 1000 patients and 18.2 (95% CI, 7.7-28.7) excess deaths per 1000 complicated patients. We were unable to estimate excess deaths or failures associated with a ratio of 10 patients per nurse (one of the levels proposed in California) because there were so few hospitals in our sample staffed at that level.

COMMENT

Registered nurses constitute an around-the-clock surveillance system in hospitals for early detection and prompt intervention when patients' conditions deteriorate. The effectiveness of nurse surveillance is influenced by the number of registered nurses available to assess patients on an ongoing basis. Thus, it is not surprising that we found nurse staffing ratios to be important in explaining variation in hospital mortality. Numerous studies have reported an association between more registered nurses and lower hospital mortality, but often as a by-product of analyses focusing directly on some other aspect of hospital resources such as ownership, teaching status, or anesthesiologist direction.[19,27,36-42] Therefore, a simple search for literature dealing with the relationship between nurse staffing and patient outcomes yields only a fraction of the studies that have relevant findings. The relative inaccessibility of this evidence base might account for the influential Audit Commission in England concluding recently that there is no evidence that more favorable patient-to-nurse ratios result in better patient outcomes.[43]

Our results suggest that the California hospital nurse staffing legislation represents a credible approach to reducing mortality and increasing nurse retention in hospital practice, if it can be successfully implemented. Moreover, our findings suggest that California officials were wise to reject ratios favored by hospital stakeholder groups of 10 patients to each nurse on medical and surgical general units in favor of more generous staffing requirements of 5 to 6 patients per nurse. Our results do not directly indicate how many nurses are needed to care for patients or whether there is some maximum ratio of patients per nurse above which hospitals should not venture. Our major point is that there are detectable differences in risk-adjusted mortality and failure-to-rescue rates across hospitals with different registered nurse staffing ratios.

In our sample of 168 Pennsylvania hospitals in which the mean patient-to-nurse ratio ranged from 4:1 to 8:1, 4535 of the 232342 surgical patients with the clinical characteristics we selected died within 30 days of being admitted. Our results imply that had the patient-to-nurse ratio across all Pennsylvania hospitals been 4:1, possibly 4000 of these patients may have died, and had it been 8:1, more than 5000 of them may have died. While this difference of 1000 deaths in Pennsylvania hospitals across the 2 staffing scenarios is approximate, it represents a conservative estimate of preventable deaths attributable to nurse staffing in the state. Our sample of patients represents only about half of all surgical cases in these hospitals, and other patients admitted to these hospitals are at risk of dying and similarly subject to the effects of staffing. Moreover, in California, which has nearly twice as many acute care hospitals and discharges and an overall inpatient mortality rate higher than in our sample in Pennsylvania (2.3% vs 2.0%), it would be reasonable to expect that the difference of 4 fewer patients per nurse might result in 2000 or more preventable deaths throughout a similar period.

Our results further indicate that nurses in hospitals with the highest patient-to-nurse ratios are more than twice as likely to experience job-related burnout and almost twice as likely to be dissatisfied with their jobs compared with nurses in the hospitals with the lowest ratios. This effect of staffing on job satisfaction and burnout suggests that improvements in nurse staffing in California hospitals resulting from the new legislation could be accompanied by declines in nurse turnover. We found that burnout and dissatisfaction predict nurses' intentions to leave their current jobs within a year. Although we do not know how many of the nurses who indicated intentions to leave their jobs actually did so, it seems reasonable to assume that the 4-fold difference in intentions across these 2 groups translated to at least a similar difference in nurse resignations. If recently published estimates of the costs of replacing a hospital medical and surgical general unit and a specialty nurse of $42000 and $64000, respectively, are correct, improving staffing may not only save patient lives and decrease nurse turnover but also reduce hospital costs.[44]

Additional analyses indicate that our conclusions about the effects of staffing and the size of these effects are similar under a variety of specifications. We allowed the effect of nurse staffing to be nonlinear (using a quadratic term) and vary in size across staffing levels (using dummy variables and interaction terms) and found no evidence in this sample of hospitals that additional registered nurse staffing has different effects at differing staffing levels. Limiting our analyses to general and orthopedic surgery patients and eliminating vascular surgery patients (who have higher mortality and complication rates) did not affect our conclusions and effect-size estimates. Also, our findings were not changed by restricting attention to inpatient deaths vs deaths within 30 days of admission. Results were unaffected by restricting analyses to patients who were discharged after our staffing measures were obtained, rather than to the patients who were discharged from 9 months before to 9 months following the nurse surveys that produced our staffing measures. They were also unchanged by restricting the sample of nurses from which we derived our staffing measures to medical and surgical nurses, as opposed to all staff nurses. Finally, they were neither altered by adjusting for patient-to-licensed practical nurse ratios and patient-to-unlicensed assistive personnel ratios (neither of which were related to patient outcomes) nor affected by excluding the

hospitals in our sample with smaller numbers of patients or nurses.

One limitation of this study is the potential for response bias, given a 52% response rate. We find no evidence that the nurses in our sample were disproportionately dissatisfied with their work relative to Pennsylvania staff nurses from the National Sample Survey of Registered Nurses (a national probability-based sample survey performed in 2000).[21] Furthermore, with respect to demographic characteristics (sex, age, and education) included in both surveys, our sample of nurses also closely resembles those participating in the National Sample Survey of Registered Nurses. We are confident that these results are not specific to this particular sample of nurses. Ultimately, longitudinal data sets will be needed to exclude the possibility that low hospital nurse staffing is the consequence, rather than the cause, of poor patient and nurse outcomes.

Our findings have important implications for 2 pressing issues: patient safety and the hospital nurse shortage. Our results document sizable and significant effects of registered nurse staffing on preventable deaths. The association of nurse staffing levels with the rescue of patients with life-threatening conditions suggests that nurses contribute importantly to surveillance, early detection, and timely interventions that save lives. The benefits of improved registered nurse staffing also extend to the larger numbers of hospitalized patients who are not at high risk for mortality but nevertheless are vulnerable to a wide range of unfavorable outcomes. Improving nurse staffing levels may reduce alarming turnover rates in hospitals by reducing burnout and job dissatisfaction, major precursors of job resignation. When taken together, the impacts of staffing on patient and nurse outcomes suggest that by investing in registered nurse staffing, hospitals may avert both preventable mortality and low nurse retention in hospital practice.

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