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Educational Levels of Hospital Nurses and Surgical Patient Mortality

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Abstract

Context—Growing evidence suggests that nurse staffing affects the quality of care in hospitals, but little is known about whether the educational composition of registered nurses (RNs) in hospitals is related to patient outcomes.

Objective—To examine whether the proportion of hospital RNs educated at the baccalaureate level or higher is associated with risk-adjusted mortality and failure to rescue (deaths in surgical patients with serious complications).

Design, Setting, and Population—Cross-sectional analyses of outcomes data for 232–342 general, orthopedic, and vascular surgery patients discharged from 168 nonfederal adult general Pennsylvania hospitals between April 1, 1998, and November 30,1999, linked to administrative and survey data providing information on educational composition, staffing, and other characteristics.

Main Outcome Measures—Risk-adjusted patient mortality and failure to rescue within 30 days of admission associated with nurse educational level.

Results—The proportion of hospital RNs holding a bachelor's degree or higher ranged from 0% to 77% across the hospitals. After adjusting for patient characteristics and hospital structural characteristics (size, teaching status, level of technology), as well as for nurse staffing, nurse experience, and whether the patient's surgeon was board certified, a 10% increase in the proportion of nurses holding a bachelor's degree was associated with a 5% decrease in both the likelihood of patients dying within 30 days of admission and the odds of failure to rescue (odds ratio, 0.95; 95% confidence interval, 0.91–0.99 in both cases).

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Conclusion—In hospitals with higher proportions of nurses educated at the baccalaureate level or higher, surgical patients experienced lower mortality and failure-to-rescue rates.

INTRODUCTION

Nurse understaffing is ranked by the public and physicians as one of the greatest threats to patient safety in US hospitals.[1] Last year we reported the results of a study of 168 Pennsylvania hospitals showing that each additional patient added to the average workload of staff registered nurses (RNs) increased the risk of death following common surgical procedures by 7%, and that the risk of death was more than 30% higher in hospitals where nurses' mean workloads were 8 patients or more each shift than in hospitals where nurses cared for 4 or fewer patients.[2] These findings are daunting given the widespread shortage of nurses, increasing concern about recruiting an adequate supply of new nurses to replace those expected to retire over the next 15 years,[3] and constrained hospital budgets. These findings also raise questions about whether characteristics of the hospital RN workforce other than ratios of nurses to patients are important in achieving excellent patient outcomes.

Nurses constitute the surveillance system for early detection of complications and problems in care, and they are in the best position to initiate actions that minimize negative outcomes for patients.[4] That the exercise of clinical judgment by nurses, as well as staffing adequacy, is key to effective surveillance may explain the link between higher nursing skill mix (ie, a higher proportion of RNs among the nursing personnel of a hospital) and better patient outcomes.[5–10]

Registered nurses in the United States generally receive their basic education in 1 of 3 types of programs: 3-year diploma programs in hospitals, associate degree nursing programs in community colleges, and baccalaureate nursing programs in colleges and universities. In 1950, 92% of new RNs graduated from hospital diploma programs,[11] whereas by 2001, only 3% graduated from hospital diploma programs, 61% came from associate degree programs, and 36% were baccalaureate program graduates.[12] Surprisingly little is known about the benefits, if any, of the substantial growth in the numbers of nurses with bachelor's degrees. Indeed the conventional wisdom is that nurses' experience is more important than their educational levels.

Despite the diversity of educational programs preparing RNs, and a logical (but unconfirmed) connection between education and clinical judgment, little if anything is known about the impact of nurses' education on patient outcomes.[13] Results of some studies have suggested that baccalaureate-prepared nurses are more likely to demonstrate professional behaviors important to patient safety such as problem solving, performance of complex functions, and effective communication.[14–16] However, few studies have examined the effect of nurse education on patient outcomes, and their findings have been inconclusive.[17]

The 168 Pennsylvania hospitals included in our previous study[2] of patient-to-nurse staffing and patient mortality varied substantially in the proportion of staff nurses holding baccalaureate or higher degrees. This variability provides an opportunity to conduct a similar study examining the association between the educational composition of a hospital's RN staff and patient outcomes. Specifically, we tested whether hospitals with higher proportions of direct-care RNs educated at the baccalaureate level or above have lower risk-adjusted mortality rates and lower rates of failure to rescue (deaths in patients with serious complications). We also examined whether the educational backgrounds of hospital RNs are a predictor of patient mortality beyond factors such as nurse staffing and experience. These findings offer insights into the potential benefits of a more highly educated nurse workforce.

METHODS

Data Sources, and Variables

We analyzed outcomes data derived from hospital discharge abstracts that were merged with information on the characteristics of the treating hospitals, including unique data obtained from surveys of hospital nurses.[2] The institutional review board of the University of Pennsylvania approved the study protocol.

Hospitals—The sample consisted of 168 (80%) of the 210 adult acute-care general hospitals operating in Pennsylvania in 1999 that (1) reported surgical discharges to the Pennsylvania HealthCare Cost Containment Council in the specific categories studied here, (2) had data on structural characteristics available from 2 external administrative databases (American Hospital Association [AHA] annual survey[18] and Pennsylvania Department of Health Hospital Questionnaire[19]), and (3) had at least 10 nurses responding to our questionnaire, which previous empirical work demonstrated was sufficient to provide reliable estimates of survey-based organizational characteristics of the hospitals. Six of the excluded hospitals were Veterans Affairs hospitals, which do not report discharge data to the state. Twenty-six hospitals were excluded because of missing data, most often because their reporting to external administrative sources was done as aggregate multi hospital entities. Ten small hospitals, most of which had 50 or fewer beds, had an insufficient number of nurses responding to the questionnaire to be included.

A 50% random sample of RNs residing in Pennsylvania and on the rolls of the Pennsylvania Board of Nursing received questionnaires at their homes in the spring of 1999. Surveys were completed by 10–184 nurses, an average of more than 60 nurses per hospital, and the 52% response rate compares favorably with other voluntary, anonymous surveys of health professionals.[20] We compared our data with information from the AHA annual survey and found that the number of nurses from each hospital responding to our survey was directly proportional to the number of RN positions in each hospital. This suggests similar response rates across hospitals and no response bias at the hospital level. Moreover, demographic characteristics of the respondents paralleled those of Pennsylvania hospital nurses in the National Sample Survey of Registered Nurses.[21] For example, the mean ages of Pennsylvania hospital nurses in our sample and in the National Sample Survey of Registered Nurses were 40 and 41 years, respectively; the percentages of Pennsylvania hospital nurses working full-time were 66% and 69%, respectively; and those having earned bachelor of science in nursing (BSN) degrees were 30% and 31%, respectively.

Hospital staff nurses were asked to indicate whether their highest credential in nursing was a hospital school diploma, an associate degree, a bachelor's degree, a master's degree, or another degree. The proportion of nurses in each hospital who held each type of credential was computed. Because the educational preparation of the 4.3% of nurses who checked "other" was unknown, their answers were not included in our hospital-level measures of educational qualifications. It was later verified that this decision did not bias the results. Because there was no evidence that the relative proportions of nurses holding diplomas and associate degrees affected the patient outcomes studied, those 2 categories of nurses were collapsed into a single category and the educational composition of the hospital staff was characterized in terms of the percentage of nurses holding bachelor's or master's degrees.

Two further variables were derived from the nurse survey. Nursing workload was computed as the mean number of patients assigned to all staff nurses who reported caring for at least 1 but fewer than 20 patients on the last shift they worked. Because nurse experience was an important potential confounding variable related to both clinical judgment and education,

the mean number of years of experience working as an RN for nurses from each hospital was also calculated and used in the analyses.

Three hospital characteristics were used as control variables: size, teaching status, and technology. Hospital-level data were obtained from the 1999 AHA annual survey and the 1999 Pennsylvania Department of Health Hospital Survey. Three size categories (<100 beds, 101–250 beds, ≥251 beds) were used. Hospitals without any postgraduate medical residents or fellows (non teaching) were distinguished from those with 1:4 or smaller trainee-to-bed ratios (minor teaching) and those with ratios higher than 1:4 (major teaching). High-technology hospitals were those that had facilities for either open-heart surgery, major organ transplantations, or both.

Patients and Patient Outcomes—Discharge abstracts for the universe of 232–342 patients aged 20 to 85 years who underwent general surgical, orthopedic, or vascular procedures from April 1, 1998, to November 30, 1999, in the 168 nonfederal hospitals were obtained from the Pennsylvania Health Care Cost Containment Council, which checks the data for completeness and quality. A list of the diagnosis related groups studied was provided previously.[2]

We examined the association between the educational attainments of nurses across hospitals and both deaths within 30 days of hospital admission (derived by linking discharge abstract data and Pennsylvania vital statistics data) and deaths within 30 days of admission among patients who experienced complications (failure to rescue). Patient complications were determined with *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes in the secondary diagnosis and procedure fields of discharge abstracts indicative of 39 clinical events using protocols drawing on expert consensus as well as empirical evidence to distinguish complications from preexisting comorbidities.[22–24]

The 2 patient outcomes studied were risk-adjusted by including 133 variables in our models, including age, sex, whether the admission was a transfer from another hospital, whether it was an emergency admission, a series of 48 variables indicating surgery type, dummy variables indicating the presence of 28 chronic preexisting conditions as classified by *ICD-9-CM* codes, and interaction terms chosen on the basis of their ability to predict mortality and failure to rescue in the present dataset. Construction of the patient risk adjustment models used an approach similar to that reported by Silber and colleagues.[22–26] The *c* statistic for the mortality risk adjustment model was 0.89 and for the failure to rescue model, 0.81.

We also estimated and controlled for the effect of having aboard-certified surgeon on risk for mortality and failure to rescue. For each patient, the license number of the operating physician of record was matched to a physician's name using a public use file from the Pennsylvania Bureau of Professional and Occupational Affairs, and subsequently to records from the American Board of Medical Specialties directory of board-certified medical specialists.[27] A dummy variable was constructed to indicate whether or not the operating physician was board-certified in general surgery or another surgical specialty. A second dummy variable was used to identify patients (8% of all patients) with operating physicians whose license numbers could not be linked to names to determine board-certification status. Use of these 2 variables in tandem produced a reasonable way of controlling for surgeon qualifications in our models.

Data Analysis

Descriptive statistics (means, SDs, and percentages) and significance tests (χ^2 and F tests) were computed to compare groups of hospitals that varied in terms of their educational composition on hospital characteristics, including nurse experience and nurse staffing, and patient characteristics. Logistic regression models were used to estimate the effects of a 10% increase in the proportion of nurses who had a bachelor's or master's degree on patient mortality and failure to rescue, and to estimate the effects of nurse staffing, nurse experience, and surgeon board certification. The associations of educational composition, staffing, experience of nurses, and surgeon board certification with patient outcomes were computed before and after controlling for patient characteristics (demographic characteristics, nature of the hospital admission, comorbidities, and relevant interaction terms) and hospital characteristics (bed size, teaching status, and technology).

To account for the clustering of patients within hospitals in our sample, all model estimates were computed using Huber-White(robust) procedures to adjust the SEs of the estimated parameters. Direct standardization estimates derived from the final model are presented to indicate the size of the effects of educational composition of nursing staff independently of and jointly with nurse staffing levels. With all patients and using the final fully adjusted models for predicting death and failure to rescue, the probabilities of poor outcomes were calculated for patients in hospitals assuming that 20%, 40%, and 60% of the hospital RNs held bachelor's or master's degrees and under various patient-to-nurse ratios (4, 6, and 8 patients per nurse), with all other patient and hospital characteristics unchanged.[28] All analyses were conducted using STATA version 7.0 (STATA Corp, College Station, Tex), using $P<.05$ as the level of statistical significance.

RESULTS

Characteristics of Hospitals and Patients

Table 1 provides information on characteristics of the 168 hospitals in our sample. About 19% of the hospitals had more than 250 beds, 36% were teaching hospitals, and 28% had high-technology facilities. Across all hospitals, nurses had a mean (SD) of 14.2 (2.7) years of experience and a mean (SD) workload on their last shift of 5.7 (1.1) patients. The proportion of staff nurses with bachelor's degrees or higher degrees ranged from 0% to 70% across the hospitals. In 20% of the hospitals (34/168) less than 20% of staff nurses had BSN or higher degrees, while in 11% of the hospitals (19/168) 50% or more of the nurses had BSN or higher degrees. Hospitals with higher percentages of nurses with BSN or master's degrees tended to be larger and have postgraduate medical training programs, as well as high-technology facilities. Hospitals with higher proportions of baccalaureate-and master's-prepared nurses also had slightly less experienced nurses on average and significantly lower mean workloads. The strong association between the educational composition of hospitals and other hospital characteristics, including nurse workloads, makes clear the need to control for these latter characteristics in estimating the effects of nurse education on patient mortality.

Table 2 describes characteristics of the patients in our sample and how they varied across hospitals with different nurse educational compositions. Of the patients studied, 43.7% were men and the mean (SD) age was 59.3 (16.9) years. Of the 232–342 patients, 53 813 (23.2%) experienced a major complication not present on admission, 4535 (2.0%) died within 30 days of admission, and the death rate among patients with complications (failure to rescue) was 8.4%. The 2 largest categories of surgical procedures patients underwent were orthopedic (51.2%) and digestive tract/hepatobiliary (36.4%) procedures.

The most common patient comorbidities were hypertension (34.4%)and diabetes (13.5%). While the largest proportion of patients(58 329 or 25%) were cared for in hospitals in which 30%to 39% of the nurses were at least BSN-educated, the numbers ranged across the sample (Table 2). Moreover, characteristics of patients, including whether the operating physician was aboard-certified surgeon, differed across the groups of hospitals defined by the percentage of nurses with BSN or higher degrees, although few of these characteristics varied across groups in a consistent pattern.

Effects of Hospital RN Education on Mortality and Failure to Rescue

Table 3 presents odds ratios (ORs) representing the raw or unadjusted effects of nurse education, staffing, and experience, and the effect of a board-certified surgeon as operating physician. Also in Table 3 the adjusted ORs show the effects of those factors in a model controlling for all of these factors and for other hospital and patient characteristics. There was a statistically significant relationship between the proportion of nurses in a hospital with bachelor's and master's degrees and the risks of both mortality and failure to rescue, both before and after controlling for other hospital and patient characteristics.

Each 10% increase in the proportion of nurses with higher degrees decreased the risk of mortality and of failure to rescue by a factor of 0.95, or by 5%, after controlling for patient and hospital characteristics. This adjusted OR of 0.95 (95% confidence interval, 0.91–0.99) is a multiplicative parameter. To estimate how much of a difference would be expected between hospitals in which 20% vs 60% of the nurses had at least BSNs, it should be taken to the fourth power (since the difference between 20%and 60% is equivalent to four 10% intervals). The resultant ratio ($0.95^4 = 0.81$) indicates that all else being equal, the odds of 30-day mortality and failure to rescue would be 19%lower in hospitals where 60% of the nurses had BSNs or higher degrees than in hospitals where only 20% of nurses did.

All 3 of the other clinician characteristics studied (nurse staffing, experience, and board-certified surgeon as operating physician) had significant associations with mortality before controlling for each other, the educational composition of RNs, and all other patient and hospital characteristics. The final model indicates only very slight changes in the parameters estimating the nurse staffing effect that we previously reported[2] when nurse education is added (from a 7% increase in risk of both negative outcomes with a 1 patient-per-nurse increase in mean workload originally reported to a 6% increase in mortality risk and a 5% increase in risk of failure to rescue).

Nurses' years of experience were not found to be a significant predictor of mortality or failure to rescue in the full models. The strong and significant decrease in mortality associated with having a board-certified surgeon as operating physician is largely explained by the tendency of patients with board-certified surgeons to be treated at hospitals with other characteristics associated with better outcomes. None of the interaction terms created by combining these 4 variables achieved statistical significance, suggesting that nurse education, nurse staffing, and surgeon board certification operate independently of each other in predicting mortality and failure to rescue.

These effects imply that altering the educational background of hospital nurses by increasing the percentage of those earning a BSN would produce substantial decreases in mortality rates for surgical patients generally and for patients who develop complications. Direct standardization techniques were used to predict the excess deaths in all patients and patients with complications that would be expected with varying levels of nurse educational levels and workloads. As Table 4 shows, if the proportion of BSN nurses in all hospitals was 60% rather than 20%, 3.6 fewer deaths per 1000 patients (21.1–17.5) and 14.2 fewer deaths per 1000 patients with complications (failure to rescue) would be expected. Moreover, Table 4

indicates that the effect on mortality of a 20% increase in the percentage of BSNs in the workforce would be roughly equivalent to the effect of a reduction in mean nurse workload of 2 patients, and that both the mortality and failure-to-rescue rates would be decidedly lower if both the workloads were lighter and the workforce were composed of higher percentages of BSN-prepared nurses.

COMMENT

To our knowledge, this study provides the first empirical evidence that hospitals' employment of nurses with BSN and higher degrees is associated with improved patient outcomes. Our findings indicate that surgical patients cared for in hospitals in which higher proportions of direct-care RNs held bachelor's degrees experienced a substantial survival advantage over those treated in hospitals in which fewer staff nurses had BSN or higher degrees. Similarly, surgical patients experiencing serious complications during hospitalization were significantly more likely to survive in hospitals with a higher proportion of nurses with baccalaureate education.

When the proportions of RNs with hospital diplomas and associate degrees as their highest educational credentials were examined separately, the particular type of educational credential for nurses with less than a bachelor's degree was not a factor inpatient outcomes. Furthermore, mean years of experience did not independently predict mortality or failure to rescue, nor did it alter the association between educational background or of staffing and either patient outcome. These findings suggest that the conventional wisdom that nurses' experience is more important than their educational preparation may be incorrect. The improved outcomes associated with higher levels of BSNs in a hospital was found to be independent of and additive to the associations of superior outcomes in hospitals with better nurse staffing we reported previously.[2] Thus, both lower patient-to-nurse ratios and having a majority of RNs educated at the baccalaureate level appear to be jointly associated with substantially lower mortality and failure-to-rescue rates for patients undergoing common surgical procedures.

In our sample of 168 Pennsylvania hospitals in which the proportion of nurses with bachelor's degrees and mean patient-to-nurse ratios varied widely, 2% (4535/232 342) of the surgical patients undergoing the procedures we studied died within 30 days of hospital admission. Our results imply that had the proportion of nurses with BSN or higher degrees been 60% and had the patient-to-nurse ratio been 4:1, possibly 3810 of these patients (725 fewer) might have died, and had the proportion of baccalaureate nurses been 20% and had staffing uniformly been at 8:1 patient-to-nurse ratios, 5530 (995 more) might have died. While this difference of more than 1700 deaths across 2 educational and staffing scenarios is approximate, it represents a conservative estimate of preventable deaths potentially attributable to nurses' education and RN staffing levels because our patient sample represents only about half of all surgical cases in the study hospitals.

One limitation of our analysis is the potential for response bias in the education and staffing measures derived from the nurse survey, given a 52% response rate. However, examining the Pennsylvania respondents in the probability-based National Sample Survey of Registered Nurses conducted in 2000,[21] we found no evidence of overall differences between our sample and Pennsylvania hospital staff nurses at large in terms of job satisfaction or demographic characteristics, including education.

A second limitation relates to study design. Longitudinal datasets, preferably including hospitals from more than 1 state, will be essential for establishing the generalizability of these findings as well as establishing whether and how levels of baccalaureate-prepared

nurses and nurse staffing in a hospital are causally related to patient outcomes. Also, as in any research drawing on administrative patient outcomes data, there is a potential for differences in completeness and consistency of diagnostic coding across hospitals to influence risk adjustment.[29]

A number of checks on the validity of these findings were completed. Allowing nurse education to have a nonlinear effect and testing whether the effect of education varied across levels of educational composition using quadratic and dummy variables did not significantly improve model fit, suggesting that incremental increases in more educated nurses in a hospital were associated with progressively better outcomes. Including the small proportion of nurses who checked “other” as their highest degree with nurses in the baccalaureate or higher category or in the associate degree or diploma category rather than omitting them from calculations yielded no change in the estimated associations between education and patient outcomes. In an attempt to determine whether unobserved variables that distinguished patients treated in hospitals with different levels of nurse education, we computed propensity scores[30] representing the likelihood that patients with various characteristics were treated in hospitals with high and low levels of baccalaureate nurses. These scores were not a significant predictor of mortality or of failure to rescue, nor did they significantly alter our estimates of the association between education and outcomes.

Research suggests that nurse executives in university teaching hospitals prefer a nurse workforce with approximately 70% prepared at the baccalaureate level and estimate that current levels average 51%. Also, community hospital nurse executives prefer to have 55% of their RNs educated at the baccalaureate level.[31] Data are not currently available to estimate the proportion of hospitals nationally that have 50% or more of their RN workforces prepared at the BSN level or higher, but since only 11% of Pennsylvania hospitals met this standard in our sample there appears to be a wide gap between the preferences of hospital executives and current staffing patterns.

Only 43% of all hospital staff nurses nationally in 2000 were prepared at the BSN level or higher. Enrollments in baccalaureate nursing programs declined by almost 10% from 1995 to 2000, although the past few years have seen an upturn.[21, 32] The return of diploma- and associate degree prepared RNs to colleges and universities after their initial preparation has been an important source of baccalaureate-prepared nurses. About 22%of currently employed hospital RNs with BSN or higher degrees received them after their basic educations.[21] However, the proportion of hospital nurses pursuing further studies declined from 14%in 1984 to 9% in 2000, as did the proportion of hospital nurses who received tuition assistance from their employers (from 66%in 1992 to 53% in 2000).[21, 33] Meeting the demand for baccalaureate-prepared hospital nurses requires renewed support and incentives by employers to encourage nurses to pursue education to the level of baccalaureate and beyond.

In the current nurse shortage, as in previous ones, public policy discussion has centered on how to increase the supply of RNs. However, little attention has been paid to considering where investments in public funds in the 2 major educational pathways into nursing practice–associate or bachelor’s degree programs–will best serve the public good and the interests of employers. Nursing education policy reports published in the past decade concluded that the United States has an imbalance in the educational preparation of its nurse workforce with too few RNs with BSN and higher degrees.[34–36] Our findings provide sobering evidence that this imbalance may be harming patients.

Our documentation of significantly better patient outcomes in hospitals with more highly educated RNs at the bedside underscores the importance of placing greater emphasis in

national nurse workforce planning on policies to alter the educational composition of the future nurse workforce toward a greater proportion with baccalaureate or higher education as well as ensuring the adequacy of the overall supply. Public financing of nursing education should aim at shaping a workforce best prepared to meet the needs of the population. Finally, our results suggest that employers' efforts to recruit and retain baccalaureate-prepared nurses in bedside care and their investments in further education for nurses may lead to substantial improvements in quality of care.

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References

1. Blendon RJ, DesRoches CM, Brodie M, et al. Views of practicing physicians and the public on medical errors. N Engl J Med. 2002; 347:1933–1940. [PubMed: 12477944]
2. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. JAMA. 2002; 288:1987–1993. [PubMed: 12387650]
3. Buerhaus PI, Staiger DO, Auerbach DI. Implications of an aging registered nurse workforce. JAMA. 2000; 283:2948–2954. [PubMed: 10865272]
4. Clarke SP, Aiken LH. Failure to rescue. Am J Nurs. 2003; 103:42–47. [PubMed: 12544057]
5. American Nurses Association. Nurse Staffing and Patient Outcomes: In the Inpatient Hospital Setting. Washington, DC: American Nurses Association; 2000.
6. Blegen MA, Goode CJ, Reed L. Nurse staffing and patient outcomes. Nurs Res. 1998; 47:43–50. [PubMed: 9478183]
7. Unruh L. Licensed nurse staffing and adverse events in hospitals. Med Care. 2003; 41:142–152. [PubMed: 12544551]
8. Hartz AJ, Krakauer H, Kuhn EM, et al. Hospital characteristics and mortality rates. N Engl J Med. 1989; 321:1720–1725. [PubMed: 2594031]
9. Kovner C, Gergen PJ. Nurse staffing levels and adverse events following surgery in US hospitals. Image J Nurs Sch. 1998; 30:315–321. [PubMed: 9866290]
10. Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K. Nurse-staffing levels and the quality of care in hospitals. N Engl J Med. 2002; 346:1715–1722. [PubMed: 12037152]
11. Source Book-Nursing Personnel. Hyattsville, Md: US Dept of Health and Human Services; 1981.
12. National Council of State Boards of Nursing. Annual report 2001. [Accessed May 2, 2003]. Available at: http://www.ncsbn.org/public/about/res/AnnRpt_FY01.pdf
13. Hickam, DH.; Severance, S.; Feldstein, A., et al. Evidence Report/Technology Assessment 74. AHRQ publication 03-E031. Rockville, Md: Agency for Healthcare Research and Quality; 2003. The Effect of Health Care Working Conditions on Patient Safety.
14. Minnick AF, Roberts MJ, Young WB, et al. What influences patients' reports of three aspects of hospital services? Med Care. 1997; 35:399–409. [PubMed: 9107207]
15. Young WB, Lehrer EL, White WD. The effect of education on the practice of nursing. Image J Nurs Sch. 1991; 23:105–108. [PubMed: 2060948]
16. Johnson JH. Differences in the performances of baccalaureate, associate degree, and diploma nurses: a meta-analysis. Res Nurs Health. 1988; 11:183–197. [PubMed: 3399699]
17. Blegen MA, Vaughn T, Goode CJ. Nurse experience and education: effect on quality of care. J Nurs Adm. 2001; 31:33–39. [PubMed: 11198839]
18. American Hospital Association. Hospital Statistics 1999 Edition. Chicago, Ill: Health Forum; 1999.

19. Hospital Questionnaire: Reporting Period July 1, 1998-June 30, 1999. Harrisburg: Pennsylvania Dept of Health, Division of Statistics; July. 1999
20. Asch DA, Jedrziewski MK, Christakis NA. Response rates to mail surveys published in medical journals. J Clin Epidemiol. 1997; 50:1129–1136. [PubMed: 9368521]
21. The Registered Nurse Population: Findings From the National Sample Survey of Registered Nurses. Rockville, Md: US Dept of Health and Human Services; March. 2000
22. Silber JH, Rosenbaum PR, Trudeau ME, et al. Multivariate matching and bias reduction in the surgical outcomes study. Med Care. 2001; 39:1048–1064. [PubMed: 11567168]
23. Silber JH, Kennedy SK, Even-Shoshan O, et al. Anesthesiologist direction and patient outcomes. Anesthesiology. 2000; 93:152–163. [PubMed: 10861159]
24. Silber JH, Kennedy SK, Even-Shoshan O, et al. Anesthesiologist board certification and patient outcomes. Anesthesiology. 2002; 96:1044–1052. [PubMed: 11981141]
25. Silber JH, Rosenbaum PR, Schwartz JS, Ross RN, Williams SV. Evaluation of the complication rate as a measure of quality of care in coronary artery bypass graft surgery. JAMA. 1995; 274:317–323. [PubMed: 7609261]
26. Silber JH, Rosenbaum PR. A spurious correlation between hospital mortality and complication rates: the importance of severity adjustment. Med Care. 1997; 35(10 suppl):OS77–OS92. [PubMed: 9339779]
27. American Board of Medical Specialties. The Official ABMS Directory of Board Certified Medical Specialists. 32. New Providence, NJ: Marquis Who's Who; 2000.
28. Bishop, YMM.; Fienberg, SE.; Holland, PW. Discrete Multivariate Analysis: Theory and Practice. Cambridge, Mass: MIT Press; 1975.
29. Iezzoni, LI. Risk Adjustment for Measuring Healthcare Outcomes. 2. Chicago, Ill: Health Administration Press; 1997.
30. Rosenbaum PR, Rubin DB. Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. Am Stat. 1985; 39:33–38.
31. Goode CJ, Pinkerton S, Mc Causland MP, et al. Documenting chief nursing officers' preference for BSN-prepared nurses. J Nurs Adm. 2001; 31:55–59. [PubMed: 11271678]
32. American Association of Colleges of Nursing. Though enrollments rise at US nursing colleges and universities, increase is insufficient to meet the demand for new nurses. December2002 [Accessed May 2, 2003]. Available at: http://www.aacn.nche.edu/media/newsreleases/enrl02.htm
33. The Registered Nurse Population: Findings from the National Sample Survey of Registered Nurses. Vol. 55. Washington, DC: US Dept of Health and Human Services; March. 1992 p. 4872USDHHS
34. Seventh Report to the President and Congress on the Status of Health Personnel in the United States. Rockville, Md: US Dept of Health and Human Services; 1990.
35. National Advisory Council on Nurse Education and Practice. Report to the Secretary of the Department of Health and Human Services on the Basic Registered Nurse Workforce. Washington, DC: US Dept of Health and Human Services, Division of Nursing; October. 1996
36. Recreating Health Professional Practice for a New Century: The Fourth Report of the Pew Health Professions Commission. San Francisco, Calif: Pew Health Professions Commission; 1998.

Table 1

Characteristics of the Study Hospitals, Overall and by Educational Composition of the Nurse Workforce

Characteristic	All Hospitals (N = 168)	Percentage of the Hospital Nurse Workforce With BSN or Higher Degrees					*P* Value for Trend*
		<20% (n = 34)	20%–29% (n = 53)	30%–39% (n = 36)	40%–49% (n = 26)	≥50% (n = 19)	
Large (≥251 beds), No. (%)	32 (19.1)	1 (2.9)	3 (5.7)	9 (25.0)	8 (30.8)	11 (57.9)	<.001
Teaching hospitals, No. (%)	61 (36.3)	5 (14.7)	14 (26.4)	15 (41.7)	12 (46.2)	15 (78.9)	<.001
High technology, No. (%)†	47 (28.0)	2 (5.9)	10 (18.9)	12 (33.3)	10 (38.5)	13 (68.4)	<.001
Nurse experience, mean (SD), y	14.2 (2.7)	14.9 (3.6)	14.4 (2.1)	14.0 (2.3)	14.3 (2.6)	12.5 (3.1)	.19
Nurse staffing, mean (SD) ratio of patients per nurse	5.7 (1.1)	6.5 (1.1)	5.7 (1.0)	5.5 (1.1)	5.5 (1.0)	5.2 (1.1)	<.001

*P values were derived from χ^2 and F tests

†High technology was defined as hospitals that had facilities for open-heart surgery, major organ transplantations, or both.

Table 2

Characteristics of Surgical Patients in the Study Hospitals, Overall and by Educational Composition of Staff Registered Nurses*

		Percentage of the Hospital Nurse Workforce With BSN or Higher Degrees				
	All Hospitals (N = 168)	**<20% (n = 34)**	**20%–29% (n = 53)**	**30%–39% (n = 36)**	**40%–49% (n = 26)**	**≥50% (n = 19)**
Total patients, No. (%)	232 342	24 766 (10.7)	54 366 (23.4)	58 329 (25.1)	47 955 (20.6)	46 926 (20.2)
Age, mean (SD), y	59.3 (16.9)	61.3 (16.9)	60.8 (13.7)	58.9 (17.1)	59.0 (16.9)	57.3 (16.8)
Men, No. (%)	101 624 (43.7)	10 350 (41.8)	23 298 (42.9)	25 369 (43.5)	20 891 (43.6)	21 716 (46.3)
Emergency admissions, No. (%)	63 355 (27.3)	4691 (18.9)	15 495 (28.5)	16 535 (28.3)	13 583 (28.3)	13 051 (27.8)
Deaths within 30 days of admission, No. (%)	4535 (2.0)	582 (2.3)	1170 (2.2)	1057 (1.8)	911 (1.9)	815 (1.7)
Patients with complications, No. (%)	53 813 (23.2)	5731 (22.9)	12 439 (22.9)	13 278 (22.8)	10 551 (22.0)	11 814 (25.2)
Deaths among patients with complications (failure to rescue), No. (%)	4535 (8.4)	582 (10.2)	1170 (9.4)	1057 (8.0)	911 (8.6)	815 (6.9)
Major diagnostic categories (MDCs), No. (%) Vascular surgery (MDC 5)	11 194 (4.8)	1006 (4.1)	2275 (4.2)	2610 (4.5)	2307 (4.8)	2996 (6.4)
Digestive system (MDC 6)	54 919 (23.6)	6728 (12.3)	13 159 (24.0)	13 377 (24.4)	10 898 (22.7)	10 757 (22.9)
Hepatobiliary system (MDC 7)	29 660 (12.8)	4050 (13.7)	6909 (12.7)	8138 (14.0)	5651 (11.8)	4912 (10.5)
Musculoskeletal system (MDC 8)	118 945 (51.2)	11 124 (44.9)	28 515 (52.5)	30 256 (51.9)	25 019 (52.2)	24 031 (51.2)
Skin, subcutaneous tissue, breast (MDC 9)	12 771 (5.5)	1390 (5.6)	2634 (4.8)	3156 (5.4)	3015 (6.3)	2576 (5.5)
Endocrine, nutritional, and metabolic diseases and disorders (MDC 10)	4853 (2.1)	468 (1.9)	874 (1.6)	792 (1.4)	1065 (2.2)	1654 (3.5)
Comorbidities, No. (%) Hypertension	79 827 (34.4)	8524 (34.4)	19 243 (35.4)	18 604 (31.9)	16 726 (34.9)	16 730 (35.7)
Diabetes mellitus	31 385 (13.5)	3705 (11.8)	8001 (14.7)	7207 (12.4)	6294 (13.1)	6178 (13.2)
Insulin-dependent diabetes	3607 (1.6)	420 (1.7)	785 (1.4)	949 (1.6)	700 (1.5)	753 (1.6)
Cancer	28 558 (12.3)	3050 (12.3)	6438 (11.8)	6425 (11.0)	6121 (12.8)	6524 (13.9)
Chronic pulmonary disease	19 819 (8.5)	2566 (10.4)	5251 (9.7)	4670 (8.0)	4063 (8.5)	3269 (7.0)
Congestive heart failure	11 795 (5.1)	1445 (5.8)	2899 (5.3)	2688 (4.6)	2313 (4.8)	2450 (5.2)
Arrhythmia	3965 (1.7)	444 (1.8)	973 (1.8)	886 (1.5)	856 (1.8)	806 (1.7)
Aortic stenosis	2248 (1.0)	235 (.9)	498 (.9)	574 (1.0)	479 (1.0)	462 (1.0)
Board-certified surgeon	170 063 (73.2)	16 324 (65.9)	37 580 (69.1)	45 178 (77.5)	37 053 (77.3)	33 928 (72.3)

*All characteristics differed significantly across the groups of hospitals at the $P<.001$ level, according to an F test (in the case of age) and χ^2 tests (in all others).

Table 3

Odds Ratios Estimating the Effects of Nurse and Physician Variables on Patient Mortality and Failure to Rescue*

Outcome and Effect	Estimated Separately and Unadjusted, OR (95% CI)	*P* Value	Estimated Jointly and Adjusted, OR (95% CI)†	*P* Value
Mortality Nurse education	0.94 (0.89–0.99)	.02	0.95 (0.91–0.99)	.008
Nurse staffing	1.14 (1.08–1.19)	<.001	1.06 (1.01–1.10)	.02
Nurse experience	1.03 (1.01–1.06)	.009	1.00 (0.98–1.02)	.86
Board-certified surgeon	0.51 (0.41–0.63)	<.001	0.85 (0.73–0.99)	.03
Failure to rescue Nurse education	0.92 (0.89–0.96)	<.001	0.95 (0.91–0.99)	.02
Nurse Staffing	1.11 (1.06–1.16)	<.001	1.05 (1.01–1.10)	.03
Nurse experience	1.03 (1.01–1.06)	.009	1.01 (0.98–1.03)	.52
Board-certified surgeon	0.61 (0.50–0.74)	<.001	0.80 (0.68–0.94)	.007

Abbreviations: CI, confidence interval; OR, odds ratio.

*Odds ratios indicate the change in the risk of mortality or failure to rescue (deaths in patients with serious complications) associated with a 10% increase in the proportion of nurses with bachelor's or master's degrees (nurse education), an increase in workload of 1 patient per nurse (nurse staffing), a 1-year increase in average staff nurse experience, and having an operating physician holding board certification in surgery or a surgical specialty. Significance of all effects assessed using z statistics.

†Odds ratios and CIs were derived from robust logistic regression models that accounted for clustering of observations within hospitals. Adjusted for patient's age, sex, diagnosis related group, comorbidities, and significant interactions between them. Also adjusted for hospital characteristics including high technology, teaching status and number of beds.

Table 4

Estimated Rates of Mortality and Failure to Rescue per 1000 Patients, by Levels of Nurse Education and Staffing

	Staffing (Patients per Nurse)			
Education, % With BSN	**8**	**6**	**4**	**Overall**
Mortality				
20	23.8	21.6	19.7	21.1
40	21.7	19.8	18.0	19.2
60	19.8	18.0	16.4	17.5
Overall	22.0	20.0	18.2	19.5
Failure to Rescue				
20	100.2	92.6	85.4	90.4
40	92.2	85.0	78.4	83.1
60	84.7	78.0	71.8	76.2
Overall	93.4	86.2	79.5	84.3

Abbreviation: BSN, bachelor of science in nursing degree.