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Nurse Specialty Certification, Inpatient Mortality, and Failure to Rescue

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Abstract

Purpose—To determine if hospital proportion of staff nurses with specialty certification is associated with risk-adjusted inpatient 30-day mortality and failure to rescue (deaths in surgical inpatients following a major complication).

Design—Secondary analysis of risk-adjusted adult general, orthopedic, and vascular surgical inpatients discharged during 2005–2006 (n = 1,283,241) from 652 nonfederal hospitals controlling for state, hospital, patient, and nursing characteristics by linking outcomes, administrative, and nurse survey data (n = 28,598).

Method—Nurse data, categorized by education and certification status, were aggregated to the hospital level. Logistic regression models were used to estimate effects of specialty certification and other nursing characteristics on mortality and failure to rescue.

Findings—Hospital proportion of baccalaureate and certified baccalaureate staff nurses were associated with mortality and failure to rescue; no effect of specialization was seen in the absence of baccalaureate education. A 10% increase in hospital proportion of baccalaureate and certified baccalaureate staff nurses, respectively, decreased the odds of adjusted inpatient 30-day mortality by 6% and 2%; results for failure to rescue were identical.

Conclusions—Nurse specialty certification is associated with better patient outcomes; effect on mortality and failure to rescue in general surgery patients is contingent upon baccalaureate education.

Clinical Relevance—Investment in a baccalaureate-educated workforce and specialty certification has the potential to improve the quality of care.

Keywords

Certification; nursing; nursing education; experience; outcomes; outcome assessment

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Surgical complications are a global health concern, with major surgical complication rates ranging from 3% to 17% in industrialized nations; half are deemed preventable (Gawande, Thomas, Zinner, & Brennan, 1999; Haynes et al., 2009; Kable, Gibberd, & Spigelman, 2002). A growing body of evidence suggests that surgical morbidity and mortality result from a complex interaction among patient, organizational, and human factors (Ghaferi, Birkmeyer, & Dimick, 2009; Hall et al., 2009; Haynes et al., 2009; Itani, 2009; Paull et al., 2009).

A recent systematic review concluded that there is ample evidence of an association between patient-to-nurse workloads and hospital mortality (Kane, Shamliyan, Mueller, Duval, & Wilt, 2007); the more patients nurses care for, the higher the mortality rate. Concern about nurse staffing levels is a worldwide phenomenon (Clarke & Aiken, 2008). Aspects of nursing other than staffing have received less attention. While there is evidence that the qualifications of physicians, often measured by board certification, are associated with patient outcomes (Aiken, Clarke, Cheung, Sloane, & Silber, 2003; Chen, Rathore, Wang, Radford, & Krumholz, 2006; Silber et al., 2002), little comparable research is available for nurses. A small but growing body of research suggests that higher nurse education is associated with better patient outcomes. Specifically, a greater proportion of nurses in a hospital with at least a baccalaureate (bachelor of science in nursing [BSN]) education has been shown to be associated with lower mortality (Aiken et al., 2003; Estabrooks, Midodzi, Cummings, Ricker, & Giovannetti, 2005; Tourangeau et al., 2007; Van den Heede et al., 2009). While more nurses are obtaining specialty certification, there is little evidence of the association between nurse specialty certification and patient outcomes.

This study extends the work of Aiken and colleagues to examine the impact of hospital proportion of registered nurses with specialty certification on risk-adjusted outcomes of 1,283,241 adult general, orthopedic, and vascular surgery patients discharged during 2005–2006 from nonfederal hospitals in California, Florida, New Jersey, and Pennsylvania (Aiken et al., 2010). Conceptually, registered nurse specialty certification is thought to improve patient outcomes through expert and collaborative nursing practice (Kendall-Gallagher & Blegen, 2009). Registered nurse specialty certification represents a validated level of clinical knowledge gained through a combination of formal education and experience (Kendall-Gallagher & Blegen, 2009). Clarifying the respective effects of nurse specialty certification and formal education on surgical outcomes is important to better inform educators, chief nursing officers, and policymakers charged with the responsibility of designing efficient and effective strategies for ensuring a competent nursing workforce qualified to function in today's highly complex, rapidly changing healthcare environment.

Methods

The analysis of surgical outcomes reported here uses secondary data derived from merging nurse survey data, American Hospital Association (AHA) annual survey data, and de-identified hospital discharge abstracts for patients hospitalized in four U.S. states– California, Florida, New Jersey, and Pennsylvania– to examine the impact of hospital proportion of certified staff registered nurses on inpatient 30-day mortality and failure-to-rescue rates. The nurse survey data were from a large cross-sectional study conducted in 2005–2007 (R01-NR-004513, L. H. Aiken, principal investigator) that examined the effects of nursing factors– including nurse staffing, nurse education, and the nurse practice environment– on a wide variety of nurse and patient outcomes. The University of Pennsylvania Institutional Review Board approved the study protocol.

Sample

Hospitals

Data were collected on all adult acute care hospitals located in California, Florida, New Jersey, and Pennsylvania. Information on hospital characteristics was obtained from the 2005 AHA Annual Survey and the respective state agencies. Hospitals that had discharge data on at least 100 surgical patients of interest, AHA data, and survey data from at least 10 nurses were included in analyses. Previous research demonstrated that 10 survey responses per hospital provide reliable estimates of survey-based organizational characteristics (Aiken, Clarke, Sloan, Sochalski, & Silber, 2002). In this study, hospitals had on average 54 nurse survey respondents. Nurses were categorized by education and certification status; hospitals were ultimately coded according to the percentage of their nurse workforce that had a BSN or higher degree, the percentage of nurses overall, and the percentages of BSN nurses and diploma or associate degree nurses (AD or diploma) who were certified. The final sample included 652 hospitals representing at least 80% of the respective adult acute care nonfederal hospitals in each state (American Hospital Directory, n.d.).

Nurses

Using lists provided by the Board of Nursing in each state, surveys were mailed to a random sample of registered nurses holding an active license. The sampling fractions were based on available funding and included 40% in California and Pennsylvania, 25% in Florida, and 50% in New Jersey. A two-stage double sampling strategy (Smith, 2008) was used to maximize external validity and determine whether there were any biases in the samples of nurse respondents in the different states. In two-stage designs, a repeat mailing of the survey is made to initial nonresponders. While the initial response rate was 36% (surveys were returned by 98,000 nurses, including many nurses not working in hospitals and some nurses not working at all), the response rate to the second, shorter survey (mailed at random to samples of 650 nonresponders in Pennsylvania and California) had a response rate of 91%. No significant differences in nursing characteristics were found between responders and nonresponders in a subsequent related follow-up study (Kutney-Lee et al., 2009). As an additional check on the representativeness of the nurse sample, nurse demographic data were compared with information for hospital nurses from the same states from the 2004 National Sample Survey of Registered Nurses (NSSRN; U.S. Department of Health and Human Services Health Resources and Services Administration Bureau of Health Professions, 2006). The characteristics of nurses in the two samples were found to be in general agreement, although the percentage of hospital nurses with a diploma or AD were slightly higher in the study sample than in the NSSRN sample (58.9% vs. 51.8%). The final sample of hospital nurses included 28,017 staff nurses across four states.

Patients

All patients with a diagnosis-related group classification of general, orthopedic, or vascular surgery were included in the sample. The final sample of patients used in these analyses included 1,283,241 patients 21 years of age and older who were admitted to a hospital in California, Florida, New Jersey, or Pennsylvania during the 24-month period 2005–2006. So that each patient was counted only once, we included only the first admission for a patient for which there was no prior medical or surgical admission during the previous 180 days. Risk adjustment included the Elixhauser comorbidity index (28 dummy variables indicating the presence of preexisting conditions; see Elixhauser, Steiner, Harris, & Coffey, 1998) in conjunction with other adjusters that included patient demographics, admission type, and 48 dummy variables indicating surgery type (Silber et al., 2002).

Measures

Nursing variables

The nurse-related variables used in this report were derived by aggregating individual staff nurse survey responses to the hospital level. The nursing variables of primary interest were nurse educational composition, which was measured by the percentage of nurses in each hospital with a BSN or higher degree, and nurse specialty certification, which was measured by the percentage of nurses in each hospital who were certified. Education data were obtained by asking survey respondents to identify their highest credential in nursing (hospital-based 3-year diploma, AD, baccalaureate degree, master's degree, or higher). Previous empirical work demonstrated that collapsing the five types of nursing education into two categories, (a) diploma and associate degree, and (b) baccalaureate degree or higher did not result in significant loss of information related to the effect education had on outcomes (Aiken et al., 2003). The same procedure was used in this study. Certification data were obtained from responses to the survey question that asked, “Are you currently certified in specialty practice by the American Nurses Association or a national nursing specialty organization? (Do not include American Heart Association competencies, such as CPR [cardiopulmonary resuscitation], ACLS [advanced cardiac life support], or PALS [pediatric advanced life support], and do not include internal hospital certifications).” The 2004 NSSRN collected data on nurse certification but only reported results for advance practice nurses (U.S. Department of Health and Human Services, 2006), effec tively precluding comparisons to the study sample. In this study, we consider not only the percentage of nurses in each hospital overall who are certified, but also the percentages of nurses with a BSN or higher who are certified, and the percentage of nurses with an AD or diploma who are certified. In line with prior research by Aiken and colleagues (2003), we also controlled for nurse experience in our patient outcome models, as well as the unit composition of the study hospitals, indicated by the percentages of nurses on medical-surgical units, intensive care units, and other units.

Hospital variables

Hospital structural characteristics were derived from the 2005 AHA Annual Survey. Three hospital characteristics were included in the analytic models: (a) teaching status, which distinguished major teaching hospitals from minor teaching hospitals and nonteaching hospitals (based on the ratio of postgraduate medical residents to beds); (b) bed size, which classified hospitals into three categories (< 100 beds, 101–250 beds, and ≥ 250 beds); and (c) high-technology hospitals, designated as facilities that provide services for open-heart surgery, organ transplantation, or both (Aiken et al., 2002). We also used dummy variables to indicate the state in which each hospital was located and to control for unmeasured differences in outcome by state.

Outcome variables

Two outcome variables were used to explore the relationship between nurse specialty certification and patient outcomes for surgical patients who were admitted to the study hospitals, inpatient deaths within 30 days of admission and failure-to-rescue, or inpatient deaths for patients who experienced complications (Schmid, Hoffman, Happ, Wolf, & DeVita, 2007; Silber et al., 2007). Complications were determined with ICD-9-CM codes in the secondary diagnosis fields and procedure fields of discharge abstracts indicative of 39 clinical events using validated protocols (Silber et al., 2001).

Data Analysis

After aggregating nurse survey data to the hospital level and merging them with AHA and patient discharge data, we first show how the 652 study hospitals vary in terms of their structural characteristics (bed size, teaching status, technology, and the state in which they are located) and in terms of their nursing characteristics (average years of experience, percentage of nurses with BSN and higher degrees, and percentages of nurses overall and of BSN nurses and AD or diploma nurses who are certified). We provide descriptive information on the nearly 1.3 million surgical patients discharged from these hospitals during the period of the study, including their age, sex, major diagnostic categories, and comorbidities, as well as the percentages of patients who died overall and those experiencing complications. We then show the results of fitting logistic regression models to estimate the effects of the nursing characteristics on mortality and failure to rescue, before and after controlling for other hospital characteristics and patient characteristics. Logistic regression is a statistical technique that estimates the probability of an event occurring, such as death while in the hospital, in the context of independent variables that may influence the probability of occurrence (e.g., hospital percentage of nurses with specialty certification; Anderson, Ruyun, & Grunkemeier, 2003). Our models included state fixed effects to statistically account for unmeasured differences across states. All data analyses were conducted using STATA Data Analysis and Statistical Software, Version 10 (STATA Corp, College Station, TX, USA).

Results

Descriptive

Characteristics of Hospitals and Patients. The characteristics of the study hospitals are described in **Table 1**. Forty-one percent of hospitals were large (> 250 beds), 41% and 7% of the hospitals, respectively, were minor and major teaching hospitals, and 40% were designated as high technology. The mean years of experience in nursing for the nurses in the study hospitals averaged just over 16 years, although this ranged across hospitals from 4.9 years to 27.7 years. The mean hospital percentage of staff nurses with a BSN or higher degree was 40% and ranged across hospitals from 0% to 75%, while the mean hospital percentage of specialty certified staff nurses was 36% and ranged from 0% to nearly 88%. On average, the mean percentage of BSN nurses who were certified was slightly higher than the mean percentage of AD or diploma nurses who were certified (38% vs. 35%), although these percentages also varied quite dramatically across the study hospitals, from 0% to 100% in the case of BSN nurses and from 0% to 86% for AD or diploma nurses.

Analysis of the 1,283,241 surgical patients discharged from the study hospitals indicated that roughly 43% were male, with a mean age of 61 years; 40% of the patients were considered emergency admissions. The top three diagnostic categories were musculoskeletal (MDC 8), digestive system (MDC 6), and hepatobiliary (MDC 7), which characterized 52%, 26%, and 11% of the patients, respectively. Among selected patient comorbidi-ties, the most frequent diagnoses were hypertension (48%), diabetes without complications (15%), chronic pulmonary disease (15%), and congestive heart failure (6%). Overall, 35% of the patients in the sample experienced complications. Just over 1% of all patients died within 30 days of admission, including roughly 4% of the subset of patients with complications.

Multivariate

Bivariate and multivariate analyses—The odds ratios in **Table 2** show the unadjusted and adjusted effects of the selected nursing factors of interest on 30-day mortality and failure to rescue. The odds ratio is calculated by dividing the probability of an event occurring by the probability of the event not occurring (Anderson et al., 2003). The unadjusted effects are from bivariate models that estimate the effect of each variable while ignoring every other. The adjusted effects are from multivariate models that consider the different nursing characteristics simultaneously and estimate their net effects after controlling and adjusting for the effects of the other hospital characteristics (size, teaching status, and technology) and for the characteristics of the patients, which may differ markedly from one hospital to the next (including all the conditions and comorbidities). All of the models were estimated using robust procedures to take account of the clustering of patients within hospitals, and the adjusted model included a dummy variable for the state in which hospitals were located to take account of the unmeasured differences between states that might affect our results. Except for the hospital-level nurse experience variable, which is measured in years, the other variables were measure in percentages (rather than proportions) and transformed (divided by 10) so that each unit increase (in the percentage of BSNs, the percentage of certified nurses, etc.) reflects the effect of a 10 percentage point difference on the two different outcomes.

Table 2 shows that, when the effect of each of the nursing variables on 30-day mortality is considered separately, using bivariate logistic regression models, there is a significant effect of nurse experience ($.01 < p < .05$), and a significant effect of the percentage of BSN nurses (includes those with master's and higher degrees) in each hospital ($p < .001$). In the bivariate models, there is no significant effect of the percentage of specialty certified nurses, nor of the percentage of BSN nurses who are certified, but the effect of the percentage of AD or diploma nurses who are certified is significant ($.01 < p < .05$). When, in the first multivariate model shown (Model 1 in **Table 2**), we reestimate the simultaneous and net effects of nurse experience, the percentage of BSN nurses, and the percentage of certified nurses, while adjusting for differences in hospital and patient characteristics, we find only a significant effect of the percentage of BSN nurses, and no effects of experience or certification. Model 3, however, which replaces the percentage of nurses overall with two variables that measure the percentage of BSN nurses who are certified and the percentage of AD or diploma nurses who are certified, indicates that in addition to the significant effect of the percentage of BSN nurses, there is a highly significant effect of the percentage of BSN nurses who are certified. These findings hold whether or not nurses with graduate degrees are included among the BSN nurses. Moreover, the models estimating these same effects on failure to rescue, or 30-day inpatient mortality for the subset of patients experiencing complications, yields virtually identical results. There is strong evidence of a significant effect of the percentage of BSN nurses on mortality and failure to rescue in the different hospitals, no evidence of an effect of the percentage of nurses who are certified, but a separate and pronounced effect of the percentage of BSN nurses who are specialty certified. Every 10% increase in the percentage of BSN nurses in hospitals is associated with a 6% decrease in the odds of patients dying, and every 10% increase in the percentage of BSN nurses who are specialty certified is associated with a 2% decrease in the odds of patients dying. These effects are the same for failure to rescue (deaths following complications).

Discussion

Nurse specialty certification at the nonadvanced practice level of nursing is a voluntary strategy for validating clinical expertise in the nursing workforce (Kendall-Gallagher & Blegen, 2009). The categorization of staff nurses by education and certification status, controlling for nurse experience, provided the opportunity to examine the effect on patient outcomes of these three factors separately. Decreased risk of inpatient 30-day mortality and failure to rescue were associated with higher proportions of nurses with BSN and higher degrees, confirming results by Aiken and associates (2003) using 1999 data. Specialty certification of nurses was also associated with lower mortality and failure to rescue, but only among nurses with BSN or higher education. Mean years of hospital nurse experience was not a significant predictor of patient mortality after taking into account education, confirming earlier findings (Aiken et al., 2003).

Possible explanations for why the independent effect of nurse certification was limited to nurses with a BSN or higher degree in nursing could be related to either potential bias associated with study methodology or unidentified differences in nurse education. To check for potential bias, multivariate models were constructed using the certified BSN variable with and without the inclusion of staff nurses with graduate degrees; the effect of certified BSNs remained significant for both models, with a slightly larger effect seen for certified BSN nurses with inclusion of nurses with graduate degrees. Recent research has shown that AD- and BSN-educated nurses, respectively, differ in their perceptions regarding preparation related to evidence-based practice and teamwork that may influence quality of care (Caldwell, Robey-Williams, Rush, & Ricke-Kiely, 2009; Kovner, Brewer, Yingrengreung, & Fairchild, 2010). Failure to find a significant effect on patient outcomes of nurse experience in this study and the prior Aiken et al. (2003) study provide additional support that experience is not a substitute for education or specialty certification.

Several limitations regarding the analysis should be noted. As a cross-sectional study, causation cannot be established; however, significant patterns of relationships between explanatory variables and outcomes can be explored (Kane et al., 2007). The moderate nurse survey response raised concerns about possible response bias, although the two-stage sampling design provided no evidence of response bias (Smith, 2008). Administrative discharge data may not be coded accurately or fully represent illness severity (Ghaferi et al., 2009). Logistic models did not control for physician board certification (data unavailable) or other hospital characteristics such as quality improvement initiatives that may influence patient outcomes. The patient outcomes and hospital characteristics for Florida were measured using 2005 data and the nurse survey was administered in 2007, which may have resulted in an underestimate of the association between nurse education and specialty certification in that state. Lastly, details about the type of staff nurse specialty certification is unknown, making it difficult to ascertain how specific clinical knowledge influences surgical morbidity and mortality (Kendall-Gallagher & Blegen, 2009).

Practice and Policy Implications

Findings from this study suggest that specialty certification for nurses with BSN and higher education may be a promising investment for improving patient outcomes. However, since there is no evidence to suggest that specialty certification has a positive impact on patient outcomes in the absence of BSN education, hospital managers and patients might derive more benefits from investments in improving nurse education levels than in specialty certification for nurses without BSN qualifications.

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Table 1

Characteristics of the 652 Study Hospitals

Characteristic		**Percent**
Size	Small (< 100 beds)	14.3%
	Medium (100–250 beds)	45.0%
	Large (≥ 251 beds)	40.7%
Teaching status	Nonteaching hospital, No. (%)	52.2%
	Minor teaching hospital	40.6%
	Major teaching hospital	7.2%
State	California	40.4%
	New Jersey	11.2%
	Pennsylvania	23.0%
	Florida	25.3%
Technology	Non-high technology	59.7%
	High technology	40.3%
		Mean (range)
Nurse experience (in years)		16.3 (4.9–27.7)
Percentage of nurses with BSN (or higher) degree		40.2 (0–75.0)
Percentage of nurses certified		36.1 (0–87.5)
Percentage of BSN nurses who are certified		38.3 (0–100.0)
Percentage of AD/diploma nurses who are certified		35.3 (0–85.7)

Note. The sample of hospitals on which percentages and means are based varies from 636 to 652 because of missing data on some characteristics. The sample included hospitals from California (n = 264), New Jersey (n = 73), Pennsylvania (n = 150), and Florida (n = 165).

Table 2

Odds Ratios Associated With the Effects of Various Nursing Characteristics on Surgical Mortality and Failure to Rescue

Surgical mortality Nursing characteristics	**Unadjusted (bivariate) models**	**Models adjusted for hospital and patient characteristics**	
		Model 1	**Model 2**
Nurse experience (in years)	1.01*	0.99	0.99
Percentage of nurses with BSN (or higher) degree	0.95***	0.94***	0.94***
Percentage of nurses certified	1.02	0.99	
Percentage of BSN (or higher) degree nurses who are certified	1.00		0.98**
Percentage of AD/diploma nurses who are certified	1.02*		1.01
Failure to rescue Nursing characteristics	Unadjusted (bivariate) models	Model 1	Model 2
Nurse experience (in years)	1.01	0.99	0.99
Percentage of nurses with BSN (or higher) degree	0.95***	0.93***	0.94***
Percentage of nurses certified	1 .01	0.98	
Percentage of BSN (or higher) degree nurses who are certified	0.99		0.98**
Percentage of AD/diploma nurses who are certified	1.02		1.00

Note. Odds ratios are from bivariate robust logistic regression models and multivariate robust logistic regression models that adjust for patient clinical characteristics and hospital characteristics (state, size, teaching status, and technology) and the clustering of patients within hospitals. Significance of coefficients:

* $p < .05$

** $p < .01$

*** $p < .001$.