

Hospital Nurse Practice Environments and Outcomes for Surgical Oncology Patients

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Objective. To examine the effect of nursing practice environments on outcomes of hospitalized cancer patients undergoing surgery.

Data Sources. Secondary analysis of cancer registry, inpatient claims, administrative and nurse survey data collected in Pennsylvania for 1998–1999.

Study Design. Nurse staffing (patient to nurse ratio), educational preparation (proportion of nurses holding at least a bachelor's degree), and the practice environment (Practice Environment Scale of the Nursing Work Index) were calculated from a survey of nurses and aggregated to the hospital level. Logistic regression models predicted the odds of 30-day mortality, complications, and failure to rescue (death following a complication).

Principal Findings. Unadjusted death, complication, and failure to rescue rates were 3.4, 35.7, and 9.3 percent, respectively. Nurse staffing and educational preparation of registered nurses were significantly associated with patient outcomes. After adjusting for patient and hospital characteristics, patients in hospitals with poor nurse practice environments had significantly increased odds of death (odds ratio, 1.37; 95 percent confidence interval, 1.07–1.76) and of failure to rescue (odds ratio, 1.48; 95 percent confidence interval, 1.07–2.03). Receipt of care in National Cancer Institute-designated cancer centers significantly decreased the odds of death, which can be explained partly by better nurse practice environments.

Conclusions. This study is one of the first to examine the predictive validity of the National Quality Forum's endorsed measure of the nurse practice environment. Improvements in the quality of nurse practice environments could reduce adverse outcomes for hospitalized surgical oncology patients.

Key Words. Nursing, quality of care/patient safety (measurement), hospitals, health care organizations and systems, surgery, risk adjustment for clinical outcomes

NURSE PRACTICE ENVIRONMENTS AND OUTCOMES FOR SURGICAL ONCOLOGY PATIENTS

Cancer is the leading cause of death in the nation for adults below the age of 85 years (American Cancer Society 2005). Lung, breast, and colorectal cancers

accounted for over \$16 billion in direct care costs, and significant decline in life expectancy for affected patients (Brown, Lipscomb, and Snyder 2001). Yet there is evidence that the quality of cancer care varies substantially across institutions (Hewitt and Simone 1999; Nattinger 2003). Extensive quality measurement and improvement initiatives are underway, one of which is to increase health services research conducted in cancer patient populations (Lipscomb and Snyder 2002). It is hoped that such research will inform clinical and managerial decision-making to improve outcomes.

Studies examining the organization–outcomes relationship for cancer patients have centered on the role of surgical procedure volume (Hillner, Smith, and Desch 2000; Bach et al. 2001; Finlayson, Goodney, and Birkmeyer 2003; Hodgson et al. 2003; Schrag et al. 2003). Despite compelling findings for rarely performed, high-risk procedures, volume has been recognized as an “imperfect correlate of quality” (Hewitt and Pettiti 2001, p. 5). Recent research findings suggest that hospitals awarded comprehensive cancer center status by the National Cancer Institute have lower risk-adjusted mortality rates than hospitals of similar volume (Birkmeyer et al. 2005). These findings lead us to consider other organizational aspects of care associated with disparate outcomes for oncology patients.

Outside the cancer population, studies have documented superior post-operative outcomes among patients receiving care in hospitals with better nurse staffing (Aiken et al. 2002; Kovner et al. 2002; Needleman et al. 2002). However, as part of the Quality Chasm series, an Institute of Medicine report concluded that in addition to poor staffing, poor working conditions for registered nurses threaten patient safety (Institute of Medicine 2003). To date, no published studies have examined the association between nurse practice environments and outcomes for hospitalized cancer patients despite their high care complexity and fragile state. This paper seeks to fill that void by determining the impact of the quality of the nurse practice environment, as well as

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nurse staffing and educational levels, on adverse outcomes for surgical oncology patients.

The nursing practice environment has been defined as the organizational characteristics of a work setting that facilitate or constrain professional nursing practice (Lake 2002). Examples of these characteristics include the nature of nurses' relationships with managers and physicians, and the status of nurses within the hospital hierarchy. The innate complexity and unpredictability of patient care requires professional alertness and skill in "preventive, monitoring, and rectifying action" (Strauss et al. 1985, p. 71). A professional practice environment is characterized by greater registered nurse presence with the patient and greater decision-making authority and flexibility. These features enable preventive and monitoring actions and support appropriate and efficient rectifying action in the context of fragile patient conditions. Professional practice environments support nurses to function at the highest scope of clinical practice, to work effectively in an interdisciplinary team of caregivers, and to mobilize resources quickly. Through these mechanisms, professional practice environments contribute to better quality of care. Better quality of care, in turn, leads to superior outcomes. Thus, we hypothesized that hospitals with more favorable environments would have better patient outcomes.

DESIGN AND METHODS

Our secondary analysis of existing datasets was approved by our institutional review board. Patient and nurse data were stripped of any personal identifying information before analysis. This study extended the methods of an existing program of research, but applied them to a different clinical population: hospitalized surgical oncology patients (Aiken et al. 2001, 2002, 2003).

Data Sources and Linkage

Four datasets were used: (1) The 1998–1999 inpatient discharge database from the Pennsylvania Health Care Cost Containment Council (PHC4); (2) The Pennsylvania Cancer Registry records for any patient hospitalized in Pennsylvania in 1998–1999; (3) The 1999 American Hospital Association (AHA) annual survey; and (4) the survey data of Pennsylvania registered nurses collected in 1999 by the Center for Health Outcomes and Policy Research, University of Pennsylvania as part of the International Hospital Outcomes Consortium (Aiken et al. 2001). Using a unique, anonymized patient identifier,

cancer registry records were linked to inpatient records closest to the hospital admission date. Data on nurse staffing, education, and the practice environment were aggregated to the hospital level. These measures, as well as key hospital characteristics from the AHA annual survey were then appended to each patient's record based upon the hospital they received care. Additionally, the National Cancer Institute's list of clinical and comprehensive cancer centers was used to verify the four hospitals in the sample with that designation (National Cancer Institute 2002).

Study Population

We identified patients who had a tumor registry record for one of the following cancers: head and neck, esophagus, colon-rectum, pancreas, lung, ovary, prostate, and endometrium. These cancers were chosen given the reliance on surgical excision as a critical part of adequate tumor control. Patients receiving surgery for breast malignancies were excluded due to their relatively short lengths of stay in hospitals. Each patient's discharge claim also had to have a diagnosis and related procedure code for the cancer identified in the tumor registry record. An independent tumor registrar familiar with inpatient hospital coding reviewed our list of cancer diagnoses and procedures for completeness. From our dataset of patients with linked claims and cancer registry data, 25,957 had valid cancer diagnosis and staging information.

The overall sampling frame of nurses and hospitals has been described elsewhere by the original study team (Aiken et al. 2002, 2003). Briefly, a 50 percent random sample of registered nurses residing in the Commonwealth of Pennsylvania was selected to receive a mailed survey regarding their demographics, job satisfaction, burnout, staffing, and reports of their practice environment. The response rate was 52 percent, which is similar to the response rates to anonymous surveys of health care professionals (Asch, Jedrziwski, and Christakis 1997). The demographic characteristics of this sample of nurses closely resemble the characteristics of Pennsylvania hospital nurses from the National Sample Survey of Registered Nurses for the same time period (Spratley et al. 2002; Sochalski 2004). Further, the number of respondents per hospital is directly proportional to the number of nurses employed in each hospital, based on personnel data from the American Hospital Association Annual Survey. This analysis is limited to nurses practicing on medical-surgical or critical care units in hospitals that performed surgery on patients with cancer during the study period.

Measures

Outcomes. Three outcome measures were explored in this study: 30-day mortality, complications, and failure to rescue. These outcome measures were obtained by the discharge file previously linked to death records. All outcomes were measured as dichotomous events. *Thirty-day mortality* was measured as the occurrence of death within 30 days of hospital admission. Thirty-day mortality is preferable to inpatient mortality as there can be a lag time between hospital admission and deleterious effects of care (Chassin et al. 1989). *Complications* were identified using a set of 21 secondary diagnosis codes and procedure codes; these were conditions that were not identified in prior admissions (Silber et al. 1995a, 2002).

Failure to rescue (FTR) was defined as death within 30 days of hospital admission for patients who have experienced a postoperative complication (Silber et al. 1992, 2007; Silber, Rosenbaum, and Ross 1995b). FTR is more highly associated with hospital characteristics than 30-day mortality and complication rates, and has been used by other research teams to measure quality of care (Needleman et al. 2002). Following established procedures, patients who died postoperatively were assumed to have experienced a complication, even if no complication was coded in the discharge abstract (Silber et al. 1997; Aiken et al. 2002).

Nursing Characteristics. Three characteristics of hospital nursing were measured in the current study: the nurse practice environment, nurse staffing, and the educational preparation of registered nurses.

This study used the Practice Environment Scale of the Nursing Work Index (PES-NWI) to measure the practice environment, a measure recently endorsed as a nurse-sensitive indicator of quality by the National Quality Forum (Lake 2002; National Quality Forum 2004). The PES-NWI derives from the Nursing Work Index, a 49-item questionnaire that measures the presence of particular organizational attributes in a nurse's work setting (Kramer and Hafner 1989; Aiken and Patrician 2000). Items are scored to reflect agreement that the characteristic is present in their current job (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree). Five subscales, using 31 NWI items, describe the practice environment of registered nurses in hospitals: Nurse Participation in Hospital Affairs (e.g., "staff nurses have the opportunity to participate on hospital and nursing committees"); Nursing Foundations for Quality of Care ("active inservice/continuing education programs for nurses"); Nurse Manager Ability,

Leadership, and Support of Nurses (“a supervisory staff that is supportive of the nurses”); Staffing and Resource Adequacy (“enough registered nurses to provide quality patient care”); and Collegial Nurse–Physician Relations (“physicians and nurses have good working relationships”). In previous analyses, reliability at both individual and hospital levels were high, and nurses in magnet hospitals—hospitals identified by nursing experts as having favorable practice environments for nurses—reported higher scores on all subscales than nurses in nonmagnet hospitals. Higher PES-NWI scores significantly predicted higher job satisfaction, lower burnout, and higher perceptions of quality care in a sample of oncology nurses (Friese 2005).

We aggregated nurse responses on the PES-NWI items to calculate hospital-level means of the PES-NWI subscales. We then assigned hospitals to one of three categories: unfavorable nurse practice environments (scores above 2.5 on zero or one subscale), mixed (scores above 2.5 on 2–3 subscales), or favorable (scores above 2.5 on 4–5 subscales). This classification has been supported by both criterion validity and latent class analysis (Lake and Friese 2006).

To measure *nurse staffing*, survey responses from eligible registered nurses were used to calculate a mean workload (number of patients cared for on the last shift) per hospital. Consistent with prior studies, responses from nurses working in critical care areas who reported caring for more than six patients on their last shift, and nurses in non-critical care reporting a patient load of greater than 20 patients were excluded (Aiken et al. 2002, 2003). The reported workloads per hospital were treated as a five-category variable for multivariate modeling.

Educational preparation was measured similarly to the previous study (Aiken et al. 2003). Each eligible staff nurse’s response to the question “What is the highest nursing degree you have?” was used for analysis. For each hospital, we calculated the proportion of nurses who held a baccalaureate degree or higher. The proportion was treated as a continuous measure.

Hospital Characteristics. Hospital *bed size* was defined as the number of staffed beds, and categorized as follows: 100 beds or fewer, 101–250 beds, 251 beds or higher. Hospitals that performed open heart or solid organ transplants in 1999 were considered providers of *advanced procedures*. *Teaching status* was calculated by dividing the number of full-time equivalent residents and fellows by number of beds set up and staffed. Non-teaching hospitals had no residents/fellows per bed; minor teaching hospitals had a lower than 1:4

resident/fellow to bed ratio; major teaching hospitals had at least one resident/fellow per four beds (Ayanian et al. 1998; Ayanian and Weissman 2002). We identified hospitals achieving *National Cancer Institute recognition* as a comprehensive ($n = 3$) or clinical ($n = 1$) cancer center by accessing the NCI's website (National Cancer Institute 2002). These categories were dichotomized (any NCI center designation yes/no) as was done in a prior study (Birkmeyer et al. 2005).

Severity of Illness Adjustment. We included 25 variables in our models that described demographics, comorbidities (based on ICD-9-CM codes), cancer type, stage, and duration of cancer illness (see Appendix S1). These variables were retained from an original set of 83 possible patient characteristics after they significantly predicted 30-day mortality in a random half of the sample at $p < .10$. The retained variables were then used to estimate models on all three outcomes in the second half of the randomly split sample. The *C* statistics (area under the receiver operating curve) for the risk adjustment models were 0.83, 0.71, and 0.76 for death, complications, and failure to rescue, respectively (Hanley and McNeil 1982).

Data Analysis. We first explored differences in patient characteristics and outcomes by hospital and nursing characteristics in bivariate analyses. We ruled out multicollinearity among hospital and nursing characteristics by examining correlation matrices for high correlations, and by yielding acceptable variance inflation factor and tolerance values (Allison 1999). We then estimated a series of logistic regression models to predict death, complications, and failure to rescue. The unit of analysis was the patient. All models included the 25 variables identified in the risk adjustment model. To understand the full effect of each hospital and nursing characteristic considered, marginal analyses were conducted with each characteristic introduced separately with the 25 patient variables. To then consider the effect of hospital and nursing characteristics beyond the contribution of other characteristics, partial analyses considered the effects of hospital, nursing, and patient characteristics simultaneously. Coefficients were transformed to odds ratios to facilitate interpretation. Robust, cluster methods were specified in *STATA* version 8.0 (STATA Corp, College Station, TX) to adjust standard errors and account for patient clustering in hospitals (White 1982; Rogers 1993). In addition, two-level, non-linear mixed models were estimated with the same variables using *SAS* version 9.2, (SAS, Cary, NC) and the parameter

estimates did not differ significantly from those obtained by clustered logistic regression. A p -value $<.05$ was considered statistically significant for all analyses.

RESULTS

Table 1 presents the background characteristics of the patient sample. The sample size was reduced to 24,618 because of patients missing source of admission or admission severity scores. The mean age of the sample was 68.3 years, and this reflects approximately one-third of study patients below the age of 65. The majority of patients received colorectal or prostate resections. No significant differences in clinical characteristics were found between the randomly selected patients used in the risk adjustment model estimation versus the validation patient group, with the exception of chronic obstructive pulmonary disorder (1.3 percent prevalence in the estimation versus 1.1 percent in the validation sample).

The demographics of the registered nurse sample, including gender (94 percent female) and educational preparation (36 percent with bachelor's degree or above), were nearly identical to previous reports (Aiken et al. 2002, 2003). The mean age of nurses (38.8 years) was comparable to the studies previously reported, and was also similar to a national survey of nurses (Spratley et al. 2002; Sochalski 2004). There were fewer small hospitals in the study sample than in the national population of hospitals. Pennsylvania has fewer small hospitals (12.8 percent) compared with national statistics (American Hospital Association 2002). Half of the study hospitals had residents or fellows. The number of nurses and hospitals in the current sample differs from prior reports because several hospitals previously studied did not perform cancer surgery in 1999, and some cancer specialty hospitals omitted in previous reports were included in these analyses.

Nursing Characteristics

The first section of Table 2 shows the hospital-level nursing characteristics. These aggregated values show that the average nurse cared for slightly less than six patients on the last shift. Further, most nurses agreed that Foundations for Quality Care and Collegial Nurse-Physician Relations were present in their job setting. Across Pennsylvania, the average hospital had slightly over one-third of their registered nurse workforce educated at the bachelor's degree

Table 1: Characteristics of the Patient Sample, *N* = 25,957

<i>Variable</i>	<i>Mean</i>	<i>SD</i>	<i>Range</i>
Age (years)	68.25	12.28	20–103
Length of stay (days)	8.06	7.67	1–254
Number of hospital admissions 1998–1999	1.43	1.17	1–21
Length of cancer diagnosis (months)	7.72	22.24	0–178.2
			<i>N</i> (%)
Female			11,302 (43.54)
Cancer stage			
Localized			13,243 (51.02)
Regionalized			8,168 (31.47)
Systemic			3,417 (13.16)
Missing			1,129 (4.35)
Admission type			
Elective			21,544 (83.00)
Transfer			145 (0.56)
Emergency			4,183 (16.12)
Both			77 (0.30)
Missing			8 (0.03)
Admission severity			
Stage 0			3,323 (12.80)
Stage 1			8,339 (32.13)
Stage 2			8,874 (34.19)
Stage 3			3,938 (15.17)
Stage 4			152 (0.59)
Missing			1,331 (5.13)
Cancer type			
Colon–rectum			11,722 (45.16)
Prostate			7,602 (29.29)
Endometrium			2,859 (11.01)
Ovary			1,860 (7.17)
Head and neck			717 (2.76)
Lung			564 (2.17)
Esophagus			385 (1.48)
Pancreas			248 (0.96)

Note. In subsequent analyses, patients without admission source and admission severity score were excluded, with a resulting analytic sample of 24,618.

or higher. Wide variations in nurse staffing, educational preparation, and PES-NWI scores were noted. Only 16 percent of hospitals reported an average nursing workload of four or fewer patients. Seven percent of hospitals had average nurse workloads that exceeded eight patients. The bottom section of Table 2 shows the distribution of hospitals by nurse practice environments. Roughly 20 percent (34) of studied hospitals had favorable environments, whereas 7 percent of hospitals had unfavorable environments (12 hospitals).

Table 2: Nursing Organization Characteristics, Hospital Level (n = 164)

<i>Characteristic</i>	<i>Mean</i>	<i>SD</i>	<i>Range</i>
Nurse staffing (average patients cared for on last shift)	5.58	1.20	3.30–9.57
Proportion of nurses per hospital with bachelor's degree or higher (%)	35.90	13.30	0–77.60
<i>PES-NWI subscale scores</i>			
Nursing participation in hospital affairs	2.33	0.25	1.64–3.31
Nursing foundations for quality of care	2.84	0.20	2.06–3.50
Nurse manager ability, leadership, and support of nurses	2.38	0.27	1.79–3.19
Staffing and resource adequacy	2.20	0.29	1.41–3.35
Collegial relations between nurses and physicians	2.75	0.17	2.18–3.16

<i>Categorization of Nurse Practice Environment</i>	<i>Hospital Distribution</i>	
	<i>n</i>	<i>%</i>
Unfavorable (mean ≥ 2.50 on 0–1 subscale)	12	7.32
Mixed (mean ≥ 2.50 on 2–3 subscales)	118	71.95
Favorable (mean ≥ 2.50 on 4–5 subscales)	34	20.73

PES-NWI, Practice Environment Scale of the Nursing Work Index.

PES-NWI scores are scored from 1 = strongly disagree; 2 = disagree; 3 = agree, and; 4 = strongly agree that the characteristic is present in their current job.

The group of hospitals with unfavorable practice environments had average workloads of six patients per nurse (range 4.2–7.3).

Patient Outcomes

Table 3 shows the outcome rates for the patient sample. At the patient level, the overall, unadjusted rates of 30-day mortality, complications, and failure to rescue were 3.4, 35.7, and 9.3 percent, respectively. The bottom section of Table 3 shows the hospital-level rates of 30-day mortality, complications, and failure to rescue, expressed as percents. Substantial variation in outcomes at the hospital level was noted, with observed failure to rescue rates ranging from 0 to 57 percent.

Nursing Characteristics and Patient Outcomes

The association between unadjusted patient outcome rates and nursing characteristics is shown in Table 4, with associated significance tests obtained by the χ^2 statistic. For 30-day mortality, all three characteristics were significantly associated in the hypothesized direction. Hospitals with poorer nurse staffing and unfavorable nurse practice environments had higher 30-day mortality rates ($p < .01$), and hospitals whose nurses had more advanced educational

Table 3: Unadjusted Outcome Rates

<i>Patient-Level Outcome Rates (n = 24,618)</i>	<i>Frequency</i>	<i>Percent (%)</i>	
30-day mortality	836	3.40	
Complications	8,788	35.70	
Failure to rescue	836	9.33	

<i>Hospital-Level Outcome Rates (%) (n = 164)</i>	<i>Mean</i>	<i>SD</i>	<i>Range</i>
30-day Mortality	3.72	2.63	0–12.82
Complications	36.72	10.05	12.50–70.00
Failure to rescue	10.50	8.08	0–57.14

preparation had lower mortality rates ($p < .05$). Complication rates had similar, significant relationships with nurse staffing and practice environments ($p < .01$), but not with educational preparation. Better nurse staffing, favorable environments and higher education were associated with lower failure to

Table 4. Unadjusted Outcome Rates (%) by Organizational Characteristics, (n = 24,618)

<i>Characteristic</i>	<i>30-day Mortality</i>	<i>Complications</i>	<i>Failure to Rescue</i>
Nurse staffing (average reported patients per nurse, per hospital)			
≤ 4	2.75**	33.53**	8.07**
5	3.26	37.34	8.59
6	3.80	32.32	11.39
7	3.88	38.20	9.99
≥ 8	5.07	40.29	12.26
Proportion of nurses per hospital with bachelor’s degree or higher			
< 20%	4.30*	32.22	12.83**
20–29%	3.87	35.73	10.57
30–39%	3.52	35.68	9.66
40–49%	3.24	36.30	8.81
≥ 50%	2.80	35.87	7.70
Nurse practice environment (number of scales ≥ 2.50, per hospital)			
Unfavorable 0–1 scale	5.21**	37.74**	13.32**
Mixed 2–3 scales	3.44	36.31	9.30
Favorable 4–5 scales	2.86	33.34	8.42
Care received in NCI cancer center			
No	3.51**	35.91*	9.57**
Yes	2.01	33.04	6.01

*Differences across groups significant at $p < .05$.

**Differences across groups significant at $p < .01$.

NCI = National Cancer Institute

rescue rates ($p < .01$). A linear trend can be seen in practice environment for all three outcomes; as the practice environment improved, so did all three outcomes. Hospital characteristics were also significantly associated with unadjusted outcome rates. Hospitals that held NCI cancer center designation had significantly lower rates of death and failure to rescue. Hospitals of larger size, higher teaching intensity, that performed advanced procedures, and in the highest quartile of procedure volume had significantly lower death and failure to rescue rates (results not shown).

From marginal analyses (left side of Table 5), which included all patient risk adjusters and each hospital or nursing characteristic separately, the following predictors were significantly associated with 30-day mortality: NCI cancer center designation (OR 0.66, $p = .02$), nurse staffing (eight or more versus four or fewer patients per nurse) (OR 1.60, $p < .01$), unfavorable practice environments (versus favorable) (OR 1.30, $p < .05$), and nurse educational preparation (OR 0.39, $p = .02$). Unfavorable practice environments (OR 1.40, $p < .05$), and nursing education (0.35, $p = .01$) were significantly associated with failure to rescue. Hospital procedure volume was not a significant predictor of 30-day mortality, complications, or failure to rescue (results not shown).

After review of the results from the marginal analyses, three models were estimated to predict 30-day mortality, complications, and failure to rescue. In addition to the 25 patient characteristics used in all prior analyses, these partial analyses incorporated bed size, advanced procedures, teaching status, NCI cancer center status, nurse staffing, nurse educational preparation, and practice environment classification. The results from the logistic regression models are shown on the right side of Table 5. Significant predictors of 30-day mortality included poorest nurse staffing (OR 1.41, $p < .05$), and unfavorable nurse practice environments (OR 1.37, $p = .012$). An increased proportion of nurses with a bachelor's degree or higher was associated with a decreased odds of dying in 30 days (OR 0.46, $p < .05$). The poorest nurse staffing was associated with increased odds of complication (OR 1.44, $p < .05$). Finally, unfavorable practice environments (OR 1.48, $p < .05$) and nursing education (OR 0.37, $p < .01$) were significant predictors of failure to rescue in the hypothesized direction. Receipt of care in an NCI cancer center had a reduced likelihood of 30-day mortality (OR 0.66, $p = .02$), but lost statistical significance in the partial analyses. Bed size, teaching status, and advanced procedures were not significant predictors of any outcome in either partial or marginal analyses, and parameter estimates did not differ significantly when these variables were included or excluded from the models (results not shown). Additionally, an

Table 5: Predictors of Patient Outcomes, Controlling for Hospital and Patient Characteristics

Characteristic	Marginal			OR (95% CI)			Partial		
	D	C	FTR	D	C	FTR	D	C	FTR
Nurse staffing (average number of reported patients per nurse, per hospital)									
≤ 4	1.12	1.30	0.96	1.02	1.32	0.89	1.02	1.32	0.89
5	(0.88, 1.44)	(1.03, 1.64)	(0.72, 1.28)	(0.80, 1.31)	(1.03, 1.70)	(0.67, 1.19)	(0.80, 1.31)	(1.03, 1.70)	(0.67, 1.19)
6	1.33	1.03	1.27	1.17	1.06	1.13	1.17	1.06	1.13
	(0.98, 1.81)	(0.79, 1.34)	(0.89, 1.82)	(0.87, 1.60)	(0.80, 1.40)	(0.80, 1.60)	(0.87, 1.60)	(0.80, 1.40)	(0.80, 1.60)
7	1.23	1.23	1.05	1.06	1.28	0.90	1.06	1.28	0.90
	(0.87, 1.74)	(0.93, 1.63)	(0.73, 1.51)	(0.75, 1.50)	(0.95, 1.71)	(0.62, 1.30)	(0.75, 1.50)	(0.95, 1.71)	(0.62, 1.30)
≥ 8	1.60	1.39	1.34	1.41	1.44	1.18	1.41	1.44	1.18
	(1.18, 2.18)	(0.97, 1.99)	(0.90, 1.98)	(1.03, 1.91)	(1.00, 2.08)	(0.81, 1.72)	(1.03, 1.91)	(1.00, 2.08)	(0.81, 1.72)
Unfavorable nurse practice environment	1.30	0.91	1.40	1.37	0.92	2.03	1.37	0.92	2.03
	(1.01, 1.68)	(0.70, 1.19)	(1.00, 1.95)	(1.07, 1.76)	(0.72, 1.19)	(0.81, 1.72)	(1.07, 1.76)	(0.72, 1.19)	(0.81, 1.72)
Nurse educational preparation	0.39	1.21	0.35	0.46	1.34	0.37	0.46	1.34	0.37
	(0.18, 0.83)	(0.77, 1.90)	(0.16, 0.78)	(0.21, 0.98)	(0.81, 2.24)	(0.17, 0.80)	(0.21, 0.98)	(0.81, 2.24)	(0.17, 0.80)
Care received in NCI cancer center	0.66	0.94	0.73	0.76	0.99	0.83	0.76	0.99	0.83
	(0.47, 0.93)	(0.74, 1.21)	(0.48, 1.12)	(0.52, 1.10)	(0.77, 1.29)	(0.55, 1.23)	(0.52, 1.10)	(0.77, 1.29)	(0.55, 1.23)
			c-statistic	0.84	0.71	0.76	0.84	0.71	0.76
			-2LL	5,990.57	28,884.85	4,880.19	5,990.57	28,884.85	4,880.19
			χ^2	1,302.23, 46 df	3,081.76, 46 df	678.81, 46 df	1,302.23, 46 df	3,081.76, 46 df	678.81, 46 df

Note: D, 30-day mortality; C, Complications; FTR, Failure to Rescue; NCI, National Cancer Institute; CI, Confidence interval. All models include 25 patient characteristics, bed size, teaching status, and performance of advanced procedures (output suppressed). Marginal analyses consider these patient and hospital characteristics, plus each one of the predictor variables. Partial analyses consider all patient and hospital characteristics, as well as all predictor variables simultaneously. Details on variables and measurement are available in Appendix S1.

expanded bedsize variable with four categories (≤ 100 beds, 101–249 beds, 250–499 beds, ≥ 500 beds) yielded equivalent parameter estimates and confidence intervals.

DISCUSSION

This study documented significant variation in nurse practice environments and patient outcomes across acute care hospitals. The evidence from this study suggests that the practice environment of registered nurses was significantly associated with surgical outcomes for cancer patients. The relationship between nurse practice environments and outcomes persists after adjusting for differences in patients and hospitals. It is also quite striking that these three distinct but related concepts—staffing, education, and practice environment—remained significant predictors of 30-day mortality when estimated simultaneously.

Only one in five hospitals had favorable working conditions according to nurse assessments. Thus, four out of every five hospitals studied are targets for improvements, and they can be modified by hospital administration. Prior analyses from the same data suggest that favorable nurse practice environments are achievable in diverse hospital settings (Lake and Friese 2006). One example of an intervention to strengthen the organizational support for nursing is pursuit of recognition as a magnet facility by the American Nurses Credentialing Center (Urden and Monarch 2002). Such managerial reforms are arguably easier to achieve than finding an ample supply of nurses to alleviate the nursing shortage.

In over 7 percent of studied hospitals, nurses reported caring for eight or more patients on their last shift, and fewer than 25 percent of hospitals had a majority of nurses prepared at the bachelor's degree or higher. These statistics are alarming considering the available evidence that these modifiable organizational characteristics are strongly associated with outcomes.

Receiving care in an NCI-designated cancer center was not associated independently with better outcomes when nursing characteristics were included in the regression models. It is possible the previously documented benefit of NCI centers for certain oncology surgical procedures may be a proxy for favorable nursing work environments (Birkmeyer et al. 2005). In our sample, nurse staffing, educational preparation, and PES-NWI subscale scores were significantly higher in NCI cancer center hospitals.

Limitations

The underlying differences in care processes between unfavorable and favorable practice environments are not available from our data, and identification of these differences may promote improvements in organization and outcomes. Consensus has not been reached on the ideal measure of hospital nurse staffing (Needleman et al. 2002; Mark, Salyer, and Wan 2003; Harless and Mark 2006). The nurse survey and claims data do not identify the specific nursing units where nurses work and patients receive care, respectively; this restricts us to hospital-level analyses of the staffing, education, and practice environment of nurses. Prior research findings suggest that both hospital- and unit-level nursing organization variables are associated with nurse and patient outcomes (Aiken and Sloane 1997; Aiken et al. 1999; Mark, Salyer, and Wan 2003). Investigation of unit- and hospital-level effects is warranted. The proportion of critical care beds in each facility may influence hospital-level staffing measures; this value was not available for our analyses. Factors that may influence quality of care are currently under study, such as care coordination across units, nursing expertise and certification. Physician-level data, such as training, board certification, hospitalist and intensive care staffing, or surgical procedure volume might explain additional variation in mortality and would be useful covariates in future work. The data do not identify *de novo* versus relapsed disease, or include history of chemo- or radio-therapy, which are factors to consider in patient prognosis.

CONCLUSIONS

There is a significant association between the quality of the nurse practice environment and outcomes for surgical oncology patients. Our findings suggest that greater investments in improving the nurse practice environment, the adequacy of nurse staffing, and moving to a nurse work force in which a higher proportion of staff nurses have at least a baccalaureate-level education would result in substantially fewer adverse outcomes for patients.

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REFERENCES

- Aiken, L., S. Clarke, R. Cheung, D. Sloane, and J. Silber. 2003. "Education Levels of Hospital Nurses and Patient Mortality." *Journal of the American Medical Association* 290 (12): 1617–23.
- Aiken, L., S. Clarke, D. Sloane, J. Sochalski, R. Busse, H. Clarke, P. Giovannetti, J. Hunt, A. Rafferty, and J. Shamian. 2001. "Nurses' Reports on Hospital Care in Five Countries." *Health Affairs* 20 (3): 43–53.
- Aiken, L., S. Clarke, D. Sloane, J. Sochalski, and J. Silber. 2002. "Hospital Nurse Staffing and Patient Mortality, Nurse Burnout, and Job Dissatisfaction." *Journal of the American Medical Association* 288 (16): 1987–93.
- Aiken, L., and P. Patrician. 2000. "Measuring Organizational Traits of Hospitals: The Revised Nursing Work Index." *Nursing Research* 49 (3): 146–53.
- Aiken, L., and D. Sloane. 1997. "Effects of Organizational Innovations in AIDS Care on Burnout among Urban Hospital Nurses." *Work and Occupations* 24 (4): 453–77.
- Aiken, L., D. Sloane, E. Lake, J. Sochalski, and A. Weber. 1999. "Organization and Outcomes of Inpatient AIDS Care." *Medical Care* 37 (8): 760–72.
- Allison, P. 1999. *Logistic Regression Using the SAS System: Theory and Application*. Cary, NC: SAS Institute.
- American Cancer Society. 2005. *Cancer Facts and Figures, 2005*. Atlanta: American Cancer Society.
- American Hospital Association. 2002. *Hospital Statistics*. 1999th Edition. Chicago: American Hospital Association.
- Asch, D., M. Jedrzejewski, and N. Christakis. 1997. "Response Rates to Mail Surveys Published in Medical Journals." *Journal of Clinical Epidemiology* 50 (10): 1129–36.
- Ayanian, J., and J. Weissman. 2002. "Teaching Hospitals and Quality of Care: A Review of the Literature." *Milbank Quarterly* 80 (3): 569–93.
- Ayanian, J., J. Weissman, S. Chasan-Taber, and A. Epstein. 1998. "Quality of Care for Two Common Illnesses in Teaching and Nonteaching Hospitals." *Health Affairs* 17 (6): 194–205.
- Bach, P., L. Cramer, D. Schrag, R. Downey, S. Gelfand, and C. Begg. 2001. "The Influence of Hospital Volume on Survival after Resection for Lung Cancer." *New England Journal of Medicine* 345 (3): 181–8.

- Birkmeyer, N., P. Goodney, T. Stukel, B. Hillner, and J. Birkmeyer. 2005. "Do Cancer Centers Designed by the National Cancer Institute Have Better Surgical Outcomes?" *Cancer* 103 (3): 435-41.
- Brown, M., J. Lipscomb, and C. Snyder. 2001. "The Burden of Illness of Cancer: Economic Cost and Quality of Life." *Annual Review of Public Health* 22: 91-113.
- Chassin, M., R. Park, K. Lohr, J. Keeseey, and R. Brook. 1989. "Differences among Hospitals in Medicare Patient Mortality." *Health Services Research* 24 (1): 1-31.
- Finlayson, E., P. Goodney, and J. Birkmeyer. 2003. "Hospital Volume and Operative Mortality in Cancer Surgery: A National Study." *Archives of Surgery* 138 (7): 721-5.
- Friese, C. 2005. "Nurse Practice Environments and Outcomes: Implications for Oncology Nursing." *Oncology Nursing Forum* 32 (4): 765-72.
- Hanley, J., and B. McNeil. 1982. "The Meaning and Use of the Area under a Receiver Operating Characteristic (ROC) Curve." *Radiology* 143 (1): 29-36.
- Harless, D., and B. Mark. 2006. "Addressing Measurement Error Bias in Nurse Staffing Research." *Health Services Research* 41 (5): 2006-24.
- Hewitt, M., and D. Petitti, eds. 2001. *Interpreting the Volume-Outcome Relationship in the Context of Cancer Care*. Washington, DC: National Academy Press.
- Hewitt, M., and J. Simone, eds. 1999. *Ensuring Quality Cancer Care*. Washington, DC: National Cancer Policy Board, Institute of Medicine.
- Hillner, B., T. Smith, and C. Desch. 2000. "Hospital and Physician Volume or Specialization and Outcomes in Cancer Treatment: Importance in Quality of Cancer Care." *Journal of Clinical Oncology* 18 (11): 2327-40.
- Hodgson, D., W. Zhang, A. Zaslavsky, C. Fuchs, W. Wright, and J. Ayanian. 2003. "Relation of Hospital Volume to Colostomy Rates and Survival for Patients with Rectal Cancer." *Journal of the National Cancer Institute* 95 (10): 708-16.
- Institute of Medicine. 2003. *Keeping Patients Safe: Transforming the Work Environment of Nurses*. Washington, DC: National Academy Press.
- Kovner, C., C. Jones, C. Zhan, P. Gergen, and J. Basu. 2002. "Nurse Staffing and Postsurgical Adverse Events: An Analysis of Administrative Data from a Sample of US Hospitals, 1990-1996." *Health Services Research* 37 (3): 611-29.
- Kramer, M., and L. Hafner. 1989. "Shared Values: Impact on Staff Nurse Job Satisfaction and Perceived Productivity." *Nursing Research* 38 (3): 172-7.
- Lake, E. 2002. "Development of the Practice Environment Scale of the Nursing Work Index." *Research in Nursing and Health* 25 (3): 176-88.
- Lake, E., and C. Friese. 2006. "Variations in Nursing Practice Environments: Relation to Staffing and Hospital Characteristics." *Nursing Research* 55 (1): 1-9.
- Lipscomb, J., and C. Snyder. 2002. "The Outcomes of Cancer Outcomes Research: Focusing on the National Cancer Institute's Quality-of-Care Initiative." *Medical Care* 40 (6, Suppl): III-3-III-10.
- Mark, B., J. Salyer, and T. Wan. 2003. "Professional Nursing Practice: Impact on Organizational and Patient Outcomes." *Journal of Nursing Administration* 33 (4): 224-34.
- National Cancer Institute. 2002. *The National Cancer Institute Cancer Centers Program* [accessed on July 14, 2007]. Available at <http://cancercenters.cancer.gov/>

- National Quality Forum. 2004. *National Voluntary Consensus Standards for Nursing-Sensitive Care: An Initial Performance Measure Set* [accessed on July 14, 2007]. Available at <http://www.qualityforum.org/nursing/>
- Nattinger, A. 2003. "Quality of Care for Breast Cancer." *Medical Care* 41 (3): 341-3.
- Needleman, J., P. Buerhaus, S. Mattke, M. Stewart, and K. Zelevinsky. 2002. "Nurse Staffing Levels and the Quality of Care in Hospitals." *New England Journal of Medicine* 346 (22): 1715-22.
- Rogers, W. 1993. "Regression Standard Errors in Clustered Samples." *Stata Technical Bulletin* 13: 19-23.
- Schrag, D., K. Panageas, E. Riedel, L. Hsieh, P. Bach, J. Guillem, and C. Begg. 2003. "Surgeon Volume Compared to Hospital Volume as a Predictor of Outcome Following Primary Colon Cancer Resection." *Journal of Surgical Oncology* 83 (2): 68-78.
- Silber, J., S. Kennedy, O. Even-Shoshan, W. Chen, R. Mosher, A. Showan, and D. Longnecker. 2002. "Anesthesiologist Board Certification and Patient Outcomes." *Anesthesiology* 96 (5): 1044-52.
- Silber, J., P. Romano, A. Rosen, Y. Wang, O. Even-Shoshan, and K. Volpp. 2007. "Failure-to-Rescue: Comparing Definitions to Measure Quality of Care." *Medical Care* 45 (10): 918-25.
- Silber, J., P. Rosenbaum, and R. Ross. 1995b. "Comparing the Contributions of Groups of Predictors: Which Outcomes Vary with Hospital Rather Than Patient Characteristics?" *Journal of the American Statistical Association* 90 (429): 7-18.
- Silber, J., P. Rosenbaum, J. Schwartz, R. Ross, and S. Williams. 1995a. "Evaluation of the Complication Rate as a Measure of Quality of Care in Coronary Artery Bypass Graft Surgery." *Journal of the American Medical Association* 274 (4): 317-23.
- Silber, J., P. Rosenbaum, S. Williams, R. Ross, and J. Schwartz. 1997. "The Relationship between Choice of Outcome Measure and Hospital Rank in General Surgical Procedures: Implications for Quality Assessment." *International Journal for Quality in Health Care* 9 (3): 193-200.
- Silber, J., S. Williams, H. Krakauer, and J. Schwartz. 1992. "Hospital and Patient Characteristics Associated with Death after Surgery. A Study of Adverse Occurrence and Failure to Rescue." *Medical Care* 30 (7): 615-29.
- Sochalski, J. 2004. "Is More Better? The Relationship between Nurse Staffing and the Quality of Nursing Care in Hospitals." *Medical Care* 42 (2, suppl): II67-73.
- Spratley, E., A. Johnson, J. Sochalski, M. Fritz, and W. Spencer. 2002. *The Registered Nurse Population March 2000: Findings from the National Sample Survey of Registered Nurses*. Washington, DC: U.S. Department of Health and Human Services.
- Strauss, A., S. Fagerbaugh, B. Suczek, and C. Wiener. 1985. *Social Organization of Medical Work*. Chicago: University of Chicago.
- Urden, L., and K. Monarch. 2002. "The ANCC Magnet Recognition Program: Converting Research Findings into Action." In *Magnet Hospitals Revisited: Attraction and Retention of Professional Nurses*, edited by M. L. McClure and A. S. Hinshaw, pp. 103-15. Washington, DC: American Nurses Publishing.
- White, H. 1982. "Maximum Likelihood Estimation of Misspecified Models." *Econometrica* 50 (1): 1-25.

SUPPLEMENTARY MATERIAL

The following supplementary material for this article is available online:

Appendix 1. Additional Details About All Study Variables and Modeling Procedures.

This material is available as part of the online article from: <http://www.blackwell-synergy.com/doi/abs/10.1111/j.1475-6773.2007.00825.x> (this link will take you to the article abstract).

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