Evaluating the Costs and Outcomes of Hospital Nursing Resources: a Matched Cohort Study of Patients with Common Medical Conditions

Karen B. Lasater, PhD, RN[1,2], Matthew D. McHugh, PhD, RN[1,2], Paul R. Rosenbaum, PhD[2,3], Linda H. Aiken, PhD, RN[1,2], Herbert L. Smith, PhD[1,4], Joseph G. Reiter, MS[5], Bijan A. Niknam, BS[5], Alexander S. Hill, BS[5], Lauren L. Hochman, BA[5], Siddharth Jain, DrPH[2,5], and Jeffrey H. Silber, MD, PhD[1,2,5,6,7,8]

[1]Center for Health Outcomes and Policy Research, School of Nursing, University of Pennsylvania, Philadelphia, PA, USA; [2]The Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA, USA; [3]Department of Statistics, The Wharton School, University of Pennsylvania, Philadelphia, PA, USA; [4]Population Studies Center, University of Pennsylvania, Philadelphia, PA, USA; [5]Center for Outcomes Research, Children's Hospital of Philadelphia, Philadelphia, PA, USA; [6]The Departments of Pediatrics, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA; [7]Department of Anesthesiology and Critical Care, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA; [8]Department of Health Care Management, The Wharton School, University of Pennsylvania, Philadelphia, PA, USA.

BACKGROUND: Nursing resources, such as staffing ratios and skill mix, vary across hospitals. Better nursing resources have been linked to better patient outcomes but are assumed to increase costs. The value of investments in nursing resources, in terms of clinical benefits relative to costs, is unclear.

OBJECTIVE: To determine whether there are differential clinical outcomes, costs, and value among medical patients at hospitals characterized by better or worse nursing resources.

DESIGN: Matched cohort study of patients in 306 acute care hospitals.

PATIENTS: A total of 74,045 matched pairs of fee-for-service Medicare beneficiaries admitted for common medical conditions (25,446 sepsis pairs; 16,332 congestive heart failure pairs; 12,811 pneumonia pairs; 10,598 stroke pairs; 8858 acute myocardial infarction pairs). Patients were also matched on hospital size, technology, and teaching status.

MAIN MEASURES: Better ($n = 76$) and worse ($n = 230$) nursing resourced hospitals were defined by patient-to-nurse ratios, skill mix, proportions of bachelors-degree nurses, and nurse work environments. Outcomes included 30-day mortality, readmission, and resource utilization-based costs.

KEY RESULTS: Patients in hospitals with better nursing resources had significantly lower 30-day mortality (16.1% vs 17.1%, $p < 0.0001$) and fewer readmissions (32.3% vs 33.6%, $p < 0.0001$) yet costs were not significantly different ($18,848 vs 18,671, $p = 0.133$). The greatest outcomes and cost advantage of better nursing resourced hospitals were in patients with sepsis who had lower mortality (25.3% vs 27.6%, $p < 0.0001$). Overall, patients with the highest risk of mortality on admission experienced the greatest reductions in mortality and readmission from better nursing at no difference in cost.

CONCLUSIONS: Medicare beneficiaries with common medical conditions admitted to hospitals with better nursing resources experienced more favorable outcomes at almost no difference in cost.

KEY WORDS: health services research; nursing; quality of care.

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INTRODUCTION

Hospitals are under pressure to improve patient care quality amidst thinning financial margins. Clinicians are committed to the best possible outcomes for their patients. Administrators, however, must weigh the cost-quality tradeoffs of investments. A recent study found good value among major teaching hospitals by demonstrating lower mortality at slightly higher cost for medical patients in teaching hospitals as compared with similar patients in non-teaching hospitals.[1] Only 13% of US hospitals are major teaching hospitals with medical residents.[1] In contrast, every hospital employs nurses, yet we know little about the comparative value of investments in nursing resources, which are undertaken to different extents by all hospitals. In this study, we examine hospitals that have made substantial versus limited investments in nursing, comparing the costs of those investments relative to the outcomes for medical patients.

Improvements in nursing resources may pay for themselves through better care quality. For example, increasing nurse staffing has been associated with fewer deaths, adverse

outcomes, nosocomial infections, and shorter lengths of stay—with associated cost savings.[2–4] More favorable nursing environments have been associated with greater value among surgical cohorts, especially for the sickest patients.[5, 6] Increasing the proportion of nurses educated at the baccalaureate level is linked to shorter lengths of stay, fewer readmissions, and consequently lower costs.[7, 8]

In this study, we compare clinically and demographically similar patients admitted to comparable hospitals with respect to size, teaching status, and technology capabilities, but that are otherwise dissimilar with respect to their nursing resources. We match pairs of patients admitted for the same medical condition (i.e., sepsis, congestive heart failure, pneumonia, stroke, acute myocardial infarction), and then closely match the pairs to be as similar as possible on over 60 comorbidities and demographic characteristics. Patient pairs are exactly matched on categories of hospital size, teaching, and technology status. Thus, we were able to evaluate whether clinical outcomes and costs of care differ in function of nursing resources.

Our findings inform the economic case for hospital nursing by evaluating whether the clinical outcomes and costs of care differed across two distinct types of hospitals—those with better versus worse nursing resources defined by patient-to-nurse ratios, proportion of bachelor's-educated nurses, nursing skill mix, and nurse work environment. We make apparent the costs and associated clinical benefits of hospital nursing resources for patients with common medical conditions and varying degrees of clinical severity. These findings are important to clinicians who seek the best clinical outcomes for their patients and can be used to inform resource allocation decisions made by hospital administrators as well as policy decisions that impact patient care.

METHODS

Patient Sample

The patient sample includes Medicare fee-for-service beneficiaries, 65.5 years or older, who were admitted to an acute care hospital in California, Florida, New Jersey, or Pennsylvania between January 1, 2013, and September 30, 2015, for one of five medical conditions: acute myocardial infarction, congestive heart failure, pneumonia, stroke, or sepsis. Patients missing age, sex, valid date of death, or who were enrolled in an HMO or who lacked Part B coverage in the 6 months prior to admission, are excluded. Patient data includes the following CMS Research Identifiable Files: inpatient, outpatient, carrier (physician Part B), hospice, skilled nursing facility, durable medical equipment, and the master beneficiary summary file.

The index admission is defined as the first medical admission during the study period to a study hospital. A 180-day look-back across all utilization files was completed to identify patient characteristics including age, sex, race, transfer-in status, emergent admission, and 64 comorbidities (Appendix 1). Using patient covariates, we constructed propensity scores for patients' likelihood of receiving care in a hospital with better nursing resources. With a 10% random sample of patient data external to our matched sample, we generated a 30-day mortality risk model to determine study patients' probability of 30-day mortality (Appendix 2).[9, 10]

Hospital Characteristics

Hospitals with better and worse nursing resources are defined using four dimensions of nursing: patient-to-nurse staffing, skill mix, education, and the nurse work environment. These measures were constructed from the 2016 RN4CAST-US study, a large survey of registered nurses (RNs) in 4 states (i.e., CA, FL, NJ, PA) who reported on organizational features and resources of their hospitals.[11]

Nurse responses pertain to the last shift the nurse worked and were aggregated within hospitals to create hospital measures of nursing. Patient-to-nurse staffing is the number of patients per direct care RN on medical-surgical (or equivalent) units. RNs were asked to report the total number of RNs, licensed practice nurses (LPNs), and unlicensed assistive personnel (UAPs), on their unit during their last shift. Skill mix was calculated as the proportion of RNs to all nursing personnel (i.e., RNs, LPNs, UAPs). Education is the proportion of RNs with at least a bachelor's degree in nursing. The nurse work environment is measured using the 31-item Practice Environment Scale of the Nursing Work Index (PES-NWI)—a National Quality Forum endorsed scale.[12] The subscales of the PES-NWI measure aspects of the nurse environment, including nurse-physician relations, staffing and resource adequacy, and nursing leadership.

Study hospitals were categorized by their size and teaching status, using Healthcare Cost Report Information System (HCRIS) data. Small hospitals had <250 beds; large hospitals had ≥ 250 beds. Teaching status was categorized as non-teaching (<0.05 residents to bed, RB), minor (≥ 0.05 and <0.25 RB), and major (≥ 0.25 RB). Hospitals were also categorized by their technology capabilities, using the Medicare Provider of Service file. High technology hospitals had the capacity to perform major organ transplant and/or open-heart surgery.

Outcomes

Patient outcome measures were 30-day mortality, 30-day readmission (or death), length of stay, intensive care unit (ICU) admission, and ICU length of stay. Economic performance was evaluated using a measure of 30-day resource utilization-based costs, which were inflation-adjusted and computed from the costs of resources used during the in-hospital admission as well as any costs accrued 30-days post-admission (Appendix 4).[5, 6, 13, 14] If a patient was readmitted within 30 days of the index admission date, all costs accrued during the readmission (including in-patient costs beyond 30 days) were included. In-hospital costs are a function of length of stay, level of care (i.e.,

ICU vs. general unit),[15] and total relative value units from bills.[16] Our resource utilization-based measure of cost uses standardized national prices for resources to allow for meaningful comparisons between hospitals, which has advantages over alternative cost measures, such as cost-to-charge ratios based on negotiated pricing agreements.

Thirty-day costs were adjusted to reflect the costs of higher levels of nurse staffing and skill mix in better nursing resourced hospitals (i.e., 30-day nurse-adjusted costs). For each hospital, costs were adjusted to reflect whether the hospital was above or below the average staffing and to account for salary differences based on skill mix composition. The adjustments were calculated using national average nurse salary data from the Bureau of Labor and Statistics and included adjustments for benefits (Appendix 4). Based on the hospital's nursing costs per day, patient costs were concomitantly adjusted.

Statistical Analysis

Defining Better and Worse Nursing Resourced Hospitals. We defined study hospitals as having either better or worse nursing resources using a coherence rank score based on four aspects of nursing (i.e., staffing, skill mix, education, work environment) (Appendix 5).[6, 17] The four aspects of nursing within each of the 512 study hospitals were compared to all other hospitals to compute a score for every hospital using coherence methods.[18] In brief, each hospital was assigned a score between 1 and 512 and rank-ordered. Hospitals in the top 15% were defined as the better nursing resourced hospitals. Hospitals in the bottom 45% were defined as the worse nursing resource hospitals.

Matching Algorithm. Using DesignMatch in R, we built an algorithm to match each patient in a better nursing resourced hospital with a clinically and demographically similar patient in a worse nursing resourced hospital.[19–21] To ensure the matched patient pairs were as similar as possible on measurable clinical and demographic variables, we required patients to be exactly matched on ICD-9 principal diagnosis codes (Appendix 3), 30-day mortality risk score quintile, and hospital characteristics (i.e., categories of size, teaching status, technology capability). After exact matching on these variables, we used fine balance[22] and distance minimization techniques to create patient pairs that are as similar as possible on over 60 covariates. These included age, sex, race, emergent admission status, transfer-in status, propensity score for attending a better nursing resourced hospital, 64 comorbidities, and continuous measures of 30-day mortality risk score, hospital size, and resident-to-bed ratio (Appendix 1).

Quality of the patient matches was assessed using standardized differences (SD) with a goal of less than 0.1 SD on all covariates.[23] Binary outcomes were compared within patient pairs using the McNemar test.[24] Continuous outcomes were reported using m-statistics similar to a 1% trim for each tail.[25, 26]

RESULTS

Characteristics of Better and Worse Nursing Resourced Hospitals

Prior to matching patients, we defined hospitals as having better or worse nursing resources based on four dimensions of nursing. Each of these four dimensions were superior in the better nursing resourced hospitals as compared with the worse nursing resourced hospitals (Table 1). On average, nurses in better nursing resourced hospitals cared for 1.5 fewer patients at a time (4.30 vs 5.79, $p < 0.0001$), had a richer skill mix of RNs to total nursing staff (0.85 vs 0.78, $p < 0.0001$), had a greater proportion of nurses with at least a bachelor's degree (67.5% vs 43.2%, $p < 0.0001$), and reported more favorable work environments (3.01 vs 2.68, $p < 0.0001$), as compared to the worse nursing resourced hospitals.

Quality of Patient Matches

Prior to matching patients, our initial sample consisted of 86,609 medical patients in the 76 better nursing resourced hospitals and 276,857 medical patients in the 230 worse nursing resourced hospitals. After matching patients exactly on principal diagnosis code, mortality risk score quintile, hospital size category, teaching status category, and technology category, and then balancing on over 60 covariates, our analytic patient sample consisted of 74,045 matched patient pairs. Table 2 presents selected covariates, before and after matching patients. Standardized differences between patient pairs did not exceed 0.1 (Appendix 6).

Prior to matching, the patients in better nursing resourced hospitals were more likely to be in large, high-technology, major teaching hospitals. Our matching algorithm required patients to be matched exactly on size, teaching, and technology categories, as reflected by the standardized difference after matching of 0.00. Further balance within size and teaching status categories was achieved through distance minimization techniques on the continuous measures of hospital's number of beds and RB ratios (Table 2).

Table 1 Differences in Nursing Resources

Characteristic	Better nursing resourced hospitals	Worse nursing resourced hospitals	*p* value
	N = 76	*N* = 230	
Patient-to-nurse staffing ratio, mean (SD)	4.30 (0.50)	5.79 (1.05)	< 0.0001
Nurse skill mix, mean (SD)	0.85 (0.04)	0.78 (0.05)	< 0.0001
Proportion of nurses with a BSN or higher, %	67.45%	43.24%	< 0.0001
Nurse work environment, mean (SD)	3.01 (0.19)	2.68 (0.22)	< 0.0001

Bachelors of Science in Nursing (BSN)

Table 2 Selected Matched Patient and Hospital Characteristics

Characteristics (percent unless noted)	Before match	Matched	Matched	Before match	Before match	After match
	Patients in better nursing resourced hospitals	Patients in better nursing resourced hospitals	Patients in worse nursing resourced hospitals	Patients in worse nursing resourced hospitals	Standardized difference	Standardized difference
	(n = 86,609)	(n = 74,045)	(n = 74,045)	(n = 276,857)		
Patient characteristics						
Age, mean (years)	80.3	80.6	80.7	80.7	−0.05	−0.01
Male	47.6	47.1	46.9	47.7	0.00	0.00
Black	8.2	6.9	7.3	5.3	0.11	−0.01
Hispanic	13.3	14.3	13.4	6.3	0.24	0.03
Probability of 30-day mortality	17.5	17.3	17.2	16.0	0.11	0.01
Emergency admission	76.9	74.9	75.8	85.4	−0.22	−0.02
Transfer-in	0.6	0.6	0.7	0.7	−0.02	−0.01
Comorbidities						
Hypertension	84.7	85.1	87.2	87.5	−0.08	−0.06
Diabetes	44.3	44.2	46.4	45.0	−0.01	−0.04
Renal failure	43.7	43.6	43.6	41.5	0.04	0.00
Congestive heart failure	38.8	38.6	37.7	38.5	0.00	0.02
Chronic obstructive pulmonary disease	32.9	33.3	35.0	38.7	−0.12	−0.04
Stroke	12.3	12.2	11.4	11.5	0.02	0.02
Past AMI	3.8	3.8	3.7	4.0	−0.01	0.00
Medical conditions						
Acute myocardial infarction	11.4	12.0	12.0	14.2	−0.08	0.00
Congestive heart failure	22.1	22.1	22.1	24.0	−0.05	0.00
Pneumonia	16.8	17.3	17.3	20.5	−0.09	0.00
Stroke	35.6	34.4	34.4	27.9	0.16	0.00
Sepsis	14.1	14.3	14.3	13.4	0.02	0.00
Hospital characteristics						
Small (< 250 beds)	25.7	30.0	30.0	47.6	−0.47	0.00
Large (≥ 250 beds)	74.3	70.0	70.0	52.4	0.47	0.00
Beds, mean	422.5	383.0	375.3	295.0	0.63	0.04
Non-teaching	50.1	58.6	58.6	65.0	−0.30	0.00
Minor teaching	21.2	24.8	24.8	28.3	−0.17	0.00
Major teaching	28.7	16.7	16.7	6.7	0.60	0.00
Resident to bed ratio, mean	0.23	0.13	0.12	0.07	0.61	0.05
High technology status	84.2	81.5	81.5	49.0	0.80	0.00
Nursing resources						
Patient-to-nurse staffing ratio, mean	4.37	4.40	5.52	5.77	−1.93	−1.55
Nurse skill mix, mean	0.84	0.85	0.77	0.78	1.55	1.69
Proportion of nurses with a BSN or higher	68.70	67.21	47.35	44.77	2.00	1.66
Nurse work environment, mean	3.04	3.03	2.73	2.70	1.67	1.49

After matching, the number of patients in the better resourced hospitals declines from 86,609 to 74,045 because not all patients in the best resourced hospitals could be matched with patients in a worse resourced hospital. The standardized differences after matching among the four measures of nursing resources are large (as expected) since the matching algorithm selected patient pairs who were in distinctly different hospitals with respect to their nursing resources

Outcomes

Table 3 presents a comparison of outcomes between patients in better and worse nursing resourced hospitals. Among all patients (i.e., the aggregate of all medical conditions), the odds of 30-day mortality and 30-day readmission were each 7% lower for patients in the better nursing resourced hospitals as compared to matched patients in the worse nursing resourced hospitals. The likelihood of being admitted to an ICU was 6% higher in a better nursing hospital and the average length of stay in the ICU was slightly longer although not clinically meaningful (0.99 days in better nursing resourced hospitals versus 0.97 days in worse nursing resourced hospitals, p = 0.031). The overall average length of stay was shorter for patients in better nursing resourced hospitals (5.38 days vs 5.66 days, $p < 0.001$). Pairwise differences in 30-day resource utilization-based costs were lower in hospitals with better

Table 3 Comparison of Outcomes Between Matched Patients in Better and Worse Nursing Resourced Hospitals

Outcome	Better nursing resourced hospitals	Worse nursing resourced hospitals		
All conditions				
Number of patients	$n = 74{,}045$	$n = 74{,}045$		
	%	%	Odds ratio (95% CI)	p value
30-day mortality	16.14	17.06	0.93 (0.90 to 0.96)	< .0001
30-day readmission (or death)	32.26	33.63	0.93 (0.91 to 0.96)	< .0001
ICU admission	26.92	25.97	1.06 (1.03 to 1.09)	< .0001
	m-estimate	m-estimate	Paired difference (95% CI)	p value
Length of stay (days)	5.38	5.66	− 0.27 (− 0.32 to − 0.23)	< 0.001
ICU length of stay (days)	0.99	0.97	0.03 (0.00 to 0.05)	0.031
30-day costs ($)	18,436	18,708	− 285 (− 481 to − 88)	0.004
30-day nurse-adjusted costs ($)	18,848	18,671	153 (− 46 to 351)	0.133
Sepsis				
Number of patients	$n = 25{,}446$	$n = 25{,}446$		
	%	%	Odds ratio (95% CI)	p value
30-day mortality	25.31	27.63	0.88 (0.84 to 0.91)	< .0001
30-day readmission (or death)	41.15	43.79	0.89 (0.85 to 0.92)	< .0001
ICU admission	36.93	37.82	0.96 (0.93 to 1.00)	0.034
	m-estimate	m-estimate	Paired difference (95% CI)	p value
Length of stay (days)	6.66	6.98	− 0.33 (− 0.42 to − 0.23)	< 0.001
ICU length of stay (days)	1.63	1.70	− 0.07 (− 0.13 to − 0.01)	0.028
30-day costs ($)	22,744	23,547	− 819 (− 1237 to − 399)	< 0.001
30-day nurse-adjusted costs ($)	23,238	23,680	− 459 (− 884 to − 35)	0.034
Congestive heart failure				
Number of patients	$n = 16{,}332$	$n = 16{,}332$		
	%	%	Odds ratio (95% CI)	p value
30-day mortality	10.03	10.00	1.00 (0.93 to 1.08)	0.925
30-day readmission (or death)	29.88	30.33	0.98 (0.93 to 1.03)	0.370
ICU admission	14.90	12.23	1.26 (1.18 to 1.35)	< .0001
	m-estimate	m-estimate	Paired difference (95% CI)	p value
Length of stay (days)	4.90	5.14	− 0.25 (− 0.33 to − 0.16)	< 0.001
ICU length of stay (days)	0.48	0.36	0.12 (0.09 to 0.16)	< 0.001
30-day costs ($)	15,979	15,714	187 (− 173 to 547)	0.308
30-day nurse-adjusted costs ($)	16,391	15,548	773 (408 to 1,137)	< 0.001
Pneumonia				
Number of patients	$n = 12{,}811$	$n = 12{,}811$		
	%	%	Odds ratio (95% CI)	p value
30-day mortality	10.32	10.50	0.98 (0.90 to 1.06)	0.628
30-day readmission (or death)	23.92	24.61	0.96 (0.91 to 1.02)	0.179
ICU admission	10.25	9.71	1.06 (0.98 to 1.16)	0.145
	m-estimate	m-estimate	Paired difference (95% CI)	p value
Length of stay (days)	4.88	5.25	− 0.37 (− 0.46 to − 0.29)	< 0.001
ICU length of stay (days)	0.34	0.35	0.00 (− 0.03 to 0.04)	0.892
30-day costs ($)	13,664	14,349	− 703 (− 1034 to − 372)	< 0.001
30-day nurse-adjusted costs ($)	13,992	14,205	− 220 (− 554 to 114)	0.197
Stroke				
Number of patients	$n = 10{,}598$	$n = 10{,}598$		
	%	%	Odds ratio (95% CI)	p value
30-day mortality	13.38	14.18	0.93 (0.85 to 1.01)	0.075
30-day readmission (or death)	25.90	26.84	0.95 (0.89 to 1.01)	0.108
ICU admission	26.32	23.53	1.17 (1.10 to 1.25)	<.0001
	m-estimate	m-estimate	Paired difference (95% CI)	p value
Length of stay (days)	4.28	4.47	− 0.18 (− 0.27 to − 0.09)	< 0.001
ICU length of stay (days)	0.71	0.71	0.02 (− 0.03 to 0.07)	0.405
30-day costs ($)	15,455	15,463	10 (− 378 to 398)	0.960
30-day nurse-adjusted costs ($)	15,819	15,434	392 (2 to 784)	0.049
Acute myocardial infarction				
Number of patients	$n = 8{,}858$	$n = 8{,}858$		
	%	%	Odds ratio (95% CI)	p value
30-day mortality	12.78	12.60	1.02 (0.93 to 1.12)	0.706
30-day readmission (or death)	30.74	31.67	0.95 (0.89 to 1.02)	0.167
ICU admission	45.16	43.69	1.07 (1.01 to 1.14)	0.034
	m-estimate	m-estimate	Paired difference (95% CI)	p value
Length of stay (days)	4.75	4.87	− 0.14 (− 0.26 to − 0.01)	0.030
ICU length of stay (days)	1.46	1.29	0.16 (0.08 to 0.24)	< 0.001
30-day costs ($)	21,368	20,606	675 (33 to 1,315)	0.039
30-day nurse-adjusted costs ($)	21,705	20,530	1,090 (442 to 1,736)	< 0.001

p values for outcomes were calculated using McNemar test for binary outcomes and m-statistics for continuous ones

versus worse nursing resources ($18,436 vs $18,708, $p = 0.004$). However, after accounting for the higher costs of better nurse staffing and greater nursing skill mix, differences in the 30-day nurse-adjusted costs for patients cared for in either the better or worse nursing resourced hospitals were insignificant ($18,848 vs $18,671, $p = 0.133$).

Clinical outcomes and cost findings differed by medical condition. For example, significantly lower 30-day mortality and 30-day readmissions were observed in better nursing resourced hospitals for patients with sepsis. Shorter lengths of stay were observed among all conditions: sepsis, stroke, pneumonia, congestive heart failure, and acute myocardial infarction. ICU admission was significantly lower for sepsis patients in better nursing resourced hospitals, but higher among patients with congestive heart failure, stroke, and acute myocardial infarction. Nurse-adjusted costs were significantly lower in the better nursing resourced hospitals for patients with sepsis ($23,238 vs $23,680, $p = 0.034$), and not significantly different for patients with pneumonia. The pairwise difference in cost was marginally higher in the better nursing hospitals for patients with congestive heart failure ($16,391 vs $15,548, $p < 0.001$), stroke ($15,819 vs $15,434, $p < 0.049$), and acute myocardial infarction ($21,705 vs $20,530, $p < 0.001$), perhaps because the rates of admission to the ICU were also higher for patients with these conditions in the better nursing resourced hospitals. Results for in-hospital costs are reported in Appendix 7.

Outcomes by Patient Clinical Risk

To determine whether there were differences in outcomes and costs by patient clinical risk on admission, we aggregated the medical conditions (Table 4). Overall, patients in better nursing resourced hospitals had better clinical outcomes as compared to patients in worse nursing resourced hospitals, and differences were greatest among patients with higher clinical risk. For example, the mortality difference was 1.99 percentage points lower for the highest risk patients in better as compared to worse nursing resourced hospitals, while there were no significant mortality differences observed among the lowest risk patients. ICU admission rates were not significantly different for patients in the 4th and 5th risk quintiles. Instead, the greatest differences were observed among patients in the lowest quintile. Nurse-adjusted costs were no different between patients in the better and worse nursing resourced hospitals, except for the lowest risk patients, who had higher costs in the better nursing resourced hospitals as compared to the worst ($14,638 vs $14,007, $p < 0.001$). The difference of $607 is marginal, at less than 5% of the overall cost. The difference in cost is likely associated with greater ICU utilization among low risk patients in better nursing resourced hospitals.

Value

We define value as the pairwise difference in nurse-adjusted cost compared to the difference in 30-day mortality. Among the medical conditions overall, the difference in nurse-adjusted costs was small with an estimate of $153 and confidence interval of − $46 to $351, and mortality rates were more

Table 4 Comparison of Outcomes Between Matched Cases in Better and Worse Nursing Hospitals Across Risk Quintiles

		Patient risk quintiles of 30-day mortality				
Outcome	**Overall**	**Q1 (lowest)**	**Q2**	**Q3**	**Q4**	**Q5 (highest)**
	(*n* = 74,045)	**(*n* = 13,561)**	**(*n* = 14,156)**	**(*n* = 14,440)**	**(*n* = 15,433)**	**(*n* = 16,455)**
30-day mortality, %						
Better nursing	16.14	3.19	6.78	11.33	19.67	35.77
Worse nursing	17.06	3.22	6.94	12.18	20.98	37.76
Difference	− 0.92***	− 0.02	− 0.16	− 0.85*	− 1.31**	− 1.99***
30-day readmission (or death), %						
Better nursing	32.26	17.65	22.81	27.55	36.53	52.55
Worse nursing	33.63	18.29	23.83	28.86	38.61	54.20
Difference	− 1.37***	− 0.64	− 1.02*	− 1.32*	− 2.08***	− 1.65**
ICU admission, %						
Better nursing	26.92	18.97	22.13	25.37	29.98	36.07
Worse nursing	25.97	16.09	20.44	24.27	29.62	36.93
Difference	0.95***	2.88***	1.69***	1.11*	0.36	− 0.86
Length of stay, d (m-estimate)						
Better nursing	5.38	4.10	4.66	5.35	5.94	6.63
Worse nursing	5.66	4.30	5.02	5.62	6.25	6.82
Difference	− 0.27***	− 0.20***	− 0.36***	− 0.28***	− 0.32***	− 0.21***
ICU length of stay, d (m-estimate)						
Better nursing	0.99	0.51	0.68	0.94	1.21	1.56
Worse nursing	0.97	0.43	0.63	0.88	1.19	1.59
Difference	0.03*	0.09***	0.06**	0.04	0.01	− 0.05
30-day cost, $ (m-estimate)						
Better nursing	18,436	14,304	16,085	18,202	20,173	22,513
Worse nursing	18,708	14,119	16,362	18,381	20,703	22,947
Difference	− 285**	182	− 343	− 206	− 575*	− 453
30-day nurse-adjusted cost, $ (m-estimate)						
Better nursing	18,848	14,638	16,443	18,628	20,587	23,039
Worse nursing	18,671	14,007	16,270	18,371	20,723	22,997
Difference	153	607***	89	212	− 153	41

p values: < 0.05, < 0.01**, < 0.001***. Numbers are rounded for display. For binary outcomes, the difference is the difference in rates. For continuous outcomes, the difference is the m-estimate of the typical pair difference. Being nonlinear, the m-estimate of the difference is not the difference of the m-estimates*

favorable in the better nursing resourced hospitals; thus, there is a clear value case for better nursing resources. Among patients with sepsis, lower mortality was achieved in better nursing resourced hospitals at lower costs, even after adjusting for the additional costs of better nursing resources. Among the other patients, there were no observed significant differences in mortality and thus, a value estimate could not be defined.

DISCUSSION

Hospitals with superior nursing resources, including better patient-to-nurse staffing ratios, a greater skill mix of RNs to all nursing staff, a greater proportion of bachelor's-degree nurses, and more favorable nurse work environments, have better patient outcomes at no difference in costs (pairwise difference \$153, 95% CI − \$46 to \$351, $p = 0.133$) even after accounting for the higher costs associated with better nursing resources.

This study demonstrates that better clinical outcomes, including lower mortality, are achieved at no significant difference in costs among medical Medicare patients in hospitals that invest in their nursing human capital. An analysis of surgical Medicare patients similarly found lower mortality, failure-to-rescue, shorter lengths of stay and marginally higher costs among patients in better nursing resourced hospitals.[6] Other studies of medical patients have linked nursing resources with better outcomes including lower mortality,[27] lower readmissions,[28] and fewer complications.[29, 30] A study examining costs of care among medical patients in Veteran's Administration facilities and its association with nurse hours per patient day and skill mix found that greater time RNs spend with patients is associated with cost offsets derived from shorter lengths of stay.[31] In our study, medical patients in better nursing resourced hospitals also had shorter lengths of stay as compared with their matched pairs in the worse resourced hospitals.

We found the greatest differences in clinical outcomes and costs among patients admitted for sepsis. Initiatives like the Surviving Sepsis Campaign have been a positive step towards quality improvement, but despite widespread understanding of how to care for septic patients, significant variation in outcomes remains. Treatment and management of sepsis uses standardized management protocols,[32] which are primarily driven by the bedside nurse responsible for surveilling patients' response to treatment, titrating medications, and clinical decision-making. Variation in sepsis mortality outcomes across hospitals has been attributed to the hospital where the patient received care.[33–35] Our finding that sepsis outcomes and costs of care were superior in hospitals with better nursing resources suggests that attention to system-level attributes of nursing is important to improving sepsis outcomes. Whether through lower mortality, fewer readmissions, or shorter lengths of stay, patients in each of the medical condition categories in our study experienced a benefit from superior nursing resources.

Limitations

Our findings should be considered in the context of its limitations. The patient sample included only Medicare beneficiaries with one of five common medical conditions and therefore does not represent the full range of patients cared for in hospitals. Our measurements of nursing resources are cross-sectional, which limits our ability to make causal inferences, although panel studies have shown that improving nurse work environments and increasing the percentage of bachelors-educated nurses over time are associated with improvements in patient outcomes.[36–39] Although we matched on over 60 patient and hospital characteristics, we were only able to match on observable characteristics using Medicare administrative data, and thus, our results are potentially subject to unmeasured confounding. In Appendix 8, we assess sensitivity to unmeasured confounding and show that it is unlikely an explanation for our results. Finally, we use standardized national pricing. Although others have used cost-to-charge ratios, they have found similar results.[2–4]

CONCLUSION

Patients admitted for common medical conditions in hospitals with better nursing resources had a lower likelihood of mortality, readmission, and shorter lengths of stay, with almost no difference in costs as compared to matched patients in hospitals with worse nursing resources. Our findings suggest that investments in nursing resources are associated with better clinical outcomes and almost no difference in cost.

Corresponding Author: *Karen B. Lasater, PhD, RN; Center for Health Outcomes and Policy Research, School of Nursing, University of Pennsylvania, Philadelphia, PA, USA (e-mail: karenbl@nursing.upenn.edu).*

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Compliance with Ethical Standards:

Conflict of Interest: *The authors declare that they do not have a conflict of interest.*

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