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The Effect of Registered Nurse Staffing and Skill Mix on Length of Stay and Hospital Costs

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Abstract

Background: Sepsis is a common cause of hospitalization among Medicare beneficiaries, often leading to prolonged hospital stays and high costs.

Purpose: To estimate the impact of registered nurse (RN) staffing and skill mix on hospital lengths of stay and associated costs for Medicare beneficiaries with sepsis.

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Methods: A retrospective, cross-sectional analysis was conducted using 2018 data from 2,107 acute care hospitals, including 653,496 patients with sepsis.

Findings: A one-unit increase in RN hours per patient day and a one percent increase in RN skill mix reduced hospital stays by 2% and 1%, respectively. Enhancing staffing to 9 RN hours per patient day and an 80% RN skill mix could save 63,580 inpatient days annually, reducing costs by \$152.9 million. Further increases to 11 RN hours and an 85% skill mix could save \$331.9 million.

Discussion: Better RN staffing and skill mix can improve patient outcomes and yield significant cost savings.

Keywords

Health care costs; Nursing; Acute Inpatient Care; hospitals; Medicare

Introduction

In the United States, approximately 1.7 million adults are diagnosed with sepsis every year (Rhee et al., 2017). Persons with compromised immune systems, those with chronic medical conditions with functional impairment, and adults 65 years and older are at an increased risk for developing sepsis (Buchman et al., 2020). Sepsis is also the most common hospital admission with mortality rates of 75% among Medicare beneficiaries (Kramarow, 2021). Sepsis can lead to serious, life-threatening consequences and death. As the severity of sepsis and patient age increase, the mortality rate also increases (Paoli et al., 2018). It is estimated that approximately one-third of patients who die while in the hospital are diagnosed with sepsis (Buchman et al., 2020). Over 200,000 sepsis-related deaths were reported in the US in 2019, and 75% of those deaths affected older adults aged over 65 (Kramarow, 2021).

It has been reported that there are substantial increases in Medicare beneficiaries admitted to a hospital for the management of sepsis which has resulted in extended hospital lengths of stay (LOS) (Buchman et al., 2020a; Frank et al., 2021; Paoli et al., 2018). Moreover, patients hospitalized with sepsis often cannot be discharged home and require admission to long-term acute care or skilled nursing facilities. Patients with sepsis are two to three times more likely to be readmitted to the hospital with secondary complications than patients without sepsis (Farrah et al., 2021).

Hospital stays are among the costliest healthcare services provided in the U.S. In a 2017 analysis, the average private insurance payment rate was approximately \$21,000/admission and the average Medicare payment rate was about \$11,400/admission (Maeda & Nelson, 2017). As sepsis severity increases, a patient's length of hospital stay also increases. Paoli and colleagues (2018) found the average LOS was 267% higher in patients diagnosed with septic shock than those patients diagnosed with sepsis. Longer lengths of stay place a tremendous human and economic burden on patients, families, hospitals, and the nation. The costs associated with the prolonged stay for sepsis treatment represent a considerable portion of the Medicare hospital payments that increased in the past years (Lagu et al., 2012; Maeda & Nelson, 2017; U.S. Department of Health & Human Services, 2020). The Agency for Healthcare Research and Quality has reported that sepsis is the most expensive

clinical condition with aggregated annual hospital costs of \$22.8 million (Liang L, 2006). Researchers also predicted that sepsis is the costliest of all patient diagnoses for hospital stays accounting for \$45 billion annually, including both inpatient and skilled nursing facility costs (Buchman et al., 2020b).

Beyond the direct clinical economic impact of sepsis, it imposes a substantial financial burden on healthcare systems; however, this strain has been shown to present a business case for cost savings through strategic investments in nursing resources. Evidence demonstrates that adequate registered nurse (RN) staffing levels improve patient outcomes, including reduced LOS and adverse events, which in turn can significantly lower hospital costs. Needleman et al. (2006) found that higher RN staffing levels are directly associated with better patient outcomes and financial benefits, as fewer complications and shorter LOS translate into measurable savings. Similarly, a review by Griffiths et al. (2023) highlighted the cost-effectiveness of optimizing RN staffing and skill mix, emphasizing that these measures not only improve care quality but also enhance hospital efficiency. These findings underscore that RN staffing should not be seen simply as an expense but as a strategic investment, particularly in managing high-cost conditions like sepsis.

Previous research has uncovered a few factors associated with sepsis outcomes. Lasater et al. (2020) found that patients with sepsis who were treated in hospitals with higher RN staffing levels had lower mortality rates, readmission rates, and lengths of stay across New York State (Karen B Lasater et al., 2021). We too reported a link between improved RN staffing levels and an increase in sepsis prevention bundle compliance with a subsequent decrease in sepsis mortality (Cimiotti et al., 2022). Similarly, Dierkes et al. (2022) found that hospital RN staffing levels are more strongly associated with improved sepsis patient outcomes—including lower mortality, reduced readmissions, and shorter lengths of stay—than compliance with sepsis protocols, highlighting the critical role of adequate nurse staffing in sepsis care. These imply that hospitals that invest in adequate RN staffing and improved work environments are more likely to provide high-quality care to sepsis patients, resulting in better outcomes. In this study, we expanded the measurements of nursing resources by examining both RN staffing level and nursing skill mix and estimated the cost savings for hospitals given improved nursing resources. This study aims to examine how RN staffing levels and skill mix impact the length of stay for Medicare beneficiaries with sepsis and to estimate the associated hospital cost savings. By doing so, we also contribute to the literature on the business case for nursing, highlighting how investments in RN resources can lead to both improved patient outcomes and economic benefits for hospitals.

Methods

Study Design

This cross-sectional study included data in 2018 from four sources. Data from the Medicare Provider Analysis and Review (MedPAR) data on all Medicare fee-for-service acute care hospitalizations; the American Hospital Association (AHA) Annual Survey on hospital characteristics were merged with data on Severe Sepsis/Septic Shock Management Bundle (SEP-1) compliance from the CMS Hospital Compare; and cost data were based on a report that outlined the financial burden of sepsis care (Paoli et al., 2018).

Study Sample

Hospitals included in the sample were short-term, general acute care hospitals that reported SEP-1 bundle scores to CMS and RN full-time equivalents to AHA. Patients of interest were all fee-for-service Medicare beneficiaries 65 to 99 years of age with a principal diagnosis of sepsis (Table 1, Supplement). Patients who died, were transferred to another acute care hospital, had a diagnosis code for palliative care present on admission (Z515), or had a LOS longer than 60 days were excluded. Patients who were transferred to another hospital were counted in the admitting hospital. The final sample included 653,496 Medicare beneficiaries with sepsis and 2,107 hospitals nationwide. This study was reviewed and approved by the Institutional Review Board.

Variables and Measures

Outcome Variables. Our analysis focused on two key outcomes derived from these datasets. First, we examine the LOS for Medicare Beneficiaries with sepsis. Those data were sourced from the 2018 MedPAR file. Second, we investigated the impact of LOS variations on sepsis costs. The average cost of the index sepsis hospitalization served as our second outcome of interest. Cost estimates were derived from a previous report which assigned values as follows: \$1,997.60 per day for patients with sepsis without organ dysfunction, \$2,308.30 per day for patients with severe sepsis, and \$2,908 per day for patients with septic shock (Paoli et al., 2018).

Explanatory Variables. Three key independent variables of interest were 1) measures of direct care RN staffing, 2) RN skill mix, and 3) the SEP-1 bundle score. To measure the degree of direct care RN staffing provides, we computed RN hours per patient day (HPPD), where the total number of full-time-equivalent RNs was multiplied by 1,768 hours per year and divided by the total adjusted patient days (Spetz et al., 2008). This calculation provided a measure of the intensity of RN staffing provided to patients, and we hypothesized higher levels of RN intensity provided to patients would result in a shorter LOS. RN skill mix was the percentage of RNs among all nursing personnel (RNs, licensed practical nurses, and nursing assistants). Research has shown that having a skill mix with a higher proportion of RNs not only improves patient outcomes but also the time it takes to respond to patient's needs (Tamburello, 2023). Consequently, we posit that having a skill mix with a higher proportion of RN staff would result in shorter LOS and lower costs.

Another measure of interest was the SEP-1 score. A hospital SEP-1 score is the percentage of patients who received the complete care bundle for severe sepsis or septic shock. This all or nothing Sep-1 bundle includes serum lactate levels, blood cultures, and broad-spectrum antimicrobials within 3 hours of onset for severe sepsis; intravenous fluids within 3 hours, vasopressors within 5 hours, and repeated volume assessments within 6 hours for patients with septic shock.

Hospital-level Confounding Variables. Other variables used as controls included hospital bed size, ownership, rurality, high technology status, and teaching status. Bed size was <100 beds, 101-250 beds, 251- 500 beds, or > 500 beds. Ownership was public, nonprofit, or for-profit hospital, and rurality was metropolitan (a core urban area of 50,000

or more population), micropolitan (an urban core of at least 10,000 but less than 50,000 population), or rural (All counties that are not part of a Metropolitan Statistical Area). Technology status was whether a hospital performed transplant surgery of the heart, kidney, lungs, and liver or adult cardiac surgery. Teaching status was measured as the number of residents per bed, where hospitals were nonteaching, minor teaching (0-4 medical residents per bed), or major teaching (4 medical residents per bed).

Patient-level Confounding Variables. Patient characteristics were used to risk-adjust analytic models and included age, sex, transfer in from another hospital, an ICU admission, sepsis severity, and 29 comorbid diseases represented in the Elixhauser Comorbidity Index. Sepsis severity was identified based on ICD-10-CM codes for sepsis without organ dysfunction and no classification (A40.x, A41.x, R65.10, R65.11); severe sepsis (R65.20); and sepsis shock (R65.21, T81.12XA, T81.12XD, T81.12XS).

Statistical Analysis

A zero-truncated negative binomial regression model was fit to examine the association between LOS and key independent variables with robust standard errors to account for the clustering of patients within hospitals. The projected changes in LOS were computed based on all hospitals meeting hypothetical minimum levels of RN staffing and skill mix. The costs associated with the reduction of LOS were estimated by multiplying the reduction of LOS with the estimated per-day costs of sepsis. All analyses were conducted using Stata, version 15.1 (StataCorp, College Station: TX), and significance was set at $p < .05$.

Results

The characteristics of the 2,107 study hospitals are shown in Table 1. The average hospital LOS was 6.2 days (SD=1.7), RN HPPD was 8.84, RN skill mix was 77.29% and the average Sep-1 score was 56.01. Hospitals were small or moderately small with 250 or fewer beds (66.8%), non-profit hospitals (74.2%), located in metro areas (74.5%), high-technology hospitals (41.2%), and non-teaching hospitals (73.3%).

The demographic characteristics of the 653,496 patients diagnosed with sepsis are shown in Table 2. On average, patients were 78.1 years of age, 51.5% female, 5.0% transferred in from another acute care hospital, 46.4% admitted to an ICU and 10.0% died within 60 days of admission. Most patients (60.6%) had sepsis without organ dysfunction or no classification, followed by patients with severe sepsis (19.5%) and those with septic shock (19.9%). The most common comorbidities included complicated hypertension (78.5%), fluid and electrolyte disorders (62.8%), chronic pulmonary disease (33.4%), congestive heart failure (32.7%), and renal failure (30.71%).

The results of the zero-truncated negative binomial model are shown in Table 3 (full regression results are shown in Table 2, Supplement). Controlling for patient and hospital characteristics, one unit increase in RN HPPD was significantly associated with shorter lengths of stay by a factor of 2% (IRR=0.98, $p<0.001$); one percent increase in RN skill mix was associated with shorter lengths of stay by a factor of 3% (IRR=0.97, $p<0.001$); one unit

increase in the Sep-1 score was associated with shorter lengths of stay by a factor of 2% (IRR=0.98, $p<0.001$).

The projected reduction in LOS and the associated costs, if all hospitals were staffed at different levels of RN HPPD and RN skill mix, are shown in Table 4. These findings suggest that if all hospitals were staffed at 9 RN HPPD and 80% RN skill mix or above, there could be a reduction of 63,580 inpatient days, yielding a total annual cost saving of \$152,899,303. This projected trend continued, in which if all hospitals were staffed at 11 RN HPPD and 85% RN skill mix or above, there could be a reduction of 138,017 inpatient days, yielding a total cost saving of \$331,907,882.

Discussion

In this study, we found RN workload and skill mix were associated with patient LOS and hospital costs. Our results indicate this balance between RN staffing and resource use can be refined by increasing RN HPPD and changing the skill mix so higher levels of RN staff and increased levels of RN skill mix can result in shorter LOS and potentially significant savings on hospital costs. These results are consistent with previous findings that better RN staffing and skill mix were associated with improved outcomes for patients with sepsis (Cimiotti et al., 2022; Lasater et al., 2021). Our research broadens these findings through an assessment of the potential cost savings associated with reductions in LOS in septic patients.

Over the past 25 years, the relationship between RN staffing and patient outcomes has been a central focus of nursing research, with early studies demonstrating links to mortality, complications, and patient satisfaction (Aiken et al., 2002). More recently, attention has turned to understanding the economic implications of staffing decisions, aligning with the increasing emphasis on value-based care (Lasater et al., 2021). Our study extends this body of work by showing that better RN staffing and skill mix are associated not only with improved patient outcomes but also with shorter LOS and reduced hospital costs. This evidence underscores the dual clinical and financial benefits of investing in nursing resources.

The role of RNs in hospital operations and patient outcomes is critical but often challenged by staffing shortages, high turnover, and mounting financial pressures. These issues lead to increased workloads, compromised patient care, and ethical dilemmas as RNs strive to meet national quality metrics. Our findings highlight that strategic investments in RN staffing can yield cost savings and improve outcomes, but barriers such as limited budgets, competing priorities, and difficulties in quantifying returns often hinder progress. Addressing these challenges requires further research to validate the economic benefits of nursing and policy initiatives to incentivize workforce investment. RNs are especially vital in sepsis care, where increased RN assessments and interventions have been shown to improve outcomes and reduce costs (Jones et al., 2015). Simulated scenarios offer a promising approach to determining the optimal RN staffing levels needed for effective management of complex cases like sepsis. How hospitals address these challenges will significantly impact patient care quality, hospital performance, and workforce sustainability.

Nursing leaders have been actively engaged in discussions regarding the impact of RN value generation on both hospital operations and patient outcomes. This conversation stems from the common perception that RNs primarily contribute to one aspect of a hospital's financial ledger: expenditure. However, numerous studies, including the one conducted here, suggest that investing in the nursing workforce can result in cost savings across hospital operations (Everhart et al., 2013; Griffiths et al., 2023; Lasater et al., 2021). While it is true that RNs do not directly contribute to revenue generation through billing processes, their pivotal role in patient care cannot be overstated. RNs are instrumental in orchestrating and delivering care, ensuring its effectiveness and efficiency.

To that end, our study aligns with nursing production economics principles, which emphasize that optimizing nursing inputs may enhance healthcare efficiency (Newbold, 2008). By showing that increased RN staffing and skill mix are associated with shorter LOS and reduced costs, we highlight how strategic nursing investments may improve both financial and patient care outcomes. While these investments entail higher labor costs, they may be offset by savings from reduced LOS and better outcomes, as supported by studies like Griffiths et al. (2023), which reinforce the business case for investing in nursing. However, hospitals often hesitate to adopt optimal staffing levels due to budget constraints, competing priorities, and challenges in quantifying financial returns (Everhart et al., 2013). A lack of awareness about the long-term gains from improved staffing further limits these investments. Despite these barriers, our findings contribute to the evidence supporting nursing as a strategic investment.

This study had a few limitations. First, our findings show important links between RN staffing, skill mix, LOS, and hospital costs, but the cross-sectional design limits our ability to establish causation. It is important to note that the relationships that we did observe may, in fact, be influenced by other unmeasured factors. Therefore, readers should view these results as part of a broader evidence base rather than conclusive proof. Future longitudinal studies should explore dynamic relationships between staffing, patient outcomes, and financial performance over time, integrating economic modeling to deepen our understanding of these interactions. Additionally, given today's workforce crisis, innovative staffing strategies and their implications for nurse retention, well-being, and patient care quality merit further exploration. Second, our sample included only those acute care hospitals that provided completed data on RN staffing, skill mix, and Sep-1 scores, which could limit the generalizability of findings. However, our sample of hospitals was large and represented 2,107 hospitals (55%) nationwide. Third, the estimates of hospital sepsis-related costs were national Medicare averages, and the actual costs could vary by hospital and geographical region. However, the estimates were obtained from 659 million Medicare sepsis-related encounters representing 20% of the U.S. population and reflective of Medicare's costs (Paoli et al., 2018).

The findings from this study provide further evidence that RN staffing is associated with the quality of patient care. In this case, we noted a substantial decrease in LOS among Medicare beneficiaries with sepsis; a decrease that was associated with better RN staffing and substantial cost savings to hospitals. These findings create a business case for nursing; suggesting that enhancing nursing resources is not merely an expense but a

strategic investment that can improve patient outcomes and offer economic advantages to hospitals. The challenge at hand is the ongoing workforce crisis and how healthcare systems position themselves moving forward. It is those systems that provide RNs with a reasonable workload and a supportive environment that will attract and retain RNs and improve the overall quality of care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Increased RN staffing and skill mix reduce hospital length of stay in sepsis patients.
- Hospitals can achieve substantial cost savings by improving RN staffing and skill mix.
- This study shows the financial benefits of improving nursing resources for sepsis care.

Table 1.
Hospital Characteristics (N=2,107).

Hospital characteristics	N(%)
Length of Stay, mean (SD), range	6.2 (1.7) (1,60)
RN hours per patient day, all hospitals, mean (SD), IQR	8.8 (2.8)
Skill Mix, all hospitals, mean (SD), IQR	77.3 (10.5)
Sepsis Treatment Bundle Score, all hospitals, mean (SD)	56.0 (16.9)
Ownership	
Non-Profit	1,490 (74.2%)
Public	280 (13.9%)
For-Profit	241 (12.0%)
Rurality	
Rural	160 (7.9%)
Micro	354 (17.6%)
Metro	1503 (74.5%)
Bed Size	
<=100	684 (33.9%)
101-250	663 (32.9%)
251-500	460 (22.8%)
>500	210 (10.4%)
High Technology hospital	
Yes	830 (41.2%)
No	1,187 (58.8%)
Teaching hospital	
Non-teaching hospitals	1,479 (73.3%)
4 or less than 4 residents per bed	338 (16.8%)
More than 4 residents per bed	200 (9.9%)

Table 2.

Patient Characteristics (N=653,496)

Patient Characteristics	N(%)
Age, mean(SD)	78.09 (8.67)
Gender	
Female	336,540 (51.5%)
Male	316,956 (48.5%)
Transferred in from another acute care facility	32,853 (5.0%)
Sepsis Severity	
Sepsis without organ dysfunction (including sepsis without classification)	396,138 (60.6%)
Severe sepsis	127,221 (19.5%)
Septic shock	130,137 (19.9%)
Death within 60 days of admission	65,435 (10.0%)
Stayed in ICU	302,827 (46.4%)
Comorbidities*	
Hypertension, complicated	513,282 (78.5%)
Fluid and Electrolyte Disorders	410,182 (62.8%)
Chronic pulmonary disease	218,496 (33.4%)
Congestive heart failure	213,771 (32.7%)
Renal failure	200,711 (30.7%)
Deficiency anemias	188,222 (28.8%)
Diabetes with complication	186,503 (28.5%)
Hypothyroidism	129,410 (19.8%)
Neurological disorders	112,448 (17.2%)
Weight loss	102,057 (15.6%)
Obesity	101,659 (15.6%)
Depression	86,385 (13.2%)
Coagulopathy	83,940 (12.8%)
Diabetes without complication	79,675 (12.2%)
Valvular disease	69,172 (10.6%)
Peripheral vascular disease	66,878 (10.2%)

* Only those diagnoses with 10% or higher were presented.

Table 3.

Incidence Rate Ratios Showing the Effect of RN Staffing, Skill Mix, and Score of Sepsis Bundle Treatment, on Length of Stay (N=653,496, with 2,107 hospitals)

Variable	IRR (CI)	p-Value
RN Staffing	0.98 (0.98-0.99)	0.000
Skill Mix	0.97 (0.96-0.99)	0.000
Sepsis Treatment Bundle Score	0.98 (0.98-0.99)	0.000

Notes: The model included all patients and hospital characteristics as controls.

Table 4.

Projected Reduction in Length of Stay and Associated Costs Based on RN Staffing Levels, Skill Mix, and Sepsis Severity for All Hospitals (N=2,107).

			Skill Mix		
			Observed	80%	85%
Observed RN HPPD	No organ dysfunction	Reduction of LOS	-	-22,014	-41,086
		Associated Cost Savings	-	-43,975,166	-82,073,394
	Severe Sepsis	Reduction of LOS	-	-7,543	-14,172
		Associated Cost Savings	-	-17,411,507	-32,713,228
	Septic Shock	Reduction of LOS	-	-10,783	-20,578
		Associated Cost Savings	-	-31,363,434	-59,853,171
9 RN HPPD	No organ dysfunction	Reduction of LOS	-13,296	-35,066	-54,006
		Associated Cost Savings	-26,560,090	-70,047,842	-107,882,386
	Severe Sepsis	Reduction of LOS	-4,475	-11,942	-18,527
		Associated Cost Savings	-8,939,260	-27,565,719	-42,765,874
	Septic Shock	Reduction of LOS	-5,888	-16,572	-26,311
		Associated Cost Savings	-17,125,837	-48,201,319	-76,528,175
10 RN HPPD	No organ dysfunction	Reduction of LOS	-22,756	-44,418	-63,271
		Associated Cost Savings	-45,457,386	-88,729,397	-126,390,150
	Severe Sepsis	Reduction of LOS	-7,672	-15,106	-21,661
		Associated Cost Savings	-17,709,278	-34,869,180	-50,000,086
	Septic Shock	Reduction of LOS	-10,433	-21,070	-30,768
		Associated Cost Savings	-30,345,424	-61,284,202	-89,491,805
11 RN HPPD	No organ dysfunction	Reduction of LOS	-35,216	-56,740	-75,478
		Associated Cost Savings	-70,347,482	-113,343,824	-150,774,853
	Severe Sepsis	Reduction of LOS	-11,921	-19,309	-25,827
		Associated Cost Savings	-27,517,244	-44,570,965	-59,616,464
	Septic Shock	Reduction of LOS	-16,493	-27,068	-36,713
		Associated Cost Savings	-47,971,540	-78,729,985	-106,783,432