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Nurse staffing and the work environment linked to readmissions among older adults following elective total hip and knee replacement

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Abstract

Objective: To examine the effect of nurse staffing and the work environment on 10- and 30-day unplanned readmissions for US Medicare patients following elective total hip and knee replacement.
Design: A cross-sectional analysis of secondary data.
Setting: Acute care hospitals in California, Florida, New Jersey and Pennsylvania, during 2006.
Participants: Medicare patients ($n = 112\,017$) admitted to an acute care hospital for an elective total hip or knee replacement.
Main Outcome Measures: The adjusted odds ratio (OR) of experiencing an unplanned readmission within 10 and 30 days of discharge following an elective total hip or knee replacement.
Results: Our sample included 112 017 Medicare patients in 495 hospitals. Nearly 6% of the patients were readmitted within 30 days; more than half of whom were rehospitalized within 10 days. Adjusted for patient and hospital characteristics, patients had 8% higher odds of 30-day readmission and 12% higher odds of 10-day readmission, for each additional patient per nurse. Patients cared for in the best work environments had 12% lower odds of 30-day readmission.
Conclusions: Readmission outcomes following major joint replacement are associated with hospital nursing care. Attention to nurse work conditions may be central to improving readmissions in this postoperative Medicare population.

Key words: readmission, nursing, work environment, knee replacement, hip replacement

Introduction

Each year, nearly 1 million older adults undergo total hip and knee replacements in the USA [1]. Approximately 3.5% of these patients experience postoperative complications, many of which warrant rehospitalization [2]. Hospital postsurgical complication rates following these procedures range between 1.8 and 8.9%, suggesting significant room for improvement [2]. In fact, recent evidence points to complications, including infection, as the major driver of readmissions among older postoperative adults [3, 4]. For older adults undergoing major joint replacement, intensive nursing care is essential for preventing

complications and promoting healing. While many of the efforts to reduce readmissions have focused on transitional and post-acute care, few acknowledge the importance of the nursing care delivered during the hospitalization. We hypothesized that patients in hospitals with better nurse staffing and work environments would have a lower likelihood of readmission. Our study examined the influence of inpatient nurse staffing and the work environment on unplanned readmissions for older adults following elective total hip and knee replacement.

In the immediate postoperative period, patients are at risk for serious and potentially fatal complications including infection, bleeding,

blood clots, pulmonary emboli and falls. During the days and weeks following surgery, patients require mobility assistance, physical rehabilitation, wound management and ongoing education about postoperative self-care. For orthopedic surgical patients, inpatient nursing care extends beyond the care provided in the hospital to include coordinating follow-up care after discharge and ensuring safe transitions to independent living. However, unmanageable patient workloads, limited time resources, and unsupportive work environments can detract from nurses' ability to provide care, thus compromising patients' potential to safely and successfully transition to independence.

Growing evidence demonstrates a relationship between readmissions and nurse working conditions, including staffing and the work environment, among medical and general surgical patients, yet less is known about these relationships among older adults following total hip and knee replacement [5–8]. Readmissions represent a patient safety problem globally; however, they have raised heighted attention in the USA where hospitals are under financial pressure to reduce rehospitalizations. Beginning in fiscal year 2015, unplanned readmissions following elective total hip and knee replacement are being targeted by the Centers for Medicare and Medicaid Services (CMS) as an indicator of hospital quality under the Hospital Readmissions Reduction Program [9].

Our study follows the methodology used by CMS to identify Medicare patients undergoing *elective* surgical procedures and to distinguish *unplanned* readmissions from potentially planned readmissions, such as inpatient rehabilitation [10]. Consistent with the Hospital Readmissions Reduction Program policy, readmissions within 30 days were analyzed. Readmissions within 10 days of discharge were also examined to determine the association between 'early' readmissions and hospital nursing. We hypothesized that hospital nursing would have a stronger association with early readmissions, based on the understanding that readmissions closer to discharge are more strongly correlated with hospital quality [11].

Methods

Design and sample
This cross-sectional analysis used three secondary data sources from 2006: the Medicare Provider Analysis and Review Research Identifiable File, the Multi-State Nursing Care and Patient Safety Study survey, and the American Hospital Association (AHA) Annual Survey. The patient sample included 112 017 Medicare beneficiaries discharged alive following elective total hip and knee replacement in 495 acute care non-federal hospitals in 4 states across the USA (California, Florida, New Jersey and Pennsylvania).

Patients
Patients were Medicare beneficiaries who were discharged alive following an elective total hip or knee replacement and met the inclusion and exclusion criteria based on the methodology used by CMS to calculate readmission penalties (Table 1) [10]. Generally, patients were included if they (i) were age 65 years or older, (ii) were enrolled in fee-for-service Medicare, (iii) had an elective primary total hip or knee replacement and (iv) were discharged alive. Patients were excluded if they (i) left against medical advice, (ii) were transferred to another facility or (iii) had more than two total hip and/or knee replacement procedures during the index admission [10].

Hospitals
Adult non-federal acute care hospitals were included in this study if they (i) had 10 or more nurse respondents on the Multi-State Nursing Care and Patient Safety Study survey, (ii) had 10 or more study patients discharged alive following an elective total hip or knee replacement and (iii) participated in the AHA Annual Survey. Previous empirical work suggests that 10 or more nurse survey respondents is sufficient for providing reliable estimates of the hospital's organizational features [12]. Hospital measures of nurse staffing and the work environment were derived from the Multi-State Nursing Care and Patient Safety Study survey, which involved a random sampling of a percentage of registered nurses in California (40%), Florida (25%), New Jersey (50%) and Pennsylvania (40%). Nurses were asked to provide information about the last shift they worked and to include the name of their employer. Details about the survey are available elsewhere [13]. Reporting the employer name allowed us to link nurse responses on the survey to a database of hospital characteristics and to identify patients admitted to those hospitals. The mean number of registered nurses per hospital was 47 (SD 38), and ranged from 10 to 282 registered nurses.

Measures
Outcome variables
The outcomes of interest were unplanned readmission within 30 and 10 days of discharge (early readmission). An unplanned readmission was defined by the criteria used by CMS to calculate hospital readmission penalties for readmissions following total hip and knee replacement [10]. Generally, unplanned readmissions were considered to be acute clinical events requiring immediate medical attention and readmission [10].

Explanatory variables
The explanatory variables of interest were nurse staffing and the work environment. A measure of nurse staffing was created from nurse reports of the number of patients on the unit during the last shift, divided by the number of registered nurses on the unit during the last shift. This nurse-level measure was then aggregated to create a hospital-level measure of nurse staffing. This measure of nurse staffing has been well established and validated in the literature [6, 8, 13, 14]. Our approach has advantages over administrative data, including differentiating direct care and administrative nurses, thus allowing us to clearly attribute our staffing measure to those nurses providing direct patient care.

The work environment was measured from the nurse survey which included the Practice Environment Scale of the Nursing Work Index (PES-NWI). This National Quality Forum endorsed measure contains 31 items categorized into 5 subscales that represent domains of the work environment: (i) nurse participation in hospital affairs, (ii) nursing foundations for quality of care, (iii) nurse manager ability, leadership and support of nurses, (iv) staffing and resource adequacy and (v) collegial nurse–physician relations [15]. Responses from each nurse respondent were aggregated within hospitals to create a hospital-level composite measure based on the mean of the five subscale scores [15]. Hospitals ranking in the top 20th percentile on the work environment scale were referred to as having the 'best' work environments and were compared with the remaining hospitals, characterized as having 'lower quality' work environments.

Potential confounding variables
Potential confounding variables in our regression models included both patient and hospital-level variables. Consistent with the risk-adjustment methodology used by CMS to calculate readmission penalties, patient-level covariates included: age, sex, comorbidities, type of surgery (hip or knee) and number of procedures (1 or 2) [10].

Table 1 Inclusion/Exclusion criteria and rationale for the study of elective total hip/knee arthroplasty (THA/TKA) readmissions

Inclusion criteria	Rationale
1. Enrolled in Medicare fee-for-service	Hospital claims data are regularly available only for Medicare fee-for-service beneficiaries.
2. Age 65 or older	Medicare patients younger than age 65 qualify for Medicare due to severe disability, making them distinctly different from the elderly Medicare population.
3. Discharged from a non-federal acute care hospital alive	Only those patients who are alive at time of hospital discharge are eligible for a readmission.
4. Enrolled in Parts A and B Medicare for the 12 months prior to the date of the index admission	Including Medicare Part A beneficiaries ensures there are no Medicare Part C (Medicare Advantage patients) in the data. Enrollment in Medicare in the 12 preceding months ensures 1 year of administrative data for risk adjustment purposes.
5. Have a qualifying elective primary THA/TKA procedure, without any of the following:	Elective primary THA/TKA is the procedure of interest in this study.
(a) Femur, hip or pelvic fractures coded in the principal or secondary discharge diagnoses fields of the index admission	Procedures to correct an orthopedic fracture are considered non-elective. Patients with orthopedic fracture tend to have higher mortality, complication and readmission rates.
(b) Partial hip arthroplasty procedures with concurrent THA/TKA	Partial hip arthroplasty are primarily indicated for hip fractures.
(c) Revision procedures with a concurrent THA/TKA	Few hospitals perform THA/TKA revision procedures and are associated with higher mortality, complication and readmission rates.
(d) Resurfacing procedures with a concurrent THA/TKA	Resurfacing procedures are distinctly different than THA/TKA and are primarily indicated for younger, healthier patients.
(e) Mechanical complication of the pelvis, sacrum, coccyx, lower limbs, or bone/bone marrow or disseminated malignant neoplasm coded in the principal discharge diagnosis field	A mechanical complication was likely present on admission and may require more technically complex procedures to correct. Patients with malignant neoplasms undergoing a THA/TKA are likely not elective and the patients are more likely to have a readmission.
(f) Removal of implanted devices/prostheses	Removal of implanted device/prostheses may be more complicated.
(g) Transfer from another acute care facility for THA/TKA	Transfers from another acute care facility for THA/TKA is likely not elective.
Exclusion criteria	
1. Without at least 30 days post-discharge enrollment in fee-for-service Medicare	Since readmissions are identified using claims data, 30 days of post-discharge enrollment in Medicare fee-for-service is required.
2. Discharged against medical advice (AMA)	Patients leaving AMA may not allow providers to deliver complete and full care to prepare the patient for discharge.
3. Admitted for the index procedure and subsequently transferred to another acute care facility	Including these cases in the readmission measure makes it difficult to determine to which hospital the readmission outcome should be attributed.
4. With more than two THA/TKA procedure codes during the index hospitalization	More than two THA/TKA procedures likely reflects an error in coding.

Source: Suter *et al.* [10].

Comorbidities were identified using patient data at the time of hospitalization and 12 months prior to adjust for patient acuity.

Hospital-level variables included: hospital size, teaching status and technology status. Hospital size was defined by number of beds: <100 beds (small); 101–250 beds (medium); >250 beds (large). Teaching status was defined by the ratio of medical fellows and residents to beds: no medical fellows and residents (non-teaching); ≤1:4 (minor); >1:4 (major). High technology hospitals had the capacity to perform open-heart and/or major organ transplantation, whereas low technology hospitals did not.

Analysis

We first described the hospitals in our sample and the patients who had surgeries within those hospitals, including the 10 most common reasons for readmission with 30 days. To determine the relationships between nurse staffing, the work environment and readmissions, we estimated multivariable logistic regression models. Robust standard errors were used to account for the clustering of patients within hospitals [16]. The level of significance at which the null hypothesis was rejected was $\alpha < 0.05$ for a two-tailed test. The first models were unadjusted models examining the bivariate effect of one additional patient per nurse on the odds of readmission; and the effects of being cared for in the best work environment on the odds of readmission. The following models sequentially built on each other, adjusting for patient characteristics, then patient and hospital characteristics.

Results

Among the 112 017 patients in our study, the majority (70.40%) were initially admitted for a knee replacement. Nearly, all patients (95.18%) had only one joint procedure during the index admission; however, some patients had bilateral replacements. Six thousand three hundred and twenty-two (5.64%) had an unplanned readmission within 30 days of discharge (Table 2). More than half of the patients readmitted within 30 days were rehospitalized within 10 days following discharge. Among the readmitted patients, the most common reason for readmission was postoperative infection, followed by packed cell transfusion and osteoarthritis.

Among the 495 study hospitals, the majority of patients were cared for in hospitals that were large (63.57%), non-teaching (51.65%), high technology hospitals (65.03%) (Table 3). Over 75% of the

Table 2 Patient characteristics and most common reasons for 30-day readmission

Patient characteristics	Patients N = 112 017	
	N/mean	%/SD
Readmission 30 days after discharge	6322	5.64
Readmission 10 days after discharge	3505	3.13
Age (years), (mean, SD)	75.48	5.90
Sex		
Male	40 855	36.47
Female	71 163	63.53
Type of procedure		
Total hip replacement	33 155	29.60
Total knee replacement	78 862	70.40
No. of procedures		
1	106 615	95.18
2	5402	4.82
No. of comorbidities, (mean, SD)	1.77	1.28
Most common reasons for 30-day readmission		
Postoperative infection	358	5.66
Packed cell transfusion	347	5.49
Osteoarthritis	256	4.05
Atrial fibrillation	237	3.75
Venous catheterization	198	3.13
Infection due to joint prosthesis	191	3.02
EGD with closed biopsy	185	2.93
Intestinal infection due to *C. diff*	169	2.67
Arthrocentesis	147	2.33
Congestive heart failure	147	2.33

Percentages may not sum to 100% due to rounding. *C. diff, Clostridium difficile*; EGD, esophagogastroduodenoscopy.

Table 3 Distribution of the hospital and patient study sample by hospital characteristics

Hospital characteristics	Hospitals n = 495		Patients n = 112 017	
	N	%	N	%
State				
California	182	36.77	34 393	30.70
New Jersey	57	11.52	11 246	10.04
Pennsylvania	126	25.45	25 399	22.67
Florida	130	26.26	40 979	36.58
Hospital size				
Small	48	9.70	5313	4.74
Medium	222	44.85	35 495	31.69
Large	225	45.45	71 209	63.57
Teaching status				
Non-teaching	261	52.73	57 860	51.65
Minor	203	41.01	45 401	40.53
Major	351	6.26	8756	7.82
High technology	236	47.68	72 848	65.03
Nurse staffing				
<4	74	14.95	14 654	13.08
4 to <5	183	36.97	47 951	42.81
5 to <6	162	32.73	38 056	33.97
6 to <7	52	10.51	8586	7.66
7+	24	4.85	2770	2.47
Work environment				
Best	99	20.93	28 700	26.43

Percentages may not sum to 100% due to rounding. Nurse staffing indicates a ratio of the number of patients to the number of registered nurses.

patients were cared for in hospitals with staffing ratios of four to six patients per nurse. The average nurse's workload was five patients per nurse. One-fifth of the hospitals was characterized as having the best work environments, and included 26.43% of the patients.

Before adjusting for patient and hospital characteristics, patients had a 10% greater likelihood of 30-day readmission for each additional patient per nurse (Table 4; OR 1.10, 95% CI 1.04–1.17). Patients in the best work environments were 16% less likely to be readmitted compared with patients in lower quality environments (OR 0.84, 95% CI 0.74–0.95). After adjusting for patient and hospital characteristics, patients had 8% higher odds of 30-day unplanned readmission for each additional patient per nurse (OR 1.08, 95% CI 1.02–1.15). Patients cared for in the best work environments had 12% lower odds of 30-day unplanned readmission, as compared with patients in a lower quality environment (OR 0.88, 95% CI 0.77–0.99).

Among patients readmitted within 10 days, the unadjusted odds of readmission was 12% greater for each additional patient per nurse (Table 4; OR 1.12; 95% CI 0.68–0.98). Patients in the best environments were 17% less likely to be readmitted (OR 0.83; 95% CI 0.69–0.99). After adjusting for patient characteristics, the effect of the work environment was rendered insignificant. After adjusting for patient and hospital characteristics, patients had 12% higher odds of 10-day unplanned readmission for each additional patient per nurse (OR 1.12, 95% CI 1.02–1.23).

Discussion

Our study demonstrated an association between features of hospital nursing—staffing and the work environment—and 30-day unplanned

readmissions among Medicare patients following elective total hip and knee replacement. The association between readmissions and nurse staffing was more pronounced among early readmissions (within 10 days) as compared with 30 days, suggesting that the nursing care delivered *in the hospital* is particularly significant for reducing the odds of patients experiencing acute clinical events that require rehospitalization shortly after discharge. The main findings of this study highlight the importance of staff nurses in facilitating favorable health outcomes for surgical orthopedic patients.

In hospitals, registered nurses deliver around-the-clock perioperative care at the patient's bedside, which makes them uniquely positioned to identify and intervene on early warning signs of surgical site infection, blood loss or other complications that may necessitate readmission. Our measure of nurse staffing is a proxy for how intensively nurses deliver care to patients during their hospitalization. Consistent monitoring for signs and symptoms of clinical deterioration, pain management, infection prevention, early and frequent mobilization and ongoing education regarding self-care following major joint replacement are all essential nurse-initiated care activities to promote effective healing and safe transitions from hospital to home [17–19].

The most common reason for readmission was postoperative infection. This finding is consistent with recent findings in a similar patient population [4]. Nurses are involved in many aspects of infection prevention, including: timely initiation of antibiotics prior to surgery, stopping antibiotics at the appropriate time, wound care management, monitoring for signs and symptoms of infection or sepsis and patient education about preventing infection after discharge. Nurses also prevent infection through consistent and thorough hand washing practices. When nurses are stressed for time, any and all of these

Table 4 Effects of hospital nursing on 30- and 10-day unplanned readmission

	Unadjusted OR (95% CI)	Adjusted for patient characteristics OR (95% CI)	Adjusted for hospital and patient characteristics OR (95% CI)
30-Day readmission			
Staffing	1.10** (1.04–1.17)	1.08** (1.02–1.15)	1.08* (1.02–1.15)
Work environment	0.84** (0.74–0.95)	0.86* (0.76–0.98)	0.88* (0.77–0.99)
10-Day readmission			
Staffing	1.12* (1.03–1.22)	1.10* (1.01–1.20)	1.12* (1.02–1.23)
Work environment	0.83* (0.69–0.99)	0.86 (0.71–1.13)	0.86 (0.71–1.04)

Nurse staffing indicates a ratio of the number of patients to the number of registered nurses. Patient characteristics include: age, sex, comorbidities, type of surgery, number of procedures. Hospital characteristics include: hospital size, teaching status, technology status. All of the models account for clustering of patients within hospitals.

$*P < 0.05$; $**P < 0.01$.

infection prevention measures may be compromised. A systematic review of over 40 studies demonstrated overwhelming evidence that nurse staffing is linked to healthcare-associated infections [20]. A more recent study linked nurse burnout—emotional exhaustion associated with both emotional and cognitive detachment from one's work—with an increase in surgical site infection [14].

The second most common reason patients were readmitted was for packed cell transfusion, which is indicative of anemia secondary to blood loss. Blood loss following orthopedic surgery can be multifactorial and include gastrointestinal bleeding or bleeding around joints due to blood thinning medication. Identifying slow blood loss requires ongoing assessment of lab values, vital signs and physical status overtime. However, when nurses lack the requisite time to consistently and intermittently assess these trends, patient care may be jeopardized. Manageable nurse workloads enable nurses to surveil potential problems related to the patient's clinical condition and to communicate changes in the patient's condition with the healthcare team.

The work environment describes 'the organizational characteristics of a work setting that facilitate or constrain professional nursing practice' [18] and has previously been associated with readmissions [5–8]. In this study, patients cared for in more favorable work environments were less likely to be readmitted within 30 days. When nurses have strong collegial relationships with physicians, are autonomous in clinical practice and are supported by competent, effective leadership, the effects of a positive work environment impact patient care. Surgeons are integral to promoting positive work environments by contributing to a culture that values communication and coordination of care between providers. Fostering these collaborative environments can promote better health outcomes for patients [5–8, 13].

Although more favorable work environments were associated with lower odds of 30-day readmission, this relationship was not statistically significant for readmissions within 10 days. A plausible explanation for this could be that benefits of more favorable care environments more strongly influence potential readmissions rooted in social contextual causes than acute medical problems. Social contextual circumstances that may contribute to a readmission following a major joint replacement include being discharged home without adequate caregiver support, or otherwise lacking resources to follow self-care instructions. Nurses' close proximity to patients in the hospital allows them to develop interpersonal relationships through which nurses can become informed of patient's individual social contextual resources and needs. Supportive work environments prioritize the value of this information by communicating among providers, individualizing care plans and coordinating the necessary services for patients.

Since the enactment of the Affordable Care Act, reimbursements in the USA are increasingly shifting from volume of services to the value of care. For some hospitals, this shift has resulted in meaningful revenue losses as a result of CMS reimbursement penalties for poor performance on outcomes such as readmissions [21]. Since the Hospital Readmissions Reduction Program began including elective total hip and knee replacement readmissions in the reimbursement penalties, orthopedic surgeons may also be experiencing increased administrative and financial pressures to improve postoperative patient outcomes. Our findings suggest that hospital nurses can help to reduce postoperative readmissions. Specifically, emphasizing collaboration and communication between nurses and surgeons may be key to ensuring safe outcomes for patients.

Our findings provide implications for hospital administrators and policymakers. Empirical evidence suggests that when hospital budgets are squeezed, nursing services are often the first resource to be cut; however, doing so may be costly [22]. Hospital administrators should be cautious of reducing investments in nursing in an effort to cut expenses. One study demonstrated that investing in inpatient nurses was a cost-saving strategy that reduced readmissions through better preparing patients prior to discharge [23]. In fact, other recent evidence suggests that inpatient nursing may be a high-value investment [24–26].

Hospital investments in readmission reduction strategies often fail to optimally utilize their most numerous healthcare providers—nurses. Readmission reduction strategies that depend on existing staff to carryout additional care tasks (e.g. telephone follow-up calls), or require additional specialized personnel (e.g. patient care coordinators, community health workers), add additional complexity to an already complex system and lack strong empirical evidence [27, 28]. Indeed, our study demonstrates that hospital nursing is a foundation for high quality care, and when nurses are well-resourced and well-supported, patients may be less likely to experience a negative outcome.

Limitations

The cross-sectional study design limits our understanding of causal relationships; however, the risk adjustment we used allowed for more valid comparisons across patients and hospitals. A major strength of this study is that the risk adjustment used in this analysis was consistent with the risk adjustment used by CMS to calculate hospital readmission rates, thus making our findings particularly informative for providers and policymakers.

The age of the data poses only negligible limitations to this study. While the data collection and the introduction of the readmission

penalties are not contiguous, inpatient staffing and work environments have likely not changed significantly as a result of the penalties. The reimbursement penalties currently levied against hospitals are too small to incentivize many hospitals to meaningfully invest in improvements for inpatient hospital nursing [29–31]. Future studies may consider adjusting for surgical technique (e.g. robotic-assisted), which we were unable to do due to limitations of the data.

Conclusions

Despite increasing attention to care quality, hospitals remain a dangerous environment for many older adults. Hospital care is critical for many invasive surgeries and acute health needs, and remains a safety-net for the nation's most vulnerable people. While the causes of readmission are multifactorial, our findings demonstrate that hospital nursing care has important implications for patient outcomes. Indeed, the priority of all healthcare providers should be providing safe care to patients. Failure to reduce readmissions remains a signal for low quality, high cost healthcare and jeopardizes the health, safety and quality of life of patients.

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