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Executive Summary

- Under a proposal from the Centers for Medicare and Medicaid Services, hospitals would no longer be reimbursed for 30-day re-admissions or emergency department (ED) visits.
- Increasing RN staffing to reduce post-discharge utilization is one possible solution, but one that is not financially attractive to hospitals.
- This study demonstrates the impact of fluctuating staffing levels on ED visits within 30 days of discharge.
- RN overtime and RN vacancies also affected subsequent ED visits.
- It is important for nurse managers, directors, and administrators to recognize the impact of RN staffing on patient outcomes.
- Reimbursement models will need to be realigned to benefit both hospitals and payers.

REDUCTION OF HOSPITAL re-admissions and emergency department visits has been proposed as a strategy to reduce costs of health care. Jencks, Williams, and Coleman (2009) found nearly 20% of Medicare beneficiaries were re-hospitalized within 30 days of hospital discharge, with an estimated cost to Medicare at $17.4 billion. Re-admissions have been identified as potentially preventable and are considered an indicator of poor quality of care (Goldfield et al., 2008; Minott, 2008). Post-discharge utilization has been attributed to inadequate discharge planning, lack of outpatient followup care, and inadequate systems to support the transition to home-based care (Coleman et al., 2004; Goldfield et al., 2008; Jack et al., 2009; Mistiaen, Francke, & Poot, 2007; Naylor et al., 1999; Weiss et al., 2007). While organization-level staffing has been linked to re-admission in specific populations (Heggestad, 2002; Van Doren, Bowman, Landstrom, & Graves, 2004), measurement of unit-level staffing on post-discharge outcomes may be a better reflection of nursing care that can impact outcomes.

In this study, researchers examined the impact of unit-level nurse staffing on unplanned re-admissions and emergency department (ED) visits within 30 days after discharge from 16 adult medical-surgical units. We estimated the financial impact of modifications to nursing staffing in terms of cost avoidance by hospitals and payers for post-discharge utilization. Specific nursing unit staffing characteristics included non-overtime registered nurse (RN) hours per patient day (RNHPPD), non-overtime hours per patient day by non-RN patient care staff (non-RNHPPD), RN and non-RN overtime hours per patient day (RNOT, non-RNOT), and RN vacancy rate (RNVac). The specific aims were (a) investigate the predictive relationship between unit-level nurse staffing and all-cause unplanned post-discharge utilization (ED visits and re-admission); (b) investigate the predictive relationship between nurse staffing and un-

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planned related post-discharge utilization (ED visits and re-admission for reasons directly related to the index admission or co-morbidities); and (c) conduct cost-benefit evaluation of increasing staffing levels (RNHPPD, non-RNHPPD, RNOT, and non-RNOT) on post-discharge utilization (ED visits and re-admission) for hospitals and payers.

Literature Review

There is a growing body of evidence of the impact of nurse staffing, measured at the organization level, on patient outcomes. Higher RN hours of nursing care per day, calculated based on full-rime equivalents (FTEs), were associated with reduced length of stay and other inpatient adverse events (Aiken, Clarke, Sloane, Lake, & Cheney, 2008; Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002). Kane, Shamliyan, Mueller, Duval, and Wilt (2007), in a meta-analysis, found hospitals with more nursing hours had fewer inpatient adverse events. They noted differences with definitions of staffing, computational approaches, and units of analysis in the various studies made comparisons between studies difficult. Staffing data are often derived from administrative databases and are sometimes calculated as FTEs per patient and other times as hours per patient day.

The effects of organizational-level RN staffing characteristics on 30-day post-discharge outcomes of re-admission of elderly patients have been investigated in two studies (Heggestad, 2002; Van Doren et al., 2004). Van Doren et al. (2004) found no relationship between RNHPPD and re-admissions in a congestive heart failure population. Heggestad (2002) reported elderly patients were more likely to be re-admitted when the ratio of patients to nurses was higher.

Studies conducted with unit-level variables concluded unit characteristics could impact patient outcomes. Boyle (2004) explored relationships between unit work environment and nursing-sensitive adverse inpatient outcomes. She used the Nursing Work Index-Revised (Aiken & Patrician, 2000) as a measure of work environment and found units with a better perceived work environment had fewer adverse inpatient events. Seago, Williamson, & Atwood (2006) found higher RNHPPD increased patient satisfaction and decreased adverse events, such as medication errors. Recommendations from the Seago study included adding other unit-level characteristics to determine what other factors may be important in improving patient outcomes. No reported studies to date have examined the impact of unit-level nurse staffing on post-discharge utilization of ED visits or re-admission.

The cost effectiveness of increasing nursing staffing has recently been noted. Since nursing is always a cost in hospital budgets, it is necessary to show offsets that can be attained through increased staffing (Aiken, 2008). Rothberg, Abraham, Lindenauer, and Rose (2005) demonstrated potential annual savings of 72,000 patient lives by increasing nurse-to-patient ratios. Needleman, Buerhaus, Steward, Zelevinsky, and Mattke (2006) found cost offsets for increased staffing occur as a result of avoided days of care. In this study, avoided days of care are reduced re-admissions and ED visits after an index hospitalization.

The theoretical framework used for this study was derived from Donabedian's (1966) structure-process-outcomes model, specifically addressing the link between structure and outcome. Structure was defined as nursing unit staffing. The amount of nursing time made available to patients for care during hospitalization, including preparation for discharge, can be described in terms of RNHPPD, non-RNHPPD by unit staff who assume non-RN care tasks, RNOT and non-RNOT, and staffing stability measures, such as RN vacancy rates. These unit-level care metrics represent the average amount of direct care provided to patients by the collective of nurses on a unit.

This study does not evaluate processes of care. However, care processes, such as discharge preparation, medication administration, and assessment, are provided to patients over the course of hospitalization by numerous nurses within the unit. Discharge preparation is a core process for which staff nurses assume primary responsibility in many hospitals (Nosbusch, Weiss, & Bobay, 2010) and which is provided over the course of the patient's hospitalization by the complement of nurses who staff a unit (Weiss et al., 2007). The study of the relationship between structure and discharge-related care processes and these processes and post-discharge outcomes are important to a comprehensive understanding of the complex relationships between structure, process, and outcomes but are beyond the scope of this study. This study focuses on the structure-outcome relationship. Re-admission and/or ED visits are proxy measures for adverse outcomes in this study.

Methods

The study was a retrospective multi-level analysis of the impact of variation *within-unit-over-time* in nurse staffing characteristics of medical-surgical units on patients' post-discharge utilization.

Unit-level variables. Nursing unit-level variables included RNHPPD and non-RNHPPD, RNOT, non-RNOT, and RN vacancy. Nursing unit staffing variables were reported monthly for each of the 16 units over the 6 months of the study period. RNHPPD is defined as the number of productive hours worked by nursing staff assigned to the nursing unit who have direct patient care responsibilities for greater than 50% of

their shift (National Database for Nursing Quality Indicators [NDNQI], 2008). RNOT was defined by the study organization as time worked over 80 hours in a 2-week pay period or more than 12.5 hours in a 24-hour period. RN vacancy was defined by the organization as the percentage of FTEs that remain vacant for more than 2 weeks. Non-RNHPPD is defined as the number of productive hours worked by non-RNs (licensed practical nurses and unlicensed assistive personnel) who have direct patient care responsibilities greater than 50% of their shift (NDNQI, 2008). Non-RNOT was defined by the organization as time worked over 80 hours in a 2-week period or more than 12.5 hours in a 24-hour period by non-RNs.

Patient-level variables. The outcome variable of interest was unplanned re-admissions or ED visits within 30 days post discharge. Medical records, both electronic and paper, were reviewed for each occurrence. Cause of unplanned re-admission or ED visits was determined by joint agreement of two investigators and was coded as either related or not related to the index hospitalization. Related cases were those where the re-admission/ED visit diagnosis was the same as the primary diagnosis of the index admission, or a co-morbid condition present on admission or contributing to the index admission, or where the reason for the re-admission/ED visit was a complication associated with the index hospitalization. Unrelated cases were those where the re-admission could not be linked to the index hospitalization.

Patient characteristics used as control variables including age, gender, type of health insurance (private vs. public), major diagnostic category, and type of admission (medical or surgical) were obtained from electronic clinical information systems (see Table 1).

Samples and Data Sources

The study was conducted within a four-hospital Magnet®-designated health care system in the Midwestern United States. Sixteen nursing units defined as medical, surgical, or medical-surgical based on NDNQI (2008) criteria were included as the unit-level sample. Following approval by health system and university institutional review boards, unit and patient data were obtained electronically.

For the patient-level variables, a list of 110 randomly selected patients from each of 16 study units who were hospitalized during January 2007 through June 2007 was generated by the clinical information systems department of the health system, for a total of 1,760 patients. The sample size was estimated using the Power IN Two-level designs program, Version 2.1 (PINT) (Bosker, Snijders, & Guldemond, 2003). Inclusion criteria for patients were age 18 years or older and discharged to home without home hospice services. Patients discharged to other locations, such as sub-acute units, rehabilitation units, or long-term care facilities, were not included in this analysis. Using financial databases, re-admission and ED encounters were identified by searching hospital financial databases of the index hospitalization and of the other three study hospitals. Re- admissions and ED visits were included in the analyses if they occurred at any one of the study hospitals for any unplanned cause within 30 days of the index hospitalization discharge date. One hundred cases were subsequently excluded due to failure to meet inclusion criteria for the index admission. In cases of multiple admissions within a 30-day period, the first admission was coded as the index hospitalization and subsequent admissions recod-

Table 1.
Study Sample Descriptives (N=1,660)

Variable	Mean	SD
RNHPPD	4.96	0.71
Non-RNHPPD	3.70	0.66
RNOT	0.19	0.08
Non-RNOT	0.14	0.09
RNVAC	7.25	7.30
ADR	0.02	0.01
Age	59.05	17.14
	N	%
Sex		
Male	861	51.87
Female	799	48.13
Type of insurance		
Private	641	38.61
Other	1,019	61.39
Type of admission		
Medical	1,016	61.2
Surgical	644	38.8

Table 1 continued on next page

Table 1. (continued)
Study Sample Descriptives (N=1,660)

Major Diagnostic Category		N	%
Transplant	0	13	0.78
Neurologic	1	141	8.49
Eye	2	1	0.06
ENT	3	20	1.2
Respiratory	4	196	11.81
Cardiac	5	415	25
Abdominal	6	189	11.39
Hepatic	7	73	4.4
Orthopedic	8	288	17.35
Dermatologic	9	53	3.19
Endocrine	10	49	2.95
Renal	11	61	3.67
Male reproductive	12	10	0.6
Female reproductive	13	28	1.69
Obstetric	14	6	0.36
Hematologic	16	16	0.96
Oncology	17	7	0.42
Infectious disease	18	47	2.83
Mental health	19	5	0.3
Substance abuse	20	13	0.78
Poisoning	21	15	0.9
Rehabilitation	23	8	0.48
HIV	24	6	0.36
Re-admission			
Unplanned		186	11.2
Unplanned related		156	9.4
ED visit			
Unplanned		103	6.2
Unplanned related		84	5.06

RNHPPD = RN hours per patient day
Non-RNHPPD = Non RN hours per patient day
RNOT = RN overtime hours per patient day
Non-RNOT = Non RN hours overtime hours per patient day
RNVAC = RN vacancy
ADR = admission discharge ratio

ed as re-admissions linked to the primary index event. There were 1,660 patients in the final sample.

Financial data for cost-benefit analysis was derived from the hospital system's cost accounting database. Patient-level financial data were extracted at least 6 months after the hospital discharge date to increase the likelihood of completion of reimbursement appeal processes.

Analysis Methods

Analysis of the relationship between nursing unit hours and re-admission/ED visits was performed using multi-variable fixed-effects panel regression analysis (Woolridge, 2002). This type of analysis investigates the impact of variation within a nursing unit over time and the impact of this variation on outcomes. In this study, the investigation focused on the impact of the variations in month-to-month staffing within nursing units. We controlled for patient characteristics that might otherwise explain post-discharge utilization. Unit-level and hospital-level fixed effects were included in all models, which allowed us to evaluate the impact of within-nursing unit variation in staffing over time and to control for between-unit variance in variables that may have confounded the relationship between work hours and patient outcomes (such as nurse experience, education, or type of patients).

A multinomial logistic regression model was used to examine relationships between nurse staffing variables and post-discharge utilization. The outcome variable, re-admission and/or ED visits, had three possible values: (0) patient had no occurrences of post-discharge utilization within 30 days, (1) patient had at least one ED visit and no re-admissions, and (2) patient had at least one re-admission, with or without subsequent ED visits. The nurse staffing variables (RNHPPD, non-RNHPPD, RNOT, non-RNOT, and RNVac) were standardized by subtracting the mean and dividing by the standard deviation of each variable. The models controlled for patient's age, sex, type of insurance, and the Major Diagnostic Categories (MDC) derived from the APR-DRGs (Averill et al., 2003). Odds ratios for re-admission/ED visits were computed for each staffing variable. The analysis was repeated to first reflect all unplanned occurrences, and then

only unplanned and related occurrences.

Once impact estimates were calculated, we conducted a cost-benefit analysis for the impact of modifying nurse staffing at the unit level to determine costs and/or savings calculated from the perspective of hospitals and payers. All dollar amounts were reported in 2008 dollars to reflect the latest available cost estimates. Costs and savings were calculated per patient for the total study sample of 1,660 patients in order to reflect the estimated savings per hospitalized patient.

Cost-benefit analysis for hospitals. Hospitals incur costs of adding nursing staff to the index hospitalization, as well the resulting change in patient revenue associated with changes in incidence of post-discharge re-admissions or ED visits. Depending on reimbursement rates, return visits could result in net cost or savings to a hospital. Staffing costs were calculated as the Increase in Staffing Costs = [Hourly Cost of Compensation] × [St. Dev.] × [Average Length of Stay]. We used the average hourly cost of compensation, including salary and benefits, from the U.S. Bureau of Labor Statistics (2009). RN compensation was $45.83 (salary, $31.66; benefits, $14.17) and non-RN compensation was $29.66 (salary, $19.28; benefits, $10.38). Cost of overtime was calculated as 1.5 times the hourly salary without benefits. Multiplying hourly cost of compensation by the standard deviation of work hours [St. Dev.] scales the hourly cost figure up or down to reflect a one standard deviation adjustment. Average length of stay (LOS) is the unit-level mean length of hospital stay during the index hospitalization, and reflects the total cost of additional staffing from increasing hours per patient day will be greater for patients with longer LOS.

Change in patient net revenue from reduced re-admission/ED visits was calculated using the following formula: Change in Net Revenue = [Re-admission Net Revenue] × [Change in number of re-admissions] + [ED Visit Net Revenue] × [Change in number of ED visits]. Only statistically significant relationships were considered. Total financial impact of increased staffing on hospitals incorporates both higher staffing costs and any change in patient revenue from reduced post-discharge utilization.

Cost-benefit analysis for payers. Reduced post-discharge utilization benefits payers by lowering reimbursement payments to hospitals and physicians. The financial impact of higher staffing levels for payers was estimated as the total expected reduction in payment to both hospitals and physicians, from lowering the incidence of re-admissions and ED visits: Total Financial Impact = [Re-admission Reimbursement to Hospital + Re-admission Reimbursement to Physician] × [Change in number of re-admissions] + [Reimbursement to Hospital for ED Visit + Reimbursement to Physician for ED Visit Pay] × [Change in the number of ED visits]. Reimbursements to hospitals for re-admission and ED visits are the sample means of hospital charges for patients who were re-hospitalized or had an ED visit.

Physician reimbursements were estimated using 2008 Medicare physician reimbursement formulas based on relative value units (RVU), geographic practice cost indices (GPCI), and conversion factors (CF) for the state of Wisconsin (Centers for Medicare and Medicaid Services [CMS], 2009a, 2009b, 2009c).

Results

The estimated results for the predictive relationship between nurse staffing variables and post-discharge utilization, controlling for patient characteristics and major diagnostic category, are shown in Table 2 (all unplanned occurrences of re-admission and ED visits) and Table 3 (unplanned and related occurrences only). Odds ratios were used to determine the probability that an event, in this case re-admission or ED visit, will or will not occur (Polit & Hungler, 1999). An odds ratio greater than 1 indicates the percent greater probability of the event occurring (odds ratio [OR] = 1.55, indicates a 55% greater likelihood of event occurring). Similarly, an OR less than 1 indicates a lower probability of the event occurring.

The estimates suggest that within a nursing unit over time, at times when unit RNHPPD was higher, unplanned ED visits were lower. Specifically, an increase of 1 standard deviation (0.71 hrs) in RNHPPD was associated, all else equal, with a 45% lower odds of an unplanned ED visit in models for unplanned and unplanned related ED visits ($p < 0.01$) (see Table 2). Similarly, within a nursing unit over time, a 1 standard deviation increase (0.66 hrs) in non-RNHPPD was associated with a 32% reduction in the odds of an unplanned ED visit (p value <0.05) and 45% reduction in the odds of an unplanned related ED visit (p value <0.05). On the other hand, a one standard deviation (0.08 hrs) increase in RNOT was associated with a 33% increase in the odds of an unplanned ED visit (p value = 0.05), and a 36% increase in the odds of an unplanned related ED visit (p value = 0.06). The odds of an ED visit were significantly higher during the times on nursing units when RN vacancy was higher (OR 22.29, p value <0.01). RNHPPD, non-RNHPPD, and RNVac were not significantly related to the odds of inpatient re-admission. Non-RNOT was not significantly related to any measures of re-admission or ED visits.

Unit and patient characteristics were included as control variables in the above regression models and several were identified as significant contributors to odds of

Table 2.
Multinomial Logistic Results of Relationships Between Staffing and Unplanned Post-Discharge Utilization (N=1,660)

	ED Visits (n=102)			Re-Admissions (n=165)		
	OR	Robust Standard Error	*p*>z	OR	Robust Standard Error	*p*>z
RNHPPD	0.55	0.09***	0.00	1.00	0.19	0.98
Non-RNHPPD	0.68	0.12**	0.03	0.86	0.13	0.31
RNOT	1.33	0.19**	0.05	1.12	0.20	0.53
Non-RNOT	1.19	0.29	0.48	0.83	0.13	0.25
RNVac	1.85	1.61	0.48	2.78	1.59*	0.07
ADR	1.69	0.64	0.17	0.52	0.15**	0.03
Male	0.68	0.23	0.26	0.74	0.13*	0.07
Age	0.98	0.01**	0.03	1.00	0.01	0.64
Private_Insurance	0.31	0.10***	0.00	0.64	0.17*	0.10
Private_Insurance x Pt_Age_65	1.39	1.44	0.75	1.42	1.06	0.64
MDC 0	0.63	0.97	0.77	1.67	1.38	0.53
MDC 1	0.87	0.47	0.80	1.06	0.48	0.90
MDC 2	0.00	0.00***	0.00	0.00	0.00***	0.00
MDC 3	0.93	0.80	0.93	0.52	0.64	0.60
MDC 4	0.91	0.37	0.81	1.52	0.66	0.34
MDC 5	0.40	0.18**	0.04	0.65	0.32	0.39
MDC 6	0.29	0.14**	0.01	0.77	0.26	0.45
MDC 7	0.71	0.47	0.60	0.73	0.31	0.46
MDC 9	0.28	0.20*	0.08	1.24	0.57	0.64
MDC 10	0.87	0.70	0.87	1.26	0.76	0.70
MDC 11	0.48	0.40	0.38	0.36	0.21*	0.09
MDC 12	0.00	0.00***	0.00	0.88	0.35	0.76
MDC 13	0.81	0.81	0.83	2.12	1.57	0.31
MDC 14	0.00	0.00***	0.00	2.23	2.87	0.53
MDC 16	0.36	0.42	0.39	0.47	0.44	0.42
MDC 17	0.00	0.00***	0.00	2.88	2.79	0.27
MDC 18	0.17	0.14**	0.03	0.32	0.33	0.27
MDC 19	0.00	0.00***	0.00	1.75	1.71	0.56
MDC 20	1.06	1.00	0.95	0.79	1.02	0.86
MDC 21	1.94	1.49	0.39	0.61	0.70	0.67
MDC 24	0.99	1.25	1.00	0.00	0.00**	0.00
R-Squared	0.09					
Chi-Squared	160.01					

NOTES: *<0.10, **<0.05, ***<0.01. Other controls include a time trend and unit and hospital fixed effects (not shown in the table). The omitted diagnostic category is MDC8. Standard errors are controlled for clustering. See Table 1 for description of MDC codes.

Table 3.
Multinomial Logistic Results of Relationships Between Staffing and Unplanned Related Post-Discharge Utilization (N=1,660)

	ED Visits (n=84)			Re-Admissions (n=156)		
	OR	Robust Standard Error	*p*>z	OR	Robust Standard Error	*p*>z
RNHPPD	0.55	0.12***	0.01	1.05	0.18	0.78
Non-RNHPPD	0.55	0.15**	0.03	0.81	0.10	0.11
RNOT	1.36	0.22*	0.06	1.09	0.19	0.61
Non-RNOT	1.39	0.33	0.17	0.84	0.12	0.22
RNVac	22.29	25.40***	0.01	1.94	1.22	0.29
ADR	1.41	0.58	0.40	0.47	0.15**	0.02
Male	0.55	0.20*	0.10	0.73	0.12*	0.06
Age	0.99	0.01	0.12	1.00	0.01	0.95
Private_Insurance	0.37	0.10***	0.00	0.64	0.17*	0.09
Private_Insurance x Age ≥ 65	1.29	1.41	0.81	1.50	1.12	0.59
MDC 0	1.06	1.67	0.97	1.82	1.51	0.47
MDC 1	1.22	0.94	0.79	1.08	0.52	0.87
MDC 2	0.00	0.00***	0.00	0.00	0.00***	0.00
MDC 3	1.77	1.65	0.54	0.57	0.71	0.65
MDC 4	0.97	0.51	0.96	1.60	0.71	0.29
MDC 5	0.60	0.32	0.35	0.69	0.37	0.49
MDC 6	0.42	0.24	0.13	0.81	0.31	0.59
MDC 7	0.95	0.69	0.94	0.76	0.33	0.53
MDC 9	0.21	0.23	0.16	1.11	0.59	0.84
MDC 10	1.12	1.03	0.90	1.10	0.59	0.87
MDC 11	0.73	0.69	0.74	0.40	0.24	0.13
MDC 12	0.00	0.00***	0.00	0.93	0.41	0.87
MDC 13	0.62	0.56	0.59	2.15	1.52	0.28
MDC 14	0.00	0.00***	0.00	2.33	3.03	0.52
MDC 16	0.60	0.75	0.69	0.53	0.51	0.51
MDC 17	0.00	0.00***	0.00	3.10	3.00	0.24
MDC 18	0.25	0.25	0.16	0.35	0.36	0.31
MDC 19	0.00	0.00***	0.00	0.00	0.00***	0.00
MDC 20	0.63	0.93	0.76	0.00	0.00***	0.00
MDC 21	1.87	1.72	0.49	0.58	0.64	0.62
MDC 24	1.25	1.61	0.86	0.00	0.00***	0.00
R-Squared	0.08					
Chi-Squared	140.09					

NOTES: *<0.10, **<0.05, ***<0.01. Other controls include a time trend and unit and hospital fixed effects (not shown in the table). The omitted diagnostic category is MDC8. Standard errors are controlled for clustering. See Table 1 for description of MDC codes.

Table 4.
Financial Impact of Increased Staffing on Hospitals and Payers

	Unplanned Utilization				Unplanned Related Utilization			
	Hospitals		Payers		Hospitals		Payers	
	Net Revenue	Staffing Costs	Hospital Pay	Physician Pay	Net Revenue	Staffing Costs	Hospital Pay	Physician Pay
Increase RNHPPD	-1.767	129.72	-18.17	-2.04	-1.51	129.7	-15.5	-1.74
Total Financial Impact	-131.48		20.21		-131.22		17.22	
Increase Non-RNHPPD	-1.11	82.22	-11.45	-1.29	-1.43	82.22	-14.68	-1.65
Total Financial Impact	-83.33		12.73		-83.65		16.33	
Increase RNOT	0.80	10.64	8.24	0.93	—	—	—	—
Total Financial Impact	-9.84		-9.16		—		—	

NOTES: Values are derived based on a one standard deviation increase in each of the staffing variables and the following data: hourly cost of staffing is $45.43 (RN), $29.66 (non-RN), and $31.66 (RNOT); standard deviation is 0.71 (RNHPPD), 0.66 (non-RNHPPD), and 0.08 (RNOT); average LOS is 4.24 days; net revenue for an ED visit is $54.40; reimbursement for an ED visit is $645.93; physician payment for an ED visit is $62.84. Estimates are presented on a per-patient basis, multiply by patient census to get the total amount. Values are expressed in 2008 dollars, multiply by 1.031 to calculate equivalent 2007 dollars.

re-admission or ED visits. For example, patients discharged from units with a higher admission to discharge ratio (ADR) were less likely to be re-admitted (OR 0.52 and 0.47 in Tables 2 and 3, respectively; p value <0.05), and more likely to have an ED visit (OR 1.69 and 1.41, and p value 0.17 and 0.40, respectively). Privately insured patients were significantly less likely to have an ED visit (OR 0.31 for all unplanned and 0.37 for unplanned-related ED visits; p value <0.01). Older patients had slightly lower odds of having an ED visit in the model for all unplanned occurrences (OR 0.98; p value=0.03), but not in the related occurrences model. Patient characteristics and type of insurance were insignificant predictors of re-admission.

Patients in some diagnostic categories were less likely to be re-admitted or have post-discharge ED visits. Patients with orthopedic diagnoses (MDC8) were the reference category because it was a highly populated diagnostic group (see Table 1) with the highest rates of post-discharge utilization. Patients with MDC2 (eye), MDC5 (cardiac), MDC6 (abdominal), MDC 12 (male genitourinary), MDC14 (female reproductive), MDC17 (oncology), MDC18 (infectious disease), and MDC19 (mental health) patients had lower odds of having an unplanned ED visit. Patients with MDC2, MDC 12, MDC14, MDC17, and MDC19 were less likely to have an unplanned and related ED visit. With respect to re-admission, MDC2 and MDC24 (HIV) patients were less likely to have an unplanned re-admission. Patients with MDC2, MDC19, MDC20 (substance abuse), and MDC24 patients were less likely to be re-admitted for a related reason (see Table 3). However, due to the small number of patients in many of the diagnostic categories, the corresponding odds ratios and standard errors (shown in Tables 2 and 3) may not be generalizable. There were no significant differences in ED visits or re-admission among other diagnostic categories.

Cost-benefit estimations are shown in Table 4. Since there were no statistically significant relationships between staffing and inpatient re-admission, only effects on post-discharge ED utilization were considered. Increasing RNHPPD by one standard deviation is expected to increase hospitals' costs of nursing labor by $129.72. According to the unplanned occurrences model, the resulting reduction in post-discharge ED utilization is expected to reduce hospital net revenue by $1.77 for each hospitalized patient ($1.51 in the unplanned related model). Therefore, hospitals would expect to incur a loss in the total amount of $131.48 per hospitalized patient ($131.22 in the unplanned-related model). Due to reduced ED utilization, payers are expected save $18.17 in hospital reimbursements and $2.04 in physician reimbursements ($15.50 and $1.74 in the unplanned related model), realizing a savings in the total amount of $20.21 per hospitalized patient ($17.22 in the unplanned-related model).

Lower RN overtime was associated with lower ED utilization in the unplanned occurrences model. A decrease in RNOT of one standard deviation will decrease hospital costs by $10.64, and is expected to reduce ED revenue by $0.80, leading to a net gain in the amount of $9.84 per hospitalized patient. Due to decreased ED uti-

lization, insurance companies are expected to see an $8.24 decrease in hospital reimbursement and a $0.93 decrease in physician reimbursement, thus experiencing a total gain of $9.16 per hospitalized patient.

Discussion

This study used a *within-unit-over-time* methodology to estimate the effects of unit-level nurse staffing on the post-discharge outcomes of all unplanned and unplanned-related re-admissions and ED utilization. The results indicate that at times when RNHPPD measured at the unit level are higher, the likelihood of an ED visit was lower. At times when RNOT were lower, the likelihood of an ED visit was lower. We believe this is the first study to consider the effects of nurse staffing during the initial hospitalization on post-discharge utilization and, in particular, the effect of within-unit variation in staffing, a factor that can be managed by unit-level managers. The results extend the work of others whose earlier studies demonstrated the impact of nurse staffing measured at the organization level on patient outcomes of hospitalization (Aiken et al., 2008; Kane et al., 2007; Needleman et al., 2002).

In this analysis, higher RNHPPD were associated with lower likelihood of ED utilization. More RN hours per patient may allow the nurse to spend more time with individual patients to better assess post-discharge needs. Additional hours of non-RN providers may free up RNs to perform high-level care activities that require their expertise including the discharge preparation functions of discharge planning, coordination, and teaching.

Higher RN overtime hours were associated with greater odds of ED visits. These findings are not surprising. When RNs work overtime, fatigue may lead to poorer patient outcomes (Rogers, Hwang, Scott, Aiken, & Dinges, 2004). Higher non-RNHPPD were also associated with fewer ED visits.

Higher RN vacancy increased the likelihood patients would have higher unplanned-related ED visits post-discharge (OR 22.29, $p < 0.05$). Vacancy hours on a unit are typically covered by increased overtime or by part-time staff working more hours. Fatigue may be a factor in poorer patient outcomes.

The cost-benefit analysis demonstrates a cost savings for payers when nurse staffing is higher. The benefit comes from lower reimbursement to hospitals and physicians for decreased ED visits. Hospitals would not recognize a financial benefit from additional staffing; however, improved patient outcomes, evidenced by reduced ED utilization, is a desired quality outcome. In fact, hospitals would incur the combined costs of increased staffing costs and reduction in reimbursements that currently accrue for most re-admissions and ED visits related to an index hospitalization. The Medicare Payment Advisory Commission's (2008) proposal to bundle accountability for hospitalization and post-hospitalization would change the payment structures and incentives for management of patients across the discharge transition, supporting investment in pre-discharge care to improve post-discharge outcomes. The role of optimizing unit staffing through increases in RNHPPD and decreased use of RNOT should be considered potential avenues to achieve better and more cost-effective outcomes. Aligning index hospitalization reimbursements to hospitals to create incentives for optimizing staffing will be critical to this initiative. Ultimately, patients benefit from better quality of care and fewer adverse outcomes that necessitate post-discharge utilization.

This study has several limitations that compromise generalizability. The study used only 16 nursing units to measure *within-unit-over-time* variation in staffing. The 6-month time span of data points is brief, meaning that our findings may not be robust over time. The study occurred within Magnet-designated hospitals, which may also affect generalizability to other settings. The outcome variables, re-admission, and ED visits occurred at rates of only 11.2% and 6.2%, respectively. Therefore, the study's power to accurately detect relationships may be limited. These limitations point to the need for replication with a larger sample of nursing units, with more data points over time, and a greater diversity of hospital types, such as non-Magnet designated hospital systems, academic medical centers, and rural facilities.

The analysis models incorporated several patient-level control variables to assist in uncovering a causal relationship of nurse staffing to post-discharge outcomes independent of the effects of other variables that are likely to contribute to post-discharge utilization. Variables were included that were available through electronic sources. Other variables that may explain re-admission or ED utilization, such as socioeconomic status, living alone, transition support services, and/or case management should be added to the models during retesting. Due to the *within-unit-over-time* analysis model, nurse staffing and practice environment variables that are collected at less-frequent intervals than monthly or are not available electronically were not included but should be considered for future research. RN turnover, RN education level, RN expertise, RN experience, and RN job satisfaction might be considered.

The study design permitted investigation of relationships between unit structure, as measured by staffing and patient outcomes. While the relationship to ED utilization was evident, the reason why improved staffing would lead to improved outcomes was not evident. The missing link,

process, was not investigated in this study. Specifically, how nurse staffing impacts nursing processes on the nursing unit and how nurse processes are associated with post-discharge utilization requires investigation. For example, are nurse staffing levels associated with the quality of discharge preparation, subsequent ability to self-manage at home after discharge, and ultimately to post-discharge utilization?

Conclusions

This study demonstrates the impact of fluctuating staffing levels on ED visits within 30 days of discharge. RN overtime and RN vacancies also affected subsequent ED visits. It is important for nurse managers, directors, and administrators to recognize the impact of RN staffing on patient outcomes.

Under a proposal from CMS, hospitals would no longer be reimbursed for 30-day re-admissions or ED visits. Increasing RN staffing to reduce post-discharge utilization is one possible solution, but one that is not financially attractive to hospitals. Health systems and payers will need to work together to improve patient outcomes by finding a payment system that benefits all. Reimbursement models will need to be realigned to benefit both hospitals and payers.

We believe this study is unique for its contribution in describing the relationships between *within-unit-over-time* staffing and post-discharge utilization and associated costs. With the current focus on reducing re-admissions in new health reform plans, this study provides important information hospitals can use in planning care by managing within-unit staffing fluctuation to avoid understaffing. **$**

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