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Predictors of 30-Day Readmission for Pneumonia

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OBJECTIVE: This study examined data from 4 sources: number of hospital-acquired conditions, patient perception of care, quality outcome measures, and demographic data to explain variances associated with 30-day pneumonia readmission rates.
BACKGROUND: Patients readmitted within 30 days for pneumonia increases the length of hospital stay by 7 to 9 days, increases crude mortality rate 30% to 70%, and costs of $40 000 or greater per patient.
METHODS: Variances in outcomes measures associated with 30-day pneumonia readmissions from 577 nonfederal general hospitals in Massachusetts, California, and New York were analyzed using datasets from Hospital Consumer Assessment of Healthcare Providers and Systems, Centers of Medicare & Medicaid Services, Agency for Healthcare Research and Quality, and American Hospital Association.
RESULTS: Three factors increased pneumonia readmission rates: poor nurse-patient communication, poor staff responsiveness to patient needs, and iatrogenic pneumothorax. Conversely, factors lowering pneumonia readmission rates included patients hospitalized in California, higher RN staffing, and higher proportions of nursing staff to total hospital personnel.
CONCLUSION: Findings suggest lower nurse staffing, poor nurse-patient communication, and nurse responsiveness to patient needs contribute to increased pneumonia readmission rates.

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Hospital readmissions within 30 days are costly, unnecessary, and burdensome. In 2011, it was estimated that all-cause hospital readmissions were associated with approximately $4.3 billion Medicare dollars related to hospital costs. In 2011, readmissions within 30 days totaled 3.3 million, and more than 55% of those patients were on Medicare.[1] Hospital readmissions are harmful to all patients, but older adult readmissions in particular are associated with delirium, frailty, and a significant decline in functional ability, resulting in disability and loss of independence.[2] It is estimated that 836 000 of the more than 7 million readmissions annually are avoidable.[3]

Pneumonia is a common reason patients are readmitted within 30 days. The incidence of pneumonia in 2011 was approximately 157 500.[4] The American Lung Association reports that almost 90% of pneumonia cases occur while patients are mechanically ventilated in intensive care units. In addition, pneumonia increases hospital length of stay by 7 to 9 days, has a crude mortality rate of 30% to70%, and is associated with an estimated cost of $40 000 or more per patient.[5] Postoperatively, pneumonia has been shown to develop in 9% to 40% of patients after abdominal surgery, with an associated 30% to 40% mortality rate.[6]

Study Background

With the passage of the Affordable Care Act in 2010,[7] changes are now in place to the Inpatient Prospective Payment System,[8] which control Medicare expenditures. In 2013, hospitals with excess readmission rates for pneumonia received a 1% reduction in payment from Centers of Medicare & Medicaid Services (CMS); in 2014, it increased to a 2% reduction.[8] As

a result, quality indicators are being utilized to determine best practices for improving patient outcomes. These quality indicators include patients' perspective of care as measured through the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey,[9] the number of hospital-acquired conditions as captured by CMS, and patient safety indicators as defined by the Agency for Healthcare Research and Quality (AHRQ) quality outcomes measures.[10] The American Hospital Association (AHA) annual survey of hospitals is a source to retrieve updated information related to organizational structures and personnel data.[11]

While individually these data provide information about quality of care, a gap exists in understanding how these multiple sources of data are associated with pneumonia readmission rates. Using Donabedian's model of structure, process, and outcomes,[12] this study addresses potential gaps by examining associations between data from AHA, HCAHPS, AHRQ, and CMS with pneumonia readmission. In addition, factors will be analyzed that may explain variances associated with pneumonia 30-day readmission rates.

The AHA data provided the Donabedian model structural information using hospital organizational structure, geographic indicators, and physician and nurse staffing. The HCAHPS survey, providing the Donabedian process dimension, uses questions from a section of the survey that specifically describes the patient perspective of nursing care. These data are collected by dissemination to a random sample of adult patients 30 days after discharge.[13] Both CMS[14] and AHRQ[10] data provide information about the outcomes of hospital-acquired conditions and patient safety. The study sample included nonfederal general hospitals in Massachusetts, California, and New York, which are 3 states with similarity relative to cost of living, a high percentage of academic medical centers per capita, and total hospital discharges as reported in the American Hospital Directory.[15]

Methods

Protection of Human Subjects

This study used publicly available, deidentified data and therefore was exempt from internal review board approval.

Sample

The 3 states selected, California, Massachusetts, and New York, met criteria for holding similar characteristics related to cost of living and hospital discharges, but also yielded a sample providing a wide range of variability for the occurrence of pneumonia readmissions, thus facilitating the evaluation of the relationship of covariates on this condition. California reported low pneumonia excess readmission ratios (14.3), whereas Massachusetts represented moderate levels (15.7), and New York held high readmission levels (16.4).[16] Sampling was completed at the state level. The total number of nonfederal general hospitals included in this study was 577, with the largest sample from California (n = 336), followed by New York (n = 179) and Massachusetts (n = 62).

Data Sources

The data sources included the 2011 AHA Annual Survey of Hospitals, the CMS hospital performance measures from 2008 to 2011, AHRQ Quality Outcomes Measures from 2009 to 2011, and HCAHPS from 2011 to 2012. These time periods may appear widely different, but reporting of data collected by each entity is often delayed so data periods coincide despite perceived variation. The CMS 30-day risk standardized excess readmission ratio for pneumonia, HCAHPS process of care measures sensitive to nursing, CMS performance measures, and AHRQ quality outcome measures were merged to the AHA dataset by the CMS provider number. The technical specifications to produce the CMS 30-day risk standardized excess readmission ratio,[17,18] the full description and technical specifications for the HCAHPS[13,19] and the publicly reported AHRQ and CMS measures are described elsewhere.[10,14,17] To permit comparisons across hospitals, the AHRQ and CMS quality indicator rate per 1000 discharges was used in the data analysis.

Variables were computed in the AHA dataset to permit comparisons across hospitals in the linear model analysis. Dummy variables (0 = no and 1= yes) were created for each of the 3 states. In addition to the Medicare case-mix index, 3 variables were created from the AHA dataset to account for intensity of care as follows: (1) a dummy variable was created from the AHA dataset for hospitals that were a member of the Council of Teaching Hospitals of the Association of American Medical Colleges; (2) the proportion of ICU beds to total hospital beds was calculated by summing "ICU medical-surgical beds," "ICU cardiac beds," and "ICU other beds," dividing by the total facility beds staffed; and (3) total Medicaid days was divided by adjusted patient days.

In the AHA Annual Survey of Hospitals,[15] the staffing domain includes full-time, part-time, and full-time equivalent (FTE) staffing for hospital personnel. Full-time employees are defined as working 35 or more hours a week, and part-time employees as working less than 35 hours a week.[15] Full-time equivalents are defined as equal to the sum of full-time workers plus 0.5 of the part-time workers.[15] Employee hours per patient day (HPPD) were

calculated by multiplying full-time and FTE employees by 2080 (40 h/wk × 52 weeks) and dividing by adjusted patient days.[14] Total nursing staff FTE HPPD was calculated by summing RN, licensed practical nurse (LPN), and nursing assistant (NA) FTE HPPD. To permit comparisons on the proportion of nursing staff to total hospital personnel, a variable was calculated by dividing nursing staff FTE HPPD by total personnel FTE HPPD. RN HPPD was captured as a distinct variable, in addition to other defined HPPD calculations.

The data file was examined for random or systematic missing data and marked skewness. No systematic missing data were found in the variables included in the data analysis. Pairwise correlations were examined for significant association and scientific relevance with the dependent variable, pneumonia 30-day excess readmission ratio (Table 1).

Statistical Analysis

Statistical analyses were conducted using SPSS version 21 (Boston, Massachusetts).[20] Covariates positively and negatively associated with the pneumonia excess readmission ratio, as well as the rate of patients with iatrogenic pneumothorax, were included in the linear model analysis. Scatterplots of the candidate predictors and the response were examined to look for applicability of the linear model, outliers, or unusual distributional shapes. All terms were initially placed in the model and then eliminated by stepwise modeling if they remained associated at $P = .05$ and were removed at $P = .10$. This was determined by stepwise procedures and likelihood ratio tests. A likelihood ratio test shows that the 2-way interactions did not significantly improve the model once all the main effects were included.

Results

Pneumonia Readmissions and Selection of Model Factors

Factors that were significantly negatively associated with the pneumonia excess readmission ratio were as follows: California ($r = -0.377$, $P < .001$), the percentage of patients given information about what to do during their recover at home ($r = -0.187$, $P < .001$), hospitalists FTE HPPD ($r = -0.169$, $P < .008$), RN FTE HPPD ($r = -0.129$, $P < .005$), Medicare case-mix index ($r = -0.125$, $P < .007$), and nursing staff FTE HPPD/total personnel FTE HPPD ($r = -0.122$, $P < .016$). Factors positively associated with the pneumonia excess readmission ratio were as follows: New York ($r = 0.365$, $P < .001$), teaching hospital ($r = 0.233$, $P < .001$), residents and interns full-time

Table 1. Factors Significantly Correlated With Pneumonia Excess 30-Day Readmission Ratio (n = 469)

Donabedian Framework	Independent Variables	n	Coefficient	P (1-Tailed)
Structure[a]	California (California = 1, Massachusetts, and New York = 0)	469	−0.377	<.001
	New York (New York = 1, Massachusetts, and California =0)	469	0.365	<.001
	Teaching hospital (teaching = 1, nonteaching = 0)	469	0.233	<.001
	Residents and interns full-time HPPD 2011	463	0.208	<.001
	Medicaid days/adjusted patient days 2011	463	0.196	<.001
	Hospitalist FTE HPPD 2011	247	−0.169	.008
	Total adult ICU beds/total facility beds staffed	309	0.160	.005
	RN FTE HPPD 2011	463	−0.129	.005
	Medicare case-mix fiscal year (FY) 2011	469	−0.125	.007
	Nursing staff FTE HPPD/total personnel FTE HPPD 2011	463	−0.112	.016
	MD full-time HPPD 2011	463	0.107	.021
Process[b]	Patients "sometimes" or "never" received help as soon as they wanted (%)	469	0.281	<.001
	Patient's pain was "sometimes" or "never" well controlled (%)	469	0.258	<.001
	Nurses "sometimes" or "never" communicated well with the patient (%)	469	0.233	<.001
	Patient's given information about what to do during their recovery at home (%)	469	−0.187	<.001
	Staff "sometimes" or "never" explained medicines before giving it to them (%)	469	0.182	<.001
Outcomes	Rate of patients with PE or DVT after surgery/1000 discharges[c]	454	0.133	.005
	Rate of pressure ulcer stages II and IV/1000 discharges[d]	469	0.131	.005
	Central line–associated bloodstream infections score[d]	357	0.128	.015
	Rate of patient deaths from serious treatable complications postsurgery/1000 discharges[c]	322	0.124	.026
	Rate of patients with iatrogenic pneumothorax/1000 discharges[c]	468	0.065	.158

Total nursing staff FTE HPPD = RN FTE HPPD + LPN FTE HPPD + NA FTE HPPD
Data sources: [a]American Hospital Association (2011). *Annual Survey of Hospitals*. Chicago, IL: AHA. [b]CMS HCAHPS (9/2011-10/2012). [c]AHRQ Quality Outcomes Measures (7/2009-6/2011). [d]CMS Performance Report on Outcomes Measures (7/2008-6/2011).

HPPD (r = 0.208, P < .001), Medicaid days/adjusted patient days (r = 0.196, P < .001), total adult ICU beds/total facility beds staffed (r = 0.160, P < .005), and physician full-time HPPD (r = 0.107, P < .021). The rate of patients with iatrogenic pneumothorax was highly correlated (r = 0.160, P < .001) with resident HPPD and teaching hospitals.

HCAHPS measures positively associated with the pneumonia readmission ratio were the percentage of patients self-reporting, patients "sometimes" or "never" received help as soon as they wanted (r = 0.281, P < .001), patient's pain was "sometimes" or "never" well controlled (r = 0.258, P < .001), nurses "sometimes" or "never" communicated well with patient (r = 0.233, P < .001), and staff "sometimes" or "never" explained medicines before giving it to them (r = 0.233, P < .001). AHRQ and CMS indicators positively associated with the pneumonia readmission ratio were as follows: pulmonary embolism (PE) or deep vein thrombosis (DVT) after surgery (r = 0.133, P < .005), pressure ulcer stages II and IV (r = 0.131, P < .005), central line–associated bloodstream infections (r = 0.128, P < .015), and patient deaths from serious treatable complications after surgery (r = 0.124, P < .001) (Table 1).

Pneumonia Readmissions

The goal of the general linear model analysis was to choose from a set of 21 factors that correlate to the excess readmission ratio for pneumonia. The criteria used were scientific relevance and by examining binary correlations. Scatterplots of the possible predictors and the response were examined for applicability of the linear model, outliers, or unusual distributional shapes. Strong interaction between factors measuring nurse and RN staffing was accounted for in the model. All terms initially placed in the model were eliminated if they added no additional information about the response given other terms in the model. This was determined by stepwise procedures and likelihood ratio tests. A likelihood ratio test shows that the 2-way interactions did not significantly improve the model once all the main effects were included. Higher order interactions were not included and could be a source of potential bias.

Of the 21 independent variables highly correlated with the dependent variable, 6 factors significantly predicted the pneumonia excess readmission ratio (Table 2). The mean pneumonia excess readmission ratio was lower in California than in New York and Massachusetts by 0.069. For each increase in the RN FTE HPPD and the ratio of nursing staff FTE HPPD to the total facility personnel FTE HPPD, the pneumonia excess readmission ratio was lowered by 0.029. Conversely, the pneumonia excess readmission ratio increased by 0.003 for each percentage increase in the patients reporting nurses "sometimes or "never" communicated well with patients and by 0.002 if patients "sometimes" or "never" received help as soon as they wanted.

Each increase in the number of patients who acquired iatrogenic pneumothorax also raised the pneumonia excess readmission ratio by 0.059. To summarize, 3 factors increased the excess pneumonia readmission ratio: (1) poor nurse communication with patients, (2) poor staff responsiveness to patient's need for help, and (3) iatrogenic pneumothorax. Conversely, 3 other factors lowered the pneumonia readmission ratio: (1) if patients were hospitalized in California, (2) higher RN staffing, and (3) higher proportions of nursing staff to total hospital personnel. Overall, these 6 factors explained 23.6% of the variance in the pneumonia excess readmission ratio (R^2 = 0.248) (Table 2).

Table 2. *General Linear Model Pneumonia Excess 30-Day Readmission Ratio With Predictors (n = 462)*

Predictors	*B*	SE (*B*)	*P*
Nursing staff FTE HPPD/total personnel FTE HPPD × RN FTE HPPD 2011[a]	−0.029	0.014	.040
Nurses "sometimes" or "never" communicated well with the patient (%)[b]	0.003	0.002	.046
California[a]	−0.069	0.008	<.001
Rate of patients with iatrogenic pneumothorax/1000 discharges[c]	0.059	0.026	.023
Patients "sometimes" or "never" received help as soon as they wanted (%)[b]	0.002	0.001	.014

Stepwise: R^2 = 0.248; adjusted R^2 = 0.236; SE of estimate = 0.044; SS = 0.736; P < .001.
Total nursing staff FTE HPPD = RN FTE HPPD + LPN FTE HPPD + NA FTE HPPD.
Excluded independents: New York, teaching hospital, Medicare case-mix FY 2011, Medicaid days/adjusted patient days 2011, total adult ICU beds/total facility beds staffed, hospitalist FTE HPPD 2011, physician full-time HPPD 2011, residents and interns full-time HPPD 2011, patient's pain was "sometimes" or "never" well controlled (%), patient's given information about what to do during their recovery at home (%), staff "sometimes" or "never" explained medicines before giving it to them (%), rate of patients with PE or DVT after surgery/1000 discharges, rate of pressure ulcer stages II and IV/1000 discharges, central line–associated bloodstream infections scored, rate of patient deaths from serious treatable complications after surgery/1000 discharges.
Data sources: [a]American Hospital Association (2011). *Annual Survey of Hospitals*. Chicago, IL: AHA. [b]CMS HCAHPS (9/2011-10/2012). [c]AHRQ Quality Outcomes Measures (7/2009-6/2011).

Discussion

Findings from this study suggest that 6 factors explained 23.6% of the variance in the pneumonia excess readmission ratio. Results suggest that better RN staffing lowered the readmission rate for pneumonia. When compared with states that do not have mandated nurse-to-patient ratios, California, which limits the number of patients assigned to RNs, has significantly lower pneumonia readmission rates. This finding is consistent with work examining nurse staffing and heart failure readmission.[21] Findings from this study indicate that poor nurse patient communication and nurse responsiveness to patient needs was a significant factor contributing to higher rates of 30-day readmission for pneumonia. While this study does provide findings about total RN staffing and its impact on outcomes, this study does not provide enough information about how RN staffing impacts the process of care (communication and responsiveness). Simply increasing the number of RNs alone may or may not improve nurse-patient communication. Experience and educational preparation are additional factors that may influence the process of nursing care captured in HCAHPS.

This study was not able to discern staffing patterns (ie, part-time vs full-time nurses). Future research should further explore if there are associations between readmissions, staffing patterns, and nurse-patient communication. Specifically, the impact of full-time versus part-time nurses and continuity of nurses' shifts in relation to the outcomes of nurse-patient communication and lower readmission rates should be explored. Furthermore, while increased numbers of nurses may improve outcomes, findings from a significant body of work on nurse educational preparation consistently report more positive patient outcomes when nurses are prepared at least the bachelor's level[22-25]; however; these publicly available databases do not describe nursing educational preparation.

While the incidence of iatrogenic pneumothorax is positively correlated with pneumonia readmission, there was not enough information to determine if this was an issue of patient complexity or poor assessment or issues related to hospital teaching status and medical training.

Limitations

This study provides information about the variance associated with the 30-day readmission rate for pneumonia using 3 public and 1 private databases. The databases used in this study are helpful in determining some of the factors related to the structure, process, and outcomes of care. However, they do not provide data about educational preparation, continuity of care, the existence of transitional care models aimed at reducing readmission, and other influences that may contribute to the 30-day readmission rate. The 3 states chosen for this study are not representative of all hospitals across the United States and perhaps provide a skewed picture in terms of the sample including a greater number of academic medical centers.

Conclusion

The findings from this study provide information about factors from the AHA, CMS, HCAHPS, and AHRQ databases that explain variance in the excess readmission ratio for pneumonia across 3 states. This study is important in that it suggests that nurse staffing, nurse-patient communication, and nurse responsiveness to patient's needs are important factors that contribute to the pneumonia readmission rate. However, staffing alone does not explain the process of care adequately. Future studies should explore how more specific nurse characteristics contribute to poor nurse communication and lack of responsiveness. Future work should also explore the specific attributes of nurse staffing models associated with lower readmission rates as compared with higher readmission rates. Lastly, the circumstances associated with pneumothorax and pneumonia warrant further exploration.

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