MAJOR ARTICLE

Readmission Following Hospitalization for Pneumonia: The Impact of Pneumonia Type and Its Implication for Hospitals

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(See the Editorial Commentary by Sexton on pages 368–9.)

Background. Readmission rates following discharge after pneumonia are thought to represent the quality of care. Factors associated with readmission, however, remain poorly described. It is unclear if readmission rates vary based on pneumonia type.

Methods. We retrospectively identified adults admitted to an index hospital with non-nosocomial pneumonia (January through December 2010) and who survived to discharge. We only included patients with bacterial evidence of infection. Readmission in the 30 days following discharge to any of 9 hospitals comprising the index hospital's healthcare system served as the primary end point. We recorded demographics, severity of illness, comorbidities, and infection-related factors. We noted whether the patient had healthcare-associated pneumonia (HCAP) versus community-acquired pneumonia. We utilized logistic regression analysis to determine factors independently associated with readmission.

Results. The cohort included 977 subjects; 78.9% survived to discharge. The readmission rate equaled 20%. Neither disease severity nor the rate of initially inappropriate antibiotic therapy correlated with readmission. Subjects with HCAP were 7.5 (95% confidence interval [CI], 3.6–15.7) times more likely to be readmitted. Four HCAP criteria were independently associated with readmission: admission from long-term care (adjusted odds ratio [AOR], 2.2 [95% CI, 1.4–3.4]); immunosuppression (AOR, 1.9 [95% CI, 1.3–2.9]); prior antibiotics (AOR, 1.7 [95% CI, 1.2–2.6]); and prior hospitalization (AOR, 1.7 [95% CI, 1.1–2.5]).

Conclusions. Readmission for pneumonia is common but varies based on pneumonia type. The variables associated with readmission do not reflect factors that hospitals directly control. Use of one rule to guide payment that fails to account for HCAP and the HCAP criteria on readmission seems inappropriate.

Keywords. community-acquired; healthcare-associated; hospitalization; pneumonia; readmission.

Pneumonia remains a leading reason for hospital admission and results in substantial morbidity and mortality. Because of its clinical impact, pneumonia results in significant healthcare expenditures. Some estimate that the US healthcare system devotes in excess of $6 billion annually to the direct costs related to pneumonia care [1]. In light of this major burden, pneumonia has continued to be a focus of quality improvement initiatives. Third-party payers such as the Centers for Medicare and Medicaid Services (CMS) have promulgated a number of policies that attempt to tie reimbursements and payments to measures of quality of care [2]. One recent endeavor addresses readmissions rates following an inpatient stay for pneumonia. CMS suggests that by providing one payment to cover an

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"episode of care," it can alter incentives so that hospitals and physicians modify their behavior [2]. It is hoped that as a result, care will be better coordinated and transitions from the hospital to home improved. In turn, this will prevent the subsequent need for readmission.

Many prior efforts to understand the epidemiology of readmission following a hospitalization for pneumonia have derived from large analyses of CMS datasets mainly covering those 65 years of age and older. Approximately 20%–25% of these subjects are readmitted within 30 days [3–6]. However, such analyses have been limited in that they have generally lacked patient-level data on severity of illness and process of care factors such as the appropriateness of initial antibiotic therapy.

More importantly, no effort has attempted to explore the distinction between community-acquired pneumonia (CAP) and healthcare-associated pneumonia (HCAP) on readmissions. HCAP describes a group of patients who present to the hospital with pneumonia, similar to those with CAP, but who are distinct because of their ongoing interaction with the healthcare system [7, 8]. As such, persons with HCAP are at risk for infection with a range of pathogens more broad than those traditionally seen in CAP. Subjects with HCAP also generally suffer from more comorbidities and are more severely ill than individuals with CAP [7, 8]. As a result, HCAP yields distinct outcomes when compared to CAP. Understanding the differential impact of HCAP and CAP on readmission is crucial to determining if variability in case mix between the 2 might alter a hospital's aggregate readmission rate. Appreciating the import of HCAP is also necessary if one hopes to identify potentially modifiable risk factors that institutions could target to reduce rates of rehospitalization.

We hypothesize that individuals with HCAP face higher 30-day readmission rates for pneumonia than do those diagnosed with CAP. We further theorize that the criteria defining HCAP identify a cohort of persons at high risk for short-term readmission. To evaluate our hypothesis, we conducted a retrospective analysis of all subjects admitted to an index hospital with culture-confirmed bacterial pneumonia during a 1-year period.

METHODS

Study Overview

We retrospectively evaluated all subjects with bacterial pneumonia admitted to a single institution between January and December 2010. The study only included adult patients (aged >18 years) admitted through the emergency department. We excluded those persons transferred directly to the hospital from other institutions. We further excluded patients who died while hospitalized as they are necessarily not at risk for readmission. This project was approved by the Barnes-Jewish Hospital institutional review board and there was no requirement for informed consent given our retrospective design.

Pneumonia was identified based on traditional signs and symptoms of chest infection. We further required evidence of an infiltrate on chest imaging (eg, either chest radiograph or computed tomographic scan). All radiology studies were reviewed by a single investigator (M.H.K.). We defined a pneumonia as bacterial in origin if sputum, lower airway, blood, or pleural cultures were positive. Positive urinary antigen testing for *Streptococcus pneumoniae* or *Legionella* species also served to categorize an infection as bacterial.

Components of the data in the present analysis have been previously utilized as part of projects to describe the microbiology of non-nosocomial pneumonia [9].

Primary End Point

Readmission for any reason (ie, all-cause readmission) to an acute care facility in the 30 days following discharge after the initial hospitalization served as the primary end point. The index hospital serves as the main teaching institution for a large integrated healthcare system of both inpatient and outpatient care. The system includes a total of 9 hospitals in a compact geographic region surrounding and including St Louis, Missouri, and we included readmission to any of these hospitals in our analysis. Persons treated within this healthcare system are, in nearly all cases, readmitted to one of the system's participating 9 hospitals. If a patient who receives healthcare in the system presents to a nonsystem hospital, he/she is often transferred back into the integrated system because of issues of insurance coverage.

Definitions and Variables

We defined HCAP in accordance with the American Thoracic Society's position statement on nosocomial pneumonia [10]. We categorized a subject as having HCAP if any of the following criteria were present: admission from a long-term care (LTC) facility or nursing home (NH), inpatient hospitalization for at least 48 hours during the preceding 90 days, exposure in the prior 30 days to broad-spectrum antimicrobials, immunosuppression, and/or receipt of hemodialysis or wound care. We defined patients as immunosuppressed if they had an active malignancy and were undergoing chemotherapy, were treated with immunosuppressants (ie, 10 mg prednisone or equivalent daily for at least 30 days or alternate agents such as methotrexate), and/or if they had AIDS. All those not meeting any of the criteria for HCAP were classified as suffering from CAP.

Beyond the conditions defining HCAP, we recorded information regarding demographics, severity of illness, and infection-related variables. In addition to age, we noted patient sex and race. We utilized the CURB-65 (confusion, urea, respiratory rate, blood pressure, age) score to describe disease severity

and determined if there was a need for either intensive care unit care or mechanical ventilation [11]. We classified the initial antibiotic regimen as appropriate if the patient received an antibiotic that was active in vitro against the subsequently identified pathogen within 6 hours of presentation. Finally, we ascertained if bacteremia complicated the patient's pneumonia.

To asses a subject's chronic health state, we examined if they suffered from coronary artery disease, chronic obstructive pulmonary disease (COPD), diabetes mellitus, or dementia and/or had a history of a stroke (cerebrovascular accident [CVA]). To represent the global burden of comorbidities in each patient, we calculated their Charlson scores [12].

Statistical Analysis

We used the Fisher exact test or Student *t* test, as appropriate, for univariate analyses. The Mann-Whitney *U* test was used for continuous, nonparametrically distributed data. All analyses were 2-tailed, and a *P* value of <.05 was assumed to represent statistical significance. We relied on logistic regression for identifying variables independently associated with 30-day readmission. Based on univariate analysis, variables significant at the $P < .10$ level were entered into model. To arrive at the most parsimonious model, we utilized a stepwise backward elimination approach. We evaluated colinearity with correlation matrices. We report adjusted odds ratios (AORs) and 95% confidence intervals (CIs) where appropriate. The model's goodness-of-fit was assessed via calculation of the R^2 value and the c statistic. We conducted a cross-validation of the model in order to assess for overfitting. We reran the logistic model on 90% of the sample sequentially dropping 10% of the population with each run. We contrasted the mean accuracy of these analyses with the overall accuracy of the model developed with the entire cohort. All analyses were performed with SPSS software, version 19.0 (IBM SPSS, Chicago, Illinois).

RESULTS

The initial cohort included 977 patients, of whom 771 (78.9%) survived to hospital discharge. A readmission to one of the 9 participating hospitals within the 30 days following discharge occurred in 19.3% (n = 149). The most common reasons for readmission were COPD (n = 37) and congestive heart failure (n = 34). Pneumonia was identified as the diagnosis in 11 (7.4%) readmissions. Infectious complications generally (eg, pneumonia, urinary tract infection, bloodstream infection) accounted for 17.4% of all readmissions.

Table 1 reveals the characteristics of those readmitted and those remaining free from rehospitalization at 30 days. There were no differences in demographics between those readmitted and not readmitted. There was also no difference in severity of illness. As Table 1 shows, CURB-65 scores were similar between the cohorts, as was the need for either intensive care unit admission or mechanical ventilation.

With respect to infection-related characteristics, more patients readmitted had received broad-spectrum antibiotic therapy prior to the index hospitalization (61.7% vs 38.9%, $P < .001$). However, the prevalence of bacteremia did not differ based on eventual readmission status. The rate of initially appropriate antibiotics was high in the entire study group and failed to correlate with the need for readmission. The median

Table 1. Patient Characteristics

Characteristic	Readmission (n = 149)	No Readmission (n = 622)	*P* Value
Demographics			
Age, y, mean (SD)	60 (17.8)	59.3 (16.9)	.683
Male sex	53.0%	55.9%	.522
Race			.919
White	46.3%	45.0%	
African-American	53.7%	54.4%	
Other	0	1.0%	
Severity of illness			
CURB-65 score, median	3	3	.201
ICU admission	50.3%	47.4%	.525
Mechanical ventilation	36.2%	36.5%	.999
Infection-related characteristics			
Prior antibiotics	61.7%	38.9%	.001
Bacteremia	33.6%	31.0%	.557
Initially appropriate antibiotics	73.2%	78.0%	.233
Length of stay, d, mean (SD)	12.8 (10.8)	11.2 (12.3)	.151
Comorbidities			
Charlson score	6	4	.001
Long-term care admission	26.2%	14.0%	.001
Coronary artery disease	22.8%	15.8%	.052
Congestive heart failure	39.6%	31.7%	.067
COPD	61.7%	51.4%	.028
Diabetes mellitus	35.6%	27.0%	.044
Dementia	4.7%	3.9%	.643
Cerebrovascular accident	17.4%	12.2%	.106
Malignancy	38.9%	22.2%	.001
HIV	4.0%	1.9%	.134
Immunosuppressed	44.3%	26.7%	.001
Chronic hemodialysis	10.7%	5.0%	.013
Prior hospitalization	57.0%	36.0%	.001

Abbreviations: COPD, chronic obstructive pulmonary disease; CURB-65, confusion, urea, respiratory rate, blood pressure, age; HIV, human immunodeficiency virus; ICU, intensive care unit; SD, standard deviation.

length of stay for the index pneumonia (Table 1) was nearly 2 days longer in the readmission group, but this difference was not statistically significant.

We did note an association between the prevalence and type of comorbidities and hospital readmission. The median Charlson score was higher in subjects who were readmitted (6 vs 4, $P < .001$). Neurologic conditions such as dementia and CVAs occurred equally between the cohorts, whereas other chronic diseases, such as COPD and diabetes mellitus, transpired more often in those individuals readmitted within 30 days. Of the comorbidities evaluated, those linked to the definition of HCAP all correlated with readmission. For example, hemodialysis patients were more than twice as likely (OR, 2.29 [95% CI, 1.22–4.32]) to require readmission. Similarly, persons admitted from an NH (OR, 2.18 [95% CI, 1.42–3.35]) or with a malignancy (OR, 2.24 [95% CI, 1.53–3.27]) were significantly more prone to be readmitted.

A substantial proportion of the cohort (40.1%) had been admitted for any reason in the preceding 90 days prior. Having had a prior admission increased the probability on rehospitalization. More than half of those readmitted after the index event had been previously hospitalized compared to approximately a third of those not readmitted ($P < .001$).

Figure 1 shows that patients meeting criteria for HCAP were significantly more likely to require readmission. Of the 148 subjects readmitted, only 9 suffered from CAP. Reflecting this, the readmission rate among persons with CAP equaled 4.1% as opposed to 24.4% of persons with HCAP ($P < .001$). As a screening test for readmission, a diagnosis of HCAP was associated with a sensitivity of 94.6% and a specificity of 29.9%. The corresponding positive and negative predictive values were 24.4% and 95.6%.

The results of the logistic regression are shown in Table 2. Four factors remained independently associated with readmission: admission from LTC/NH (AOR, 2.15 [95% CI, 1.37–3.38]), immunosuppression (AOR, 1.93 [95% CI, 1.31–2.86]), prior antibiotic therapy (AOR, 1.74 [95% CI, 1.15–2.62]), and prior hospitalization in the last 90 days (AOR, 1.66 [95% CI, 1.11–2.49]). The model had a good fit of the data with a c statistic of 0.787 and an R^2 value of 0.12. Based on the cross-validation, we did not observe overfitting. The AORs for the variables that were significant predictors in the model in all of the 10 sequential reruns (with 90% of the cohort) did not differ from the findings in the complete population.

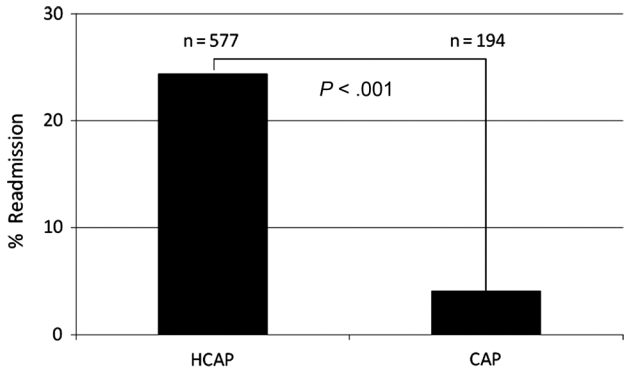

Figure 1. Readmission based on pneumonia type. Abbreviations: CAP, community-acquired pneumonia; HCAP, healthcare-associated pneumonia.

Table 2. Independent Variables Associated With Readmission

Variable	Adjusted Odds Ratio	95% Confidence Interval	*P* Value
Long-term care admission	2.15	1.37–3.38	.001
Immunosuppressed	1.93	1.31–2.86	.001
Previous antibiotics	1.74	1.15–2.62	.009
Prior hospitalization	1.66	1.11–2.49	.014

DISCUSSION

The retrospective analysis of a large cohort of persons with culture-confirmed bacterial pneumonia documents that short-term readmission following a hospitalization for pneumonia occurs frequently. Nearly 1 in 5 patients presenting to the hospital with pneumonia are readmitted in the 30 days following discharge. However, rates of readmission vary substantial based on the type of non-nosocomial pneumonia. The probability of readmission is significantly higher in HCAP than in CAP. Moreover, factors independently associated with readmission represent variables that are not easily prone to modification. This observation suggests that hospitals may be able to identify select persons at increased risk for readmission but may not be easily able to alter the likelihood for returning to the hospital.

Our observation of a high readmission rate confirms the findings of others. Joynt and coworkers noted that nearly 22% of Medicare beneficiaries were readmitted in the 30 days following a hospitalization for pneumonia [3]. Chen and colleagues, also focusing on Medicare patients, similarly noted that the risk for short-term rehospitalization was high following a pneumonia admission [4]. Epstein et al, utilizing national Medicare data, found that readmission rates for pneumonia varied substantially across hospitals and ranged from 13% to 25%, with a median readmission rate of 18% [5]. These authors further concluded that readmission rates fluctuated directly with a hospital's general admission rates and volumes.

Unlike these earlier investigations, however, we relied on a cohort of subjects with culture-confirmed pulmonary infection. Administrative and discharge coding information, as employed in analyses of Medicare datasets, may lack precision for the

diagnosis of pneumonia. Many conditions may mimic pneumonia and thus confound conclusions drawn from such databases. In addition, the generalizability of findings from Medicare datasets is necessarily limited. Many subjects with pneumonia who present to the hospital are not necessarily covered by Medicare. Finally, because Medicare registries lack information on antibiotic therapy and severity of illness, they can provide only limited insight into the patient-level factors that may be associated with readmission. Reflecting this, the current CMS calculations to benchmark a hospital's anticipated pneumonia readmission rate rely on a series of hierarchical linear regression models that include only 2 patient demographic characteristics and a multitude of discharge diagnostic codes [13].

Neupane et al adopted a different strategy and conducted an observational cohort analysis of elderly patients with pneumonia. In contrast to our results and those reported in descriptions of CMS data, these researchers documented a much lower readmission rate (11%) [14]. After adjusting for a number of covariates including appropriateness of antibiotics and severity of illness, they determined that only male sex was independently associated with the risk of readmission. In an observational cohort of persons suffering from pneumonia, Capelastegui et al calculated a readmission rate of <8% and found that the type and extent of a patient's comorbidities were linked to subsequent readmission [15]. Notably, each of these reports describing lower readmission rates originate from outside the United States, suggesting that healthcare system organization and structure may be an important contributor to readmission rates.

Our finding of discordant readmission rates based on pneumonia type is unique in that others have not previously attempted to specifically focus on this issue. Understanding the differential impact of HCAP and CAP on the potential for later readmission has several important implications. First, it suggests that if national organizations insist on using readmission rates as a surrogate marker for hospital quality, equations for calculating expected readmission rates must consider a hospital's relative case mix of HCAP versus CAP. Second, as a matter of policy, tying reimbursement and payments to pneumonia readmission will necessarily punish healthcare institutions with relatively more HCAP patients.

More specifically, the results of our logistic regression indicate that hospitals can easily identify subjects at increased potential for needing rehospitalization. Therefore, if institutions hope to lower their readmission rates for pneumonia, they should concentrate their efforts on this cohort of patients. It appears that targeted initiatives addressing readmission among HCAP patients seem warranted as they disproportionately account for those returning to the hospital. Conversely, given the close connection between admission source (eg, LTC facility) and readmission, hospitals should consider partnering with local LTC facilities to address the conundrum of readmission. In fact, the relationship between admission source and readmission suggests that reimbursement policies might be better directed at penalizing LTC institutions, rather than or in addition to acute care hospitals, for pneumonia readmissions.

The lack of a relationship between one key process of care variable, appropriateness of antibiotics, and being rehospitalized illustrates that care delivery may have only a limited causal role in driving rehospitalization. The timeliness and appropriateness of initial antibiotic therapy is a crucial determinant of outcome in severe infection and a major emphasis of national pneumonia treatment guidelines. As a component of pneumonia care, antibiotic therapy is clearly under the control of physicians and hospitals. The absence of a nexus between initial antibiotic therapy for the index pneumonia and readmission underscores that nonmodifiable patient characteristics, such as the source of admission, are likely the key determinant of whether a subject with pneumonia is eventually readmitted.

The present analysis has several important limitations. First, we only included patients with evidence of bacterial infection. We certainly neglected subjects whose cultures were falsely negative. On the other hand, a positive culture may actually reflect colonization rather than infection. Second, our study is retrospective in nature and therefore prone to many types of bias. Despite striving to evaluate all aspects of the HCAP definition, we likely miscategorized some patients because of a lack of information regarding recent antibiotic exposure. Likewise, the findings of the logistic regression can only indicate association and not causation. Third, our data originate from a single hospital within a larger healthcare system. Hence, our findings may not apply to other institutions and the generalizability of the results is limited, and we did not have access to information about the use of antibiotics in LTC facilities. Finally, we may have not captured readmission that occurred at hospitals not part of this system.

In conclusion, readmission following an episode of pneumonia occurs often. The type of pneumonia appears related to the probability of rehospitalization, and select patient characteristics identify persons at enhanced risk for requiring readmission.

Notes

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