ED Discharge with Pneumonia: Factors Associated with Rehospitalization

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Abstract

Our objective is to identify factors which put ED patients at increased risk for failing outpatient pneumonia therapy. We used logistic regression models to estimate the odds that a patient discharged from the ED with a pneumonia diagnosis will be readmitted as an inpatient within 30 days. We considered the following possible covariates: age, co-morbidity, (e.g. asthma, COPD, hypertension) and medication (beta blocker, beta agonist, ARBs, ACE inhibitors, etc.). Model inclusion criteria included: α=.05, AIC and Goodness-of-Fit test. Among 2967 patients, 2851 were not admitted as an inpatient within 30 days after an ED discharge; 116 were admitted at least once. Medications were found to have significant relationship to ED readmission, include: beta blocker, beta agonist, ARB, diuretics and Ca channel blockers. Gender, age, and comorbidities did not have a significant relationship. AUC of the final model is .643. In this population of ED pneumonia patients discharged home, most medications used to treat asthma and hypertension were associated with increased odds of return and inpatient admission.

Keywords: Pneumonia, Medication, Hypertension, Readmission, Admission, Outpatient, Inpatient

1. Introduction

Pneumonia is a major cause of death in the US and the rest of the word, with an age adjusted mortality approaching 20% for US inpatients. 1.7 million US patients/year are admitted to the hospital for pneumonia. Treatment of pneumonia in the US costs about $9 billion/year. (Park et al., 2011, Nazarian et al 2009). Meanwhile pneumonia readmission leads to additional costs for hospitals and individuals. Readmission rate of pneumonia has been used as a measure of health care quality (Shorr et al., 2013). Most existing literature regarding the decision to admit pneumonia patients is based on populations of patients who were admitted and who had the laboratory tests needed for the scoring system Ebell 2006, . The biased patient sampling limits applicability as an ED guide; the required lab tests further limit the value for some other outpatient settings. We study patients seen in the ED and discharged; we track which of those patients are then seen again within 30 days and admitted to one of our hospitals. We model the factors associated with these admission rates.

2. Objective

This study aims to identify factors which put ED patients at increased risk for failing outpatient pneumonia therapy, especially modifiable factors such as medications. Four types of factors are selected as candidate factors: age, gender, comorbidities, and medications. We particularly studied comorbidities treated with beta active agents, including hypertension, asthma, and dysrhythmia. Inclusion of the above comorbidities allow us to investigate medical factors while adjusting for reasons for taking certain medications.

3. Data

Data were abstracted from ongoing administrative monitoring at New York City Health and Hospital Corporation (HHC). Data for this project were de-identified. HHC operates a network of 11 acute and community hospitals, 5 long-term care centers, and 6 treatment centers. Raw data were extracted from two sources: 1) diagnoses and visit dates data from the billing databases, and 2) medication pharmacy database. Data from the above two sources were then merged to form the working dataset. The working dataset contains data from four of the acute care hospitals during a period of nine months, ranging from January 2013 to September 2013. A total of 2967 patients were diagnosed with pneumonia at least once during that time. The finalized analysis dataset consists of data from those 2967 patients.

For the purpose of this analysis, we narrowly define a specific form of "ED readmission." We define "Admission following ED discharge, AFEDC" as: after being discharged from the emergency department, if a patient is admitted into the hospital within 30 days of the discharge, then that admission is a "AFEDC." If a pneumonia patient was ever readmitted, the outcome variable pneumonia AFEDC was coded as 1. If no AFEDC occurs, pneumonia AFEDC was coded as 0.

Explanatory variables are gender, age, medications, and comorbidities. Age is rounded to decade. All medications and comorbidities are binary variables. Medication predictors and comorbidities predictors are selected based on consultation with the clinicians. Medication variables included in this study are: beta blockers, beta1 blockers, beta agonists, beta2 agonists, long acting beta agonist, ARBs, ACE inhibitors, diuretics, thiazide diuretics, loop diuretics, K+ sparing diuretics, and Calcium channel blockers. The comorbidities we considered are: hypertension, coronary artery disease (CAD), acute myocardial infarction (AMI), pneumonia, chronic obstructive pulmonary disease (COPD[1]), emphysema, asthma, dysrhythmia and congestive heart failure (CHF).

4. Methods

4.1 Statistical Methods

The dependent variable pneumonia readmission was first coded as a count variable. Among the 2967 patients who were diagnosed with pneumonia, 2851 had no AFEDC during the nine-month period. There are 101 patients admitted once after ED discharge; 13 readmitted twice; and 2 readmitted three times. A Poisson model was considered, however, the assumption that the mean is equal to the variance was not met.

[1] COPD and asthma is coded as the variable COPD due to the structure of the source dataset. COPD covariate that is mentioned in later sections is a composite variable of COPD and asthma: 1 in COPD means at least one occurrence of either COPD or asthma.

As an alternative, pneumonia AFEDC was recoded dichotomously: patients with one or more AFEDC after ED discharge was coded as 1; no AFEDC was coded as 0. Logistic models were then used to model the likelihood of pneumonia patients being readmitted into after an ED discharge.

The following depicts the predictor function for how likely a patients will be readmitted:

$$\text{Logit}\,(E(Y_i|x_{1i}, \ldots, x_{ki})) = \text{logit}(p_i) = \ln() = \beta_0 + \beta_1 x_{1i} + \ldots + \beta_k x_{ki}$$

where p_i denotes the probability patient i would be readmitted, and x_{1i} to x_{ki} denotes covariates of interests.

4.2 Model Selection

Model fit statistics such as AIC and goodness of fit test were used to compare models. The first model includes gender and the complete list of medication and comorbidities as mentioned in the data section. Age is rounded to decade and treated as a categorical variable; the age effect is not linear or monotonic. We used PROC LOGISTIC to fit the model in SAS® and recorded AIC, Hosmer-Lemshow Goodness of Fit, as well as ROC AUC. A group of medications with either insignificant p-values or less clinical values were removed to improve the model. This process was repeated four times and we have five models to compare (Table 1).

Table 1. Model Comparison

Model	Covariates	AIC	Goodness-of-fit test*	ROC AUC
1	Gender; decade0; decade1; decade2; decade3; decade4; decade5; decade6; decade7; decade8; decade9; cad; ami; emphysema; asthma; dysrhythmia; chf; hypertension; copd; ARB; ACEI; diuretic; ca channel blocker; beta blocker; beta agonist; beta1 blocker; beta2 agonist; beta long; alpha agonist; alpha2 agonist; renin blocker; K diuretic; T diuretic; loop diuretic	952.005	p=0.3301	0.719
2	Gender; decade0; decade1; decade2; decade3; decade4; decade5; decade6; decade7; decade8; decade9; cad; ami; emphysema; asthma; dysrhythmia; chf; hypertension; copd; ARB; ACEI; diuretic; ca channel blocker; beta blocker; beta agonist	951.765	p=0.9002	0.700
3	Gender; decade0; decade1; decade2; decade3; decade4; decade5; decade6; decade7; decade8; decade9; hypertension; copd; ARB; ACEI; diuretic; ca channel blocker; beta blocker; beta agonist	943.270	p=0.4157	0.693
4	Gender; hypertension; copd; ARB; ACEI; diuretic; ca channel blocker; beta blocker; beta agonist	946.054	P=0.7267	0.667
5	Gender; Hypertension; copd; ARB; diuretic; ca channel blocker; beta blocker; beta agonist	946.490	P=0.6467	0.662

All five models passed the Hosmer and Lemeshow Goodness-of-fit test ($p>0.05$); there is no evidence to reject the null hypothesis that the model is correctly specified (Hosmer and Lemeshow, 2000). Model 3 has the smallest AIC statistic (AIC=943.270) among the five models with a relatively high ROC AUC, and is selected as our provisional model.

Figure 1 demonstrates forest plot of our provisional model. Gender and most of the age covariates are not significant in this model. Medications that are found to be significantly associated with pneumonia AFEDC are ARBs, diuretics, Calcium channel blocker, beta blocker, and beta agonist. Note that the two comorbidities—hypertension, and COPD—do not have a statistically significant effect on the outcome. We forced these two comorbidities into the final model so that underlying reasons for taking beta-blockers and beta-agonists were adjusted for. The model is finalized after excluding other predictors that are statistically insignificant (see figure 2). Our final model includes hypertension, COPD, ARBs, diuretics, Calcium channel blocker, beta blocker, and beta agonist. PROC LOGISTIC is used one more time to fit the final model, SAS code for fitting the final model is as follows:

```
proc logistic data=dataset plots=all;
model pneu(descending)=beta_blocker beta_agonist
hypertension COPD ARB diuretic
ca_channel_blocker/clodds=wald clparm=wald;
run;
```

Figure 1. Forest plot of odds ratios of the provisional model

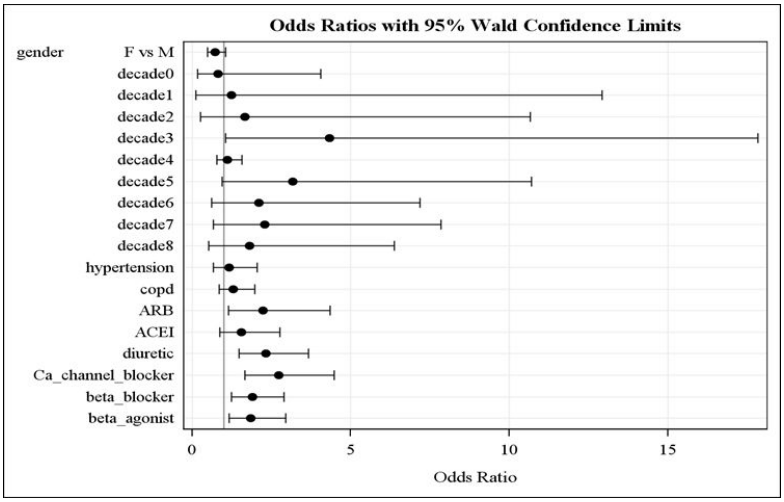
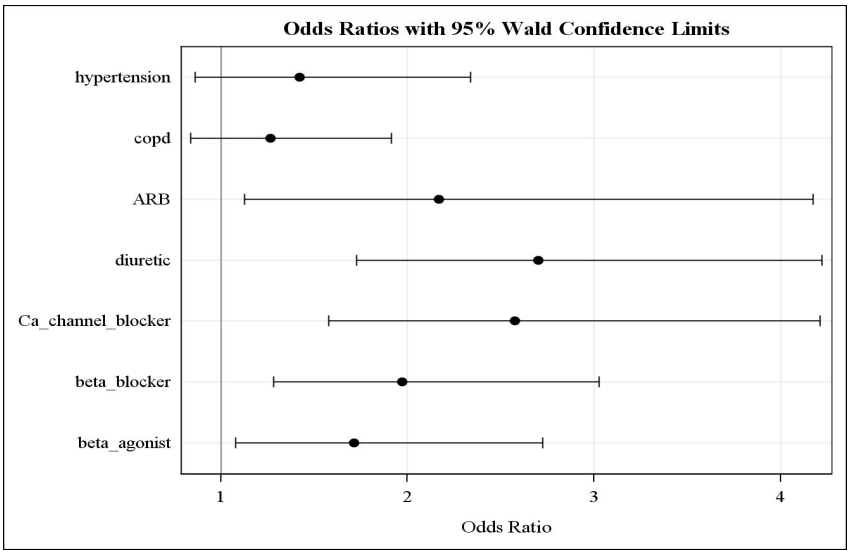


Figure 2. Forest plot of odds ratios of the final model



5. Results

The global null hypothesis that all regression coefficients equal to zero was rejected, χ^2 (7, 2967) =47.6893, p<0.0001. At least one predictor has a non-zero regression coefficient. The model provides a fair prediction of how AFEDC likelihood with a ROC area under the curve of 0.6434 (Figure 3).

Table 2 below gives odds ratio estimates and 95% confidence interval of each selected predictor. Diuretics ranks the highest in the odds ratio (OR) estimates with an OR of 2.7 (1.727, 4.221), which corresponds to a probability of 0.73. All of the medication predictors remain to be statistically significant. Beta agonist and ARB are significant at the .05 level, and the other three medications are significant at the .01 level. Note that even after adjusting for the most common reasons to take beta blockers and beta agonists (Hypertension and obstructive pulmonary disease, including asthma), these two medications remain to be significant predictor of pneumonia AFEDC.

Figure 3. ROC curve for the final model

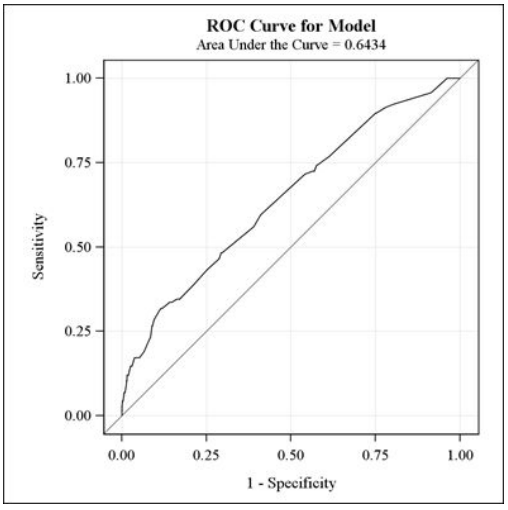


Table 2. Odds ratio estimates and Wald Confidence Intervals

Effect	OR (95%)
Hypertension	1.421 (0.863, 2.339)
COPD	1.266 (0.837, 1.913)
ARBs *	2.167 (1.125, 4.173)
Diuretic **	2.700 (1.727, 4.221)
Ca Channel Blocker**	2.577 (1.577, 4.209)
Beta Blocker **	1.970 (1.284, 3.025)
Beta Agonist *	1.714 (1.078, 2.726)
* Significant at .05 level; **Significant at .01 level	

6. Discussion and Conclusion

As discussed in the result section, the most influential predictor in our model is diuretics: patients who took diuretics are 2.7 times more likely to be admitted following ED discharge. All the medications that are used to reduce blood pressure, ARBs, diuretics, calcium channel blocker, beta blocker have an OR roughly equal or above 2.

Another factor that may lead to higher rate of pneumonia AFEDC is the interaction between beta blocker and beta agonist. Beta blockers reduce heart rate, decrease rennin, and lower cardiac oxygen demand. Beta agonist, however, produces an opposite effect as beta blocker and increases heart rate. Theortetically, taking them simultaneously could be problematic. We examined the interaction effect in the early models: that effect is not significant.

In this population of ED pneumonia patients discharged home, most medications used to treat COPD, asthma, and hypertension were associated with increased chances of return and inpatient admission. Two binary markers, hypertension and COPD may fail to completely model underlying illness. Further study may discriminate which drugs are proxy indicators and which directly exacerbate pneumonia. Further

research into these effects may also be useful in determining which pneumonia patients require admission and which can be safely discharged home.

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