International Journal of Infectious Diseases 15 (2011) e382–e387

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

# One-year outcomes of community-acquired and healthcare-associated pneumonia in the Veterans Affairs Healthcare System

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ARTICLE INFO

*Article history:*
Received 13 October 2010
Received in revised form 8 January 2011
Accepted 1 February 2011

**Corresponding Editor:** William Cameron, Ottawa, Canada

*Keywords:*
Pneumonia
Healthcare disparities
Nosocomial infection
Community-acquired pneumonia
CAP
HCAP

SUMMARY

*Background:* While studies have demonstrated higher medium-term mortality for community-acquired pneumonia (CAP), mortality and costs have not been characterized for healthcare-associated pneumonia (HCAP) over a 1-year period.
*Methods:* We conducted a retrospective cohort study to evaluate mortality rates and health system costs for patients with CAP or HCAP during initial hospitalization and for 1 year after hospital discharge. We selected 50 758 patients admitted to the Veterans Affairs (VA) healthcare system between October 2003 and May 2007. Main outcome measures included hospital, post-discharge, and cumulative mortality rates and cost during initial hospitalization and at 12 months following discharge.
*Results:* Hospital and 1-year HCAP mortality were nearly twice that of CAP. HCAP was an independent predictor for hospital mortality (odds ratio (OR) 1.62, 95% confidence interval (CI) 1.49–1.76) and 1-year mortality (OR 1.99, 95% CI 1.87–2.11) when controlling for demographics, comorbidities, pneumonia severity, and factors associated with multidrug-resistant infection, including immune suppression, previous antibiotic treatment, and aspiration pneumonia. HCAP patients consistently had higher mortality in each stratum of the Charlson–Deyo–Quan comorbidity index. HCAP patients incurred significantly greater cost during the initial hospital stay and in the following 12 months. Demographics and comorbid conditions, particularly aspiration pneumonia, accounted for 19–33% of this difference.
*Conclusion:* HCAP represents a distinct category of pneumonia with particularly poor survival up to 1 year after hospital discharge. While comorbidities, pneumonia severity, and risk factors for multidrug-resistant infection may interact to produce even higher mortality compared to CAP, they alone do not explain the observed differences.


## 1. Introduction

Pneumonia is the leading cause of infectious disease-related death, with a financial impact exceeding $8 billion dollars.[1,2] For nearly two decades, it has been recognized that patients previously classified with community-acquired pneumonia (CAP) admitted from a nursing home or those frequently exposed to the healthcare system, suffered a disproportionately higher morbidity and mortality.[3] Accordingly, multiple schemes were developed to better identify these patients; in 2005 the American Thoracic Society (ATS) with the Infectious Disease Society of America (IDSA) defined a new category for lower respiratory tract infections, termed healthcare-associated pneumonia (HCAP).[4] HCAP is defined as pneumonia in a non-hospitalized person with at least one of the following characteristics: (1) residing in a nursing home or long-term care facility; (2) being hospitalized within the prior 90 days; (3) receiving intravenous therapy, wound care, or intravenous chemotherapy within the prior 30 days; or (4) receiving hemodialysis within the previous 30 days.[4]

The rising incidence of bacterial resistance to previously effective antibiotics, and the frequent emergence of novel respiratory infections are leading to an increasing prevalence of pneumonia.[5] Because of the expanding elderly population, this increase may disproportionately include disease likely to be classified as HCAP. Many studies have demonstrated that HCAP portends a significantly poorer hospital survival than CAP (10% vs. 4%).[6–9] After discharge, patients with CAP continue to suffer a substantial health burden, with 1-year mortality rates up to

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doi:10.1016/j.ijid.2011.02.002

41%.[10–12] Yet, little is known regarding post-discharge mortality among HCAP patients, and no studies have evaluated the 1-year differences in clinical and financial outcomes between these two entities. Moreover, controversy exists regarding the clinical validity of the ATS/IDSA HCAP classification,[3] meaning that clinical practice may vary widely, leading to over- or under-treatment, each with potential to substantially impact patient survival.

The Department of Veterans Affairs (VA) healthcare system comprises over 150 acute-care hospitals throughout the USA and Puerto Rico. It has a uniform electronic health record and collects encounter-level cost data. The VA system provides a unique opportunity to study the epidemiology of pneumonia with adequate numbers of patients to address the effects of multiple covariates, including immune suppression, prior antibiotic use, and aspiration pneumonia, which are related to infection with multidrug-resistant (MDR) pathogens.[6,13,14] Herein, we evaluated mortality and VA healthcare cost during the index hospital stay, and for 1 year after discharge, among patients admitted to all VA hospitals with pneumonia during the years 2003–2007. In addition, we evaluated the clinical validity of the ATS/IDSA HCAP classification. We hypothesized that the 1-year mortality rate and VA costs would be significantly higher for HCAP patients than for CAP patients after controlling for demographic and clinical variables.

## 2. Methods

### 2.1. Design, setting, and participants

We performed a retrospective analysis of hospital discharge records from all acute-care hospitals in the VA system. This analysis was conducted with approval from the Stanford University Institutional Review Board (approval number 13980).

### 2.2. Definitions

A pneumonia patient was defined as any person admitted to an acute care hospital with an admission and discharge diagnosis of pneumonia (International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 480–483, 485–487.0) or with a discharge diagnosis of pneumonia and an admission diagnosis of decompensated chronic obstructive pulmonary disease (COPD) with acute exacerbation (491.21), asthma (493.9), food/vomitus pneumonitis (507), acute respiratory failure (518.81), acute respiratory distress (518.82), or other respiratory distress/insufficiency (786.09).[11] We then applied three exclusion criteria: transfer from another hospital, less than 48 h of antimicrobial therapy upon hospital admission, and admission within 7 days of a prior VA hospital stay.

HCAP was defined according to ATS/IDSA criteria as pneumonia occurring outside the hospital setting in a patient who had at least one of four criteria: (1) a VA-funded inpatient hospitalization within 90 days prior to the index hospitalization; (2) admission from a VA-funded long-term care stay; (3) VA-funded hemodialysis within the prior 30 days; or (4) VA-funded wound care, intravenous therapy, or chemotherapy within the prior 30 days. VA-funded care occurs primarily at VA facilities but may be purchased on contract from other institutions.

Following ATS major criteria, we defined severe pneumonia as occurring when a patient received either a diagnosis of shock or invasive mechanical ventilation.[15] We defined an intensive care unit (ICU) stay as one that occurred within 72 h of hospital admission, increasing the likelihood that the ICU admission was due to pneumonia acquired outside the hospital setting. We stratified data by factors previously associated with an increased risk of MDR infection, including immune suppression, aspiration pneumonia (507), and antibiotic use (any class) in the 6 months prior to hospitalization.[3,6,13,14] Immune suppression was defined as an admission or discharge diagnosis of neutropenia (288.00) during the index hospitalization, a previous history of HIV-infection (042), a history of any solid organ (V42) or hematopoietic stem cell transplantation (HSCT) (41.0), or prednisone use (>20 mg) for more than 3 weeks in the year prior to hospitalization. While hospitalization in the previous 90 days is also associated with MDR infection, we chose not to stratify by this parameter, as it is an integral part of the case definition for HCAP.[4,6,14]

### 2.3. Data sources

Clinical and demographic data came from the VA Medical SAS Inpatient Dataset ('PTF') and Outpatient Dataset ('OPC').[16] Financial data were drawn from the VA Health Economics Resource Center (HERC) Inpatient and Outpatient Average Cost files, which link to PTF and OPC.[17,18] By construction there is a one-to-one match of the HERC data to inpatient stays recorded in PTF.[19] Outpatient pharmacy costs, lacking in the HERC data, were extracted from the VA Decision Support System.[20] Death during the hospital stay was indicated in the inpatient (PTF) encounter record. One-year mortality was obtained from the VA Beneficiary Identification and Record Locator Subsystem (BIRLS).[21] Data from BIRLS and PTF are combined with Medicare data to create the VA Vital Status file. Relative to the National Death Index, the VA Vital Status file has 98.3% sensitivity and 97.6% exact agreement with dates.[22]

### 2.4. Statistical methods

Outcomes of interest were hospital mortality, 1-year mortality among patients discharged from their indexed hospital admission (termed 'one-year post-discharge mortality'), and 1-year cumulative mortality, which included mortality during or after hospitalization. We extracted clinical, demographic, and cost data for each pneumonia-related inpatient stay having admission and discharge dates between October 2003 and the end of May 2007. We selected only the first qualifying event for each individual. To classify comorbid illness we used the enhanced version of the Charlson–Deyo comorbidity index developed by Quan et al., termed the 'Charlson–Deyo–Quan (CDQ) comorbidity index'.[23] Costs were converted to 2008 dollars using the Consumer Price Index.

We calculated descriptive statistics for demographic, clinical, and cost variables by pneumonia status. Chi-square, log-rank and *t*-tests were employed as appropriate. We used Kaplan–Meier curves and logistic regression to assess the relation of HCAP and CAP to hospital and 12-month survival, controlling for clinical covariates including age, CDQ comorbidity index, ICU admission, pneumonia severity, and factors associated with MDR infections. Analyses were carried out in SAS 9.1 (SAS Institute, Cary, NC, USA). We estimated the marginal effect of HCAP on cost using regression analysis with the previously described covariates. Model selection followed standard methods.[24,25] Regression analyses were performed in Stata 11 (StataCorp. LP, College Station, TX, USA).

## 3. Results

### 3.1. Patient characteristics

A total of 55 963 patients met entry criteria. After exclusions the final sample numbered 50 758 stays, of which 15 578 (30.7%) qualified as HCAP and 35 180 as CAP (69.3%) (Figure 1). Table 1 presents demographic and clinical characteristics of the study sample. ICU admission and mechanical ventilation were more common among HCAP patients (19.3% and 9.7%, respectively) than