Healthcare-Associated Pneumonia and Community-Acquired Pneumonia:

A Single Center Experience

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ABSTRACT

Pneumonia occurring outside of the hospital setting has traditionally been categorized as community-acquired pneumonia (CAP). However, when pneumonia is associated with healthcare risk factors (prior hospitalization, dialysis, residing in a nursing home, immunocompromised state) it is now more appropriately classified as a healthcare-associated pneumonia (HCAP). The relative incidence of CAP and HCAP among patients requiring hospital admission is not well described. The objective of this retrospective cohort study, involving 639 patients with culture-positive CAP and HCAP admitted between January 1, 2003 and December 31, 2005, was to characterize the incidence, microbiology, and treatment patterns for CAP and HCAP among patients requiring hospital admission.

HCAP was more common than CAP (67.4% versus 32.6%). The most common pathogens identified overall included methicillin-resistant *Staphylococcus aureus* (24.6%), *Streptococcus pneumoniae* (20.3%), *Pseudomonas aeruginosa* (18.8%), methicillin-sensitive *Staphylococcus aureus* (13.8%), and *Hemophilus influenzae* (8.5%). Hospital mortality was statistically greater among patients with HCAP compared to CAP (24.6% versus 9.1%; P < 0.001). Initial administration of inappropriate antimicrobial treatment was statistically more common among HCAP patients (28.3% versus 13.0%; P < 0.001) and was identified as an independent risk factor for hospital mortality.
Our study found that the incidence of HCAP was greater than CAP among patients with culture-positive pneumonia requiring hospitalization at Barnes-Jewish Hospital. Patients with HCAP were more likely to receive initial inappropriate antimicrobial treatment and had a greater risk of hospital mortality. Healthcare providers should differentiate patients with HCAP from those with CAP in order to provide more appropriate initial antimicrobial therapy.
INTRODUCTION

Pneumonia developing outside of the hospital setting has traditionally been classified as community-acquired pneumonia (CAP). Nosocomial pneumonia refers to infection acquired during hospitalization and has been further differentiated into ventilator-associated pneumonia (VAP), if pneumonia developed during the course of mechanical ventilation, and hospital-acquired pneumonia (HAP), if infection was not associated with mechanical ventilation (5). Healthcare-associated pneumonia (HCAP) is a relatively new category of nosocomial pneumonia referring to infections that occur prior to hospital admission in patients with specific risk factors (immunosuppression, recent hospitalization, residence in a nursing facility, requiring dialysis) (5,10). Categorization as HCAP is not due to the provision of healthcare per se, but to exposure to environments within which reservoirs of infection exist (e.g., prior hospitalization, nursing homes, dialysis clinics). Patients with HCAP are usually infected with potentially antibiotic-resistant bacteria (methicillin-resistant Staphylococcus aureus, Pseudomonas aeruginosa, Acinetobacter species) while CAP is typically attributed to more susceptible bacteria (Streptococcus pneumoniae, Hemophilus influenzae, Legionella species) (10,14).

The relative incidence of CAP and HCAP among patients admitted to the hospital setting for pneumonia has not previously been systematically evaluated. Therefore, we performed a study with two goals. Our first goal was to determine the relative incidence of culture-positive CAP and HCAP in an urban teaching hospital. The second goal of
this study was to examine the pathogens associated with culture-positive CAP and

HCAP and the relative occurrence of inappropriate initial antimicrobial treatment.
MATERIALS AND METHODS

Study Design

A retrospective cohort analysis was performed of all culture-positive patients admitted to Barnes-Jewish Hospital (1200-bed urban teaching hospital) with a diagnosis of pneumonia between January 1, 2003 and December 31, 2005.

Data Source

One of the investigators (RMR) identified all study patients by the presence of either a primary or secondary ICD-9-CM code indicative of pneumonia and a concomitant positive respiratory bacterial culture, blood culture or urine antigen test specific for \textit{Legionella pneumophila} serogroup 1. The study database was constructed by merging patient-specific data from the automated hospital records, microbiology database, and pharmacy database of Barnes-Jewish Hospital.

Definitions

CAP was defined as a diagnosis of pneumonia in patients who did not meet any of the criteria for HCAP. The clinical diagnosis of CAP and HCAP had to be established within 48 hours of hospitalization to include obtaining confirmatory respiratory cultures. Two of the following clinical criteria were required: fever ($>38.3^\circ$C) or hypothermia ($\leq36.0^\circ$C), leukocytosis ($>10 \times 10^9$ cells/liter) or leukopenia ($\leq4 \times 10^9$ cells/liter), or purulent tracheal aspirate or sputum. HCAP was defined as patients admitted to the hospital with a diagnosis of pneumonia who met the following criteria: (1) admission from a nursing home, rehabilitation hospital, or other long-term nursing care facility; (2)
previous hospitalization within the immediately preceding twelve months; (3) receiving outpatient hemodialysis, peritoneal dialysis, or infusion therapy necessitating regular visits to a hospital-based clinic; and (4) having an immunocompromised state. This definition for HCAP was based on our prior experience with healthcare-associated infections (10,16,18).

The diagnosis of pneumonia was verified by one of the investigators (MHK, KEK) from the medical records and required the presence of a new radiographic infiltrate plus at least two of the following: (1) white blood cell count of greater than 10,000 x 10^3/ml; (2) temperature ≥ 38.3°C; (3) purulent secretions from the lower respiratory tract; and (4) a ratio of the partial pressure of arterial oxygen to the inspired fraction of oxygen (PaO₂/FiO₂) less than 300. Acceptable positive culture specimens included sputum, tracheal aspirate, bronchosopic or blind bronchoalveolar lavage (BAL), or blood. Blood cultures were accepted if the same microorganism was identified in a respiratory specimen and no other source for the positive blood culture could be identified. Additionally, a positive urine antigen for Legionella species qualified as a culture-positive specimen.

Antimicrobial treatment was classified as being inappropriate if the initially prescribed antibiotics were not active against the identified pathogens based on in vitro susceptibility testing. Appropriate antimicrobial treatment had to be prescribed within 24 hours of hospital admission. The antimicrobial regimens employed at Barnes-Jewish Hospital for the treatment of suspected community-acquired pneumonia are ceftriaxone
plus azithromycin or moxifloxacin monotherapy. All antimicrobial agents prescribed for CAP and HCAP, as well as for other infections at Barnes-Jewish Hospital, are also administered at adequate doses and intervals of administration as monitored by the Pharmacy Department and as described previously (5-7,9,16). The community phenotype of methicillin-resistant *Staphylococcus aureus* was defined as isolates resistant to methicillin but sensitive to 3 or more of the following antibiotics including: gentamicin, ciprofloxacin, trimethoprim-sulfamethoxazole, and clindamycin.

The definition of immunosuppression included the following: (1) daily administration of corticosteroids (at least 5 mg per day of prednisone or equivalent drug); (2) sero-positive for the human immunodeficiency virus; (3) having received either a solid organ transplant or bone marrow transplant; (4) treated with radiation therapy or chemotherapy for an underlying malignancy during the six months prior to hospital admission; and (5) having an underlying acquired immune deficiency disorder (hypogammaglobulinemia, combined variable immunodeficiency).

**Data Analysis**

All comparisons were unpaired and all tests of significance were two-tailed. Continuous variables were compared using the Student *t*-test for normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. The chi-square or Fisher’s exact test was used to compare categorical variables. We performed multiple logistic-regression analysis using SPSS, version 11.0 for Windows (SPSS, Inc., Chicago, IL). Multivariate analysis was performed using models that were judged a
priori to be clinically sound. This was prospectively determined to be necessary to avoid
producing spuriously significant results with multiple comparisons. All potential risk
factors significant at the 0.2 level in univariate analyses were entered into the model.
RESULTS

Patient Characteristics

A total of 639 culture-positive patients with pneumonia were admitted to Barnes-Jewish Hospital during the study period. The mean age of the population was 58.9 ± 18.1 (range 17 to 102); there were 356 (55.7%) males and 283 (44.3%) females. There were 431 (67.4%) patients classified as having HCAP and 208 (32.6%) with CAP. Patient characteristics for patients with HCAP and CAP are provided in Table 1. Hospitalization during the previous twelve months was the most common criteria for HCAP. Most patients meeting the criteria for HCAP were previously hospitalized within 90 days of their current admission (Table 1). Patients with HCAP were significantly more likely to require mechanical ventilation and intensive care unit admission compared to patients with CAP.

Pathogen Distribution

The microbiologic diagnosis of pneumonia was most often established by sputum culture or tracheal aspirate culture in 450 patients [CAP, 132 (63.5%) versus HCAP, 318 (73.8%)], blood cultures in 211 patients [CAP, 78 (37.5%) versus HCAP, 133 (30.9%)], bronchoalveolar lavage cultures in 30 patients [CAP, 9 (4.3%) versus HCAP, 21 (4.9%)], and a positive urine antigen for Legionella pneumophila serogroup 1 in 8 patients [CAP, 7 (3.4%) versus HCAP, 1 (0.2%)].

The distribution of pathogens for CAP and HCAP are provided in Table 2. Methicillin-resistant Staphylococcus aureus was the most common pathogen. Patients...
with HCAP were significantly more likely to be infected with methicillin-resistant *Staphylococcus aureus*, *Pseudomonas aeruginosa*, other non-fermenting Gram-negative rods, and other *Enterobacteriaceae* compared to patients with CAP. HCAP patients were significantly less likely to be infected with *Streptococcus pneumoniae*, *Haemophilus* species, and *Legionella pneumophila* serogroup 1 compared to patients with CAP. For patients classified as having HCAP based on a prior hospitalization, the distribution of bacterial pathogens isolated from the respiratory tract was similar, favoring nosocomial pathogens regardless of the timing of the previous hospitalization (≤ 90 days, > 90 days and ≤ 180 days, > 180 days and ≤ 1 year). The community phenotype of methicillin-resistant *Staphylococcus aureus* was not significantly different between methicillin-resistant *Staphylococcus aureus* isolates in patients with CAP compared to HCAP ([9 of 25] 36% versus [30 of 132] 23%; P = 0.153).

Secondary bacteremia occurred in 211 (33.0%) patients. The occurrence of secondary bacteremia was not significantly different between patients with CAP and HCAP (37.5% versus 30.9%; P = 0.094). The percentage of secondary bacteremia among the various pathogens is provided in Table 2.

**Appropriate Antimicrobial Treatment**

Appropriate initial antimicrobial treatment was administered to 490 (76.7%) patients within 24 hours of hospital admission and 149 (23.3%) patients received inappropriate initial antimicrobial treatment. Patients with HCAP were statistically more likely to receive inappropriate antimicrobial treatment compared to patients with CAP.
(28.3% versus 13.0%; P < 0.001). Figure 1 provides the rates of inappropriate treatment by pathogen distribution. Methicillin-resistant *Staphylococcus aureus*, *Pseudomonas aeruginosa*, other non-fermenting Gram-negative rods, and other *Enterobacteriaceae* were the most common pathogens to be initially treated with an inappropriate antimicrobial regimen. Among the 220 patients initially treated only with a community-acquired antimicrobial regimen (ceftriaxone plus azithromycin or moxifloxacin), 49 (22.3%) received initial inappropriate antimicrobial treatment [CAP, 15 (13.6%) versus HCAP, 34 (30.9%); P = 0.002].

**Hospital Mortality**

The overall hospital mortality rate was 19.6% (125 patients expired during their hospital stay). Patients with HCAP were significantly more likely to die compared to patients with CAP (24.6% versus 9.1%; P < 0.001). Similarly, patients treated with an inappropriate initial antimicrobial regimen had a greater hospital mortality compared to patients treated with an appropriate initial regimen (32.2% versus 15.7%; P < 0.001). Logistic regression analysis identified seven variables as independent predictors of hospital mortality (Table 3). Administration of inappropriate initial antimicrobial treatment was independently associated with hospital mortality. Figure 2 shows the hospital mortality for the pathogens associated with culture-positive pneumonia. Methicillin-resistant *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella*
1 species, and other nonfermenting Gram-negative rods were associated with a hospital
2 mortality greater than twenty percent.
DISCUSSION

We showed that in an urban teaching hospital HCAP was more common than CAP among patients admitted with a culture-positive diagnosis of pneumonia. Methicillin-resistant *Staphylococcus aureus, Streptococcus pneumoniae, Pseudomonas aeruginosa*, methicillin-sensitive *Staphylococcus aureus*, and *Haemophilus influenzae* were the most common pathogens associated with culture-positive pneumonia. HCAP patients were statistically more likely to be infected with methicillin-resistant *Staphylococcus aureus, Pseudomonas aeruginosa*, other non-fermenting Gram-negative rods, other *Enterobacteriaceae* and were significantly more likely to receive inappropriate initial antimicrobial treatment compared to patients with CAP. Patients receiving inappropriate initial antimicrobial treatment were significantly more likely to die during their hospitalization compared to patients treated with an initial appropriate antimicrobial regimen.

Previous investigations have shown that antimicrobial regimens lacking activity against identified microorganisms causing serious infections (e.g., nosocomial pneumonia, bloodstream infections) are associated with greater hospital mortality (1, 3, 6, 7-11, 13, 15, 17). In these studies inappropriate initial antimicrobial treatment was most often associated with infection due to potentially antibiotic-resistant bacteria (methicillin-resistant *Staphylococcus aureus, Pseudomonas aeruginosa, Acinetobacter species*). More recently, similar finding has been demonstrated for patients with severe sepsis and septic shock (2, 4, 12, 16). Unfortunately, changing antimicrobial therapy to an
appropriate regimen in patients with serious nosocomial infections, including pneumonia, after susceptibility data become available has not been demonstrated to improve clinical outcomes in patients initially receiving inappropriate treatment (1,11,13). Our present findings are consistent with these previous studies in demonstrating that potentially antibiotic-resistant pathogens (Pseudomonas aeruginosa, methicillin-resistant Staphylococcus aureus, other nonfermenting Gram-negative rods, other Enterobactereae) were significantly more likely to occur in patients with HCAP and to be treated with an inappropriate antibiotic regimen, and that patients treated with an initial inappropriate antimicrobial regimen were more likely to die during their hospitalization.

In a previous multi-center study of culture-positive pneumonia from an administrative data base, the occurrence of HCAP was found to be less common than CAP (10). Kollef et al found that among patients with culture-positive pneumonia admitted to the hospital setting, 2221 (69.2%) patients had CAP and 988 (30.8%) had HCAP. However, the pathogen distribution was similar to our current findings. The multi-center study demonstrated that CAP patients were statistically more likely to have infection with Streptococcus pneumoniae (16.6% versus 5.5%; P < 0.01) and Hemophilus influenzae (16.6% versus 5.8%; P < 0.01) whereas patients with HCAP were significantly more likely to be infected with methicillin-resistant Staphylococcus aureus (26.5% versus 8.9; P < 0.01), Pseudomonas aeruginosa (25.3% versus 17.1; P < 0.01) and other Gram-negative bacteria (9.5% versus 4.1%; P < 0.01). The greater
frequency of HCAP patients observed at Barnes-Jewish Hospital may be related to the
different case mix of patients enrolled in our study. For example, over ninety percent of
HCAP patients at Barnes-Jewish Hospital had at least one previous hospitalization
during the preceding twelve months suggesting a high likelihood of exposure to
potentially antibiotic-resistant bacteria.

Several important limitations of this investigation should be noted. First, we only
evaluated patients with culture-positive pneumonia. Therefore, we may have missed
patients with pneumonia having negative cultures due to either early antibiotic
administration or inadequate specimens submitted for microbiologic evaluation.
Additionally, we did not employ non-culture methods (e.g., serology, polymerase chain
reaction assays) to establish the diagnosis of CAP, which limited our ability to identify
atypical pathogens (e.g., viruses, *Mycoplasma* species, *Chlamydia* species). This is an
important limitation that likely reduced the number of patients with CAP identified.
Second, we limited our study to patients with identified bacterial pneumonia excluding
all other causes. Therefore, our findings are not applicable to patients with non-bacterial
causes of pneumonia. Third, we did not employ a severity of illness score. It is possible
that the patients dying with inappropriate initial antimicrobial treatment may have been
sicker than those receiving appropriate initial treatment. The results of our multivariate
analysis refute this in showing that markers of greater disease severity (older age,
requiring mechanical ventilation) were independently associated with mortality along
with the administration of inappropriate initial antimicrobial treatment. Lastly, our study
was performed at a single hospital and may not be applicable to other hospitals. For example, hospitals caring for patients who infrequently have risk factors for HCAP would not expect to see similar rates of inappropriate initial antimicrobial treatment among patients with culture-positive pneumonia admitted to their hospital.

The observed impact of inappropriate initial antimicrobial therapy on patient outcomes suggests that measures aimed at improving the administration of appropriate antibiotic therapy to patients with risk factors for HCAP is required. Micek et al previously demonstrated in the emergency department setting that a standardized order set for the treatment of severe sepsis and septic shock increased the administration of appropriate initial antimicrobial therapy from 71.7% to 86.7% and was associated with a significant reduction in hospital mortality (16). The standardized order set required physicians to screen patients for healthcare-associated infection risk factors and to treat with a combination antimicrobial regimen targeting methicillin-resistant *Staphylococcus aureus* and potentially resistant Gram-negative bacteria when these risk factors were identified. A similar study by Ibrahim et al found that a treatment protocol for the management of VAP increased the administration of initial appropriate antimicrobial therapy employing a combination antimicrobial regimen (7). Implementation of standardized approaches for the treatment of HCAP, and other healthcare-associated infections, seems reasonable since failure to identify risk factors for healthcare-associated infection appears to be the most common cause for the administration of
inappropriate antimicrobial therapy to patients hospitalized with serious infections (16,18).

In summary, we found that HCAP was more common than CAP among patients with culture-positive pneumonia admitted to an urban teaching hospital. Patients with HCAP were more likely to receive inappropriate initial antimicrobial treatment and had a greater risk of hospital mortality. Clinicians caring for patients with pneumonia requiring hospital admission should be aware of the risk factors for HCAP and the predominant bacterial pathogens associated with healthcare-associated infections at their hospital. Awareness of these issues may result in improved initial administration of appropriate antimicrobial treatment to patients with HCAP. Additionally, new studies are required to develop uniform and validated criteria for HCAP and other healthcare-associated infections.
REFERENCES


Table 1. Patient Characteristics*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>CAP (n = 208)</th>
<th>HCAP (n = 431)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, yr:</strong></td>
<td>57.0 ± 16.9</td>
<td>59.8 ± 18.5</td>
<td>0.072</td>
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<tr>
<td><strong>Sex, n (%):</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>121 (58.2)</td>
<td>235 (54.8)</td>
<td>0.418</td>
</tr>
<tr>
<td>Female</td>
<td>87 (42.8)</td>
<td>196 (46.2)</td>
<td></td>
</tr>
<tr>
<td><strong>Race, n (%):</strong></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>White</td>
<td>100 (48)</td>
<td>273 (63.3)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>106 (51)</td>
<td>158 (36.7)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2 (1)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>HCAP Criteria, n (%):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recent hospitalization</td>
<td>---</td>
<td>402 (93.3)</td>
<td>---</td>
</tr>
<tr>
<td>Within 90 days</td>
<td>---</td>
<td>297 (68.9)</td>
<td>---</td>
</tr>
<tr>
<td>&gt;90 days and ≤180 days</td>
<td>---</td>
<td>87 (20.2)</td>
<td>---</td>
</tr>
<tr>
<td>&gt;180 days and ≤1 year</td>
<td>---</td>
<td>18 (4.2)</td>
<td>---</td>
</tr>
<tr>
<td>Immunosuppression</td>
<td>---</td>
<td>169 (39.2)</td>
<td>---</td>
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<tr>
<td>Nursing home resident</td>
<td>---</td>
<td>121 (28.1)</td>
<td>---</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>---</td>
<td>43 (10.0)</td>
<td>---</td>
</tr>
<tr>
<td><strong>Bacteremia</strong></td>
<td>78 (37.5)</td>
<td>133 (30.9)</td>
<td>0.094</td>
</tr>
<tr>
<td><strong>ICU Admission</strong></td>
<td>77 (37.0)</td>
<td>210 (48.7)</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Mechanical Ventilation</strong></td>
<td>65 (31.3)</td>
<td>192 (44.5)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* Values are presented as mean ± SD.

HCAP = healthcare-associated pneumonia; ICU = intensive care unit.
<table>
<thead>
<tr>
<th>Pathogen, n (%)</th>
<th>Combined (n = 639)</th>
<th>% Bacteremia</th>
<th>CAP (n = 208)</th>
<th>HCAP (n = 431)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>157 (24.6)</td>
<td>30.6</td>
<td>25 (12.0)</td>
<td>132 (30.6)</td>
<td>&lt;0.001</td>
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<tr>
<td><em>Streptococcus pneumoniae</em></td>
<td>130 (20.3)</td>
<td>53.1</td>
<td>85 (40.9)</td>
<td>45 (10.4)</td>
<td>&lt;0.001</td>
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<td><em>Pseudomonas aeruginosa</em></td>
<td>120 (18.8)</td>
<td>15.8</td>
<td>10 (4.8)</td>
<td>110 (25.5)</td>
<td>&lt;0.001</td>
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<td>MSSA</td>
<td>88 (13.8)</td>
<td>23.9</td>
<td>28 (13.5)</td>
<td>60 (13.9)</td>
<td>0.874</td>
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<td><em>Haemophilus</em> species</td>
<td>54 (8.5)</td>
<td>5.6</td>
<td>36 (17.3)</td>
<td>18 (4.2)</td>
<td>&lt;0.001</td>
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<tr>
<td>Other non-fermenting Gram-negative rods*</td>
<td>46 (7.2)</td>
<td>21.3</td>
<td>4 (1.9)</td>
<td>43 (10.0)</td>
<td>&lt;0.001</td>
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<tr>
<td>Other <em>enterobacteriaceae</em>†</td>
<td>44 (6.9)</td>
<td>29.5</td>
<td>5 (2.4)</td>
<td>39 (9.0)</td>
<td>0.002</td>
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<td><em>Klebsiella</em> species</td>
<td>35 (5.5)</td>
<td>34.3</td>
<td>7 (3.4)</td>
<td>28 (6.5)</td>
<td>0.103</td>
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<tr>
<td><em>Escherichia coli</em></td>
<td>30 (4.7)</td>
<td>60.0</td>
<td>12 (5.8)</td>
<td>18 (4.2)</td>
<td>0.372</td>
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<td><em>Legionella</em> species</td>
<td>8 (1.3)</td>
<td>0</td>
<td>7 (3.4)</td>
<td>1 (0.2)</td>
<td>0.017</td>
</tr>
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</table>

*Acinetobacter species, Stenotrophomonas maltophilia, Alcaligenes xylosidans, Burkholderia species.
† Enterobacter species, Citrobacter species, Serratia marcescens, Proteus species, Morganella species.
MRSA=methicillin-resistant *Staphylococcus aureus*; MSSA=methicillin-sensitive *Staphylococcus aureus*.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted Odds Ratio</th>
<th>95% CI</th>
<th>P value</th>
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<tr>
<td>Age (1-year increments)</td>
<td>1.02</td>
<td>1.01-1.04</td>
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<td>Healthcare-associated Pneumonia</td>
<td>2.28</td>
<td>1.67-3.13</td>
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<tr>
<td>Requires mechanical ventilation</td>
<td>5.05</td>
<td>3.68-6.92</td>
<td>&lt;0.001</td>
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<tr>
<td>Inappropriate initial antimicrobial therapy</td>
<td>2.19</td>
<td>1.27-3.78</td>
<td>0.005</td>
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<tr>
<td>Bacteremia</td>
<td>3.26</td>
<td>2.54-4.82</td>
<td>&lt;0.001</td>
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<tr>
<td>Caucasian</td>
<td>1.80</td>
<td>1.12-2.89</td>
<td>0.015</td>
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<tr>
<td><em>Klebsiella</em> species infection</td>
<td>2.53</td>
<td>1.66-3.91</td>
<td>0.034</td>
</tr>
</tbody>
</table>

Other covariates not presented in the table had a P value on > 0.05: intensive care unit admission, monotherapy antibiotic regimen, *methicillin-resistant Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Streptococcus pneumoniae*, and methicillin-sensitive *Staphylococcus aureus* infection.

The Hosmer-Lemeshow goodness of test, P = 0.653.
Figure 1. Rates of inappropriate antimicrobial treatment in patients according to the pathogen distribution. CAP = community-acquired pneumonia; HCAP = healthcare-associated pneumonia.

Figure 2. Rates of hospital mortality according to pathogen distribution. CAP = community-acquired pneumonia; HCAP = healthcare-associated pneumonia.
Inappropriate Initial Therapy (%)

- S. pneumoniae
- MRSA
- MSSA
- P. aeruginosa
- E. coli
- Klebsiella sp.
- Other nonfermenting GNR
- Other Enterobacteriaceae
- Haemophilus sp.

**Figure 1.**
Figure 2.