

# Processes and Outcomes of Care for Patients With Community-Acquired Pneumonia

## Results From the Pneumonia Patient Outcomes Research Team (PORT) Cohort Study

Michael J. Fine, MD, MSc; Roslyn A. Stone, PhD; Daniel E. Singer, MD; Christopher M. Coley, MD; Thomas J. Marrie, MD; Judith R. Lave, PhD; Linda J. Hough, MPH; D. Scott Obrosky, MSc; Richard Schulz, PhD; Edmund M. Ricci, PhD; Joan C. Rogers, PhD; Wishwa N. Kapoor, MD, MPH

**Background:** Although understanding the processes of care and medical outcomes for patients with community-acquired pneumonia is instrumental to improving the quality and cost-effectiveness of care for this illness, limited information is available on how physicians manage patients with this illness or on medical outcomes other than short-term mortality.

**Objectives:** To describe the processes of care and to assess a broad range of medical outcomes for ambulatory and hospitalized patients with community-acquired pneumonia.

**Methods:** This prospective, observational study was conducted at 4 hospitals and 1 health maintenance organization in Pittsburgh, Pa, Boston, Mass, and Halifax, Nova Scotia. Data were collected via patient interviews and reviews of medical records for 944 outpatients and 1343 inpatients with clinical and radiographic evidence of community-acquired pneumonia. Processes of care and medical outcomes were assessed 30 days after presentation.

**Results:** Only 29.7% of outpatients had 1 or more microbiologic tests performed, and only 5.7% had an assigned microbiologic cause. Although 95.7% of inpa-

tients had 1 or more microbiologic tests performed, a cause was established in only 29.6%. Six outpatients (0.6%) died, and 3 of these deaths were pneumonia related. Of surviving outpatients, 8.0% had 1 or more medical complications. At 30 days, 88.9% (nonemployed) to 95.6% (employed) of the surviving outpatients had returned to usual activities, yet 76.0% of outpatients had 1 or more persisting pneumonia-related symptoms. Overall, 107 inpatients (8.0%) died, and 81 of these deaths were pneumonia related. Most surviving inpatients (69.0%) had 1 or more medical complications. At 30 days, 57.3% (nonemployed) to 82.0% (employed) of surviving inpatients had returned to usual activities, and 86.1% had 1 or more persisting pneumonia-related symptoms.

**Conclusions:** In this study, conducted primarily at hospital sites with affiliated medical education training programs, virtually all outpatients and most inpatients had pneumonia of unknown cause. Although outpatients had an excellent prognosis, pneumonia-related symptoms often persisted at 30 days. Inpatients had substantial mortality, morbidity, and pneumonia-related symptoms at 30 days.

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**C**OMMUNITY-acquired pneumonia (CAP) affects more than 4 million adults and accounts for more than 1 million hospital admissions each year in the United States.<sup>1,2</sup> Pneumonia and influenza are the sixth leading cause of death in this country, and age-adjusted mortality attributed to these illnesses is increasing.<sup>3</sup> Community-acquired pneumonia is responsible for 64 million days of restricted activity, 39 million days of bed confinement, and 10 million days of work loss annually.<sup>4</sup>

Knowledge of current processes of care is a basic requirement for improving

the quality of medical treatment for patients with CAP. Although prior studies<sup>5-9</sup> of CAP have described the clinical characteristics and microbiologic causes of their study populations based on standard investigational protocols, many processes of care, such as how often laboratory or microbiologic tests are routinely performed, have, to our knowledge, not been described.

Understanding medical outcomes of CAP is important for quality improvement efforts, as well as patient education and satisfaction with care, because it allows physicians to inform their patients about the likelihood of potential compli-

*The affiliations of the authors appear in the acknowledgment section at the end of the article.*

## PATIENTS AND METHODS

### STUDY SITES AND PATIENTS

The Pneumonia PORT prospective cohort study was conducted from October 1991 through March 1994 at 3 university hospitals, 1 community teaching hospital, and 1 group-model health maintenance organization, in Pittsburgh, Pa, Boston, Mass, and Halifax, Nova Scotia; methods and criteria have been previously described.<sup>19</sup> This study of immunocompetent and immunocompromised human immunodeficiency virus-negative patients with CAP was approved by the biomedical institutional review boards of all study sites.

Enrolled patients initially treated in an ambulatory setting, including those who were subsequently admitted to a hospital, were classified as outpatients. All patients admitted to a hospital on presentation to a study site facility were classified as inpatients. Both outpatients and inpatients were enrolled from each of the 4 hospital sites; only outpatients were enrolled from the single health maintenance organization study site.

During the study enrollment period, more than 12 500 potential cases of CAP were screened to identify 3964 potential participants who satisfied all eligibility criteria. Overall, 2287 eligible patients (57.7%) were enrolled; 1343 (55.5%) of 2418 eligible inpatients and 944 (61.1%) of 1545 eligible outpatients (site of care was unknown for 1 eligible patient who was not enrolled). The leading reasons for nonenrollment of the 1677 eligible patients were patient or physician refusal (44.1%) and inability to contact the patient within the 6-day period for enrollment (34.8%). Enrollment of eligible patients varied across sites, ranging from 76.0% in Halifax to 45.3% for the 2 Pittsburgh sites. The lower enrollment rate for the Pittsburgh sites resulted from our exclusion of all data collected for 185 patients by 1 research assistant who failed to adhere to study protocols. Analysis of data for age, race, sex, and baseline severity of illness collected independently for these patients provided no evidence that they were systematically different from the remaining patients enrolled from the Pittsburgh study sites (data not shown).

To assess potential selection biases, the same data (age, race, sex, and baseline severity of illness determined by 19 clinical variables from presentation used to determine the risk of short-term mortality in CAP<sup>20</sup>) were collected for eligible patients who were not enrolled in the study. In comparison with eligible patients who were not enrolled, enrolled patients were slightly younger (mean age, 56 vs 61 years;  $P < .001$ ), more likely to be white (85.2% vs 76.8%;  $P < .001$ ), and more likely to be classified as low risk (ie, predicted probability of less than .04) for short-term mortality (68.9% vs 57.3%;  $P < .001$ ).

### PATIENT BASELINE ASSESSMENT

For all study patients, baseline sociodemographic characteristics and clinical data were assessed at presentation to a study site by patient interview and review of medical records. A proxy respondent was sought from the

patients' caregivers if a patient was unable to participate in a direct interview because of physical barriers (eg, mechanical ventilation), language barriers, or mental confusion.

Clinical data collected included the presence of symptoms and physical examination findings at presentation, comorbid illnesses, and results of pertinent laboratory tests performed within 48 hours of presentation. Five respiratory symptoms (cough, dyspnea, sputum production, pleuritic chest pain, and hemoptysis) and 14 nonrespiratory symptoms (fatigue, fever, anorexia, chills, sweats, headache, myalgia, nausea, sore throat, confusion, inability to eat, vomiting, diarrhea, and abdominal pain) were assessed. During the baseline interview, patients or proxies were also asked to report retrospectively the presence of 5 common CAP-related symptoms (cough, dyspnea, sputum production, pleuritic chest pain, and fatigue) for the month before the onset of illness with CAP. Physical examination data collected at presentation included vital signs and an evaluation of mental status. Laboratory data collected included white blood cell count, hematocrit, blood urea nitrogen level, serum sodium level, liver enzyme levels, arterial blood gas levels, and pulse oximetry.

Severity of illness at presentation was quantified by means of a validated prediction rule for 30-day mortality and medical complications in patients with CAP.<sup>21</sup> This rule is based on 3 demographic characteristics, 5 comorbid illnesses, 5 physical examination findings, and 7 laboratory and radiographic findings from the time of presentation. The rule classified patients into 5 risk classes with 30-day observed mortality ranging from 0.1% for class 1 (lowest risk) to 27.0% for class 5 (highest risk).

Copies of initial chest radiographs used for the diagnosis of pneumonia at each study site were independently reviewed by a 3-member panel of staff radiologists at the University of Pittsburgh who had no patient-specific clinical information. For all patients with an infiltrate confirmed as possible, probable, or definite by 2 of the panel radiologists, further characterization of the radiograph was performed by 1 panel member using a standardized data collection form. A prior analysis of 232 chest radiographs characterized independently by 2 panel members demonstrated fair to good interrater reliability for the presence of infiltrate ( $\kappa = 0.37$ ), number of pulmonary lobes with infiltrate ( $\kappa = 0.51$ ), and pleural effusion ( $\kappa = 0.46$ ).<sup>22</sup> Pleural effusion was quantified by the maximum present in either lung as follows: none, minimal (costophrenic angle blunting only), moderate (less than one third of the pleural space), and large (one third or more of the pleural space). The pattern of infiltrate was categorized as predominantly alveolar, predominantly interstitial, miliary, or mixed alveolar and interstitial.<sup>23,24</sup> The extent of radiographic infiltrate was determined by the number of pulmonary lobes with any identifiable infiltrate.

### ASSIGNMENT OF PNEUMONIA CAUSE

Data were collected through chart review for the following microbiologic tests, when ordered at the discretion of

Continued on next page

cations, natural history of symptom resolution, and expected time to return to usual activities.<sup>10</sup> Few previously published reports of prognosis for CAP have assessed outcomes other than all-cause mortality,<sup>11</sup> and

few have studied patients treated in the ambulatory setting.<sup>12-17</sup>

As part of the Pneumonia Patient Outcomes Research Team (PORT) project, we conducted a mul-

the physicians managing these patients: sputum Gram stains and bacterial cultures obtained within 2 days of presentation, blood cultures drawn before initiating antimicrobial therapy, pleural fluid cultures, and acute (within 1 week of presentation) and convalescent (from 1 to 8 weeks after presentation) serologic tests. Results of these tests were reviewed, and a microbiologic cause was assigned independently by 2 of 5 clinical investigators (C.M.C., M.J.F., W.N.K., T.J.M., D.E.S.), using previously published criteria.<sup>8</sup> The 5-member committee discussed all discrepancies between the initial 2 reviewers, and the final assignment of cause was based on the unanimous consensus opinion of the full committee.

A degree of certainty (definite or presumptive) was assigned to each etiologic diagnosis. Assignment of a definite microbiologic cause required positive blood or pleural fluid cultures or a 4-fold rise in an IgG antibody titer for *Legionella* species, *Mycoplasma pneumoniae*, or *Chlamydia pneumoniae*. A presumptive microbiologic cause was based on heavy or moderate growth of a predominant bacterial pathogen in sputum culture or light growth of a bacterial pathogen in sputum culture confirmed by the presence of a compatible predominant organism in a sputum Gram stain. Definite and presumptive causes were combined for reporting purposes. When 2 or more microbiologic causes were coded as definite or presumptive pathogens for a patient, the cause was classified as multiple pathogens. A patient was considered to have pneumonia of unknown cause if no diagnostic tests were performed or tests were performed but test results did not meet criteria for assigning microbiologic cause.

Based on radiographic data and synopses of clinical data, diagnoses of presumptive aspiration pneumonia and postobstructive pneumonia were also assigned by the clinical committee. Presumptive aspiration pneumonia was diagnosed in patients with a disorder known to alter consciousness, the normal gag reflex, or swallowing mechanism in whom the chest radiograph revealed an infiltrate involving the superior or basilar segments of the lower lobes or the posterior segments of the upper lobes.<sup>25</sup> Presumptive postobstructive pneumonia was diagnosed radiographically or bronchoscopically in the presence of a pulmonary infiltrate located distal to an obstructing neoplasm.

#### PROCESSES OF CARE

The extent of laboratory and microbiologic testing, length of hospital stay, number of specialty care unit (intensive care unit, coronary care unit, and telemetry) admissions, and the reason for the first admission to any specialty care unit were assessed by medical record review. In addition, the dose, route of administration, frequency, and duration of antimicrobial therapy were recorded for all agents prescribed within 30 days of presentation and are reported in detail elsewhere.<sup>26</sup> Length of hospital stay was calculated as the date of discharge minus the date of admission.

#### MEDICAL OUTCOMES

Survival at 30 days following the radiographic diagnosis of pneumonia was ascertained for all 2287 study patients. Detailed case summaries of all deaths, based on medical record review, autopsy results when available (14 of 113 patients who died underwent autopsies), and interviews with caregivers and family members, were reviewed independently by 2 of the 5 clinical investigators. The cause of death was assigned using World Health Organization criteria.<sup>27</sup> Based on these criteria, death was considered to be pneumonia related when CAP was identified as the underlying cause of death (ie, initiated the series of morbid events directly leading to death), the immediate cause of death (ie, immediately preceded death), or a major contributing cause of death (ie, neither the underlying nor immediate cause, but death would not have occurred without it). Each death was discussed by the full 5-member committee until complete agreement for causality was reached. Data concerning all new medical complications, and worsening of previously stable chronic medical conditions (eg, congestive heart failure), that occurred within 30 days of presentation were collected for 96.1% of 944 outpatients and 99.7% of 1343 inpatients by medical record review.

The same 5 CAP-related symptoms (cough, dyspnea, sputum production, pleuritic chest pain, and fatigue) assessed at baseline and retrospectively were assessed at 30 days by patient or proxy interview. Each of these symptoms are reported for all patients who were alive at 30 days and had complete data at 3 time points (retrospective, baseline, and 30 days). Data for individual symptoms were complete for 93.3% to 94.6% of the 938 outpatients and 84.9% to 91.1% of the 1236 inpatients who were alive at 30 days.

Subsequent hospitalization for outpatients and hospital readmission for inpatients were assessed at 30 days after presentation. Subsequent hospitalization for outpatients was attributed to CAP or comorbid illness, based on previously described criteria.<sup>28</sup>

Additional outcome measures that were evaluated for patients alive at 30 days included return to usual activities and return to work. Initially, these data were collected for only a subset of patients; the protocol was later modified so that these data were collected for all subsequently enrolled patients. Data for return to usual activities were complete for 86.5% of the 938 outpatients and 69.0% of the 1236 inpatients who were alive at 30 days. Data for return to work were complete for 89.8% of the 539 outpatients and 75.8% of the 215 inpatients who were employed at the time of presentation and alive at 30 days.

#### STATISTICAL METHODS

Descriptive statistics were generated separately for outpatients and inpatients because the focus of this article is to describe processes and outcomes for these 2 groups rather than to compare them. For time-to-event outcomes (ie, return to usual activities and work), Kaplan-Meier estimated probabilities were computed, with inpatients assumed not to be at risk before hospital discharge.<sup>29</sup>

ticenter, prospective, observational study to accomplish 2 objectives: to describe the processes of care and to assess a broad range of medical outcomes for ambulatory and hospitalized patients with CAP. The

processes of care, or components of the encounter between a patient and medical care provider, described in this study consist of baseline laboratory and microbiologic tests, length of hospital stay, and treat-

ment within a specialty care unit (eg, intensive care unit) for inpatients.<sup>18</sup>

## RESULTS

### PATIENT BASELINE CHARACTERISTICS

Most outpatients were between 18 and 44 years of age (59.5%), had more than a high school education (58.7%), and were employed (57.2%) (**Table 1**). Overall, 204 outpatients (21.7%) received their care through a health maintenance or preferred provider organization, including 69 outpatients who were enrolled from hospital sites. Most inpatients (58.7%) were 65 years or older, about one third (32.9%) had more than a high school education, and relatively few (16.3%) were employed. Most US inpatients (62.0%) had Medicare insurance. Almost all the Canadian patients had Medical Services Insurance, the national health insurance provided in Nova Scotia.

Most outpatients (59.1%) had none of the comorbid conditions listed in Table 1, and 95.7% were in the 3 lowest-severity risk classes. Only 14.4% of inpatients had none of the comorbid conditions listed in Table 1, and half (50.0%) were in the 2 highest-severity risk classes.

Most patients reported multiple respiratory and non-respiratory symptoms at presentation, with cough and fatigue being most frequently reported by both outpatients and inpatients (**Table 2**). Vital signs (respiratory rate, heart rate, systolic blood pressure, and temperature) were assessed for 50.5% to 72.8% of outpatients, while mental status was assessed for 99.8%. Clinically meaningful abnormalities in vital signs or mental status were observed in fewer than 5% of the outpatients for whom signs were assessed. Vital signs and mental status were assessed for almost all inpatients; tachypnea (respiratory rate,  $\geq 30/\text{min}$ ) was observed for 23.0%, tachycardia (heart rate,  $\geq 125/\text{min}$ ) for 13.0%, and altered mental status for 17.3%.

Of the 907 outpatients for whom copies of the baseline chest radiographs were available for review, pulmonary infiltrate was independently confirmed for 84.3% and pleural effusions were present in 3.3% (**Table 3**). Only 1 lobe was involved for most outpatients with a confirmed infiltrate (76.5%), and bilateral infiltrates were present for 12.9%. The initially identified pulmonary infiltrate was independently confirmed for 89.5% of 1276 inpatients, with pleural effusions present in 10.8%. More than 1 lobe was involved for 50.7% of those inpatients with confirmed infiltrates, and bilateral infiltrates were present for 29.6%.

Fewer than half (47.8%) of the outpatients had any of the laboratory tests listed in **Table 4** performed. White blood cell count, hematocrit, and platelet count were ordered most frequently (31.4%-39.8%), followed by creatinine level, blood urea nitrogen level, glucose level, pulse oximetry, and sodium level (18.1%-19.7%). For outpatients with 1 or more laboratory tests performed, the most frequent abnormal findings were elevated white blood cell count (34.6%), hypoalbuminemia (25.0%), and elevated aspartate aminotransferase level (15.6%). Each of the laboratory tests in Table 4 was performed for most inpatients, and elevated white blood cell count and hy-

**Table 1. Baseline Demographic and Clinical Characteristics\***

Characteristics	Outpatients (n = 944), No. (%)	Inpatients (n = 1343), No. (%)
<b>Demographic</b>		
Study site		
University of Pittsburgh Medical Center	109 (11.5)	332 (24.7)
St Francis Medical Center	49 (5.2)	111 (8.3)
Massachusetts General Hospital	280 (29.7)	539 (40.1)
Harvard Community Health Plan	135 (14.3)	0 (0.0)
Victoria General Hospital	371 (39.3)	361 (26.9)
Age, y		
18-44	562 (59.5)	264 (19.7)
45-64	208 (22.0)	290 (21.6)
$\geq 65$	174 (18.4)	789 (58.7)
Sex, male	441 (46.7)	703 (52.3)
Race, white	789 (83.6)	1160 (86.4)
Living arrangements		
Private residence, alone	125 (13.2)	275 (20.5)
Private residence, with others	782 (82.8)	817 (60.9)
Nursing home or chronic care facility	9 (0.9)	186 (13.9)
Other†	28 (3.0)	64 (4.8)
Education, >high school	552 (58.7)	433 (32.9)
Employment status, employed	539 (57.2)	218 (16.3)
Medical insurance		
Medicaid only	50 (5.3)	114 (8.5)
Medicare	108 (11.4)	608 (45.5)
Medical Services Insurance (Canada)	367 (38.9)	348 (26.0)
Private only	366 (38.8)	208 (15.6)
Uninsured	53 (5.6)	58 (4.3)
Care through health maintenance organization	204 (21.7)	48 (3.6)
<b>Clinical</b>		
Comorbid conditions		
Chronic pulmonary disease‡	134 (14.3)	454 (33.9)
Coronary artery disease	57 (6.0)	349 (26.0)
Alcohol or intravenous drug abuse	124 (14.2)	260 (25.0)
Cancer	55 (5.9)	239 (17.8)
Congestive heart failure	28 (3.0)	225 (16.8)
Neuromuscular or musculoskeletal disorder§	25 (2.7)	218 (16.3)
Diabetes mellitus	37 (3.9)	198 (14.7)
Cerebrovascular disease	19 (2.0)	191 (14.2)
Immunosuppression	27 (2.9)	162 (12.1)
Renal disease	14 (1.5)	139 (10.4)
Dementia	7 (0.7)	134 (10.0)
Seizure disorder	16 (1.7)	75 (5.6)
None of the above	529 (59.1)	189 (14.4)

\*Missing data were excluded from the denominator; data were missing for less than 2% of patients for all variables except alcohol or intravenous drug abuse (7.2% missing for outpatients; 22.6% missing for inpatients).

†Other living arrangements include group settings and the homeless.

‡Chronic pulmonary disease was defined as 1 or more of the following: chronic obstructive pulmonary disease, interstitial or restrictive lung disease, and/or asthma.

§A neuromuscular or musculoskeletal disorder was defined as 1 or more of the following: amyotrophic lateral sclerosis, myasthenia gravis, multiple sclerosis, kyphoscoliosis, Parkinson disease, paraplegia, quadriplegia, and/or rheumatoid arthritis.

||Immunosuppression was defined as 1 or more of the following: white blood cell count less than  $3 \times 10^3/\text{L}$ , asplenia, hypogammaglobulinemia, use of myelosuppressive drugs within 90 days of presentation, use of systemic corticosteroids ( $\geq 10 \text{ mg/d}$  of prednisone or its equivalent), and/or solid organ transplantation.

poalbuminemia were found in most inpatients in whom these tests were performed (57.2% and 63.0%, respectively). Among inpatients for whom these tests were performed, abnormal liver function test result (aspartate aminotransferase and alkaline phosphatase), blood urea

**Table 2. Symptoms and Signs at Presentation\***

Symptoms and Signs	Outpatients (n = 944), No. (%)	Inpatients (n = 1343), No. (%)
<b>Respiratory symptoms</b>		
Cough	853 (90.6)	1046 (78.8)
Dyspnea	631 (67.1)	990 (75.2)
Sputum production	614 (65.2)	782 (59.7)
Pleuritic chest pain	457 (48.8)	497 (39.4)
Hemoptysis	148 (15.8)	187 (14.4)
<b>Nonrespiratory symptoms</b>		
Fatigue	857 (91.3)	1169 (90.1)
Fever	691 (75.3)	914 (71.4)
Anorexia	675 (72.0)	892 (70.2)
Chills	712 (76.1)	824 (64.1)
Sweats	690 (74.0)	742 (57.9)
Headache	599 (64.1)	547 (44.1)
Myalgia	554 (59.5)	493 (39.9)
Nausea	342 (36.5)	528 (41.8)
Sore throat	399 (42.8)	309 (25.1)
Confusion	193 (20.7)	439 (34.1)
Unable to eat	204 (21.8)	387 (30.3)
Vomiting	178 (19.0)	372 (28.5)
Diarrhea	213 (22.8)	325 (25.3)
Abdominal pain	200 (21.4)	295 (23.8)
<b>Signs</b>		
Respiratory rate $\geq$ 30/min	11/477 (2.3)	305/1328 (23.0)
Heart rate $\geq$ 125/min	26/633 (4.1)	174/1338 (13.0)
Systolic blood pressure <90 mm Hg	4/683 (0.6)	45/1337 (3.4)
Temperature, °C		
<35.0	0/687 (0.0)	13/1331 (1.0)
$\geq$ 40.0	5/687 (0.7)	17/1331 (1.3)
Altered mental status†	6/942 (0.6)	232/1343 (17.3)

\*Missing data were excluded from the denominator. For symptoms, missing data ranged from 0.3% to 2.8% for outpatients and from 1.1% to 8.4% for inpatients. For signs, denominators are shown in the table.

†Altered mental status was defined as lethargy, stupor, coma, or confusion representing an acute change from usual state before presentation with pneumonia.

nitrogen level, and creatinine level were observed in about one quarter (24.0%-27.6%) and abnormal PO<sub>2</sub> in 36.7%.

Only 29.7% of outpatients had a sputum Gram stain or culture, blood or pleural fluid culture, or serologic or other diagnostic test performed to determine the cause of pneumonia (Table 4). Most inpatients (95.7%) had 1 or more tests performed; 52.5% had a sputum Gram stain, 58.0% had a sputum bacterial culture, and 71.2% had a blood culture obtained before the administration of antimicrobial therapy.

### PNEUMONIA CAUSE

A microbiologic cause was determined for only 5.7% of outpatients, primarily because no diagnostic tests were performed in 70.3% of outpatients (Table 5). A microbiologic cause was established in only 29.6% of inpatients despite 1 or more microbiologic tests being performed for 95.7% of inpatients. The most frequently identified pathogens among both outpatients and inpatients were *Streptococcus pneumoniae* and *Haemophilus influenzae* (1.8% and 1.5%, respectively, for outpatients and 9.1% and 4.8%, respectively, for inpatients). Clinical di-

**Table 3. Baseline Pulmonary Radiographic Characteristics\***

Radiographic Characteristics	Outpatients (n = 907), No. (%)	Inpatients (n = 1276), No. (%)
<b>Infiltrate confirmed</b>		
No	142 (15.7)	134 (10.5)
Possible/probable	257 (28.3)	430 (33.7)
Definite	508 (56.0)	712 (55.8)
<b>Pleural effusion</b>		
Minimal	35 (3.9)	127 (10.0)
Moderate-large	1 (0.1)	41 (3.2)
<b>Number of lobes</b>		
1	585 (76.5)	562 (49.3)
2	144 (18.8)	374 (32.8)
$\geq$ 3	36 (4.7)	205 (18.0)
Bilateral infiltrate	99 (12.9)	338 (29.6)
<b>Pattern of infiltrate</b>		
Alveolar or air space	741 (97.1)	1094 (96.9)
Interstitial	20 (2.6)	31 (2.7)
Mixed alveolar and interstitial	2 (0.3)	4 (0.4)
Miliary	0 (0.0)	0 (0.0)

\*Copies of the initial pulmonary radiographs were unavailable for 37 outpatients and 67 inpatients. Missing data were excluded from the denominator (ranging from 0.0% to 0.3% for outpatients and from 0.0% to 1.2% for inpatients). Of the 765 outpatients with possible/probable or definite infiltrate, data for pattern of infiltrate were missing for 2 patients. Of the 1142 inpatients with possible/probable or definite infiltrate, data for number of lobes and pattern of infiltrate were missing for 1 patient and 13 patients, respectively. Infiltrates were characterized only for those patients with possible/probable or definite infiltrate confirmed by the independent radiology panel.

agnoses of presumptive aspiration (0.4%) and presumptive postobstructive pneumonia (0.2%) were rare among outpatients and were assigned in 7.5% and 3.3% of inpatients, respectively.

### PROCESSES OF CARE

Seventy-one outpatients (7.5%) were subsequently hospitalized within 30 days of their initial presentation with pneumonia, including 5 patients who had initially refused hospitalization. Forty of the remaining 66 subsequent hospitalizations were determined to be pneumonia related, while the other 26 were primarily related to comorbid illness. The median length of stay for the subsequently hospitalized patients was 5 days. Of the 9 patients (13.8%) admitted to an intensive care, cardiac care, or telemetry unit during the hospitalization, 6 were admitted for monitoring only, 2 for treatment of respiratory failure, and 1 for treatment of shock.

For inpatients, the median length of stay for the index hospitalization was 8 days, with 5.2% of these patients remaining in the hospital at least 30 days. The most common discharge dispositions were return to home (71.2%), return to nursing home or chronic care facility (10.4%), and new admission to a nursing home or chronic care facility (3.9%). The 248 inpatients (18.5%) who were admitted to an intensive care, cardiac care, or telemetry unit during their initial hospital stay included 115 patients with respiratory failure of which 73 required mechanical ventilation. A total of 121 inpatients (10.1%) were

**Table 4. Baseline Laboratory and Microbiologic Tests**

Tests	Outpatients, No. (%)*		Inpatients, No. (%)*	
	Performed	Abnormal	Performed	Abnormal
Laboratory	(N = 944)		(N = 1343)	
White blood cell count, ×10 <sup>9</sup> /L	376 (39.8)	...	1336 (99.5)	...
<4	...	3 (0.8)	...	32 (2.4)
>11	...	130 (34.6)	...	764 (57.2)
Hematocrit <0.30	375 (39.7)	11 (2.9)	1337 (99.6)	134 (10.0)
Platelet count, ×10 <sup>9</sup> /L	296 (31.4)	...	1278 (95.2)	...
<150	...	15 (5.1)	...	140 (10.9)
>450	...	14 (4.7)	...	96 (7.5)
Glucose >13.9 mmol/L (250 mg/dL)	179 (19.0)	7 (3.9)	1281 (95.4)	88 (6.9)
Sodium <130 mmol/L	171 (18.1)	7 (4.1)	1324 (98.6)	82 (6.2)
Blood urea nitrogen >10.7 mmol/L (30 mg/dL)	185 (19.6)	10 (5.4)	1315 (97.9)	316 (24.0)
Creatinine ≥133 μmol/L (1.5 mg/dL)	186 (19.7)	17 (9.1)	1312 (97.7)	362 (27.6)
Aspartate aminotransferase >40 U/L	96 (10.2)	15 (15.6)	882 (65.7)	221 (25.1)
Alkaline phosphatase >125 mmol/L	82 (8.7)	9 (11.0)	849 (63.2)	207 (24.4)
Albumin <35 g/L	64 (6.8)	16 (25.0)	779 (58.0)	491 (63.0)
Arterial blood gas	45 (4.8)	...	914 (68.1)	...
pH <7.35	...	1 (2.2)	...	83 (9.1)
PCO <sub>2</sub> >45 mm Hg	...	5 (11.1)	...	132 (14.4)
PO <sub>2</sub> <60 mm Hg	...	4 (8.9)	...	336 (36.7)
Pulse oximetry (O <sub>2</sub> saturation <90%)	172 (18.2)	4 (2.3)	914 (68.1)	246 (26.9)
None of the above (laboratory)	493 (52.2)	NA	3 (0.2)	NA
Microbiologic	(N = 907)		(N = 1339)	
Sputum Gram stain within 48 h	76 (8.4)	NA	701 (52.5)	NA
Sputum bacterial culture within 48 h	100 (11.0)	NA	775 (58.0)	NA
Blood culture before antibiotics	77 (8.5)	2 (2.6)	951 (71.2)	82 (8.6)
Pleural fluid culture within 30 d	6 (0.7)	0	61 (4.6)	5 (8.2)
Serologic testing				
Acute only	10 (1.1)	2 (20.0)	157 (11.7)	12 (7.6)
Acute and convalescent	12 (1.3)	5 (41.7)	37 (2.8)	5 (13.5)
Other diagnostic tests†	90 (9.9)	NA	91 (6.8)	NA
None of the above (microbiologic)	638 (70.3)	NA	57 (4.3)	NA

\*“Performed” denotes the number and percentage of patients who had the test performed within 48 hours of presentation for laboratory tests and within the time frame noted for microbiologic tests. Of those who had the test performed, “abnormal” is the percentage of patients with results within the indicated range. For microbiologic tests, “abnormal” indicates a positive result of a culture or serologic test that resulted in the assignment of a microbiologic cause. Due to variations in reported measurements among institutions for sputum Gram stain and bacterial culture, a summary measure of “abnormal” results could not be reported. NA indicates not applicable.

†Other diagnostic tests include microbiologic tests performed after the time restrictions shown and other diagnostic tests used to assign pneumonia cause; “abnormal” was not systematically determined for other diagnostic tests.

rehospitalized within 30 days of their initial presentation with pneumonia.

### MEDICAL OUTCOMES

Six outpatients (0.6%) died within 30 days (1 in risk class 1 and 5 in risk class 4); 3 deaths were determined to be CAP related (**Table 6**). Of the 3 deaths that were not CAP related, 2 were due to coronary artery disease and 1 to neoplastic disease. Two (66.6%) of the 6 deaths among outpatients occurred in the hospital, 1 of which was in an intensive care unit. None of the outpatients who died had a do-not-resuscitate code at baseline, but 3 were assigned this code status before death.

Overall, 107 inpatients (8.0%) died within 30 days; 81 deaths were considered to be CAP related. The risk class-specific all-cause mortality rates for inpatients ranged from 0.5% in risk class 1 to 27.1% in risk class 5. Ninety-two (86.0%) of the 107 inpatient deaths occurred in the hospital, of which 23 occurred in an intensive care unit. Fifty-one (47.7%) had a do-not-resuscitate code status

at baseline; an additional 44 (41.1%) were assigned this code status before death.

For all patients who died, the leading immediate causes of death were respiratory failure (42.5%), cardiac arrhythmia (8.0%), and sepsis (5.3%).

Of the 901 outpatients who were alive at 30 days and had medical record reviews completed, most (92.0%) had none of the medical complications shown in **Table 7**. The most prevalent medical complications among the surviving outpatients were rash (2.0%) and vomiting or diarrhea requiring intravenous fluids (1.6%). Three of the 6 outpatients who died within 30 days had 1 or more complications.

Most inpatients alive at 30 days (69.0%) and almost all who died (94.4%) had 1 or more medical complications (**Table 7**). The most prevalent complications among surviving inpatients and those who died within 30 days were respiratory failure (36.5% and 65.4%, respectively) and congestive heart failure (19.0% and 42.1%, respectively). Among inpatients, 9.0% of those alive and 17.8% of those who died within 30 days had at least 1

potentially treatment-related complication. The most prevalent presumed treatment-related complication was pseudomembranous colitis or *Clostridium difficile*-associated diarrhea (3.8% and 5.6% among inpatients alive and dead, respectively, at 30 days).

For outpatients and inpatients, the reported prevalence of each symptom was reduced at 30 days relative to baseline, although not to the level reported retrospec-

tively for the month before the onset of illness with CAP (**Figure 1**). Most outpatients reported fatigue (56.2%) and a few reported cough (48.9%), sputum production (38.1%), or dyspnea (32.4%) at 30 days. Among outpatients with complete data on all 5 symptoms, 76.0% reported at least 1 of these symptoms at 30 days. Among inpatients, 72.6% reported fatigue and a few reported cough (47.1%), dyspnea (46.5%), or sputum production (42.3%) at 30 days (**Figure 1**). Most inpatients (86.5%) with complete longitudinal data on all 5 symptoms reported at least 1 of these symptoms at 30 days.

For outpatients who were not employed at presentation, the estimated probability of return to usual activities by 30 days was 88.9% (**Figure 2**), with a median time to return to usual activities of 7 days. Among outpatients who were employed at presentation, the median times to return to usual activities and to work were 6 days and 7 days, respectively; based on estimated probabilities, 95.6% returned to usual activities and 95.3% returned to work by 30 days. The median time to return to usual activities for inpatients who were not employed at presentation was 24 days, with an estimated probability of 57.2% of returning to usual activities by 30 days (**Figure 2**). For the employed inpatients, the median times to return to usual activities and to work were 15 days and 22 days, respectively, with corresponding estimated probabilities of returning to usual activities and to work by 30 days of 82.0% and 68.1%, respectively.

**Table 5. Microbiologic Cause of Pneumonia\***

Pneumonia Cause	Outpatients	Inpatients
	(n = 907), No. (%)	(n = 1339), No. (%)
<i>Streptococcus pneumoniae</i>	16 (1.8)	122 (9.1)
<i>Haemophilus influenzae</i>	14 (1.5)	64 (4.8)
Enterobacteriaceae†	2 (0.2)	37 (2.8)
<i>Staphylococcus aureus</i>	1 (0.1)	28 (2.1)
Atypical pathogens‡	9 (1.0)	20 (1.5)
<i>Pseudomonas aeruginosa</i>	0 (0.0)	12 (0.9)
<i>Haemophilus parainfluenzae</i>	0 (0.0)	11 (0.8)
Other streptococcal species§	1 (0.1)	11 (0.8)
<i>Branhamella catarrhalis</i>	2 (0.2)	7 (0.5)
<i>Mycobacterium tuberculosis</i>	2 (0.2)	6 (0.4)
<i>Pneumocystis carinii</i>	0 (0.0)	4 (0.3)
Viral species	0 (0.0)	4 (0.3)
Anaerobic bacterial species¶	0 (0.0)	2 (0.1)
Miscellaneous#	2 (0.2)	4 (0.3)
Multiple pathogens	3 (0.3)	65 (4.9)
Unknown cause**		
Tests performed	217 (23.9)	885 (66.1)
No tests performed	638 (70.3)	57 (4.3)

\*Diagnostic information used to determine cause was not available for 37 outpatients and 4 inpatients.

†Enterobacteriaceae consist of *Citrobacter diversus*, *Citrobacter freundii*, *Enterobacter aerogenes*, *Enterobacter agglomerans*, *Enterobacter cloacae*, *Escherichia coli*, *Hafnia alvei*, *Klebsiella pneumoniae*, *Morganella morganii*, *Proteus mirabilis*, *Providencia species*, and *Serratia marcescens*.

‡Atypical pathogens consists of *Chlamydia pneumoniae*, *Chlamydia psittaci*, *Coxiella burnetii*, *Mycoplasma pneumoniae*, and *Legionella species*.

§Other streptococcal species consists of groups A, B, C, and G streptococci, non-group A streptococci, *Streptococcus viridans*, enterococcal species, and nonhemolytic streptococci.

||Viral species consists of influenza A virus and cytomegalovirus.

¶Anaerobic bacterial species consists of *Bacteroides species*, *Fusobacterium species*, *Selenomonas sputigena*, and *Veillonella species*.

#Miscellaneous consists of *Acinetobacter species*, *Blastomyces dermatitidis*, *Nisseria meningitidis*, *Flavobacterium species*, *Pasturella multocida*, and *Corynebacterium species*.

\*\*Unknown cause was classified by whether 1 or more of the following had been performed: Gram stain of sputum, sputum bacterial culture, blood culture, pleural fluid culture, serologic testing, or another diagnostic test used to assign pneumonia cause.

## COMMENT

The Pneumonia PORT observational cohort study has several strengths that distinguish it from prior studies of CAP. In this study, processes of care instituted at the discretion of physicians in the routine management of their patients were prospectively assessed, whereas most prior studies<sup>5-9</sup> used standard study protocols to obtain laboratory and microbiologic tests. In contrast to most studies<sup>11</sup> of prognosis in CAP that focused on mortality as the sole outcome measure, this study assessed a broad range of medical outcomes describing the natural history of this illness. Furthermore, to our knowledge, this is the first study to report a comprehensive assessment of processes and outcomes of medical care for a large cohort of patients treated in the ambulatory care setting, where approximately three quarters of patients with this illness are managed.

**Table 6. All-Cause and Pneumonia-Related Mortality Within 30 Days\***

Risk Class	Outpatients			Inpatients		
	Patients, N	All-Cause Deaths, No. (%)	CAP-RelatedDeaths, No. (%)	Patients, N	All-Cause Deaths, No. (%)	CAP-RelatedDeaths, No. (%)
1	587	0 (0.0)	0 (0.0)	185	1 (0.5)	0 (0.0)
2	244	1 (0.4)	0 (0.0)	233	2 (0.9)	1 (0.4)
3	72	0 (0.0)	0 (0.0)	254	3 (1.2)	3 (1.2)
4	40	5 (12.5)	3 (7.5)	446	40 (9.0)	31 (7.0)
5	1	0 (0.0)	0 (0.0)	225	61 (27.1)	46 (20.4)
<b>Total</b>	<b>944</b>	<b>6 (0.6)</b>	<b>3 (0.3)</b>	<b>1343</b>	<b>107 (8.0)</b>	<b>81 (6.0)</b>

\*The cause of death was defined as related to community-acquired pneumonia (CAP) if pneumonia was the underlying cause of death, immediate cause of death, or a major contributing cause of death. For the percentage, the numerator is the number of deaths and the denominator is the total number of patients (N).

**Table 7. Medical Complications Within 30 Days by Vital Status at 30 Days\***

Complications	Outpatients, %		Inpatients, %	
	Alive (n = 901)	Dead (n = 6)	Alive (n = 1232)	Dead (n = 107)
<b>Pulmonary</b>				
Respiratory failure†	1.4	0.0	36.5	65.4
Pulmonary embolus	0.0	0.0	0.2	0.9
<b>Cardiovascular</b>				
Congestive heart failure	1.3	16.7	19.0	42.1
Shock‡	0.6	16.7	9.5	38.3
Atrial arrhythmia§	0.9	0.0	8.6	20.6
Myocardial infarction	0.1	0.0	2.4	11.2
Ventricular arrhythmia	0.2	0.0	1.5	4.7
<b>Gastrointestinal or hepatic</b>				
Liver function test result abnormalities	1.4	33.3	13.3	25.2
Gastrointestinal bleeding	0.3	0.0	2.5	10.3
Vomiting or diarrhea requiring intravenous fluids	1.6	0.0	4.2	4.7
<b>Hematologic</b>				
Anemia (hematocrit <0.25)	0.3	0.0	10.1	21.5
Thrombocytopenia (platelets <100 × 10 <sup>9</sup> /L)	0.2	0.0	5.1	16.8
Leukopenia (white blood cell count <3 × 10 <sup>9</sup> /L)	0.2	0.0	3.2	5.6
<b>Potentially treatment-related</b>				
Pseudomembranous colitis or <i>Clostridium difficile</i> diarrhea	0.1	0.0	3.8	5.6
Pneumothorax	0.1	0.0	2.3	5.6
Nosocomial pneumonia	0.1	0.0	1.9	5.6
Intravenous site phlebitis	0.0	0.0	0.9	0.9
Bleed at site of procedure	0.0	0.0	0.6	1.9
Line-related sepsis	0.1	0.0	0.2	0.0
Axillary thrombosis	0.0	0.0	0.2	0.0
<b>Miscellaneous</b>				
Renal insufficiency	0.4	33.3	11.8	38.3
Rash	2.0	16.7	8.6	9.3
Stroke or transient ischemic attack	0.0	0.0	0.7	4.7
Suppurative infection¶	0.1	0.0	1.3	1.9
Deep vein thrombosis	0.0	0.0	0.8	0.9
None of the above complications	92.0	50.0	31.0	5.6

\* Information for complications was unavailable for 37 outpatients and 4 inpatients (all alive at 30 days).

† Respiratory failure was defined as 1 or more of the following:  $P_{O_2}$  less than 60 mm Hg,  $O_2$  saturation less than 90%, or  $P_{CO_2}$  more than 45 mm Hg at presentation; intensive care unit admission due to respiratory failure during initial hospitalization; and/or mechanical ventilation at any time during initial hospitalization.

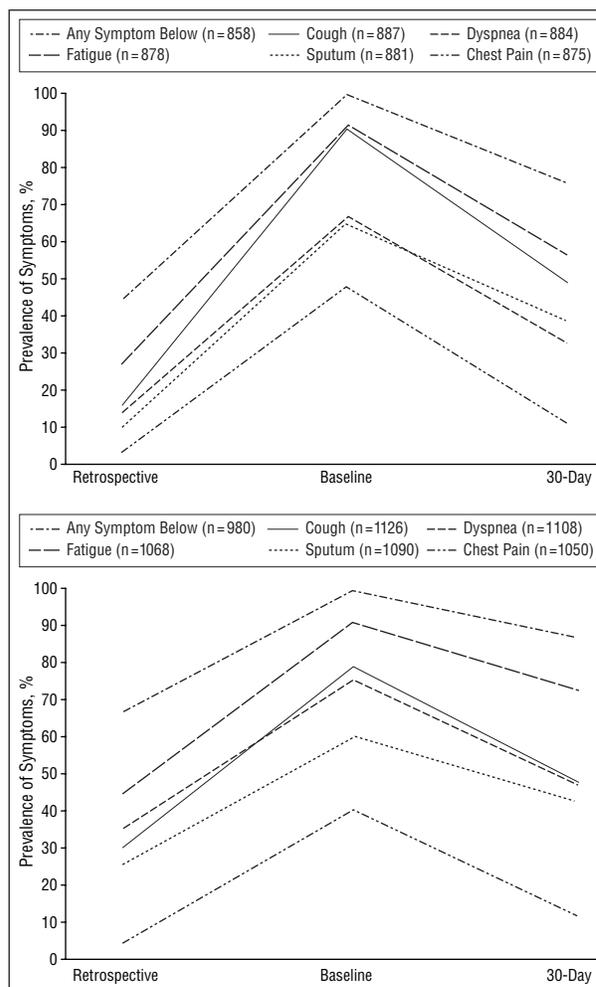
‡ Shock was defined as systolic blood pressure less than 90 mm Hg corrected by intravenous fluids or requiring vasopressor medications or an intra-aortic balloon pump.

§ Atrial arrhythmia was defined as newly recognized atrial fibrillation, atrial flutter, supraventricular tachycardia, or multifocal atrial tachycardia.

|| Ventricular arrhythmia was defined as a 3-or-more beat run of ventricular tachycardia documented by Holter monitor, rhythm strip, or other form of electrocardiographic monitoring.

¶ Suppurative infection was defined as 1 or more of the following: brain abscess, empyema, endocarditis, meningitis, osteomyelitis, and/or septic arthritis.

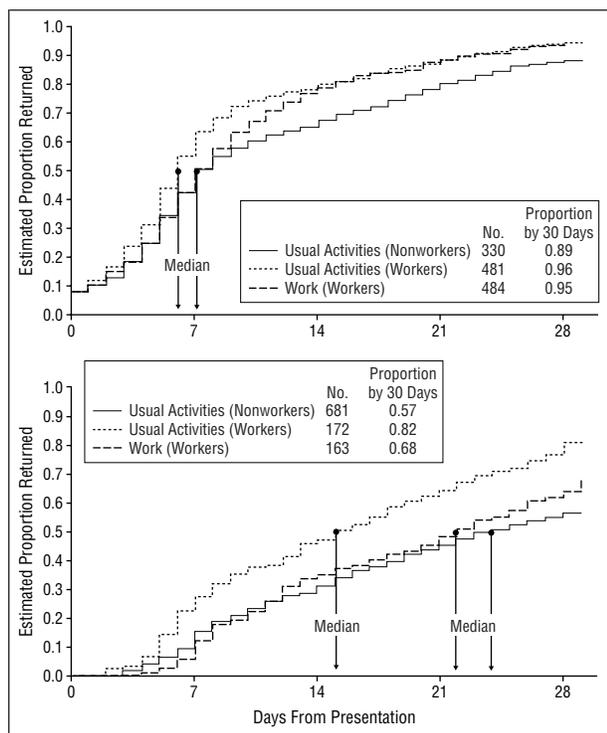
This study demonstrated that some form of laboratory testing, such as measurement of a complete blood cell count, serum electrolyte levels, and/or glucose level, was performed in nearly half of outpatients, but test results were rarely abnormal. In addition, routine microbiologic testing was infrequently performed among out-



**Figure 1.** Prevalence of community-acquired pneumonia-related symptoms for outpatients (top) and inpatients (bottom) 1 month before the onset of illness (retrospective) at presentation to a study site (baseline) and 30 days after presentation (30-day). The number of patients reported (n) had an assessment for that symptom at all 3 time points.

patients and rarely led to a microbiologic diagnosis. Because 4 of the 5 study sites were hospitals with affiliated medical education training programs where more aggressive diagnostic evaluation is often advocated, the 48% of outpatients who had 1 or more laboratory tests and the 30% who had 1 or more microbiologic tests may be overestimates of the actual frequency of testing that occurs in community-based medical office practices. The infrequent discovery of laboratory abnormalities among outpatients suggests that directed testing (eg, ordering a blood glucose test for a diabetic patient or a serum sodium test for a volume-depleted patient) is preferable to routine laboratory testing in this patient population. The failure to perform a microbiologic evaluation among most outpatients suggests that an empiric management strategy was the standard of care within the study population. Although testing was rarely performed and test results were rarely abnormal, this study did not directly assess the impact of routine laboratory and microbiologic testing on medical outcomes and costs of care for outpatients with CAP.

In contrast to outpatients, virtually all inpatients in this cohort had 1 or more laboratory tests performed, and



**Figure 2.** Kaplan-Meier plots of return to usual activities and return to work for outpatients (top) and inpatients (bottom) with community-acquired pneumonia. Return to work was only assessed in patients employed at presentation (workers); return to usual activities was plotted separately for patients employed and not employed (nonworkers) at presentation. The proportions of patients who returned to work or usual activities by 30 days were estimated from the Kaplan-Meier analyses.

more than 95% had 1 or more microbiologic tests performed at presentation. Although this study did not determine whether such processes of care had an association with improved patient outcomes, which would be the highest standard for establishing the appropriateness of processes of care, we believe that certain laboratory or microbiologic tests are useful because they help quantify prognosis and guide clinical management decisions. For example, because of the prognostic importance of leukopenia, anemia, hyponatremia, azotemia, and liver function test abnormalities,<sup>11,20,21</sup> we concur with the American Thoracic Society and Infectious Diseases Society of America pneumonia guidelines that it is appropriate to order these tests for patients with CAP who require hospitalization.<sup>30,31</sup> A measure of arterial oxygenation (ie, arterial blood gas or pulse oximetry), performed in more than 90% of inpatients in this study, also should be obtained in patients hospitalized with CAP. Hypoxemia at presentation is independently associated with short-term mortality<sup>20,21</sup> and is a marker for respiratory failure requiring intensive care unit admission in patients with this illness.<sup>30,32</sup> Likewise, blood cultures are warranted by the prognostic importance of bacteremia in CAP,<sup>11</sup> and the potential for establishing a definitive microbiologic diagnosis that would allow therapy focused on the antibiotic sensitivities of the isolated organism.<sup>30-32</sup> Although prior studies<sup>33,34</sup> have demonstrated a low yield of positive findings for routine blood cultures and failure of physicians to modify clinical prac-

tice based on results, performance of blood cultures within 24 hours of presentation has recently been identified as a process measure that is associated with improved 30-day survival in hospitalized patients with CAP.<sup>35</sup> In the present study, only 71% of inpatients had blood cultures obtained before the initiation of antimicrobial therapy, identifying an area for quality improvement in the provision of medical care.

Most outpatients in this study had an excellent prognosis. Five of the 6 deaths and all 3 of the pneumonia-related deaths were in outpatients designated as high risk based on a validated prediction rule for prognosis in pneumonia.<sup>21</sup> Only 8% of outpatients who survived had 1 or more medical complications and only 7.5% of outpatients required subsequent hospitalization. Subsequent hospitalization does not necessarily imply treatment failure for pneumonia; nearly half of the subsequently hospitalized outpatients were admitted because of underlying comorbid illness or because they refused initially recommended hospitalization.<sup>28</sup>

Overall mortality for inpatients in this study was 8.0%, and nearly 70% of inpatients who survived had 1 or more medical complications. However, there are wide ranges in illness severity, comorbidity, and prognosis among inpatients. In the present study, half of inpatients were in the 3 lowest-severity risk classes, with 30-day all-cause mortality rates ranging from 0.5% to 1.2%. A previous study, as well as recently published Infectious Diseases Society of America guidelines for the management of CAP,<sup>31,36,37</sup> suggests that many of these patients can be safely managed in the outpatient setting at substantially lower medical care costs. The remaining half of inpatients were in risk classes 4 and 5, with all-cause mortality rates of 9.0% and 27.1%, respectively. The reported mortality may underestimate the actual frequency of this outcome among inpatients with CAP because of the relatively lower enrollment of older and more severely ill patients in this cohort. A previously published meta-analysis<sup>11</sup> of prognosis in CAP reported a 13.6% mortality in more than 25 000 hospitalized patients.

This study confirms that pneumonia often occurs in patients with underlying comorbid illness and demonstrates that the pneumonia often results in a worsening of such underlying conditions. One or more medical complications occurred in nearly 70% of inpatients who survived and in 95% of inpatients who died. An example of the interaction between comorbidity and the acute episode of pneumonia is that nearly 17% of inpatients in this study had a history of congestive heart failure at presentation and 19% of survivors and 42% of non-survivors had new or worsening congestive heart failure within 30 days of presentation.

Nearly 90% of outpatients had returned to usual activities or work by the 30-day follow-up; 57% of non-working inpatients and 82% of working inpatients returned to usual activities during this period. Physicians should inform patients and their caregivers that symptoms are likely to persist beyond the acute phase of the illness; more than three quarters of the outpatients and nearly 90% of the inpatients in this study had 1 or more pneumonia-related symptoms at 30 days. Separate

analyses of a subgroup of outpatients and inpatients enrolled in this study demonstrated that 28% had dyspnea, 32% had cough, and 51% had fatigue for up to 90 days after presentation.<sup>38</sup> Failure of symptom resolution also has an impact on health care resource use. Symptom severity measured 7 and 30 days after presentation was independently associated with pneumonia-related physician office visits at both 30 and 90 days after presentation.<sup>39</sup>

Based on the microbiologic tests obtained by the managing physicians in this study, only 5.7% of outpatients and 29.7% of inpatients had an assigned microbiologic pneumonia cause. These proportions are much lower than the 53% to 97% reported in studies with diagnostic protocols designed to determine pneumonia cause.<sup>5-9,39</sup> However, the most common pathogen identified in this study, *S pneumoniae*, is the same as the leading pathogen identified in many studies of pneumonia cause.<sup>5,8,9,39</sup> It is likely that atypical pathogens, including *Legionella* species, *M pneumoniae*, *Coxiella burnetii*, *C pneumoniae*, and viral species, were less commonly identified than in prior studies designed to determine pneumonia cause due to the relative infrequency with which serologic testing was performed in this observational study compared with studies using standard diagnostic protocols.<sup>5-9,39</sup> The relatively low rate of assignable microbiologic diagnoses among study patients suggests that increased use of diagnostic tests and the institution of epidemiological surveillance programs similar to those established by the Centers for Disease Control and Prevention may be important in determining the complete spectrum of microbiologic pathogens responsible for causing pneumonia among hospitalized patients and identifying the emergence of antimicrobial resistance patterns among these pathogens.<sup>3</sup>

The present study has limitations that are important to acknowledge. Although the screening and recruitment process was designed to be comprehensive, all consecutive patients were not identified because of infrequent nonenrollment days throughout the 29-month study period. However, it is unlikely that this led to any systematic bias in the identification of patients with CAP from the participating study sites. Moreover, the findings may not be generalizable to all patients with CAP because the study was conducted primarily at urban hospital sites with affiliated medical education training programs. Enrollment of a substantial proportion of patients from a single Canadian hospital site may reduce the generalizability of study findings for patients treated in the United States. Furthermore, the prognosis of these study patients may not reflect the full spectrum of patients with this illness because of selection biases that resulted in decreased enrollment of relatively older and more severely ill patients who met study eligibility criteria. Finally, the process measures assessed may be institution specific and not generalizable to other health care settings. Large variations in certain processes of care, such as antimicrobial therapy, were discovered even within the hospitals participating in the present study.<sup>26</sup> It should also be emphasized that the analyses presented herein do not describe associations between process measures and outcomes, which repre-

sent the highest standard for defining appropriate processes of care.

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From the Division of General Internal Medicine, Department of Medicine (Drs Fine and Kapoor, Ms Hough, and Mr Obrosky), Departments of Health Services Administration (Drs Lave and Ricci) and Biostatistics (Dr Stone), Graduate School of Public Health, Department of Psychiatry (Drs Schulz and Rogers), and Center for Research on Health Care (Drs Fine, Stone, Lave, Ricci, and Kapoor, Ms Hough, and Mr Obrosky), University of Pittsburgh, Pittsburgh, Pa; General Internal Medicine Division, Department of Medicine, Massachusetts General Hospital and Harvard Medical School, Boston (Drs Singer and Coley); and Departments of Medicine and Microbiology, Queen Elizabeth II Health Sciences Center and Dalhousie University, Halifax, Nova Scotia (Dr Marrie).

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Corresponding author: Michael J. Fine, MD, MSc, Montefiore University Hospital, Room E-820, 200 Lothrop St, Pittsburgh, PA 15213-2582 (e-mail mjf1+@pitt.edu).

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