Treatment and outcomes among patients ≥85 years hospitalized with community-acquired pneumonia

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ABSTRACT

Our objective was to describe community-acquired pneumonia (CAP) among patients ≥85 years and compare them to patients aged 65–74. This was a retrospective cohort study. The study setting included 638 hospitals in the USA participating in the Premier database from 2010 to 2015. The study participants were 488,382 adults aged ≥65 years hospitalized with CAP. Patients ≥85 years were more likely to be white (79.8% vs 76.2%), female (58.1% vs 48.3%), and admitted with aspiration pneumonia (17.1% vs 7.0%) as compared with those aged 65–75 years. They had higher rates of dementia (30.4% vs 7.8%), but lower rates of diabetes (11.2% vs 17.6%) and chronic obstructive pulmonary disease (25.5% vs 54.7%). While *Staphylococcus aureus* (33.4%) was the most common pathogen across all age groups, patients aged ≥85 were more likely to have *Escherichia coli* pneumonia (16.1% vs 10.7%) compared with those aged 65–74. In adjusted models, patients aged ≥85 had greater in-hospital mortality (OR 1.14, 95% CI 1.11 to 1.18), but were less likely to be admitted to the intensive care unit (OR 0.54, 95% CI 0.53 to 0.55) and receive mechanical ventilation (OR 0.47, 95% CI 0.46 to 0.48). They also had lower rates of acute kidney injury (OR 0.95, 95% CI 0.91 to 1.00) and *Clostridium difficile* infection (OR 0.91, 95% CI 0.85 to 0.99), shorter lengths of stay (mean multiplier 0.93, 95% CI 0.92 to 0.93) and lower cost (mean multiplier 0.81, 95% CI 0.80 to 0.81), and were more likely to be discharged to a skilled nursing facility (OR 2.19, 95% CI 2.15 to 2.24) or hospice (OR 2.19, 95% CI 2.11 to 2.27). In conclusion, patients aged ≥85 have different comorbidities and etiologies of CAP, receive less intense treatment, and have greater mortality than patients between 65 and 75 years.

Significance of this study

What is already known about this subject?

- Among patients older than 65, there is a higher incidence of community-acquired pneumonia (CAP).
- Patients older than 65 also tend to have higher rates of admission from CAP as well as worse associated outcomes, including higher rates of mortality, as compared with adults younger than 65.
- Poor outcomes have been attributed to several factors, such as greater burden of comorbidities and initial presentation with atypical findings, such as altered mental status.

What are the new findings?

- Compared with patients aged 65–74 years, patients older ≥85 years had higher rates of pneumonia caused by Gram-negative bacteria and lower rates of *Streptococcus pneumoniae.*
- Patients ≥85 years were less likely to receive mechanical ventilation or be admitted to the intensive care unit, but had higher rates of in-hospital mortality.
- Patients ≥85 years were more likely to be discharged to a skilled nursing facility or hospice.
- Patients ≥85 years had shorter lengths of stay and lower cost of admission than patients aged 65-74 years

How might these results change the focus of research or clinical practice?

- Further research is needed to determine whether provider bias or patient choice drives less intensive treatment among patients ≥85 years.

INTRODUCTION

Community-acquired pneumonia (CAP) is estimated to cause 1.5 million hospitalizations annually, imposing a substantial burden on the US healthcare system.[1] Patients older than 65 years have a higher incidence of CAP, greater likelihood of hospitalization, and worse outcomes.[2–4] Poor prognosis among older patients has been attributed to greater burden of comorbidities, as well as presentation with atypical symptoms, such as altered mental status (AMS) and absence of fever.[3 5 6]

As US life expectancy increases, patients over age 80 now represent the fastest growing demographic. Understanding pneumonia among the

oldest patients is important for understanding the scope of the problem, assessing quality of care, and resource planning. However, few studies have described treatment and outcomes of pneumonia for patients aged 85 years and older. One study found that the incidence of CAP is 5 times higher among those older than 90 years and mortality is double.[4] Several international cohorts found differences in presentation characteristics and mortality among older versus younger patients over 65.[7–9]

We aimed to describe the clinical characteristics and treatment course for US inpatients older than 85 years hospitalized for CAP and compare them to patients between the ages of 65 and 74. We hypothesized that patients aged ≥85 would receive less aggressive treatment, and have shorter lengths of stay (LOS) and greater mortality than patients between the ages of 65 and 74.

METHODS

We conducted a retrospective cohort study using the Premier database, a fee-supported administrative database comprising 638 hospitals in the USA, including patients discharged between July 2010 and June 2015. Data include International Classification of Diseases, Ninth Revision (ICD-9), Clinical Modification diagnosis and procedure codes, patient demographic and social information, care provider and hospital characteristics, admission source, and discharge disposition. It has been well described previously.[10–12] As the database contains no identifiable patient information, the Cleveland Clinic Institutional Review Board determined the study did not constitute human subjects research.

Population

Adults aged 65 years and older hospitalized for CAP were included. CAP diagnosis was based on either a principal ICD-9 code of pneumonia (codes: 481–486, and 507) or a principal diagnosis of sepsis (codes: 785.52, 790.7, 995.91, 995.92, 038.x) or respiratory failure (codes: 518.18, 518.82, 518.84, 799.1) plus a secondary diagnosis of pneumonia that was present on admission. We defined 3 groups based on age: 65–74, 75–84, and ≥85 years.

Exclusion criteria included patients transferred from or discharged to acute care (hospital or long-term acute care facility) because we could not determine their treatments or outcomes; those who did not receive a chest X-ray or CT scan on the day of or the day after admission or did not receive initial antibiotics for at least 3 days or until discharged, because such patients would be unlikely to have pneumonia; and those on chronic ventilator support, which represent a different clinical population.

Patient characteristics

Patient characteristics included demographic information, comorbidities, and chronic disease severity at presentation. Demographic information included age, sex, race, marital status, admission source, and insurance status. Comorbidities were assessed using ICD-9 codes and software from the Agency for Healthcare Research and Quality based on the work of Elixhauser.[13] All comorbidities and do not resuscitate (DNR) status were limited to codes with a present-on-admission designation. Smoking status was assessed through presence of an ICD-9 code for smoking or inpatient prescription of nicotine replacement. Dementia was defined as presence of an ICD-9 code or prescription of donepezil or memantine. We also assessed low functional status/weight loss (ICD-9 codes: v46x, 799.3, 797, 260–262, 263.0–263.2, 263.8–263.9, 783.2, 783.21) and urinary tract infection (UTI) as coexisting conditions. We identified DNR status based on the presence of ICD-9 code V49.86.

Outcomes

We describe early management, microbiology, and the following outcomes: complications, in-hospital mortality, and 6-month readmission rates. Early management included tests and treatments billed on the day of admission (eg, labs, imaging, and antibiotics). Microbiology data were collected from a subset of hospitals (n=172) that participated in the SafetySurveillor program, and included organisms isolated from blood and respiratory cultures. Patients with the same organism in urinary and blood cultures were excluded from microbiology analysis as these patients may have had bacteremia secondary to UTI. Complications included intensive care unit (ICU) admission and invasive mechanical ventilation (IMV), *Clostridium difficile* infection (CDI), and acute kidney injury (AKI) at any point during the hospitalization. We also compared LOS and hospital cost. Costs were inflation adjusted to 2015 US dollars by using the medical cost component of the consumer price index.

Statistical analysis

We performed descriptive statistics for the population to compare the baseline characteristics (demographics, insurance status, comorbidities, initial treatments/test, and hospital characteristics) among the 3 age groups (65–74, 75–84 and ≥85) where frequencies, proportions plus Pearson's χ^2 tests were used for categorical data and medians, and IQRs plus Kruskal-Wallis tests were used for continuous data. In the subset of patients with microbiology data, we described the etiology of pneumonia among those who had positive blood or respiratory cultures drawn in the emergency room or on hospital day 1.

We used mixed logistic regressions to model dichotomous outcomes (in-hospital mortality, readmission within 6 months, AKI, CDI, and ICU, IMV or vasopressor treatment) and log-link gamma generalized linear mixed model for continuous outcomes (LOS, cost). All models were adjusted for demographics, DNR status, insurance status, and comorbidities and included hospitals as random intercept effect. Analyses were performed using SAS V.9.4 (SAS Institute).

RESULTS

Our cohort consisted of 488,382 patients aged 65 years or older admitted with CAP to 638 hospitals. Roughly one-third of these patients were aged ≥85 years. Demographic data by age group (65–74, 75–84, and ≥85) are reported in table 1.

Due to the large sample size, all p values are <0.001 unless otherwise noted. In the text, we compare patients aged 85 and older with patients aged 65–74. Patients aged 75–84 generally had intermediate values and are presented in the tables and figures only. Compared with patients aged 65–74, patients aged ≥85 were more likely to be female (58.1% vs 48.3%), white (79.8% vs 76.2%), and insured by Medicare (95.2% vs 88.1%).

Table 1 Demographics, comorbidities, admission, and discharge characteristics by age group

Characteristic (%)	65–74 years	75–84 years	≥85 years	P value*
n	152,309	177,745	158,328	
Female	73,614 (48.3)	88,693 (49.9)	92,048 (58.1)	<0.001
Race				<0.001
White	116,005 (76.2)	138,718 (78.0)	126,280 (79.8)	
Black	15,434 (10.1)	13,282 (7.5)	8939 (5.6)	
Other	20,993 (13.7)	25,745 (14.5)	23,109 (14.6)	
Married	71,115 (46.7)	75,299 (42.4)	42,238 (26.7)	<0.001
Insurance				<0.001
Medicare	134,225 (88.1)	166,842 (93.9)	150,801 (95.2)	
Medicaid	3226 (2.1)	2536 (1.4)	1813 (1.1)	
Other	14,855 (9.8)	8367 (4.7)	5713 (3.7)	
Admission from SNF/ICF	10,974 (7.2)	17,214 (9.7)	21,250 (13.4)	<0.001
Discharge disposition				<0.001
Home	72,902 (47.9)	59,260 (33.3)	31,297 (19.8)	
Home with home health	23,971 (15.7)	30,966 (17.4)	25,242 (15.9)	
Hospice	7625 (5.0)	13,012 (7.3)	17,022 (10.8)	
Expired	11,464 (7.5)	15,706 (8.8)	16,573 (10.5)	
SNF	31,976 (21.0)	54,411 (30.6)	64,923 (41.0)	
Other	4371 (2.9)	4390 (2.5)	3271 (2.1)	
Principal diagnosis				<0.001
Pneumonia	79,307 (52.1)	91,846 (51.7)	76,818 (48.5)	
Aspiration pneumonia	10,718 (7.0)	19,468 (11.0)	27,903 (17.1)	
Sepsis	51,206 (33.6)	57,101 (32.1)	49,004 (31.0)	
Respiratory failure	11,078 (7.3)	9330 (5.2)	5413 (3.4)	
Concurrent UTI	19,363 (12.7)	30,435 (17.1)	34,687 (21.9)	<0.001
Do not resuscitate (DNR) order	13,184 (8.7)	26,809 (15.1)	43,210 (27.3)	<0.001
Comorbidities				
Combined comorbidity score (median [Q1, Q3])	3.0 [1.0, 5.0]	3.0 [1.0, 5.0]	3.0 [2.0, 5.0]	<0.001†
Smoking	28,035 (18.4)	13,890 (7.8)	3908 (2.5)	<0.001
COPD	83,388 (54.7)	86,380 (48.6)	56,254 (35.5)	<0.001
Chronic heart failure	41,637 (27.3)	59,540 (33.5)	61,657 (38.9)	<0.001
Diabetes	26,781 (17.6)	28,093 (15.8)	17,727 (11.2)	<0.001
Obesity	24,671 (16.2)	16,163 (9.1)	5795 (3.7)	<0.001
Metastatic cancer	8447 (5.5)	6086 (3.4)	2475 (1.6)	<0.001
Paralysis	7273 (4.8)	7918 (4.5)	5451 (3.4)	<0.001
Liver disease	4971 (3.3)	2985 (1.7)	1079 (0.68)	<0.001
Low functional status	41,290 (27.2)	50,208 (28.2)	41,315 (26.1)	<0.001
Chronic kidney disease	26,511 (17.4)	42,003 (23.6)	44,451 (28.1)	<0.001
Dialysis	8777 (5.8)	7392 (4.2)	2991 (1.9)	<0.001
Dementia	11,893 (7.8)	34,921 (19.6)	48,057 (30.4)	<0.001
Pressure ulcers	8592 (5.6)	12,851 (7.2)	13,712 (8.7)	<0.001

Demographic, comorbidity, admission, and discharge data are compared between the 3 age groups (65–74, 75–84, and ≥85 years).
*Pearson's χ^2 tests unless otherwise noted.
†Kruskal-Wallis test.
COPD, chronic obstructive pulmonary disease; ICF, intermediate care facility; SNF, skilled nursing facility; UTI, urinary tract infection.

Comorbidities and presentation

Compared with patients aged 65–74, adults aged ≥85 were more likely to have congestive heart failure (38.9% vs 27.3%), dementia (30.4% vs 7.8%), and chronic kidney disease (28.1% vs 17.4%) but less likely to be smokers (2.5% vs 18.4%), to have chronic obstructive pulmonary disease (COPD) (35.5% vs 54.7%), and to require dialysis (1.9% vs 5.8%). Patients aged ≥85 also had lower rates of obesity (3.7% vs 16.2%) and diabetes (11.2% vs 17.6%). Similar proportions of patients were likely to have low functional status/weight loss, but older patients were 3 times as likely to have a DNR order at admission (27.3% vs 8.7%). Patients aged ≥85 were more likely to have a principal diagnosis of aspiration pneumonia (17.1% vs 7.0%) and to have a coexistent UTI on admission (21.9% vs 12.7%).

Early tests and treatments

Table 2 shows the tests performed and treatments given in the emergency room or on hospital day 1. Almost 90% of patients

Table 2 Tests and treatments performed on hospital day 1 by age group

Test/treatment	65–74 years	75–84 years	≥85 years	P value*
n	152,309	177,745	158,328	
Blood cultures	136,445 (89.6)	159,149 (89.5)	141,052 (89.1)	<0.001
Urine cultures	50,895 (33.4)	67,803 (38.1)	67,373 (42.6)	<0.001
Sputum cultures	12,119 (8.0)	11,757 (6.6)	7867 (5.0)	<0.001
Foley catheter	14,610 (9.6)	19,281 (10.8)	18,790 (11.9)	<0.001
Head CT	24,238 (15.9)	32,456 (18.3)	31,548 (19.9)	<0.001
Chest CT	20,660 (13.6)	20,603 (11.6)	14,501 (9.2)	<0.001
Arterial/venous blood gas	61,267 (40.2)	63,328 (35.6)	47,509 (30.0)	<0.001
Lactate	73,227 (48.1)	84,668 (47.6)	76,274 (48.2)	0.004
Intensive care unit admission	41,997 (27.6)	41,852 (23.5)	29,774 (18.8)	<0.001
Invasive mechanical ventilation	14,802 (9.7)	12,931 (7.3)	7947 (5.0)	<0.001
Non-invasive ventilation	16,413 (10.8)	16.201 (9.1)	11,911 (7.5)	<0.001
Intravenous steroid	41,876 (27.5)	38,462 (21.6)	22,797 (14.4)	<0.001
Without chronic obstructive pulmonary disease(COPD)	6686/68,921 (9.7)	7226/91,365 (7.9)	6648/102,074 (6.5)	<0.001
With COPD	35,190/83,388 (36.9)	31,236/86,380 (36.2)	16,149/56,254 (28.7)	<0.001
Vasopressors	11,986 (7.9)	11,701 (6.6)	7909 (5.0)	<0.001
Third-generation cephalosporin	65,272 (42.9)	77,378 (43.5)	69,688 (44.0)	<0.001
Respiratory quinolone	63,833 (41.9)	72,202 (40.6)	61,960 (39.1)	<0.001
Macrolide	58,092 (38.1)	68,348 (38.5)	60,592 (38.3)	0.18
Antipseudomonal quinolone	62,239 (40.9)	70,186 (39.5)	60,853 (38.4)	<0.001
Anti-MRSA agent	51,064 (33.5)	56,090 (31.6)	48,498 (30.6)	<0.001
Piperacillin/tazobactam	35,002 (23.0)	41,122 (23.1)	37,920 (24.0)	<0.001

Tests and treatments performed on day 1 of admission are compared between the 3 age groups (65–74, 75–84, and ≥85 years).
*Pearson's χ^2 tests.
MRSA, methicillin-resistant *Staphylococcus aureus*.

had blood cultures. Patients aged ≥85 were more likely to have urine cultures (42.6% vs 33.4%) and head CT scans (19.9% vs 15.9%). They were less likely to receive intravenous steroids (14.4% vs 27.5%), but more likely to receive a Foley catheter (11.9% vs 9.6%). Initial antibiotic treatments were comparable. Overall, 43.5% received third-generation cephalosporins, 40.5% received respiratory quinolones, 38.3% received macrolides, and 31.9% received anti-methicillin-resistant *Staphylococcus aureus* (MRSA) agents.

Microbiological causes of pneumonia appear in table 3. *Staphylococcus aureus* was the most common organism at all ages; patients aged ≥85 were more likely than younger patients to have *Escherichia coli* (16.1% vs 10.7%) but less likely to have *Streptococcus pneumoniae* (17.2% vs 23.7%) and *Pseudomonas aeruginosa* (10.8% vs 16.0%).

Table 3 Microbiological etiologies of CAP by age group

Organism	65–74 years	75–84 years	≥85 years	P value*
n	3170	3269	2361	
Staphylococcus aureus	1000 (31.5)	1087 (33.3)	857 (36.3)	<0.001
MSSA	562 (17.7)	572 (17.5)	457 (19.4)	0.16
MRSA	441 (13.9)	518 (15.8)	402 (17.0)	0.005
Escherichia coli	340 (10.7)	400 (12.2)	381 (16.1)	<0.001
Streptococcus pneumoniae	750 (23.7)	580 (17.7)	407 (17.2)	<0.001
Pseudomonas aeruginosa	508 (16.0)	505 (15.4)	255 (10.8)	<0.001
Klebsiella pneumoniae	261 (8.2)	278 (8.5)	203 (8.6)	0.87
Proteus mirabilis	83 (2.6)	121 (3.7)	81 (3.4)	0.04
Haemophilus influenzae	136 (4.3)	139 (4.3)	107 (4.5)	0.87
Serratia marcescens	54 (1.7)	59 (1.8)	19 (0.80)	0.005
Stenotrophomonas (*Xanthomonas*) *maltophilia*	63 (2.0)	52 (1.6)	21 (0.89)	0.005
Klebsiella oxytoca	37 (1.2)	35 (1.1)	33 (1.4)	0.53

*Pearson's χ^2 tests.
CAP, community-acquired pneumonia; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*.

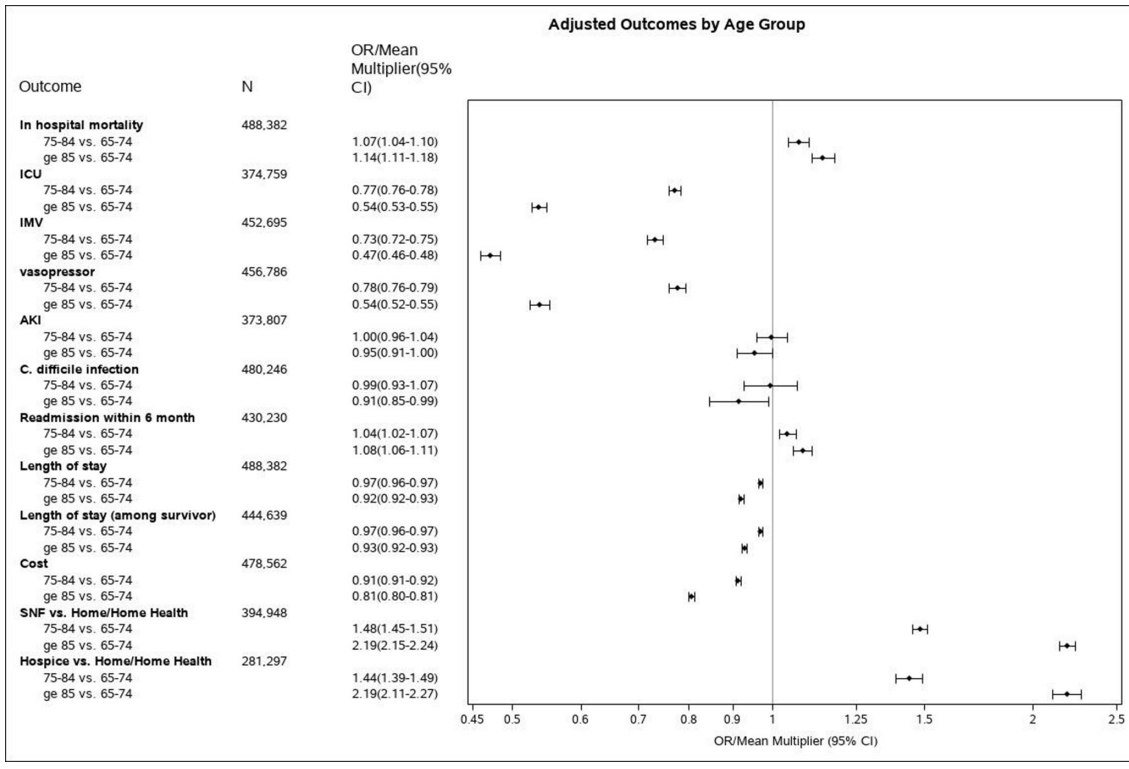

Figure 1 Adjusted outcomes by age group are presented. Patients who had AKI and *Clostridium difficile* infection (CDI) on admission are not included in AKI and CDI outcomes, respectively. Patients who were discharged in 2015 are excluded from the readmission outcome given limitations on data subsequently. For discharge to skilled nursing facility versus home/home health and hospice versus home/home health, only patients with those discharge dispositions are included. AKI, acute kidney injury; ICU, intensive care unit; IMV, invasive mechanical ventilation.

Hospital course and discharge disposition

Compared with patients aged 65–74 years, those aged ≥85 had higher in-hospital mortality (10.5% vs 7.5%), but lower rates of admission to ICU (23.8% vs 34.5%), IMV (8.9% vs 17%), and vasopressor administration (9.2% vs 14.9%), as well as shorter LOS (mean 6.5 vs 7.0 days) and lower costs (median $9160 vs $9705). Patients aged ≥85 were twice as likely to be discharged to a skilled nursing facility (SNF) (41.0% vs 21.0%) or to hospice (10.8% vs 5.0%).

Adjusted outcomes appear in figure 1. Adjusting for demographics, comorbidities and DNR status, compared with patients aged 65–74, patients aged ≥85 had higher odds of in-hospital mortality (OR 1.14, 95% CI 1.11 to 1.18) but lower odds of admission to the ICU (OR 0.54, 95% CI 0.53 to 0.55), IMV (OR 0.47, 95% CI 0.46 to 0.48) or vasopressor use (OR 0.54, 95% CI 0.52 to 0.55). People aged ≥85 had lower odds of AKI (OR 0.95, 95% CI 0.91 to 1.00) and CDI (OR 0.91, 95% CI 0.85 to 0.99). LOS for patients aged ≥85 were shorter whether they survived to discharge (mean multiplier 0.93, 95% CI 0.92 to 0.93) or not (OR 0.82, 95% CI 0.80 to 0.84), and costs were lower (mean multiplier 0.81, 95% CI 0.80 to 0.81). Patients aged ≥85 were more likely to be discharged to a skilled nursing facility (OR 2.19, 95% CI 2.15 to 2.24) or to hospice (OR 2.19, 95% CI 2.11 to 2.27) than to home. They also had higher odds of readmission within 6 months (OR 1.08, 95% CI 1.06 to 1.11).

The complete mortality model appears in online supplemental table S1 and the ICU model is in online supplemental table S2. The strongest predictors of death were DNR status (OR 2.29, 95% CI 2.24 to 2.35) and comorbidities including pressure ulcers (OR 1.48, 95% CI 1.43 to 1.53), solid tumors without metastasis (OR 1.49, 95% CI 1.36 to 1.63), and liver disease (OR 1.49, 95% CI 1.4 to 1.58). Patients with comorbidities were generally more likely to be admitted to ICU. Notable exceptions included patients with COPD (OR 0.92, 95% CI 0.91 to 0.93), dementia (OR 0.73, 95% CI 0.72 to 0.74) and metastatic cancer (OR 0.4, 95% CI 0.39 to 0.42).

DISCUSSION

In this retrospective cohort study of almost half a million patients from 638 US hospitals, we describe the clinical characteristics, treatment and outcomes of more than 150,000 patients aged ≥85 years hospitalized with CAP and compare them to patients aged 65–74 years. Reflecting population demographics, patients aged ≥85 were more likely than younger patients to be female and white, with Medicare as their primary insurance. They were more commonly admitted from an SNF, but most patients were living at home. The oldest patients had slightly more comorbidities, but not all comorbidities increased with age. Dementia and heart failure increased, but chronic pulmonary disease and diabetes decreased. We also found some differences in pneumonia etiology—after age 84, Gram-negative organisms were more common and *S. pneumoniae* less common. People aged ≥85 years received less intensive treatment, with lower rates of mechanical ventilation and ICU admission, but had higher in-hospital mortality. They had shorter

LOS and lower inpatient costs, but on discharge, they were more likely to go to an SNF or to hospice.

The characteristics and comorbidities we found among people aged ≥85 are comparable to those reported by others.[4 9] However, the higher rate of concurrent UTI appears to be a novel finding. It is well established that UTI incidence increases with age.[14–16] Contributing factors include urinary retention, higher postvoid urine volumes, and institutionalization associated with cognitive decline.[16] We found the oldest patients were more likely to have Foley catheters, which predispose to infection. Asymptomatic bacteriuria also increases and is often misdiagnosed as a UTI.[17 18] Unfortunately, our data could not distinguish between a UTI and asymptomatic bacteriuria. Patients ≥85 had more head CTs than those between 65 and 74, consistent with the idea that CAP often presents with AMS in geriatric patients,[19] and AMS is an important negative prognostic marker.[20 21]

Previous studies have reported that *S. pneumoniae* remains the most common cause of pneumonia among older adults, with frequency increasing with age.[22 23] We found that *S. aureus* was the most commonly isolated pathogen, and that *E. coli* was more common than *S. pneumoniae* after age 75. These findings also appear novel. The lower prevalence of *S. pneumoniae* after age 84 years may reflect the impact of pneumococcal vaccination. Though the vaccine is recommended for all older adults, uptake increases with age, from 25% at ages 65–69 years to >58% after 85 years.[24] The increasing burden of *E. coli* pneumonia with age may reflect colonization, aspiration or immunosenescence.[25] Falling rates of *P. aeruginosa* with age are harder to explain. *P. aeruginosa* is usually a nosocomial pathogen. Lower rates of some comorbidities—chronic pulmonary disease, diabetes, and metastatic cancer—with age may reduce exposure and colonization. Use of empiric antipseudomonal drugs did not vary by age.

Our finding that cost is lowest among patients ≥85 is consistent with previous studies,[8] and represents shorter LOS and less intensive treatment. The former reflects, in part, higher in-hospital mortality, but also may be explained by earlier discharge to SNF. Patients discharged to SNF may have continued treatment, such as intravenous antibiotics, whereas those who are discharged home might complete them in the hospital. An older study[4] found that patients aged 90 and older had much higher mortality, longer LOS and higher costs, but intervening changes in care delivery, including greater use of DNR orders, and methodological differences make it difficult to directly compare our results.

The combination of less intensive care but greater mortality suggests a less aggressive approach among the oldest patients. This may reflect patient preferences or physicians' triage decisions. Among adult patients with pneumonia, DNR orders have been associated with greater in-hospital mortality, with the majority of deaths occurring among patients with DNR status.[26] We found that DNR orders were associated with a more than 2-fold odds of mortality. Adjustment for DNR orders attenuated this difference but did not eliminate it.

Treatment may also reflect physician behavior. A multicenter, prospective observational cohort evaluating ICU triage in Norway found that nearly 30% of inpatients over the age of 80 were triaged out of ICU admission by critical care physicians because they were either 'too ill/old' or 'too well'.[27] For patients who were considered too ill/old to be admitted, age and functional status were risk factors for ICU non-admission.[27] We also found that patients aged ≥85 were much less likely to be admitted to ICU or receive mechanical ventilation. However, adjustment for comorbidities, functional status and DNR status did little to attenuate this difference. Most comorbid conditions were associated with increased ICU admission. The exceptions were dementia, metastatic cancer and COPD. Age was a more powerful predictor of not going to ICU than any of these, except metastatic cancer. Unfortunately, our data cannot explain how much such decisions are driven by patient or family preference and how much by physician prejudice. Additional prospective and qualitative studies are needed to clarify these findings. Interestingly, reduced use of intensive care in those aged ≥85 may have reduced nosocomial complications, as these patients had the lowest rates of AKI and CDI, despite their comorbidities[28 29] and lower functional status.[30]

That older patients have higher mortality is consistent with earlier studies, both in the USA and internationally, though in our sample adjusted mortality was lower than previously reported.[4 7 9] This may be due to better adjustment, especially for advance directives. Previous studies have attributed the mortality to more severe disease and reduced ability to compensate, potentially reflecting frailty, malnutrition/sarcopenia, and immunosenescence.[7 9 31] We found that older patients had only slightly higher adjusted mortality, and no increase in malnutrition/low functional status. It is possible that our administrative codes failed to capture some of these comorbidities[32] or that the high mortality rate reflects patient preference for less invasive care, even without DNR orders. The high rate of discharge to hospice hints at the latter. Additional investigation is necessary to identify whether mortality rates reflect clinical characteristics or patient and family preferences. Pneumonia has been considered the 'old man's friend' in that death from pneumonia or its complications can be relatively painless, whereas patients who recover from pneumonia often have difficult recoveries with high mortality in the ensuing months.[33 34]

Our study has a number of strengths. The large sample provided substantial power to compare age groups. The fact that we used a national database makes the results generalizable. The granularity of the data allowed us to compare outcomes such as ICU admission, AKI and CDI which are difficult to capture in other administrative data sets, such as the National Inpatient Sample. The limitations of our study primarily pertain to the use of an administrative database. It is possible that patient characteristics and outcomes or physician practices may differ at hospitals which do not participate in Premier. However, given the national nature of the database and the large number of included hospitals, it is unlikely that there would be a systematic difference in these variables. Moreover, it is not possible to fully understand provider reasoning or patients' clinical pictures, including disease severity or atypical presentation, through these codes. Thus, our evaluation of decision-making pertaining to disease severity or treatment intensification is limited. Much of the behavior witnessed may represent patient wishes for less intensive care, but we cannot be sure.

In conclusion, we found that patients aged ≥85 years admitted with CAP had different comorbidities and etiologies of their illness in comparison to patients aged 65–75. They also had lower rates of treatment intensification,

including ICU admission and mechanical ventilation, and worse outcomes, including higher rates of in-hospital mortality and readmission within 6 months. Prospective studies are necessary to elucidate whether the combination of less intense treatment and poorer outcomes reflects patient choice or physician bias.

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