1-9-2020

Older adults hospitalized for pneumonia in the United States: Incidence, epidemiology, and outcomes.

Forest W. Arnold
University of Louisville, School of Medicine Infectious Diseases, f.arnold@louisville.edu

Andrea Reyes-Vega
University of Louisville, andrea.reyesvega@louisville.edu

Vidyulata Salunkhe
vidyulata.salunkhe@louisville.edu

Stephen P. Furmanek
University of Louisville, Division of Infectious Diseases, stephen.furmanek@louisville.edu

Christian Furman
University of Louisville

See next page for additional authors

Original Publication Information
JAGS-Journal of the American Geriatrics Society
v. 68, no. 5:1007-1014, 2020© 2020 The American Geriatrics Society
0002-8614

Older Adults Hospitalized for Pneumonia in the United States: Incidence, Epidemiology, and Outcomes

Forest W. Arnold, DO, MSc, Andrea M. Reyes Vega, MD,* Vidyulata Salunkhe, MD, MPH,* Stephen Furmanek, MS, MPH,* Christian Furman, MD, MSPH, AGSF,†‡§ Laura Morton, MD, CMD,‡§ Anna Faul, PhD,§¶‖ Pam Yankeelov, PhD,§¶ and Julio A. Ramirez, MD**

OBJECTIVES: To define the current incidence, epidemiology, and mortality of older adult patients hospitalized with community-acquired pneumonia (CAP) in Louisville, KY and thus estimate the burden of CAP in the older adult population of the United States. To define risk factors associated with early and late outcomes.

DESIGN: This was a secondary analysis of older adults (aged ≥65 years) from the University of Louisville Pneumonia Study, a prospective population-based cohort study of all hospitalized adults with CAP between June 1, 2014, and May 31, 2016.

SETTING: The study took place in all nine acute care hospitals for adults in Louisville, KY.

PARTICIPANTS: Residents in the city of Louisville, KY, who were diagnosed with CAP between the inclusion dates were included and who were aged 65 years or older.

MEASUREMENTS: Incidence of CAP and outcomes were measured. A total of nine risk factors were also assessed for any potential association with time to clinical stability, length of stay (LOS), and mortality.

RESULTS: During the 2-year study, from a Louisville population of 102 264 adults aged 65 years or older, 4760 were hospitalized with CAP. The incidence of older adults hospitalized with CAP was 2093 per 100 000 population. This corresponds to 967 470 older adults in the United States hospitalized per year with CAP. The median time to clinical stability was 2 days, and the median LOS was 6 days. The 30-day all-cause mortality was 17%. The 1-year all-cause mortality was 38% (829 patients), which corresponds to 361 982 deaths in the United States with CAP in older adults.

CONCLUSION: The estimated burden of CAP in older adults is substantial in the United States. Nearly 1 million older adults are hospitalized for CAP, and over a third of those die within 1 year. **J Am Geriatr Soc 68:1007-1014, 2020.**

Key words: epidemiology; health outcomes; incidence; older adults; pneumonia

Community-acquired pneumonia (CAP) is the eighth leading cause of death in the United States, and in adults aged 65 years and older.[1,2] It also causes more death in the United States than any other infectious disease.[3] The cumulative cost in the United States for all inpatients with CAP has been estimated to be $9 to $17 billion/year.[4-6] The last National Hospital Discharge survey addressing pneumonia as a first-listed *International Classification of Diseases, Ninth Revision* (*ICD-9*), diagnosis was for 2007 when 1 056 000 patients were identified, of whom 610 000 were aged 65 years or older.[7]

The incidence of hospitalization for CAP that is currently known for older adults ranges from 1150 to 1830 per 100 000 population.[8-10] Every large epidemiological study has been limited by defining patients with *ICD* data rather than with clinical and radiographic data. There are no studies that have included comprehensive CAP data for one city from which values could be translated to the US population as a whole. A

From the *Division of Infectious Diseases, Department of Medicine, School of Medicine, University of Louisville, Louisville, Kentucky; †Division of General Internal Medicine, Palliative Medicine and Medical Education, Department of Medicine, School of Medicine, University of Louisville, Louisville, Kentucky; ‡Division of Geriatric Medicine, Department of Family and Geriatric Medicine, School of Medicine, University of Louisville, Louisville, Kentucky; §Trager Institute, University of Louisville, Louisville, Kentucky; ¶Kent School of Social Work, University of Louisville, Louisville, Kentucky; and the ‖Department of Social Work, University of the Free State, Bloemfontein, South Africa.

Address correspondence to Forest W. Arnold, DO, MSc, or Julio A. Ramirez, MD, Division of Infectious Diseases, Department of Medicine, School of Medicine, University of Louisville, 501 E Broadway, Ste 140 B, Louisville, KY 40292. E-mail: f.arnold@louisville.edu or E-mail: j.ramirez@louisville.edu

DOI: 10.1111/jgs.16327

0002-8614/20/$15.00

comprehensive study is needed. Advancement in this field will come with accurate and timely familiarity of the epidemiology, incidence, and mortality of CAP in older adults. This information would help determine what risk factors are relevant to improve outcomes. The Louisville Pneumonia Study was created for specifically that purpose. It is a multidisciplinary collaboration of investigators from the University of Louisville Infectious Diseases, the Louisville Metro Department of Public Health and Wellness, and the Kentucky Office of Vital Statistics.

The primary objective of this study was to define the current incidence, epidemiology, and mortality of older adult patients hospitalized with CAP in Louisville, KY; and to estimate the burden of CAP in the older adult population of the United States. The secondary objective was to define risk factor–specific indices with an association with time to clinical stability, length of stay (LOS), and mortality.

METHODS

This was a secondary analysis of older adults (aged ≥65 years) from the University of Louisville Pneumonia Study, a large prospective population-based cohort study of hospitalized adults with CAP in Louisville, KY. The primary study was performed over 2 years between June 1, 2014, and May 31, 2016, and included 7449 patients with CAP, aged 18 years or older, to define incidence, epidemiology, and mortality of adult patients hospitalized with CAP in an entire city.[11] Admitted patients to the nine adult hospitals in Louisville were screened for inclusion criteria. Candidates who fulfilled inclusion criteria were included, and data were collected. Unique patients were identified by their social security number, preventing readmitted patients from being counted twice. The primary study was approved by the Institutional Review Board (IRB) at the University of Louisville Human Subjects Research Protection Program Office (IRB No. 11.0613) and by the research offices at each participating hospital. The study was exempt from informed consent. All data operations were conducted by the study coordinating center located at the University of Louisville Division of Infectious Diseases.[11]

Inclusion Criteria

A diagnosis of CAP and an age of 65 years or older were required for study eligibility. A patient was considered to have CAP when certain radiographic and clinical criteria were met. Radiographic criteria included a pulmonary infiltrate on imaging (computed tomography or chest x-ray) at the time of admission. Clinical criteria required having at least one of the following: new or increased cough, fever higher than37.8°C (100.0°F), hypothermia lower than 35.6°C (96.0°F), a change in serum white blood cells (leukocytosis >11 000 cells/mL, left shift >10% band forms, or leukopenia <4000 cells/mL). Additional screening criteria are in the Supplementary Methods. Finally, no alternative diagnosis at the time of hospital discharge that justified the radiographic or clinical criteria could be present.

Exclusion Criteria

Patients were excluded if their valid residence was outside of Louisville. Patients were also excluded if they did not have a valid social security number or were in prison at the time of enrollment. Patients diagnosed with pneumonia more than 72 hours after admission were excluded. If an alternate diagnosis to CAP was present at the time of discharge, then a patient was withdrawn. If a patient was rehospitalized due to CAP, only the first admission in a given year was used in analysis.

Study Definitions

All patients were aged 65 years or older and were categorized for those aged 65 to 84 years and older than 85 years. A patient admitted to the hospital from a nursing home was considered to be a resident. Poverty status for each US Census Bureau census tract was recorded. A body mass index (BMI) of 30 kg/m^2 or greater was considered as overweight, and a BMI of less than 18.5 kg/m^2 was considered underweight. Variables evaluated in the medical record at the time of enrollment included comorbidities (congestive heart failure [CHF], chronic obstructive pulmonary disease [COPD], chronic renal failure, cerebrovascular disease, diabetes, liver disease, and neoplastic disease [active or within the last year]), race, and smoking status. Pathogens detected by routine standard of care were reported from a respiratory, blood, or urine sample. Vital signs, laboratory values, and severity of disease were also recorded. Severity of disease was defined using the Pneumonia Severity Index (PSI) and its 23 factors, including age, medical history, vital signs, and laboratory values.[12] Patients older than 50 years may be in PSI risk classes II to V, but never risk class I.

Incidence Calculations

The numerator for the incidence of hospitalizations for CAP was the yearly average number of unique adults hospitalized with CAP over the 2-year study. The denominator was based on the US Census Bureau projections for 2014 from age-specific data of the 2010 US Census Data for Louisville. The incidence rates were standardized per 100 000 population. The estimated number of patients hospitalized with CAP and the number of deaths due to CAP among older adults in the United States were calculated by multiplying the Louisville incidence rate by the estimated 2014 US older adult population and adjusting for age, sex, and race using robust statistics described in the Supplementary Methods.

Geospatial Epidemiology

Cases of pneumonia among older adults were plotted in dot density, kernel density, and choropleth maps. A dot density map shows a distribution of cases per dot on a map. Our dot density maps showed one case of CAP per dot on a map of Louisville, KY (Jefferson County). A choropleth map shows the distribution of a characteristic per section. Our choropleth maps show four degrees (one color shade for each interquartile) of poverty and race per census tract in Louisville. A kernel density heat map shows a distribution of cases for a region portrayed similarly to a topographical map with increasing concentrations of cases culminating in the highest density of cases appearing as "hills." Finally, Kulldorff's spatial scan statistic outlines a single area on a map with the highest density of a certain

factor while taking into account an underlying population. We identified this general area of increased incidence of CAP among older adults in Louisville using this statistic. ArcGIS 10.4 (Esri) and SaTScan version 9.5 were used for all geospatial analysis.[13]

Study Outcomes

Study outcomes included time to clinical stability, LOS, and mortality. A patient was defined as clinically stable on the day that the following four criteria were met: (*a*) improved cough and shortness of breath, (*b*) lack of fever for at least 8 hours, (*c*) improving leukocytosis (improved at least 10% from the previous day), and (*d*) tolerating oral intake. Patients were evaluated daily for the first 7 days of hospitalization to determine when

Table 1. Characteristics of Patient Population

Characteristics	Total Study Population (n = 4279)		*P* Value
	Aged 65-84 y	Aged ≥85 y	
	(n = 3134 [73%])	(n = 1145 [23%])	
Demographics			
Age, median (IQR)	74 (69-79)	89 (87-92)	<.001
Male sex	1493 (48)	464 (41)	<.001
Black race	481 (15)	119 (10)	<.001
Nursing home resident	462 (15)	334 (29)	<.001
Medical and social history			
Chronic obstructive pulmonary disease	1742 (56)	417 (36)	<.001
Congestive heart failure	1054 (34)	461 (40)	<.001
Renal disease	1043 (33)	448 (39)	<.001
Diabetes mellitus	1181 (38)	300 (26)	<.001
BMI, kg/m^2			<.001
<18.5	249 (8)	137 (12)	
18.5-30	1841 (59)	828 (72)	
≥30	1042 (33)	180 (16)	
Current smoker	709 (23)	64 (6)	<.001
Neoplastic disease (active or within the last year)	528 (17)	149 (13)	.003
Stroke	484 (15)	187 (16)	.509
Liver disease	152 (5)	15 (1)	<.001
Physical examination findings, median (IQR)			
Heart rate, beats/min	102 (89-117)	98 (84-113)	<.001
Respiratory rate, breaths/min	22 (20-27)	22 (20-26)	<.001
Systolic blood pressure, mmHg	117 (100-136)	118 (100-135)	.964
Diastolic blood pressure, mmHg	55 (47-65)	54 (46-63)	.022
Temperature, °C	37.2 (36.8-37.8)	37.1 (36.8-37.8)	.012
Laboratory findings, median (IQR)			
Hematocrit, %	35 (31-39)	35 (31-39)	.151
Serum bicarbonate, mEq/L	26 (23.3-30)	26 (24-29)	.275
Blood urea nitrogen, mg/dL	21 (15-32)	25 (19-36)	<.001
Serum glucose, mg/dL	146 (117-200)	134 (112-176)	<.001
Serum sodium, mEq/L	137 (134-140)	137 (134-141)	.003
Severity of disease			
Need for intensive care	562 (18)	145 (13)	<.001
Altered mental status	648 (21)	325 (28)	<.001
Vasopressors received	88 (3)	29 (3)	.700
Ventilatory support received	448 (14)	104 (9)	<.001
Pneumonia Severity Index, median (IQR)	111 (88-136)	129 (108-153)	<.001
Risk class I	[a]	[a]	
Risk class II	252 (8)	[b]	
Risk class III	612 (20)	92 (8)	
Risk class IV	1,340 (43)	506 (44)	
Risk class V	930 (30)	547 (48)	

Note: Data are given as number (percentage), unless otherwise indicated.

Abbreviations: BMI, body mass index; IQR, interquartile range.

[a]Those older than 50 years are not eligible to be in risk class I.

[b]Those aged 70 years or older are not eligible to be in risk class II.

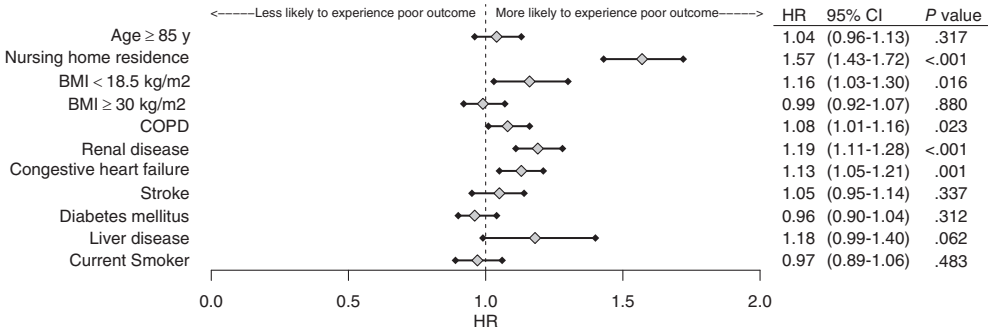

Figure 1. Forest plot for time to clinical stability among patients aged 65 years or older who were hospitalized with community-acquired pneumonia. BMI indicates body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio.

clinical stability was reached. LOS was defined by subtracting the admission date from the discharge date. Patients hospitalized for more than 2 weeks were censored at 14 days in an effort to capture LOS related only to CAP. All-cause mortality was evaluated for in-hospital, 30-day, 6-month, and 1-year mortality. Mortality was evaluated after discharge by reviewing medical records and by matching a patient's social security number with mortality data obtained from the Kentucky Department for Public Health Office of Vital Statistics.

Statistical Analysis

Descriptive statistics were performed, with patient demographics, medical and social history, physical examination findings, laboratory findings, and pneumonia severity (using PSI) described as either median and interquartile range (IQR) or frequency and percentage. Comparisons of patient characteristics between those aged 65 to 84 years and those aged 85 years or older were performed using either Mann-Whitney U tests or χ^2 tests for continuous and categorical data, respectively. Confidence intervals (CIs) were calculated using normal approximation. Cox proportional hazards regression was performed to identify risk factors for study outcomes, with hazard ratios reported so that negative outcomes would be indicated by hazard ratios greater than 1. $P < .05$ was considered statistically significant. All statistical analysis was performed in R version 3.5.1 (R Foundation for Statistical Computing).[14]

RESULTS

Study Population

There were 102 264 older adults, aged 65 years or older, in the city of Louisville during 2014. During the 2-year study period, there were 4760 (4.7%) hospitalizations of older adults with CAP. A total of 4279 (4.2%) were unique patients, of whom 2196 patients were in the first year of the study and 2083 patients were in the second year of the study. Of the 396 patients who were readmitted 473 times, only the first admission was evaluated.

Patient Characteristics

Patient characteristics are shown in Table 1. The age range was 65 to 102 years, the average age was 78.5 years, and the median age was 78 years. Most were female (54%), and 14% were African American. The most common comorbidities were COPD (51%), CHF (35%), diabetes mellitus (35%), and obesity (29%). A total of 17% were admitted to the intensive care unit (ICU), and 13% required ventilatory support. Of patients, 10% did not have a comorbidity, 24% had one comorbidity, 28% had two comorbidities, 21% had three comorbidities, 12% had four comorbidities, and 5% had five or more comorbidities. Some differences were noted to be statistically different because the population was so large, but are not clinically significant, such as the respiratory rate and the levels of serum

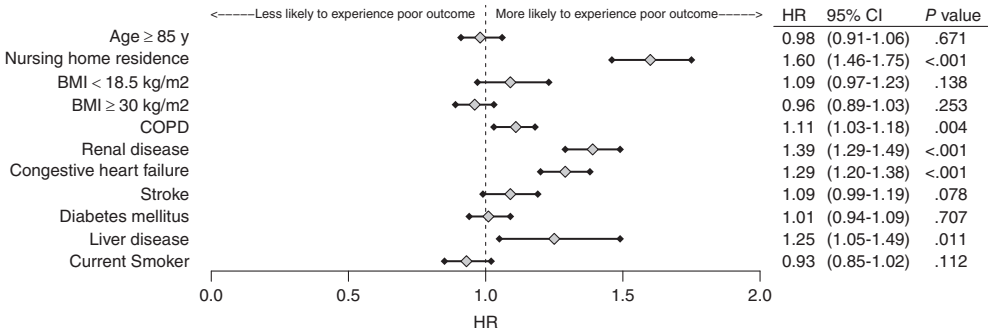

Figure 2. Forest plot for length of hospital stay among patients aged 65 years or older who were hospitalized with community-acquired pneumonia. BMI indicates body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio.

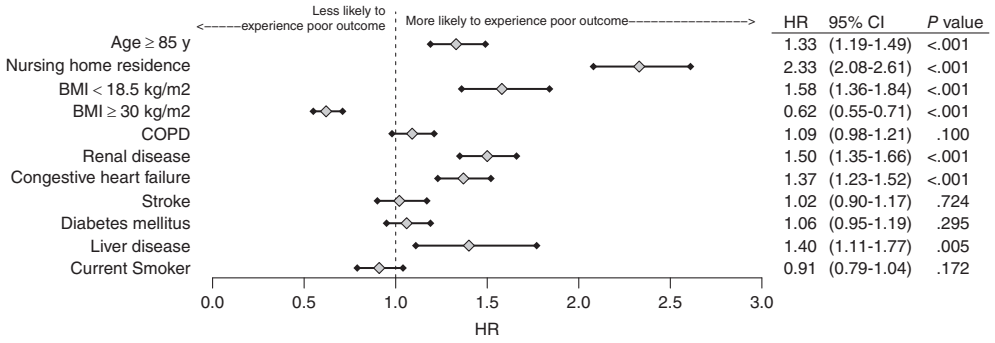

Figure 3. Forest plot for mortality among patients aged 65 years or older who were hospitalized with community-acquired pneumonia. BMI indicates body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio.

bicarbonate. The etiology of CAP for the 20% of patients who had a positive laboratory test is in Supplementary Table S1.

Incidence

The yearly incidence of older adults hospitalized for CAP was 2093 (95% CI = 2005-2182) per 100 000 population. This

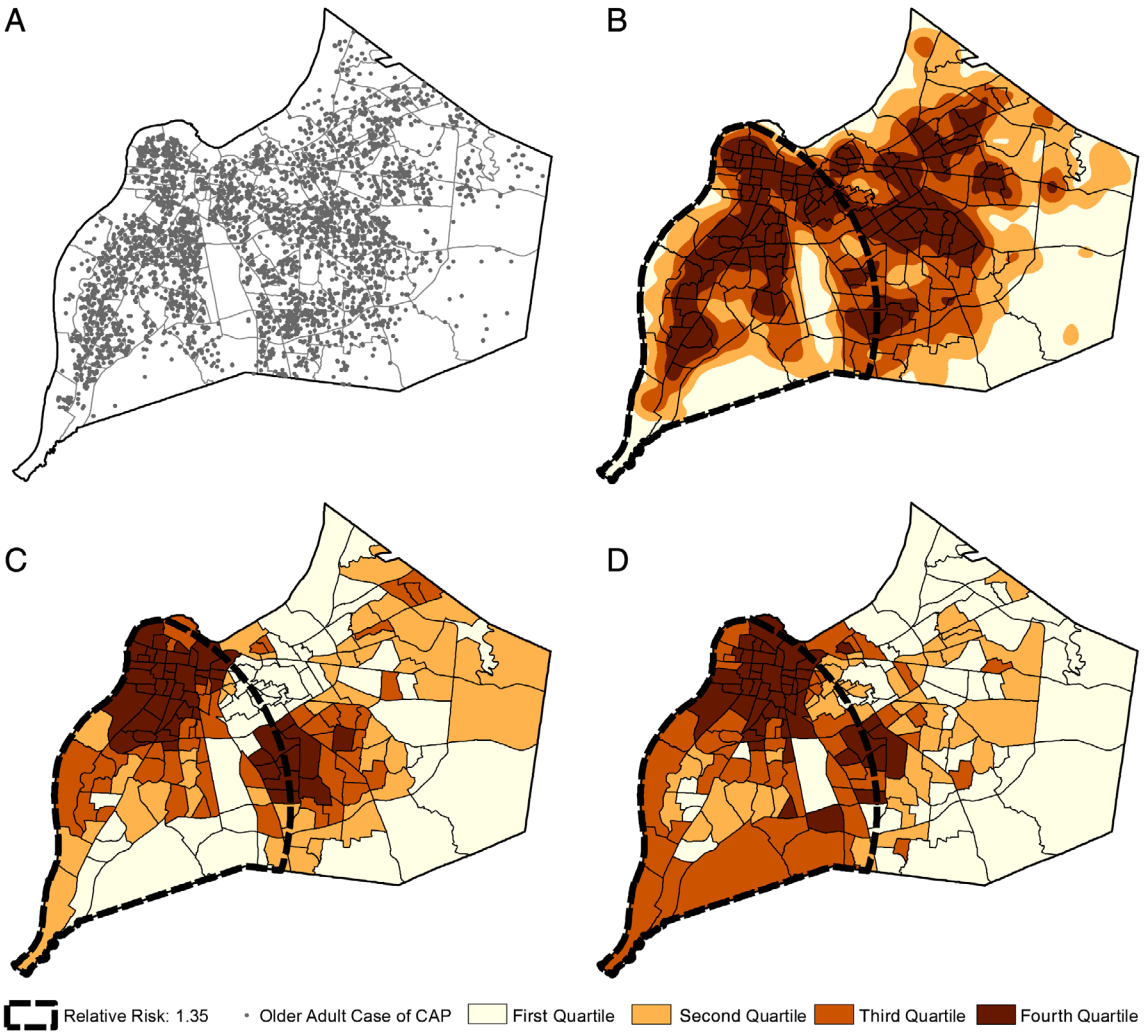

Figure 4. A dot density distribution of older adults hospitalized with community-acquired pneumonia (CAP) in the city of Louisville, KY (A). A kernel density heat map is shown with darker shades associated with higher concentrations of CAP (B). Choropleth distributions among census tracts show the associations of CAP clustering with African American race (C) and poverty level (D). A darker shade represents a higher interquartile range for race (A) or poverty (B). Kulldorff's spatial scan statistic is represented by a dashed shape showing the general area of highest concentration for CAP among older adults in Louisville (B-D).

incidence translates to an adjusted number of older adults hospitalized with CAP in the United States to be 942 437 older adults per year. The incidence in Louisville without considering patients admitted with CAP from a nursing home was 1703 per 100 000 population. This translates to an incidence in the United States of 773 187 older adults per year.

The incidence of hospitalization with CAP among adults aged 65 to 84 years was 1786 (95% CI = 1698-1874), and that of adults aged 85 years or older was 3948 (95% CI = 3625-4271) per 100 000. As age increased, the incidence of hospitalization for CAP also increased (Supplementary Table S2). The incidence for African Americans aged 65 years or older was 2169 (95% CI = 1924-2414), and that for whites aged 65 years or older was 2062 (95% CI = 1968-2157) per 100 000 population.

Outcomes

The median time to clinical stability was 2 days (IQR = 1-4 days). The median LOS was 6 days (IQR = 4-9 days). All-cause mortality was 184 (8%) deaths per year during hospitalization. The 30-day mortality for patients in each PSI risk class was: II = 0.8%, III = 3.9%, IV = 10.3%, and V = 33.8%. The 30-day mortality was 371 (17%), and 6-month mortality was 644 (30%). One-year mortality was 829 (38%) deaths per year, which translates to 361 982 deaths per year in the United States. The 30-day mortality for ward patients was 14%, and it was 33% for ICU patients.

Nursing home residence, a history of renal disease, and CHF were associated with worsening of the three outcomes evaluated; time to clinical stability, LOS, and all-cause, 1-year mortality (Figures 1-3). Being underweight resulted in longer time to clinical stability and higher mortality, while being overweight was actually protective for mortality. Mortality was higher in patients older than 85 years, as expected. As age increased, the mortality also increased (Supplementary Figure S1).

Geospatial Epidemiology

The dot density map showed more cases in the areas of more population (downtown), but did not identify a specific area of risk for CAP as patients were from all over the city (Figure 4A). The kernel density map specifically showed that residents within certain areas had a 35% increased risk for CAP (Figure 4B). The Kulldorff's spatial scan statistic identified that older adults living in western Louisville had an increased risk for hospitalization due to CAP (Figure 4B-D). Choropleth maps identified census tracts of patients with CAP who may have had a higher association of being African American and impoverished (Figure 4C,D).

DISCUSSION

The most important finding of this study was determining the incidence of hospitalization for CAP in older adults, which was 2093 per 100 000 population. This translates to nearly 1 million older adults (942 437) in the United States who are hospitalized each year for CAP. In previous research, it was found that the number of older adults hospitalized with CAP reported in the United States was only 610 000 (SE = 43 000).[7] That study and the present study have attempted to report the actual incidence of older adults hospitalized with CAP as accurately as possible. But, the difference highlights the methodological differences in inclusion and incidence estimates and even slight epidemiological variations that may have occurred over the 7 years between the two studies. Consequently, these estimates require attention and further investigation to determine if there has been an underestimation of older adults hospitalized with CAP until now.

A study using the Agency for Healthcare Research and Quality Nationwide Inpatient Sample (NIS) data reported incidences of hospitalization.[15] They found an incidence from 2007 to 2009 for those aged 65 to 84 year of 1492 and an incidence for those aged 85 year or older of 4396 per 100 000 population. NIS data report hospitalizations, not unique patients, which increased their rates slightly. Furthermore, they identified patients using *ICD* codes for hospitalization. These reasons may explain why their rates were higher for those aged 65 84 years and lower for those aged 85 years or older than the present study.

A study on the etiology of pneumonia in the community also evaluated the incidence of CAP.[16] They enrolled patients from 2 of 13 hospitals in Nashville, TN, and 3 of 133 hospitals in Chicago, IL. They excluded patients who had been recently hospitalized or who were immunosuppressed. In older adults aged 65 to 79 years, the incidence of CAP was 630 (95% CI = 564-703) per 100 000 population, and in adults aged 80 years or older, it was 1643 (95% CI = 1419-1893) per 100 000 population.

There were three risk factors associated with all three outcomes measured. Nursing home residence, renal disease, and CHF correlated with longer time to clinical stability, longer LOS, and higher mortality. Three other risk factors (cachexia, COPD, and liver disease) were each associated with two of three outcomes measured. It is not surprising that major organ diseases were associated with worse outcomes. It is understandable that comorbidities would prevent a patient from recuperating as quickly or getting discharged as early as a patient without comorbidities, but physicians may find it surprising that comorbidities had an impact on mortality up to 1 year after having CAP. One exception was obesity, which was found to be protective. It has been shown that obese patients hospitalized with CAP had a lower mortality if they did not need intubation and mechanical ventilation or inotropic support.[17] Knowing the risk factors associated with worse outcomes may prompt more aggressive management by physicians for those patients who have them.

The in-hospital mortality of the present study was generally similar to previous studies if one considers that the range is broad in the literature for older adults, ranging from 5% for ward patients and as high as 50% for ICU patients on inotropic support.[18,19] We reported 30-day mortalities of 14% for ward patients and 33% for ICU patients. The all-cause mortality rates for the present study also increased significantly as time elapsed from the day of admission. Within a month of admission, nearly one patient in five died. By 6 months, one patient in three died, and approximately 40% died within a year of admission. This translates to over 360 000 deaths in older adults admitted for CAP in the United States per year. Appreciating CAP in this manner would make it the third most common cause of

death in the United States ahead of noninfectious "chronic lower respiratory diseases."[2] These values reveal a higher incidence of mortality with CAP in the older population than the 42 479 deaths reported by the Centers for Disease Control and Prevention (CDC) for 2016.[2] The CDC, however, reports death from death certificates, which list pneumonia as the primary cause of death, while we counted all-cause mortality in patients admitted for CAP because CAP initiates many of the complications that lead to death, such as cardiovascular complications.[20-22]

The incidence of CAP in whites vs African Americans was relatively similar, though slightly higher for African Americans. A higher proportion of African Americans live in western Louisville, where poverty is also higher. The area of Louisville with the most poverty overlapped with the area of the highest density of CAP. Poverty is a marker of several factors associated with respiratory infection (eg, poor nutrition, housing, and air quality), as well as a lack of adequate medical insurance, poor access to healthcare, and increased smoking.

The incidence of CAP might be investigated more if it was easier to measure rates and thus make simple comparisons. Rates of certain populations should be compared with similar age groups. Incidence studies interested in true annual incidence count single admissions per year per patient and have slightly different rates than prevalence studies interested in burden of disease, which count multiple admissions per year per patient. Some studies depend on the science (and art) of radiography, requiring some degree of interpretation, while others use *ICD* coding to capture patients with CAP. The incidence of CAP may also vary during years of an influenza outbreak, so even noting study years is prudent when making comparisons.

One of the implications of knowing the incidence of CAP in older adults is to calculate cost so that resources can be allocated accordingly. Before an accurate cost can be provided, incidence, severity of disease, location cared for, and insurance issues need to be clarified. Among those variables, this study helps to better describe incidence. The current range of cost attributed to CAP in older adults has been reported from $4851 to $27 661 per case.[23,24] Using these values, the range of total cost in the United States using the incidence determined in the present study for older adults with CAP yields $4.7 to $26.7 billion per year, a broad range, but one that includes the commonly referenced $10 billion per year. Studies addressing the other variables need to be performed before an accurate total cost for CAP in older adults in the United States can be provided.

Limitations and Strengths

Our study was limited by the lack of a gold standard for the definition of CAP. We used one clinical criterion, while many studies use two. In an effort not to overestimate the incidence, patients were excluded if no alternative diagnosis was present at the time of discharge. We also had a radiological criterion to support that patients actually had CAP. Another limitation was that some Louisville residents likely sought hospitalization outside of the region. This would have decreased our estimated incidence rate. Finally, we translated our incidences and deaths to the nation as a whole, which is reasonable because, among cities with more than 500 000 people, Louisville ranks second in similarity to the United States.[25] That ranking is based on 59 variables from the American Community Survey 5-Year Estimates and the Behavior Risk Factor Surveillance System, which includes categories of demographics, comorbidities, socioeconomic status, and health behaviors. For example, the median household income in Louisville is $51 259 compared to $55 775 for the United States. The poverty rate is 15.1% for Louisville and 14.7% for the United States. The proportion of whites in Louisville is 70%, while it is 63% in the United States. However, the proportion of Hispanics is 4.4% and of African Americans is 20.6% in Louisville vs 16.3% and 12.2%, respectively, in the United States. The proportion of present smokers in Louisville is 10% compared to 8% in the United States. The proportion of those who received a pneumococcal vaccine was 65% in both Louisville and the United States, and the proportion who received an influenza vaccine was 53% in Louisville and 55% in the United States.

Our definition of poverty may have been compromised because we used the US Census Bureau information, which relies on income, and many older adults are retired. The bureau was helpful, however, for defining location of all patients with CAP. This study was primarily strengthened by its comprehensiveness, which garnered all cases of patients with CAP in a major metropolitan city for 2 years, which increases the accuracy of the epidemiological findings. This study was also strengthened by using social security numbers to prevent counting patients twice. The short- and long-term outcomes evaluated provide valuable information for physicians and other healthcare providers when admitting older adults to the hospital for CAP. This becomes more relevant with an aging US population.

CONCLUSION

In conclusion, the incidence of older adults hospitalized for CAP in the entire city of Louisville was 2093 per 100 000 population. It translates to nearly 1 million older adults in the United States hospitalized with CAP per year, which is higher than documented in recent years. Nearly one-third of the CAP patients will die within 1 year. The burden of CAP in older adults is substantial. Efforts to prevent CAP and strategies to minimize its impact are needed to extend life and decrease its burden.

ACKNOWLEDGMENTS

Financial Disclosure: The study is a secondary analysis of the Louisville Pneumonia Study, which was supported primarily by the Division of Infectious Diseases, University of Louisville, Louisville, KY. Partial support was given by Pfizer, Inc.

Conflict of Interests: The authors have no conflicts of interest to report.

Author Contributions: F.W.A. made substantial contributions to conception and design and interpretation of data; drafted the article; and had final approval of the version to be published.

A.M.R.V. made substantial contributions to conception and design; drafted the article; and had final approval of the version to be published.

V.S. made substantial contributions to conception and design; drafted the article; and had final approval of the version to be published.

S.F. made acquisition of data and interpretation of data; drafted the article; and had final approval of the version to be published.

C.F. analyzed and interpreted data; revised data critically for important intellectual content; and had final approval of the version to be published.

L.M. analyzed and interpreted data; revised data critically for important intellectual content; and had final approval of the version to be published.

A.F. analyzed and interpreted data; revised data critically for important intellectual content; and had final approval of the version to be published.

P.Y. analyzed and interpreted data; revised data critically for important intellectual content; and had final approval of the version to be published.

J.A.R. made substantial contributions to conception and design; revised data critically for important intellectual content; and had final approval of the version to be published.

Sponsor's Role: None.

REFERENCES

1. Heron M. Deaths: leading causes for 2016. Natl Vital Stat Rep. 2018;67(6):1-77.
2. Xu J, Murphy SL, Kochanek KD, Bastian B, Arias E. Deaths: final data for 2016. Natl Vital Stat Rep. 2018;67(5):1-76.
3. Heron M. Deaths: leading causes for 2010. Natl Vital Stat Rep. 2013;62(6):1-96.
4. Pfuntner A, Wier LM, Steiner C. Costs for hospital stays in the United States. HCUP statistical brief. Rockville, MD: Agency for healthcare research and quality. 2010. Available at http://www.hcupus.ahrq.gov/reports/statbriefs/sb146.pdf. Accessed March 14, 2019.
5. Bonafede MM, Suaya JA, Wilson KL, Mannino DM, Polsky D. Incidence and cost of CAP in a large working-age population. Am J Manag Care. 2012;18:380-387.
6. File TM Jr, Marrie TJ. Burden of community-acquired pneumonia in North American adults. Postgraduate Med. 2010;122:130-141.
7. Hall MJ, DeFrances CJ, Williams SN, Golosinskiy A, Schwartzman A. National hospital discharge survey: 2007 summary. Natl Health Stat Rep. 2010;24:1-20.
8. Kaplan V, Angus DC, Griffin MF, Clermont G, Scott Watson R, Linde-Zwirble WT. Hospitalized community-acquired pneumonia in the elderly: age-and sex-related patterns of care and outcome in the United States. Am J Resp Crit Care Med. 2002;165:766-772.
9. Froes F, Diniz A, Mesquita M, Serrado M, Nunes B. Hospital admissions of adults with community-acquired pneumonia in Portugal between 2000 and 2009. Eur Resp J. 2013;41:1141-1146.
10. Jackson ML, Neuzil KM, Thompson WW, et al. The burden of community-acquired pneumonia in seniors: results of a population-based study. Clin Infect Dis. 2004;39:1642-1650.
11. Ramirez JA, Wiemken TL, Peyrani P, et al. Adults hospitalized with pneumonia in the United States: incidence, epidemiology, and mortality. Clin Infect Dis. 2017;65:1806-1812.
12. Fine MJ, Auble TE, Yealy DM, et al. A prediction rule to identify low-risk patients with community acquired pneumonia. N Engl J Med. 1997;336:243-250.
13. Kulldorff M. A spatial scan statistic. Commun Stat. 1997;26:1481-1496.
14. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing; 2018. https://www.R-project.org/. Accessed February 7, 2019.
15. Griffin MR, Zhu Y, Moore MR, Whitney CG, Grijalva CG. U.S. hospitalizations for pneumonia after a decade of pneumococcal vaccination. N Engl J Med. 2013;369:155-163.
16. Jain S, Self WH, Wunderink RG, et al. Community-acquired pneumonia requiring hospitalization among US adults. N Engl J Med. 2015;373:415-427.
17. Singanayagam A, Singanayagam A, Chalmers JD. Obesity is associated with improved survival in community-acquired pneumonia. Eur Resp J. 2013;42:180-187.
18. Angus DC, Marrie TJ, Obrosky DS, et al. Severe community-acquired pneumonia: use of intensive care services and evaluation of American and British Thoracic Society diagnostic criteria. Am J Respir Crit Care Med. 2002;166:717-723.
19. Rodriguez A, Mendia A, Sirvent JM, et al. Combination antibiotic therapy improves survival in patients with community-acquired pneumonia and shock. Crit Care Med. 2007;35:1493-1498.
20. Corrales-Medina VF, Musher DM, Wells GA, Chirinos JA, Chen L, Fine MJ. Cardiac complications in patients with community-acquired pneumonia: incidence, timing, risk factors, and association with short-term mortality. Circulation. 2012;125:773-781.
21. Musher DM, Rueda AM, Kaka AS, Mapara SM. The association between pneumococcal pneumonia and acute cardiac events. Clin Infect Dis. 2007;45:158-165.
22. Ramirez J, Aliberti S, Mirsaeidi M, et al. Acute myocardial infarction in hospitalized patients with community-acquired pneumonia. Clin Infect Dis. 2008;47:182-187.
23. Sato R, Gomez Rey G, Nelson S, Pinsky B. Community-acquired pneumonia episode costs by age and risk in commercially insured US adults aged >/-=50 years. Appl Health Econ Health Policy. 2013;11:251-258.
24. Konomura K, Nagai H, Akazawa M. Economic burden of community-acquired pneumonia among elderly patients: a Japanese perspective. Pneumonia (Nathan Qld). 2017;9:19.
25. Furmanek S, Glick C, Chandler T, et al. The city of Louisville encapsulates the US demographics. Univ Louisville J Resp Infect. In Press.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

Supplementary Table S1: The Incidence of Older Adults Hospitalized With Community-Acquired Pneumonia in Louisville, KY, for Specific Age Groups and the Estimated Number of Patients in the United States.

Supplementary TableS2: The Positive Laboratory Test Results and Their Respective Body Fluid Source Collected per Standard of Care From Older Adults Admitted for Community-Acquired Pneumonia.

Supplementary Figure S1: Mortality among patients aged 65 years or older for specific age groups who were hospitalized with community-acquired pneumonia; in-hospital, 30-day, 6-month, and 1-year mortality rates are given.