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Short Communication

Mortality and associated factors among community-acquired pneumonia patients: A cross-sectional study in a provincial referral hospital in Indonesia

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Abstract

Community-acquired pneumonia (CAP) poses a significant impact on the healthcare system due to rehospitalization and mortality. About one-third of hospitalized CAP patients died within one year. In addition to advanced age, vulnerable groups with comorbidities such as cancer, diabetes, and cerebrovascular disease (CVD) are more likely to suffer from severe CAP. The aim of this study was to investigate the factors linked to mortality in adult hospitalized CAP patients. The study extracted the medical records of patients aged ≥18 years, admitted to a referral hospital in Riau Province, who were diagnosed with CAP between January and December 2023. Multiple logistic regression step-wise analysis was employed to determine the factors associated with mortality in CAP patients. The study involved 334 patients with a median age of 58 years. Based on the confusion, urea, respiratory rate, blood pressure, and age ≥65 years (CURB-65) score, 11.9% of patients had severe CAP (CURB-65 scores 3 and 4). Age was a significant predictor of severe CAP ($p \leq 0.001$). The most prevalent comorbidities were malignancy (33.2%), CVD (30.2%), and diabetes (28.4%). Mortality incidence during hospitalization reached 35.9%. Significant factors associated with mortality in hospitalized CAP patients included renal dysfunction/elevated serum urea levels ($p=0.031$), CURB-65 score ($p=0.023$), vasopressor use ($p \leq 0.001$), mechanical ventilator use ($p \leq 0.01$) and steroid use ($p=0.029$). However, CVD was associated with a decreased risk of mortality ($p=0.019$). Gram-negative bacteria predominated, accounting for 50.6% of all positive isolates. Several significant factors were associated with mortality in adult patients hospitalized with CAP at referral Hospital in Riau, including renal dysfunction, CURB-65 score, vasopressor use, mechanical ventilator use, and steroid use. This finding underscored the importance of early identification factors in CAP patients.

Keywords: CAP, CURB-65 score, mortality, factors related, cerebrovascular disease

Introduction

Community-acquired pneumonia (CAP) remains a significant public health concern with significant impacts on healthcare systems, particularly in low- and middle-income countries [1,2]. The burden of CAP is not uniformly distributed; geographical variations in incidence and

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outcomes highlight disparities in healthcare resources and disease management [3]. In adults, CAP incidence ranges from 24.8 to 110 per 100,000 persons annually in the United States, and 62.6 per 100,000 in South Korea [4]. A recent study across three Asian nations reported substantial incidence rates of CAP among hospital discharges: 1424.5 per 10,000 in Malaysia, 420.5 in Indonesia, and 98.8 in the Philippines [5]. These figures underscore CAP's significant contribution to morbidity and mortality in the region.

Pneumonia, classified alongside other lower respiratory infections, is a leading cause of death in Indonesia, ranking eighth among the most prevalent causes of adult mortality [6]. Alarmingly, approximately one-third of CAP patients deaths occur within a year of diagnosis, highlighting the disease's severity [7]. The hospitalization rate for CAP has risen significantly, from 2.8 to 4.3 per 1,000 individuals, disproportionately affecting vulnerable groups such as children under five and adults over 75 years [8]. However, adults with specific comorbidities also face elevated risks. Comorbid conditions such as diabetes, malignancy, cardiovascular disease (CVD), and cerebrovascular events (CVE) are strongly associated with increased susceptibility to CAP, severe disease progression, and recurrent hospital admissions [9]. A study identified heart failure (18.6%), coronary artery disease (18.6%), diabetes mellitus (30.5%), and central nervous system illnesses (28.8%) as prevalent comorbidities [5]. Similarly, in Korea, cerebrovascular disease (22.2%), diabetes mellitus (31.6%), and hypertension (50.5%) were predominant among CAP patients [10]. These findings emphasize the critical interplay between comorbidities and CAP outcomes.

Severe CAP is linked to high mortality rates, prolonged hospital stays, and frequent emergency department readmissions, imposing considerable strain on healthcare systems [11]. In the United States, approximately 30% of hospitalized CAP patients die within a year, and 5–15% do not survive beyond 30 days despite adequate care [7]. The situation is similar in Indonesia, where a study conducted in Jakarta reported a 23.9% in-hospital mortality rate for CAP patients [12]. Early stratification of CAP severity is vital for effective management, particularly in resource-limited settings. The confusion, urea, respiratory rate, blood pressure, and age >65 years (CURB-65) score has proven to be a practical tool for assessing CAP severity and predicting prognosis in such environments [13].

Riau Province, located in Indonesia's island region, faces a growing prevalence of diabetes, malignancies, and infectious diseases, including pneumonia. Data from Indonesia's Basic Health Research revealed a 25% increase in pneumonia prevalence between 2013 and 2018 [14]. While pediatric pneumonia incidence in Riau was estimated at 1.5%, adult CAP remains understudied [15]. A prior study indicated a high prevalence of multidrug-resistant pathogens in hospitalized pneumonia cases among adults in Riau, with *Streptococcus pneumoniae* remaining the primary causative agent [16]. Therefore, the aim of this study was to determine the mortality and associated factors among hospitalized adult CAP patients.

Methods

Study design and setting

A cross-sectional study was conducted to assess the factors associated with mortality among hospitalized CAP patients. The study was performed at Arifin Achmad Hospital, a leading referral hospital in Riau Province, Indonesia, with 673 beds, serving a population of 6.3 million people in central Sumatra. All CAP patients admitted to the hospital between January 1 and December 31, 2023 were included.

This study enrolled all adults aged over 18 years who were diagnosed with CAP, either as a primary or secondary diagnosis. CAP was defined according to the modified Infectious Diseases Society of America (IDSA) criteria [17]. All patients with International Classification of Diseases (ICD-10) codes related to pneumonia (J18.0, J18.9, J18.8, U69.01, J95.851) were included. All data presented in this study were obtained through medical record extraction, including emergency room assessments, daily progress notes, laboratory and radiology findings, and discharge summaries. Patient demographics, admission and discharge dates, discharge status (recovered or deceased), and all recorded diagnoses (primary and secondary) were collected.

During the study period, 527 patients' medical records were reviewed based on the inclusion and exclusion criteria. A total of 334 out of 527 CAP patients were included in the final analysis.

Patients and criteria

All patients who had no history of hospitalization for more than 14 days or were hospitalized less than 72 hours before the onset of symptoms were eligible for the study. The inclusion criteria required patients to have at least one symptom or sign: (1) a new or worsening cough with or without sputum production; (2) fever (>37.8°C) or hypothermia (<35.6°C); or (3) altered breath sounds and/or localized rales. In addition, the diagnosis had to be supported by at least one of the following laboratory or radiological findings: (1) abnormal white blood cell count (leukopenia or leukocytosis); (2) elevated C-reactive protein (CRP) above the local upper limit; or (3) pulmonary opacity or infiltrates on chest X-ray. Patients were excluded if they met any of the following criteria: (1) confirmed hospital-acquired pneumonia; (2) concurrent tuberculosis; (3) discharge within 24 hours of admission; (4) death within 24 hours of admission; or (5) consecutive hospitalization or readmission for CAP during the study period.

Data collection and study variables

Basic data, including sex, age, and length of hospital stay, were automatically extracted from the electronic medical record system, while the remaining variables were manually retrieved from the electronic patient records by the research team. To minimize bias, the extracted data were reviewed by two researchers and validated by clinical experts in the field. The variables available at the time of admission included demographic characteristics, vital signs (mental status/confusion, systolic blood pressure, pulse rate, respiratory rate, and temperature), laboratory parameters, and radiological findings. Chest X-rays were performed on the first day of admission or in the emergency room to support the diagnosis of CAP.

Associated symptoms, including those related to lower respiratory tract illness and systemic disorders such as fatigue, myalgia, abdominal pain, anorexia, and headache, were also documented in addition to the primary complaint. All clinical findings were obtained from the initial assessment reports and daily progress notes. The progression of all conditions, including shock events, the need for ventilatory support, vasopressor administration, and systemic steroid use, was documented daily in progress notes.

Comorbidities that are plausibly associated with mortality were collected, including malignancy, diabetes mellitus, cardiovascular disease, myocardial infarction, renal dysfunction, and structural lung disease. Since each patient could have multiple comorbidities, all recorded conditions were included. Due to severe CAP or worsening illness requiring advanced treatments, additional risk factors were documented, including the use of vasopressors, corticosteroid administration, and ventilatory support during hospitalization. Malignancy data were extracted from all available sources, including initial assessments, previous medical history, laboratory examinations, progress notes, and discharge summaries. Diabetes mellitus was confirmed based on clinical findings and either a random blood glucose level >200 mg/dL, HbA1c ≥6.5%, or routine use of antidiabetic medication or insulin. Hypertension was defined by a systolic blood pressure ≥140 mmHg, a diastolic blood pressure ≥90 mmHg, a documented history of hypertension, or the routine use of antihypertensive medication. Heart failure was diagnosed based on a history of cardiovascular disease and additional specific assessments. Chronic obstructive pulmonary disease (COPD) was confirmed based on medical history and physical examination findings, while asthma was identified through clinical history or findings.

Laboratory examinations conducted at admission, as part of standard care, included hematocrit levels (%), leukocyte count (cells/μL), serum sodium (mmol/L), random blood glucose (mg/dL), blood urea nitrogen (mg/dL), and creatinine levels (mg/dL), all of which were verified by clinical pathologists at the hospital. Radiological examination of chest X-rays focused on identifying infiltrates or opacity, increased vascularization, and pleural effusion.

The risk predictive score for severe CAP was assessed using the CURB-65 score. This scoring system incorporates the following components: (1) confusion (score 1); (2) blood urea nitrogen (BUN) >20 mg/dL (score 1); (3) respiratory rate >30 breaths per minute (score 1); (4) blood pressure <90/60 mmHg (score 1); and (5) age >65 years (score 1) [13]. Patients were classified as having severe CAP if their CURB-65 score was ≥3, moderate CAP if their score was 2, and mild

CAP if their score was ≤1 [13]. Due to the unavailability of direct urea measurements at the hospital, BUN values were derived from blood urea levels using the formula: BUN (mg/dL)=Urea (mg/dL)/2.1428 [13]. BUN level greater than 20 mg/dL was considered as renal impairment.

Blood and sputum specimens were cultured on blood agar (Oxoid, Basingstoke, UK), chocolate agar (Oxoid, Basingstoke, UK), and MacConkey agar media (Oxoid, Basingstoke, UK). Microorganism identification was performed using the VITEK® 2 compact system (bioMérieux, Marcy l'Etoile, France).

Study outcome

The outcome of the study was the mortality of CAP patients. The mortality was defined as death occurring after 24 hours of admission from any cause.

Statistic analysis

The Chi-squared or Fisher's exact test was used to examine the associations between categorical risk factors and mortality. Variables demonstrating *p*-values less than 0.25 from Chi-squared or Fisher's exact tests were included in a multivariate logistic regression model for further analysis to assess the independent effects of multiple predictors. The threshold for statistical significance was set at $p<0.05$. All analyses were performed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA).

Results

Characteristics of the patients

A total of 527 patients diagnosed with ICD-10-code-related pneumonia (J18.0, J18.9, J18.8, U69.01, J95.851) were identified from the main data register, with 334 patients meeting the inclusion criteria for the study. Of the excluded 193 patients, 86 lacked confirmatory data for CAP. These patients were diagnosed with pneumonia based on previous discharge summary; however, supporting data to establish a diagnosis of CAP according to the inclusion criteria were not available. Specifically, 25 patients had limitations in clinical and laboratory data, chest X-rays of 22 patients did not meet the pneumonia criteria, and 37 patients had a history of surgery or pure malignancy. Additionally, nine patients had lung tuberculosis, 79 were diagnosed with hospital-acquired pneumonia, and 19 either died or were discharged within 24 hours of admission. The inclusion flowchart is illustrated in **Figure 1**.

The characteristics of the participants are summarized in **Table 1**. The median age was 58 years, and 54.9% were male. Vital sign analysis revealed that the median systolic blood pressure was 127 mmHg, and the median respiratory rate was 24 times/min. The median leucocyte count was 13,570 µL, the median random blood sugar level was 119 mg/dL, and the median urea serum level was 47 mg/dL, in concordance with the median BUN of 21.93 mg/dL. Renal dysfunction affected 27.1% of patients. A total of 11.1% of patients were categorized as having severe CAP based on the CURB-65 score. The three most common co-incidence conditions or comorbidities were diabetes (28.4%), CVD (30.2%), and malignancy (33.2%).

Table 1. Characteristics of patients with community-acquired pneumonia included in the study (n=334)

Characteristics	Frequency (percentage)
Sex	
Female	151 (45.1)
Male	184 (54.9)
Age (years), median (IQR)	58 (18–100)
Coexisting illness/comorbid	
Diabetes mellitus (DM)	95 (28.4)
Hypertension	90 (26.9)
Renal dysfunction	91 (27.3)
Chronic obstructive pulmonary disease (COPD)	15 (4.5)
Malignancy	111 (33.1)
Autoimmune disease	5 (1.5)
Asthma	3 (0.9)
Cardiovascular disease (CVD)	101 (30.1)

Characteristics	Frequency (percentage)
Cerebrovascular event (CVE)	42 (12.5)
Clinical findings, median (IQR)	
Respiratory rate (time/min)	24 (14–45)
Systolic blood pressure (SBP) (mmHg)	127 (70–225)
Laboratory result, median (IQR)	
Leucocyte (/µL)	13,570 (380–299.480)
Neutrophil (%)	82.25 (0.6–98.5)
Random blood sugar (mg/dL)	119 (17–859)
Urea (mg/dL)	47 (6–432)
Creatinine (mg/dL)	1.01 (0.19–28)
Blood urea nitrogen (BUN) (mg/dl)	21.93 (2.80–201.61)
Medical treatment	
Vasopressor use	92 (27.8)
Treated with mechanical Ventilator	46 (14)
Steroid use	118 (35.5)
Severity	
CURB-65 score 0	18 (15)
CURB-65 score 1	40 (33,3)
CURB-65 score 2	34 (28,3)
CURB-65 score 3	23 (19,2)
CURB-65 score 4	5 (4,2)
Outcomes	
Mortality	120 (35.9)
Days of hospitalization (days), median (IQR)	9 (2–45)

CURB-65: Confusion, Urea, Respiratory Rate, Blood Pressure, and Age >65 years score

Nearly 28% of patients need vasopressors during hospitalization, and 35.5% were treated with systemic steroids due to shock or other clinical reasons. Although 11% of patients were classified as having severe CAP according to the CURB-65 score at admission, 14% required ventilation support in the intensive care unit (ICU) for various reasons during their hospital stay. Based on the basic data, the median duration of hospitalization/length of stay was nine days. Regarding discharge status, the overall mortality was calculated to be 35.9%.

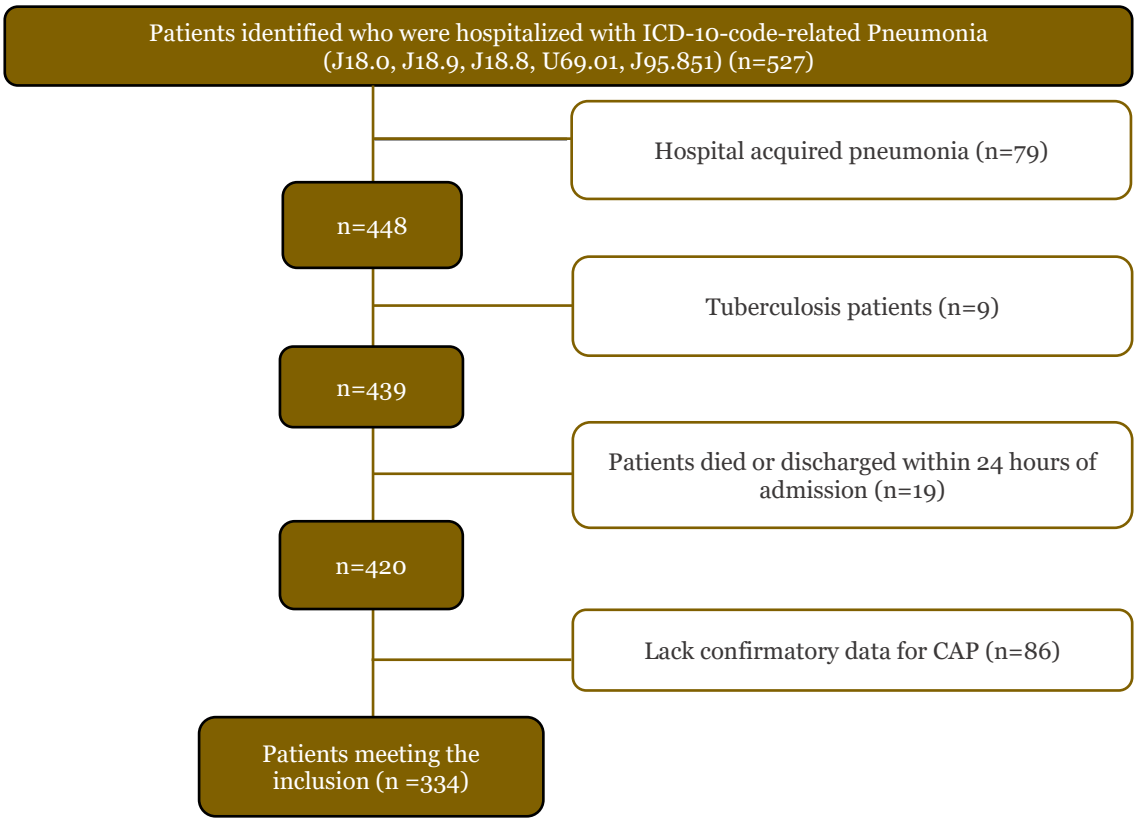

Figure 1. Patient selection flowchart for hospitalized community-acquired pneumonia cases.

Pathogens isolated from blood and sputum cultures

Of the 334 patients included in the study, 208 (63.3%) had microbiological culture testing. Among these, sputum cultures were obtained from 158 patients (75.9%), blood cultures from 86 patients (41.3%), and both sputum and blood cultures from 51 patients (24.5%). Pathogens isolated from blood and sputum cultures are presented in **Figure 2** and **Figure 3**, respectively.

Positive culture results were observed in 85 of 158 sputum samples (53.8%) and 17 of 86 blood samples (19.8%). Coagulase-negative *Staphylococcus* was the most frequently isolated pathogen from positive blood cultures, accounting for 39% of the isolates. Other common pathogens identified in blood cultures included *Escherichia coli* (7%) and *Staphylococcus aureus* (12%) (**Figure 2**). In sputum cultures, Gram-negative bacteria predominated, accounting for 50.6% (80 of 158) of all positive isolates. *Klebsiella pneumoniae* emerged as the most frequent Gram-negative pathogen, detected in 39% of the sputum culture-positive patients (**Figure 3**).

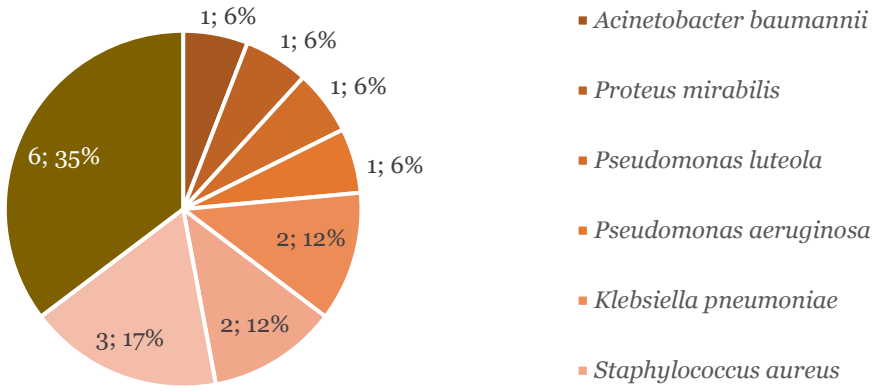

Figure 2. Percentage of pathogens isolated from blood cultures from hospitalized patients with community-acquired pneumonia included in the study (n=17).

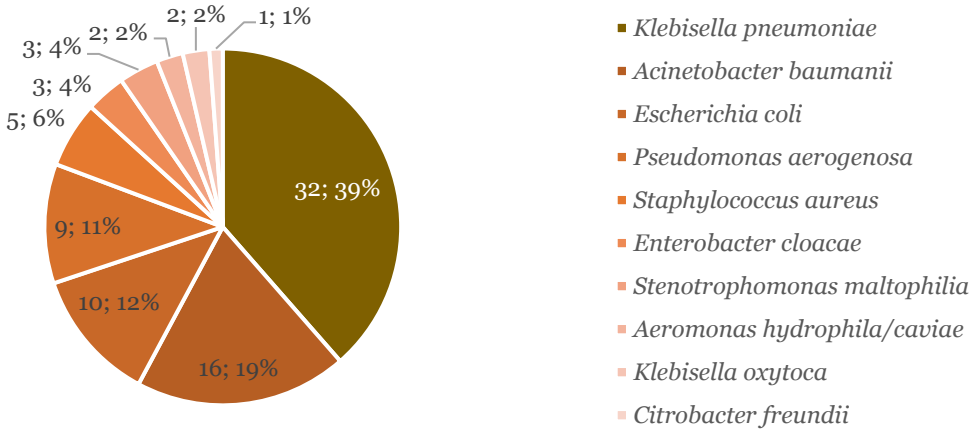

Figure 3. Pathogens isolated from sputum cultures from hospitalized patients with community-acquired pneumonia included in the study (n=85).

Mortality rate and factors related

During treatment, the mortality rate among patients was 35.9% (120/334). The results of multivariate analysis assessing factors associated with CAP mortality are presented in **Table 2**. Notably, the first step analysis showed that comorbid conditions such as diabetes (p=0.047), COPD (p=0.047), and CVE (p=0.007) were associated with mortality. Furthermore, physical examination and laboratory parameters also demonstrated significant association with mortality. These included low median systolic blood pressure (p=0.095), elevated serum creatinine levels (p≤0.001), and increased BUN concentration (p≤0.001) (**Table 2**).

Table 2. Factors associated with mortality among patients with community-acquired pneumonia

Variables	Mortality, n (%)		Univariate analysis	Multivariate logistic regression analysis	
	Yes (n=120)	No (n=214)	*p*-value	*p*-value	OR (95%CI)
Demographic characteristic					
Sex					
Male	68 (56.7)	115 (53.7)	0.606[a]		
Female	52 (43.3)	99 (46.3)			
Age[#]	58 (18–89)	58 (18–100)	0.965[b]		
Co-existing illness/comorbidity					
Diabetes mellitus (DM)	42 (35)	53 (24.8)	0.047[a*]		
Hypertension	30 (25)	60 (28)	0.548[a]		
Renal dysfunction	36 (30)	55 (25.7)	0.397[a]		
Chronic obstructive pulmonary disease (COPD)	9 (7.5)	6 (2.8)	0.047[a*]		
Malignancy	43 (35.8)	68 (31.8)	0.450[a]		
Autoimmune Disease	3 (2.5)	2 (0.9)	0.355[a]		
Asthma	0 (0)	3 (1.4)	0.556[a]		
Cardiovascular disease (CVD)	29 (24.2)	72 (33.6)	0.070[a]	0.019	0.363 (0.156–0.844)
Cerebrovascular event (CVE)	23 (19.2)	19 (8.9)	0.007[a*]		
CURB-65 score					
0	18 (15)	52 (24.3)	<0.001[a*]	0.023	1.589 (1.067–2.366)
1	40 (33.3)	94 (43.9)			
2	34 (28.3)	56 (26.2)			
3	23 (19.2)	12 (5.6)			
4	5 (4.2)	0 (0)			
Medical intervention					
Vasopressor use	72 (61)	20 (9.3)	<0.001[a*]	<0.001	11.112 (5.291–23.337)
Treated with Ventilator	42 (35.9)	4 (1.9)	<0.001[a*]	<0.001	21.795 (6.478–73.335)
Steroid use	56 (54.4)	62 (32.6)	<0.001[a*]	0.029	2.173 (1.084–4.357)
Clinical finding					
Respiratory rate[#]	24 (14–45)	24 (18-42)	0.142[b]		
Systolic blood pressure (SBP) (Mean±SD)	127.07±29.47	132.64±28.98)	0.095[c]		
Laboratory result					
Leucocyte[#]	13540 (380–115500)	13580 (1120–299480)	0.667[b]		
Random blood sugar[#]	117 (17–859)	120 (20–586)	0.196[b]		
Ureum[#]	58 (6–422)	120 (20–586)	<0.001[b*]	0.031	1.005 (1.000–1.009)
Creatinine[#]	1.07 (0.24–25.85)	0.09 (0.19–28)	0.216[b]		
Blood urea nitrogen (BUN)[#]	27.07 (2.80–196.94)	20.07 (4.20–201.61)	<0.001[b*]		
Microbiology result					
E. Coli	5 (4.17)	4 (1.87)	0.013		
Outcome					
Days of hospitalization	8.5 (2–45)	9 (2–36)	0.489[b]		

[a]Analyzed using Chi-square test
[b]Analyzed using Mann-Whitney test
[c]Analyzed using Student t-test
*Statistically significant at p=0.05
#presented in median

Critical care interventions such as vasopressor use ($p \leq 0.001$), mechanical ventilator use ($p \leq 0.001$), and steroid use ($p \leq 0.001$) were associated with mortality. However, the treatment did not cause high mortality; rather, patients requiring these treatments were in severe condition. The need for critical illness treatments was driven by severe CAP and the worsening of other comorbidities.

Multivariate stepwise regression analysis confirmed the persistence of significant associations for specific variables. CVD or history of CVD reflected protector effect toward mortality rate (odds ratio (OR): 0.363; 95% confidence interval (95%CI): 0.156–0.844; $p \leq 0.019$). Independent predictors of mortality included serum urea level by 1,005 times (95%CI: 1.00–1.009) in line with CURB-65 score by 1.589 (95%CI: 1.067–2.366; $p \leq 0.023$), vasopressor medication by 11.1 times (95%CI: 5.2–23.3; $p < 0.001$), mechanical ventilation by 21 times (95%CI: 6.4–73.3; $p < 0.001$) and steroid medication by 2 times (95%CI: 1.0–4.3; $p = 0.029$) emerged as independent predictors of mortality (**Table 2**). Additionally, 12,6% of patients had high urea levels and the requirement for vasopressor, 12.0% had high urea levels and steroid medication. The co-incidence of high urea levels with vasopressors and steroid therapy was 17.1%.

Discussion

This study demonstrated that several factors were significantly related to mortality, including renal dysfunction, the CURB-65 score, as well as the use of vasopressors use, mechanical ventilator use, and steroid use. These factors highlight the multifaceted nature of mortality risk in hospitalized CAP patients and underscore the importance of closely monitoring these variables in clinical practice. Conversely, patients with CVD or history of CVD showed a protective effect against mortality.

Among the 184 male patients (59%) in our study, the prevalence aligns with similar studies, including one conducted at Dr. Soetomo Hospital in Surabaya, Indonesia (61.3%) [18], and another at a general hospital in Singapore (55.5%) [19]. Additionally, a study conducted in Turkey identified male sex as a risk factor for long-term mortality in CAP patients [20]. This increased risk in males may be linked to lifestyle factors, such as tobacco exposure, which has been shown to heighten vulnerability to pneumonia. In contrast, a study from Cipto Mangunkusumo National General Hospital in Jakarta, Indonesia, reported a predominance of female patients among CAP cases, accounting for 58% of the study population [12].

Traditionally, children and the elderly have been identified as high-risk groups for pneumonia and its associated mortality. However, emerging evidence suggests that adults with comorbidities, such as diabetes, cancer, CVD, and CVE, face similar risks. Pneumonia remains a leading cause of death in Indonesia, ranking as the eighth leading cause, while in Portugal, it is the foremost cause of respiratory death, excluding lung cancer [9]. Mortality rates in this study were consistent with those observed in other research, where mortality among hospitalized CAP patients generally ranges from 6% to 20%, contingent upon treatment settings and disease severity [21]. A study on geriatric CAP patients at M. Djamil Padang Hospital in West Sumatera, Indonesia, reported an alarmingly high mortality rate of 42.74% [13] . At Dr. Kariadi Hospital in Semarang, Indonesia, patients aged 60 and older constituted 32% of the CAP cohort, with one in nine requiring ICU admission due to septic shock, severe sepsis, or respiratory failure [22].

The severity of CAP in this study was assessed using the CURB-65 score, with scores ranging from 1 to 5 based on clinical parameters. The results revealed that the highest mortality rate was observed in patients with a score of 2 (28.3%), while the highest survival rate occurred in those with a score of 1 (43.9%). For scores 3 and 4, mortality was notably severe, with a mortality rate of 11.1%. This aligns with a study at Kurashiki Central Hospital (2007–2016) in Japan, where a CURB-65 score of 2 was associated with a 32% mortality rate, the highest among their cohort [23]. In India, a study categorized CURB-65 scores into four groups, with the highest mortality rate (41.66%) observed in score 3 patients [24]. Additionally, a previous study found that a high CURB-65 score significantly influenced long-term mortality in CAP patients [20].

Over 25% of the study population had glucose metabolism disorders, including diabetes. Although univariate analysis did not show a significant correlation with mortality, the increasing prevalence of diabetes in Indonesia is concerning. A previous study indicated that patients with diabetes experience worse outcomes in CAP compared to non-diabetic patients, primarily due to

poor glycemic control [25]. A study in West China reported a relative risk of 1.70 (95%CI: 1.63–1.77) for severe CAP in diabetes patients, with an OR of 1.54 (95%CI: 1.14–2.09) [26]. The immunocompromised state in DM patients, characterized by impaired neutrophil function, altered T-cell responses, and cytokine production, likely contributes to the poorer prognosis in these individuals [27] .

In terms of pathogens, *Klebsiella pneumoniae* was identified as the predominant causative agent of CAP in this study, consistent with a survey conducted in Thailand in 2022 [28]. However, other reports from Asia suggest that *Streptococcus pneumoniae* is the leading bacterial cause of CAP in adults [29]. The difficulty in detecting *S. pneumoniae* in this study may be attributed to the lack of a CO_2 incubator at Arifin Achmad Hospital, which is essential for the optimal growth of this fastidious bacterium [30]. The emergence of multi-drug resistant organisms as a cause of pneumonia warrants further investigation, particularly in referral hospitals in Riau Province, to guide targeted treatment strategies.

Univariate analysis of mortality-related factors revealed a significant association between malignancy and death among hospitalized CAP patients at Riau Provincial Hospital (p=0.047). Cancer has been identified as a leading cause of long-term mortality in CAP patients, with a study indicating a higher pneumonia mortality rate among cancer patients (Hazard ratio (HR): 1.41; 95%CI: 1.08–1.84) [31]. Notably, those within one year of a cancer diagnosis demonstrated an even greater mortality risk (HR: 23.0; 95%CI: 2.98–177.3) [31]. This underscores the compounded risk faced by CAP patients with malignancies, who are particularly vulnerable to severe outcomes.

Cardiovascular disease (CVD) emerged as another inversed significant co-morbidity associated with mortality in hospitalized CAP patients (p=0.019). In contrast with this finding, previous studies highlighted that CVD is prevalent in 10% to 30% of CAP patients and increased both in-hospital and long-term mortality [32],[33]. Cardiovascular events, including plaque-related and plaque-unrelated issues, raise the risk of mortality, occurring not only during hospitalization but also within a year post-discharge. In fact, heart-related complications contributed to 30% of deaths in CAP patients during long-term follow-up, making CVD a key contributor to mortality [31],[34]. The patients with CVD comorbidity here were suggested to had a previous treatment before admission.

The present study also identified *Escherichia coli* pneumonia as a significant predictor of mortality. Previous studies have shown that *E. coli* pneumonia is associated with bacteremia and an increased likelihood of ICU admission [35,36]. The pathogen's potential for antibiotic resistance further exacerbates its risk, contributing to high mortality rates [37]. However, our study did not include antibiotic susceptibility testing, which limits our ability to directly assess the role of resistance in the outcomes. Contrary to our findings, other studies have reported *Klebsiella pneumoniae* as the leading cause of death in CAP patients, suggesting variability in pathogen-related mortality risk across different settings [38].

Hemodynamic instability, often exacerbated by underlying co-morbidities and pneumonia complications, was another factor contributing to poor outcomes. Early intervention failures, including suboptimal use of antibiotics, inadequate hydration, and the absence of ICU facilities, often lead to worsened prognoses. Our multivariate analysis confirmed that the use of vasopressors was strongly associated with increased mortality in hospitalized CAP patients (p<0.001). Previous studies have reported that patients requiring mechanical ventilation and/or inotropic support exhibit a significantly higher 30-day mortality rate, further emphasizing the critical nature of timely and aggressive management in severe cases [39,40].

Finally, steroid use was found to be associated with higher mortality in hospitalized adult CAP patients (p=0.029). This finding contradicts earlier studies, which suggested that corticosteroid therapy does not significantly impact mortality rates or increase adverse outcomes [41]. However, corticosteroids may still play a role in preventing respiratory failure progression in CAP patients, and this potential benefit should be carefully considered in clinical decision-making [26,42].

A limitation of this study was the absence of detailed data regarding the specific causes of death and follow-up information to identify 30-day mortality outcomes. While the study focused on 30-day mortality related to hospitalized CAP in Riau Province, the lack of follow-up data and

cause-specific mortality details limits the depth of the findings. Future studies should incorporate these elements to provide a more comprehensive understanding of mortality causes and risk factors in this patient population.

Conclusion

The study identified key factors associated with mortality in adult patients hospitalized with CAP at a referral hospital in Riau. Specifically, renal dysfunction, the CURB-65 score, CVD, and the use of vasopressors, ventilators, and steroids were found to be critical predictors of mortality. These findings underscore the importance of early risk assessment and intervention in CAP patients. Timely recognition of these factors may improve patient outcomes by enabling more targeted management strategies and reducing the likelihood of adverse clinical events. Further research is warranted to explore these relationships in broader populations and refine clinical protocols for managing high-risk CAP patients.

Ethics approval

This study was approved by the Institutional Review Board/ Ethics Committee review/Etic Commite FK UNRI, with the approval number B/080/UN 19.5.1.1.8/UEPKK/2023_Adendum. Informed consent was not required.

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Competing interests

All the authors declare that we do not have any conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the data based on medical chart patients at Arifin Achmad Hospital Riau Province.

Declaration of artificial intelligence use

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or system

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