



# Effectiveness of fluoroquinolone de-escalation in community-acquired pneumonia: impact on hospital stay and mortality

Aseel Abu Awad<sup>1</sup>, Khawla Abu Hammour<sup>2</sup>, Alaa Abuawad<sup>1</sup>, Mohammed Zawiah<sup>3\*</sup>, Rana K. Abu-Farha<sup>1</sup>

<sup>1</sup>Faculty of Pharmacy, Applied Science Private University, Amman 11937, Jordan

<sup>2</sup>Faculty of Pharmacy, The University of Jordan, Amman 11942, Jordan

<sup>3</sup>Department of Pharmacy Practice, College of Clinical Pharmacy, Hodeidah University, Al Hodeidah 3114, Yemen

**\*Correspondence:** Mohammed Zawiah, Department of Pharmacy Practice, College of Clinical Pharmacy, Hodeidah University, Al Hodeidah 3114, Yemen. [mhzawiah@gmail.com](mailto:mhzawiah@gmail.com)

**Academic Editor:** Hongzhou Lu, Shenzhen Third People's Hospital, National Clinical Research Center for Infectious Diseases, China

**Received:** September 26, 2025 **Accepted:** December 8, 2025 **Published:** December 22, 2025

**Cite this article:** Abu Awad A, Abu Hammour K, Abuawad A, Zawiah M, Abu-Farha RK. Effectiveness of fluoroquinolone de-escalation in community-acquired pneumonia: impact on hospital stay and mortality. *Explor Med.* 2025;6:1001379. <https://doi.org/10.37349/emed.2025.1001379>

## Abstract

**Aim:** Community-acquired pneumonia (CAP) is a leading cause of global morbidity and mortality, and it is often treated with fluoroquinolone antibiotics. Misuse of fluoroquinolones is a known driver of antimicrobial resistance, and de-escalation of antibiotics is not only effective for patient outcomes but also reduces resistance. The aim of this study was to assess the association of fluoroquinolone de-escalation with length of stay (LOS), mortality, and other microbiological culture results in hospitalized adults with CAP.

**Methods:** A retrospective cohort investigation took place with adult patients suspected of CAP in a tertiary care center in Jordan. The study examined outcomes for fluoroquinolone de-escalation that included hospital LOS, mortality, and examined the relationship between the results of microbial cultures and the outcome of de-escalation.

**Results:** The study sample consisted of 125 patients with a median age of 73 years [interquartile range (IQR) = 24]. Around 65% ( $n = 81$ ) of the patients were male, and 35% ( $n = 44$ ) were female. The fluoroquinolone therapy was mostly levofloxacin (99.2%,  $n = 124$ ). Fluoroquinolone de-escalation was medically justified in 32.8% ( $n = 41$ ) of patients. When comparing the rate of successful de-escalation between those with positive and negative cultures (after the exclusion of 3 patients), positive cultures were statistically more likely to de-escalate than negative cultures, 61.5% (16/26) to 26.0% (25/96) ( $p = 0.002$ ). Patients in the successful de-escalation had a statistically shorter length of hospital stay; 12 days (IQR = 8) against the failed/inappropriate group, 18 days (IQR = 11) ( $p = 0.004$ ). There was no significant difference in mortality; 70.1% ( $n = 29$ ) survived in the de-escalated group and 76.5% ( $n = 62$ ) in the failed/inappropriate group ( $p = 0.514$ ).



**Conclusions:** In CAP, fluoroquinolone de-escalation may result in shorter hospital stays but does not alter mortality rates. However, limitations in establishing appropriateness for de-escalation imply the need for further studies to validate the findings.

## Keywords

community-acquired pneumonia, fluoroquinolone de-escalation, antimicrobial resistance, hospital length of stay, mortality

---

## Introduction

Community-acquired pneumonia (CAP), a common and serious lung infection, is one of the leading causes of morbidity and mortality worldwide. In the United States alone, CAP results in approximately 1.5 million hospitalizations annually [1], while globally, it accounts for approximately three million deaths each year [2]. CAP is caused by a variety of infectious agents, including bacteria, viruses, and fungi, with bacterial infections being the most prevalent [3].

The rise of microbial resistance is a significant worldwide health issue, leading to more difficult infection treatment, greater morbidity and mortality, and increased healthcare costs. Since the advent of antibiotics, misuse and overuse of antibiotics in healthcare and agriculture have been a significant contributor to the crisis [4–7]. Furthermore, bacterial resistance continues to develop through mutation and horizontal gene transfer [7]. The COVID-19 pandemic has resulted in increased prevalence of antimicrobial resistance. A survey revealed that 40.6% of the individuals who had an antibiotic prescription stopped taking it without consulting a provider, a practice that contributed to an increase in resistance [8].

Due to the increased concern for antimicrobial resistance, antibiotic stewardship initiatives such as antibiotic de-escalation have emerged to be an essential part of clinical decision-making [9]. De-escalation of antibiotic therapy typically consists of adopting empirical broad-spectrum antibiotics and waiting for the results of pathogen susceptibility testing before employing a targeted therapy [10, 11]. The philosophy behind this approach is to reduce unnecessary antibiotic exposure while still providing effective clinical treatment, thus improving patient care and outcomes [9–11]. The evaluation of antibiotic de-escalation strategies has primarily focused on hospital length of stay (LOS) and mortality rates [12].

Fluoroquinolones, such as ciprofloxacin, levofloxacin, and moxifloxacin, are broad-spectrum antibiotics used to treat pneumonia due to their potent activity against a range of bacterial pathogens [13–15]. Although current Infectious Diseases Society of America (IDSA) guidelines recommend beta-lactams as the first empiric therapy for most patients with CAP, fluoroquinolones continue to be used in many practices [13–15]. In consideration of the fluoroquinolone's broad-spectrum antibiotics and the emerging concern of resistance, especially among pathogens like *Escherichia coli* and *Pseudomonas aeruginosa*, it is important to examine its management [16]. Because of the growing resistance, it is timely to examine effective antibiotic management strategies, like de-escalation, to minimize the risk of further resistance.

Although antibiotic de-escalation has documented benefits for reducing antimicrobial resistance and improving patient outcomes in select situations, there is limited evidence regarding the use of antibiotic de-escalation in fluoroquinolone therapy for pneumonia patients. For this reason, this study aims to evaluate the rate and outcomes of antibiotic de-escalation in additional CAP patients treated with fluoroquinolones and de-escalated to a narrower spectrum with 48 h of culture and sensitivity results. In particular, we are examining the clinical outcomes of patients who experienced adherence to de-escalation successfully and then consider the outcomes of patients in whom de-escalation was not appropriate, examining hospital LOS and all-cause mortality.

## Materials and methods

### Study design

This was a retrospective cohort observational study conducted at Jordan University Hospital (JUH) to assess the rate and outcomes of fluoroquinolone de-escalation in patients who were diagnosed with CAP from December 2022 to March 2024. The population of interest was adults aged  $\geq 18$  years with a suspected diagnosis of CAP (CAP is defined as an acute infection of the pulmonary parenchyma acquired in the community or within 48 h of admission). We only included those patients who had a positive CAP diagnosis using the ICD-10 diagnostic codes. Other inclusion criteria were: the patients had blood and sputum cultures ordered, received a fluoroquinolone regimen of therapy as the empiric treatment regimen, and were admitted to the hospital until cultures and sensitivity were performed. We excluded patients who were pregnant, were not certain of their diagnosis, and/or had incomplete data. Severity of illness was not assessed in the study.

### Sample size calculation

The Raosoft sample size calculator was used to calculate the sample size for this study with a 10% margin of error, a 95% confidence level, and an expected proportion of successful de-escalation of 50%. Based on these parameters, the minimum sample size required was calculated to be 96 patients.

### Ethical considerations

The study was conducted in accordance with the principles outlined in the World Medical Association Declaration of Helsinki. It received approval from the JUH Institutional Review Board (approval number 10/2024/1389). To ensure patient confidentiality, all data were de-identified and anonymized. Given the retrospective, observational design, the ethical committee granted a waiver for informed consent.

### Data collection

Data collection comprised the gathering of extensive information from the medical records of eligible patients using a planned data collection form. Collected data included demographic data such as age, gender, admission date, discharge date, and LOS. We gathered clinical data, including diagnoses, empiric antibiotic therapy (including name, route of administration, and duration of therapy), and information related to targeted antibiotics after culture results. We also collected laboratory data that included blood and sputum cultures and their sensitivity results to study the susceptibility patterns of the microbiological pathogens that caused CAP.

### Primary outcome

The main aim of this research is to assess the rate of antibiotic de-escalation in patients with CAP who were treated with fluoroquinolones. The term de-escalation means moving from broad-spectrum antibiotics (fluoroquinolones) to a narrower spectrum of antibiotics based on final culture and sensitivity results. The narrower-spectrum antibiotics to consider would be cephalosporins, penicillins, trimethoprim/sulfamethoxazole, vancomycin, or linezolid. This approach is used to decrease antibiotic use, and de-escalation might also include discontinuation of antibiotics if cultures do not demonstrate any infection, ideally within 48 h of culture results. Patients were grouped together for analysis into two primary groups based on whether or not they required de-escalation. Patients were down-graded based on final culture and sensitivity results. Patients with positive cultures for atypical bacteria or MRSA were not considered possible candidates for fluoroquinolone de-escalation because fluoroquinolones could likely be indicated as part of the treatment of patients with atypical bacteria or MRSA. Patients categorized as requiring de-escalation were further divided into successful de-escalation, failed de-escalation, and inappropriate de-escalation.

Failed de-escalation pertains to interventions where empiric antibiotics were continued after culture results yielded no definitive evidence to continue antibiotic therapy and/or when broad-spectrum antibiotics were continued after the patient was cultured and a narrower-spectrum antibiotic was more

appropriate. Inappropriate de-escalation corresponds to errors or missed opportunities that deteriorate patient care. For example, in the case of negative culture results related to inappropriate de-escalation, transition to narrower-spectrum antibiotics could occur when the very best approach would have been to discontinue antibiotic therapy altogether. In contrast, if positive culture results were obtained, a scenario of inappropriate de-escalation could be where antibiotics are discontinued instead of switched to more directed therapy when more directed therapy would have been of greater benefit for patient care.

Assessment of the adequacy or appropriateness of antibiotics was based on culture and sensitivity, as well as the IDSA guidelines. It should be noted that the decision regarding adequacy or appropriateness of antibiotic therapy did not incorporate patient-specific clinical variables such as the severity of illness or other comorbidities.

### Secondary outcomes

The secondary outcomes of the study included assessing various factors among patients who underwent successful de-escalation compared with those who did not successfully de-escalate treatment or performed de-escalation incorrectly after excluding inappropriate de-escalation of antibiotics (e.g., antibiotics were stopped instead of de-escalating towards a narrower spectrum medication following a positive culture). Secondary outcomes assessed included the LOS and in-hospital mortality, which was defined as any death occurring while the patient was still admitted and did not have to be related to the reason for admission. The study also assessed the success rates of fluoroquinolone de-escalation among patients with a positive culture versus a negative culture.

### Statistical analysis

Analysis of the data was conducted using version 26 of the IBM SPSS software. Descriptive statistics presented frequencies and percentages for categorical variables and medians and interquartile range (IQR) for continuous variables. Normality of the data was tested using the Shapiro-Wilk test. Fisher's exact test was used to compare all-cause in-hospital mortality between patients who were successfully de-escalated and those who failed or were inappropriately de-escalated. The Mann-Whitney *U* test was used to describe the LOS. To assess the association between the microbial culture results and de-escalation practice, the Chi-square test was used. All statistical tests were two-tailed, and significance was determined by  $p < 0.05$ .

## Results

### Demographic and medical characteristics of the study sample

A total of 125 patients met eligibility criteria after screening for inclusion criteria during the study. The median age of participants was 73 years old (IQR = 24). The number of female patients was 44 (35.2%) and 81 male patients (64.8%). The median LOS for all patients was 13 days (IQR = 11). In addition, 93 patients (74.4%) survived the hospital stay, while 32 patients (25.6%) died while in the hospital. Among the patients, 20 (16%) were transferred to the ICU, 100 (80%) stayed in the general ward, and 5 patients (4%) were in the ICU upon admission. [Table 1](#) summarizes the demographic and medical characteristics of the study sample.

### Antibiotic prescription patterns among the study sample

All patients in the study received therapy utilizing fluoroquinolones, with the great majority receiving levofloxacin ( $n = 124$ ; 99.2%). A small number of patients received fluoroquinolone monotherapy ( $n = 12$ ; 9.6%), but most patients received combinations of antibiotics along with fluoroquinolone therapy. A total of 42 patients (33.6%) received two antibiotics, 49 patients (39.2%) received three antibiotics, and 22 patients (17.6%) received four antibiotics. Vancomycin was prescribed most frequently ( $n = 72$ ; 57.6%) among adjunct antibiotics. The median number of prescribed empiric antibiotics was 3 (IQR = 1.0), with a total of 331 empiric antimicrobial agents prescribed, including fluoroquinolones.

**Table 1. Demographic and medical characteristics of the study sample (n = 125).**

Parameter	Median (IQR)	n (%)
Age (years)	73.0 (24)	
Gender		
Female		44 (35.2)
Male		81 (64.8)
Length of stay	13.0 (11)	
In-hospital mortality		
Survival		93 (74.4)
Died		32 (25.6)
ICU admission		
Yes		20 (16.0)
No		100 (80.0)
Already admitted to ICU		5 (4.0)

IQR: interquartile range.

### Blood or sputum culture and susceptibility testing

The microbial culture results indicated that 96 of the patients (76.8%) were negative for culture, and 29 of the patients (23.2%) were positive for culture (Table 2). The majority of the positive samples (28/29, 96.6%) underwent susceptibility testing, while one positive sample (3.4%) did not undergo susceptibility testing. The majority of specimens contained pathogens that were resistant to fluoroquinolones (23/28, 82.1%), and the minority of samples were sensitive to fluoroquinolones (3/28, 10.7%). Interestingly, two samples (7.1%) did not undergo susceptibility testing for fluoroquinolones but did undergo antibiotic susceptibility testing (Table 2).

**Table 2. Isolated bacterial pathogens, fluoroquinolone resistance profiles, and antibiotic de-escalation outcomes among patients with suspected CAP and positive cultures (n = 29).**

Patient No.	Specimen type	Bacteria name	Resistance pattern to fluoroquinolones	De-escalation outcome
1	Blood specimen	<i>Viridans group streptococci</i>	Resistant to levofloxacin	Successfully de-escalated
2	Sputum specimen	<i>Streptococcus pyogenes (Group A)</i>	Resistant to levofloxacin	Successfully de-escalated
3	Blood specimen	<i>Staphylococcus species Coagulase</i>	Resistant to levofloxacin	Successfully de-escalated
4	Blood specimen	<i>Staphylococcus species Coagulase</i>	Resistant to levofloxacin	Successfully de-escalated
5	Blood specimen	<i>Staphylococcus species Coagulase</i>	NA	Incorrectly de-escalated
6	Blood specimen	<i>Staphylococcus species Coagulase</i>	Resistant to levofloxacin	Failed de-escalation
7	Blood specimen	<i>Staphylococcus hominis</i>	Resistant to levofloxacin	Successfully de-escalated
8	Blood specimen	<i>Staphylococcus hominis</i>	Resistant to levofloxacin	Failed de-escalation
9	Blood specimen	<i>Staphylococcus hominis</i>	NA	Successfully de-escalated
10	Blood specimen	<i>Staphylococcus hominis</i>	Resistant to levofloxacin	Failed de-escalation
11	Blood specimen	<i>Staphylococcus hominis</i>	Resistant to levofloxacin	Failed de-escalation
12	Blood specimen	<i>Staphylococcus hominis</i>	Resistant to levofloxacin	Failed de-escalation
13	Blood specimen	<i>Staphylococcus haemolyticus</i>	Resistant to levofloxacin	Successfully de-escalated

**Table 2. Isolated bacterial pathogens, fluoroquinolone resistance profiles, and antibiotic de-escalation outcomes among patients with suspected CAP and positive cultures (n = 29). (continued)**

Patient No.	Specimen type	Bacteria name	Resistance pattern to fluoroquinolones	De-escalation outcome
14	Blood specimen	<i>Staphylococcus haemolyticus</i>	Sensitive to levofloxacin	Successfully de-escalated
15	Blood specimen	<i>Staphylococcus epidermidis</i>	NA	Incorrectly de-escalated
16	Blood specimen	<i>Staphylococcus epidermidis</i>	Sensitive to levofloxacin	Failed de-escalation
17	Blood specimen	<i>Staphylococcus epidermidis</i>	Sensitive to levofloxacin	Failed de-escalation
18	Blood specimen	<i>Staphylococcus aureus</i>	Resistant to levofloxacin	Incorrectly de-escalated
19	Sputum specimen	<i>Klebsiella pneumoniae</i>	Resistant to levofloxacin	Successfully de-escalated
20	Blood specimen	<i>Klebsiella pneumoniae</i>	Resistant to levofloxacin	Successfully de-escalated
21	Blood specimen	<i>Klebsiella pneumoniae</i>	Resistant to levofloxacin	Successfully de-escalated
22	Blood specimen	<i>Klebsiella pneumoniae</i>	Resistant to levofloxacin	Successfully de-escalated
23	Blood specimen	<i>Klebsiella pneumoniae</i> and <i>Staphylococcus aureus</i>	Resistant to levofloxacin	Failed de-escalation
24	Blood specimen	<i>Escherichia coli</i>	Resistant to levofloxacin	Successfully de-escalated
25	Sputum specimen	<i>Escherichia coli</i>	Resistant to ciprofloxacin	Successfully de-escalated
26	Blood specimen	<i>Diphtheroids bacilli</i>	Resistant to levofloxacin	Successfully de-escalated
27	Blood specimen	<i>Diphtheroids bacilli</i>	Resistant to levofloxacin	Failed de-escalation
28	Sputum specimen	<i>Acinetobacter baumannii</i>	Resistant to ciprofloxacin	Successfully de-escalated
29	Blood specimen	<i>Acinetobacter baumannii</i>	Resistant to levofloxacin	Failed de-escalation

CAP: community-acquired pneumonia.

The positive culture specimens predominantly showed 1 microorganism (28/29, 96.6%); there was 1 specimen (3.4%) that had two pathogens, which had a total of 30 isolated pathogens. The most commonly reported pathogens were *Staphylococcus hominis* (6/30, 20.0%), *Klebsiella pneumoniae* (5/30, 16.7%), and *Staphylococcus epidermidis* (3/30, 10.0%) (see Table 2).

### Assessing the appropriateness of fluoroquinolone de-escalation

Of the patients suspected to have CAP, 76.8% had a negative blood culture. All patients were then classified into one of three groups depending on the appropriateness of fluoroquinolone de-escalation. There were those who incorrectly de-escalated (42/96, 43.8%), those who had a failed de-escalation (29/96, 30.2%), and those who successfully de-escalated (25/96, 26.0%).

On the contrary, in the sample, 29 patients (23.2%) had a positive culture finding for otherwise suspected CAP (25 positive blood cultures and four positive sputum cultures). All patients required de-escalation. The 29 patients were then stratified into three categories. There were those who incorrectly de-escalated ( $n = 3$ , 10.3%), those who failed de-escalation ( $n = 10$ , 34.5%), and those who successfully de-escalated ( $n = 16$ , 55.2%). These results appear in Figure 1. Likewise, Table 3 includes examples demonstrating the decision process surrounding de-escalation for patients with both positive and negative cultures.

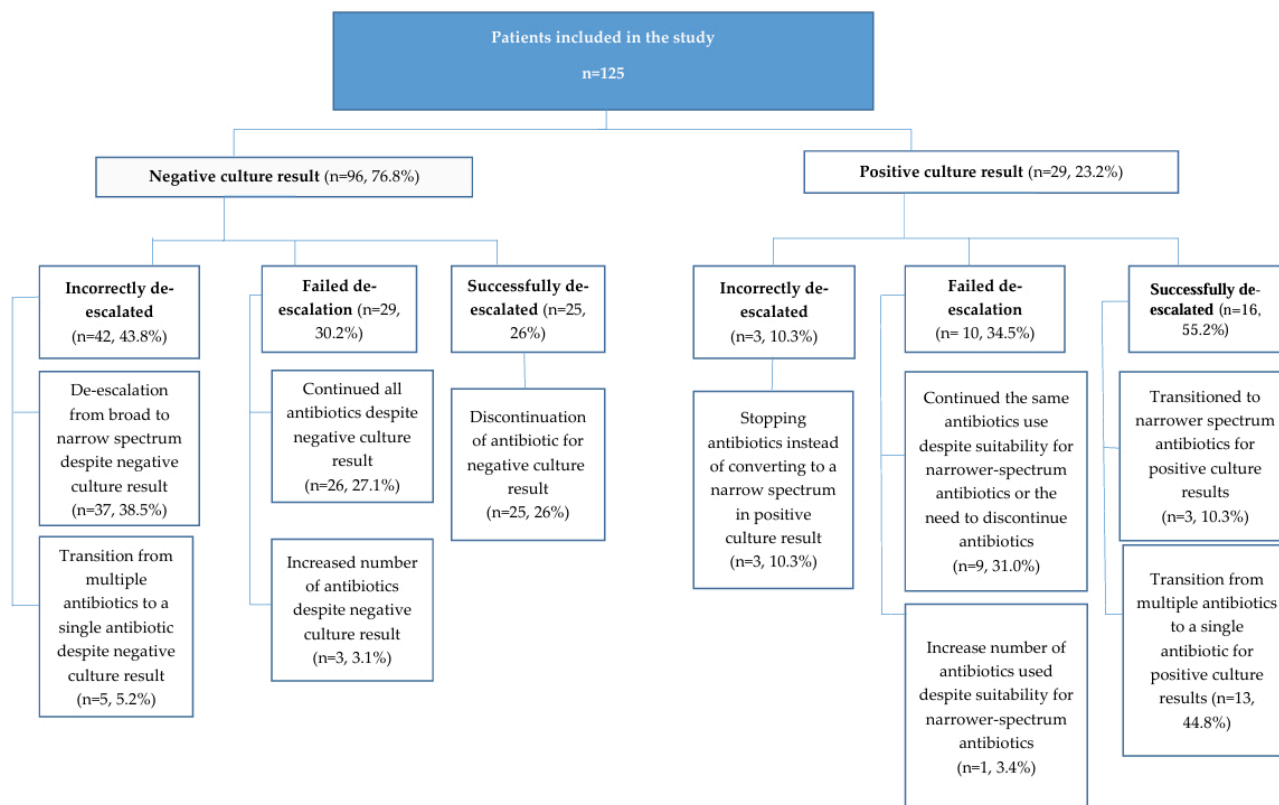


Figure 1. Decision-making scheme for the de-escalation process.

Table 3. Examples illustrating decisions related to the de-escalation process for patients with positive and negative cultures.

Decision	Example
Incorrectly de-escalated (de-escalation from broad to narrow spectrum despite negative culture result)	An 88-year-old female was admitted to JUH. The patient received intravenous levofloxacin before the results of the blood culture were available. Within 48 h of admission, the culture results showed no bacterial growth. Subsequently, the patient's treatment was de-escalated to ceftriaxone sodium injection 1 g on the following day, coinciding with the availability of the culture results.
Incorrectly de-escalated (transition from multiple antibiotics to a single antibiotic despite a negative culture result)	An 81-year-old male was admitted to JUH. The patient received intravenous levofloxacin and piperacillin/tazobactam injections before the results of the blood culture were available. After more than 72 h of admission, the culture result showed no bacterial growth. Levofloxacin was discontinued, and the patient continued with piperacillin/tazobactam on the same day that the culture results became available.
Failed de-escalation (continued all antibiotics despite negative culture results)	A 100-year-old male was admitted to JUH. The patient received intravenous levofloxacin, intravenous vancomycin, and intravenous imipenem before the culture results were available. After more than 72 h of admission, both blood and sputum cultures showed no bacterial growth. The patient's treatment was maintained with intravenous levofloxacin, intravenous vancomycin, and intravenous imipenem after the culture results became available.
Failed de-escalation (increased number of antibiotics despite negative culture result)	A 63-year-old female was admitted to JUH. The patient received intravenous levofloxacin before the results of the blood culture were available. Within 72 h of admission, the blood culture showed no bacterial growth. The patient's treatment regimen was adjusted, and she began receiving intravenous piperacillin/tazobactam injection in addition to levofloxacin on the same day as the culture results became available.
Successfully de-escalated (discontinuation of antibiotic for negative culture result)	A 71-year-old male was admitted to JUH. The patient received intravenous levofloxacin, intravenous piperacillin/tazobactam, and oral amoxicillin/clavulanic acid tablets before the results of the blood culture were available. After more than 72 h of admission, the blood culture showed no bacterial growth. Consequently, the patient's treatment was de-escalated, and all antibiotics were discontinued on the same day as the culture results became available.
Failed de-escalation (continued all antibiotics despite colonization, which suggests negative culture results)	A 60-year-old male was admitted to JUH with suspected community-acquired pneumonia and was started empirically on intravenous levofloxacin and piperacillin/tazobactam. Within 48 h, culture results showed <i>Staphylococcus hominis</i> isolated from a non-sterile respiratory sample. Despite this result, which likely represented colonization rather than true infection, the broad-spectrum antibiotics were continued rather than de-escalated or discontinued.

**Table 3. Examples illustrating decisions related to the de-escalation process for patients with positive and negative cultures. (continued)**

Decision	Example
Failed de-escalation (increased the number of antibiotics used despite suitability for narrower-spectrum antibiotics)	A 76-year-old female was admitted to JUH. The patient received intravenous levofloxacin, vancomycin, and meropenem before the availability of culture results. More than 72 h after admission, a culture result was received, revealing the presence of <i>Acinetobacter baumannii</i> . Despite suitability of narrower antibiotics, gentamycin was initiated in addition to the ongoing antibiotics levofloxacin, vancomycin, and meropenem.
Incorrectly de-escalated (stopping antibiotics instead of converting to a narrow spectrum in culture result)	A 55-year-old female was admitted to JUH. The patient received intravenous levofloxacin in addition to imipenem/cilastatin before the results of the culture were available. After more than 72 h of admission, the culture result showed the presence of <i>Staphylococcus aureus</i> . Subsequently, the patient's treatment was discontinued, and all antibiotics were stopped, leaving the patient untreated.
Successfully de-escalated (transitioned to narrower spectrum antibiotics for positive culture results)	An 88-year-old male was admitted to JUH. The patient received intravenous levofloxacin and imipenem/cilastatin before the culture results were available. After more than 72 h of admission, the culture results showed the presence of <i>Escherichia coli</i> . Subsequently, the patient's treatment was transitioned from the broad-spectrum levofloxacin to the narrower-spectrum vancomycin in addition to imipenem/cilastatin.
Successfully de-escalated (transition from multiple antibiotics to a single antibiotic for positive culture results)	A 65-year-old female was admitted to JUH. The patient received intravenous levofloxacin, meropenem, gentamycin, and ceftazidime/avibactam. Within 72 h of admission, the culture result showed the presence of <i>Klebsiella pneumoniae</i> . Levofloxacin was discontinued, and the patient's treatment was continued with intravenous meropenem, gentamycin, and ceftazidime/avibactam without levofloxacin.

JUH: Jordan University Hospital.

### Clinical outcomes and demographics by de-escalation status comparison

Before assessing the study's secondary objectives, we duly attempted to ensure that cases were included that were relevant to our goals. Consequently, we excluded cases in which de-escalation occurred incorrectly, with particular reference to cases where antibiotics were stopped instead of switching to a narrower spectrum after a positive culture result (3 patients). After excluding these 3 patients, the reduced sample size was 122 patients. Of the 122 patients, 41 were successfully de-escalated and 81 either improperly de-escalated or did not de-escalate.

The study noted that patients who were successfully de-escalated had a median LOS of 12 days (IQR = 8 days) compared to patients who lacked successful de-escalation or proper de-escalation [median LOS 18 days (IQR = 11 days)], with a statistically significant  $p$ -value of 0.004 via Mann-Whitney  $U$  test.

Regarding mortality at discharge, there was no difference between the two study groups. Among the patients who had successful de-escalation, 29 of 41 (70.7%) survived, whereas of those who had either failed de-escalation or were inappropriately de-escalated, 62 of 81 (76.5%) survived. Fisher's exact test yielded no significant difference in in-hospital mortality between the two groups for this variable ( $p = 0.514$ ).

Age, gender, and ICU admission status were not significantly different between the two groups ( $p \geq 0.05$  for all). Further details can be found in [Table 4](#).

**Table 4. Comparison of patient demographics and clinical outcomes between successful and failed/inappropriate antibiotic de-escalation groups.**

Parameter	Successfully de-escalated ( $n = 41$ )	Failed/Inappropriate de-escalated ( $n = 81$ )	$P$ -value
Age (years), median (IQR)	74.0 (20.0)	71.0 (25.0)	0.659 <sup>^</sup>
Gender, $n$ (%)			
Female	15 (36.6%)	27 (33.3%)	0.721 <sup>#</sup>
Male	26 (63.4%)	54 (66.7%)	
ICU admission, $n$ (%)			
Yes	8 (19.5%)	12 (14.8%)	0.324 <sup>#</sup>
No	33 (80.5%)	64 (79.0%)	
Already admitted to ICU	0 (0%)	5 (6.2%)	

**Table 4. Comparison of patient demographics and clinical outcomes between successful and failed/inappropriate antibiotic de-escalation groups. (continued)**

Parameter	Successfully de-escalated (n = 41)	Failed/Inappropriate de-escalated (n = 81)	P-value
Length of hospital stay (days), median (IQR)	12 (8.0)	18 (11.0)	0.004* <sup>^</sup>
In-hospital mortality, n (%)			
Survived	29 (70.7%)	62 (76.5%)	0.514#
Died	12 (29.3%)	19 (23.5%)	

\*: Significant at 0.05 significance level; <sup>^</sup>: using Mann-Whitney *U* test; #: using Chi-square/Fisher exact test. IQR: interquartile range.

### Association between culture results and de-escalation practice

Among patients with a positive culture, 16 of 26 patients (61.5%) had successful de-escalation. Of those patients with negative cultures, 26.0% (*n* = 25) had successful de-escalation. Chi-square analysis demonstrated a significantly greater rate of de-escalation success with positive cultures compared to negative cultures (*p* = 0.002). The details are displayed in Table 5.

**Table 5. Assessing the association between cultural results and de-escalation practice.**

Microbial culture result	Positive culture result (n = 26)	Negative culture result (n = 96)	P-value
Successfully de-escalated	16 (61.5%)	25 (26.0%)	0.002*#
Failed/Inappropriate de-escalated	10 (38.5%)	71 (74.0%)	

\*: Significant at 0.05 significance level; #: using Chi-square test.

## Discussion

This study assessed the rate and effectiveness of fluoroquinolone de-escalation in 125 adult patients diagnosed with CAP at a tertiary teaching hospital in Jordan. Levofloxacin, a broad-spectrum respiratory fluoroquinolone, was the most commonly used antibiotic (99.2%) in our cohort. It is often used because it is effective against typical pathogens like *Streptococcus pneumoniae*, and atypical pathogens such as *Mycoplasma pneumoniae* and *Chlamydomphila pneumonia*. Nevertheless, the research revealed concerning, high rates of toxin-associated resistance to levofloxacin at 82.2% across the many strains of bacteria. The rate is concerning and emphasizes the shared importance of appropriate use and antimicrobial stewardship, especially when selecting for empiric therapy patients. Microbial surveillance is a reasonable approach where frequent evaluations of resistance patterns inform empiric treatment guidelines and reduce the use of broad-spectrum antibiotics when they are not applicable [17, 18].

We discovered a success rate of fluoroquinolone de-escalation at 32.8%, which aligns with data from previous studies. For instance, Deshpande et al. [19] reported de-escalation rates of 2–35% in a 14,170 patient multicenter study. Joung et al. [20] found a de-escalation rate of 32.1%. We found a significant difference in de-escalation success rates with negative cultures (26%) and positive cultures (61%) (*p* = 0.002). We suspect this difference is due to positive cultures identifying the pathogen, allowing the clinicians to de-escalate from broad-spectrum to narrower-spectrum antibiotics. For negative cultures, it is likely that clinicians are unsure of the causative pathogen, so they continue to use broad-spectrum antibiotics, consequently decreasing the chances of de-escalation.

An important finding of this study was that three patients with positive cultures stopped all antibiotics rather than de-escalating to narrower spectrum alternatives. This is an alarmingly concerning practice as it may lead to inadequate treatment, longer LOS in the hospital, treatment failure, and increase the risk of complications, including the emergence of antibiotic resistance. These findings demonstrate the significance of de-escalating protocols to ensure appropriate antibiotic treatment is maintained during treatment.

The study also found a significant difference in hospital LOS between the successfully de-escalated group (median 12 days) and the failed or inappropriate de-escalated group (median 18 days), highlighting

the potential benefits of de-escalation in reducing hospital stays and improving hospital resource utilization [21]. This is consistent with other studies, such as Giantsou et al. [22], which showed a reduction in LOS among patients who underwent successful de-escalation. However, our results contrast with those of Knaak et al. [23], who reported no significant difference in LOS between de-escalated and non-de-escalated patients. These discrepancies suggest that factors like disease severity, comorbidities, and hospital protocols may influence outcomes, emphasizing the need for individualized treatment plans and tailored antibiotic management strategies.

While our study found no significant difference in mortality rates between the successful and failed de-escalation groups, López-Cortés et al. [24] also reported no significant difference in mortality. They showed no significant differences in mortality between those with and without de-escalation [24]. In contrast, Joung et al. [20] observed lower mortality rates in the de-escalated group, suggesting that de-escalation may be more beneficial for certain patient populations. One potential reason for the lack of difference in mortality is that mortality is driven by multiple factors, including baseline disease severity, baseline comorbidities, and overall clinical status—all of which are not fully captured in this retrospective study. Consequently, mortality alone may not be sensitive enough to detect the de-escalation's benefits. Other outcomes that measure clinical value might include total LOS, and the right use of antibiotics is a more valuable indicator. In summary, the findings of this study should provide reassurance to clinicians that appropriate de-escalation, including in cases of uncertainty or when a culture is negative, does not adversely affect patient safety.

While these findings are important, the retrospective nature of the study, single-center delivery, and small sample size are important limitations of the study in the context of generalizability. The aforementioned may introduce bias due to incomplete or inaccurate medical records. The study also could not control for every possible confounding factor, such as disease severity or common comorbidities that may have affected the results. Lack of data precluded adjustment for potential confounders that may have had a bearing on clinical outcomes (e.g., length of hospital stay). Also, this study has a limitation in that no information on biomarkers such as neutrophil-to-lymphocyte ratio and C-reactive protein was obtained, as they may contain some important information about the inflammatory response and could prove helpful in predicting patient outcomes during an antibiotic de-escalation.

In addition, CAP cases were identified based on ICD-10 diagnostic codes rather than standardized clinical or radiologic criteria. This could have led to the inadvertent inclusion of patients with non-bacterial etiologies such as viral pneumonia. When patients have negative cultures, it is invariably difficult to know if they truly had a viral infection or a bacterial infection that could not be microbiologically confirmed because diagnostic sensitivity for determining the presence and extent of infection sometimes limits diagnostic accuracy. That ambiguity could have directly influenced any of the assessments of de-escalation appropriateness and potentially created a level of uncertainty for clinical decision-making.

In conclusion, we found that fluoroquinolone de-escalation in patients with CAP was associated with a shorter LOS without any evidence of increased mortality. We want to clarify that our definitions of de-escalation appropriateness were primarily formed from cultural results (due to the nature of our retrospective analysis and limitations in clinical documentation), so our findings should be interpreted accordingly. Future prospective studies with standardized diagnostic criteria and clinically contextually defined appropriate de-escalation criteria are needed to validate these associations and in order to develop the field of stewardship practice based on the highest quality of evidence.

## Abbreviations

CAP: community-acquired pneumonia

IDSA: Infectious Diseases Society of America

IQR: interquartile range

JUH: Jordan University Hospital

LOS: length of stay

## Declarations

### Author contributions

AAA: Conceptualization, Methodology, Writing—original draft, Writing—review & editing, Data curation. KAH: Conceptualization, Methodology, Writing—original draft, Writing—review & editing, Data curation. AA: Conceptualization, Methodology, Writing—original draft, Writing—review & editing. MZ: Conceptualization, Methodology, Writing—original draft, Writing—review & editing. RKAF: Conceptualization, Methodology, Writing—original draft, Writing—review & editing, Data curation. All authors read and approved the submitted version.

### Conflicts of interest

The authors declare that there are no conflicts of interest.

### Ethical approval

The study was conducted in accordance with the principles outlined in the World Medical Association Declaration of Helsinki. It received approval from the JUH Institutional Review Board (approval number 10/2024/1389).

### Consent to participate

To ensure patient confidentiality, all data were de-identified and anonymized. Given the retrospective, observational design, the ethical committee granted a waiver for informed consent.

### Consent to publication

Not applicable.

### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Funding

This study did not receive any funding support.

### Copyright

© The Author(s) 2025.

## Publisher's note

Open Exploration maintains a neutral stance on jurisdictional claims in published institutional affiliations and maps. All opinions expressed in this article are the personal views of the author(s) and do not represent the stance of the editorial team or the publisher.

## References

1. File TM Jr, Ramirez JA. Community-Acquired Pneumonia. *N Engl J Med.* 2023;389:632–41. [DOI] [PubMed]
2. who.int [Internet]. [cited 2025 Dec 15]. Available from: <https://www.who.int/>
3. Jain S, Self WH, Wunderink RG, Fakhran S, Balk R, Bramley AM, et al.; CDC EPIC Study Team. Community-Acquired Pneumonia Requiring Hospitalization among U.S. Adults. *N Engl J Med.* 2015; 373:415–27. [DOI] [PubMed] [PMC]

4. Prestinaci F, Pezzotti P, Pantosti A. Antimicrobial resistance: a global multifaceted phenomenon. *Pathog Glob Health*. 2015;109:309–18. [DOI] [PubMed] [PMC]
5. Shrestha P, Cooper BS, Coast J, Oppong R, Do Thi Thuy N, Phodha T, et al. Enumerating the economic cost of antimicrobial resistance per antibiotic consumed to inform the evaluation of interventions affecting their use. *Antimicrob Resist Infect Control*. 2018;7:98. [DOI] [PubMed] [PMC]
6. Founou RC, Founou LL, Essack SY. Clinical and economic impact of antibiotic resistance in developing countries: A systematic review and meta-analysis. *PLoS One*. 2017;12:e0189621. [DOI] [PubMed] [PMC]
7. Dadgostar P. Antimicrobial Resistance: Implications and Costs. *Infect Drug Resist*. 2019;12:3903–10. [DOI] [PubMed] [PMC]
8. Chaaban T, Ezzeddine Z, Ghssein G. Antibiotic misuse during the COVID-19 pandemic in Lebanon: a cross-sectional study. *COVID*. 2024;4:921–9. [DOI]
9. Daniel Markley J, Bernard S, Bearman G, Stevens MP. De-escalating Antibiotic Use in the Inpatient Setting: Strategies, Controversies, and Challenges. *Curr Infect Dis Rep*. 2017;19:17. [DOI] [PubMed]
10. Trupka T, Fisher K, Micek ST, Juang P, Kollef MH. Enhanced antimicrobial de-escalation for pneumonia in mechanically ventilated patients: a cross-over study. *Crit Care*. 2017;21:180. [DOI] [PubMed] [PMC]
11. Kollef MH. Broad-spectrum antimicrobials and the treatment of serious bacterial infections: getting it right up front. *Clin Infect Dis*. 2008;47 Suppl 1:S3–13. [DOI] [PubMed]
12. Tabah A, Cotta MO, Garnacho-Montero J, Schouten J, Roberts JA, Lipman J, et al. A Systematic Review of the Definitions, Determinants, and Clinical Outcomes of Antimicrobial De-escalation in the Intensive Care Unit. *Clin Infect Dis*. 2016;62:1009–17. [DOI] [PubMed]
13. Mancuso G, Midiri A, Gerace E, Biondo C. Bacterial Antibiotic Resistance: The Most Critical Pathogens. *Pathogens*. 2021;10:1310. [DOI] [PubMed] [PMC]
14. Nadeem SF, Gohar UF, Tahir SF, Mukhtar H, Pornpukdeewattana S, Nukthamna P, et al. Antimicrobial resistance: more than 70 years of war between humans and bacteria. *Crit Rev Microbiol*. 2020;46: 578–99. [DOI] [PubMed]
15. Pitiriga V, Vrioni G, Saroglou G, Tsakris A. The Impact of Antibiotic Stewardship Programs in Combating Quinolone Resistance: A Systematic Review and Recommendations for More Efficient Interventions. *Adv Ther*. 2017;34:854–65. [DOI] [PubMed]
16. Kherroubi L, Bacon J, Rahman KM. Navigating fluoroquinolone resistance in Gram-negative bacteria: a comprehensive evaluation. *JAC Antimicrob Resist*. 2024;6:dlae127. [DOI] [PubMed] [PMC]
17. Lynch JP 3rd, File TM Jr, Zhanel GG. Levofloxacin for the treatment of community-acquired pneumonia. *Expert Rev Anti Infect Ther*. 2006;4:725–42. [DOI] [PubMed]
18. Khan AS, Iqbal A, Muhammad AA, Mazhar F, Lodhi MF, Ahmed KF, et al. Safety and Efficacy of Nemonoxacin vs Levofloxacin in Patients With Community-Acquired Pneumonia: A Systematic Review and Meta-Analysis of Randomized Control Trials. *Cureus*. 2023;15:e37650. [DOI] [PubMed] [PMC]
19. Deshpande A, Richter SS, Haessler S, Lindenauer PK, Yu PC, Zilberberg MD, et al. De-escalation of Empiric Antibiotics Following Negative Cultures in Hospitalized Patients With Pneumonia: Rates and Outcomes. *Clin Infect Dis*. 2021;72:1314–22. [DOI] [PubMed] [PMC]
20. Joung MK, Lee JA, Moon SY, Cheong HS, Joo EJ, Ha YE, et al. Impact of de-escalation therapy on clinical outcomes for intensive care unit-acquired pneumonia. *Crit Care*. 2011;15:R79. [DOI] [PubMed] [PMC]
21. Arnold HM, Micek ST, Skrupky LP, Kollef MH. Antibiotic stewardship in the intensive care unit. *Semin Respir Crit Care Med*. 2011;32:215–27. [DOI] [PubMed]
22. Giantsou E, Liratzopoulos N, Efraimidou E, Panopoulou M, Alepopoulou E, Kartali-Ktenidou S, et al. De-escalation therapy rates are significantly higher by bronchoalveolar lavage than by tracheal aspirate. *Intensive Care Med*. 2007;33:1533–40. [DOI] [PubMed] [PMC]

23. Knaak E, Cavalieri SJ, Elsasser GN, Preheim LC, Gonitzke A, Destache CJ. Does antibiotic de-escalation for nosocomial pneumonia impact intensive care unit length of stay? *Infect Dis Clin Pract.* 2013;21:172–6. [[DOI](#)]
24. López-Cortés LE, Delgado-Valverde M, Moreno-Mellado E, Goikoetxea Aguirre J, Guio Carrión L, Blanco Vidal MJ, et al.; SIMPLIFY study group. Efficacy and safety of a structured de-escalation from antipseudomonal  $\beta$ -lactams in bloodstream infections due to Enterobacterales (SIMPLIFY): an open-label, multicentre, randomised trial. *Lancet Infect Dis.* 2024;24:375–85. [[DOI](#)] [[PubMed](#)]