

Original Research

Impact of clinical pharmacist-led interventions on early intravenous-to-oral antibiotic switching in patients with community-acquired pneumonia at a Vietnamese hospital

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Abstract

Background: The inappropriate or prolonged use of intravenous (IV) antibiotics increases healthcare costs and hospitalization time. Early switching from IV to oral (PO) antibiotics has been proven to be clinically effective and cost-saving in many settings. This study aimed to evaluate the cost-effectiveness of switching from IV-to-PO antibiotics in the treatment of community-acquired pneumonia (CAP). **Methods:** A randomized controlled clinical trial was conducted from June 2024 to August 2025 on patients aged over 18 years who were diagnosed with community-acquired pneumonia (CAP) and received intravenous antibiotic therapy for at least two consecutive days in the Internal Medicine Department of Hoan My Dong Nai Hospital. Information on patient characteristics, antibiotic use, length of hospital stay, and treatment outcomes was obtained from electronic medical records (EMR). Participants were randomly assigned to either a control group or an intervention group. Patients in the control group received standard care without clinical pharmacist involvement. In the intervention group, IV-to-PO antibiotic switch guidelines were introduced to physicians, and clinical pharmacists provided feedback on cases eligible for early switching. The impact of the pharmacist-led interventions was assessed by comparing primary outcomes (rate of appropriate early switching and cost-effectiveness) and secondary outcomes (clinical and laboratory treatment outcomes) between the two study periods.

Results: A total of 111 patients were included (55 in control group and 56 in intervention group). The appropriate early switch rate from IV-to-PO therapy was significantly higher in intervention group compared with control group (71.4% vs 3.6%, $p < 0.001$). The duration of IV antibiotic use and hospital stay were significantly shorter in intervention group ($p < 0.001$). There were no statistically significant differences between the two groups with respect to clinical and laboratory treatment outcomes. The mean total treatment cost was significantly lower in the intervention group (5.98 ± 6.10 vs 9.71 ± 7.55 million VND, $p < 0.001$). Logistic regression analysis showed that the clinical pharmacist-led interventions were associated with a higher rate of IV-to-PO switching, whereas increasing age was negatively associated with the likelihood of switching. **Conclusion:** Implementation of clinical pharmacist-led IV-to-PO antibiotic switch improved the rate of appropriate early conversion and demonstrated superior cost-effectiveness without compromising clinical outcomes. This strategy could serve as an effective antimicrobial stewardship intervention to optimize antibiotic use in hospitalized patients.

Keywords: Community-Acquired Pneumonia, Anti-Bacterial Agents, Drug Substitution, Cost-Benefit Analysis, Pharmacists, Length of Stay, Antimicrobial Stewardship.

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INTRODUCTION

The rational use of antibiotics plays a vital role in optimizing clinical outcomes, minimizing adverse drug reactions, and combating the growing threat of antimicrobial resistance. Inappropriate or prolonged intravenous (IV) antibiotic use has been associated with increased treatment costs, extended hospital stays, and higher risks of catheter-related infections^{1,2}. To address these challenges, antimicrobial stewardship programs (ASPs) worldwide have recommended switching from IV-to-PO antibiotics once patients show clinical improvement and meet specific stability criteria³. Several studies have demonstrated that early IV-to-PO conversion is both safe and effective for a wide range of infectious diseases, including CAP⁴⁻⁶. Early conversion allows patients to continue therapy with PO formulations

after stabilization, which can reduce length of hospital stay, minimize healthcare costs, and improve patient comfort without compromising clinical outcomes^{5,7,8}. Moreover, clinical pharmacists play an essential role in promoting this practice by assessing patients' eligibility, monitoring therapy, and collaborating with physicians to optimize antibiotic use^{9,10}.

In Vietnam, the implementation of structured ASPs and clinical pharmacist-led interventions remains inconsistent among hospitals. The application of IV-to-PO switch guidelines is still limited, particularly in private or non-central hospitals. At Hoan My Dong Nai Hospital, clinical pharmacists have recently been integrated into the antimicrobial stewardship team to support rational antibiotic use. However, data on the clinical and economic impact of clinical pharmacist-led IV-to-PO conversion for CAP patients in Vietnam are still lacking.

Therefore, this study was conducted to evaluate the effectiveness and cost-effectiveness of switching from IV-to-PO antibiotics in the treatment of community-acquired pneumonia at Hoan My Dong Nai Hospital. We hypothesized that early IV-to-PO conversion guided by clinical pharmacists could reduce antibiotic costs and hospital stay while maintaining comparable clinical outcomes. Findings from this study may provide real-world evidence to support the implementation of clinical pharmacist-driven IV-to-PO antibiotic switch programs as part of antimicrobial stewardship efforts in Vietnamese hospitals.



METHODS

Study Design and Setting

A randomized controlled clinical trial was conducted over a 15-month period, from June 2024 to August 2025, at the Department of Internal Medicine, Hoan My Dong Nai Hospital—a private general hospital in southern Vietnam. The study aimed to evaluate the clinical outcomes and cost-effectiveness of clinical pharmacist-led IV-to-PO antibiotic conversion among inpatients diagnosed with CAP. The study protocol was reviewed and approved by the institutional ethics committee of Hoan My Dong Nai Hospital (approval number: 27/QĐ-BVQTĐN, approved on May 9, 2024). All patient data were anonymized, and no personal identifiers were collected apart from clinical and medication information.

Clinical and economic data were collected prospectively from EMRs, including demographic information, comorbidities, CURB-65 score, antibiotic regimens, duration of IV therapy, length of hospital stay, and laboratory parameters (white blood cell count [WBC], neutrophil count [NEUT], and C-reactive protein [CRP]) before and after treatment. Cost data were obtained from the hospital's billing system and categorized into direct antibiotic costs and related treatment costs (nursing services, consumables, and management of antibiotic-related adverse events). The total antibiotic cost was calculated as the sum of direct antibiotic costs and related treatment costs, while the total treatment cost represented the overall amount payable by the patient upon hospital discharge. All data were carefully checked and validated by two independent pharmacists.

Participants and Intervention

Eligible patients: were adults aged 18 years or older who were admitted with a diagnosis of community-acquired pneumonia (CAP) and received intravenous (IV) antibiotic therapy for at least two consecutive days. Patients who met clinical stability criteria based on national guidelines were considered candidates for conversion to PO therapy^{10,11}. The criteria for clinical stability included the following:

Stable and improving vital signs

- Systolic blood pressure > 90 mmHg without the use of vasopressors or ongoing fluid resuscitation.
- Heart rate ≤ 100 beats per minute.
- Respiratory rate ≤ 24 breaths per minute.
- Arterial oxygen saturation (SaO₂) ≥ 90% or partial pressure of oxygen (PaO₂) ≥ 60 mmHg on room air.

Infection-related symptoms improved or resolved

- Afebrile: body temperature ≤ 37.8°C for at least 24 hours without the use of antipyretic agents.
- No hypothermia: body temperature > 36°C for at least 24 hours.

Exclusion criteria: included contraindications to PO administration (such as gastrointestinal dysfunction), lack of suitable PO formulations, or incomplete clinical or

laboratory data before or after treatment. Furthermore, as per the IV-to-PO conversion guidelines, conversion is not recommended for patients with severe systemic or deep-seated infections, including but not limited to severe sepsis, *Staphylococcus aureus* bacteremia, necrotizing fasciitis or cellulitis, encephalitis, meningitis, mediastinitis, endocarditis, osteomyelitis, septic arthritis, necrotizing soft tissue infections, prosthetic device-related infections, acute exacerbations of cystic fibrosis or bronchiectasis, and other deep tissue infections¹⁰. Consequently, patients presenting with any of these concomitant conditions were excluded from the study.

The sample size for each period was estimated using the following formula:

where p_1 and p_2 are the rate of patients switched from IV-to-PO antibiotics in the pre-intervention and intervention periods, respectively. $p_1 = 0.3477$ and $p_2 = 0.6269$ (based on a previous study conducted by Xu S)¹²; $n = (p_1 + p_2)/2$; $\Delta = p_1 - p_2$; $= 1.96$ with $\alpha = 0.05$, 95% confidence interval; $= 0.84$ with $\beta = 0.2$, power = 0.8. Based on these calculations, we estimated that the minimum sample size for each study period should be 49 patients.

Eligible patients who met the inclusion criteria were randomly assigned to the intervention or control group using a web-based random integer generator (<https://www.random.org/>). Randomization sequences were generated in advance and concealed, and patients were allocated to their respective groups upon enrollment by a research coordinator who was not involved in clinical care or outcome assessment. This simple randomization ensured unbiased group assignment despite variable daily numbers of eligible patients. In the control group, patients received standard care without clinical pharmacist intervention. In the intervention group, clinical pharmacists actively reviewed electronic medical records (EMRs) and applied an IV-to-PO conversion protocol derived from the Vietnam Ministry of Health IV-to-PO antibiotic switch guidelines¹⁰. Clinical pharmacists provided daily recommendations to attending physicians via EMR notifications or direct communication at the ward. Each intervention was documented along with physician feedback regarding acceptance or refusal and the reason for the decision. Outcome assessors were blinded to group allocation to minimize bias.

Clinical pharmacist training and intervention characteristics:

The clinical pharmacist involved in this study held a Bachelor of Pharmacy degree and had more than 7 years of clinical pharmacy experience, with formal training in antimicrobial stewardship and intravenous-to-oral (IV-to-PO) antibiotic conversion in accordance with the Vietnam Ministry of Health guidelines.

Pharmacist interventions were conducted daily at 7:30 a.m., prior to physicians issuing medical orders, through systematic review of electronic medical records (EMRs). Each eligible case was assessed for appropriateness of IV-to-PO conversion, and recommendations were communicated to physicians via EMR



Table 1. Cost – Effectiveness grid

	Total treatment cost IG < CG	Total treatment cost IG = CG	Total treatment cost IG > CG
Effectiveness IG < CG	1: Calculation of ICER	4: CG was more effective than IG	7: CG was more effective than IG
Effectiveness IG = CG	2: IG was more effective than CG	5: Other factors were considered	8: CG was more effective than IG
Effectiveness IG > CG	3: IG was more effective than CG	6: IG was more effective than CG	9: Calculation of ICER

IG: intervention group; CG: control group

documentation or direct ward-based discussion. The frequency of pharmacist interventions and the acceptance of pharmacist recommendations were prospectively recorded for each eligible case.

Outcomes

The primary outcomes were:

1. the rate of appropriate early switching from IV-to-PO antibiotics, and
2. the cost-effectiveness of therapy between the intervention and control groups.

Secondary outcomes included:

- a. Clinical outcomes,
- b. improvement in infection biomarkers (WBC, NEUT, CRP).

Clinical success was defined as complete or partial recovery without treatment failure, clinical deterioration, the need to restart intravenous antibiotics, hospital readmission, or death during the treatment episode.

Definitions

Appropriate early switching from IV-to-PO antibiotics was defined as meeting all evaluation criteria, including early switch timing, appropriate antibiotic selection, and correct dosage. Switch timing was considered early if patients were transitioned to oral antibiotics within 24 hours of fulfilling the criteria outlined in the Vietnam Ministry of Health IV-to-PO antibiotic switch guidelines. The appropriateness of antibiotic selection and dosage was assessed based on adherence to both the Vietnam Ministry of Health IV-to-PO antibiotic switch guidelines and the Vietnam Ministry of Health guidelines for the diagnosis and treatment of community-acquired pneumonia in adults^{10,11}. Each eligible patient constituted one pharmacist intervention. Acceptance of a pharmacist recommendation was defined as the attending physician's implementation of IV-to-PO conversion within 24 hours of the pharmacist's recommendation.

The cost–effectiveness analysis was performed following a four-step approach to compare two treatment strategies (control group and intervention group) in the management of community-acquired pneumonia.

Step 1: Determination of costs and effectiveness

Effectiveness was defined as the clinical success rate. The cost–effectiveness ratio (CER): was calculated as the mean total treatment cost per unit of effectiveness gained:

$$\text{CER} = \frac{\text{Total treatment cost}}{\text{Effectiveness}}$$

Step 2: Cost–effectiveness grid comparison

A cost–effectiveness grid was applied to classify the relationship between cost and effectiveness for the two treatment groups (see table 1).

Step 3: Calculation of the Incremental Cost–Effectiveness Ratio (ICER)

For scenarios where one treatment was more effective but also more costly, the incremental cost-effectiveness ratio (ICER) was computed to quantify the additional cost required to gain one additional unit of effectiveness:

$$\text{ICER} = \frac{\text{Total treatment cost Intervention group} - \text{Total treatment cost Control group}}{\text{Effectiveness Intervention group} - \text{Effectiveness Control group}}$$

Step 4: Comparison with the willingness-to-pay (WTP) threshold.

The ICER value was then compared against the WTP threshold recommended by the World Health Organization (WHO)¹³. As Vietnam currently lacks an officially defined WTP threshold and healthcare resources remain constrained, this WHO-recommended threshold was applied to interpret the cost–effectiveness results. This approach is commonly used in low- and middle-income countries, including Vietnam, to support economic evaluations in resource-limited healthcare settings.

- **Highly cost-effective:** ICER < 50 million VND per clinical success
- **Cost-effective:** 50 million ≤ ICER ≤ 150 million VND per clinical success
- **Not cost-effective:** ICER > 150 million VND per clinical success

Data Analysis

Data were stored and analyses were conducted using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Patient characteristics were summarized using descriptive statistics. Continuous variables with a normal distribution were expressed as mean (SD), while non-normally distributed continuous variables were reported as median (interquartile range). Categorical variables were described as frequencies and percentages. Comparisons between the intervention and control groups were performed using the Student's t-test for normally distributed continuous variables or the Mann–Whitney U test for non-normally distributed data. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. A two-sided p-value of less than 0.05 was considered statistically significant.

Multivariate logistic regression analysis was performed to identify independent factors associated with successful IV-

Table 2. Baseline Characteristics of the Study Population			
Characteristics	Control group, N₁ = 55	Intervention group, N₂ = 56	p value
Age	64.4 (SD=18.9)	61.5 (SD=19.0)	0.221
Male sex, n (%)	21 (38.2%)	20 (35.7%)	0.788
Comorbidities, number of comorbidities	2.9 (SD=1.7)	2.7 (SD=1.7)	0.748
Cardiovascular disease	39 (70.9%)	37 (66.1%)	0.583
Diabetes mellitus	16 (29.1%)	20 (35.7%)	0.456
Comorbidities, n(%)			
Number of comorbidities	2.9 (SD=1.7)	2.7 (SD=1.7)	0.748
Cardiovascular disease	39 (70.9%)	37 (66.1%)	0.583
Diabetes mellitus	16 (29.1%)	20 (35.7%)	0.456
Dyslipidemia	31 (56.4%)	30 (53.6%)	0.768
Asthma	7 (12.7%)	6 (10.7%)	0.742
COPD	6 (10.9%)	3 (5.4%)	0.321
Cerebrovascular disease	7 (12.7%)	5 (8.9%)	0.519
Liver disease	2 (3.6%)	6 (10.7%)	0.271
Non-respiratory infection	3 (5.5%)	10 (17.9%)	0.042
Cushing	7 (12.7%)	3 (5.4%)	0.203
CURB-65 score (median [IQR 25–75])	1 [1 – 1]	1 [1 – 1]	0.248
Laboratory findings before treatment			
WBC (x10 ⁹ /L)	11.6 (SD = 4.9)	10.9 (SD = 5.2)	0.388
NEUT (x10 ⁹ /L)	8.7 (SD = 4.5)	8.2 (SD = 4.2)	0.598
CRP (mg/L)	48.8 (SD = 56.5)	36.1 (SD = 44.6)	0.078
Intravenous Antibiotic Therapy			
Monotherapy			
Third-generation cephalosporin	30 (54.5%)	37 (66.1%)	0.214
Combination of two antibiotics			
Third-generation cephalosporin + fluoroquinolone	16 (29.1%)	12 (21.4%)	0.353
Third-generation cephalosporin + aminoglycoside	5 (9.1%)	4 (7.1%)	0.707
Combination of three antibiotics			
Third-generation cephalosporin + aminoglycoside + fluoroquinolone	2 (3.6%)	3 (5.4%)	0.662
Third-generation cephalosporin + aminoglycoside + oxazolidinone	2 (3.6%)	0 (0.0%)	

COPD: Chronic obstructive pulmonary disease; CURB-65: Confusion-Uremia-Respiratory-Blood pressure- Age ≥ 65 years; IQR: Interquartile Range; SD: standard deviation.

Table 3. Comparison of early switching rates of IV-to-PO antibiotics			
Parameters	Control group, N₁ = 55	Intervention group, N₂ = 56	p value
Appropriate Early Switching from IV-to-PO Antibiotics			
Switch timing, n (%)	2 (3.6)	40 (71.4)	< 0.001
Selection of PO antibiotics, n (%)	52 (94.5)	56 (100)	0.076
Dosage of PO antibiotics, n (%)	55 (100)	56 (100)	-
Overall appropriateness, n (%)	2 (3.6)	40 (71.4)	< 0.001



Table 4. Treatment Outcomes				
Parameters		Control group, N ₁ = 55	Intervention group, N ₂ = 56	p value
Laboratory findings after treatment	WBC (x10 ⁹ /L)	8.5 (SD = 2.9)	8.4 (SD = 3.4)	0.678
	NEUT (x10 ⁹ /L)	5.8 (SD = 2.6)	4.8 (SD = 2.7)	0.077
	CRP (mg/L)	29.4 (SD = 39.5)	21.0 (SD = 21.6)	0.859
Clinical outcomes	Length of hospital stay (days)	6.8 (SD = 1.6)	4.1 (SD = 1.4)	<0.001
	Duration of intravenous antibiotic therapy (days)	6.4 (SD = 1.5)	3.7 (SD = 1.4)	<0.001
	Clinical recovery, n (%)	55 (100)	56 (100)	1

WBC: white blood cell count; NEUT: neutrophil count; CRP: C-reactive protein.

to-PO conversion. The dependent variable was the switching decision. The independent variables were age, gender, comorbidities, CURB-65 score, and clinical pharmacist intervention (yes/no).

RESULTS

Basic Information

A total of 111 patients were included in the study, comprising 55 patients in the control group and 56 patients in the intervention group. The mean ages of the two groups were 64.4 ± 18.9 years and 61.5 ± 19.0 years, respectively ($p = 0.221$), with no significant difference in demographic or baseline clinical characteristics (Table 2). The two groups were comparable in terms of gender distribution, comorbidities, and CURB-65 scores. The majority of patients had mild community-acquired pneumonia, with a CURB-65 median of 1 (IQR 1–1) in both groups. Cardiovascular diseases (68.5%) and dyslipidemia (55%) were the most common comorbidities. Baseline laboratory values (WBC, NEUT, and CRP) did not differ significantly between the groups ($p > 0.05$).

Empiric IV antibiotic regimens primarily included third-generation cephalosporins, either as monotherapy or in combination with fluoroquinolones or aminoglycosides. Monotherapy accounted for 60.4% of treatments. Combination therapy most frequently involved cephalosporin + fluoroquinolone (25.2%) or cephalosporin + aminoglycoside (8.1%).

Impact of clinical pharmacist-led interventions in promoting the conversion from IV-to-PO antibiotics

The appropriate early switch rate from IV to PO antibiotics was markedly higher in the intervention group compared with the control group (71.4% vs 3.6%, $p < 0.001$). In addition, the intervention group demonstrated significantly better appropriateness across multiple components of the switching process, including switch timing and overall appropriateness, while PO antibiotic selection showed a non-significant trend toward improvement (100% vs 94.5%, $p = 0.076$). (Table 3)

Among 56 patients in the intervention group, 56 pharmacist interventions were performed. Forty recommendations were accepted by physicians, corresponding to an acceptance rate of 71.4%.

After treatment, both groups demonstrated significant improvement in infection-related laboratory parameters (WBC, NEUT, and CRP; $p < 0.05$ within groups). However, the degree of improvement between groups was not statistically different ($p > 0.05$).

The mean duration of IV antibiotic therapy was significantly shorter in the intervention group than in the control group (3.7 ± 1.4 vs 6.4 ± 1.5 days, $p < 0.001$). Similarly, the mean length of hospital stay was reduced in the intervention group (4.1 ± 1.4 days) compared with the control group (6.8 ± 1.6 days, $p < 0.001$). Clinical cure was achieved in 100% of patients in both groups, with no cases of treatment failure or in-hospital mortality, as shown in Table 4. The total mean direct antibiotic cost per treatment episode was significantly lower in the intervention group (1.58 ± 1.45 million VND) compared with the control group (3.79 ± 2.51 million VND, $p < 0.001$). Likewise, total mean related costs—including medical consumables, nursing care, and management of antibiotic-related adverse events—were reduced in the intervention group (0.44 ± 0.23 million VND vs 0.80 ± 0.29 million VND, $p < 0.001$).

Overall, the total mean treatment cost was significantly lower for the intervention group (5.98 ± 6.10 million VND) compared with the control group (9.71 ± 7.55 million VND, $p = 0.001$) (Table 5).

The cost-effectiveness analysis showed that the clinical pharmacist-led IV-to-PO antibiotic conversion program fell under Scenario 2 in Table 5, indicating lower costs with comparable effectiveness. The intervention group had similar treatment success rates and biomarker improvements (WBC, NEUT, CRP) compared with the control group, while total treatment costs, including antibiotic expenditure, were significantly lower.

Factors related to IV-to-PO conversion

Multivariate logistic regression analysis identified two independent predictors significantly associated with successful IV-to-PO antibiotic conversion. Clinical pharmacist intervention was the strongest factor (OR = 80.99, [95%CI: 20.23 - 565.91, $p < 0.001$]), indicating that patients managed by clinical pharmacists were far more likely to be switched early to PO therapy. Age was inversely related to switch likelihood (OR



Type of Cost (VND)	Control group, N ₁ = 55	Intervention group, N ₂ = 56	p value
Direct cost of antibiotics	3,790,000 (SD = 2,512,737)	1,576,590 (SD = 1,449,744)	<0.001
Antibiotic-related indirect cost	803,711 (SD = 293,311)	438,416 (SD = 235,347)	<0.001
Total antibiotic cost	4,593,712 (SD = 2,679,685)	2,015,006 (SD = 1,631,475)	<0.001
Total treatment cost	9,706,637 (SD = 7,554,666)	5,983,972 (SD = 6,101,736)	0.001

SD: standard deviation.

Factor	Odds Ratio (OR)	95% CI	p value
Clinical pharmacist intervention (yes)	80.992	20.231 - 565.907	<0.001
Age (years)	0.964	0.929 - 0.996	0.038
Male sex	1.233	0.377 - 4.245	0.731
CURB-65 score > 1	3.33	0.676 - 21.471	0.164
>2 comorbidities	1.396	0.406 - 5.052	0.6

95% CI: 95% confidence Interval

= 0.964, [95%CI: 0.929 - 0.996, p = 0.038]), suggesting that younger patients were more likely to undergo successful conversion. Other variables, including gender, CURB-65 score, and number of comorbidities, showed no significant associations (p > 0.05) (Table 6).

DISCUSSION

This study demonstrated that clinical pharmacist-led IV-to-PO antibiotic conversion in patients with CAP significantly improved both clinical and economic outcomes compared with standard care. The intervention increased the conversion rate from 3.6% to 71.4% and reduced the duration of IV therapy and hospitalization without compromising treatment efficacy. These findings provide strong evidence supporting the integration of clinical pharmacists into AMS programs in Vietnamese hospitals.

Our conversion rate of 71.4% is comparable to results from prior stewardship interventions worldwide, where rates ranged from 60% to 75% after implementing pharmacist-led switch protocols^{12,14,16}. The sharp contrast with the control group (3.6%) confirms the importance of proactive pharmacist involvement rather than physician discretion alone. Early conversion reduces unnecessary IV exposure, minimizes catheter-related risks, and promotes patient mobility—benefits consistently noted in previous studies on respiratory infections^{17,18}.

The duration of IV therapy decreased by nearly three days in the intervention group, leading to a corresponding reduction in length of stay (LOS) from 6.8 to 4.1 days (p<0.001). Similar patterns have been observed in large-scale antimicrobial stewardship projects, where pharmacist-driven interventions reduced LOS by 2 - 4 days without increasing readmissions^{12,19}. Shorter IV duration also translates into improved patient comfort and lower nursing workload, both of which enhance hospital efficiency.

Although both groups achieved comparable improvements in WBC, neutrophil, and CRP levels after therapy, there was no

significant difference in final biomarker outcomes (p>0.05). This suggests that switching from IV-to-PO antibiotics did not impair clinical efficacy. These findings align with previous reports that PO antibiotics with high bioavailability (e.g., fluoroquinolones, macrolides, amoxicillin-clavulanate) can achieve equivalent tissue concentrations to their IV counterparts once patients are clinically stable^{9,12,21}.

The consistent biomarker response between groups reinforces that the decision to switch, when based on stability criteria, maintains therapeutic effectiveness. This mirrors findings from a randomized controlled study in Japan, in which early conversion from IV-to-PO therapy demonstrated comparable microbiological cure rates to continued IV treatment²².

Economically, our data demonstrated substantial savings in both total antibiotic and treatment costs. The intervention reduced total mean direct antibiotic expenditure by more than 50% (1.58 vs 3.79 million VND, p < 0.001) and overall mean treatment cost by nearly 40% (5.98 vs 9.70 million VND, p<0.001). These outcomes are consistent with prior studies demonstrating that pharmacist-driven switch programs can lower drug and hospitalization costs without negative clinical impact^{15,19,23,24}.

A recent evaluation of linezolid utilization following a revision of IV-to-oral conversion criteria within a healthcare system demonstrated a 32% reduction in IV linezolid costs at the academic hospital and a 63% reduction at non-academic hospitals, while maintaining comparable microbiological cure rates¹⁶. Similarly, In a study by Xu S involving inpatients with communityacquired pneumonia, a pharmacistled intervention using EMR reminders to support eligible intravenous-to-oral antibiotic conversions reduced hospital length of stay by approximately 1.38 days¹². Collectively, these findings indicate that integrating clinical pharmacists into AMS programs to oversee IV-to-PO switching is an effective and cost-saving strategy. The intervention not only maintained treatment efficacy but also optimized the use of hospital resources by



reducing unnecessary IV therapy and shortening inpatient care. Our findings reinforce global evidence that structured clinical pharmacist participation enhances the appropriateness of antimicrobial use and strengthens stewardship initiatives. Clinical pharmacists play a key role in reviewing antibiotic therapy, assessing patient stability, and recommending timely IV-to-PO conversion. The overall conversion rate of 71.4% in the intervention group demonstrates that when clinical pharmacists are actively involved in clinical decision-making, a majority of patients can safely transition to PO therapy, thereby reducing unnecessary IV exposure and optimizing hospital resource utilization.

Multivariate analysis further confirmed that clinical pharmacist intervention (OR = 80.99; $p < 0.001$) was the strongest predictor of successful conversion, while patient age ($p = 0.038$) also significantly influenced the likelihood of switching. These findings are consistent with prior research indicating that pharmacist-driven monitoring is crucial for successful conversion, whereas advanced age and comorbidities often lead clinicians to delay switching therapy^{9,12,18,25}.

However, despite the high conversion rate, complete conversion was not achieved in all eligible cases. The main reasons identified were:

Clinical and age-related concerns: physicians tended to be more cautious in older patients or those whose symptoms had only partially improved, fearing potential relapse or treatment failure;

Concerns about PO drug quality and bioavailability: some prescribers questioned whether PO formulations provided equivalent clinical efficacy, especially with certain cephalosporins and combination regimens;

Delays in communication between clinical pharmacists and physicians: due to high workloads or non-overlapping shifts, some conversion opportunities were missed before patient discharge.

These barriers are consistent with reports from other AMS programs that cited prescriber hesitation, perception of drug efficacy, and workflow inefficiencies as key obstacles to universal IV-to-PO switching^{9,12,26}. Strengthening interdisciplinary communication, ensuring confidence in PO antibiotic quality, and continuous education on conversion criteria may further improve conversion rates in future implementations.

Limitations and Future Perspectives

This study has several limitations. It was conducted at a single private general hospital, limiting generalizability. The relatively small sample size and focus on CAP may not represent other infection types or healthcare settings. Furthermore, post-discharge outcomes, such as readmissions or antimicrobial resistance trends, were not assessed. Because the study was conducted within a single ward, it was not possible to completely prevent participants from being aware of the study, which may have introduced bias. Future multicenter, longitudinal studies should evaluate the long-term sustainability of IV-to-PO protocols and explore digital decision-support tools integrated into EMR systems to automate physician alerts.

Despite these limitations, our findings contribute meaningful real-world data supporting clinical pharmacist-led IV-to-PO interventions as a cost-effective and safe strategy for optimizing antibiotic therapy in Vietnam. Implementation of similar programs nationwide could enhance stewardship outcomes, improve resource utilization, and align local practices with WHO's objectives on antimicrobial resistance containment.

CONCLUSION

This study revealed that clinical pharmacist-led IV-to-PO antibiotic conversion effectively optimized antibiotic use in patients with community-acquired pneumonia. The intervention improved appropriate early switch rates, reduced hospital stay and treatment costs, and maintained clinical efficacy. Clinical pharmacist involvement appears to be a practical and valuable strategy to enhance rational antibiotic use, resulting in positive outcomes for both patients and healthcare providers.

AUTHOR'S CONTRIBUTION

Cuong Nguyen Van: Conceptualization, Methodology, Randomization (sequence generation), Data curation, Validation, Writing – review & editing.

Phat Tran Vinh: Investigation (clinical pharmacist interventions), Supervision, Validation, Software.

Huong Ta Nguyen Thao: Visualization, Writing – original draft

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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