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Original research paper

# Impact of clinical pharmacist counselling at discharge on adherence to oral antibiotics: A pilot study

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ABSTRACT

Antibiotic resistance is a growing global health threat, with patient non-adherence to prescribed antibiotic regimens representing an important contributing factor. This prospective interventional study investigated the impact of clinical pharmacist counselling at hospital discharge on adherence to oral antibiotic therapy. The study was conducted at the Department of Nephrology and Endocrinology, General Hospital "Dr. Tomislav Bardek", Koprivnica, between March 2022 and July 2025. A total of 98 participants aged ≥18 years who were prescribed oral antibiotics at discharge were randomised into intervention (counselling) and non-intervention groups. Baseline socio-demographic and clinical data were collected, and adherence was assessed following treatment completion using a structured questionnaire developed by the authors. Of the 98 participants, 94 were included in the final analysis. Non-adherence was significantly lower in the intervention group, compared to the non-intervention group (2.1 % *vs.* 36.2 %, $p < 0.001$). Urinary tract infections represented the most common indication for antibiotic therapy, with ciprofloxacin and amoxicillin-clavulanic acid being the most frequently prescribed medicines. This study demonstrates that pharmacist-led discharge counselling markedly improves adherence to short-term antibiotic therapy. These findings provide preliminary evidence supporting integration of clinical pharmacists into hospital discharge processes to promote rational antibiotic use and combat antimicrobial resistance.

*Keywords:* antibiotics, adherence, clinical pharmacist, hospital discharge, antibiotic resistance

## INTRODUCTION

Antibiotic resistance represents a global and rapidly escalating challenge, contributing to increased mortality and prolonged hospitalisations (1, 2).

According to the 2023 report from the European Centre for Disease Prevention and Control (ECDC), one-third of *Klebsiella pneumoniae* isolates and nearly half of *Escherichia coli*

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isolates in Europe were resistant to at least one class of antibiotics (3). Resistance of *Pseudomonas aeruginosa* to carbapenems, piperacillin/tazobactam, and ceftazidime has risen significantly, as has vancomycin resistance in *Enterococcus faecium.* Encouragingly, resistance of *Acinetobacter* spp. to carbapenems has declined over the past two years (3).

Beyond the direct clinical implications, antibiotic resistance places a considerable financial burden on healthcare systems (1, 4). In 2009, the ECDC and the European Medicines Agency (EMA) estimated that the combined costs of hospitalisations, medications, and productivity losses associated with resistance reached approximately 1.5 billion euros annually in Europe (5). In the United States, more recent estimates supported by the Centres for Disease Control and Prevention (CDC) indicate that multidrug-resistant bacterial infections among hospitalised patients accounted for an additional 4.6 billion U.S. dollars in healthcare expenditures in 2017 (6). Projections by the World Bank indicate that antimicrobial resistance could cause a decline in the global annual gross domestic product (GDP) by 2050 (7).

Besides its association with increased mortality and prolonged hospital stays, antimicrobial resistance has additional significant clinical consequences, such as challenges in antibiotic prophylaxis, more frequent intensive care unit admissions, and treatment difficulties, particularly in immunocompromised patients (8).

The World Health Organization's (WHO's) 2022 Global Antimicrobial Resistance and Use Surveillance System report highlights that the primary drivers of antimicrobial resistance are excessive and inappropriate antibiotic use in the human population (9). Among the diverse strategies to mitigate resistance, improving patient adherence to prescribed antibiotic regimens is a crucial but often overlooked component. Hospital discharge represents a particularly vulnerable transition point, when patients are frequently prescribed new medications. This added complexity may increase the risk of non-adherence. A prospective cohort study conducted in Australia reported that 39.7 % of participants were non-adherent after hospital discharge, while a similar Canadian study found that 28 % of patients did not fill new prescriptions within seven days of discharge, and 24 % did not do so within thirty days (10, 11). Antibiotics were among the newly prescribed medications in this cohort (11). In a global study on antibiotic adherence for acute outpatient infections conducted across eleven countries, non-adherence rates ranged from 9.9 to 44 % (12), whereas a French non-interventional study found a 43.2 % non-adherence rate to antibiotic therapy post-discharge (13). Collectively, these findings underscore the frequency of non-adherence and emphasise the need for patient education at the time of discharge.

While adherence research predominantly addresses chronic therapies, adherence to short-term antibiotic regimens is equally important. Even minor deviations in antibiotic use can lead to therapeutic failure, recurrent infections, and the emergence of resistance (14). The transition from inpatient to outpatient care is a particularly vulnerable period, especially when oral antibiotics are prescribed or switched from parenteral at discharge. Patients may face barriers such as insufficient understanding of the prescribed regimen, limited awareness of the importance of completing therapy, or confusion about dosing instructions. Clinical pharmacist counselling at discharge can address these challenges through individualised education, clarification of the treatment plan, and reinforcement of adherence (15).

To date, and to the best of our knowledge, no studies have investigated this approach in Southeast Europe, a region characterised by high antibiotic consumption and consider-

able antimicrobial resistance rates. In particular, Koprivnica-Križevci County, Croatia, where antibiotic prescribing remains common, provides a relevant setting to explore interventions aimed at improving rational use. As a preliminary investigation, this pilot study was designed to provide initial evidence on the potential benefits of clinical pharmacist counselling at discharge and to inform the design of larger interventional studies.

## EXPERIMENTAL

### *Participants*

This prospective interventional study was conducted at General Hospital "Dr. Tomislav Bardek" Koprivnica, between March 2022 and July 2025, until a total of 98 participants were recruited. Identification of patients for inclusion in the study was conducted using the hospital information system (BIS) and information obtained from the ward. The study included participants hospitalised at the Department of Nephrology and Endocrinology aged 18 years or older who were prescribed oral antibiotics at hospital discharge. Exclusion criteria included patients who were not prescribed oral antibiotics, those younger than 18 years, patients unable to communicate verbally, individuals without a telephone, and those who declined to sign informed consent. After identifying participants who met the inclusion criteria, they were provided with comprehensive information about the study, including its type, objectives, potential benefits and risks, the right to decline participation, data collection and confidentiality. Informed consent was obtained from all participants prior to study enrolment.

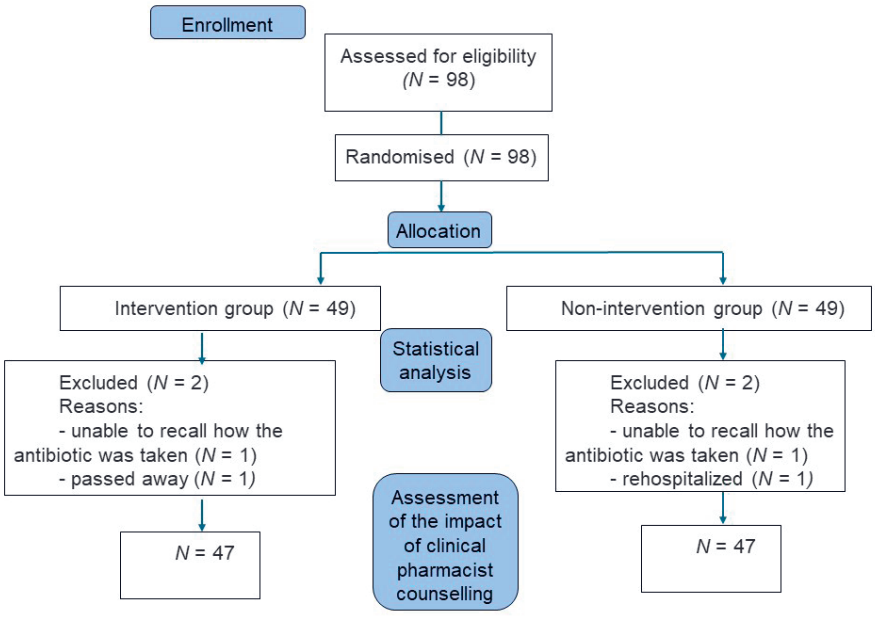


Fig. 1. Randomisation flowchart.

## *Methods*

Participants who met the eligibility criteria for the study were randomised prior to completing the questionnaire by the same pharmacist who was conducting the counselling. They were randomly assigned in equal numbers to the intervention or non-intervention group using the Study Randomizer software, resulting in 49 participants (50 %) per group (16). The intervention group received clinical pharmacist counselling, while the non-intervention group did not. Randomization flowchart is presented in Fig. 1. Participants from both the intervention and non-intervention group were informed of the follow-up phone call and completion of the post-discharge questionnaire.

### *Pre-discharge data collection*

Prior to hospital discharge, socio-demographic and clinical data were collected using a pre-discharge questionnaire developed for the purposes of this pilot study, patient interviews, and review of medical documentation in BIS. In addition, adherence to chronic therapy was assessed using the Medication Adherence Report Scale (MARS-5) developed by Rob Horne and used with his permission (17).

The pre-discharge questionnaire administered during hospitalisation consisted of 23 questions divided into three parts. It was developed by the authors and is presented in Fig. 2. The first part gathered socio-demographic information including gender, education, occupation, living arrangements, alcohol, cigarettes and drugs consumption, comorbidities, and chronic therapy data prior to hospitalisation, as well as details of the antibiotic prescribed at discharge (generic name, indication, dosage, dosing interval, and duration of therapy). The second part assessed patients' attitudes and opinions toward antibiotics, and the third part measured adherence to chronic therapy using the MARS-5 scale. As the MARS-5 scale was administered during hospitalisation, when the medications were administered by nursing staff, participants may not have been fully aware of the specific therapies they were receiving. Therefore, before administering the questionnaire, the clinical pharmacist explained to all participants that the MARS-5 questions, presented as question 23 in the pre-discharge questionnaire, referred to the patient's chronic medications. This clarification ensured consistent interpretation and minimised the risk of confusion. The participants completed the questionnaire with the assistance of the clinical pharmacist. Before administering the questionnaire, the clinical pharmacist introduced and explained its purpose to each participant, ensuring that all questions were clearly understood. Participants then completed the questionnaire independently, without any guidance that could influence their responses. The pharmacist's role was strictly limited to clarifying terminology and procedural details (*e.g.*, medication names and dosing schedules) if patients expressed uncertainty. This approach ensured a consistent understanding across participants while minimising potential interviewer bias.

### *Intervention*

Intervention employed clinical pharmacist counselling services providing patient-specific advice, education and guidance on appropriate medication use. Counselling was conducted by a clinical pharmacist, who first reviewed the discharge summary in the BIS to confirm the prescribed antibiotic, dosage, dosing interval, and treatment duration. For par-

1. Date_____
2. Full name / phone number
_____
3. Gender M F
4. Age _____
5. Employment status:
a) Employed b)
Unemployed c) Retired d)
Student e) Other _____
6. Education level:
a) University degree b) Bachelor degree c)
High school diploma d) Primary school
7. Do you live: a) alone b) with family
8. Do you consume:

- Alcohol? YES NO
- Cigarettes? YES NO
- Drugs? YES NO

9. What illnesses do you have?
_____
_____
10. How many medications do you take daily?
_____
11. Prescribed oral
antibiotic YES NO
12. Generic name of
antibiotic _____
13. Diagnosis for which the antibiotic was
prescribed _____
_____
14. Dosing regimen:
a) < 7 days b) 7-10 days c) 10-14 days d)
> 14 days e) other _____
a) QD (once daily) b) BID (twice daily) c)
TID (three times daily) d) QID (four times
daily) e) other _____
15. Expected start and end dates of antibiotic use
16. Clinical pharmacist
counseling YES NO
17. How confident are you that the treatment will
have a positive effect on your health?
a) Not confident at all
b) Mostly not confident
c) Mostly confident
d) Completely confident
e) Don't know
18. How often do you notice any side effects from
the medication?
a) Once a week
b) A few times a month
c) Once a month
d) Once every six months
e) Once a year
f) No medication side effects experienced
19. In your opinion, can an infection be cured just
as well without antibiotics as with antibiotics?
a) Strongly disagree
b) Mostly disagree
c) Mostly agree
d) Completely agree
e) Don't know
20. In your opinion, are antibiotics toxic?
a) Strongly disagree
b) Mostly disagree
c) Mostly agree
d) Completely agree
e) Don't know
21. In your opinion, will antibiotics improve your
quality of life?
a) Strongly disagree
b) Mostly disagree
c) Mostly agree
d) Completely agree
e) Don't know
22. Taking antibiotics represents a significant
burden to you compared to the positive effects
they may produce?
a) Strongly disagree
b) Mostly disagree
c) Mostly agreed) Completely agree
e) Don't know

23. *Medication Adherence Report Scale, MARS-5*
© Professor Rob Horne

| | Never = 5 | Rare = 4 | Sometimes = 3 | Often = 2 | Always = 1 |
|---|---|---|---|---|---|
| 1. Patient takes less medicines than prescribed | | | | | |
| 2. Patient stops his/her medicines | | | | | |
| 3. Patient misses out a dose of the medicine | | | | | |
| 4. Patient alters the dose of medicines | | | | | |
| 5. Patient forgets to take his/her medicines | | | | | |

Score _____

Fig. 2. Pre-discharge questionnaire for socio-demographic characteristics, comorbidities, attitudes towards antibiotics, and chronic therapy adherence.

ticipants in the intervention group, the pharmacist explained the importance of taking the antibiotic exactly as prescribed, discussed potential consequences of inappropriate use (such as reinfection, rehospitalisation, or resistance), clarified the method of administration (dose, interval, duration), outlined possible side effects, and answered any patient questions regarding therapy. The intervention was performed before completing the pre-discharge questionnaire. The non-intervention group did not receive any clinical pharmacist counselling and were discharged according to the hospital's usual care protocol.

## *Post-discharge data collection*

After discharge, all participants were contacted by telephone within ten days of completing the prescribed antibiotic therapy to assess adherence. This time frame allowed for flexibility in scheduling follow-up calls based on patient availability and researcher workload, while ensuring a timely assessment to minimise recall bias. All calls were conducted by the same clinical pharmacist, ensuring uniformity in data collection and minimising interviewer bias. Due to the lack of a standardised tool for the assessment of adherence to short-term antibiotic therapy, a short and easy-to-use questionnaire was developed by the authors (Fig. 3). Unlike the MARS-5, a validated and widely used tool for the assessment

AFTER HOSPITALIZATION (and completion of the prescribed antibiotic therapy)

1. Did you contact your primary care physician to obtain the antibiotic prescribed in the hospital?
   YES NO

2. How many units (tablets, capsules, spoonfuls of syrup, etc.) of the antibiotic did you take per dose?
   _____
   (*e.g., if the antibiotic is dosed as 2 x 2 tablets, then 2 tablets must be taken per dose)

3. How many units (tablets, capsules, spoonfuls of syrup, etc.) of the antibiotic did you take per day?
   _____
   (*e.g., if the antibiotic is dosed as 2 x 2 tablets, then 4 tablets must be taken per day)

4. For how many days did you take the antibiotic?
   a) < 7 days b) 7-10 days c) 10-14 days d) > 14 days e) other _____

5. When did you finish taking the antibiotic? _____

6. How many units (tablets, capsules, spoonfuls of syrup, etc.) of the antibiotic remained?
   _____

7. Did you experience any side effects during antibiotic treatment? If yes, please specify?
   _____

8. If you stopped taking the antibiotic before the scheduled end of therapy or did not take it according to the physician's instructions, please state reasons for non-adherence:
   _____

Date _____

Signature _____

Fig. 3. Post-discharge (follow-up) questionnaire for assessing adherence to prescribed oral antibiotic therapy.

of adherence to chronic therapy, this tool was specifically designed to capture adherence behaviours relevant to short-term antibiotic use after discharge. The questions were formulated to address concrete elements of adherence behaviours, such as prescription collection, dosing, duration, and completion of therapy, rather than broader attitudes or reasons for non-adherence. This focus reflects the study aim of assessing whether clinical pharmacist counselling effectively reinforced adherence behaviour after discharge. The full questionnaires used during hospitalisation (Fig. 2) and post-discharge (Fig. 3) are included in the manuscript to facilitate reproducibility. The questionnaires were originally developed in Croatian and subsequently translated into English for the purpose of this publication, ensuring no loss of meaning.

### *Outcome measures*

Participants were considered adherent only if they fully complied with the prescribed antibiotic regimen. They were classified as non-adherent if they missed any doses, extended or shortened treatment duration, altered the prescribed dose, or otherwise deviated from the discharge instructions. Because antibiotic therapy is of short duration compared to chronic therapy, even minor deviations may contribute to resistance, complications, or rehospitalisation. Literature demonstrates that prolonged exposure to low antibiotic concentrations promotes the emergence of resistant strains (18). Studies on acute antibiotic therapy have defined adherence as strict compliance with physicians' recommendations (12, 19).

### *Ethics considerations*

The study was approved by the Ethics Committee of the General Hospital "Dr. Tomislav Bardek" Koprivnica (KLASA: 053-02/22-01/3, UR.BROJ: 2137-84-01-22-02) and the Ethics Committee for Experimental Work at the Faculty of Pharmacy and Biochemistry, University of Zagreb (KLASA: 643-02/22-03/01, UR.BROJ: 251-62-03-22-47).

All participants had the right to refuse participation at any point during the study. All collected data were handled in accordance with data protection standards, ensuring participant anonymity and confidentiality. The study procedures followed all applicable ethical guidelines and regulations. All participants provided written informed consent prior to inclusion in the study.

### *Statistical analysis*

Data were analysed using IBM SPSS software® (20). As this was a pilot study, no formal sample size calculation was conducted. Descriptive statistics summarised all allocated participants' general characteristics. The main outcome analysis was conducted on the 94 participants for whom data on adherence were available. The research hypothesis was tested using the chi-square ($\chi^2$) test. The statistical significance was set at $p < 0.05$.

## RESULTS AND DISCUSSION

The study population mainly consisted of older adults, with a median age of 70 years (interquartile range [IQR] 62–76). Demographic characteristics are presented in Table I.

As expected in this age group, most participants had multiple comorbidities, with a median of 2 comorbidities (IQR 1–3). More than half of the participants (55.1 %) were using five or more medications, indicating polypharmacy. According to the WHO, polypharmacy is commonly defined as the routine use of five or more medications (21). The median number of prescribed medications in this study was 5 (IQR 2–8). The distribution of comorbidities and the number of described chronic medications used prior to hospitalisation are shown in Table II.

Indications for antibiotic prescription are presented in Table III. Urinary tract infections (UTIs) were the most common indication, accounting for 63.3 % of cases. These find-

*Table I. Demographic characteristics of included participants*

| Characteristics of subjects | Number of participants | | Percentage (%) | |
|---|---|---|---|---|
| | Intervention group | Non-intervention group | Intervention group | Non-intervention group |
| Gender | | | | |
| Male | 18 | 26 | 36.7 | 53.1 |
| Female | 31 | 23 | 63.3 | 46.9 |
| Education | | | | |
| Elementary school | 21 | 16 | 42.9 | 32.7 |
| High school | 23 | 27 | 46.9 | 55.1 |
| Bachelor's degree | 3 | 3 | 6.1 | 6.1 |
| Master's degree | 2 | 3 | 4.1 | 6.1 |
| Occupation | | | | |
| Employee | 7 | 9 | 14.3 | 18.4 |
| Unemployed | 2 | 1 | 4.1 | 2.0 |
| Retired | 37 | 37 | 75.5 | 75.5 |
| Student | 0 | 1 | 0.0 | 2.0 |
| Other | 3 | 1 | 6.1 | 2.0 |
| Living arrangements | | | | |
| Alone | 13 | 9 | 27.5 | 18.4 |
| With family | 36 | 40 | 73.4 | 81.6 |
| Alcohol consumption | | | | |
| Yes | 4 | 11 | 8.2 | 22.4 |
| No | 45 | 38 | 91.8 | 77.6 |
| Cigarettes consumption | | | | |
| Yes | 7 | 11 | 14.3 | 22.4 |
| No | 42 | 38 | 85.7 | 77.6 |
| Drugs consumption | | | | |
| Yes | 0 | 0 | 0 | 0 |
| No | 49 | 49 | 100 | 100 |

ings align with data from the Interdisciplinary Section for Antibiotic Resistance Control (ISKRA), which reports UTIs as the leading indication for antibiotic use (22). Consistent with this, the most frequently prescribed antibiotics were ciprofloxacin (50 %) and amoxicillin-clavulanic acid (36.7 %). According to ISKRA guidelines, amoxicillin-clavulanic acid

*Table II. Distribution of participants according to comorbidities and the number of prescribed chronic medications prior to hospitalisation*

| | Number of participants | | Percentage (%) | |
|---|---|---|---|---|
| | Intervention group | Non-intervention group | Intervention group | Non-intervention group |
| Comorbidities | | | | |
| Hypertension | 37 | 37 | 75.5 | 75.5 |
| Diabetes type 2 | 14 | 15 | 28.6 | 30.6 |
| Chronic kidney disease | 10 | 7 | 20.4 | 14.3 |
| Carcinoma | 7 | 11 | 14.3 | 22.4 |
| Atrial fibrillation | 6 | 3 | 12.2 | 6.1 |
| Anemia | 4 | 4 | 8.2 | 8.2 |
| Gastritis | 6 | 2 | 12.2 | 4.1 |
| Arthritis | 2 | 4 | 4.1 | 8.2 |
| Heart failure | 2 | 3 | 4.1 | 6.1 |
| Benign prostatic hyperplasia | 2 | 3 | 4.1 | 6.1 |
| Number of prescribed medications | | | | |
| 0 | 2 | 5 | 4.1 | 10.2 |
| 1 | 5 | 3 | 10.2 | 6.1 |
| 2 | 7 | 6 | 14.3 | 12.2 |
| 3 | 3 | 5 | 6.1 | 10.2 |
| 4 | 4 | 4 | 8.2 | 8.2 |
| 5 | 6 | 6 | 12.2 | 12.2 |
| 6 | 7 | 3 | 14.3 | 6.1 |
| 7 | 1 | 3 | 2.0 | 6.1 |
| 8 | 1 | 3 | 2.0 | 6.1 |
| 9 | 2 | 2 | 4.1 | 4.1 |
| 10 | 2 | 3 | 4.1 | 6.1 |
| 11 | 3 | 1 | 6.1 | 2.0 |
| 12 | 0 | 1 | 0.0 | 2.0 |
| 13 | 2 | 0 | 4.1 | 0.0 |
| 14 | 3 | 2 | 6.1 | 4.1 |
| 16 | 0 | 1 | 0.0 | 2.0 |
| 18 | 1 | 1 | 2.0 | 2.0 |
| Polypharmacy[a] | | | | |
| No | 21 | 23 | 42.9 | 46.9 |
| Yes | 28 | 26 | 57.1 | 53.1 |

[a] Five medications and more (20).

is the first-line therapy for UTIs in women, while ciprofloxacin is recommended as first--line treatment for complicated UTIs in men. Nitrofurantoin was the third most frequently prescribed antibiotic (14.3 %), reflecting its role in prophylaxis for recurrent UTIs (23). As ciprofloxacin, amoxicillin-clavulanic acid, sulfamethoxazole/trimethoprim, and nitrofurantoin are typically administered twice daily, most participants (84.7 %) reported this frequency of dosing (Table III).

*Table III. Distribution of participants by prescribed antibiotics*

| Participants distribution by prescribed antibiotics | Number of participants | Percentage (%) |
|---|---|---|
| Number of prescribed antibiotics | | |
| 1 | 54 | 55.1 |
| 2 | 40 | 40.8 |
| 3 | 4 | 4.1 |
| Antibiotic | | |
| Ciprofloxacin | 49 | 50.0 |
| Amoxicillin-clavulanic acid | 36 | 36.7 |
| Nitrofurantoin | 14 | 14.3 |
| Sulfamethoxazole and trimethoprim | 10 | 10.2 |
| Cefpodoxime | 6 | 6.1 |
| Cefuroxime | 5 | 5.1 |
| Metronidazole | 5 | 5.1 |
| Doxycycline | 4 | 4.1 |
| Norfloxacin | 3 | 3.1 |
| Vancomycin *p.o.* | 3 | 3.1 |
| Fosfomycin | 3 | 3.1 |
| Moxifloxacin | 2 | 2.0 |
| Cefixime | 2 | 2.0 |
| Amoxicillin | 1 | 1.0 |
| Levofloxacin | 1 | 1.0 |
| Linezolid | 1 | 1.0 |
| Duration of antibiotic therapy | | |
| < 7 days | 13 | 13.3 |
| 7–10 days | 40 | 40.8 |
| 10–14 days | 16 | 16.3 |
| > 14 days | 29 | 29.6 |
| Dosing frequency | | |
| QD | 7 | 7.1 |
| BID | 83 | 84.7 |
| TID | 5 | 5.1 |
| QID | 3 | 3.1 |

| | | |
|---|---|---|
| Indications | | |
| Urinary tract infection | 62 | 63.3 |
| Sepsis | 24 | 24.5 |
| Pneumonia | 10 | 10.2 |
| Pyelonephritis | 10 | 10.2 |
| *C. difficile* infection | 6 | 6.1 |
| Erysipelas | 3 | 3.1 |
| STD | 2 | 2.0 |

QD – once daily, BID – twice daily, TID – three times daily, QID – four times daily, *C. difficile* – *Clostridioides difficile*, STD – sexually transmitted disease

The majority of participants (40.8 %) received antibiotic therapy for 7–10 days after discharge. Considering that the average length of hospitalisation in Croatian internal medicine wards at the General Hospital Koprivnica is approximately seven days (24) and that antibiotic treatment typically lasts 10–14 days according to ISKRA guidelines, this duration was consistent with clinical practice (23). Nitrofurantoin prophylaxis for recurrent UTIs explained why nearly one-third of participants (29.6 %) had therapy extending beyond 14 days. Full distribution of prescribed antibiotics, treatment duration, dosing frequency, and indications are provided in Table III.

Adherence outcomes (available for 94 participants) are presented in Table IV. Clinical pharmacist counselling significantly improved adherence to antibiotic therapy following hospital discharge. Non-adherence occurred in 36.2 % participants in the non-intervention group compared with only 2.1 % in the intervention group ($\chi^2 = 17.591$, $p < 0.001$).

The proportion of non-adherent patients in the non-intervention group in the study was lower than reported in comparable studies. Previous non-interventional studies found non-adherence rates of approximately 43 % (25, 13). In the interventional study by Suffoletto *et al*., non-adherence was 55 % in the control group and 43 % in the intervention group, both higher than observed in our cohort (26). The discrepancy may be attributed to the smaller sample size of this pilot study and to differences in adherence assessment methods. While our study used an author-developed questionnaire, other studies employed tools such as the Morisky scale, electronic monitoring (MEMS), or pharmacy dispensing records, which may capture non-adherence differently. Self-reported questionnaires also carry an inherent risk of recall and reporting bias. Several contextual factors may further contribute

*Table IV. The distribution of participants according to adherence*

| | | Adherence to the prescribed antibiotic regimen after hospital discharge | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Clinical pharmacist counselling | NO | 17 | 30 | 47 |
| | YES | 1 | 46 | 47 |
| | TOTAL | 18 | 76 | 94 |

to the lower proportion of non-adherent patients in our non-intervention group. The study was conducted in a single regional hospital with a relatively small and closely monitored patient population, allowing for frequent patient-healthcare provider interaction and individualised discharge instructions. Most participants were comorbid older adults, more likely to be accustomed to regular medication use, potentially contributing to better adherence behaviour overall. Moreover, antibiotic prescribing at our institution strictly follows ISKRA national guidelines, which provide clear and standardised instructions regarding dosage and duration of therapy, potentially reducing misunderstandings and dosing errors after discharge. Lastly, the structured telephone follow-up within ten days of therapy completion may have encouraged a sense of accountability among participants, further supporting adherence even in the non-intervention group. These factors likely explain the lower non-adherence observed in the non-interventional group compared to larger studies involving more heterogeneous populations and less direct follow-up.

Among the 17 non-adherent participants in the non-intervention group, four (23.5 %) took a lower dose than prescribed, two (11.8 %) took a higher dose, six (35.3 %) prolonged therapy beyond the recommended duration, four (23.5 %) shortened therapy, and one (5.9 %) both reduced the dose and prolonged the duration. In the intervention group, a single participant missed one dose due to forgetfulness.

Regarding reported reasons for non-adherence, eight (47.1 %) participants in the non-intervention group could not specify a cause, two (11.8 %) prolonged therapy by consuming the entire antibiotic package, four (23.5 %) misunderstood the physician's instructions, one (5.9 %) discontinued antibiotic therapy prematurely believing the prescribed treatment period had been completed, and two (11.8 %) did not collect a new prescription from the pharmacy. In a comparable French study, half of the non-adherent patients extended antibiotic use beyond the prescribed duration, and 75 % were unable to specify reasons, which is slightly higher than observed in our cohort (13). The small sample size in both studies limits conclusions about the predominant reasons for non-adherence.

Previous non-interventional studies concluded that preventive measures, including clinical pharmacist counselling, are essential to improve adherence (25, 13). The findings of this study confirmed that pharmacist-led discharge counselling effectively enhances adherence, thereby supporting our study hypothesis. A literature review identified three relevant studies in which clinical pharmacists provided patient counselling. In one study, conducted in a tertiary care hospital, patients counselled before discharge demonstrated higher adherence to antibiotics than those in the control group who did not receive such counselling, although the difference did not reach statistical significance due to the small sample size (27). Two additional randomised studies at the pharmacy level reported significantly better adherence to antibiotics among patients who received counselling at the time of medication pickup or educational leaflets compared with the control group (28, 29). In contrast, one U.S. study using SMS reminders to prompt antibiotic pickup and dosing found no significant difference between intervention and control groups. Notably, the lack of the educational component, as discussed by Suffoletto *et al.*, may explain the absence of the effect compared with pharmacist-led counselling (26).

According to the WHO, improvement of adherence may have a greater impact on treatment outcomes than the development of new medical therapies (30). Integrating clinical pharmacists into patient care represents one effective approach to achieving this goal.

Consistent with this, a systematic review by Conn and Ruppar demonstrated that the most effective adherence interventions were those delivered directly by pharmacists (31).

This study has several strengths. To our knowledge, it is the first interventional pilot study in Southeast Europe to evaluate the impact of clinical pharmacist counselling at hospital discharge on adherence to oral antibiotic therapy. The methodology was clearly defined and reproducible, with strict eligibility criteria, randomisation, and transparent reporting of exclusions. The custom-designed adherence questionnaires are provided in full to ensure transparency. By embedding the intervention into routine hospital workflow and conducting systematic follow-up, the study reflected real-world practice, enhancing the applicability of its findings.

Several limitations should also be acknowledged. The study was conducted at a single hospital department with a relatively small sample size, reflecting its pilot design and limiting generalizability. Adherence was assessed using an author-developed questionnaire that has not been validated, which may affect the robustness of the findings. In addition, the questionnaire included only a limited number of questions addressing reasons for non-adherence, which restricted the depth of exploration of underlying causes. These issues should be addressed in future multicentre trials with sufficient power for subgroup analyses. Future studies should also combine self-reported data with objective measures such as pharmacy refill records or electronic monitoring and extend follow-up to capture clinical outcomes, including infection recurrence, hospital readmissions, and resistance development.

## CONCLUSIONS

This pilot study demonstrated that clinical pharmacist counselling at hospital discharge significantly improves patient adherence to oral antibiotic therapy, reducing non-adherence from 36.2 to 2.1 %. By integrating pharmacist-led education into routine hospital practice, the intervention addressed key behaviours to non-adherence and highlighted the pharmacist's role in promoting rational antibiotic use. Given the rates of high antibiotic consumption and resistance in Southeast Europe, these findings provide important preliminary evidence supporting the integration of clinical pharmacists into discharge processes. Larger, multicentre trials are needed to confirm these results and to evaluate their impact on clinical outcomes such as infection recurrence, hospital readmissions, and resistance development.

*Availability of data and materials.* – The data analysed in this study are available from the corresponding author upon reasonable request.

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