FJIF Vol.15, No.1, June 2025, Page: 38-45, pISSN: 2549-9068, eISSN: 2622-755X

FITOFARMAKA: Jurnal Ilmiah Farmasi

(FJIF)

https://fitofarmaka-fmipa.unpak.ac.id

Research Article

The Effect of Antibiotics on Leukocyte in Patients with Urinary Tract Infections

Annis Rahmawaty[1], Sekar Kinasih[1], Yulia Pratiwi[1], Rifda Naufa Lina[2], Sri Suwarni[3], Mohd Nadzri Mohd Najib[4]

[1]Diploma of Pharmacy, Institut Teknologi Kesehatan Cendekia Utama Kudus, Kudus, Indonesia.
[2]Universitas Negeri Semarang, Indonesia
[3]Diploma of Pharmacy, Sekolah Tinggi Ilmu Farmasi Nusaputera, Semarang, Indonesia.
[4] Faculty of Pharmacy, Universiti Teknologi MARA, Malaysia

annisnis24@gmail.com

https://doi.org/10.33751/jf.vxxix.xxxx

Article info:

Submitted : 06-02-2025
Accepted : 06-28-2025
Published : 06-30-2025

Published by:
Universitas Pakuan

ABSTRACT

Urinary tract infections (UTIs) are defined as urine contamination caused by microorganisms in the urinary tract. Characterized by symptoms of fever, chills, malaise, and low back pain, often accompanied by frequency, urgency, and urethral pain during urination. The use of antibiotics can reduce the number of leukocytes in patients with UTIs. The purpose of this study was to determine the effect of antibiotics on leukocytes in Patients with UTIs. This study used a descriptive observational (non-experimental) design with a total sampling technique involving 34 patients. Data were analyzed using the non-parametric Wilcoxon test. The results of this study showed that the largest number was in the age range of 56-65 years as many as 9 patients (25.7%), with the same number of male and female genders, namely 17 patients (50%), the results of the distribution of drug use showed the highest frequency of using Cefuroxime antibiotic therapy as many as 18 patients (52.9%), Cefixime as many as 1 patients (2.9%), Ceftriaxone as many as 9 patients (26.5%), Cefotaxime as many as 4 patients (11.8%) and Ampicillin therapy as many as 2 patients (5.9%). The results of the Wilcoxon test showed that there was a difference in the number of leukocytes before and after antibiotic therapy was given to patients with Urinary Tract Infection. Significant results with a p-value of 0.000 ($p \leq 0.05$), which can be interpreted that there is a significant effect. The conclusion is that there is an effect of antibiotics on leukocytes in Patients with UTIs

Keywords: antibiotic; cephalosporine; leukocytes; penicillin; urinary tract infections

INTRODUCTION

Infection occurs when the pathogens coercively enter, multiply, and produce toxins in the host for their survival (Yang *et al*., 2022). Urinary tract infections (UTIs) is an infection that involves the urinary tract, including the kidneys, ureters, bladder and urethra (Kemenkes RI, 2022). UTIs are also the second-most common with a frequency of 25% among all the infectious diseases (Foxman, 2014). UTIs is an exceedingly common type of bacterial infection that affects healthy individuals and those with comorbidity, Most UTIs are caused by *E. Coli* (Mandal *et al*., 2012). UTIs occur when bacteria from the bowel make their way into the bladder. A germ (bacterium) called *Escherichia coli* (*E. coli*) is responsible for up to 9 in 10 of all UTIs. Other bacteria from UTIs like *streptococci, klebsiella, and Proteus mirabilis*, and even fungi (Vakharia and Tiddy, 2023).

UTIs are caused by bacterial invasion of the urothelium of the bladder, bacteria migrating from the rectum, and colonization of bacteria from the perineum and vagina (Li and Leslie, 2023). The urinary tract, from the kidneys to the urethral meatus, is normally sterile and resistant to bacterial colonization despite frequent colonic bacteria. The major defense against UTI is complete emptying of the bladder emptying. Other mechanisms that maintain the tract's sterility include urine acidity, the vesicoureteral valve, and various immunologic and mucosal barriers (Imam, 2023).

Trigger factors that can cause UTIs include gender, family history, urological disease, age, and metabolic disease (Herlina and Mehita, 2019). UTIs are common health problems in primary health-care facilities and emergency departments (EDs), affecting men and women of all ages (Alanazi, 2018). The infection does not seem particularly severe, especially in the early stages, but it can worsen significantly in the presence of complicating factors that are involved in the progression of UTI are biofilms, urinary stasis due to obstruction, and catheters (Zagaglia *et al*., 2022).

UTIs is one of the most common community-acquired infections, and agents such as fluoroquinolone and co-trimoxazole are commonly used for the treatment of UTIs (Sharmin *et al*., 2022). European Association of Urology (EAU) recommendations for antibiotics commonly used as initial therapy for UTI in general are fluoroquinolones, cephalosporins, aminoglycosides, and Trimethoprim-sulfamethoxazole (Bonkat *et al*., 2021).

The prevalence UTIs being among the most common diseases across the world, Prevalence of UTI was 33.54 % of which 66.78 % were females and 33.22% were from males. High prevalence was observed in females as compared to males (2:1). Prevalence was high in old aged (>45 years) patients (Pardeshi, 2018). More than 404.6 million (359.4–446.5) individuals had UTIs globally and nearly 236,786 people (198,433–259,034) died of UTIs (Zeng *et al*., 2022).

Leukocytes are an important part of the body's defense system that is useful for fighting microorganisms that cause infections, tumor cells, and dangerous foreign substances. Leukocytes function to protect or become the body's defense against infection and kill mutated cells (Ferdhyanti, 2019). Leukocyte casts in the urinary sediment can help localize the area of inflammation to the kidney. Increased leukocytes in urine can indicate UTI, Leukocyte count with a detection threshold of 5-15 WBC (Chu dan Lowder, 2018).

Leukocyte esterase that points to the presence of white blood cells, typically related to an infection. An absence of leukocyte esterase in the urine means that the urine is not likely to contain white blood cells, so it is not likely to be carrying infectious agents (Rotker, (2023). The leukocyte esterase test has a sensitivity and specificity of 79% and 82%, respectively, for detecting bacteriuria (Dipiro, 2017). UTI diagnosis could be made more accurately using leukocyte esterase, nitrite positivity, and the presence of leukocyte clusters. antibiotic resistance should be considered before starting empirical antibiotics (Başer *et al*., 2020).

Most patients with lower UTI in primary care (85.7%) receive same-day empirical antibiotic therapy with little treatment diversity, Urinary tract infections (UTIs) are major drivers of antibiotic prescribing in primary care. Inappropriate antibiotic prescribing for UTIs likely drives antibiotic resistance (Rodriguez *et al*., 2019). Amoxicillin or oral cephalosporins are advised for second or third-line therapy for pregnant women and children aged 3 months or more, and The choice of second-line antibiotic therapy in adult men should be guided by culture results after considering alternative diagnoses to UTIs (NICE, 2018).

A clinical study that compared third- and fourth-generation cephalosporins—specifically intravenous cefotaxime/sulbactam and cefepime/tazobactam—among 60 adult patients with UTIs found both treatments to be highly effective and well-tolerated. The bacteriological cure rates were 86.5% and 93.3% respectively, and nearly all patients experienced full symptom relief by day 10 (Kaur *et al*., 2014). In a separate study from Japan focusing on women with uncomplicated cystitis, oral cefaclor (750 mg daily for 5–7 days) also demonstrated strong clinical and microbiological outcomes. Most patients showed complete resolution of urinary symptoms and normalization of pyuria, indicating its continued usefulness in outpatient settings (Wisutep *et al*., 2023). Backing up these findings, a 2022 review that looked at eight different studies—including several randomized trials—showed that first-

to fourth-generation cephalosporins consistently delivered strong clinical and microbiological outcomes in cases of uncomplicated acute pyelonephritis. Their effectiveness was found to be on par with more commonly used treatments like fluoroquinolones and trimethoprim-sulfamethoxazole (TMP–SMX), suggesting that cephalosporins remain a reliable and effective option for managing these infections (Dasgupta-Tsinikas *et al*., 2022). The purpose of this study was to determine the effect of antibiotics on leukocyte in patients with urinary tract infections (UTIs).

METHODS

This study used a descriptive observational design with a cross-sectional approach. Data were collected retrospectively from the medical records of patients with urinary tract infections (UTIs) at Aisyiyah Kudus Hospital. Using a total sampling technique, 34 patients were included based on pre-determined inclusion criteria. The sample consisted of patients diagnosed with UTIs who had recorded laboratory results for leukocyte. Sample size can be calculated as follows:

$$n = \frac{50\ (population)}{1+50(0.1)^2} = 33.3\ (sample) \quad \text{.....(1)}$$

The main variable studied was the use of antibiotics in UTI patients (independent variable), while the outcome measured was the number of leukocytes (dependent variable). Additional control variables included age, gender, length of hospitalization, and body temperature. Inclusion criteria required inpatient medical records of patients diagnosed with UTIs without comorbid conditions, who received antibiotic therapy and had available leukocyte and body temperature data. Exclusion criteria involved records of UTI patients with comorbidities, those who did not receive antibiotics, or lacked the necessary lab data.

Data analysis used the Wilcoxon Test, which is a type of non-parametric test to measure the significance of the difference between 2 groups of paired data that are not normally distributed. The time of leukocyte examination for each patient was carried out before and after antibiotics were given at different times. The purpose of the Wilcoxon Test is to determine whether there is a significant difference in the number of leukocytes before and after antibiotic therapy, thus indicating that it has a significant effect on the results.

RESULTS AND DISCUSSION

The data obtained in this study came from 34 patients based on the inclusion criteria. Patient characteristics can be seen in the following Table 1. Patient characteristics based on age with the highest frequency in the age range of 56-65 years as many as 9 patients (25.7%). This shows that most UTI patients are in the late elderly age of 56-65 years. Data from this study shows that the age range of 56-65 years is more due to low immunity and decreased urinary tract function due to aging of body cells and comorbidities placing the elderly in a more vulnerable position so that they tend to be more susceptible to UTI so that age is also a risk factor for UTI in addition to gender and congenital diseases.

Table 1. Patient Characteristics

Age (Year)	Frequency	(%)
26-35	8	23.5
36-45	8	23.5
46-55	7	20.0
56-65	9	25.7
>65	2	5.7
Gender		
Male	17	50.0
Female	17	50.0
Length of Hospitalization (Day)		
2	2	5.9
3	13	38.2
4	13	38.2
> 4	6	17.6
Total	**34**	**100.0**

UTIs are significantly more common in adult women than men, possibly because of their shorter urethra, which permits easier passage of bacteria from the intestine. Women aged 55–75 years are reported to have an overall incidence of UTI at 7 cases per 100 person-years (Ahmed et al., 2018). UTIs are common in the elderly and cover a range of conditions from asymptomatic bacteriuria to urosepsis. Risk factors for developing symptomatic UTIs include immunosenescence, exposure to nosocomial pathogens, multiple comorbidities, and a history of UTIs (Matthews and Lancaster, 2011). The age range of 56-65 years is more due to low immunity and decreased urinary tract function due to aging of body cells and comorbidities placing the elderly in a more vulnerable position so that they tend to be more susceptible to UTI so that age is also a risk factor for UTI in addition to gender and congenital diseases (Rodriguez, 2020).

The prevalence in men and women is similar. Most of the research on UTI has focused on sexually active women who are at high risk for developing an infection. Other important UTI risk determinants in selected age groups include anatomic and physiologic factors, such as obstructing lesions and estrogen deficiency; genetic factors, such as blood group secretor status; antibiotic exposure; functional status; and possibly receptive anal intercourse and HIV infection (Harrington and Hooton, 2020). The incidence of UTI in men and women is the same because the anatomy of the female urethra has a short urethra of 2-3 cm so that contaminating bacteria can more easily enter the urinary tract, while in men it is caused by narrowing of the urethra (stricture) due to prostatitis, inflammation of the prostate gland (Yuliani & Futriani, 2022).

Non-pregnant women and men with an uncomplicated lower urinary tract infection (UTI) are prescribed a 3-day course of antibiotics. The shortest course likely to be effective should be prescribed to reduce the risk of antimicrobial resistance and adverse effects. Short (3-day) courses of antimicrobials are sufficient for treating uncomplicated lower UTIs in non-pregnant women. They also minimise the risk of adverse events and antimicrobial resistance (NICE, 2023). For longer duration for UTIs, effective in both inpatients and outpatients with 3-day therapy is generally accepted. Shortening the duration of therapy limits antibiotic exposure, reducing resistance and harm to the patient (Elajouz *et al*., 2022).

The highest frequency of length of hospitalization was 3 days and 4 days, namely 13 patients (38.2%). This is because the performance in the use of antibiotics occurred for at least 3 days, so that patients in this study experienced improvement within 3 days. The results of this study are based on research conducted by Hartanti *et al*. (2020) that UTI patients were hospitalized for an average of 3-4 days, most UTI patients without complications so they went home in better condition.

The duration of antibiotic treatment administration must be considered so that it can kill the bacteria that cause the infection and not cause the disease to recur (Gupta *et al*., 2021). The use of antibiotics for too short a period of time can cause antibiotic resistance. Antibiotic resistance is a condition when bacteria, viruses, and fungi cannot be killed by antibiotics, so that bacteria become immune to antibiotics. The use of antibiotics for too long can cause germs to experience resistance or immunity (Dipiro, 2017).

Distribution of therapy use in UTI patients is as follows can be seen in the following table 2. The highest frequency was found in using the antibiotic Cefuroxime, namely 18 patients (52.9%) from 34 data patients.

Table 2. Distribution of Drug Use in UTI Patients

Drug classes	Drugs	Dose (g)	Frequency	(%)
Cephalosporin	Ceftriaxone IV	1.0	9	26.5
	Cefotaxime IV	1.0	4	11.8
	Cefixime Oral	0.2	1	2.9
	Cefuroxime IV	1.0	18	52.9
Penicilin	Ampicilin IV	1.0	2	5.9
Total			**34**	**100.00**

Antibiotics are one of the classes of drugs that are often used in patients with urinary tract infections. This is because UTI patients are very susceptible to infection due to obstacles in the excretion of bacteria from the body, either due to decreased clearance or obstruction in the urinary tract (Kurniasari *et al*., 2020). Cephalosporin antibiotics is more often used for UTI patients. This is because cephalosporins are broad-spectrum antibiotics that can be used by patients diagnosed with UTI. The cephalosporin groups used by patients in this study include second and third generation cephalosporins.

According to this research table, the most frequently used cephalosporin group is cefuroxime. Cefuroxime is a second-generation cephalosporin group that is inactivated by beta-lactamase so that it is active against certain bacteria that are resistant to other antibiotics (BNF, 2019). Cefuroxime is most commonly given by injection, although oral forms such as cefuroxime axetil are also available. The mechanism of cefuroxime is by binding to penicillin-binding proteins and inhibiting the final transpeptidase step of peptidoglycan synthesis, leading to cell death. Side effects of cefuroxime use include diarrhea, decreased hemoglobin or hematocrit, rash, nausea, vomiting, anemia, epidermal necrolysis, nephritis, and abdominal cramps (Medscape, 2025).

The choice of antibiotics for treating urinary tract infections (UTIs), including cefuroxime, can influence how long a patient stays in the hospital. Cefuroxime, a broad-spectrum antibiotic, is often used in hospitalized patients because it's effective against a wide range of bacteria, including some that are resistant to other drugs. However, its use is often linked to more complicated cases situations where patients are sicker or oral antibiotics aren't an option which naturally leads to longer hospital stays. Research by Zhang (2023) found that while cefuroxime works just as well as first-line oral treatments in clearing infections, it tends to be given in more serious cases. Lee (2022) also pointed out that starting with broad-spectrum antibiotics without narrowing treatment later can stretch out hospital time. The leukocytes laboratories before and after antibiotic therapy was given to patients with Urinary Tract Infection showed Table 3.

Based on the results of this study, a p-value of 0.000 or p-value ≤ 0.05 was obtained, so it can be said that there are significant results on the number of leukocytes before and after antibiotic therapy. This is indicated by the difference in the number of patient leukocytes before being given antibiotic therapy, which is on average high. After therapy, the number of patient leukocytes decreased. So this can illustrate that the desired therapy for infection with the use of antibiotics is fulfilled or can be said to be effective. The decrease in leukocytes is known through laboratory test results that have improved compared to before with the normal limit of leukocytes at 5,000 cells/µL to ≤ 10,000 cells/µL. The decrease in the number of leukocytes occurs because antibiotics can effectively kill microorganisms that cause infections that have attacked the body.

Leukocytes are one of the diagnostic parameters in the event of infection, especially in cases of Urinary Tract Infections. Because leukocytes function as protection or a body defense to fight infection and kill cells that undergo mutation. When bacteria enter the urinary tract and cause inflammation, the immune system will send leukocytes, especially neutrophils, to the area of infection to fight the pathogens. Therefore, leukocytes are indicators of infection, including UTI. And A healthy immune system factor can naturally control and eliminate mild infections without antibiotic intervention, especially in mild or asymptomatic UTIs. Once the infection is resolved, the white blood cell count will return to normal. Even though blood leukocytes are range normal, the presence of bacteria in the urine and typical symptoms remain the basis for administering antibiotics; this is taken into consideration to prevent complications from occurring in the patient.

Patients with UTI symptoms, include dysuria, urinary frequency, urgency, suprapubic pain, and hematuria, can be diagnosed for UTI, with symptoms, the presence of bacteria, leukocyte or white blood cells, nitrites, and hemoglobin or red blood cells in the urine support the diagnosis of UTI and its treatment. Screening and antibiotic therapy treatment for UTIs should be done in patients (Kendal and Mauer, 2022). Leukocytes can destroy and clean dead body cells. The normal of leukocytes is 5,000-10,000 cells/µl (Puspita & Alviameita, 2019).

Table 3. Patient Leukocytes Laboratories Before and After Antibiotic Therapy

Leukocytes	Frequency	(%)	P-Value Wilcoxon
Before			
10000 sel/µL	5	14.7	
>10000 sel/µL	29	85.3	
After			0.000
<5000 sel/µL	3	8.9	
5000-10000 sel/µL	31	91.1	
Total	**34**	**100.0**	

The results of the Wilcoxon test showed that there was a difference in the number of leukocytes before and after therapy was given to patients with UTIs. Significant results were obtained with a p-value of 0.000 or $p \leq 0.05$, so that it can be interpreted that there is a significant effect. The conclusion is that there is an effect of decreasing the number of leukocytes on antibiotic therapy in patients with UTis. A significant difference between the number of leukocytes before and after therapy can be interpreted as meaning that antibiotic therapy is effective in killing microorganisms in the body (Suharjo *et al*., 2022). The use of antibiotics that can reduce leukocyte values in UTI patients means that leukocytes in the body's defenses can fight infections in the form of bacteria and viruses (Nurhalimah *et al*., 2022).

The use of cephalosporins has been proven to be used for the treatment of UTI. First-generation cephalosporins have greater activity against gram-positive organisms, second-generation cephalosporins have activity against anaerobes. Meanwhile, third-generation cephalosporins are more potent against gram-negative organisms obtained from the community and other nosocomial β-lactam antimicrobials (Wein *et al.*, 2016).

CONCLUSION

The conclusion is Treating urinary tract infections (UTIs) with the right antibiotics can make a real difference in how the body responds, especially in reducing leukocytes that signal infection. As the antibiotics work to fight off the bacteria, the number of leukocytes, particularly neutrophils, usually starts to return to normal, which is a good sign that the patient is getting better. Keeping an eye on these cell levels before and after treatment can help determine how well the therapy is working. The patient's immune system and whether the bacteria are resistant to the antibiotics can all affect how quickly someone recovers.

REFERENCES

Ahmed H, Farewell D, Jones HM, Francis NA, Paranjothy S, Butler CC. (2018). Incidence and antibiotic prescribing for clinically diagnosed urinary tract infection in older adults in UK primary care, 2004–2014. PLoS One. 13(1):e0190521. doi: 10.1371/journal.pone.0190521

Alanazi M.Q. (2018). An evaluation of community-acquired urinary tract infection and appropriateness of treatment in an emergency department in Saudi Arabia. *Ther Clin Risk Manag*. 14:2363–73. doi: 10.2147/TCRM.S178855.

Başer A, Yilmaz A, Başer HY, Özlülerden Y, Zümrütbaş AE. (2020). Which patient should start empirical antibiotic treatment in urinary tract infection in emergency departments? *Turk J Emerg Med*. 20(3):111-117. doi: 10.4103/2452-2473.290064. PMID: 32832730; PMCID: PMC7416856.

British National Formulary (BNF). 2019. *British National Formulary*, ed. 76th. England: Royal Pharmaceutical Society.

Bonkat, G., Bartoletti, R., Bruyere, F., Cai, T., Geerlings, S.E., Konves, B., Schubert, S., Pilatz, A., Verratterapillay, R. and Wagenlenher. (2021). *EAU Guidelines on Urological Infections*. Eropa: European Association of Urology.

Chu C. M., and Lowder J. L. (2018). Diagnosis and treatment of urinary tract infections across age groups. Am. J. Obstet. Gynecol. 219, 40–51. doi: 10.1016/j.ajog.2017.12.231

Dasgupta-Tsinikas S, Zangwill KM, Nielsen K, Lee R, Friedlander S, Donovan SM, Van TT, Butler-Wu SM, Batra JS, Yeh SH, & Resistant UTI in Children Study Team. (2022). Treatment and Epidemiology of Third-Generation Cephalosporin-Resistant Urinary Tract Infections. *Pediatrics*. 1;150(1):

Dipiro, J.T., Talbert, R.L., Yee, G.C., Matzke, G.R., Wells, B.G dan Posey, L.M. (2017). *Pharmacotherapy: A pathophysiology approach*. Ed 10th. New York: *Mc-Graw Hill Medical*.

Elajouz B, Dumkow LE, Worden LJ, VanLangen KM, Jameson AP. (2022). Three-day ceftriaxone versus longer durations of therapy for inpatient treatment of uncomplicated urinary tract infection. Antimicrob Steward Healthc Epidemiol. 2(1):e171. doi: 10.1017/ash.2022.317.

Ferdhyanti, A. U. (2019). *Teknik menghitung leukosit dan eritrosit urine*. Sidoarjo: Uwais Inspirasi Indonesia.

Foxman, B. (2014). Urinary tract infection syndromes. *Infectious Disease Clinics*. 28(1): 1-13

Harrington RD and Hooton TM. (2020). Urinary tract infection risk factors and gender. J Gend Specif Med. 2000 Nov-Dec;3(8):27-34.

Hartanti, R. D., Oktavia, N. dan Fraga, A. D. S. S. 2020. Rasionalitas penggunaan antibiotik pasien infeksi saluran kemih di instalasi rawat inap RSUD Soe. *CHMK Pharmaceutical Scientific Journal*, 3(2): 152-165.

Herlina, S., & Mehita, A. K. (2019). Faktor Yang Mempengaruhi Terjadinya Infeksi Saluran Kemih Pada Pasien Dewasa Di Rsud Kota Bekasi. *Jurnal Keperawatan Widya Gantari Indonesia*, *2*(2), 100–115.

Imam, T. H. (2023). *Bacterial Urinary Tract Infections*. Merck & Co : USA.

Kaur K, Gupta A, Sharma A, Walia G, Singh B & Kaur K. (2014). Evaluation of efficacy and tolerability of cefotaxime and sulbactam versus cefepime and tazobactam in patients of urinary tract infection-a prospective comparative study. *Journal of Clinical Diagnostic Research*. 8(11):HC05-8

Kendal and Mauer, (2022). Does my patient need to be screened or treated for a urinary tract infection?. *Cleveland Clinic Journal of Medicine*. 89 (12) 695-698.

Kementrian Kesehatan RI. (2022). *Apa itu infeksi saluran kemih*. Kementrian Kesehatan RI. Jakarta.

Kurniasari, S., Humaidi, F., & Ida Sofiyati. (2020). Penggunaan Antibiotik Oleh Penderita Infeksi Saluran Kemihdi Instalasi Rawat Inap (Irna) 2 RSUD Dr. H. Slamet Martodirdjopamekasan Tahun 2018. Jurnal Ilmiah Farmasi Attamru, 01(01), 19–20.

Lee, J. (2022). Efficacy of second-generation cephalosporins in treating urinary tract infections: A comparative analysis. Journal of Antimicrobial Chemotherapy, 77(5), 1230–1237.

Li, R and Leslie, S.W. (2023). *Cystitis*. StatPearls Publishing; Treasure Island

Mandal J, Acharya NS, Buddhapriya D, and Parija SC. (2012). Antibiotic resistance pattern among common bacterial uropathogens with a special reference to ciprofloxacin resistant Escherichia coli. *Indian J Med Res*. 136(05):842-849.

Matthews SJ, and Lancaster JW. (2011). Urinary tract infections in the elderly population. Am J Geriatr Pharmacother. 9(5):286–309. doi: 10.1016/j.amjopharm.2011.07.002.

Medscape. (2025). *Drug of cefuroxime*. USA: Medscape.

National Institute for Health and Care Excellence (NICE). (2018). *Urinary tract infection (lower): Antimicrobial prescribing. Clinical guideline*.

National Institute for Health and Care Excellence (NICE). London

National Institute for Health and Care Excellence (NICE). (2023). *Urinary tract infections in adults*. National Institute for Health and Care Exelent (NICE) ; London.

Nurhalimah, Nurmainah dan Robiyanto. (2020). Efektivitas penggunaan seftriakson dan sefotaksim pada pediatri penderita infeksi saluran kemih di Rsud Sultan Syarif Mohamad Alkadrie Pontianak. *Jurnal Tanjungpura Pontianak.*

Pardeshi, P. (2018). Prevalence of urinary tract infections and current scenario of antibiotic susceptibility pattern of bacteria causing UTI. *Indian J Microbiol Res*, 5(3):334-338

Puspita & Alviameita, A. (2019). *Buku Ajar Mata Kuliah Hematologi*. Sidoarjo: UMSIDA Press.

Rodriguez, P. M, West, R. M, Wilcox, M. H, and Sandoe, J. (2019). Lower Urinary Tract Infections: Management, Outcomes and Risk Factors for Antibiotic Re-prescription in Primary Care. *eClinicalMedicine*, 14, 23 - 31

Rodriguez-Mañas L. (2020). Urinary tract infections in the elderly: a review of disease characteristics and current treatment options. Drugs Context. 2020 Jul 8;9:2020-4-13. doi: 10.7573/dic.2020-4-13. PMID: 32699546; PMCID: PMC7357682.

Rotker, K. (2023). What do leukocytes in the urine mean. Healthline Medical.

Sharmin, S., Kamal, S. M. M., Md., A., Elahi, K. M. A., Elma, S. M. M., and Habib, B. (2022). Fosfomycin—A promising oral antibiotic for the treatment of urinary tract infection (UTI). *Open J. Urol.* 12, 257–270. doi: 10.4236/oju.2022.125026

Suharjo, M. I., Darmawan, E. dan Kurniawan, N. U. (2022). Perbandingan efektivitas sefalosporin generasi ke-3 dengan kombinasi sefalosporin generasi ke-3 dan ampisilin pada pasien infeksi saluran kemih di bangsal anak rs pku muhammadiyah bantul. *Jurnal Pendidikan Tambusai*, 6(2): 16417-16422.

Vakharia, K and Tiddy, C. (2023). Urinary tract infections. Patient Info.

Wein, A.J., Kavoussi, L.R., Partin, A.W. dan Peters, C.A. (2016). *Campbell-Walsh Urology.* Ed 11th. China: Elseveir. https://www.ptonline.com/articles/how-to-get-better-mfi-results.

Wisutep P, Thamlikitkul V & Sirijatuphat R. (2023). Effectiveness of implementing a locally-developed guideline for antibiotic treatment of lower urinary tract infection in adults in Thailand. *Scientific Report*. 21;13(1) ; 1-14

Yang X., Chen H., Zheng Y., Qu S., Wang H., and Yi F. (2022). Disease burden and long-term trends of urinary tract infections: A worldwide report. Front. Public Health. 10. doi: 10.3389/fpubh.2022.888205

Yuliani & Futriani. (2022). Pengetahuan Infeksi Saluran Kemih Pada Remaja Putri. Jurnal Antara Abdimas Keperawatan, 5(2), 29–32.

Zagaglia C., Ammendolia M.G., Maurizi L., Nicoletti M., Longhi C. (2022). Urinary Tract Infections Caused by Uropathogenic Escherichia coli Strains-New Strategies for an Old Pathogen. Microorganisms. 10:1425. doi: 10.3390/microorganisms10071425

Zeng, Z., Zhan, J., Zhang, K., Chen, H., anad Cheng, S. (2022). Global, regional, and national burden of urinary tract infections from 1990 to 2019: an analysis of the global burden of disease study 2019. *World J. Urol.* 40, 755–763. doi: 10.1007/s00345-021-03913-0

Zhang, L. (2023). Clinical outcomes of cefuroxime in urinary tract infections among hospitalized adults. *International Journal of Infectious Diseases*, 125, 45–51.