

Perfil de resistencia microbiana en urocultivos positivos de pacientes con infecciones del tracto urinario en una clínica de alta complejidad (2022–2024)

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RESUMEN

Introducción: Las infecciones del tracto urinario (ITU) representan una causa frecuente de atención médica y hospitalización. La creciente resistencia antimicrobiana de los uropatógenos, constituye un desafío para el tratamiento empírico efectivo. Este estudio tuvo como objetivo caracterizar los perfiles de resistencia bacteriana en urocultivos positivos en pacientes adultos atendidos en una clínica de alta complejidad en Barranquilla, Colombia.

Objetivo: Analizar el perfil de resistencia microbiana en urocultivos positivos obtenidos de pacientes con diagnóstico de infección del tracto urinario en una clínica de alta complejidad entre los años 2022 y 2024.

Metodología: Se realizó un estudio observacional, retrospectivo y analítico en pacientes de 18 años o más con ITU confirmada por urocultivo entre enero de 2022 y diciembre de 2024. Se excluyeron casos con cultivos contaminados, reinfecciones en el mismo episodio y registros incompletos. Se analizaron variables sociodemográficas, clínicas, microbiológicas y de desenlace. Se utilizaron estadísticos descriptivos, pruebas no paramétricas y modelos multivariados.

Resultados: Se incluyeron 858 pacientes, de los cuales el 67.1% eran mujeres, con una mediana de edad de 62 años. *Escherichia coli* fue el principal patógeno (64.8%). Se identificaron cepas multirresistentes (MDR) en el 41.3% y BLEE en el 23.7% de los aislamientos. Las infecciones asociadas a la atención en salud mostraron mayores tasas de resistencia. La estancia hospitalaria fue prolongada (>7 días) en el 18.4% de los casos.

Conclusión: Las ITU mostraron una alta prevalencia de multirresistencia, especialmente en el ámbito hospitalario. Estos hallazgos refuerzan la necesidad de fortalecer la vigilancia microbiológica local y optimizar el uso de antibióticos.

Palabras clave: Infección del tracto urinario; Resistencia a los antimicrobianos; *Escherichia coli*; Urocultivo; Colombia; Multirresistencia; Betalactamasas de espectro extendido.

ABSTRACT

Background: Urinary tract infections (UTIs) represent a frequent cause of medical consultation and hospitalization. The increasing antimicrobial resistance of uropathogens poses a major challenge to effective empirical treatment. This study aimed to characterize bacterial resistance profiles in positive urine cultures from adult patients treated at a high-complexity clinic in Barranquilla, Colombia.

Objective: To analyze the microbial resistance profile in positive urine cultures obtained from patients diagnosed with urinary tract infection at a high-complexity clinic between 2022 and 2024.

Methods: An observational, retrospective, and analytical study was conducted in patients aged 18 years or older with culture-confirmed UTI between January 2022 and December 2024. Cases with contaminated cultures, reinfections within the same episode, and incomplete records were excluded. Sociodemographic, clinical, microbiological, and outcome variables were analyzed. Descriptive statistics, non-parametric tests, and multivariate models were applied.

Results: A total of 858 patients were included, of whom 67.1% were women, with a median age of 62 years. *Escherichia coli* was the main pathogen (64.8%). Multidrug-resistant (MDR) strains were identified in 41.3% and extended-spectrum beta-lactamase (ESBL)-producing isolates in 23.7% of cases. Healthcare-associated infections showed higher resistance rates. Hospital stay was prolonged (>7 days) in 18.4% of cases.

Conclusion: UTIs showed a high prevalence of multidrug resistance, especially in hospital settings. These findings highlight the need to strengthen local microbiological surveillance and optimize antibiotic use.

Keywords: Urinary tract infection; Antimicrobial resistance; *Escherichia coli*; Urine culture; Colombia; Multidrug resistance; Extended-spectrum beta-lactamases.

REFERENCIAS BIBLIOGRÁFICAS

- [1] Flores-Mireles AL, Walker JN, Caparon M, Hultgren SJ. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. *Nat Rev Microbiol* 2015;13:269–84. <https://doi.org/10.1038/nrmicro3432>.
- [2] Medina M, Castillo-Pino E. An introduction to the epidemiology and burden of urinary tract infections. *Ther Adv Urol* 2019;11. <https://doi.org/10.1177/1756287219832172>.
- [3] Foxman B. Urinary Tract Infection Syndromes. *Infect Dis Clin North Am* 2014;28:1–13. <https://doi.org/10.1016/j.idc.2013.09.003>.
- [4] Gupta K, Hooton TM, Naber KG, Wullt B, Colgan R, Miller LG, et al. International Clinical Practice Guidelines for the Treatment of Acute Uncomplicated Cystitis and Pyelonephritis in Women: A 2010 Update by the Infectious Diseases Society of America and the European Society for Microbiology and Infectious Diseases. *Clin Infect Dis* 2011;52:e103–20. <https://doi.org/10.1093/cid/ciq257>.
- [5] Tandogdu Z, Wagenlehner FME. Global epidemiology of urinary tract infections. *Curr Opin Infect Dis* 2016;29:73–9. <https://doi.org/10.1097/QCO.0000000000000228>.
- [6] Rodríguez-Baño J, Gutiérrez-Gutiérrez B, Machuca I, Pascual A. Treatment of Infections Caused by Extended-Spectrum-Beta-Lactamase-, AmpC-, and Carbapenemase-Producing Enterobacteriaceae. *Clin Microbiol Rev* 2018;31. <https://doi.org/10.1128/CMR.00079-17>.
- [7] Gajdács M, Urbán E. Comparative Epidemiology and Resistance Trends of Proteae in Urinary Tract Infections of Inpatients and Outpatients: A 10-Year Retrospective Study. *Antibiotics* 2019;8:91. <https://doi.org/10.3390/antibiotics8030091>.
- [8] Magill SS, O’Leary E, Janelle SJ, Thompson DL, Dumyati G, Nadle J, et al. Changes in Prevalence of Health Care–Associated Infections in U.S. Hospitals. *N Engl J Med* 2018;379:1732–44. <https://doi.org/10.1056/NEJMoa1801550>.
- [9] Bassetti M, Shorr AF. Update on epidemiology and appropriate treatment of life-threatening gram-negative infections. *Curr Opin Infect Dis* 2018;31:553–4. <https://doi.org/10.1097/QCO.0000000000000501>.
- [10] Woerther P-L, Burdet C, Chachaty E, Andremont A. Trends in Human Fecal Carriage of Extended-Spectrum β -Lactamases in the Community: Toward the Globalization of CTX-M. *Clin Microbiol Rev* 2013;26:744–58. <https://doi.org/10.1128/CMR.00023-13>.
- [11] Tacconelli E, Carrara E, Savoldi A, Harbarth S, Mendelson M, Monnet DL, et al. Discovery, research, and development of new antibiotics: the WHO priority list of antibiotic-resistant bacteria and tuberculosis. *Lancet Infect Dis* 2018;18:318–27. [https://doi.org/10.1016/S1473-3099\(17\)30753-3](https://doi.org/10.1016/S1473-3099(17)30753-3).
- [12] Abdelsalam Elshenawy R, Umaru N, Aslanpour Z. WHO AWaRe classification for antibiotic stewardship: tackling antimicrobial resistance - a descriptive study from an English NHS Foundation Trust prior to and during the COVID-

- 19 pandemic. Front Microbiol 2023;14:1298858. <https://doi.org/10.3389/fmicb.2023.1298858>.
- [13] Mazzariol A, Bazaj A, Cornaglia G. Multi-drug-resistant Gram-negative bacteria causing urinary tract infections: a review. *J Chemother* 2017;29:2–9. <https://doi.org/10.1080/1120009X.2017.1380395>.
- [14] Guzmán-Blanco M, Labarca JA, Villegas MV, Gotuzzo E. Extended spectrum β -lactamase producers among nosocomial Enterobacteriaceae in Latin America. *Brazilian J Infect Dis* 2014;18:421–33. <https://doi.org/10.1016/j.bjid.2013.10.005>.
- [15] Chowdhury SS, Tahsin P, Xu Y, Mosaddek ASM, Muhamadali H, Goodacre R. Trends in Antimicrobial Resistance of Uropathogens Isolated from Urinary Tract Infections in a Tertiary Care Hospital in Dhaka, Bangladesh. *Antibiot (Basel, Switzerland)* 2024;13. <https://doi.org/10.3390/antibiotics13100925>.
- [16] Eichenberger EM, Thaden JT. Epidemiology and Mechanisms of Resistance of Extensively Drug Resistant Gram-Negative Bacteria. *Antibiot (Basel, Switzerland)* 2019;8. <https://doi.org/10.3390/antibiotics8020037>.
- [17] Martínez EP, Verbon A, Schoffelen AF, Altorf-van der Kuil W, van Rosmalen J, Cohen Stuart JWT, et al. Dynamic association of antimicrobial resistance in urinary isolates of *Escherichia coli* and *Klebsiella pneumoniae* between primary care and hospital settings in the Netherlands (2008–2020): a population-based study. *Lancet Reg Heal - Eur* 2025;50:101197. <https://doi.org/10.1016/j.lanepe.2024.101197>.
- [18] A. Abdalla B, A. Anwar K, S. Fakhraldden S, Sardar Saida B, Bapir R, M. Ahmed S, et al. Decoding urinary tract infections: pathogen profiles and antimicrobial resistance in a cross-sectional study. *African J Urol* 2025;31. <https://doi.org/10.1186/s12301-025-00508-8>.
- [19] Xie Z, Jian J, Chen L. Epidemiology and Mechanism of Drug Resistance of Multidrug-Resistant *Klebsiella Pneumoniae* Isolated from Patients with Urinary Tract Infection in Beijing Teaching Hospital, China. *Infect Drug Resist* 2025;18:135–49. <https://doi.org/10.2147/IDR.S478580>.
- [20] Prestinaci F, Pezzotti P, Pantosti A. Antimicrobial resistance: a global multifaceted phenomenon. *Pathog Glob Health* 2015;109:309–18. <https://doi.org/10.1179/2047773215Y.0000000030>.
- [21] Gajdács M. The Concept of an Ideal Antibiotic: Implications for Drug Design. *Molecules* 2019;24:892. <https://doi.org/10.3390/molecules24050892>.
- [22] Johnson JR, Russo TA. Acute Pyelonephritis in Adults. *N Engl J Med* 2018;378:48–59. <https://doi.org/10.1056/NEJMcp1702758>.
- [23] Pitout JD, Laupland KB. Extended-spectrum β -lactamase-producing Enterobacteriaceae: an emerging public-health concern. *Lancet Infect Dis* 2008;8:159–66. [https://doi.org/10.1016/S1473-3099\(08\)70041-0](https://doi.org/10.1016/S1473-3099(08)70041-0).
- [24] Linhares I, Raposo T, Rodrigues A, Almeida A. Frequency and antimicrobial resistance patterns of bacteria implicated in community urinary tract infections: a ten-year surveillance study (2000–2009). *BMC Infect Dis* 2013;13:19. <https://doi.org/10.1186/1471-2334-13-19>.
- [25] Pallecchi L, Lucchetti C, Bartoloni A, Bartalesi F, Mantella A, Gamboa H, et al. Population Structure and Resistance Genes in Antibiotic-Resistant Bacteria

- from a Remote Community with Minimal Antibiotic Exposure. *Antimicrob Agents Chemother* 2007;51:1179–84. <https://doi.org/10.1128/AAC.01101-06>.
- [26] Tängdén T, Giske CG. Global dissemination of extensively drug-resistant carbapenemase-producing *Enterobacteriaceae*: clinical perspectives on detection, treatment and infection control. *J Intern Med* 2015;277:501–12. <https://doi.org/10.1111/joim.12342>.
- [27] Rodríguez-Baño J, Navarro MD, Romero L, Martínez-Martínez L, Muniain MA, Perea EJ, et al. Epidemiology and Clinical Features of Infections Caused by Extended-Spectrum Beta-Lactamase-Producing *Escherichia coli* in Nonhospitalized Patients. *J Clin Microbiol* 2004;42:1089–94. <https://doi.org/10.1128/JCM.42.3.1089-1094.2004>.
- [28] Gutiérrez-Gutiérrez B, Salamanca E, de Cueto M, Hsueh P-R, Viale P, Paño-Pardo JR, et al. A Predictive Model of Mortality in Patients With Bloodstream Infections due to Carbapenemase-Producing *Enterobacteriaceae*. *Mayo Clin Proc* 2016;91:1362–71. <https://doi.org/10.1016/j.mayocp.2016.06.024>.
- [29] Muñoz Lozada CM. Consumo de antibióticos en el ámbito hospitalario. *Inst Nac* 2025:43.
- [30] Foxman B. The epidemiology of urinary tract infection. *Nat Rev Urol* 2010;7:653–60. <https://doi.org/10.1038/nrurol.2010.190>.
- [31] Wagenlehner FME, Naber KG. Treatment of Bacterial Urinary Tract Infections: Presence and Future. *Eur Urol* 2006;49:235–44. <https://doi.org/10.1016/j.eururo.2005.12.017>.
- [32] Hooton TM. Uncomplicated Urinary Tract Infection. *N Engl J Med* 2012;366:1028–37. <https://doi.org/10.1056/NEJMcp1104429>.
- [33] Marrs CF, Zhang L, Foxman B. *Escherichia coli* mediated urinary tract infections: Are there distinct uropathogenic *E. coli* (UPEC) pathotypes? *FEMS Microbiol Lett* 2005;252:183–90. <https://doi.org/10.1016/j.femsle.2005.08.028>.
- [34] Mulvey MA, Schilling JD, Hultgren SJ. Establishment of a Persistent *Escherichia coli* Reservoir during the Acute Phase of a Bladder Infection. *Infect Immun* 2001;69:4572–9. <https://doi.org/10.1128/IAI.69.7.4572-4579.2001>.
- [35] Nicolle LE. Catheter associated urinary tract infections. *Antimicrob Resist Infect Control* 2014;3:23. <https://doi.org/10.1186/2047-2994-3-23>.
- [36] Hernández-Gámez O, Camacho-Romero O, González-Torres HJ, Pajaro-González Y, Silva-Castro MM, Hernandez O, et al. Estudio de utilización de antibióticos en Hospitales de Mediana y Alta Complejidad del Departamento del Atlántico-Colombia entre el 2016 y 2017. *Arch Venez Farmacol y Ter* 2018;37:311–5.
- [37] Ackerson BK, Tartof SY, Chen LH, Contreras R, Reyes IAC, Ku JH, et al. Risk Factors for Recurrent Urinary Tract Infections Among Women in a Large Integrated Health Care Organization in the United States. *J Infect Dis* 2024;230:1101–11. <https://doi.org/10.1093/infdis/jiae331>.
- [38] Mir TA, Shareef T, Lone SA, Mir SA, Ahmad J, Ganai BA. Antibiotic Resistance Profiling and Identification of Risk Factors Associated With Prevalence of Urinary Tract Infections: A Cross-Sectional Study. *APMIS* 2025;133. <https://doi.org/10.1111/apm.70074>.
- [39] Hirji I, Guo Z, Andersson SW, Hammar N, Gomez-Caminero A. Incidence of

- urinary tract infection among patients with type 2 diabetes in the UK General Practice Research Database (GPRD). *J Diabetes Complications* 2012;26:513–6. <https://doi.org/10.1016/j.jdiacomp.2012.06.008>.
- [40] Nicolle LE. Catheter-Related Urinary Tract Infection. *Drugs Aging* 2005;22:627–39. <https://doi.org/10.2165/00002512-200522080-00001>.
- [41] Tambyah PA, Maki DG. Catheter-Associated Urinary Tract Infection Is Rarely Symptomatic. *Arch Intern Med* 2000;160. <https://doi.org/10.1001/archinte.160.5.678>.
- [42] Delzell JE, Lefevre ML. Urinary tract infections during pregnancy. *Am Fam Physician* 2000;61:713–21.
- [43] Hooton TM. Recurrent urinary tract infection in women. *Int J Antimicrob Agents* 2001;17:259–68. [https://doi.org/10.1016/S0924-8579\(00\)00350-2](https://doi.org/10.1016/S0924-8579(00)00350-2).
- [44] Delgado P, Ortega Y. Infecciones de la vías urinarias y de transmisión sexual. *Nefrol Al Día* 2022;97–118.
- [45] Wilson ML, Gaido L. Laboratory Diagnosis of Urinary Tract Infections in Adult Patients. *Clin Infect Dis* 2004;38:1150–8. <https://doi.org/10.1086/383029>.
- [46] Kouri T, Hofmann W, Falbo R, Oyaert M, Schubert S, Berg Gertsen J, et al. The EFLM European Urinalysis Guideline Update 2023 Hospital District of 2023.
- [47] Stamm WE, Counts GW, Running KR, Fihn S, Turck M, Holmes KK. Diagnosis of Coliform Infection in Acutely Dysuric Women. *N Engl J Med* 1982;307:463–8. <https://doi.org/10.1056/NEJM198208193070802>.
- [48] Nicolle LE, Bradley S, Colgan R, Rice JC, Schaeffer A, Hooton TM. Infectious Diseases Society of America Guidelines for the Diagnosis and Treatment of Asymptomatic Bacteriuria in Adults. *Clin Infect Dis* 2005;40:643–54. <https://doi.org/10.1086/427507>.
- [49] Lewis JS., Weinstein MP., Bobenchik AM., Cameau S, Cullen SK., Dingle T, et al. CLSI supplement M100. 2023.
- [50] Jacobsen SM, Stickler DJ, Mobley HLT, Shirliff ME. Complicated Catheter-Associated Urinary Tract Infections Due to *Escherichia coli* and *Proteus mirabilis*. *Clin Microbiol Rev* 2008;21:26–59. <https://doi.org/10.1128/CMR.00019-07>.
- [51] Lister PD, Wolter DJ, Hanson ND. Antibacterial-Resistant *Pseudomonas aeruginosa* : Clinical Impact and Complex Regulation of Chromosomally Encoded Resistance Mechanisms. *Clin Microbiol Rev* 2009;22:582–610. <https://doi.org/10.1128/CMR.00040-09>.
- [52] Arias CA, Murray BE. The rise of the Enterococcus: beyond vancomycin resistance. *Nat Rev Microbiol* 2012;10:266–78. <https://doi.org/10.1038/nrmicro2761>.
- [53] Raz R, Chazan B, Kennes Y, Colodner R, Rottensterich E, Dan M, et al. Empiric Use of Trimethoprim-Sulfamethoxazole (TMP-SMX) in the Treatment of Women with Uncomplicated Urinary Tract Infections, in a Geographical Area with a High Prevalence of TMP-SMX-Resistant Uropathogens. *Clin Infect Dis* 2002;34:1165–9. <https://doi.org/10.1086/339812>.
- [54] Magiorakos A-P, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant

- bacteria: an international expert proposal for interim standard definitions for acquired resistance. *Clin Microbiol Infect* 2012;18:268–81. <https://doi.org/10.1111/j.1469-0691.2011.03570.x>.
- [55] Murray CJL, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet* 2022;399:629–55. [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0).
- [56] Paterson DL, Bonomo RA. Extended-Spectrum β -Lactamases: a Clinical Update. *Clin Microbiol Rev* 2005;18:657–86. <https://doi.org/10.1128/CMR.18.4.657-686.2005>.
- [57] Nordmann P, Naas T, Poirel L. Global Spread of Carbapenemase-producing Enterobacteriaceae. *Emerg Infect Dis* 2011;17:1791–8. <https://doi.org/10.3201/eid1710.110655>.
- [58] Li X-Z, Nikaido H. Efflux-mediated drug resistance in bacteria: an update. *Drugs* 2009;69:1555–623. <https://doi.org/10.2165/11317030-000000000-00000>.
- [59] Ventola CL. The antibiotic resistance crisis: part 1: causes and threats. *P T* 2015;40:277–83.
- [60] Weinstein RA. Controlling Antimicrobial Resistance in Hospitals: Infection Control and Use of Antibiotics. *Emerg Infect Dis* 2001;7:188–92. <https://doi.org/10.3201/eid0702.010206>.
- [61] Donlan RM. Biofilms and Device-Associated Infections. *Emerg Infect Dis* 2001;7:277–81. <https://doi.org/10.3201/eid0702.010226>.
- [62] Sader HS, Jones RN, Winokur PL, Pfaller MA, Doern G V., Barrett T, et al. Antimicrobial susceptibility of bacteria causing urinary tract infections in Latin American hospitals: Results from the SENTRY Antimicrobial Surveillance Program (1997). *Clin Microbiol Infect* 1999;5:478–87. <https://doi.org/10.1111/j.1469-0691.1999.tb00177.x>.
- [63] resistencia antimicrobiana en infecciones asociadas a dispositivos IAD colombia 2023. n.d.
- [64] Giamarellou H, Poulakou G. Multidrug-Resistant Gram-Negative Infections. *Drugs* 2009;69:1879–901. <https://doi.org/10.2165/11315690-000000000-00000>.
- [65] Tumbarello M, Spanu T, Sanguinetti M, Citton R, Montuori E, Leone F, et al. Bloodstream Infections Caused by Extended-Spectrum- β -Lactamase-Producing *Klebsiella pneumoniae* : Risk Factors, Molecular Epidemiology, and Clinical Outcome. *Antimicrob Agents Chemother* 2006;50:498–504. <https://doi.org/10.1128/AAC.50.2.498-504.2006>.
- [66] Zarkotou O, Pournaras S, Tselioti P, Dragoumanos V, Pitiriga V, Ranellou K, et al. Predictors of mortality in patients with bloodstream infections caused by KPC-producing *Klebsiella pneumoniae* and impact of appropriate antimicrobial treatment. *Clin Microbiol Infect* 2011;17:1798–803. <https://doi.org/10.1111/j.1469-0691.2011.03514.x>.
- [67] Sabih A, Leslie SW. Complicated Urinary Tract Infections. 2025.
- [68] Bonkat G, Bartoletti R, Bruyere F. EAU Guidelines on Urological Infections. Edn. presented at the EAU Annual Congress, Milan, Italy, 2023. Online

(Accessed March 2023) 2023.

- [69] Cortes-Penfield NW, Trautner BW, Jump RLP. Urinary Tract Infection and Asymptomatic Bacteriuria in Older Adults. *Infect Dis Clin North Am* 2017;31:673–88. <https://doi.org/10.1016/j.idc.2017.07.002>.
- [70] Abbott IJ, Peel TN, Cairns KA, Stewardson AJ. Antibiotic management of urinary tract infections in the post-antibiotic era: a narrative review highlighting diagnostic and antimicrobial stewardship. *Clin Microbiol Infect* 2023;29:1254–66. <https://doi.org/10.1016/j.cmi.2022.05.016>.
- [71] CUNHA MA, ASSUNÇÃO GLM, MEDEIROS IM, FREITAS MR. ANTIBIOTIC RESISTANCE PATTERNS OF URINARY TRACT INFECTIONS IN A NORTHEASTERN BRAZILIAN CAPITAL. *Rev Inst Med Trop Sao Paulo* 2016;58. <https://doi.org/10.1590/S1678-9946201658002>.
- [72] Pipitone G, Di Bella S, Maraolo AE, Granata G, Gatti M, Principe L, et al. Intravenous Fosfomycin for Systemic Multidrug-Resistant *Pseudomonas aeruginosa* Infections. *Antibiot (Basel, Switzerland)* 2023;12. <https://doi.org/10.3390/antibiotics12121653>.
- [73] Brigadoi G, Liberati C, Gres E, Barbieri E, Boreggio E, Rossin S, et al. Impact of an antibiotic stewardship program on adherence to antibiotic prescription in children admitted with urinary tract infection. *Ther Adv Infect Dis* 2024;11. <https://doi.org/10.1177/20499361241282824>.
- [74] Abbo LM, Hooton TM. Antimicrobial Stewardship and Urinary Tract Infections. *Antibiot (Basel, Switzerland)* 2014;3:174–92. <https://doi.org/10.3390/antibiotics3020174>.
- [75] Fromer DL, Luck ME, Cheng WY, Mahendran M, da Costa WL, Pinaire M, et al. Risk Factors for Empiric Treatment Failure in US Female Outpatients with Uncomplicated Urinary Tract Infection: an Observational Study. *J Gen Intern Med* 2025;40:862–70. <https://doi.org/10.1007/s11606-024-09029-6>.
- [76] van Duin D, Paterson DL. Multidrug-Resistant Bacteria in the Community. *Infect Dis Clin North Am* 2016;30:377–90. <https://doi.org/10.1016/j.idc.2016.02.004>.
- [77] Marepalli NR, Nadipelli AR, Manohar Kumar Jain RJ, Parnam LS, Vashyani A. Patterns of Antibiotic Resistance in Urinary Tract Infections: A Retrospective Observational Study. *Cureus* 2024. <https://doi.org/10.7759/cureus.62771>.
- [78] Stapleton PJ, Lundon DJ, McWade R, Scanlon N, Hannan MM, O’Kelly F, et al. Antibiotic resistance patterns of *Escherichia coli* urinary isolates and comparison with antibiotic consumption data over 10 years, 2005–2014. *Irish J Med Sci (1971 -)* 2017;186:733–41. <https://doi.org/10.1007/s11845-016-1538-z>.
- [79] Nguyen HQ, Nguyen NTQ, Hughes CM, O’Neill C. Trends and impact of antimicrobial resistance on older inpatients with urinary tract infections (UTIs): A national retrospective observational study. *PLoS One* 2019;14:e0223409. <https://doi.org/10.1371/journal.pone.0223409>.
- [80] Shaker M, Zaki A, Asser SL, Sayed I EI. Trends and predictors of antimicrobial resistance among patients with urinary tract infections at a tertiary hospital facility in Alexandria, Egypt: a retrospective record-based classification and

- regression tree analysis. *BMC Infect Dis* 2024;24:246.
<https://doi.org/10.1186/s12879-024-09086-6>.
- [81] Esposito S, Maglietta G, Di Costanzo M, Ceccoli M, Vergine G, La Scola C, et al. Retrospective 8-Year Study on the Antibiotic Resistance of Uropathogens in Children Hospitalised for Urinary Tract Infection in the Emilia-Romagna Region, Italy. *Antibiotics* 2021;10:1207.
<https://doi.org/10.3390/antibiotics10101207>.
- [82] Nicolle LE. Urinary Tract Infections in the Older Adult. *Clin Geriatr Med* 2016;32:523–38. <https://doi.org/10.1016/j.cger.2016.03.002>.
- [83] Rowe TA, Juthani-Mehta M. Urinary Tract Infection in Older Adults. *Aging Health* 2013;9:519–28. <https://doi.org/10.2217/ahe.13.38>.
- [84] Fallon R, Farrell K, Leon G, Rajan A, Duane S, FitzGerald C, et al. GPs' attitudes towards the diagnosis and treatment of male urinary tract infections: a qualitative interview study in Ireland. *BJGP Open* 2019;3:bjgpopen19X101667. <https://doi.org/10.3399/bjgpopen19X101667>.
- [85] Martin RM, Bachman MA. Colonization, Infection, and the Accessory Genome of *Klebsiella pneumoniae*. *Front Cell Infect Microbiol* 2018;8. <https://doi.org/10.3389/fcimb.2018.00004>.
- [86] Rodriguez-Bano J, Navarro MD, Retamar P, Picon E, Pascual A. -Lactam/ -Lactam Inhibitor Combinations for the Treatment of Bacteremia Due to Extended-Spectrum -Lactamase-Producing *Escherichia coli*: A Post Hoc Analysis of Prospective Cohorts. *Clin Infect Dis* 2012;54:167–74. <https://doi.org/10.1093/cid/cir790>.
- [87] Brooke JS. *Stenotrophomonas maltophilia*: an Emerging Global Opportunistic Pathogen. *Clin Microbiol Rev* 2012;25:2–41. <https://doi.org/10.1128/CMR.00019-11>.
- [88] Chang Y-T, Lin C-Y, Chen Y-H, Hsueh P-R. Update on infections caused by *Stenotrophomonas maltophilia* with particular attention to resistance mechanisms and therapeutic options. *Front Microbiol* 2015;6. <https://doi.org/10.3389/fmicb.2015.00893>.
- [89] Talan DA, Takhar SS, Krishnadasan A, Mower WR, Pallin DJ, Garg M, et al. Emergence of Extended-Spectrum β -Lactamase Urinary Tract Infections Among Hospitalized Emergency Department Patients in the United States. *Ann Emerg Med* 2021;77:32–43. <https://doi.org/10.1016/j.annemergmed.2020.08.022>.
- [90] Klein EY, Van Boeckel TP, Martinez EM, Pant S, Gandra S, Levin SA, et al. Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proc Natl Acad Sci* 2018;115. <https://doi.org/10.1073/pnas.1717295115>.
- [91] Mathers AJ, Peirano G, Pitout JDD. The Role of Epidemic Resistance Plasmids and International High-Risk Clones in the Spread of Multidrug-Resistant Enterobacteriaceae. *Clin Microbiol Rev* 2015;28:565–91. <https://doi.org/10.1128/CMR.00116-14>.