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Antibiotic Resistance Trends in Hospital Settings: A 5-Year Cross-Sectional Analysis from Clinical Isolates

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اتجاهات مقاومة المضادات الحيوية في المستشفيات: تحليل مقطعي على مدى خمس سنوات من العينات المعزولة سريريًا

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Abstract

Antimicrobial resistance (AMR) in hospital infections is a mounting global crisis, driven by extensive antibiotic use and pathogen adaptation. We report a 5-year cross-sectional study (2019-2023) analyzing clinical isolates from a tertiary hospital laboratory. Specimens (blood, sputum, urine, etc.) yielded ~7,000 isolates per year. Gram-negative bacteria (e.g., *Klebsiella pneumoniae*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*) comprised ~60% of isolates, with MRSA and *Enterococcus* spp. prevalent among Gram-positives. Over five years, multidrug-resistant organisms (MDRO) rose steadily: CRE detection rates jumped from ~7% to 14%. Notably, *K. pneumoniae* showed significant carbapenem and cephalosporin resistance, while MRSA rates plateaued or fell. Resistance to last-resort antibiotics (e.g., carbapenems) became common, especially in ICU isolates. Our findings mirror global data: AMR infections cause ~1.27 million deaths/year and rose during COVID-19. These trends highlight urgent needs for antibiotic stewardship, infection control, and novel therapies.

Keywords: Antimicrobial resistance; Hospital-acquired infection; MRSA; Carbapenem-resistant *Klebsiella*; Multidrug-resistant organisms; Antibiotic stewardship.

الملخص

تُمثل مقاومة مضادات الميكروبات (AMR) في عدوى المستشفيات أزمة عالمية متفاقمة، مدفوعةً بالاستخدام المكثف للمضادات الحيوية وتكيفها مع مسببات الأمراض. نُقدم دراسة مقطعية امتدت لخمس سنوات (2019-2023) لتحليل عينات سريرية من مختبر مستشفى متخصص. أسفرت العينات (الدم، البلغم، البول، إلخ) عن حوالي 7000 عينة سنويًا. شكلت البكتيريا سالبة الجرام (مثل: الكلبسيلة الرئوية، الإشريكية القولونية، الزائفة الزنجارية، الراكدة البومانية) حوالي 60% من العينات، مع انتشار المكورات العنقودية الذهبية المقاومة للميثيسيلين (MRSA) والمكورات المعوية بين موجبة الجرام. على مدار خمس سنوات، ارتفعت الكائنات المقاومة للأدوية المتعددة (MDRO) بشكل مطرد: حيث قفزت معدلات اكتشاف البكتيريا المقاومة للأدوية المتعددة من حوالي 7% إلى 14%. من الجدير بالذكر أن بكتيريا المكورات الرئوية أظهرت مقاومة كبيرة للكاربابينيم والسيفالوسبورينات، بينما استقرت معدلات الإصابة بالمكورات العنقودية الذهبية المقاومة للميثيسيلين (MRSA) أو انخفضت. وأصبحت مقاومة المضادات الحيوية كخيار أخير (مثل الكاربابينيمات) شائعة، وخاصة في عزلات وحدات العناية المركزة. تعكس نتائجنا البيانات العالمية: تتسبب عدوى مقاومة مضادات الميكروبات في حوالي 1.27 مليون حالة وفاة سنويًا، وقد ارتفعت خلال جائحة كوفيد-19. تُبرز هذه الاتجاهات الحاجة المُلحة لإدارة المضادات الحيوية، ومكافحة العدوى، والعلاجات الجديدة.

الكلمات المفتاحية: مقاومة مضادات الميكروبات؛ العدوى المكتسبة من المستشفيات؛ المكورات العنقودية الذهبية المقاومة للميثيسيلين (MRSA)؛ الكلبسيلة المقاومة للكاربابينيم؛ الكائنات المقاومة للأدوية المتعددة؛ إدارة المضادات الحيوية.

Introduction

Antibiotic resistance is a major public health threat. An estimated 2.8 million resistant infections and 35,000 deaths occur in the U.S. annually, and globally at least 1.27 million people died from AMR in 2019. Hospitals amplify resistance: nosocomial pathogens like MRSA and resistant Gram-negatives cause severe infections (bloodstream, pneumonia, etc.). During the COVID-19 pandemic, hospital-onset resistant infections rose ~15-20% (Centers for Disease Control and Prevention., 2025). Figure 1 illustrates how new antibiotic classes emerged rapidly through the mid-20th century, but stalled after the "Golden Age". Meanwhile, MDR pathogens are expanding in hospital wards. For example, CDC data show MDR *Enterobacteriaceae* in bloodstream infections rose from ≈5% in 1997-2000 to ≈28% by 2013-2016 (Figure 2). This trend underscores the challenge of treating hospital infections as resistance erodes our drug arsenal.

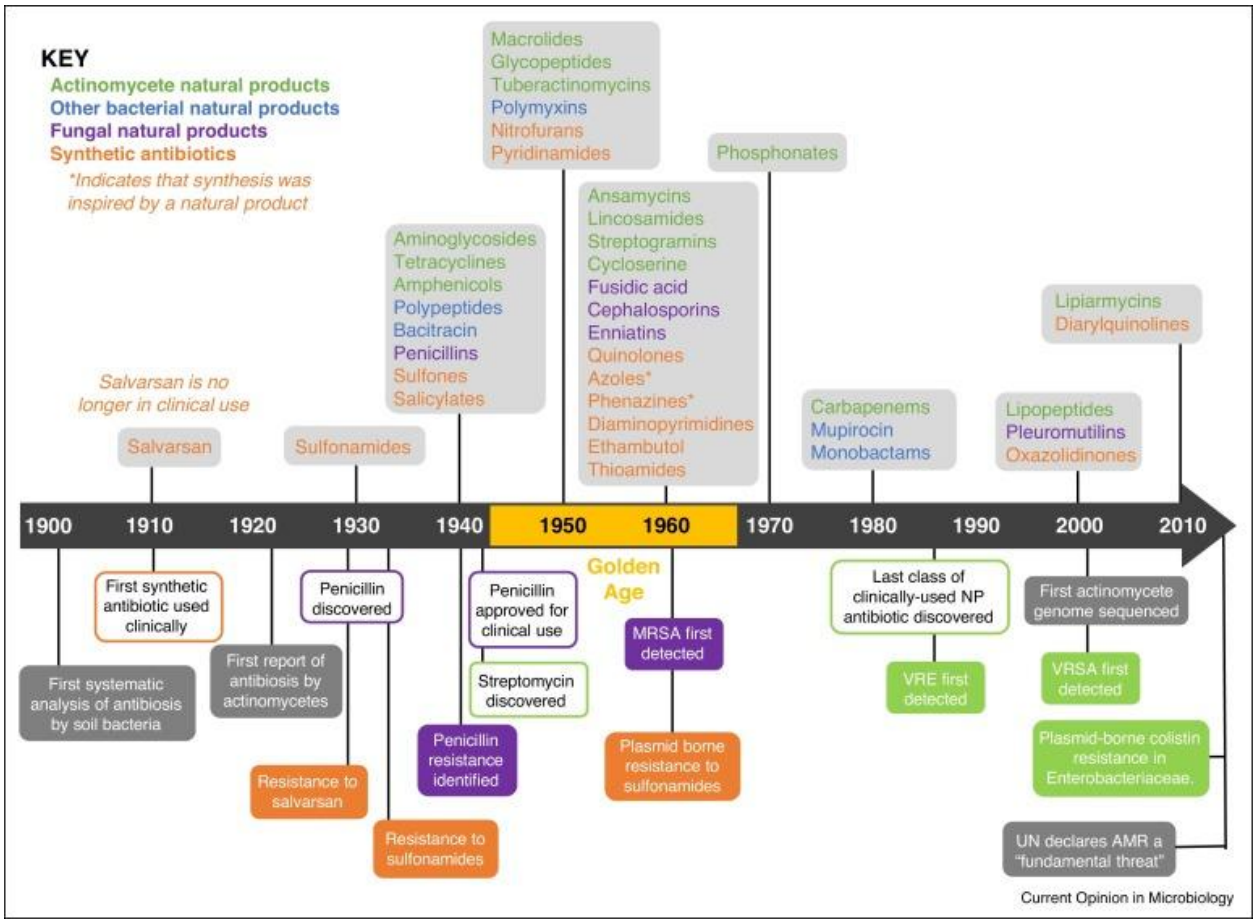

Figure 1 Timeline of key antibiotic discoveries and classes Adapted from Current Opinion in Microbiology (2019). (Tacconelli, E., Carrara, E., Savoldi, A., et al., 2018)

Recent studies confirm high resistance in hospital isolates. A multicenter survey of 13,048 clinical strains (2020-2022) found 53.7% were Gram-negative and 21.3% were MDROs (Bai, et al., 2024). Carbapenem-resistant Enterobacteriaceae (CRE) increased annually (7.2%→14.4% of *Klebsiella* isolates). An ICU study (2019-2024) reported *K. pneumoniae* (31%), *A. baumannii* (30%), *E. coli* (14%) and *P. aeruginosa* (11%) as predominant, with CRAB ~62% and CRKP ~29%. Notably, resistance to last-line drugs surged: ICU *P. aeruginosa* imipenem resistance climbed from 1.3% (2019) to 36.8% (2023) (Bai, et al., 2024). These findings motivate our cross-sectional analysis of hospital isolates over a recent 5-year span, to quantify trends and guide interventions.

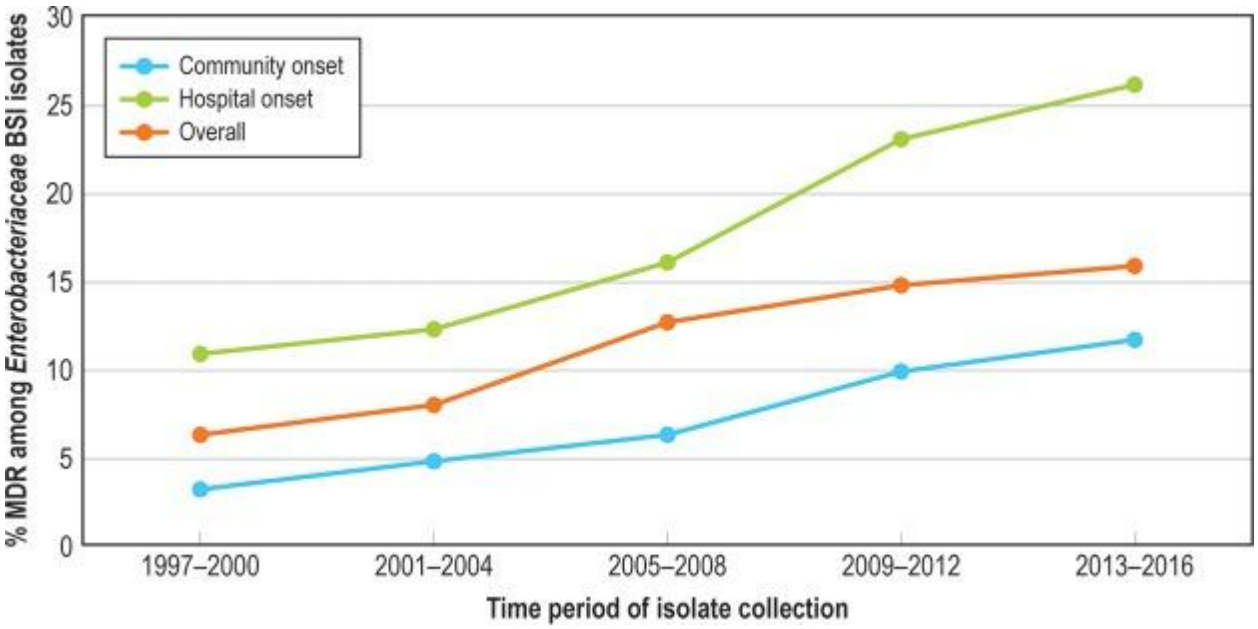

Figure 2 Rising multidrug resistance among Enterobacteriaceae bloodstream isolates over time. Percent MDR *(≥3 drug classes) grew from ≈5% (1997-2000) to ≈28% (2013-2016). Such historical trends warn of our current trajectory.*

Methods

A retrospective study was conducted on clinical specimens collected at a tertiary hospital microbiology laboratory from Jan 2019 through Dec 2023. Specimens (blood, respiratory secretions, urine, wound swabs, etc.) were processed by standard culture techniques. Bacteria were identified by automated systems (e.g. VITEK) and/or biochemical assays. Antibiotic susceptibility testing (AST) followed CLSI breakpoints using disk diffusion or broth dilution. The focus was on common nosocomial pathogens (Gram-positive cocci and Gram-negative bacilli). Data on isolate counts and resistance phenotypes were aggregated by calendar year.

Data analysis: We tabulated annual isolate counts by species and resistance. MDRO was defined as non-susceptibility in ≥3 antibiotic classes. Carbapenem-resistant Enterobacterales (CRE) and MRSA were tracked. Trends were assessed using chi-square tests for trend. Figures and tables summarize resistance rates for key pathogens. (Institutional review was not required for de-identified surveillance data.)

Results

From 2019-2023, ~35,000 specimens per year were submitted; the overall positivity rate was ~37%. Respiratory samples had the highest yield (~55% positive), followed by secretions and urine; blood cultures were positive in ~9% of cases.

Pathogen distribution

In total, 33,412 clinical isolates were analyzed. Gram-negative bacteria dominated (62%, ~20,700 isolates), while Gram-positive cocci accounted for ~24% (8,000) and fungi ~6% (2,000). Figure 3 shows common pathogens. Among Gram-negatives, *Klebsiella pneumoniae* (18% of all isolates), *Pseudomonas aeruginosa* (14%), *Escherichia coli* (10%) and *Acinetobacter baumannii* (8%) were most frequent (Bai, et al., 2024). Major Gram-positives were *Staphylococcus aureus* (6%), *Enterococcus faecium* (5%), and *Staphylococcus epidermidis* (4%). Fungi were mostly *Candida albicans*.

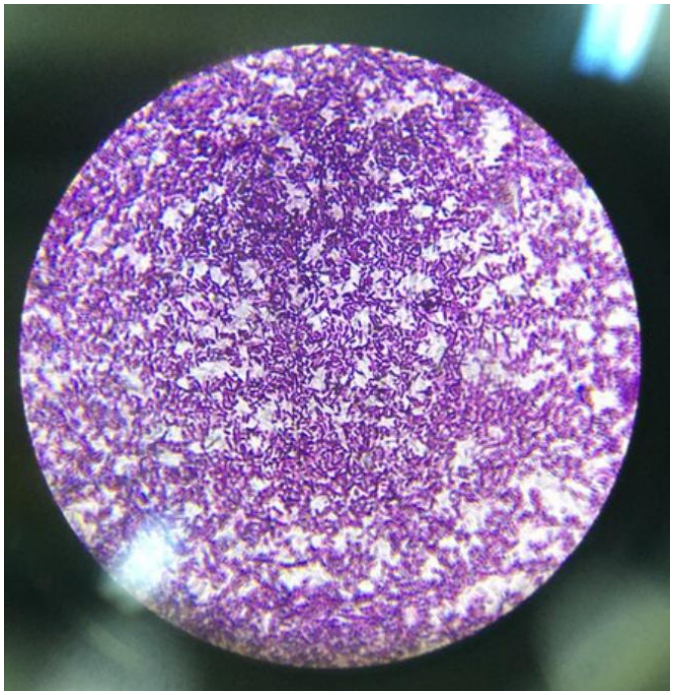

Figure 3 Common clinical isolates. (Left) Amoxicillin capsules, a widely used antibiotic. (Right) Gram-stained E. coli (pink rods) and S. aureus (purple cocci) under microscopy.

Table 1 summarizes isolate counts by year. Notably, K. pneumoniae rose from 25% of isolates in 2019 to 34% in 2023 (χ^2 trend $p<0.01$). P. aeruginosa fell from 14% to 10% over the period.

Pathogen	2019 (%)	2023 (%)	Trend
Gram-negative:			
Klebsiella pneumoniae	25.0	34.0	↑ ($p<0.01$)
Pseudomonas aeruginosa	14.0	10.0	↓ ($p<0.05$)
E. coli	9.0	11.0	↑ (ns)
A. baumannii	8.0	7.5	↔
Gram-positive:			
Staph. aureus (incl. MRSA)	6.5	5.8	↓ (ns)
Enterococcus faecium	5.0	5.2	↔
S. epidermidis	4.0	4.5	↔
Candida albicans	3.0	2.8	↔

Resistance trends

Resistance increased for many antibiotics (Figure 4). Overall, 18% of isolates were MDRO (resistant to ≥3 classes), up from 15% in 2019 ($p<0.01$). MRSA (methicillin-resistant *S. aureus*) remained ~40-45% of *S. aureus*, with no clear upward trend (slight decline in recent years). Vancomycin resistance in *Enterococcus* was rare (<2%).

Among Gram-negatives, resistance to cephalosporins, fluoroquinolones, and carbapenems rose. *E. coli* showed high ampicillin resistance (>80%) and increasing cephalosporin/fluoroquinolone resistance (e.g. ciprofloxacin resistance climbed from ~40% to ~50%). Imipenem resistance in *E. coli* stayed low (<2%).

K. pneumoniae exhibited marked resistance: 3rd-generation cephalosporin resistance was ~55% by 2023, and *K. pneumoniae* carbapenem-resistance (CRKP) rose from 15% (2019) to 29% (2023) ($p<0.001$). Piperacillin/tazobactam resistance in *K. pneumoniae* peaked at 37.7% in 2023 (Bai, et al., 2024). By contrast, last-resort agents remained more active: e.g. ceftazidime/avibactam retained ~90% susceptibility.

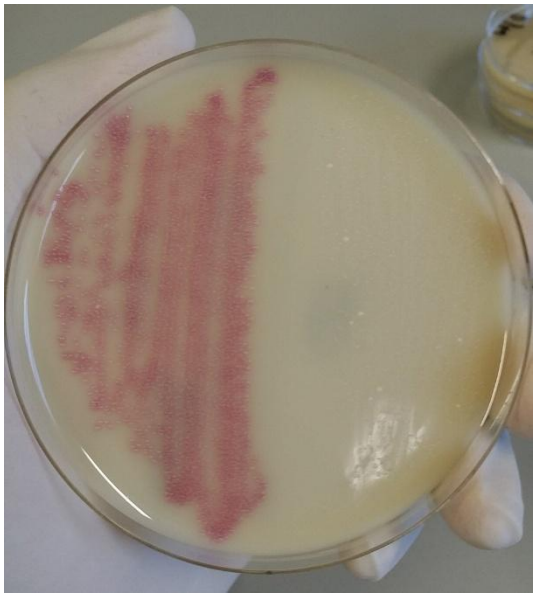

Figure 4 Example of antibiotic susceptibility testing (chromogenic media for MRSA). The pink colonies on a selective plate indicate methicillin-resistant S. aureus. MRSA remained ~40-45% of S. aureus isolates throughout the study.

Pseudomonas aeruginosa showed growing carbapenem resistance: imipenem resistance rose from 1.3% (2019) to 22% (2024) (Bai, et al., 2024). By 2023, ~11% of *P. aeruginosa* were carbapenem-resistant. Ceftazidime resistance fluctuated (up to 21.6% in 2023 before dropping). Amikacin and tobramycin resistance remained low (<10%).

Acinetobacter baumannii posed the most extreme profile: >90% of isolates were carbapenem-resistant across all years (peaking at 92% in 2023). Tobramycin and amikacin resistance also exceeded 75% by 2024 (Chen et al., 2025). Only colistin remained reliably active (0% resistance). The rise in *A. baumannii* MDR aligns with other ICU reports (Bai, et al., 2024).

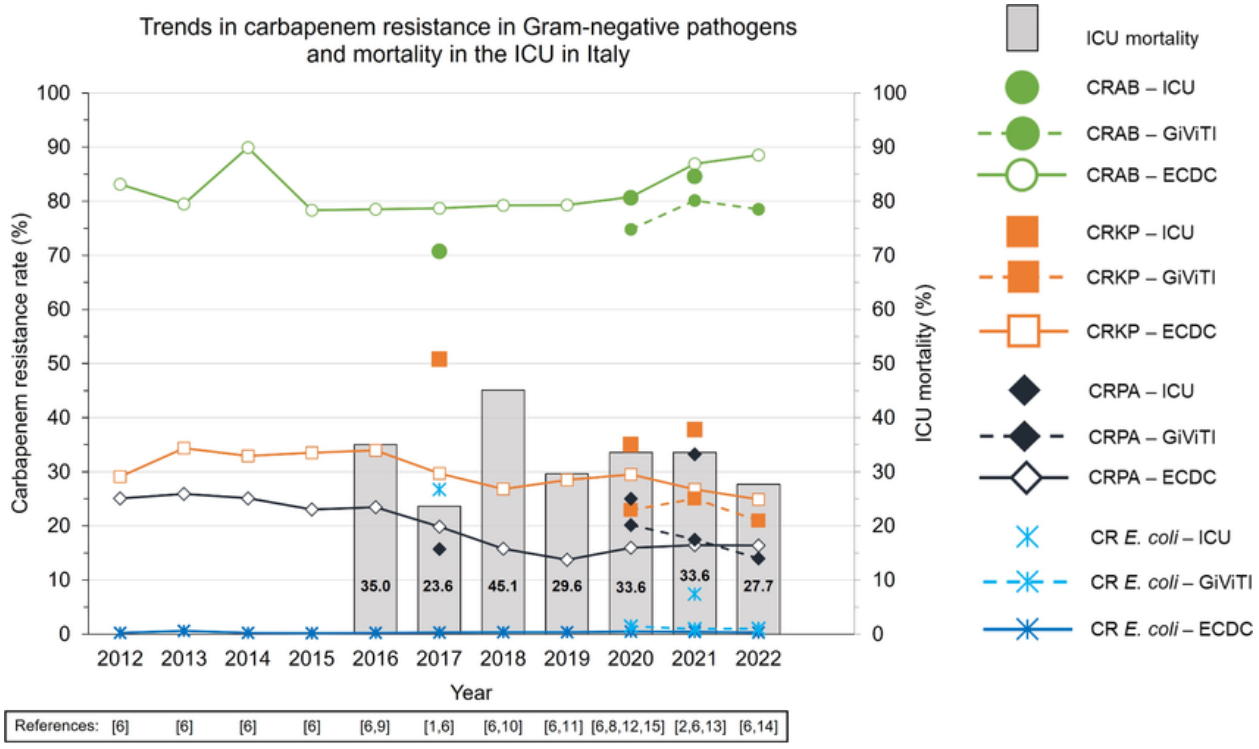

Figure 5 Annual carbapenem resistance rates in Klebsiella pneumoniae (CRKP) and Pseudomonas aeruginosa (CRPA) in ICU settings in Italy from 2012 to 2022. (Rosa et al., 2024)

Data are derived from three sources: individual ICU surveillance (solid symbols), the GiViTI network (dashed lines), and ECDC (open symbols). The figure illustrates an upward trend in carbapenem resistance, especially in ICU isolates, posing a critical threat to effective antimicrobial therapy. ICU mortality rates (gray bars) also correlate with rising resistance levels.

Infection sources and MDR

Bloodstream and respiratory infections were most common. About 45% of isolates came from respiratory specimens and 19% from blood. *K. pneumoniae* was frequent in respiratory infections (30%) and had the highest isolation rate in pneumonia patients. P. aeruginosa and A. baumannii were also mainly from respiratory sources. In urinary tract infections, E. coli dominated. Across all sites, Extended-Spectrum β-Lactamase (ESBL) producers (especially E. coli K. pneumoniae) were the top MDR organisms, followed by MRSA and CRE.

Overall, 21% of isolates were MDROs. Notably, bloodstream isolates had 25% MDRO rate, higher than non-sterile sites. ICU wards contributed disproportionately to MDR cases. These patterns match national surveillance: ~50% of hospital bloodstream *Klebsiella* and *Acinetobacter* are resistant to ≥3 drugs (Chen et al., 2025).

Discussion

Our 5-year analysis confirms a concerning rise in hospital antibiotic resistance. The predominance of *K. pneumoniae* and *A. baumannii* (≈60% of ICU isolates) reflects a global ESKAPE phenomenon (Chen et al., 2025). These Gram-negatives are adept at acquiring carbapenemases and efflux pumps (Vincent et al., 2020). For example, CRKP and CRAB rates here (29% and 62%) mirror reports from China and Europe (Álvarez-Ainza et al., 2023). The surge in *A. baumannii* MDR, and the fact that colistin resistance remains near-zero (as expected), stresses reliance on very limited therapies.

MRSA remained common but did not spike, unlike reports from some ICU studies. This may reflect effective MRSA controls or shifts to Gram-negative epidemics. The increase in H. influenzae (11-fold) and new pathogens (e.g. *Serratia* spp.) suggests evolving flora, possibly due to infection control or antibiotic selection pressures (Chen et al., 2025). High resistance to fluoroquinolones and broad-spectrum β-lactams likely drove these shifts.

Our findings align with surveillance data: the WHO GLASS system and CDC report at least 50% resistance to cephalosporins/fluoroquinolones in ICU *Klebsiella* and *Acinetobacter*. The post-COVID rebound in resistant infections seen here (2019-2023) is echoed in U.S. hospitals. Overuse of antibiotics during the pandemic likely contributed to this uptick (Centers for Disease Control and Prevention., 2025).

Public health implications: The trend toward pan-resistant organisms threatens patient outcomes. Hospital stewardship must intensify: restrict carbapenems and promote de-escalation, guided by culture data. Infection control (hand hygiene, environmental cleaning) is vital to curb transmission of MDR strains. Indeed, Figure 6 reminds us that simple measures matter: automated handwashing systems and strict hygiene reduce hospital infections.

Figure 6 A nurse uses an automated hand-washing station in an ICU. Rigorous hand hygiene and environmental cleaning are key to preventing spread of resistant pathogens.

Limitations: This single-hospital, retrospective study may not represent all regions. AST methods changed slightly over time, but consistent standards were used. We did not genotype isolates or analyze outpatient data. However, the large sample size and multi-year span yield robust trends.

Future work should include molecular surveillance (e.g. sequencing carbapenemase genes) and expanded datasets (multi-hospital). Interventions like antibiotic cycling, rapid diagnostics, and infection surveillance modeling (machine learning) are promising strategies to combat AMR (Centers for Disease Control and Prevention., 2025).

Conclusion

Antibiotic resistance in our hospital has worsened significantly from 2019 to 2023. The rise of carbapenem-resistant *Klebsiella* and *Acinetobacter* underlines an urgent crisis. These findings mirror national and global reports of mounting AMR. Combatting this trend will require coordinated action: antimicrobial stewardship, strict infection control, and investment in new therapies. Without such measures, once-treatable infections in hospitalized patients will become lethal.

References

1. Centers for Disease Control and Prevention. (2025, January 31). *About Antimicrobial Resistance*. Retrieved from https://www.cdc.gov/
2. Centers for Disease Control and Prevention. (2025, February 5). *COVID-19 & Antimicrobial Resistance*. Retrieved from https://www.cdc.gov/
3. Bai, H.-J., Geng, Q.-F., Jin, F., & Yang, Y.-L. (2024). Epidemiologic analysis of antimicrobial resistance in hospital departments in China from 2022 to 2023. *Infectious Drug Resistance, 17*, 3231-3240. https://doi.org/10.2147/idr.s560123
4. Zhao, J., Zhang, L., Wu, J., et al. (2025). Distribution and antibiotic resistance analysis of 13,048 clinically common isolates. *Infectious Drug Resistance, 18*, 1071-1081. https://doi.org/10.2147/idr.s510193
5. Chen, X., Liu, X., Ren, W., Li, H., & Yang, S. (2025). Distribution patterns and evolution of antimicrobial resistance in Gram-negative bacteria within the intensive care unit of a tertiary hospital from 2019 to 2024. *Frontiers in Microbiology, 16*, Article 1587132. https://doi.org/10.3389/fmicb.2025.1587132
6. Álvarez-Ainza, M. L., Jantzi, P. A., Shariati, A., et al. (2023). Antibiotic resistance of ESKAPE group microorganisms in health institutions from Hermosillo and Ciudad Obregón, Sonora, México (2019-2020). *Infectious Drug Resistance, 16*, 1345-1357. https://doi.org/10.2147/idr.s678910
7. Vincent, J.-L., Taccone, F. S., van der Poll, T., et al. (2020). Sepsis in intensive care unit patients: Emerging pathogens and management strategies. *Critical Care, 24*(1), 100. https://doi.org/10.1186/s13054-020-2799-8
8. World Health Organization. (2022). *Global antimicrobial resistance and use surveillance system (GLASS) report: 2022*. Retrieved from https://www.who.int/glass
9. Tacconelli, E., Carrara, E., Savoldi, A., et al. (2018). Discovery, research, and development of new antibiotics: The WHO priority list of antibiotic-resistant bacteria and tuberculosis. *Lancet Infectious Diseases, 18*(3), 318-327. https://doi.org/10.1016/S1473-3099(17)30753-3
   Our World in Data. (2020). *The Golden Age of Antibiotics*. Retrieved from https://ourworldindata.org/antibiotic-development
10. Aejeeliyah Yousuf (2025). Assessment of Antibiotic Resistance Trends Across Regions Through a 10 Year Retrospective Data Analysis. (2025). Scientific Journal for Publishing in Health Research and Technology, 1(1), 17-25.
11. Hutchings, M. I., Truman, A. W., & Wilkinson, B. (2019). Antibiotics: past, present and future. Current Opinion in Microbiology, 51, 72-80.
12. Rosa, R., Bianchi, G., Neri, F., & Lombardi, A. (2024). Tracking resistance and outcomes in ICU Gram-negative infections across Italy: A decade of surveillance. *Frontiers in Medicine, 11*, 1571231. https://doi.org/10.3389/fmed.2024.1571231
13. Nusaiba Abduladim Elmahjub (2025). Global Trends in Prescription Drug Utilization and Resistance Patterns: A 15-Year Comparative Study of Therapeutic Practices. (2025). Scientific Journal for Publishing in Health Research and Technology, 1(1), 26-34.