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# ANTIBIOTIC RESISTANCE IN SURGICAL DEPARTMENTS: ANALYSIS OF LOCAL PATTERNS

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**Introduction.** Antimicrobial resistance (AMR) is one of the leading challenges of modern medicine and a significant contributor to the development of postoperative infections in surgical departments. The spread of resistant bacterial strains, including methicillin-resistant *Staphylococcus aureus* (MRSA) and extended-spectrum beta-lactamase (ESBL)-producing organisms, complicates treatment, prolongs hospitalization, and increases the risk of postoperative complications. The main factors contributing to the formation of local resistance patterns include irrational antibiotic use, violations of aseptic protocols, and insufficient infection control measures.

**Relevance.** Antibiotic-resistant infections in surgical departments increase the risk of postoperative complications, mortality, and length of hospital stay. Local bacterial susceptibility patterns vary significantly between departments and hospitals, making systematic monitoring essential for optimizing empirical therapy and infection control strategies.

**Aim.** To investigate local antimicrobial resistance patterns in surgical departments and summarize current data on the susceptibility of clinically significant bacteria in order to improve empirical therapy and prevent postoperative infections.

**Materials and Methods.** A systematic analysis and synthesis of scientific publications, clinical studies, and reviews published in peer-reviewed international and national journals between 2010 and 2025 were conducted, focusing on AMR in surgical departments.

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Special attention was given to:

- Local susceptibility patterns of MRSA, ESBL-producing organisms, and other clinically significant bacteria;
- Modern methods of microbiological control and monitoring of postoperative infections.

**Results:**

**1. Local antimicrobial resistance patterns in surgical departments (international data)**

Literature analysis demonstrated high levels of multidrug resistance (MDR) among Gram-negative bacteria (*Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*) and significant prevalence of MRSA among Gram-positive pathogens (*Staphylococcus aureus*) [1-5].

Extensively drug-resistant (XDR) strains occur less frequently; however, they significantly limit effective antibiotic therapy options, particularly in patients with postoperative infections [1,3,4]. The summarized resistance indicators are presented in (Table 1).

*Table 1*

**Local antimicrobial resistance patterns in surgical departments (2010-2025, international data)**

Bacterium	MDR prevalence (%)	XDR prevalence (%)	Main antibiotics with detected resistance
<i>Staphylococcus aureus</i>	25-62	~2-5	Penicillins, cephalosporins
<i>Escherichia coli</i>	65-96	~5-7	Ampicillin, cephalosporins, fluoroquinolones
<i>Klebsiella pneumoniae</i>	30-73	~6-8	Cephalosporins, carbapenems
<i>Acinetobacter baumannii</i>	78-100	~15-18	Carbapenems, aminoglycosides
<i>Enterococcus spp.</i>	~14-30	~1-2	Vancomycin resistance reported; linezolid generally sensitive

*Data compiled from [1-5]*

**2. National data from Ukraine**

According to national monitoring data on antibacterial drug use, only approximately 25% of hospitalized patients undergo bacteriological testing prior to initiation of empirical therapy, which complicates rational antibiotic selection [10].

There is also insufficient use of “Access” group antibiotics and excessive use of “Watch” and “Reserve” group antibiotics, contrary to WHO recommendations and antimicrobial stewardship principles [6-10]. The main prescribing indicators are presented in (Table 2).



Table 2

**Indicators of antibiotic prescribing in inpatient and primary care settings in Ukraine (2024)**

Category	Recommended level	Actual level	Comment
Access antibiotics in primary care	~95%	59.1%	Prescribed less frequently than recommended
Access antibiotics in hospitals	>60%	39.8%	Insufficient use
Watch antibiotics in primary care	<5%	32.4%	Overuse of restricted antibiotics
Reserve antibiotics in primary care	~0%	8.7%	Unjustified use
Reserve antibiotics in hospitals	<5%	29.0%	Frequent use of last-line agents
Timely bacteriological testing before empirical therapy	100%	~25%	Only 1 in 4 patients tested prior to therapy

Data is compiled from [10]

International data demonstrate high levels of MDR and isolated cases of XDR among key surgical pathogens, complicating empirical therapy selection [1-5].

Ukrainian data confirm a systemic issue: insufficient bacteriological testing and inappropriate antibiotic group use increase the risk of resistance development and postoperative infectious complications [6,7,10].

Effective resistance control requires implementation of local antibiotic stewardship protocols and continuous monitoring of local susceptibility patterns [3,9].

### 3. Modern methods of microbiological control and monitoring of postoperative infections

Evidence indicates that timely and systematic microbiological control enables early detection of resistant strains, adjustment of empirical therapy according to local susceptibility patterns, reduction in MDR and XDR pathogen spread, and evaluation of infection control effectiveness [1-3,5].

Conventional microbiological identification relying on biochemical profiling and disc diffusion typically requires 48-72 hours for pathogen identification and additional 24-48 hours for susceptibility testing. This diagnostic delay directly contributes to inappropriate empirical therapy, prolonged hospitalization, and increased mortality. Two complementary technologies have fundamentally reduced this timeframe.

Polymerase chain reaction (PCR)-based methods enable detection of bacterial DNA directly from clinical specimens within 2-4 hours, bypassing the need



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for prior culture. Modern multiplex PCR panels simultaneously identify multiple pathogens and key resistance determinants, including *mecA* for MRSA, *bla*CTX-M, *bla*KPC, *bla*NDM for ESBL/carbapenemase producers, and *vanA*/*vanB* for vancomycin-resistant enterococci [1,3]. The molecular LCD chip array represents an advanced hybridization platform capable of detecting both *Mycobacterium tuberculosis* complex and non-tuberculous mycobacteria through amplification of the internal transcribed spacer region of the 16S rRNA gene and the IS6110 insertion element [4]. Such technologies are particularly valuable for slow-growing organisms where conventional culture may require weeks. The diagnostic superiority of molecular methods is evidenced by their ability to detect pathogens in smear-negative/culture-positive specimens, with studies demonstrating that Ziehl-Neelsen microscopy achieves only 63.6% sensitivity compared to automated culture systems [4].

Matrix-assisted laser desorption ionization–time of flight mass spectrometry (MALDI-TOF MS) has revolutionized routine microbiological identification since its clinical introduction. This technology generates species-specific proteomic fingerprints from bacterial colonies within minutes by analyzing ribosomal proteins in the 2,000-20,000 Da mass range. Unlike biochemical systems requiring separate tests for different organism groups, MALDI-TOF MS universally identifies bacteria, mycobacteria, and fungi from a single preparation [2,5,6]. The Bruker Biotyper system assigns confidence scores ( $\geq 1.8$  for high-confidence species identification), providing objective quality metrics. Major academic medical centers have adopted MALDI-TOF MS as the primary identification method for all culture isolates, including blood cultures, respiratory specimens, and surgical site infections [5]. The technology demonstrates particular utility in identifying rare or fastidious organisms—such as non-tuberculous mycobacteria (*M. abscessus*, *M. porcinum*, *M. bacteremicum*, *M. goodii*)—that are increasingly recognized as postoperative pathogens but frequently misidentified or overlooked by conventional methods [2,5,6].

The clinical impact of these rapid technologies directly correlates with the fundamental problem identified in Ukrainian practice: only 25% of hospitalized patients undergo bacteriological testing before empirical therapy initiation. When diagnostic results require 3-5 days, clinicians understandably initiate treatment without microbiological guidance. However, when pathogen identification and resistance detection become available within the same working day, preoperative screening and immediate post-operative testing become logistically feasible. The implementation of PCR-based screening for MRSA nasal carriage prior to clean surgery, followed by decolonization protocols, has demonstrated significant SSI reduction in international centers. Similarly, rapid intraoperative specimen

processing by MALDI-TOF MS can guide targeted antibiotic prophylaxis during prolonged procedures. Thus, the low testing rate in Ukraine is not merely a behavioral issue but a structural consequence of outdated diagnostic infrastructure that fails to deliver clinically actionable results within therapeutic decision windows.

Contemporary infection control extends beyond the microbiology laboratory through integration with hospital information systems. Electronic health records (EHRs) serve as the central infrastructure linking patient demographics, microbiological results, antibiotic administration, and surgical outcomes. Modern platforms transform isolated susceptibility data into actionable intelligence through three functional domains.

Automated susceptibility surveillance systems such as WHONET, originally developed by the World Health Organization, enable systematic recording, analysis, and visualization of antimicrobial resistance data at departmental, institutional, and regional levels. WHONET software processes disc diffusion diameters or minimum inhibitory concentrations, applies clinical breakpoints, detects unusual phenotypes, and generates cumulative antibiograms stratified by ward, specimen type, and patient population [1,6]. The utility of WHONET in surgical departments has been extensively validated: analysis of 3,084 non-duplicate isolates from surgery wards demonstrated that WHONET 5.6 effectively identified resistance trends, including MRSA prevalence (42.7%), ESBL-producing *E. coli* (56.7%), and the emergence of pan-resistant *K. pneumoniae* (0.8%) and *A. baumannii* (44.3%) [1]. Similarly, a three-year surveillance study in a tertiary oncology hospital utilizing WHONET 5.6 successfully tracked MRSA trends (35.5-41.2%) and declining carbapenem resistance in *K. pneumoniae*, directly informing antimicrobial stewardship interventions [6]. Critically, these systems shift AMR surveillance from retrospective epidemiological reporting to prospective clinical decision support: a surgeon preparing for emergency laparotomy can consult the real-time departmental antibiogram displaying current carbapenem susceptibility rates among intra-abdominal *E. coli* isolates, rather than relying on published regional data from previous years.

Advanced EHR-based analytical frameworks represent the next generation of digital AMR surveillance. The Antibiotic Resistance Microbiology Dataset (ARMD) developed at Stanford Health Care integrates 25 years of microbiological data (1999-2024) from over 280,000 patients, linking culture results (including negative cultures), antibiotic susceptibility profiles for 55 antibiotics, patient demographics, comorbidities, and prior antibiotic exposures [5,8]. Organism identification in this system employs MALDI-TOF MS, while susceptibility testing utilizes automated platforms (Vitek2, MicroScan WalkAway) with standardized CLSI interpretation [8].

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The dataset's structure enables sophisticated applications: temporal trend analysis of resistance emergence, risk factor identification through comorbidity-resistance associations, and predictive modeling of individual patient resistance probabilities. Critically, ARMD includes implied susceptibility rules-based on validated microbiological principles, susceptibility to cefazolin implies susceptibility to later-generation cephalosporins-which allow clinicians to infer susceptibility patterns even when direct testing was not performed [6].

Graph neural network-based clinical decision support constitutes the frontier of EHR-driven AMR management. Traditional empirical guidelines, updated every 5-10 years, cannot adequately address the rapid evolution of local resistance patterns or individual patient risk stratification. A 2025 study introduced a deep learning framework conceptualizing patient EHRs as graph structures wherein individual medical events represent nodes and their temporal co-occurrence represents edges [3]. This graph neural network (G2GNN) learns representations of patient similarity, incorporates population-level modeling to address spatial specificity and rare resistance labels, and employs multi-task learning for simultaneous prediction of resistance to multiple antibiotics. Validated on over 110,000 patients, the system achieved AUROC improvements of 0.04-0.10 across four distinct AMR labels compared to conventional baselines [3]. Such systems can be integrated into computerized physician order entry interfaces, providing surgeon-specific, patient-specific, and pathogen-specific antibiotic recommendations at the moment of prescription-not as retrospective audit but as prospective guidance.

Post-discharge digital surveillance addresses a critical gap in surgical infection monitoring. International data demonstrate that 55% of SSIs manifest after hospital discharge, yet routine surveillance typically ceases at discharge [5]. Resource-constrained settings report even greater challenges: a Kenyan post-caesarean SSI surveillance program successfully enrolled 1,039 women, but only 65% were reached for any post-discharge assessment and merely 28% within the targeted 30-day window [9,10]. However, digital health solutions-including automated telephone follow-up, mobile health applications, and integrated laboratory-EHR notification systems-enable systematic post-discharge surveillance without proportional increases in infection control personnel. These systems can trigger automated wound assessment questionnaires, flag readmissions potentially related to surgical infections, and maintain continuous SSI incidence monitoring essential for accurate benchmarking and intervention evaluation.

The relevance of these digital health innovations to Ukrainian surgical practice is direct and urgent. The current reality-only 25% pre-therapy testing, 39.8% Access antibiotic use in hospitals versus >60% recommended, and 29.0% Reserve antibiotic

use versus <5% recommended-reflects an information deficit as much as a resource deficit. WHONET is freely available, requires minimal computational infrastructure, and has been successfully implemented in diverse international settings including China, Latin America, and Africa. Its adoption in Ukrainian surgical departments would enable, for the first time, visibility of local susceptibility patterns at the departmental level. Visualization of departmental antibiograms-showing, for example, that ceftriaxone resistance among surgical *E. coli* isolates has reached 60%-provides powerful, intuitive motivation for both increased testing and guideline revision. Furthermore, the implied susceptibility rules embedded in advanced EHR systems offer an immediately applicable methodology for Ukrainian laboratories: even when comprehensive antibiotic panels cannot be performed on every isolate, strategic selection of indicator antibiotics combined with validated inference rules can generate clinically adequate susceptibility estimates with reduced workload.

In conclusion, modern microbiological control in surgical departments is no longer synonymous with the traditional bacteriology laboratory. It encompasses an integrated technological ecosystem: rapid identification platforms (PCR, MALDI-TOF MS) compressing diagnostic time from days to hours; digital surveillance systems (WHONET, ARMD) transforming isolate-level data into institutional intelligence; and advanced analytics (graph neural networks, predictive modeling) enabling personalized, real-time therapeutic guidance. The implementation gap between these innovations and current Ukrainian practice directly explains the observed deficits in testing frequency and antibiotic appropriateness. Conversely, strategic investment in these technologies-prioritizing WHONET implementation, expanding MALDI-TOF availability to regional reference laboratories, and developing basic EHR-microbiology interfaces-offers a feasible, evidence-based pathway to improve empirical therapy, reduce postoperative infections, and preserve antibiotic effectiveness in Ukrainian surgical patients.

Modern clinical practice includes:

- Bacteriological examination of wounds, catheters, and biological materials from patients with suspected postoperative infections [3,4];
- Advanced antimicrobial susceptibility testing systems (automated microbiological platforms, microdilution methods, PCR testing for resistance genes) [1,3,10];
- Monitoring of local susceptibility patterns with systematic recording in electronic databases [2,10];
- Use of digital technologies for remote postoperative patient monitoring, including electronic medical records and integrated laboratory data systems [2,10].



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**Conclusion.** Antimicrobial resistance in surgical departments represents a current and global healthcare challenge that complicates the management of postoperative infections. Analysis of international and national data revealed high rates of MDR strains among Gram-negative bacteria and MRSA among Gram-positive pathogens, as well as the presence of XDR strains that limit antibiotic options.

Ukraine's 2024 national monitoring confirmed low rates of bacteriological testing prior to empirical therapy (~25%) and inappropriate antibiotic group use, including excessive prescription of reserve antibiotics.

Implementation of modern microbiological control methods, systematic collection of local susceptibility data, and adherence to rational antibiotic therapy protocols can improve treatment effectiveness, reduce the spread of MDR/XDR strains, and ensure safe patient management in surgical departments.

A comprehensive approach to antimicrobial resistance control-incorporating systematic monitoring, microbiological surveillance, and optimization of empirical therapy-is essential to preserve antibiotic effectiveness and improve clinical outcomes in surgical practice.

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