# EPIDEMIOLOGICAL MONITORING OF THE HOSPITAL ENVIRONMENT: CONTROL OF ANTIBIOTIC-RESISTANT STRAINS ISOLATED FROM PATIENTS IN PRIMARY HEALTH CARE SETTINGS

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**Introduction.** The spread of antimicrobial resistance poses an economic and biological threat to many countries worldwide. The resistance of strains to antibacterial drugs is a global problem associated with millions of additional deaths each year. The main factors contributing to the development of resistance in microorganisms are the widespread and uncontrolled use of antibacterial drugs in medicine, veterinary medicine and agriculture, as well as inadequate prevention of infectious diseases over the past 20 years [1, 2].

According to the UN General Assembly, the problem of antibiotic resistance has reached massive proportions and claims 5 million lives a year, with low- and middle-income countries suffering the most. WHO has identified antibiotic resistance as one of the ten most serious threats to public health on the planet. The results of a recent study published in the authoritative medical journal Lancet in 2024 show that in the absence of effective measures to combat antibiotic resistance, the number of infections associated with this problem could increase by approximately 70 % by 2050 [3]. In addition, it is predicted that between 2025 and 2050, the total number of deaths worldwide caused by infections with multi-drug resistance to antibiotics will exceed 39 million cases, which in turn will exceed the mortality rate from cancer and increase gross domestic product expenditure by 3 %. This trend threatens the continued effective treatment of infectious diseases and the health of humanity as a whole.

The existing problem of multidrug resistance to antibiotics has significantly worsened with the onset of the COVID-19 pandemic due to the widespread and often unjustified use of antibacterial drugs. Despite the fact that antibiotics are ineffective against viral infections, they have been widely and often unjustifiably prescribed for the prevention or treatment of possible bacterial complications, which has contributed to the development of drug-resistant bacteria. [4]. This situation has exacerbated the overall problem of antibiotic resistance worldwide and led to the spread of multidrug-resistant strains, particularly ESKAPE(E) bacterial pathogens (Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter spp.), which are considered among the most difficult to treat due to their multiple drug resistance [5]. Many researchers have described various mechanisms of resistance. Genes responsible for the transmission of resistance are constantly being identified and studied. Two mechanisms of resistance have been identified: natural and acquired. From a clinical point of view, the level of antimicrobial activity is determined by the degree of 'therapeutic success' achieved, i.e. whether the microorganism is sensitive to the treatment administered. A resistant microorganism, on the contrary, will have a low 'therapeutic success' rate [6, 7].

The outcome of treatment is determined by the pharmacodynamics and pharmacokinetics of antibacterial drugs at the established concentration required for the eradication of microorganisms. It should be noted that the current EUCAST criteria have provided threshold values for several antibacterial drugs, according to which 'wild-type' strains are assessed as 'sensitive at increased exposure' instead of 'sensitive at standard dosage'. This is a clinically important criterion for deciding on the use of antibacterial drugs with low resistance levels, which may be the first manifestation of clinically significant resistance [8].

**The aim** of our work was to monitor pathogenic microflora as part of epidemiological surveillance of nosocomial infections and to study the resistance of microorganisms to antibacterial drugs.

**Materials and methods.** An analysis of the results of microbiological monitoring of pathogens of purulent-inflammatory diseases and microflora of the hospital environment in the outpatient and inpatient departments of a clinical multidisciplinary hospital in Kharkiv for 2023-2024 was conducted. The isolation and identification of microorganisms were carried out using standard methods. Monitoring of the resistance/sensitivity of microorganisms isolated from clinical material and environmental objects was carried out using the disc diffusion method after isolation of pure cultures and identification using Mueller-Hinton medium and antibiotic discs from Ukrmediasnab LLC. In order to create an information base for epidemiological surveillance, the resistance/sensitivity of microorganisms was monitored using the WHONET 5.6 analytical computer program [9]. Statistical data processing was performed using Microsoft Excel 2019 software. To determine the state of the problem, an analytical review of scientific publications was conducted using the abstract databases of scientific libraries PubMed, Medline and text databases of scientific publishers PubMed, Central, BMJ group. Methods of systematic and content analysis were used.

**Results.** Since hygiene in the hospital environment has a very important epidemiological aspect, ensuring it should be a priority for infection control specialists. Hygiene in the hospital environment is the cornerstone of modern epidemiology and control of nosocomial infections. According to recent scientific data, the hospital environment, including surfaces in wards, equipment, air and water, becomes a reservoir of pathogenic

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microorganisms, in particular antibiotic-resistant strains, which contribute to the emergence and circulation of healthcare-associated infections (HAIs) [10].

HAIs account for a significant proportion of negative outcomes for patients: increased mortality, longer hospital stays and increased financial burden on the healthcare system. According to a 2023 meta-analysis, the prevalence of hospital-acquired infections worldwide is 14 %, with an annual increase of 0.06 %. The highest levels are found in transplant units, neonatal wards, and intensive care units.

Pathogenic microorganisms, including Clostridioides difficile, Acinetobacter baumannii, MRSA, and VRE, can survive on surfaces for weeks, months, or even years. The risk of infecting a new patient increases significantly if the previous occupant of the ward was colonised by multidrug-resistant bacteria. Contaminated surfaces are also a source of contamination for the hands, gowns and gloves of medical staff, contributing to further transmission of infections [11].

Expert recommendations and research strongly indicate the need for regular cleaning and disinfection of the hospital environment, the use of innovative technologies (ultraviolet irradiation, antimicrobial coatings), strict monitoring of cleaning quality, and staff training. For example, a 10-year observation showed that implementing of training programmes, fluorescent marking systems and regular monitoring can significantly reduce the level of HAIs in hospitals [10].

Some studies have compared the effectiveness of standard disinfection and probiotic cleaning. Both approaches tended to reduce the number of infections caused by MRSA and VRE, although the difference between them was not always statistically significant [11, 12].

The COVID-19 pandemic temporarily reduced the level of hospital infections due to strict anti-epidemic measures, but in 2021–2022, the number of cases rose again. At the same time, isolates' microbiological profile and resistance have changed, with a tendency towards an increase in the number of multidrug-resistant strains of Acinetobacter baumannii and other pathogens [13, 14].

In order to prevent HAIs, considerable funds are spent annually, constituting a significant part of the budget of healthcare institutions. Today, due to the changing biological properties of the dominant pathogens of purulent-inflammatory diseases (PID), as well as the lack of data on the amount of antimicrobial drugs used, it is impossible to determine which factors contribute most to the emergence of microbial resistance. Given the ability of microorganisms to survive for long periods in hospital environments, the risk of transmitting resistant microorganisms to patients is quite high. Research into the effectiveness of epidemiological surveillance shows that in order to obtain complete and reliable information on antibiotic-resistant strains, the following steps must be taken: obtaining high-quality clinical samples, successfully isolating infectious agents, and determining sensitivity to antimicrobial drugs. It is also important to select a set of antimicrobial drugs used for testing and conducting special tests that allow identifying specific types of resistance in order to obtain additional information about the pathogen [15, 16].

According to the results of microbiological monitoring conducted in 2023–2024, it was found that among the objects of clinical research, the largest share was represented by swabs from the pharynx and nasal cavity, which accounted for 51.2 % of the total number of samples examined. Other significant groups of objects were urine — 12.3 %, sputum — 10.8 %, swabs from the vagina and cervical canal — 11.5 %, and material taken from wound surfaces — 14.2 %. Analysis of the resistance of microorganisms in these samples showed that the largest number of isolated strains was observed in material from the nasopharynx and pharynx — 95.8 %, which indicates a high potential for colonisation of these areas. At the same time, the number of isolated strains from sputum was 34.7 %, from urine — 47.3 %, from wound surfaces — 25.9 %, and from swabs from the vagina and cervical canal — 19.1 % (Table 1). The data obtained emphasise the importance of a comprehensive and multidisciplinary approach to studying the structure of microflora in various clinical materials in the context of antibiotic resistance.

Table 1. Distribution of clinical research materials and isolated strains

| Research biomaterial | Share in clinical research (%) | Share of isolated strains (%) |
|---|---|---|
| Throat and nose swabs | 51,2±8,6 | 95,8±3,9 |
| Urine | 12,3±2,5 | 47,3±8,4 |
| Sputum | 10,8±2,1 | 34,7±6,0 |
| Vaginal and cervical swabs | 11,5±3,2 | 19,1±3,7 |
| Wounds | 14,2±2,8 | 25,9±5,3 |

In total, 802 isolates of various types of microorganisms were identified in the laboratory in 2023-2024. Analysis of the aetiological structure showed that the dominant microflora in the institution were:

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Staphylococcus spp. – 49.6 %, in particular, 24.9 % was Staphylococcus aureus, 20.8 % – Staphylococcus epidermidis, 3.9 % – Staphylococcus coagulase-negative.

In the structure of morbidity, staphylococci were distributed as follows: discharge from the nose and throat – 58.8 %, genital system – 12.4 %, upper respiratory tract diseases – 10.6 %, urinary tract – 9.1 %, discharge from wounds – 9.1 %.

Enterobacteria accounted for 21.1 % of the total number of isolated pathogens, of which 10.2 % were isolated from urinary tract infections and 10.9 % from wounds. The Enterobacteria group included microorganisms of the genus Escherichia coli – 14.9 %, and Klebsiella pneumonia – 6.1 %. The conditionally pathogenic Gram-negative microorganism Pseudomonas aeruginosa was also isolated, accounting for 0.6%, which in turn is a potential agent for developing nosocomial infections, especially in burn and oncology hospitals, resuscitation and intensive care units.

The second most significant microorganism after staphylococci was Candida albicans, which accounted for 28.7% of the total number of isolates.

Its presence was distributed among the study subjects as follows: genitourinary system diseases – 45.3 %, sputum – 10.1 %, wounds – 9.2 %, nasal and throat secretions – 35.4 %.

Summary data on the structure of the presence of isolated pathogens of nosocomial infections are presented in Table 2.

Table 2. Distribution of typical pathogenic microflora by location (%)

| Pathological focus | Staphylococcus spp. (%) | Enterobacteriaceae (%) | Candida (%) |
|---|---|---|---|
| Upper respiratory tract | 10,6±2,2 | - | 10,1±2,6 |
| Genitourinary system | 21,5±4,8 | 10,2±3,1 | 45,3±7,8 |
| Wound discharge | 9,1±2,3 | 10,9±2,6 | 9,2±2,4 |
| Nose and pharynx | 58,8±9,7 | - | 35,4±6,5 |

Each isolate that was collected was tested for resistance to antibacterial drugs that are of primary clinical importance: for S. aureus and S. epidermidis – to β-lactams (benzylpenicillin, oxacillin), fluoroquinolones (ciprofloxacin, levofloxacin, ofloxacin), lincosamides (lincomycin, clindamycin), macrolides (erythromycin, azithromycin), aminoglycosides (amikacin, gentamicin), glycopeptides (vancomycin), as well as other drugs as needed (rifampicin, chloramphenicol, linezolid).

When assessing the sensitivity of representatives of the Enterobacteriaceae family, attention was primarily paid to β-lactam antibacterial drugs such as: cephalosporins (cefotaxime, ceftriaxone, ceftazidime), aminoglycosides (gentamicin), ampicillin, fluoroquinolones (ciprofloxacin), and protected aminopenicillins (amoxiclav).

Analysis of antibiotic resistance monitoring data showed that during the study period, the number of resistant (I+R) strains to various antibacterial drugs was as follows: for S. aureus – 46.6% resistance to gentamicin and 65.6% to tetracycline, S. epidermidis – 69.1% (tetracycline), Staphylococcus coagulase negative – 78.8% (tetracycline) (Fig.1).

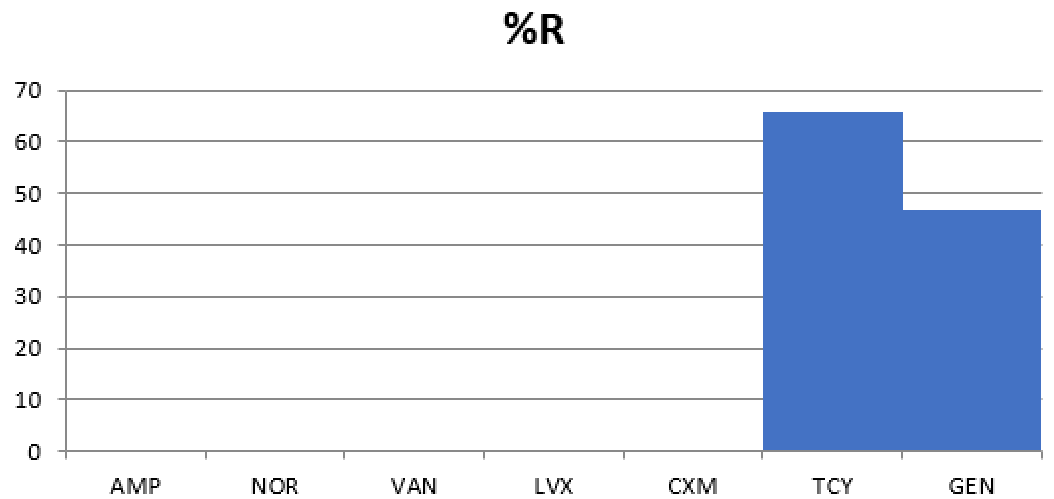


Figure 1. Percentage of resistant strains of Staphylococcus spp. Caption: AMP – ampicillin; NOR – norfloxacin; VAN – vancomycin; LVX – levofloxacin; CXM – cefuroxime; TCY – tetracycline; GEN – gentamicin.

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For E. coli, resistance to various generations of cephalosporins was 80.0–100.0%, for Klebsiella pneumonia – 50.0–100.0% (fluoroquinolones, macrolides, first- and second-generation cephalosporins), for Pseudomonas aeruginosa – 100.0% (levofloxacin) (Fig.2).

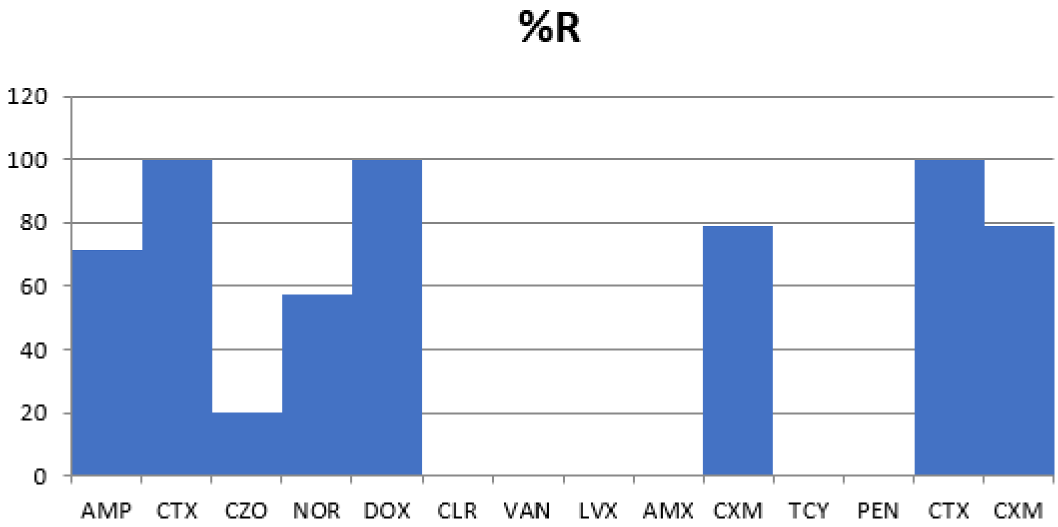


Figure 2. Percentage of resistant strains of microorganisms of the genus Enterobacteriaceae. Caption: AMP – ampicillin; CTX – ceftriaxone; CZO – cefazolin; NOR – norfloxacin; DOX – doxycycline; CRL – ceftriaxone; VAN – vancomycin; LVX – levofloxacin; AMX – amoxicillin; TCY – tetracycline; PEN – penicillin; CTX – cefotaxime; CXM – cefuroxime.

With regard to fungi of the genus Candida, resistance ranged from 50.0 to 67.1% to antifungal drugs such as itraconazole (ITR) and ketoconazole (KET) (Fig.3, 4).

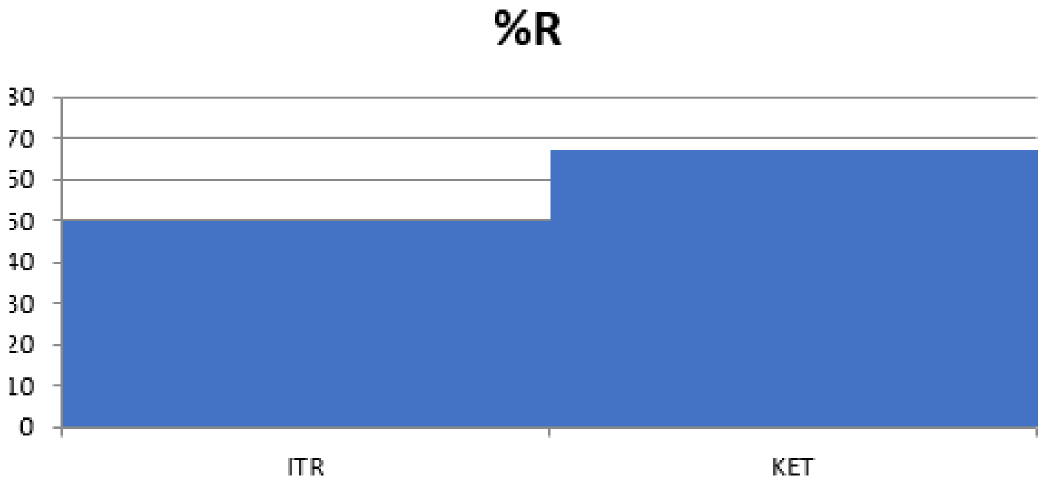


Figure 3. Percentage of resistant strains of microorganisms of the genus Candida

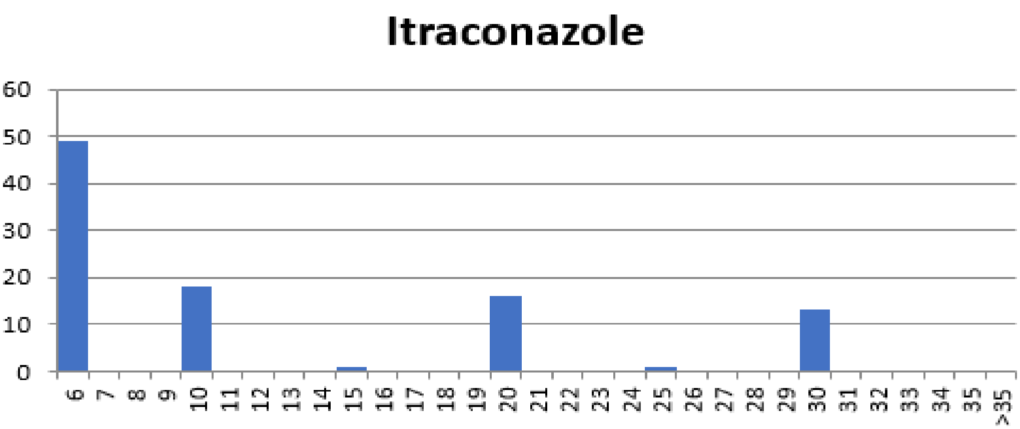


Figure 4. Sensitivity of Candida fungi to antifungal drugs

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In order to assess the epidemiological significance of S. aureus and E. coli, an analysis of the results of sanitary and bacteriological studies of a medical institution was carried out. The results obtained prove that S. aureus and E. coli play a significant role in the formation of the microbiocenosis of the hospital environment. The long-term circulation of these microorganisms leads to the formation of hospital strains of nosocomial infection pathogens.

The main criterion for preventing the development of resistance is the rational use of antimicrobial drugs, which cannot be justified without microbiological monitoring of antibiotic sensitivity, which provides an idea of the prevalence of resistance of nosocomial infection pathogens in a particular medical facility [17].

Currently, there is no accurate assessment of the extent of antimicrobial resistance in many medical institutions and outside them, which causes certain difficulties in analysing epidemiological monitoring data. At the same time, some features of developing of microbial resistance to antibacterial drugs are becoming apparent [18].

At the present stage, overcoming microbial resistance is aimed at introducing measures to address the problem of antibiotic resistance [19]. To this end, protocols for the use of antimicrobial drugs are being developed based on local data on microbial resistance, the dynamics of resistance are being monitored, educational programmes for doctors are being created, and de-escalation and stepwise antibiotic therapy is being introduced and applied in hospitals [20, 21]. Attention is drawn to the rules and requirements for standard protective measures (hand hygiene, safe disposal of medical waste, cleaning and disinfection of premises, etc.). Enhanced epidemiological surveillance is being conducted on the antimicrobial resistance of microorganisms that cause purulent-inflammatory wound infections in wounded soldiers as a result of combat operations, which is particularly relevant in the current situation in our country [22, 23].

**Conclusions and prospects for further research.** Antimicrobial resistance is one of the most acute global threats to health. The main factors contributing to its spread are the uncontrolled use of antibiotics in medicine, agriculture and veterinary medicine, as well as low levels of infection prevention. The COVID-19 pandemic has exacerbated the situation, contributing to an increase in the proportion of resistant ESKAPE pathogens (E).

Epidemiological monitoring, particularly in outpatient settings, is a key tool for the timely detection of changes in microflora structure and resistance levels. In the 2023–2024 study, the most common pathogens were Staphylococcus spp., Escherichia coli, Klebsiella pneumoniae, and Candida albicans. High levels of resistance to many groups of antibiotics have been recorded, complicating the treatment of purulent-inflammatory diseases.

Effective countermeasures require the implementation of rational antibiotic therapy, strengthened infection control, the use of modern analytical tools (including WHONET), and the continuous updating of treatment protocols based on local data.

Insufficient infrastructure, especially in low-income countries, and a lack of training and quality control of hygiene procedures remain ongoing problems. A significant number of recent scientific publications confirm the link between improved hygiene in the hospital environment and a reduction in HAI incidence. However, the feasibility and long-term effectiveness of specific interventions require further study.

The epidemiological aspect of hospital hygiene involves minimising the transmission of pathogens through, on the one hand, the systematic implementation of effective hygiene measures and, on the other hand, continuous monitoring, training and technological updating of cleaning processes. This is a critically important component of the strategy to combat the spread of hospital infections and improve patient safety and staff health.

Thus, although the minimum requirements for infection control are universal, their practical implementation and compliance create noticeable differences in the level of prevention of hospital infections in different medical institutions.

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**Epidemiological monitoring of the hospital environment: control of antibiotic-resistant strains isolated from patients in primary health care settings**

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Antibiotic resistance is not a new phenomenon in modern medical practice. However, today this problem is becoming critical in healthcare. Over several decades, pathogens of common infections have developed various resistance genes, which has subsequently become a global issue. Epidemiological surveillance is a critically important tool in the fight against antibiotic resistance, as it provides systematic monitoring of the spread of resistant strains and their sensitivity to antimicrobial drugs. Epidemiological monitoring data enable the timely detection of new resistance mechanisms, tracking of trends in their spread, and development of effective strategies for infection control and rational antibiotic therapy. **The aim:** Objective: to monitor the prevalence of hospital-acquired infection pathogens and study their antibiotic resistance. **Materials and methods.** The study analysed the results of epidemiological monitoring of the structure and antibiotic resistance of microflora in a hospital environment. Microorganisms were isolated using standard methods with simple and special nutrient media. The WHONET 5.6 system was used as an information base for epidemiological surveillance. **Results.** The article presents the results of microbiological monitoring for 2023-2024. The main focus was on identifying the structure of nosocomial

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infection pathogens and assessing their antibiotic resistance. The bacteriological study covered more than 800 isolates, among which Staphylococcus spp. (49.6%), Candida albicans (28.7%) and representatives of the Enterobacteriaceae family (21.1%) dominated. High levels of resistance to key groups of antimicrobial drugs (β-lactams, fluoroquinolones, macrolides) were recorded in E. coli (80,0–100,0 %), Klebsiella pneumoniae (50,0–100,0 %), Pseudomonas aeruginosa (100,0 %), and Staphylococcus coagulase negative (78,8 %). The data obtained indicate the significant role of the hospital environment as a reservoir of multidrug-resistant microflora and point to the need for a comprehensive approach to infection control.
**Conclusions.** The feasibility of local microbiological surveillance, adaptation of antibiotic therapy protocols taking into account local resistance profiles, and systematic staff training has been substantiated. Given the changing biological properties of pathogens and the growing threat of antibiotic resistance, it is extremely important to comprehensively implement sanitary and epidemiological measures and use antimicrobial agents appropriately.

**Keywords:** antibiotic resistance, purulent-inflammatory diseases, epidemiological surveillance, hospital hygiene.

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