HIDDEN HEALTHCARE-ASSOCIATED INFECTION BURDEN IN UROLOGY DEPARTMENTS AND THE RATIONALE FOR AN AI-SUPPORTED INTEGRATED EPIDEMIOLOGICAL MONITORING MODEL

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Abstract

Urology departments are high-risk settings for healthcare-associated infections (HAIs) due to invasive procedures, catheterization, and intensive antibiotic use. However, official reports of the Committee for Sanitary-Epidemiological Welfare and Public Health (CSEWPH) in Olmazor District registered zero HAIs in urology units during 2023–2024, suggesting possible under-detection. This study analyzed microbiological, environmental, and clinical indicators to assess the hidden infection burden. Laboratory data demonstrated persistently high biomaterial positivity (57.0–58.6%), accompanied by a significant shift toward nosocomial pathogens, including Klebsiella pneumoniae and Candida spp. Environmental monitoring revealed a sharp increase in surface contamination in 2025, including aseptic zones, indicating a critical epidemiological signal. Prolonged antibiotic use was common, potentially exceeding prophylactic recommendations. These findings support the presence of a hidden HAI burden and justify the implementation of an integrated AI-supported, signal-based epidemiological monitoring system to enhance early detection and targeted infection prevention.

Keywords: Healthcare-associated infections, urology departments, hidden infection burden, microbiological surveillance, environmental contamination, antibiotic stewardship,

antimicrobial resistance, infection prevention and control, AI-supported monitoring, epidemiological risk assessment.

Urology departments are considered high-risk settings for healthcare-associated infections (HAIs) due to the widespread use of invasive diagnostic and therapeutic procedures, long-term catheterization, endoscopic interventions, and intensive antibiotic exposure. Despite this, official surveillance reports of the Committee for Sanitary-Epidemiological Welfare and Public Health (CSEWPH) in Olmazor District documented zero registered HAIs in urology departments during 2023–2024. From an epidemiological perspective, such findings may reflect not the absence of infections but rather under-detection and incomplete registration of hospital-acquired cases.

To assess the real infectious burden, a comprehensive epidemiological and microbiological analysis was conducted using laboratory data, environmental monitoring results, and clinical indicators from urology facilities. In 2023, 5,663 biomaterial samples were examined, of which 3,225 (57.0%) yielded positive microbiological results. In the first four months of 2024, 1,099 of 1,874 samples (58.6%) were positive, with no statistically significant difference between periods ($\chi^2=1.3$; $p>0.05$), indicating a persistently high infectious load. Microbiological spectrum analysis revealed a statistically significant decrease in Escherichia coli alongside a notable increase in Klebsiella pneumoniae and Candida spp., suggesting intensification of nosocomial selection pressure and a shift toward opportunistic and potentially resistant pathogens.

Environmental surveillance further supported the presence of a hidden epidemiological risk. While surface swab positivity remained low in 2023–2024, a sharp deterioration was observed in 2025, when positive surface samples increased to 15.0% ($\chi^2=32.4$; $p<0.001$). Importantly, contamination was detected not only in septic areas but also in aseptic zones, which represents a critical epidemiological signal and indicates a breach in disinfection and infection control practices. Air microbiological monitoring showed that, although Staphylococcus aureus was not detected, the overall microbial load exceeded regulatory thresholds in several functional zones, increasing the potential for contact-mediated transmission.

An audit of antibiotic use revealed that 59.2% of patients received antibacterial therapy for four days or longer. In the absence of clear clinical or laboratory confirmation of infection, such prolonged antibiotic use may exceed guideline-recommended prophylactic durations and contribute to antimicrobial resistance, disruption of normal microbiota, and further amplification of the hospital infection reservoir. The combination of invasive procedures, prolonged hospitalization in older patients, environmental contamination, and extended antibiotic exposure collectively supports the epidemiological assumption that the relative risk

of HAIs in urology departments exceeds unity (RR>1), despite the lack of officially registered cases.

Based on these findings, an integrated AI-supported epidemiological monitoring framework is proposed. This model combines clinical indicators (postoperative fever, leukocytosis, prolonged length of stay), microbiological data (positivity rate and pathogen shifts), environmental contamination signals, and antibiotic stewardship metrics into a unified "signal–investigation–action–reassessment" cycle. Such an approach enables early detection of hidden infection risks, identification of high-risk zones and patient groups, and timely implementation of targeted preventive measures. The proposed framework shifts HAI surveillance from passive statistical reporting to an active, signal-driven management system, thereby strengthening infection prevention and control in urology departments and improving patient safety.

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