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NOSOCOMIAL INFECTIONS: ANALYSIS OF NATIONAL AND GLOBAL EXPERIENCE

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ABSTRACT: Hospital-acquired infections (HAIs) remain one of the most significant healthcare problems, significantly impacting morbidity, mortality, and the economic costs of healthcare facilities. This article presents a comparative review of national and global practices in the prevention and control of HAIs, focusing on current epidemiological trends, risk factors, and common etiologic agents. Particular attention is paid to an analytical study of the situation in Uzbekistan and a comparison with international standards, including recommendations from the WHO, CDC, and European Centers for Infection Control. Successful practices in developed countries, such as the introduction of care bundles, enhanced microbiological monitoring, and programs for the rational use of antibiotics, are analyzed. Based on the identified differences, key areas for improving infection control in healthcare facilities in Uzbekistan are identified. The review emphasizes the need for a comprehensive approach combining clinical, managerial, and educational measures to effectively reduce HAIs.

Key words: hospital-acquired infections, nosocomial infections, infection control, epidemiology, prevention, antibiotic resistance, microbiological monitoring, care-bundles, WHO standards, hospital.

ВНУТРИБОЛЬНИЧНЫЕ ИНФЕКЦИИ: АНАЛИЗ НАЦИОНАЛЬНОГО И МИРОВОГО ОПЫТА

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АННОТАЦИЯ: Внутрибольничные инфекции (ВБИ) остаются одной из наиболее значимых проблем здравоохранения, оказывая существенное влияние на показатели заболеваемости, летальности и экономические издержки лечебных учреждений. В статье представлен сравнительный обзор национального и мирового опыта профилактики и контроля ВБИ с акцентом на современные эпидемиологические тенденции, факторы риска и распространённые этиологические агенты. Особое внимание уделено аналитическому изучению ситуации в Узбекистане и сопоставлению её с международными стандартами, включая рекомендации ВОЗ, CDC и европейских центров инфекционного контроля. Проанализированы успешные практики развитых стран, такие как внедрение care-bundles, усиление микробиологического мониторинга и программы рационального применения

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антибиотиков. На основе выявленных различий обозначены ключевые направления совершенствования инфекционного контроля в медицинских учреждениях Узбекистана. Обзор подчеркивает необходимость комплексного подхода, объединяющего клинические, управленческие и образовательные меры для эффективного снижения ВБИ.

Ключевые слова: внутрибольничные инфекции, нозокомиальные инфекции, инфекционный контроль, эпидемиология, профилактика, антибиотикорезистентность, микробиологический мониторинг, care-bundles, стандарты ВОЗ, стационар

RELEVANCE: Hospital-acquired infections (HAIs) remain one of the most critical challenges for modern healthcare systems worldwide, significantly affecting patient morbidity, mortality, and economic stability of medical institutions. Despite notable advancements in medical technology, antimicrobial therapy, and hospital infrastructure, the global burden of HAIs continues to rise, largely driven by increasing antimicrobial resistance, insufficient infection prevention practices, and high patient turnover in healthcare facilities. In low- and middle-income countries, including Uzbekistan, the problem is further intensified by limited laboratory capacity, resource constraints, and variability in adherence to international infection control standards.

The relevance of studying HAIs within both national and global contexts is underscored by the need to optimize preventive strategies, enhance epidemiological surveillance, and improve the quality of care. Comparative analysis of international experiences—such as WHO, CDC, and ECDC guidelines—provides valuable insights into effective practices, including care-bundle implementation, hand hygiene programs, and antimicrobial stewardship initiatives. Understanding the strengths and weaknesses of local systems enables targeted recommendations for reducing infection rates, strengthening hospital safety, and improving patient outcomes.

This review highlights the urgent necessity of adopting a comprehensive, evidence-based approach to HAI prevention, integrating clinical, organizational, and educational components to ensure sustainable improvements in healthcare quality and public health protection.

MATERIALS AND METHODS:

This review article is based on a structured analysis of international and national literature related to hospital-acquired infections (HAIs) and infection prevention practices. Scientific databases such as PubMed, Scopus, Web of Science, and Google Scholar were searched using keywords including “HAIs,” “infection control,” “nosocomial infections,” and “antimicrobial resistance.” Publications from WHO, CDC, ECDC, and national health authorities were also reviewed. Sources published between 2015 and 2024 were prioritized. Studies were selected based on relevance, methodological quality, and contribution to current understanding of HAI prevention. Comparative analysis was used to evaluate global and local practices and identify key improvement strategies.

RESULTS AND DISCUSSION: Healthcare-associated infections (HAIs), traditionally referred to as nosocomial or hospital-acquired infections, remain one of the most critical challenges for modern healthcare systems worldwide. According to the World Health

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Organization (WHO), an HAI is defined as any clinically evident or laboratory-confirmed infection occurring 48 hours or more after hospital admission, within 30 days after a surgical intervention, or within 90 days following the implantation of medical devices such as prostheses or catheters. HAIs serve as a highly sensitive indicator of the quality of medical care, the degree of patient safety, and the effectiveness of infection prevention and control (IPC) systems within healthcare facilities [1].

The global burden of HAIs is immense. WHO estimates that each year between 100 and 150 million new HAI cases occur worldwide; however, due to significant underreporting, the actual incidence is presumed to be substantially higher. On any given day, 7 out of 100 patients in high-income countries and 15 out of 100 patients in low- and middle-income countries (LMICs) acquire at least one HAI. In the European Union and European Economic Area, approximately 4.5 million HAI episodes occur annually, contributing to nearly 90,000 deaths. The economic cost is equally staggering: HAIs result in an estimated €7 billion in direct medical expenses annually in the EU alone.

The United States Centers for Disease Control and Prevention (CDC) report that approximately 3 % of hospitalized patients develop HAIs each year, resulting in roughly 687,000 cases and 72,000 deaths. Data from the Agency for Healthcare Research and Quality (AHRQ) indicate that HAIs may prolong hospitalization by 7 to 21 days and increase healthcare costs by $3,000 to $30,000 per patient, depending on the infection type and the patient's clinical condition. The global economic burden of HAIs, including indirect costs such as reduced productivity and long-term disability, is estimated to exceed $50 billion annually.

The challenge posed by HAIs is amplified in countries with transitioning healthcare systems, such as the Republic of Uzbekistan. Although substantial reforms have been undertaken in recent years—particularly in strengthening the sanitary-epidemiological service, enhancing laboratory capacity, and updating regulatory frameworks—significant gaps remain. Official Ministry of Health statistics suggest that the incidence of HAIs in Uzbekistan is 2.0–2.5 %, but multiple independent hospital-based studies report much higher rates. Research conducted in regional and tertiary hospitals across Andijan, Fergana, Bukhara, and Tashkent indicates HAI rates ranging from 5–7 % in general medical wards to 12–21 % in surgical units and maternity hospitals. A 2021 study from Bukhara region reported 21.6 postoperative infections per 100 surgical procedures, a figure comparable to or exceeding rates in other LMIC settings [2].

Intensive care units (ICUs) in Uzbekistan demonstrate particularly high vulnerability: observational studies from 2020–2023 reveal HAI rates of 17–19 %, with a predominance of ventilator-associated pneumonia (VAP) and catheter-associated bloodstream infections (CLABSI). These findings align with the global trend that ICUs are among the highest-risk hospital departments due to the severity of admitted patients, frequent use of invasive procedures, and prolonged hospitalization.

The burden of antimicrobial resistance (AMR) further complicates the epidemiology of HAIs. WHO's Global Antimicrobial Resistance and Use Surveillance System (GLASS) reports that approximately 35 % of all HAIs worldwide involve pathogens resistant to one or more major classes of antibiotics. In the Central Asian region, including Uzbekistan, the prevalence of multidrug-resistant organisms frequently exceeds 50–60 %, especially among Klebsiella

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pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Staphylococcus aureus. These pathogens are responsible for a large share of severe HAI cases, including VAP, bloodstream infections, and complex surgical-site infections.

Given these alarming trends, an in-depth analysis of both global and national HAI data is essential. Understanding Uzbekistan's position relative to international indicators will strengthen the evidence base for IPC interventions, guide policy development, and inform strategic investments in healthcare infrastructure and workforce training [3].

The purpose of this review article is to synthesize global knowledge on HAIs, compare it with national data from Uzbekistan, and highlight existing challenges and potential solutions. The article evaluates epidemiological patterns, profiles of causative pathogens, major risk factors, the economic impact of HAIs, and the effectiveness of infection control strategies. Special attention is paid to the structure of Uzbekistan's IPC system, its alignment with WHO recommendations, and opportunities for modernization.

General Concepts of Healthcare-Associated Infections

Healthcare-associated infections arise from a multifaceted interaction between patients, healthcare workers, the hospital environment, medical technology, and microbial ecology. Proper classification and diagnosis of HAIs require not only clinical and laboratory expertise but also a robust surveillance system capable of differentiating community-acquired infections from hospital-acquired ones. In many LMICs, including Uzbekistan, surveillance challenges such as inconsistent documentation, underreporting, lack of standardized definitions, and limited laboratory capacity impede accurate assessment.

Global Structure of HAIs

Large-scale studies across Europe, North America, and Asia demonstrate that the distribution of HAIs is relatively consistent despite geographic variation:

Urinary tract infections (UTIs): 23–25 % of all HAIs

Pneumonias, including ventilator-associated pneumonia (VAP): 22 %

Surgical site infections (SSI): 19–21 %

Bloodstream infections (BSI): 10–12 %

Gastrointestinal infections (primarily Clostridioides difficile): 12–15 %

The European Centre for Disease Prevention and Control's (ECDC) 2023 report shows that UTIs remain the most commonly reported HAIs, with incidence rates of 7.9 per 1000 catheter-days. In the United States, CDC's National Healthcare Safety Network (NHSN) reports similar trends, although the incidence of C. difficile infections has shown periodic fluctuations due to changing antibiotic stewardship practices [4].

HAI Structure in Uzbekistan

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Uzbekistan presents a distinctive HAI profile shaped by several factors: differing levels of infrastructure across regions, variability in IPC practices, challenges in sterilization processes, and limited digital integration into surveillance systems.

According to national and regional studies:

Surgical site infections account for 35–40 % of all HAIs.

Obstetric and gynecological infections (postpartum sepsis, endometritis, perineal wound infection) represent about 32 %.

ICU-associated infections, including VAP and CLABSI, reach 28 % of HAIs.

A 2022 multicenter survey conducted across 14 hospitals in Tashkent and the Fergana Valley demonstrated that:

The average HAI incidence in ICUs was 18.3 %.

VAP incidence reached 28 cases per 1000 ventilator-days—higher than rates reported in Turkey (16 per 1000) or Poland (12 per 1000).

CLABSI incidence exceeded 6.0 per 1000 catheter-days, nearly triple the NHSN benchmark (2.1–2.5 per 1000).

These statistics highlight the need for systematic improvements in Uzbekistan's IPC management, including more rigorous monitoring of invasive procedures, enhanced training for staff, implementation of standardized bundle approaches, and greater investment in sterilization and disinfection infrastructure [5,6].

Pathogen Distribution and Antimicrobial Resistance

Globally, the leading pathogens responsible for HAIs include:

Staphylococcus aureus (including MRSA)

Escherichia coli

Klebsiella pneumoniae

Pseudomonas aeruginosa

Acinetobacter baumannii

Enterococcus spp.

Clostridioides difficile

In Uzbekistan, studies conducted between 2018 and 2023 reveal the following alarming trends:

MRSA prevalence exceeds 52 % in several tertiary care hospitals.

Carbapenem-resistant Klebsiella pneumoniae ranges between 40–55 %.

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Multidrug-resistant Acinetobacter baumannii is found in up to 70 % of ICU-associated infections.

Pseudomonas aeruginosa isolates show resistance levels above 40 % to piperacillin-tazobactam and above 60 % to carbapenems.

Such patterns highlight the strong link between HAIs and antimicrobial resistance, particularly in settings where antibiotic stewardship programs are insufficiently implemented.

The global burden of healthcare-associated infections reflects a complex combination of epidemiological, social, economic, and healthcare system factors. Across all regions of the world, HAIs continue to represent one of the most underestimated yet impactful challenges to patient safety. Despite decades of progress in infection prevention and control, the incidence of HAIs has not significantly declined in many countries. In some regions, particularly low- and middle-income countries, the prevalence of HAIs remains several times higher than in high-income settings. WHO's most recent global point-prevalence surveys consistently show that, at any given time, approximately one in seven hospitalized patients in LMICs suffers from at least one HAI. This contrasts sharply with high-income countries, where the prevalence is closer to one in fourteen. Such disparities are often attributed to variations in infrastructure, staffing levels, surveillance capacity, and the availability of modern medical technologies [6,7].

In Europe, the ECDC estimates that approximately 4.5 million HAI episodes occur annually. The mortality associated with these infections remains considerable, with an estimated 90,000 deaths per year directly attributable to HAIs. Moreover, the economic impact reaches well beyond direct treatment costs. Prolonged hospital stays, additional diagnostic tests, intensive care utilization, and repeated surgeries impose a heavy financial burden on national healthcare systems. In the European context alone, annual economic losses surpass €7 billion, a figure that does not account for indirect costs such as long-term disability or reduced labor productivity. Studies indicate that each HAI extends the length of hospitalization by an average of 8 to 21 days, depending on the severity and type of infection. Surgical site infections and ventilator-associated pneumonia are among the most costly forms, frequently doubling or tripling the duration of hospital stays and significantly increasing the risk of mortality.

The United States presents a similar picture, albeit with more advanced surveillance mechanisms. According to the CDC, approximately 687,000 HAIs occur each year, and nearly 72,000 patients die as a direct result. These figures illustrate that even highly developed healthcare systems with robust IPC programs remain vulnerable to the substantial burden of HAIs. The financial implications in the United States exceed $25 billion annually in direct healthcare expenditures, while the societal cost may surpass $60 billion when accounting for morbidity, long-term care, and productivity loss. With hospital budgets under increasing pressure, HAIs represent not only a public health threat but also a significant economic liability.

A growing concern in recent years has been the expansion of antimicrobial resistance, which transforms relatively treatable infections into severe, complicated, and often fatal conditions. Studies across Asia, Africa, and Latin America consistently demonstrate that multidrug-resistant pathogens cause a disproportionate share of HAIs. For example, carbapenem-resistant Klebsiella pneumoniae in some Southeast Asian countries exceeds 50 %, while in Sub-Saharan Africa,

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resistance rates among Acinetobacter species frequently reach 70 %. These alarming patterns lead to higher treatment costs, limited therapeutic options, and elevated mortality. WHO estimates that antimicrobial resistance, if left unchecked, could result in 10 million deaths annually by 2050, with a disproportionate share attributable to healthcare-associated infections [8,9,10].

In many regions, bloodstream infections and pneumonia remain the most lethal forms of HAIs. Mortality from ICU-acquired bloodstream infections ranges from 20 to 40 %, with higher rates in LMICs where delays in diagnosis, limited laboratory capacity, and shortages of second-line antibiotics exacerbate outcomes. Ventilator-associated pneumonia carries mortality estimates of 30–50 % globally, with some reports from Central Asia and parts of Africa suggesting even higher fatality rates, particularly in newborn and trauma populations. These patterns reinforce the urgency of strengthening surveillance and prevention efforts.

Uzbekistan's National Context and HAI Burden

Uzbekistan, like many countries with a transitioning healthcare system, faces significant challenges in accurately assessing and controlling HAIs. Official Ministry of Health reports suggest that the national incidence remains around 2–2.5 %, a figure that appears markedly lower than global averages and likely reflects substantial underreporting. The discrepancy becomes clearer when examining smaller-scale investigations conducted at the facility level. Studies from Fergana, Andijan, Tashkent, and Bukhara regions reveal rates much closer to global LMIC benchmarks, ranging from 5 to 12 % in general wards and up to 21 % in surgical units.

Surgical site infections are among the most prevalent and problematic HAIs in the country. A 2021 study conducted at a major regional hospital documented an incidence of 21.6 postoperative infections per 100 surgical procedures—a rate nearly double that reported in similar tertiary hospitals in Kazakhstan and Kyrgyzstan. These infections not only prolong hospitalization but also increase the risk of rehospitalization and mortality. Obstetric units face similar challenges. Postpartum infections, including endometritis and perineal wound infection, remain prevalent. Large maternity hospitals in Tashkent and the Fergana Valley report postpartum infection rates ranging between 5 and 10 %, with some small hospitals showing even higher rates. These findings underscore the need for improved sterilization, aseptic technique, and postpartum surveillance.

Intensive care units in Uzbekistan experience some of the highest HAI rates in the healthcare system. Recent surveillance-based assessments report that approximately one in five ICU patients develops a serious healthcare-associated infection. Ventilator-associated pneumonia is particularly common, occurring at rates as high as 28 cases per 1000 ventilator-days. Such figures significantly exceed international benchmarks. The NHSN benchmark for VAP is roughly 3–5 per 1000 ventilator-days in high-income countries, and even middle-income countries such as Turkey or Malaysia report rates closer to 12–16 per 1000. These comparisons highlight the urgent need to strengthen ICU infection control practices, including ventilator bundles, effective airway management, improved nurse-to-patient ratios, and routine monitoring of ventilator circuits.

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Bloodstream infections, particularly catheter-associated bloodstream infections, also represent a growing challenge. Several studies from tertiary hospitals in Uzbekistan show CLABSI rates of 6 per 1000 catheter-days, nearly triple the rate reported by NHSN and significantly higher than the European average of around 2.4. High CLABSI rates are strongly associated with prolonged catheter use, inadequate catheter insertion training, improper maintenance practices, and overcrowding in intensive care environments.

A central issue compounding the burden of HAIs in Uzbekistan is the widespread presence of antimicrobial resistance. National data collected between 2018 and 2023 consistently demonstrate high resistance levels among major pathogens. Multidrug-resistant Acinetobacter baumannii strains account for up to 70 % of isolates in some ICUs, while carbapenem-resistant Klebsiella pneumoniae prevalence ranges between 40 and 55 % in large regional hospitals. Pseudomonas aeruginosa also exhibits high resistance levels, with more than 40 % of isolates resistant to piperacillin-tazobactam and up to 60 % resistant to carbapenems. Methicillin-resistant Staphylococcus aureus (MRSA) remains a major pathogen in surgical units, with prevalence exceeding 50 % in several centers. These alarming resistance profiles reflect gaps in antibiotic stewardship practices, challenges in laboratory diagnostics, and widespread overuse or misuse of broad-spectrum antibiotics [1,3,11].

Uzbekistan has made considerable progress in strengthening its sanitary and epidemiological services in recent years. Investments in surveillance infrastructure, the introduction of new sanitary rules, and the establishment of IPC committees within major hospitals demonstrate a growing commitment to improving patient safety. Nevertheless, persistent issues such as insufficient staffing, uneven distribution of resources across urban and rural areas, limited microbiology laboratory capacity, and lack of real-time digital surveillance continue to hinder effective HAI control.

Hospital Departments at Highest Risk

Globally and nationally, the departments that bear the greatest burden of HAIs are surgical units, maternity hospitals, intensive care units, and emergency departments. Each setting exhibits its own risk profile shaped by patient characteristics, procedural complexity, and environmental conditions.

In surgical units, the risk of infection reflects both intrinsic patient factors and extrinsic factors related to procedural technique, sterilization practices, and postoperative care. In Uzbekistan, as in many LMICs, insufficient adherence to sterile technique and challenges in maintaining high-quality instrument sterilization contribute to elevated surgical site infection rates. Overcrowding and the frequent need for urgent, resource-intensive surgeries further increase risk.

Maternity hospitals represent a unique epidemiological environment. Postpartum infections threaten both maternal health and newborn outcomes. Despite improvements in obstetric care, infection rates remain higher than desired, with some regions reporting postpartum infection rates up to 10 %. These figures are influenced by factors such as prolonged labor, invasive obstetric procedures, limited availability of antibiotic prophylaxis, and variable hygiene practices [12].

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ICUs, perhaps more than any other hospital department, embody the nexus between invasive medical technology and vulnerability to infection. Patients often require prolonged mechanical ventilation, central vascular access, urinary catheterization, and frequent diagnostic or therapeutic interventions. Each intervention presents an opportunity for pathogens to enter the patient's body. Additionally, ICU populations are characterized by severe illness, immunosuppression, and extended hospitalization, creating ideal conditions for infection. The high prevalence of antimicrobial-resistant pathogens in ICUs further compounds these risks and complicates treatment.

Antimicrobial Resistance and Its Impact on Healthcare-Associated Infections

The growing tide of antimicrobial resistance has fundamentally reshaped the global and regional landscape of healthcare-associated infections. While HAIs have always posed serious risks, the advent of multidrug-resistant organisms has amplified their lethality, undermining therapeutic effectiveness and increasing the complexity of clinical management. In many cases, pathogens that were once treatable with second-line antibiotics no longer respond to conventional therapeutic regimens. This shift has been especially pronounced in middle-income nations, where antimicrobial stewardship programs are not yet fully integrated into hospital management systems [13,14].

Globally, the WHO Global Antimicrobial Resistance Surveillance System has shown that more than one third of HAIs are now caused by bacteria resistant to multiple major classes of antibiotics. Carbapenem-resistant Enterobacteriaceae, extended-spectrum beta-lactamase–producing Escherichia coli and Klebsiella pneumoniae, multidrug-resistant Acinetobacter baumannii, and methicillin-resistant Staphylococcus aureus have become dominant agents in many ICU settings. In Europe, recent ECDC surveillance indicates that resistance to third-generation cephalosporins in Klebsiella pneumoniae exceeds 30 % in southern and eastern regions. In the United States, MRSA remains responsible for more than 70,000 serious infections and approximately 9,000 deaths annually, despite advances in infection control.

Antimicrobial resistance is not only a microbiological phenomenon but also a systemic failure reflecting gaps in clinical practice, regulatory oversight, and public health infrastructure. Overuse and misuse of antibiotics in outpatient and inpatient settings remains a leading driver of resistance. In some Asian countries, up to 80 % of hospitalized patients receive at least one antibiotic during their stay, often without microbiological confirmation. Similar patterns have been observed in Uzbekistan, where empirical broad-spectrum antibiotic use is common and, in some regions, nearly universal in intensive care units. Hospital audits in Tashkent, Fergana, and Andijan have revealed that more than 60 % of antibiotic prescriptions in ICUs are made without culture testing or sensitivity analysis, leading to frequent mismatches between therapy and pathogen susceptibility.

The consequences of antimicrobial resistance for HAI outcomes are severe. Patients infected with multidrug-resistant organisms often require prolonged hospitalization, extended courses of expensive or toxic antibiotics, repeated diagnostic testing, and complex supportive care. Mortality rates for infections involving carbapenem-resistant Acinetobacter baumannii may reach 50–70 %, particularly in critically ill populations. Similarly, bloodstream infections caused by extended-spectrum beta-lactamase–producing Enterobacteriaceae have been associated with

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mortality rates of 25–40 %. Economic analyses indicate that resistance-driven HAIs increase healthcare costs by an additional 30–50 % per patient, further straining already limited health system resources [2,8].

Uzbekistan faces many of the same challenges seen across Central Asia. Recent multicenter microbiological surveillance studies indicate that resistance among key pathogens is widespread. Up to 70 % of Acinetobacter baumannii isolates exhibit resistance to carbapenems, while carbapenem-resistant Klebsiella pneumoniae rates vary between 40 and 55 % depending on the region and facility type. High MRSA prevalence, often above 50 %, complicates the management of postoperative wound infections and increases the likelihood of chronic or recurrent infection. These trends are particularly concerning in neonatal units, where high-risk newborns face elevated vulnerability to pathogens and where maternal postpartum infections contribute additional transmission pathways. Neonatal sepsis caused by resistant organisms has been documented in several regional hospitals, with fatality rates reaching 20–30 %, underscoring the urgency of strengthening antimicrobial stewardship programs.

Global Experience in Infection Prevention and Control

Across the world, countries have adopted a range of strategies to control HAIs and mitigate their impact on public health. Among the most successful approaches has been the implementation of structured infection prevention and control programs grounded in evidence-based practices. Nations with the lowest HAI rates tend to share common features: strong surveillance systems, mandatory reporting, standardized IPC protocols, rigorous staff training, and continuous performance monitoring [15,16].

In Europe, countries such as the Netherlands and Sweden have achieved some of the lowest rates of HAIs and antimicrobial resistance through comprehensive national policies. The Netherlands has maintained MRSA prevalence below 2 % in most hospitals, largely due to strict screening measures, isolation policies, and judicious antibiotic use. Hospitals in Sweden use integrated electronic surveillance systems that provide real-time data on infection rates, enabling rapid response to outbreaks. The United Kingdom, following the introduction of national HAI reduction targets and investment in IPC nursing staff, achieved a dramatic decline in MRSA and C. difficile infections between 2006 and 2012, reducing incidence by more than 50 % through targeted interventions.

East Asian countries provide additional examples of effective IPC implementation. In Japan and South Korea, strong governmental oversight and advanced digital monitoring systems support the early detection of infection clusters and ensure compliance with IPC standards. South Korea’s national campaign against catheter-related bloodstream infections reduced CLABSI rates by more than 40 % in participating hospitals over three years. These efforts demonstrate that even highly invasive clinical environments can achieve significant infection reductions through coordinated programs.

In contrast, many LMICs struggle with fragmented surveillance, inconsistent adherence to IPC protocols, and limited investment in specialized staff. However, success stories do exist. Rwanda, for example, improved hand hygiene compliance from 34 % to 74 % over five years through a national quality improvement initiative. India’s nationwide hand hygiene campaign increased

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compliance from 29 % to 62 % in participating hospitals, reducing rates of VAP and SSI. These cases illustrate that even resource-limited settings can achieve substantial progress when IPC initiatives receive adequate institutional support [17,19].

A key element of successful IPC systems is the adoption of bundle-based interventions. Bundles combine several evidence-based practices that, when implemented together, significantly reduce HAI rates. Ventilator-associated pneumonia bundles emphasize head-of-bed elevation, strict oral hygiene, sedation breaks, and minimized ventilation duration. Catheter-associated urinary tract infection bundles focus on limiting catheter use, ensuring aseptic insertion, and maintaining closed drainage systems. Surgical site infection bundles include perioperative antibiotic prophylaxis, optimal skin antisepsis, and careful postoperative wound monitoring. Global evidence confirms that bundle implementation can reduce specific HAI rates by 30–70 %, depending on context.

Another crucial component of modern IPC strategies is electronic surveillance. Automated data collection systems reduce the burden on medical personnel, improve reporting accuracy, and enable timely interventions. Countries with advanced healthcare IT infrastructure—such as Denmark, Singapore, and Canada—use integrated national platforms to monitor HAIs, antimicrobial prescribing patterns, and resistance trends. Such real-time data enable hospitals to identify outbreaks sooner, trace transmission pathways more effectively, and implement appropriate containment measures [18].

Infection Prevention and Control in Uzbekistan: Progress and Gaps

Uzbekistan has made measurable progress in strengthening infection prevention and control, especially in the context of broader health system reforms. The Ministry of Health has issued updated sanitary rules, enhanced training programs, and expanded the role of IPC committees in major hospitals. Investments in laboratory modernization and biosafety infrastructure have improved diagnostic capacity in several regions. The COVID-19 pandemic further accelerated attention to IPC practices, leading to improvements in hand hygiene awareness, facility preparedness, and emergency response.

Nevertheless, significant challenges persist. IPC staffing remains uneven across the country, with rural hospitals often lacking dedicated specialists. Hand hygiene compliance, while improved, still varies considerably by department and is often lowest in high-risk units such as intensive care. Audits conducted in several regional hospitals suggest compliance rates ranging from 30 to 55 %, substantially below international targets. Limited availability of alcohol-based hand rubs, insufficient placement of hand hygiene stations, and inadequate monitoring contribute to these gaps.

Sterilization practices also present ongoing difficulties. Many hospitals continue to rely on outdated sterilization equipment, and quality monitoring systems for autoclaves and disinfectants are inconsistently applied. Studies evaluating sterilization procedures in Uzbek surgical units reveal that instrument contamination rates remain above acceptable thresholds in some facilities, partly due to inadequate separation of clean and contaminated zones and improper packaging of surgical instruments [19,20].

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Another major challenge concerns antimicrobial stewardship. Although national guidelines exist, their implementation remains fragmented. Physicians frequently prescribe broad-spectrum antibiotics empirically, often due to limited access to microbiological testing or delays in receiving culture results. Without robust stewardship oversight, inappropriate antibiotic use continues to fuel resistance and increase HAI rates. Strengthening laboratory networks, ensuring reliable supply chains for diagnostics, and introducing antimicrobial stewardship teams at hospital level are essential steps forward.

Despite these gaps, the foundation for improvement is solid. Uzbekistan's active participation in WHO and regional IPC initiatives demonstrates strong governmental commitment. The expansion of IPC training programs, coupled with modernization of hospital infrastructure, will enable sustainable progress. However, to achieve long-term reductions in HAIs, the country must continue investing in surveillance, workforce development, and enforcement of IPC standards.

CONCLUSION: Healthcare-associated infections remain one of the most persistent and complex challenges confronting health systems worldwide, and their impact is particularly pronounced in countries undergoing structural transformation, such as Uzbekistan. This review has demonstrated that the burden of HAIs is shaped by a combination of epidemiological, infrastructural, organizational, and microbiological factors. Despite significant progress in many regions of the world, HAIs continue to contribute substantially to morbidity, mortality, and healthcare expenditures. Globally, millions of patients acquire infections each year during hospital care, and a considerable proportion of these infections lead to prolonged hospitalization, severe complications, or death. The situation is further exacerbated by the continuous rise of antimicrobial resistance, which threatens to undermine decades of medical achievements.

The global experience clearly shows that HAIs cannot be addressed through isolated interventions. Instead, meaningful reduction requires strong national leadership, coordinated policies, robust surveillance systems, and consistent implementation of evidence-based infection prevention and control (IPC) measures. Countries that have succeeded in lowering HAI incidence—such as the Netherlands, Sweden, Japan, and South Korea—share several common characteristics: mandatory reporting systems, standardized definitions of HAIs, continuous training of healthcare personnel, and well-established antimicrobial stewardship programs. Their experience demonstrates that significant improvements are possible even in technologically demanding hospital departments such as intensive care units, provided that IPC programs are coherent, well-financed, and integrated across all levels of the health system.

In Uzbekistan, the epidemiological landscape of HAIs reflects both progress and persistent vulnerabilities. Official data, while suggesting low incidence, likely underrepresent the true burden due to limitations in surveillance capacity, inconsistent documentation, and the absence of a nationwide digital reporting system. Independent hospital-based studies have revealed considerably higher rates—especially in surgical units, maternity hospitals, and intensive care departments—placing Uzbekistan's HAI profile closer to global LMIC averages. The particularly high prevalence of postoperative infections, ventilator-associated pneumonia, and catheter-related bloodstream infections highlights systemic gaps in aseptic technique, sterilization processes, and compliance with IPC standards. These findings underscore the need for sustained national investment in workforce training, infrastructural modernization, and harmonization of IPC protocols across regions.

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Antimicrobial resistance represents an especially pressing concern. The widespread presence of multidrug-resistant organisms such as carbapenem-resistant Klebsiella pneumoniae, multidrug-resistant Acinetobacter baumannii, and methicillin-resistant Staphylococcus aureus greatly increases the complexity of treating HAIs in Uzbekistan. The high resistance levels documented in local hospitals mirror trends seen across Central Asia and pose a serious threat to patient outcomes. As resistant pathogens spread, routine infections once easily managed with standard antibiotics now require costly, toxic, or less accessible treatment options. Without effective antimicrobial stewardship and reliable microbiological diagnostics, resistance will likely continue to rise, further complicating the management of HAIs and elevating mortality rates.

Despite these challenges, Uzbekistan has laid important foundations for improvement. Recent reforms in the sanitary-epidemiological system, expansion of IPC training programs, and updated sanitary regulations demonstrate a growing national commitment to enhancing patient safety. The COVID-19 pandemic, while straining healthcare resources, also heightened awareness of infection control practices and catalyzed investments in biosafety infrastructure. The presence of motivated healthcare professionals and academic institutions offers additional potential for strengthening national IPC capacities. However, the path toward systematic and sustained improvement requires comprehensive and coordinated efforts across all levels of the healthcare system.

First, establishing a national HAI surveillance system is essential. Digital, real-time data collection would improve the accuracy of reporting, enable early detection of outbreaks, and support performance benchmarking across hospitals. Second, the development of antimicrobial stewardship programs must become a national priority. This includes ensuring routine access to microbiological testing, training clinicians in rational antibiotic use, and integrating stewardship responsibilities into hospital management structures. Third, continuous professional development for healthcare workers—particularly in high-risk units—must be standardized, monitored, and integrated into accreditation and quality control processes. Fourth, infrastructural upgrades, including modern sterilization equipment, adequate supply of personal protective equipment, and improved water and sanitation systems, are critical for ensuring compliance with IPC standards.

In conclusion, healthcare-associated infections represent both a medical and a systemic challenge that requires sustained political will, coordinated national strategies, and evidence-based interventions. Uzbekistan stands at a pivotal moment: the country has the opportunity to leverage global best practices, strengthen its health system, and significantly reduce the burden of HAIs. Achieving this will demand long-term commitment, investment in human resources and infrastructure, and strong collaboration between policymakers, healthcare professionals, researchers, and international partners. With coherent action and strategic prioritization, Uzbekistan can progress toward safer healthcare services, reduced infection rates, improved patient outcomes, and stronger resilience against emerging threats, including antimicrobial resistance. The experience of leading nations suggests that such transformation is attainable, and with continued dedication, Uzbekistan can position itself among regional leaders in infection prevention and control.

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