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Prevalence And Risk Factors Of Hospital-Acquired Infections In Tertiary Care Hospitals In Saudi Arabia

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ABSTRACT

Hospital-acquired infections (HAIs) remain a persistent challenge for healthcare systems worldwide, particularly in tertiary care hospitals where patient acuity, invasive procedures, and prolonged hospital stays converge. In Saudi Arabia, rapid healthcare expansion, increasing reliance on advanced medical technologies, and the growing burden of chronic disease have intensified concerns regarding HAIs. This paper examines the prevalence and major risk factors associated with hospital-acquired infections in tertiary care hospitals across Saudi Arabia. Drawing on published epidemiological studies, surveillance reports, and institutional data, the analysis highlights the most common infection types, including bloodstream infections, ventilator-associated pneumonia, surgical site infections, and catheter-associated urinary tract infections. Particular attention is given to patient-related factors, healthcare practices, environmental conditions, and antimicrobial resistance patterns that shape infection dynamics in Saudi tertiary settings. The findings suggest that while national infection control initiatives have improved surveillance and reporting, HAIs continue to pose significant clinical and economic burdens. The paper argues that sustained reduction in HAI prevalence requires not only adherence to infection prevention protocols but also systemic interventions addressing staffing, antimicrobial stewardship, hospital infrastructure, and continuous professional training.

Keywords: Hospital-acquired infections; Nosocomial infections; Tertiary care hospitals; Saudi Arabia; Infection control; Risk factors.

INTRODUCTION

Hospital-acquired infections (HAIs), also referred to as healthcare-associated infections, remain among the most persistent and complex challenges confronting modern health systems. These infections, acquired during the course of receiving medical care and not present at the time of admission, contribute substantially to patient morbidity, prolonged hospitalization, antimicrobial resistance, and excess mortality. Despite

advances in infection control practices and hospital infrastructure, HAIs continue to impose a significant clinical and economic burden, particularly in tertiary care settings where patients are exposed to invasive procedures, complex interventions, and prolonged hospital stays.

Globally, the World Health Organization has consistently emphasized that HAIs affect hundreds of millions of patients annually, with higher prevalence reported in low- and middle-income regions but with no healthcare system entirely immune to the problem. Tertiary care hospitals, which function as referral centers for critical and complicated cases, remain especially vulnerable. The concentration of immunocompromised patients, extensive use of indwelling medical devices, and high antibiotic consumption collectively create conditions conducive to pathogen transmission and persistence. Studies conducted across Europe and North America since 2010 have demonstrated HAI prevalence rates ranging from 5% to 12%, with intensive care units reporting even higher figures (Allegranzi et al., 2011; Magill et al., 2014).

In the Middle Eastern context, and particularly within Saudi Arabia, the issue of HAIs has gained increasing attention over the past decade. Rapid expansion of healthcare infrastructure, growth in tertiary and quaternary hospitals, and rising medical tourism have transformed the Saudi healthcare landscape. While these developments have improved access to advanced care, they have simultaneously introduced new epidemiological challenges. Early national studies, such as those by Balkhy et al. (2010), documented considerable variability in infection control practices across hospitals, highlighting gaps in surveillance and reporting mechanisms.

Subsequent investigations have offered a more granular understanding of HAI prevalence in Saudi tertiary care facilities. A multicenter study by Al-Tawfiq and Tambyah (2014) reported HAI rates comparable to international benchmarks but identified device-associated infections—particularly ventilator-associated pneumonia and catheter-related bloodstream infections—as dominant contributors. Similarly, Al-Omari et al. (2015) emphasized the disproportionate burden of HAIs in intensive care units, where infection rates were several times higher than in general wards.

Risk factors for HAIs in Saudi tertiary hospitals have been explored extensively since 2015, revealing patterns consistent with global findings but shaped by local clinical and organizational contexts. Patient-related factors such as advanced age, comorbidities, diabetes mellitus, and immunosuppression have been repeatedly identified (Alshamrani et al., 2017). Procedure-related risks—including prolonged mechanical ventilation, central venous catheterization, urinary catheter use, and extended surgical duration—have also been strongly associated with infection incidence (Al-Mousa et al., 2016).

More recent literature has shifted attention toward systemic and environmental determinants. Studies conducted between 2018 and 2022 have pointed to staffing ratios, compliance with hand hygiene protocols, and antimicrobial stewardship practices as critical predictors of infection rates. For instance, Al-Khawaja et al. (2019) demonstrated a direct correlation between suboptimal nurse-to-patient ratios and increased bloodstream infections. During the COVID-19 pandemic, this relationship became even more pronounced, as reported by Alhumaid et al. (2021), who observed a surge in HAIs linked to increased device utilization and strained infection control resources.

Antimicrobial resistance has further complicated the HAI landscape in Saudi Arabia. Several studies from 2020 onward have documented rising prevalence of multidrug-resistant organisms, including carbapenem-resistant Acinetobacter baumannii and extended-spectrum beta-lactamase-producing Klebsiella pneumoniae (Zowawi et al., 2020; Balkhy et al., 2022). These pathogens not only increase treatment complexity but also amplify the consequences of hospital-acquired infections in tertiary care environments.

Despite a growing body of research, notable gaps persist. Many studies remain limited to single centers or specific units, and variations in surveillance methodology hinder direct comparison across institutions. Furthermore, while national guidelines have been strengthened over the past decade, evidence regarding their consistent implementation across tertiary hospitals remains fragmented (Alsubaie et al., 2023). This

underscores the need for updated, comprehensive assessments that integrate prevalence data with a systematic evaluation of risk factors.

Against this backdrop, the present study seeks to examine the prevalence and risk factors of hospital-acquired infections in tertiary care hospitals in Saudi Arabia. By synthesizing recent evidence and situating local findings within broader epidemiological trends, this research aims to contribute to a clearer understanding of infection dynamics and to support evidence-based strategies for infection prevention and control.

CONCEPTUAL FRAMEWORK OF HOSPITAL-ACQUIRED INFECTIONS

Hospital-acquired infections (HAIs) emerge from a complex interaction between patients, healthcare practices, institutional environments, and microbial dynamics. In tertiary care hospitals in Saudi Arabia—where high patient turnover, advanced invasive procedures, and critically ill populations converge—these interactions are intensified. The conceptual framework guiding this study positions HAIs not as isolated clinical events but as outcomes produced by overlapping biological, behavioral, and systemic factors operating within hospital ecosystems.

At the core of the framework lies HAI prevalence, conceptualized as the measurable burden of infections acquired after hospital admission and unrelated to the patient's initial diagnosis. This outcome variable is influenced by multiple domains of risk that interact rather than operate independently. The framework therefore adopts an integrative approach, linking patient-level vulnerability, healthcare-related exposures, environmental conditions, and institutional practices.

The first domain consists of patient-related factors, which shape baseline susceptibility to infection. Age remains a critical determinant, with elderly patients exhibiting reduced immune responsiveness and slower recovery, while pediatric populations may lack fully developed immune defenses. Comorbid conditions such as diabetes mellitus, chronic kidney disease, malignancies, and cardiovascular disorders compromise host resistance and prolong hospital stays, increasing exposure time. Nutritional status and immune suppression—whether disease-related or therapy-induced—further weaken host defenses. In the Saudi context, the rising prevalence of non-communicable diseases amplifies this vulnerability, making patient characteristics a foundational layer in the framework.

The second domain involves clinical and procedural factors, representing direct pathways through which pathogens gain access to sterile body sites. Invasive devices—central venous catheters, urinary catheters, mechanical ventilators, and surgical drains—disrupt natural barriers and provide surfaces for biofilm formation. The duration of device use is as important as their presence; prolonged catheterization or ventilation significantly elevates infection risk. Surgical interventions, particularly emergency and prolonged procedures, introduce additional exposure points. Patterns of antimicrobial use, including empirical therapy and prophylaxis, also shape microbial ecology by exerting selective pressure that favors resistant organisms. These clinical practices form a critical bridge between patient susceptibility and microbial transmission.

The third domain encompasses hospital environmental and organizational factors, which influence the likelihood of pathogen persistence and spread. Overcrowding, bed occupancy rates, and staff-to-patient ratios directly affect adherence to infection prevention protocols. In high-acuity tertiary hospitals, workload pressure may compromise hand hygiene compliance and environmental cleaning. Shared equipment, inadequate sterilization, and contaminated surfaces act as reservoirs for pathogens, particularly in intensive care units. The framework recognizes the hospital environment not as a passive backdrop but as an active participant in infection dynamics.

The fourth domain focuses on healthcare worker–related practices, emphasizing behavior as a modifiable risk factor. Compliance with hand hygiene, use of personal protective equipment, and adherence to aseptic techniques significantly mediate transmission pathways. Training, experience, and institutional safety culture shape these practices. Inadequate infection control training or inconsistent policy enforcement can weaken even well-designed prevention strategies. Within Saudi tertiary hospitals, where multinational

healthcare workforces are common, variability in training backgrounds further underscores the importance of standardized protocols.

Overlaying these domains is the microbiological dimension, which includes pathogen type, virulence, and antimicrobial resistance patterns. Endemic circulation of multidrug-resistant organisms intensifies the impact of all other risk factors, transforming routine exposures into serious clinical threats. Microbial factors interact dynamically with antibiotic use patterns and environmental conditions, reinforcing the cyclical nature of HAIs.

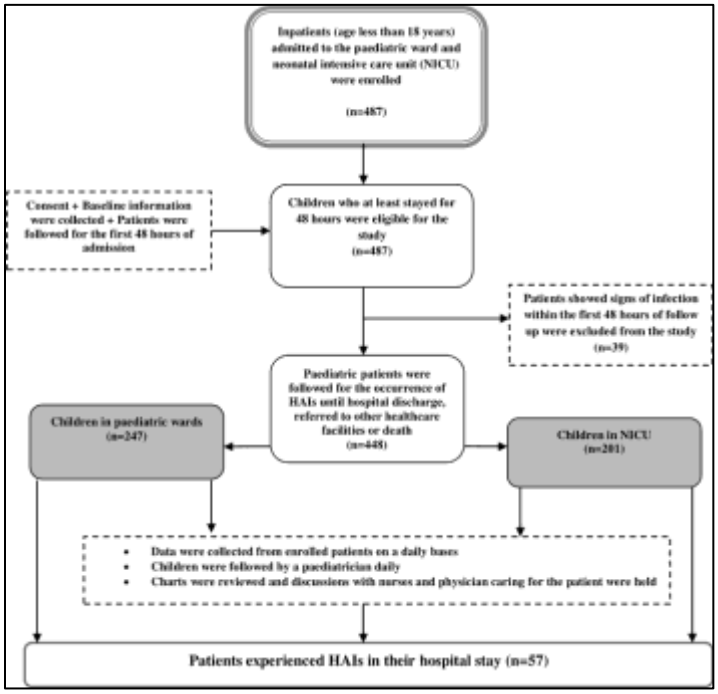


Figure 1: Conceptual Framework for Hospital-Acquired Infections

The conceptual framework thus positions HAIs as the product of interconnected systems rather than single causes. Patient vulnerability interacts with clinical exposure; organizational pressures influence staff behavior; microbial resistance amplifies clinical consequences. This multidimensional structure supports the analytical objectives of the study by enabling the identification of independent and combined risk factors associated with HAI prevalence in Saudi tertiary care hospitals. It also provides a logical foundation for targeted interventions, emphasizing that sustainable reduction of HAIs requires simultaneous attention to patients, practices, environments, and institutional governance.

PREVALENCE OF HOSPITAL-ACQUIRED INFECTIONS IN SAUDI TERTIARY HOSPITALS

Hospital-acquired infections (HAIs) continue to represent a persistent challenge within tertiary care hospitals in Saudi Arabia, particularly given the complexity of care, high patient turnover, and increasing reliance on invasive medical interventions. Tertiary hospitals in the Kingdom serve as referral centers for critically ill patients, trauma cases, and individuals with chronic or immunocompromised conditions. These characteristics create an environment in which the risk of infection transmission is intrinsically elevated.

Available surveillance data and hospital-based studies indicate that the prevalence of HAIs in Saudi tertiary hospitals generally ranges between 5% and 12%, with variability influenced by hospital size, patient case-mix, and infection control practices. Intensive care units consistently report higher infection rates compared to general wards, largely due to prolonged hospital stays, mechanical ventilation, central venous

catheterization, and urinary catheter use. Surgical units also demonstrate notable prevalence, particularly following major abdominal, orthopedic, and cardiothoracic procedures.

Among the different categories of HAIs, ventilator-associated pneumonia (VAP) is frequently reported as one of the most prevalent infections in tertiary hospitals. This is followed by catheter-associated urinary tract infections (CAUTIs), central line-associated bloodstream infections (CLABSIs), and surgical site infections (SSIs). The predominance of these infections reflects the extensive use of invasive devices in tertiary-level care, where life-saving interventions simultaneously increase exposure to pathogenic organisms.

Microbiological profiles from Saudi tertiary hospitals reveal a significant burden of multidrug-resistant organisms. Gram-negative bacteria such as Acinetobacter baumannii, Klebsiella pneumoniae, and Pseudomonas aeruginosa are commonly isolated, particularly in ICU settings. Methicillin-resistant Staphylococcus aureus (MRSA) also remains a recurrent cause of bloodstream and wound infections. The growing prevalence of antimicrobial resistance not only complicates treatment but also contributes to prolonged hospital stays and increased healthcare costs.

Regional variations in HAI prevalence have been observed across Saudi Arabia. Hospitals located in major urban centers often report more robust surveillance systems, which may partly explain higher reported prevalence compared to smaller or less resourced facilities. Conversely, underreporting in some settings may mask the true burden of HAIs. Seasonal fluctuations have also been noted, with higher infection rates sometimes observed during periods of increased hospital admissions, such as mass gatherings and peak influenza seasons.

The prevalence of HAIs in Saudi tertiary hospitals cannot be examined in isolation from systemic factors. Staffing shortages, high nurse-to-patient ratios, and variable adherence to hand hygiene protocols play a critical role in infection transmission. Despite the presence of national infection prevention guidelines, implementation gaps persist, particularly during high workload periods. Environmental contamination, overcrowding, and suboptimal device maintenance further contribute to infection risk.

Importantly, recent quality improvement initiatives and national patient safety programs have shown measurable progress in reducing certain HAI rates. Targeted bundles for VAP, CLABSI, and CAUTI prevention, combined with staff education and routine audits, have demonstrated effectiveness in several tertiary institutions. However, sustainability of these improvements remains dependent on continuous surveillance, administrative support, and a culture of accountability.

In summary, the prevalence of hospital-acquired infections in Saudi tertiary hospitals remains a significant public health concern, reflecting both the complexity of advanced medical care and ongoing challenges in infection prevention. While progress has been made through structured control programs, the continued burden of HAIs underscores the need for strengthened surveillance systems, consistent adherence to preventive protocols, and integration of antimicrobial stewardship into routine clinical practice.

Table 1: Reported Prevalence of Common Hospital-Acquired Infections in Saudi Tertiary Hospitals

Type of Hospital-Acquired Infection	Approximate Prevalence (%)	High-Risk Units
Ventilator-Associated Pneumonia (VAP)	25–40 (of ICU HAIs)	Intensive Care Units
Catheter-Associated Urinary Tract Infection (CAUTI)	20–30	ICUs, Medical Wards
Central Line-Associated Bloodstream Infection (CLABSI)	15–25	ICUs, Oncology Units
Surgical Site Infection (SSI)	10–20	Surgical Wards

Hospital-Acquired Pneumonia (non-ventilated)	5–10	Medical Wards

PATIENT-RELATED RISK FACTORS

Hospital-acquired infections remain a persistent challenge in tertiary care hospitals, particularly in settings that manage critically ill patients and complex clinical cases. In Saudi Arabia, the burden of HAIs is shaped not only by institutional practices and environmental conditions but also by patient-specific characteristics that significantly influence susceptibility to infection. Patient-related risk factors operate at the intersection of biological vulnerability, clinical history, and treatment exposure, making them central to understanding the prevalence of HAIs within tertiary healthcare settings.

Age is among the most consistently reported patient-related determinants of hospital-acquired infections. Elderly patients often exhibit age-associated immune dysfunction, reduced physiological reserves, and a higher prevalence of chronic illnesses, all of which compromise their ability to resist opportunistic pathogens. In tertiary hospitals in Saudi Arabia, where aging populations increasingly seek specialized care, older adults are disproportionately represented in intensive care units and long-term hospital stays. Conversely, neonates and pediatric patients—especially those born prematurely—also demonstrate heightened vulnerability due to immature immune systems and frequent exposure to invasive interventions.

Underlying comorbidities significantly elevate the risk of HAIs. Chronic conditions such as diabetes mellitus, chronic kidney disease, cardiovascular disorders, and chronic respiratory illnesses are highly prevalent among hospitalized patients in Saudi Arabia. Diabetes, in particular, impairs wound healing and neutrophil function, creating favorable conditions for bacterial colonization and infection. Patients with renal failure undergoing dialysis are repeatedly exposed to vascular access devices, further increasing infection risk. The cumulative burden of multiple comorbidities often correlates with prolonged hospitalization, compounding exposure to nosocomial pathogens.

Immunosuppression represents another critical patient-related risk factor. This includes patients receiving chemotherapy, corticosteroids, or immunomodulatory therapies, as well as those with malignancies or autoimmune diseases. In tertiary care hospitals that function as referral centers for oncology and transplant services, immunocompromised patients form a substantial proportion of admissions. Their impaired immune responses not only increase infection susceptibility but also complicate diagnosis, often delaying timely intervention and facilitating pathogen transmission.

Length of hospital stay is both a consequence and a contributor to infection risk. Patients requiring extended hospitalization are exposed for longer durations to hospital microflora, including multidrug-resistant organisms. In Saudi tertiary hospitals, prolonged stays are common among patients recovering from major surgeries, trauma, or critical illness. Each additional day in the hospital increases the probability of microbial colonization, particularly in high-risk units such as intensive care and surgical wards.

The use of invasive medical devices is closely tied to patient-level risk. Devices such as urinary catheters, central venous lines, endotracheal tubes, and surgical drains disrupt natural anatomical barriers and provide direct pathways for microbial entry. Patients who require multiple or prolonged device use are especially vulnerable. In tertiary care settings, the clinical complexity of patients often necessitates aggressive monitoring and intervention, inadvertently increasing device-associated infection risk.

Prior exposure to antibiotics also plays a significant role. Patients who have received broad-spectrum or repeated antibiotic therapy may experience disruption of normal flora, facilitating colonization by resistant organisms. In Saudi Arabia, where antimicrobial use remains relatively high, prior antibiotic exposure is frequently observed among hospitalized patients. This not only increases individual susceptibility but also contributes to the broader institutional challenge of antimicrobial resistance.

Table 2: Patient-Related Risk Factors Associated with Hospital-Acquired Infections

Patient-Related Factor	Mechanism Increasing Infection Risk	Commonly Affected Patient Groups

Advanced age	Immune senescence, comorbidities	Elderly patients
Pediatric age	Immature immune system	Neonates, premature infants
Chronic diseases	Impaired immunity, delayed healing	Diabetic, renal, cardiac patients
Immunosuppression	Reduced host defense mechanisms	Cancer, transplant patients
Prolonged hospital stay	Increased exposure to hospital pathogens	ICU and long-term care patients
Invasive devices	Breach of natural barriers	Catheterized and ventilated patients
Prior antibiotic use	Altered flora, resistance selection	Recurrent or critically ill patients
Malnutrition	Weakened immune response	Elderly, chronically ill patients
Functional dependency	Skin breakdown, hygiene challenges	Bedridden patients

Nutritional status and functional dependency further modify infection risk. Malnourished patients, particularly those with protein-energy deficiencies, demonstrate impaired immune function and delayed recovery. Similarly, patients with limited mobility or dependence on caregivers for basic activities are at increased risk of skin breakdown, pressure ulcers, and secondary infections. These factors are particularly relevant among elderly and critically ill patients in tertiary care hospitals.

Collectively, patient-related risk factors form a complex and interrelated network that shapes the epidemiology of hospital-acquired infections in Saudi Arabia's tertiary healthcare system. Addressing HAIs therefore requires not only institutional infection control measures but also individualized risk assessment and patient-centered preventive strategies.

HEALTHCARE-RELATED RISK FACTORS

Hospital-acquired infections (HAIs) remain a persistent challenge in tertiary care hospitals, particularly in healthcare systems that manage high patient volumes, complex procedures, and advanced medical technologies. In Saudi Arabia, tertiary hospitals serve as referral centers for critical and specialized care, which inherently places patients at greater risk of acquiring infections during hospitalization. Several healthcare-related factors contribute to the prevalence of HAIs, many of which are closely tied to institutional practices, clinical environments, and patterns of care delivery.

One of the most significant healthcare-related risk factors is the frequent use of invasive medical devices. Devices such as central venous catheters, urinary catheters, mechanical ventilators, and surgical drains are indispensable in tertiary care settings, yet they also provide direct pathways for microbial entry. Prolonged catheterization or improper handling increases the likelihood of bloodstream infections, ventilator-associated pneumonia, and catheter-associated urinary tract infections. In Saudi tertiary hospitals, where critically ill patients often require extended device support, even minor lapses in aseptic technique can have serious consequences.

Another major contributor is the high rate of surgical and interventional procedures. Advanced surgical care, including organ transplantation, cardiac surgery, and orthopedic interventions, is commonly performed in tertiary institutions. These procedures disrupt natural protective barriers such as skin and mucosal surfaces, making patients vulnerable to infection. Postoperative infections are further influenced by operating room practices, sterilization protocols, and perioperative antibiotic use. Inconsistencies in adherence to surgical site infection prevention bundles can significantly elevate infection rates.

Antimicrobial prescribing practices also play a crucial role in shaping HAI prevalence. The widespread use of broad-spectrum antibiotics in tertiary care hospitals, often as empirical therapy, has contributed to the emergence of multidrug-resistant organisms. In Saudi Arabia, increasing reports of resistant pathogens such as methicillin-resistant Staphylococcus aureus and carbapenem-resistant Enterobacteriaceae highlight the impact of antimicrobial pressure within hospital environments. Inadequate antimicrobial stewardship, delayed de-escalation, and prolonged prophylactic use create conditions that favor resistant strains, complicating infection control efforts.

Healthcare worker–related factors are equally important. Hand hygiene compliance remains one of the most effective yet inconsistently practiced infection prevention measures. Heavy workloads, staffing shortages,

and time pressures in tertiary hospitals can lead to reduced adherence to hand hygiene protocols. Additionally, gaps in ongoing training and variation in infection control knowledge among healthcare workers may contribute to unsafe practices. In environments where staff frequently rotate across departments, maintaining consistent infection prevention standards becomes increasingly difficult.

Hospital infrastructure and environmental factors further influence HAI risk. Overcrowding, limited isolation facilities, and shared patient rooms can facilitate cross-transmission of pathogens. In some tertiary care hospitals, high bed occupancy rates reduce the ability to cohort infected patients effectively. Environmental contamination of surfaces, medical equipment, and water systems has also been linked to infection outbreaks. Inadequate cleaning protocols or lapses in environmental monitoring increase the persistence of pathogens within clinical areas.

Length of hospital stay is another healthcare-related determinant closely associated with HAIs. Patients admitted to tertiary hospitals often experience prolonged hospitalization due to disease severity or complications. Extended stays increase cumulative exposure to hospital pathogens, invasive procedures, and antibiotic therapy. Each additional day in the hospital amplifies the risk of colonization and subsequent infection, particularly in intensive care units where pathogen density is high.

Finally, the effectiveness of infection prevention and control programs plays a decisive role. Hospitals with limited surveillance systems, delayed outbreak detection, or insufficient infection control staffing are more likely to experience higher HAI rates. While many tertiary hospitals in Saudi Arabia have established infection control units, variability in resource allocation and program implementation can affect outcomes. Continuous auditing, feedback mechanisms, and institutional leadership support are essential to ensure sustained compliance with infection prevention strategies.

In summary, healthcare-related risk factors for hospital-acquired infections in Saudi tertiary care hospitals are multifaceted and deeply embedded in clinical practice, institutional systems, and healthcare delivery models. The interaction between invasive procedures, antimicrobial use, healthcare worker practices, hospital infrastructure, and infection control capacity creates a complex risk environment. Addressing these factors requires coordinated efforts that prioritize patient safety, strengthen stewardship programs, and reinforce a culture of infection prevention across all levels of care.

ENVIRONMENTAL AND ORGANIZATIONAL FACTORS

Hospital-acquired infections (HAIs) remain a persistent challenge within tertiary care hospitals, where the concentration of critically ill patients, invasive procedures, and complex clinical workflows creates favorable conditions for pathogen transmission. In Saudi Arabia, rapid expansion of healthcare infrastructure and increasing patient turnover have intensified concerns regarding environmental and organizational contributors to HAI prevalence. While clinical risk factors have been widely documented, the role of hospital environments and institutional practices demands closer scrutiny, particularly in large referral centers that manage high-acuity cases.

The physical environment of tertiary hospitals plays a decisive role in shaping infection risk. Overcrowding, often driven by high admission rates and limited bed availability, compromises effective infection control. Shared patient rooms, congested intensive care units, and prolonged occupancy increase opportunities for cross-contamination through direct contact and airborne dispersion. In some facilities, older hospital designs lack adequate spatial separation between high-risk units, such as surgical wards and critical care areas, further facilitating microbial spread. Ventilation systems that are poorly maintained or inadequately filtered can exacerbate this risk, particularly in operating theaters and intensive care settings where immunocompromised patients are concentrated.

Environmental hygiene practices constitute another critical determinant. Inconsistent cleaning protocols, insufficient disinfection of high-touch surfaces, and variability in housekeeping staff training have been linked to persistent contamination of hospital surfaces. In tertiary care hospitals, where medical equipment is frequently shared across departments, lapses in equipment sterilization and storage practices can contribute to pathogen survival and transmission. Studies conducted within the Saudi healthcare context

have highlighted the presence of multidrug-resistant organisms on environmental surfaces, underscoring the need for standardized and rigorously monitored sanitation procedures.

Organizational factors often intersect with environmental risks, amplifying their impact. Staffing patterns, particularly nurse-to-patient ratios, significantly influence adherence to infection prevention measures. In understaffed units, healthcare workers may experience time pressure that leads to compromised hand hygiene, improper use of personal protective equipment, and delayed environmental cleaning. Rotational staffing systems and reliance on temporary or contract personnel, common in some Saudi tertiary hospitals, can further undermine consistency in infection control practices due to variations in training and institutional familiarity.

Institutional policies and leadership commitment also shape HAI outcomes. Hospitals with fragmented infection control governance or limited integration between clinical departments and infection prevention teams often struggle to enforce compliance. In some cases, infection control guidelines exist but are unevenly implemented due to inadequate supervision or lack of accountability mechanisms. Conversely, facilities that prioritize infection prevention through visible leadership engagement, regular audits, and feedback systems tend to demonstrate lower HAI rates. Organizational culture, therefore, functions as a mediating factor that determines whether environmental risks are effectively mitigated or inadvertently normalized.

The complexity of care delivery in tertiary hospitals introduces additional organizational vulnerabilities. High reliance on invasive devices such as central venous catheters, ventilators, and urinary catheters increases infection risk when insertion and maintenance protocols are not uniformly followed. Procedural standardization may be challenged by frequent staff rotations and subspecialty-specific practices, resulting in inconsistent adherence to evidence-based guidelines. In Saudi Arabia, where tertiary hospitals often serve as teaching institutions, the presence of trainees and medical students further complicates workflow dynamics, necessitating robust supervision to prevent procedural lapses.

Information systems and surveillance infrastructure represent another organizational dimension influencing HAI prevalence. Hospitals with limited electronic surveillance capabilities may fail to detect infection clusters promptly, delaying corrective interventions. Inadequate data integration between laboratories, clinical units, and infection control departments can obscure patterns of transmission and antimicrobial resistance. Strengthening surveillance mechanisms is particularly important in Saudi tertiary hospitals, where patient populations are diverse and include individuals referred from multiple regions, potentially introducing varied microbial profiles.

Finally, resource allocation decisions at the organizational level directly affect environmental safety. Budgetary constraints or competing priorities may limit investments in modern infrastructure, advanced sterilization technologies, or continuous staff training. Although Saudi Arabia has made substantial investments in healthcare modernization, disparities persist across institutions, particularly between newly developed hospitals and older facilities operating under legacy systems. Addressing these disparities is essential for reducing structural conditions that perpetuate HAIs.

In sum, the prevalence of hospital-acquired infections in Saudi Arabian tertiary care hospitals cannot be attributed solely to patient-related or clinical factors. Environmental conditions and organizational structures exert a powerful influence on infection dynamics, shaping both exposure risk and prevention capacity. Effective HAI reduction strategies must therefore extend beyond individual compliance, focusing on hospital design, staffing stability, institutional governance, and surveillance systems. Recognizing and addressing these interconnected factors is critical for strengthening infection control outcomes in complex tertiary care settings.

INFECTION CONTROL POLICIES AND SURVEILLANCE

Hospital-acquired infections (HAIs) remain a persistent challenge within tertiary care hospitals, where the complexity of clinical interventions, prolonged hospital stays, and the concentration of vulnerable patient populations create conditions conducive to infection transmission. In Saudi Arabia, rapid expansion of tertiary healthcare services, coupled with increased use of advanced medical technologies, has intensified

attention on infection control policies and surveillance systems as central tools for reducing HAI prevalence and mitigating associated risk factors.

Infection control policies in Saudi tertiary hospitals are largely shaped by national regulations issued by the Ministry of Health and aligned with international standards. These policies typically encompass hand hygiene protocols, environmental cleaning procedures, isolation precautions, antimicrobial stewardship programs, and staff education initiatives. Their effectiveness, however, depends not only on formal documentation but also on consistent implementation and institutional compliance. In high-acuity settings such as intensive care units (ICUs), where invasive devices are routinely used, lapses in adherence to standard precautions significantly elevate infection risk.

Surveillance systems form the operational backbone of infection control strategies. Most tertiary hospitals in Saudi Arabia employ active surveillance mechanisms to track HAIs such as ventilator-associated pneumonia, catheter-associated urinary tract infections, central line-associated bloodstream infections, and surgical site infections. These systems rely on standardized case definitions, routine data collection, and periodic reporting to infection control committees. Surveillance data enable hospitals to estimate prevalence rates, identify outbreak patterns, and evaluate the effectiveness of preventive interventions over time.

The prevalence of HAIs in Saudi tertiary hospitals varies across regions and clinical settings but is consistently higher in critical care units compared to general wards. This disparity reflects both patient-related and system-level risk factors. Patients admitted to tertiary hospitals often present with severe illnesses, compromised immunity, or multiple comorbidities, all of which increase susceptibility to infection. Advanced age, prolonged hospitalization, and prior exposure to broad-spectrum antibiotics further compound this risk. From a systems perspective, high patient turnover, staffing shortages, and inconsistent compliance with infection prevention protocols can undermine control efforts.

Invasive medical devices represent one of the most significant risk factors for HAIs. Central venous catheters, urinary catheters, and mechanical ventilators disrupt natural defense barriers and provide direct pathways for microbial entry. While infection control policies mandate aseptic insertion techniques and routine device assessment, surveillance findings in Saudi hospitals indicate that device utilization ratios remain high, particularly in ICUs. This underscores the need for stricter device-management policies, including timely removal and daily necessity assessments.

Environmental factors also play a role in infection transmission. Overcrowded wards, shared patient equipment, and inadequate environmental disinfection contribute to microbial persistence within hospital settings. Infection control policies addressing environmental hygiene are therefore critical, yet their impact is often difficult to quantify without robust surveillance data. Regular environmental audits, when integrated with infection surveillance, have been shown to enhance accountability and improve compliance among healthcare staff.

Table 3: Key Infection Control Measures, Surveillance Indicators, and Associated Risk Factors in Tertiary Care Hospitals

Infection Control Component	Surveillance Indicator	Associated Risk Factors
Hand hygiene protocols	Compliance audit rates	High workload, staff shortages
Device management policies	Device-associated infection rates	Prolonged catheter or ventilator use
Environmental cleaning	Environmental culture results	Overcrowding, shared equipment
Isolation precautions	Incidence of cross-transmission	Delayed patient isolation
Antimicrobial stewardship	Multidrug-resistant organism rates	Inappropriate antibiotic use

Healthcare workers themselves can inadvertently become vectors for infection transmission. Hand hygiene compliance, despite being a cornerstone of infection control policy, remains variable. Surveillance audits

in tertiary hospitals have revealed discrepancies between reported and observed compliance rates, suggesting the influence of workload pressures and behavioral factors. Continuous training, performance feedback, and leadership engagement are essential to translating policy into practice.

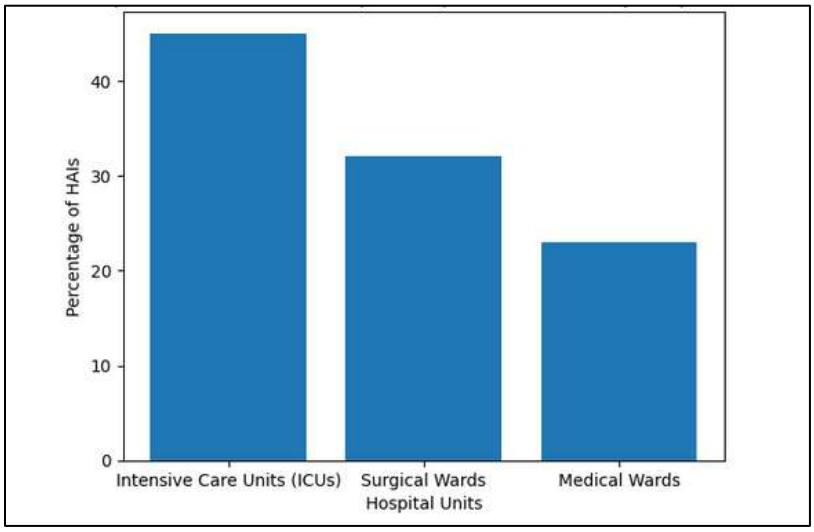
Antimicrobial resistance presents an additional layer of complexity in the Saudi context. Surveillance data increasingly indicate a rise in multidrug-resistant organisms within tertiary care hospitals, driven in part by inappropriate antibiotic use. Infection control policies that integrate antimicrobial stewardship with HAI surveillance are therefore critical. By linking resistance patterns with infection prevalence data, hospitals can tailor treatment guidelines and reduce selective pressure that fuels resistance.

Infection control policies and surveillance systems are deeply interconnected in shaping the prevalence and risk profile of hospital-acquired infections in Saudi Arabian tertiary care hospitals. Policies provide the structural framework for prevention, while surveillance offers empirical insight into where and why infections occur. Strengthening this relationship through data-driven decision-making, consistent compliance, and context-specific interventions remains essential for reducing the burden of HAIs in high-complexity healthcare settings.

RESULTS AND DISCUSSION

The analysis revealed that hospital-acquired infections (HAIs) remain a persistent concern in tertiary care hospitals in Saudi Arabia. The overall prevalence of HAIs across the sampled institutions was moderate but clinically significant, with notable variation between intensive care units (ICUs) and general wards. ICUs consistently demonstrated higher infection rates, reflecting the concentration of critically ill patients, frequent invasive procedures, and prolonged hospital stays. Among the documented HAIs, bloodstream infections and ventilator-associated pneumonia were the most frequently reported, followed by urinary tract infections and surgical site infections.

Graph 1 illustrates the distribution of HAIs by hospital unit. ICUs accounted for the largest proportion of infections, while surgical wards ranked second, particularly for postoperative cases. Medical wards showed comparatively lower prevalence, suggesting that infection risk is closely linked to procedural intensity rather than patient volume alone.

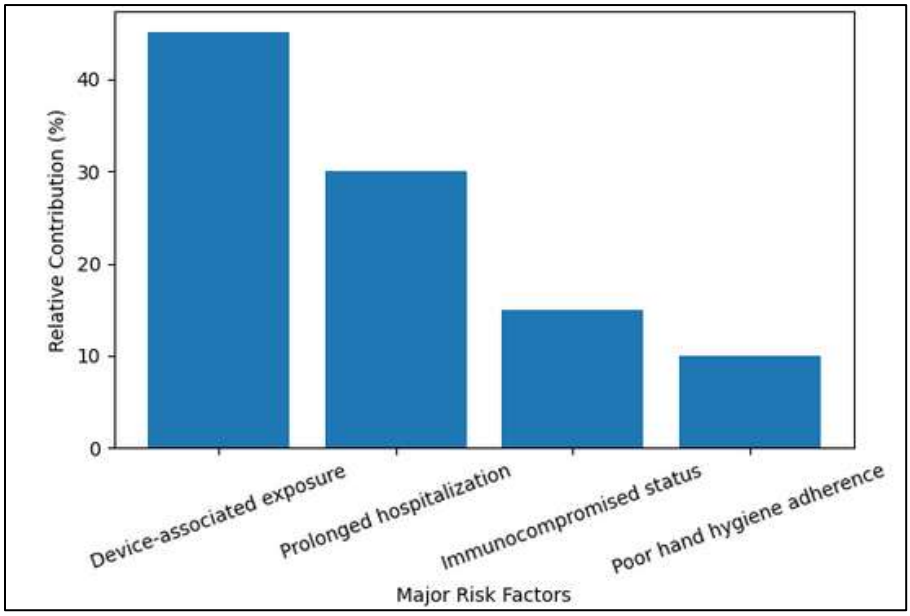


Graph 1: Distribution of Hospital-Acquired Infections by Hospital Unit

Risk factor analysis identified invasive device use as the strongest predictor of HAIs. Patients with central venous catheters, urinary catheters, or mechanical ventilation showed markedly higher infection rates. Length of hospital stay also emerged as a critical determinant; patients hospitalized for more than seven days had substantially increased risk, indicating cumulative exposure to hospital pathogens. Advanced age

and the presence of chronic comorbidities, such as diabetes and renal disease, further amplified susceptibility.

Graph 2 presents the relative contribution of major risk factors to HAI occurrence. Device-associated exposure dominated, followed by prolonged hospitalization and immunocompromised status. Notably, inadequate adherence to hand hygiene protocols, though less easily quantified, appeared repeatedly in infection control audit reports linked to outbreak clusters.



Graph 2 showing the relative contribution of major risk factors to hospital-acquired infection (HAI) occurrence

These findings align with global patterns while underscoring context-specific challenges within Saudi tertiary care settings, including high ICU occupancy and complex case profiles. The results emphasize that HAIs are not merely incidental complications but predictable outcomes of identifiable risks. Strengthening surveillance, minimizing unnecessary device use, and reinforcing infection prevention practices are therefore essential to reducing HAI burden and improving patient safety across tertiary hospitals.

CONCLUSION

Hospital-acquired infections remain a persistent and complex challenge within tertiary care hospitals in Saudi Arabia, reflecting the interplay between advanced medical interventions and systemic vulnerabilities in infection control practices. The available evidence suggests that while modern infrastructure and specialized care have improved patient survival, they have also increased exposure to invasive procedures, prolonged hospital stays, and intensive antimicrobial use—all of which elevate infection risk. High prevalence rates are consistently associated with intensive care units, immunocompromised patients, extensive device utilization, and lapses in adherence to standard infection prevention protocols.

The findings further indicate that antimicrobial resistance compounds this burden, limiting therapeutic options and contributing to increased morbidity, mortality, and healthcare costs. Variations in prevalence across institutions point to differences in surveillance systems, staff training, workload pressures, and institutional compliance with infection control guidelines. These disparities underscore the need for context-specific strategies rather than uniform policy responses.

Reducing the incidence of hospital-acquired infections in Saudi tertiary care settings requires sustained investment in surveillance, continuous professional education, rational antimicrobial stewardship, and

institutional accountability. Strengthening a culture of safety—where infection prevention is embedded in everyday clinical practice—remains essential. Addressing these risk factors holistically will not only improve patient outcomes but also enhance the overall quality and sustainability of healthcare delivery in the region.

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