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Nosocomial Infections and Antibiotic-resistance in Saudi Arabia: A Systematic Review

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Abstract

Introduction: Nosocomial infections and antibiotic resistance represent significant challenges to healthcare systems worldwide, contributing to increased morbidity, mortality, and healthcare costs. In Saudi Arabia, the prevalence of hospital-acquired infections and the emergence of resistant pathogens have prompted concerns regarding patient safety and the effectiveness of existing infection control measures. This systematic review aimed to examine the prevalence, etiology, and antibiotic resistance patterns of nosocomial infections in Saudi Arabian healthcare settings.

Methods: A comprehensive search strategy was employed across PubMed, Scopus, Web of Science, and the Cochrane Central Register of Controlled Trials to identify interventional studies and clinical trials relevant to nosocomial infections and antibiotic resistance in Saudi Arabia. Inclusion criteria were strictly defined to select studies focusing on hospital settings and reporting quantitative outcomes related to intervention effectiveness. A two-step screening process was conducted, involving title and abstract review followed by full-text assessment. The methodology emphasized the inclusion of diverse intervention types, from antibiotic stewardship programs to educational and technological interventions aimed at infection control.

Results: The review included 10 studies, showcasing a variety of interventions with sample sizes ranging from 50 to over 1,000 participants. Hand hygiene interventions demonstrated a risk reduction in nosocomial infections with risk ratios (RR) around 0.62 to 0.75. Antibiotic stewardship programs were effective in reducing broad-spectrum antibiotic prescriptions by up to 30%. Educational interventions for healthcare workers also showed significant improvements in infection control practices, with some studies reporting risk reductions for nosocomial infections with RRs of 0.68 to 0.94.

Conclusions: This systematic review highlights the effectiveness of multifaceted interventions in reducing the prevalence of nosocomial infections and combating antibiotic resistance in Saudi Arabian healthcare settings. The findings underscore the importance of implementing comprehensive, context-specific strategies that combine educational, procedural, and technological elements to improve patient safety and healthcare outcomes.

Keywords: Nosocomial Infections, Antibiotic Resistance, Interventional Studies, Healthcare Settings, Infection Control.

Introduction

Nosocomial infections, also known as hospital-acquired infections (HAIs), pose a significant threat to patient safety and healthcare outcomes globally. In Saudi Arabia, the prevalence of these infections has been a growing concern, reflecting trends observed worldwide. Studies have shown that approximately 5% to 10% of hospitalized patients in developed countries acquire at least one type of nosocomial infection during their stay, with the rates being potentially higher in developing regions due to varying standards of hygiene and infection control practices [1]. Specifically, in the context of Saudi Arabia, research indicates that the rate of nosocomial infections can range from 3.5% to 8.9%, underscoring a significant public health issue within its healthcare facilities [2].

The emergence of antibiotic-resistant organisms has further complicated the management and treatment of HAIs, leading to increased morbidity, mortality, and healthcare costs. Antibiotic resistance is a natural phenomenon exacerbated by the overuse and misuse of antibiotics in both human medicine and agriculture, leading to the selection of resistant strains. In Saudi hospitals, antibiotic-resistant pathogens such as Methicillin-resistant Staphylococcus aureus (MRSA) and multi-drug resistant (MDR) gram-negative bacteria have been reported with increasing frequency. For instance, the prevalence of MRSA among S. aureus infections in Saudi Arabia has been estimated to be around 35.9%, highlighting a critical challenge for infection control and antimicrobial stewardship programs [3]. The burden of HAIs on healthcare systems is profound, not only in terms of patient outcomes but also regarding economic impact. The cost associated with managing nosocomial infections is substantial, with estimates suggesting that each infection can add thousands of dollars to hospital costs due to prolonged hospital stays, additional diagnostic tests, and the need for more complex treatment regimens [4]. In Saudi Arabia, the economic impact of HAIs is similarly significant, although specific figures are less frequently reported. However, the cost of the implications are inferred to be substantial, alignment with global data that suggest HAIs can increase hospital costs by 20% to 40% [5]. Given the complex interplay between nosocomial infections and antibiotic resistance, understanding the epidemiology of HAIs within the Saudi healthcare context is crucial. The healthcare system in Saudi Arabia is undergoing rapid expansion and modernization, with significant investments in hospital infrastructure, healthcare workforce, and quality improvement initiatives. Despite these advancements, the persistence of nosocomial infections and the emergence of antibiotic-resistant pathogens present ongoing challenges that necessitate comprehensive surveillance and targeted intervention strategies [6].

The aim of this systematic review was to examine the prevalence, etiology, and antibiotic resistance patterns of nosocomial infections in Saudi Arabia. By synthesizing data from multiple studies, we sought to provide a comprehensive overview of the current state of HAIs and antibiotic resistance within the country's healthcare facilities. This endeavor was motivated by the need to inform policymakers, healthcare providers, and infection control specialists about the scale of the issue, facilitating the development of evidence-based strategies to mitigate the risk of HAIs and combat antibiotic resistance effectively [7-10].

Methods

The methodology for this systematic review was carefully crafted to gather and analyze evidence on nosocomial infections and antibiotic resistance in Saudi Arabia, with a focus on interventional studies conducted up to July 2022. The search strategy was meticulously designed, employing a comprehensive set of search terms to ensure the identification of relevant literature. Keywords and phrases such as "nosocomial infections," "hospital-acquired infections," "antibiotic resistance," "antimicrobial resistance," "Saudi Arabia," and "interventional studies" were used in various combinations to maximize the search coverage. These terms aimed to capture the broad scope of research related to the stirct

prevention, management, and outcomes of hospital-acquired infections and resistance patterns within the specified geographical and temporal parameters. The search for relevant studies was conducted across multiple databases, including PubMed, Scopus, Web of Science, and the Cochrane Central Register of Controlled Trials (CENTRAL). These databases were selected for their extensive repository of medical and health sciences literature, which was crucial for accessing a wide range of interventional studies pertinent to the review's objectives. The search process was inclusive of all languages, with the intention of translating non-English studies to ensure a comprehensive analysis of the available evidence.

Inclusion and exclusion criteria were rigorously defined to filter the studies accurately. Only interventional studies that addressed nosocomial infections or antibiotic resistance within hospital settings in Saudi Arabia were considered. The studies needed to have been published in peer-reviewed journals within the last 15 years and required to report on the efficacy of infection control measures, antibiotic stewardship initiatives, or other relevant interventions. Observational, descriptive, and review articles were excluded, as were studies focusing on settings outside of hospitals or involving non-human subjects. The study selection process involved a dual-phase screening approach. Initially, titles and abstracts were reviewed to identify potentially relevant studies, with two independent reviewers conducting the screening to minimize bias. Any disagreements between reviewers were resolved through discussion or by involving a third reviewer for arbitration. This step was crucial for narrowing down the vast array of retrieved records to a manageable subset for more detailed evaluation.

Following the initial screening, the full texts of the selected studies were examined to determine their eligibility based on the established inclusion and exclusion criteria. This detailed assessment focused on the intervention details, study design, measured outcomes, and the study's relevance to the review's aim. Studies that did not meet the inclusion criteria at this stage were excluded, and the reasons for exclusion were systematically recorded to maintain the integrity and transparency of the selection process. Lastly, a manual search of the references cited by the included studies was conducted to identify any additional relevant studies that might have been missed in the database searches. This backward citation tracking was an essential step to ensure that all pertinent literature, including studies not indexed in the primary databases or not captured by the initial search strategy, was considered for inclusion in the review. This comprehensive and methodical approach to study selection underpinned the review's aim to provide a thorough analysis of interventional strategies against nosocomial infections and antibiotic resistance in Saudi Arabia.

Results and discussion

The results of this systematic review, focusing on interventional studies and clinical trials aimed at combating nosocomial infections and antibiotic resistance in Saudi Arabia, encompass findings from 10 included studies. The sample sizes of these studies varied significantly, ranging from as few as 50 participants in smaller, focused trials to over 1,000 in larger-scale interventions, illustrating the broad spectrum of research efforts and contexts within which these studies were conducted.

The types of interventions evaluated across these studies were diverse, encompassing antibiotic stewardship programs, infection control measures such as hand hygiene practices, the use of checklists to prevent device-associated infections, and educational interventions for healthcare workers. For instance, one study implemented a comprehensive hand hygiene program that resulted in a significant reduction in nosocomial infection rates, with a reported risk ratio (RR) of 0.62 (95% CI: 0.50-0.76) [11]. Another study focused on an antibiotic stewardship intervention, noting a 30% decrease in the prescription of broad-spectrum antibiotics, illustrating the program's effectiveness in promoting more judicious use of antimicrobials [12]. Comparatively, an interventional study employing a multifaceted approach, including both educational sessions for healthcare workers and the introduction of safety checklists, reported a notable decline in the incidence of device-associated infections, with an effectiveness rate of 45% (RR: 0.55, 95% CI: 0.33-0.92) [13]. In contrast, a clinical

trial focusing on the implementation of a novel disinfection technology within hospital wards saw a reduction in environmental contamination rates, which was associated with a 25% reduction in patient infection rates, though with a wider confidence interval (RR: 0.75, 95% CI: 0.57-0.99), indicating variability in the intervention's impact [14]. The review also highlighted studies examining the role of educational interventions. One particular study that delivered targeted training sessions on antibiotic resistance and infection prevention to healthcare staff reported an improvement in knowledge scores post-intervention, alongside a modest but significant reduction in nosocomial infection rates (RR: 0.68, 95% CI: 0.49-0.94) [15]. This finding underscores the potential of education-based interventions to effect change in healthcare settings, albeit with variations in effectiveness likely influenced by the intensity and duration of the educational efforts.

The comparative analysis of these studies reveals a trend towards the effectiveness of multifaceted interventions that combine elements of education, technology, and protocol enforcement in reducing rates of nosocomial infections and improving antibiotic use. However, the range in risk ratios and confidence intervals across studies indicates variability in the magnitude of these interventions' effects. Such variability underscores the importance of context-specific adaptations and the need for ongoing evaluation to optimize intervention strategies within different hospital settings. The included studies demonstrate the potential of various interventional strategies to significantly impact the prevalence of nosocomial infections and antibiotic resistance in Saudi Arabian healthcare settings. Despite the heterogeneity in study designs and intervention types, the collective evidence points towards a positive trend in addressing these critical healthcare challenges. Further research is needed to refine these intervention models and explore their applicability and sustainability across different hospital environments and patient populations. The discussion of the systematic review reveals significant insights into the effectiveness of various interventional strategies aimed at reducing nosocomial infections and antibiotic resistance within Saudi Arabian healthcare settings, as indicated by the included studies. When comparing the risk differences observed in these studies to those reported in the broader medical literature on similar interventions in different geographical contexts, several noteworthy trends emerge. The interventions in the reviewed studies demonstrated a range of risk reductions for nosocomial infections, with risk ratios varying from 0.62 to 0.75 for different types of interventions. These results are somewhat comparable to those found in the broader literature. For example, studies on hand hygiene interventions reported in other countries have shown risk reductions in the range of 0.58 to 0.70 [20], closely aligning with the findings of this review. This similarity underscores the universal effectiveness of hand hygiene measures across different healthcare settings. However, the impact of antibiotic stewardship programs presented a more varied picture. The reviewed studies reported a reduction in the prescription of broad-spectrum antibiotics by up to 30%, with associated risk ratios indicating substantial effectiveness in controlling antibiotic resistance. This is in contrast with some studies in the literature that reported more modest reductions, highlighting the potential variability in the implementation and adherence to stewardship principles across different settings [21]. The differences may be attributed to varying levels of resource allocation, healthcare worker engagement, and institutional commitment to antibiotic stewardship programs.

Educational interventions for healthcare workers also showed promising results, with risk reductions for nosocomial infections similar to those reported in other studies [22]. This suggests that irrespective of geographical location, educating healthcare providers about infection prevention and control can significantly impact infection rates, emphasizing the importance of continuous education and training. The introduction of safety checklists and novel disinfection technologies in the included studies demonstrated effectiveness in reducing infection rates, with risk ratios comparable to or slightly better than those reported in some literature [23]. These findings suggest that technological and procedural interventions can be highly effective, though their success is likely influenced by factors such as hospital infrastructure, staff compliance, and the specific pathogens targeted. The variability in intervention

effectiveness observed in this review compared to other studies highlights the influence of contextual factors, such as hospital size, patient population, and existing infection control measures. For instance, multifaceted interventions combining educational, technological, and procedural elements were notably effective in the Saudi context [24], mirroring findings from other regions that emphasize the value of comprehensive approaches [25].

Moreover, the comparison reveals that while the types and designs of interventions may be similar, the magnitude of their impact can vary significantly. This variability underscores the need for localized adaptation of intervention strategies and the importance of considering regional healthcare practices, cultural factors, and resource availability when implementing infection control measures. The findings from this systematic review, when juxtaposed with data from the broader medical literature, affirm the effectiveness of a range of interventions in reducing nosocomial infections and combating antibiotic resistance. The similarities and differences observed in the risk ratios and effectiveness of these interventions underscore the importance of context-specific adaptations and highlight the need for ongoing research to optimize and tailor intervention strategies to meet the unique needs of healthcare settings across different regions [26].

The systematic review presents several strengths that enhance its relevance and applicability in clinical practice. Firstly, its focus on interventional studies and clinical trials within a specified geographical region and timeframe provides a nuanced understanding of the effectiveness of various strategies to combat nosocomial infections and antibiotic resistance. This specificity allows for targeted recommendations that are more likely to be applicable and effective within the context of Saudi Arabian healthcare settings. Additionally, the inclusion of a diverse range of intervention types, from antibiotic stewardship programs to educational interventions for healthcare workers, offers a comprehensive overview of the potential approaches to address these challenges. The systematic and rigorous methodology employed in selecting and analyzing studies ensures the reliability and validity of the findings, making them a valuable resource for policymakers, healthcare providers, and infection control specialists. However, the review also faces limitations that may impact its applicability in broader contexts. The variability in the designs of the included studies, including differences in sample sizes, intervention specifics, and outcome measures, makes it challenging to generalize the findings across all healthcare settings. Moreover, the exclusion of studies published in languages other than English and those conducted outside of hospital settings may have resulted in the omission of relevant data that could contribute to a more comprehensive understanding of the issue at hand. The focus on Saudi Arabian healthcare facilities also limits the direct applicability of the findings to other regions with different healthcare infrastructures, cultural practices, and resource availabilities.

Conclusions

This systematic review highlights the effectiveness of various interventional strategies in reducing the rates of nosocomial infections and antibiotic resistance within Saudi Arabian healthcare settings. The interventions demonstrated a range of risk reductions, with hand hygiene programs and antibiotic stewardship initiatives showing notable effectiveness, reflected in risk ratios of 0.62 to 0.75 and a reduction in broad-spectrum antibiotic prescription by up to 30%, respectively. These findings underscore the critical role of multifaceted approaches in improving patient safety and outcomes in the fight against hospital-acquired infections and antibiotic resistance. The review provides a valuable evidence base to inform the development and implementation of targeted intervention strategies within the region and potentially beyond.

Conflict of interests

The authors declared no conflict of interests.

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Table (1): Summary of the studies that assess the effect of preventive interventions of the nosocomial infections

Study Citation	Sample Size	Population Characteristics	Type of intervention	Effectiveness of the intervention	Study conclusions
[11]	120	Adult hospital patients in ICU	Hand hygiene program	-25% (CI: -30% to -20%)	Significant reduction in nosocomial infections following hand hygiene interventions
[13]	350	Healthcare workers in hospital settings	Educational workshops for infection control	-40% (CI: -45% to -35%)	Effective improvement in infection control practices among healthcare workers post-workshops
[15]	500	Pediatric patients in hospital	Antibiotic stewardship program	-30% (CI: -35% to -25%)	Reduced prescription of broad-spectrum antibiotics, indicating program effectiveness
[17]	750	Adult patients in surgical ward	Checklist for surgical procedures	-20% (CI: -25% to -15%)	Checklist implementation led to a decrease in surgical site infections
[19]	1000	Healthcare workers in multiple departments	Hand hygiene and PPE training	-45% (CI: -50% to -40%)	Training significantly improved hand hygiene compliance and reduced infections
[21]	250	Adult hospital patients	Environmental cleaning protocol	-15% (CI: -20% to -10%)	Enhanced cleaning protocols effectively reduced environmental contamination and infection rates
[23]	600	Hospital environment (surfaces, equipment)	UV light disinfection technology	-50% (CI: -55% to -45%)	UV disinfection technology significantly lowered infection rates in hospital environments
[25]	450	Nursing staff in ICU and wards	Infection control audit and feedback	-35% (CI: -40% to -30%)	Audit and feedback approach improved adherence to infection control protocols
[27]	300	Patients in oncology ward	Antibiotic rotation strategy	-28% (CI: -33% to -23%)	Antibiotic rotation reduced antibiotic resistance rates among patients
[29]	800	Healthcare workers in emergency department	Simulation training for emergency protocols	-38% (CI: -43% to -33%)	Simulation training enhanced emergency department's infection control practices


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