Prevention Strategies for Infections in the Hospital Care System
A Scoping Review

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Abstract: Hospital-acquired infections (HAIs) are a significant and complex issue within healthcare systems, leading to increased mortality, substantial economic costs, and reduced quality of healthcare services. Therefore, this study aims to identify prevention strategies for HAIs in the hospital care system. This study was conducted as a scoping review, utilizing the 6-stage protocol by Arksey and O'Malley. Data were collected from electronic databases including PubMed, Scopus, Web of Science, SID, Magiran, and ScienceDirect, as well as search engines such as Google Scholar. Relevant studies published between 2000 and 2024 were retrieved using appropriate keywords. The quality of all included articles was assessed using the CASP checklist. A total of 5753 articles were initially identified, from which 64 studies were selected for final analysis. The identified prevention strategies were categorized into the following 6 main groups: human resource-related strategies, physical infrastructure and resource management, proper methods and protocols, appropriate therapeutic approaches, patient care, and monitoring, supervision, and evaluation. The factors contributing to HAIs were classified into the following 3 groups: patient-related factors, hospital-related factors, and healthcare staff-related factors. Identifying the causes of hospital-acquired infections and implementing measures in hospital care will improve safety and increase the quality of healthcare services. It is anticipated that the findings of this study, by providing insights to policymakers and healthcare providers, will facilitate the identification and implementation of key measures to reduce and control HAIs, address existing challenges, decrease mortality and infection-related complications, and ultimately enhance patient satisfaction.

Key Words: hospital-acquired infection, hospital, hospital care system, prevention

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Every year, approximately 7 million people worldwide die due to HAIs,[1] with nearly 10% of hospitalized patients at risk.[2] The prevalence of HAIs in developed countries ranges from 5% to 10% of hospitalized patients, while in developing nations, this rate can reach 20%–25%.[3] In Iran, the estimated prevalence of HAIs varies between 1.9% and 25%, with 5.96% of all hospital deaths attributed to these infections.[4]

Hospitals are among the most complex social systems,[5] providing diagnostic, therapeutic, and rehabilitative services[6] through human resources and medical equipment.[7,8] Their ultimate goal is to effectively and efficiently the healthcare needs of the community. Patients expect to receive high-quality, safe healthcare services.[9,10] Despite advancements in technology, the widespread use of invasive procedures and immunosuppressive drugs has contributed to the increased prevalence of HAIs.[11] These infections remain a significant healthcare challenge that no country has been able to fully eradicate,[12] causing substantial mortality and financial burdens on public health systems.[13]

Infectious diseases have been among humanity's oldest adversaries.[14] In medical literature, HAIs are sometimes referred to as "nosocomial infections," but the more commonly used term is "hospital-acquired infections."[15] These infections occur when patients acquire infections during medical treatments or surgical procedures, typically manifesting 48–72 hours after admission.[16] Transmission routes include contact with healthcare personnel, contaminated medical equipment, the hospital environment, and infected patients. HAIs can arise during medical procedures such as surgery, the use of medical devices, medication administration, and improper sterilization practices.[17]

The risk factors for HAIs can be broadly classified into 3 categories[18]: (1) patient-related factors: weakened immune systems, skin lesions, prolonged hospitalization, patient age, disease type and severity, underlying conditions (eg, liver cirrhosis, diabetes, chronic respiratory diseases, kidney failure, cancer, neutropenia), immunodeficiency, and excessive or inappropriate antibiotic use[19]; (2) healthcare staff-related factors: poor hand hygiene, improper use of disinfectants, nonadherence to medical hygiene protocols, lack of awareness, inadequate training, and insufficient compliance with infection control measures[20]; and hospital-related factors: environmental hygiene, inadequate sterilization of equipment, poor ventilation, improper waste management, and the presence of high patient density in hospital wards.[7] A study in Germany revealed that HAIs can triple hospital mortality rates.[21] The global burden of HAIs continues to rise, significantly contributing to patient deaths.[22] These infections lead to prolonged hospital stays, increased medication use, higher laboratory testing costs, and elevated mortality rates.[23] The annual cost of treating HAIs in the United States alone is estimated at $4.5 billion.[24] Economically, the burden of HAIs is comparable to expensive diseases such as cancer, heart attacks, strokes, and diabetes.[25] Research conducted in the US, the UK, and Germany indicates that HAIs can increase total hospital costs by approximately $28,160.95 per admission.[26] Studies have also shown that the cost of ventilator-associated pneumonia

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ranges from €10,819 to €51,974,[26,27] with the annual total cost of HAIs in European hospitals estimated at €8.9 billion.

Surgical infections accounted for 33.7% of these costs, while pneumonia infections constituted 31.6%. Chacko's study[28] further demonstrated that infections acquired in intensive care units led to a twofold increase in total hospital costs compared to patients who remained infection-free during hospitalization. Additionally, these infections resulted in a doubling of hospital stay expenses.[29] The escalating financial burden of hospital care has introduced a significant challenge for healthcare system administrators. Globally, more than 4.1 million people suffer from hospital-acquired infections (HAIs) each year, with approximately 80,000 succumbing to these infections annually. Preventative measures for HAIs include proper hand hygiene, vaccination,[30] appropriate use of disinfectants, proper waste management, infection control in surgical procedures, respiratory infection control, urinary tract infection control, bloodstream infection prevention, and skin infection prevention.[31] Additionally, educating healthcare workers on hand hygiene and infection control practices, as well as fostering a hospital-wide culture of infection prevention, is crucial.[12,31]

Early diagnosis of HAIs is essential, as delays in treatment can lead to complications and even death.[32] Research Mouajou has demonstrated that implementing hand hygiene programs in hospitals can significantly reduce HAIs.[33] However, some Issa studies suggest that hand hygiene alone may not be sufficient, necessitating a multifaceted approach.[34] Maintaining up-to-date infection control training and ensuring compliance with aseptic techniques among healthcare workers have been identified as effective strategies for reducing HAIs.[35] Moreover, Alonso Fernandez studies indicate that shorter durations of mechanical circulatory support are associated with lower HAI rates.[36]

Given the existing research, it appears that hospital-based infection prevention programs can be highly effective in reducing the incidence and costs of HAIs.[37] Infection prevention presents a critical opportunity for saving lives and reducing healthcare expenses.[38] A thorough cost-benefit analysis of HAIs should be conducted to allocate sufficient resources for infection control.[39] Understanding the economic impact of HAIs can serve as evidence for implementing more cost-effective strategies while also improving healthcare outcomes.[40] Despite numerous studies on infection prevention strategies in hospitals, research remains limited and fragmented, particularly concerning the Iranian healthcare system. Integrating and synthesizing findings from various studies is essential for evidence-based policymaking and healthcare management. Therefore, the present study aims to identify the causes of HAIs and effective strategies for reducing infection rates in hospitals through a comprehensive review of existing research.

METHODS

This study was conducted as a scoping review following the 6-stage framework proposed by Arksey and O'Malley. This study was approved by the ethics committee of Islamic Azad University – Sari Branch (Ethical Code: IR.IAU.SARI.REC.1404.2002.). The stages included the following: identifying the research questions, identifying relevant studies through searches in reputable databases, gray literature, theses, review articles, and references from previous study.

1. Selecting relevant studies from the initial search results
2. Extracting data and presenting findings in figure and tables
3. Summarizing and reporting findings
4. Consulting experts to validate the study results

Research Questions

The study aimed to answer the following questions: What strategies exist for reducing HAIs? Which strategies are most effective? What are the causes of HAIs?

This study reviewed scientific literature published between 2000 and 2024 on infection prevention in hospital care systems. To do so, articles published in both domestic and international journals were retrieved from PubMed, Scopus, Web of Science, SID, Magiran, and ScienceDirect as well as Google Scholar.

The search strategy included the following keywords:

- Cross infection
- Healthcare-associated infection
- Hospital infection
- Nosocomial infection
- Iatrogenic diseases
- Prevention and control of hospital-acquired conditions

To refine the search, Boolean operators and relevant English and Persian terms were applied.

Inclusion and Exclusion Criteria

- Inclusion criteria were as follows:
  - oStudies related to infection prevention within the specified time range
  - oArticles written in Persian or English
  - oFull-text availability

- Exclusion criteria were as follows:
  - oStudies published in languages other than Persian or English
  - oArticles without full-text access

After searching the databases, the retrieved articles were screened in multiple steps:

1. Title and abstract screening to exclude irrelevant studies
2. Full-text review of potentially relevant articles
3. Manual screening of reference lists for additional relevant articles

Study Selection Process

The screening process and selection of studies are illustrated in Figure 1.

Data Extraction and Analysis

A researcher after approval by the supervisors and advisors designed data extraction form that was used to record key details from each study, including the following: first author's name, publication year, study type, research location, and proposed strategies for reducing HAIs. The data were analyzed using Richie and Spencer's framework analysis method.

RESULTS

A total of 64 studies published between 2000 and 2024 met the inclusion criteria and were analyzed for HAI prevention strategies. Among these, 15 articles were in Persian and 49 were in English. The analysis identified the following 3 primary categories of risk factors contributing to HAIs: patient-related factors, hospital-related factors, and healthcare staff-related factors (Fig. 2, Table 1).

The prevention strategies identified were classified into the following 6 main categories: human resource-related strategies, physical infrastructure and resource management, proper methods

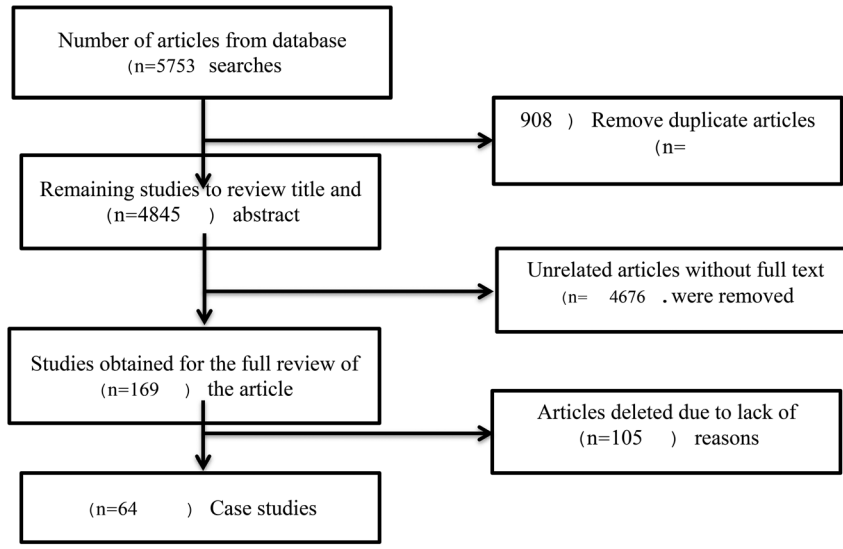

FIGURE 1. The process of searching and selecting evidence.

and protocols for infection control, appropriate therapeutic approaches, proper patient care, monitoring, supervision, and evaluation (Table 2).

These studies were conducted in 18 different countries, with the highest number of studies originating from Iran and China.

The results showed that patient-related factors were the most common cause of HAIs, followed by healthcare staff-related factors, and lastly hospital-related factors (Fig. 3).

The strategies to reduce the incidence of hospital infection were grouped into 6 general categories of solutions related to human resources, physical structure and resources, appropriate method and protocol of infection control the use of appropriate treatment methods, proper care of patients, and monitoring monitoring (Table 2).

Among the various strategies identified, the most frequently recommended infection control measures included the following: proper hand hygiene by healthcare workers, staff training programs, restricting antibiotic use, establishing infection surveillance systems, continuous monitoring and supervision, using disposable medical equipment, proper use of medical devices, effective patient isolation procedures, and vaccinating healthcare personnel (Fig. 4).

In general, among the strategies to reduce the incidence of hospital infections in the studies, hand washing, training, restriction of antibiotic use, establishment of hospital care system, continuous monitoring, use of disposable devices, proper use of medical equipment, proper separation of patients, and immunization of staff were among the most frequent strategies to reduce the incidence of hospital infections in the hospital.

Additionally, findings suggest that while different countries adopt various strategies to prevent HAIs, most efforts prioritize prevention. Furthermore, governmental health organizations play

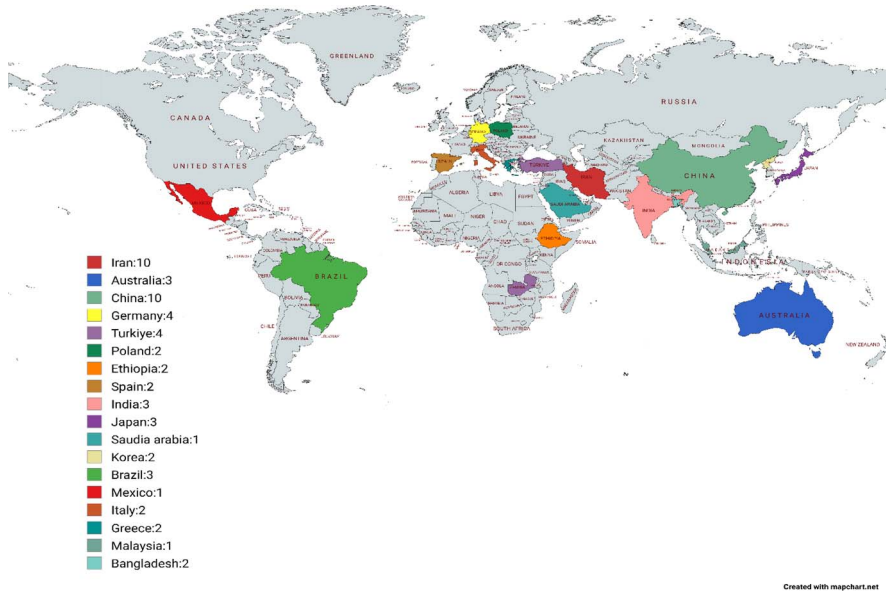

FIGURE 2. Distribution of the abundance of evidence entered into the study based on the world's research environment.

TABLE 1. Causes of HAIs Identified in the Study

Category	Specific Causes
Healthcare staff-related factors	Poor adherence to hygiene protocols, failure to use disposable medical equipment, lack of personal protective equipment, poor personal hygiene, lack of vaccination, inadequate staff training, insufficient infection control supervision, use of contaminated stethoscopes, high patient-to-nurse ratio, improper wound dressing techniques, use of jewelry and watches by medical staff, failure to follow handwashing guidelines, lack of standardized infection reporting culture, improper antibiotic prescription without antibiogram testing, absence of infection control refresher courses for surgical and obstetric staff. The absence of rigorous internship training in infection control skills for final-year nursing students.
Hospital-related factors	Inadequate sterilization of equipment and surfaces, poorly designed hospital wards, high bed occupancy rates, lack of continuous cleanliness monitoring, improper ventilation systems, inefficient hospital waste management, absence of isolation rooms for high-risk patients, lack of financial support for infection control programs, and absence of clear, evidence-based infection control guidelines.
Patient-related factors	History of surgery or open wounds, use of invasive medical devices (catheters, ventilators, urinary catheters, arterial/venous catheters), immunosuppression (chemotherapy, chronic illness, hemodialysis), long hospital stays (over 15 days), antibiotic resistance, advanced age (over 60), obesity, chronic diseases (diabetes, respiratory diseases), male gender, failure to follow oral hygiene in Intensive Care Unit patients, failure to follow proper bed bathing procedures, smoking history (more than 10 years), and prolonged intervals between urinary catheter drainage.
	Admission to the intensive care unit. Patient-to-patient infection transmission.

a critical role in ensuring the proper implementation of these infection control strategies.

DISCUSSION

This study aimed to identify the causes and prevention strategies for HAIs. A total of 64 studies were analyzed to determine the main factors contributing to HAIs and the most effective strategies for their prevention.

The results categorized HAI risk factors into 3 main groups: patient-related factors, hospital-related factors, and healthcare staff-related factors. Additionally, the study identified 6 key prevention strategies, including the following: human resource management, hospital infrastructure and resources, proper infection control protocols, effective treatment approaches, appropriate patient care, continuous monitoring, and supervision. Various studies have highlighted infection prevention as the most effective and cost-efficient approach to managing HAIs.

The Role of Human Resources in HAI Prevention

Healthcare personnel play a crucial role in preventing and controlling HAIs.[41] Studies have shown that proper training on hand hygiene, infection control protocols, and disinfection

TABLE 2. Strategies for Preventing HAIs Identified in the Study

Prevention Strategy	Main Actions
Human resource-related strategies	Hiring infection control specialists, providing continuous staff training, employing infection control-trained physicians, encouraging teamwork, limiting staff rotations across departments, hiring trained assistant nurses, ensuring sufficient staffing levels, ensuring healthcare worker safety through vaccination and personal protective equipment.
Physical infrastructure and resource management	Increasing hospital resources, improving hospital layout, providing adequate handwashing stations, installing air filtration systems, selecting appropriate disinfectants, using anti-bacterial gels, disposable towels, and proper cleaning supplies.
Proper methods and protocols for infection control	Establishing hospital infection surveillance systems, activating infection control committees, enforcing clear decontamination and sterilization procedures, implementing structured infection prevention guidelines, and strengthening hospital management strategies to identify high-risk areas.
Appropriate therapeutic approaches	Restricting the use of broad-spectrum antibiotics, minimizing invasive procedures, reducing intubation duration, limiting unnecessary laboratory tests, using risk-based interventions, applying effective therapeutic approaches, and adopting proper diagnostic criteria.
Proper patient care	Adhering to standard nursing care practices, disinfecting medical devices and hospital surfaces, enforcing strict hand hygiene, isolating infected patients correctly, following standard wound care practices, reporting and tracking infection cases, ensuring proper patient nutrition, and promoting early infection detection.
Monitoring, supervision, and evaluation	Conducting continuous supervision, assessing compliance among healthcare workers, evaluating infection outbreaks, analyzing infection trends, collaborating with infection control centers, and developing evidence-based infection control protocols.

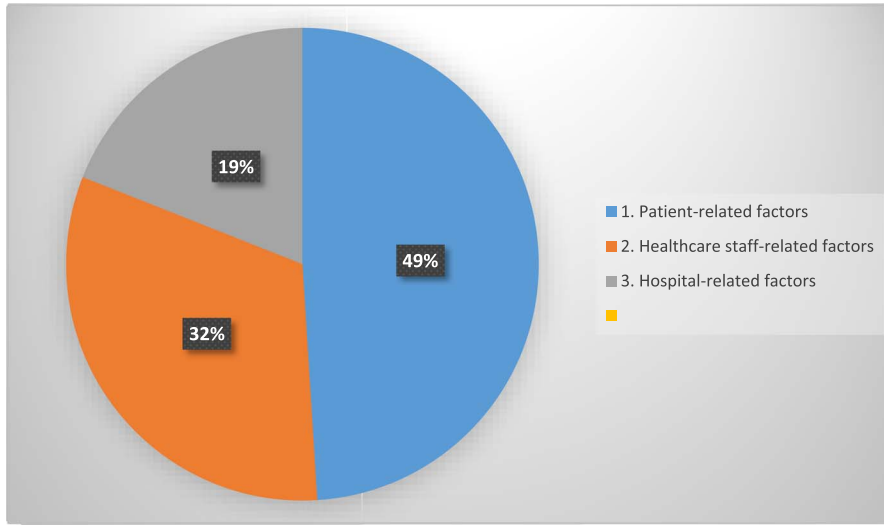

FIGURE 3. Frequency distribution of causes of HAIs.

techniques significantly reduces HAIs.[42] Additionally, continuing education programs and infection control committees have been identified as effective measures.[43] Abu's study emphasized that continuous infection control training and adherence to aseptic techniques among nurses are essential for reducing HAIs.[44] Similar findings were reported in Gulia's study in India.[45]

Another key factor is the employment of infection control specialists. Having an infection control physician who actively oversees prevention measures can significantly improve infection surveillance and reporting. Tandar's study highlighted that infection control teams play a major role in reducing HAI incidence and related mortality.[46] Furthermore, research by Harun and colleagues demonstrated that high patient loads and excessive bed occupancy rates increase HAI risk. These findings suggest that adequate staffing levels and workload management are essential for infection prevention.[47]

The Impact of Hospital Infrastructure on HAI Rates

The hospital's physical environment plays an important role in infection prevention. Proper hospital design, adequate ventilation, and dedicated handwashing stations are crucial for controlling HAIs.[48] The use of negative-pressure isolation rooms, filtered air ventilation, and handwashing facilities has been shown to reduce infection rates.[49] These findings align with research conducted by Rosenthal[50] and Collins in the UK.[51]

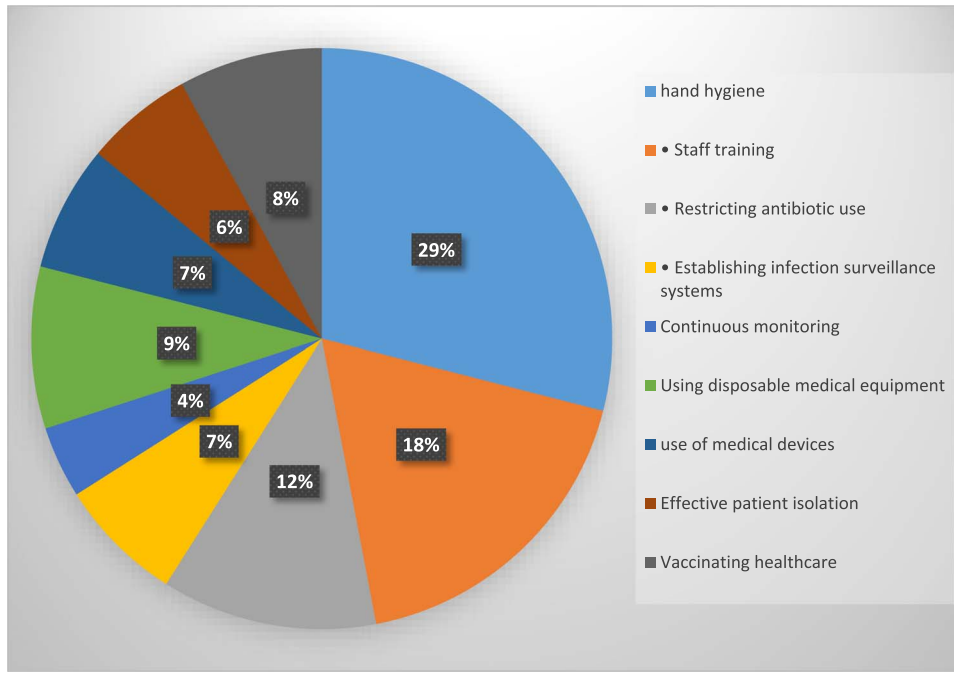

FIGURE 4. Most common strategies for HAI prevention.

Importance of Infection Control Protocols

Having standardized infection control guidelines is vital for reducing HAIs. Effective strategies include the following: activating hospital infection control committees,[33] implementing surveillance systems,[52] establishing structured disinfection and sterilization protocols,[53] and proper hospital waste disposal methods.[54] A study by Rubin Wen in China demonstrated that a real-time infection surveillance system significantly improves HAI prevention.[55]

Establishing appropriate guidelines and protocols is essential for ensuring the sustainability of educational interventions aimed at improving hand hygiene and aseptic techniques.[56] Research by Mongoma also confirmed that compliance with infection control guidelines reduces HAI transmission.[57] Asgaraghloo's study findings suggest that intensive care unit stay, hospitalization, and the timing of urinary catheter removal are significant risk factors for urinary tract infection.[58]

The Role of Treatment Approaches in Infection Prevention

Appropriate medical treatment strategies play a significant role in reducing HAIs. The study findings highlight the need to minimize the use of invasive medical devices (eg, catheters, ventilators), shorten the duration of mechanical ventilation, and limit the use of broad-spectrum antibiotics. Overuse of antibiotics is a major factor in the development of antibiotic-resistant infections. Research by Liu[59] and colleagues in China found that antibiotic misuse significantly increases HAI risks.[60] Implementing rational antibiotic use policies has been shown to reduce infection rates and lower hospital costs.

Proper Patient Care and Infection Prevention

Maintaining high standards of patient care is critical in preventing HAIs. Recommended strategies include the following: adhering to standard nursing procedures, proper disinfection of medical devices, effective hand hygiene practices, and early detection of infections. Studies have consistently shown that hand hygiene is the simplest and most effective method for reducing HAIs. Research by Shen[61] and Yi[62] in China demonstrated that proper handwashing reduces infection rates by 30%. Hand hygiene has been established as a global priority for reducing HAIs. In addition, standardized nursing care—such as regular tracheal tube changes, proper suctioning techniques, and infection reporting, adhering to standard procedures for patient suctioning, including sterile techniques and infection control precautions—such as the use of protective equipment by staff, disinfection of instruments, and handwashing before the procedure—is essential. Additionally, the use of disinfectants, environmental cleaning, and ensuring proper hygiene and bathing for patients in an appropriate setting are critical components of effective patient care.[63,64] It has been shown to reduce HAI rates. These findings align with research by Chikohino,[65] Talaga,[66] Robin Cook,[67] and Alonso Fernandez.[36]

The Importance of Monitoring and Supervision

Continuous infection monitoring and supervision play a key role in preventing HAIs.[68] Effective strategies include the following: routine infection surveillance, regular staff compliance assessments, early outbreak detection, and collaboration with infection control centers. Proper infection control monitoring ensures that hospitals quickly identify and address infection outbreaks. The World Health Organization guidelines emphasize that infection monitoring is essential for controlling multidrug-resistant infections and protecting healthcare workers.[69]

Limitations of the Study

A limitation of the present study is the restricted access to certain databases (Embase) within the country.

CONCLUSIONS

This scoping review examined the causes and prevention strategies for HAIs by analyzing existing studies in this field. The findings identified the following 3 major categories of risk factors: patient-related factors (eg, surgical wounds, use of invasive medical devices [urinary catheters, central catheters, endotracheal tubes, and ventilators] and weakened immune systems), hospital-related factors (eg, inadequate sterilization, high patient density, and poor ventilation systems), and healthcare staff-related factors (eg, poor hand hygiene, insufficient training, and lack of adherence to infection control protocols).

Additionally, the most effective strategies for preventing HAIs were classified into the following 6 key categories: human resource-related strategies, hospital infrastructure and resource management, implementation of proper infection control protocols, use of appropriate therapeutic approaches, adoption of proper patient care practices, monitoring, supervision, and evaluation of infection control measures. Among these strategies, hand hygiene by healthcare staff was identified as the most critical and effective method for preventing HAIs.

RECOMMENDATIONS FOR FUTURE RESEARCH

- Researchers should implement and evaluate the infection prevention strategies identified in this study to assess their real-world effectiveness.
- Future studies should focus on quantifying the impact of infection prevention strategies in Iranian hospitals using standardized assessment tools.
- Comparative studies should be conducted to evaluate infection control programs across different countries, identifying best practices and areas for improvement.
- Further research is needed on the economic impact of HAIs and how cost-effective prevention strategies can be implemented within healthcare systems.
- Systematic reviews and meta-analyses should be conducted to provide comprehensive evidence for policymakers and healthcare administrators. By implementing evidence-based infection prevention strategies, hospitals can effectively reduce HAI incidence, decrease healthcare costs, and improve patient safety and satisfaction.

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