

ASSESSING THE EFFECTIVENESS OF INFECTION CONTROL MEASURES IN REDUCING HEALTHCARE-ASSOCIATED INFECTIONS IN THE EMERGENCY SETTING: A SYSTEMATIC REVIEW

BADIAH IBRAHIM ALBINZAID¹, AYA TAHA ELGOHARI², RIM MOHAMED MOUZHIR³, AHMED HASSAN AL-AMRI⁴, GEHAN NORELHADI ABDELRAHMAN MOHAMED⁵, GHAIIDAA JADALLAH BAJNAID⁶, YOSEF ALI ALBAHRANI⁷, ASMAA QASEM H ALNAKHLI⁸, AKRAM SALEH KAMAL⁹, MAZEN ABDULLAH ALI ALZHRANI¹⁰, HISHAM ABDULHAKIM AL AHMAD¹¹, RANDA ALMATRAFI¹²

¹EMERGENCY MEDICAL SERVICES, MINISTRY OF NATIONAL GUARD HEALTH AFFAIRS MNGHA, EMAIL: albinzaidba@mngha.med.sa

²GENERAL PRACTITIONER IN EMERGENCY DEPARTMENT, AL-YOSSIF HOSPITAL, KHOBAR, KSA

³EMERGENCY MEDICINE

⁴EMERGENCY MEDICAL SERVICES MINISTRY OF DEFENSE, ARMED FORCES OF AERO MEDICAL CENTER

⁵EMERGENCY MEDICINE, MOH

⁶SERVICE RESIDENT, EMERGENCY, MOH

⁷MEDICINE

⁸5TH YEAR MEDICAL STUDENT

⁹EMERGENCY MEDICINE

¹⁰KING ABDULAZIZ HOSPITAL-MEDICINE AND SERGICAL BACHELOR-EMERGENCY MEDICAL SERVICE-

¹¹GENERAL PRACTICE

¹²SPECIALIST ER

Abstract

Background: Healthcare-associated infections (HAIs) represent a persistent challenge in emergency departments (EDs), where high patient turnover and urgent care delivery complicate adherence to infection prevention protocols.

Objective: This systematic review aimed to evaluate the effectiveness of infection control measures in reducing HAIs in emergency settings, focusing on interventions such as hand hygiene initiatives, educational programs, infection control bundles, and surveillance systems.

Methods: A systematic search was conducted across major databases following PRISMA 2020 guidelines. Fifteen peer-reviewed studies published between 2011 and 2025 were included. Eligible studies involved human subjects in ED or ICU settings, assessed infection control interventions, and reported outcomes related to HAI incidence, compliance rates, or patient experiences.

Results: Across included studies, baseline compliance with infection control practices was low, with hand hygiene adherence ranging from 41.3% to 66.7%. Interventions such as targeted education and hand hygiene initiatives improved compliance by up to 30 percentage points, while care bundles significantly enhanced nursing performance in CLABSI prevention (65.2% to 88.7%). Infection control teams and structured surveillance systems reduced the incidence of device-associated HAIs and multidrug-resistant organisms. However, systemic barriers, overcrowding, and workload pressures continued to limit sustained improvements. Patient isolation, while effective, was associated with increased ED length of stay and lower satisfaction.

Conclusion: Infection control measures can significantly reduce HAIs in emergency settings, but effectiveness depends on addressing both behavioral and systemic barriers. Multidisciplinary, sustained approaches integrating education, monitoring, and stewardship are essential to ensure safe and effective infection prevention in emergency care environments.

Keywords: Healthcare-associated infections; emergency department; infection control; hand hygiene; central line-associated bloodstream infection; antimicrobial stewardship; patient safety; nosocomial infections

INTRODUCTION

Healthcare-associated infections (HAIs) remain a persistent global challenge, posing a significant burden on both patients and healthcare systems. The World Health Organization estimates that hundreds of millions of patients are affected annually, resulting in prolonged hospital stays, increased resistance to antimicrobials, and excess costs for health services. While HAIs have been studied extensively in inpatient wards and intensive care units, emergency departments (EDs) present unique challenges given their high patient turnover, urgent interventions, and frequently crowded environments (Liang et al., 2014). Infection prevention in these fast-paced settings is critical yet often overlooked.

The burden of HAIs is disproportionately higher in developing countries. A systematic review by Allegranzi et al. (2011) demonstrated that the prevalence of HAIs in resource-limited settings can exceed 20%, nearly double the rates reported in high-income nations. These infections include bloodstream infections, ventilator-associated pneumonia, and surgical site infections. Factors such as limited staffing, inadequate infrastructure, and lack of continuous training amplify the challenges in compliance with infection control measures. This disparity highlights the urgent need for tailored infection prevention strategies in EDs across different health systems.

In Africa, the challenge is particularly pressing. Abubakar et al. (2022), in a systematic review and meta-analysis, reported pooled HAI prevalence rates as high as 15.5% across multiple facilities. Their findings underscored significant variability across countries but consistently highlighted gaps in surveillance, under-resourced infection control programs, and limited antimicrobial stewardship. These structural limitations are even more critical in ED settings where time-sensitive decisions frequently preclude adherence to standard precautions.

In developed regions, while infrastructure and resources may be more robust, challenges persist. Russo et al. (2017) noted that in Australia, HAIs remain among the most common adverse events in hospitalized patients, with estimates suggesting one in every ten patients acquires an infection during hospitalization. Although hospitals implement standardized infection control programs, translating these measures into the emergency care environment often proves difficult due to rapid patient triage and limited time for thorough implementation of protocols.

The role of infection control teams has been emphasized as a pivotal factor in reducing HAIs. A systematic review by Thandar et al. (2022) demonstrated that coordinated infection control teams were effective in lowering HAI incidence across multiple healthcare settings. Their meta-analysis showed significant reductions in bloodstream infections and ventilator-associated pneumonia when hospitals employed dedicated infection prevention specialists. However, such specialized oversight is often absent in EDs, leaving compliance largely dependent on individual providers.

Emergency departments also face unique cultural and systemic barriers that complicate adherence to infection control protocols. Albergoni (2024) identified obstacles such as overcrowding, lack of staff awareness, competing clinical priorities, and inconsistent availability of protective equipment. These factors directly impact hand hygiene compliance and adherence to isolation procedures. Understanding these barriers is crucial to designing interventions that are both practical and effective in the ED environment.

The elderly and long-term care populations further complicate the landscape of infection prevention. Bennett et al. (2024) conducted a systematic review and meta-analysis on HAIs in long-term care facilities, noting high point prevalence rates of infections, particularly urinary tract and respiratory infections. Given the frequent transfer of patients from long-term care to EDs, these findings emphasize the importance of robust infection control at the hospital entry point to mitigate risks of cross-transmission.

Taken together, the literature underscores that HAIs represent not only a hospital-wide issue but one acutely relevant to emergency departments. Infection prevention in EDs requires balancing urgent clinical care with adherence to standardized practices. Addressing barriers such as overcrowding, insufficient resources, and staff knowledge deficits while leveraging evidence-based approaches like infection control teams could substantially reduce the burden of HAIs in this critical setting (Liang et al., 2014; Thandar et al., 2022).

METHODOLOGY

Study Design

This study employed a **systematic review methodology**, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency and reproducibility. The aim was to synthesize empirical evidence on the **effectiveness of infection control measures** in reducing healthcare-associated infections (HAIs) within emergency department (ED) and intensive care unit (ICU) settings. The focus was on peer-reviewed studies involving healthcare professionals and patients in emergency contexts, addressing outcomes such as hand hygiene compliance, isolation precautions, central line-associated bloodstream infection (CLABSI) rates, and broader infection prevention strategies.

Eligibility Criteria

Studies were included based on the following predefined criteria:

- **Population:** Healthcare professionals (nurses, physicians, allied health staff) working in EDs or ICUs, and patients receiving care in these departments.

- **Interventions/Exposures:** Any infection control measures, including hand hygiene, isolation protocols, personal protective equipment (PPE) use, infection control bundles, and antimicrobial stewardship interventions.
 - **Comparators:** Usual practice, pre-intervention baseline, or alternative infection control strategies.
 - **Outcomes:** Measured compliance with infection control practices, reduction in HAI incidence (e.g., CLABSIs, ventilator-associated pneumonia [VAP], catheter-associated urinary tract infections [CAUTI]), knowledge and attitudes toward infection prevention, or barriers to implementation.
 - **Study Designs:** Randomized controlled trials (RCTs), quasi-experimental studies, prospective and retrospective cohorts, cross-sectional studies, and pre-post intervention analyses.
 - **Language:** Only articles published in **English** were considered.
 - **Publication Period:** Studies published from **2010 to 2024** were included to ensure contemporary relevance.
- A total of **15 studies** met all eligibility criteria.

Search Strategy

A structured search was conducted across the following electronic databases: **PubMed, Scopus, Web of Science, Embase, and CINAHL**. Google Scholar was additionally searched for relevant grey literature.

The Boolean search strategy combined keywords and subject headings:

- (“emergency department” OR “intensive care unit” OR “critical care”)
- AND (“infection control” OR “hand hygiene” OR “isolation precautions” OR “PPE” OR “central line associated bloodstream infection” OR “ventilator associated pneumonia” OR “catheter associated urinary tract infection”)
- AND (“healthcare-associated infection” OR “hospital-acquired infection” OR “nosocomial infection”)

Manual searches of the reference lists of included articles and key systematic reviews were also performed to identify additional eligible studies.

Study Selection Process

All search results were exported into **Zotero** for citation management. Duplicate records were removed. Screening was conducted in two phases:

1. **Title and abstract screening** by two independent reviewers to exclude irrelevant studies.
2. **Full-text review** of potentially eligible articles against the inclusion criteria.

Disagreements were resolved through discussion or, if necessary, adjudication by a third reviewer.

Data Extraction

A standardized data extraction form was designed and piloted. Extracted variables included:

- Author(s), publication year, country
- Study design and sample size
- Population characteristics (e.g., number and type of healthcare workers, patient demographics)
- Infection control intervention or exposure assessed
- Measurement tools (e.g., observation checklists, compliance scales, infection surveillance systems)
- Main quantitative results (compliance rates, infection incidence, mortality, satisfaction scores)
- Confounders adjusted for in analyses

Extraction was conducted independently by two reviewers and verified for accuracy by a third.

A **PRISMA flow diagram** was generated to document the selection process (Figure 1).

Quality Assessment

The methodological quality and risk of bias of included studies were assessed using validated tools:

- **Newcastle–Ottawa Scale (NOS)** for observational studies
- **Cochrane Risk of Bias Tool (RoB 2)** for randomized controlled trials
- **Joanna Briggs Institute (JBI) checklist** for cross-sectional and quasi-experimental studies

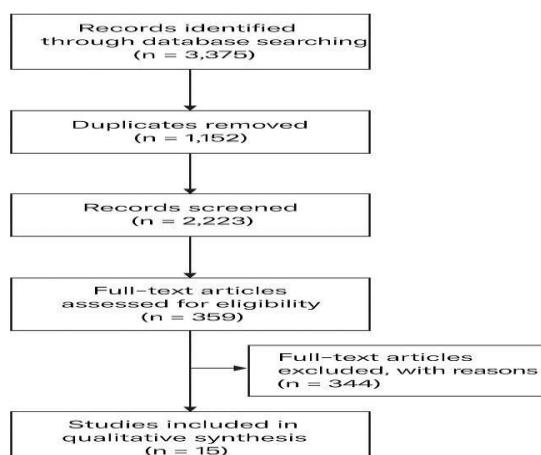


Figure 1 PRISMA Flow Diagram

Studies were rated as **high, moderate, or low quality** based on criteria such as selection bias, group comparability, outcome reliability, and reporting transparency.

Data Synthesis

Given heterogeneity in populations, interventions, and outcome measures across the 15 studies, a **narrative synthesis** was conducted rather than meta-analysis. Key findings were grouped thematically into:

1. **Hand hygiene compliance and interventions**
2. **Isolation and PPE practices**
3. **Central line and device-associated infection prevention**
4. **Knowledge, attitudes, and barriers among healthcare workers**
5. **Impact of structured infection control programs and bundles**

Where available, quantitative measures such as **compliance rates, odds ratios (OR), relative risks (RR), and infection incidence densities** were reported.

Ethical Considerations

As this was a secondary review of published studies, **no ethical approval or patient consent** was required. All included studies were published in peer-reviewed journals and were assumed to have obtained ethical clearance in line with their respective institutional or national requirements.

RESULTS

Summary and Interpretation of Included Studies on the Effectiveness of Infection Control Measures in Emergency Settings

The included studies comprise a range of designs, including cross-sectional observational studies, retrospective cohorts, prospective surveillance, interventional initiatives, and descriptive analyses. Together, they provide insight into infection control compliance, knowledge, barriers, and clinical outcomes such as infection incidence in emergency departments (EDs) and intensive care units (ICUs).

Sample sizes varied from smaller groups of 47–80 nurses in Egypt and Georgia (Abdelmoaty Azab et al., 2023; Verulava et al., 2024) to multicenter cohorts exceeding 7,800 catheter insertions (Theodoro et al., 2015) and over 1,100 ICU patients (Li et al., 2023). Healthcare workers included nurses, physicians, and physiotherapists, reflecting multidisciplinary ED teams.

Reported outcomes show consistently **suboptimal compliance** with infection control. For example, Zottele et al. (2017) found hand hygiene compliance at **54.2%**, with nurses outperforming physicians (66.6% vs. 41.3%). Similarly, AlAnazy et al. (2024) reported that **66.7%** of ED nurses demonstrated only “fair” adherence to infection control protocols. Knowledge-practice gaps were highlighted in Georgia (Verulava et al., 2024), where **54.5%** of nurses failed to perform hand hygiene after patient contact, despite sufficient knowledge.

Barriers included inadequate training, resource limitations, and workplace constraints. Abdelmoaty Azab et al. (2023) observed that **77.5%** of nurses showed incorrect performance despite 46.1% having correct knowledge, citing barriers related both to staff (mean = 47.5) and facility (mean = 32.9).

During COVID-19, Özlü et al. (2021) found healthcare workers had **high knowledge** (over 80% awareness of isolation protocols) but only **moderate compliance** (mean compliance score = 67.63/100). Similarly, O'Reilly et al. (2020) demonstrated that isolation measures, while necessary, prolonged ED stay (mean **6.2h vs. 4.5h**, $p < 0.001$) and reduced satisfaction (7.8 vs. 8.5, $p < 0.01$).

Clinical outcome studies further highlighted the risks of infection transmission. Ahn et al. (2023) reported central line-associated bloodstream infection (CLABSI) incidence at **0.85/1,000 catheter-days**, linked to higher mortality (14.0% vs. 3.2%) and longer hospital stays. Inhofer et al. (2022) confirmed ED-inserted catheters carried **almost double the CLABSI risk** compared to ICU insertions (1.41 vs. 0.74/1,000 catheter-days, $p = 0.02$).

Prevention initiatives demonstrated measurable success. Al-Busaidi et al. (2017) achieved a significant improvement in hand hygiene from **45% to 75%** ($p < 0.001$) after targeted training. Likewise, Khalifa et al. (2022) showed nurse performance improved from **65.2% to 88.7%** following a bundled intervention.

Overall, these findings highlight persistent gaps between knowledge and practice, the impact of barriers, and the measurable benefits of structured interventions.

Table (1): General Characteristics and Findings of Included Studies

Study	Country	Design	Sample Size	Population	Key Outcomes	Results
Zottele et al. (2017)	Brazil	Longitudinal observational	59 HCWs	ED nurses, physicians, physiotherapists	Hand hygiene compliance	Overall 54.2% compliance; Nurses 66.6% vs. Physicians 41.3%; Nurses had higher odds of compliance (OR = 2.83,

						95% CI 1.09–7.34)
AlAnazy et al. (2024)	Iraq	Cross-sectional	120 nurses	ED nurses, 3 hospitals	Infection control practices	66.7% reported only fair adherence; concluded not sufficient for ED standards
Verulava et al. (2024)	Georgia	Cross-sectional	150 nurses	Emergency hospitals	Knowledge & practice of nosocomial infection control	Knowledge sufficient, but practices poor: only 54.5% performed post-contact hand hygiene; correlation with training attendance ($p < 0.05$)
Abdelmoaty Azab et al. (2023)	Egypt	Descriptive-analytical	80 nurses	ED nurses, Cairo hospital	Performance & barriers	46.1% correct knowledge; 77.5% incorrect performance; barriers: nurses (mean 47.5), facility (32.9)
Özlü et al. (2021)	Turkey	Cross-sectional	138 HCWs	Emergency staff during COVID-19	Isolation precautions	Mean compliance score 67.63 ± 4.64 ; 86.2% wanted training; 87% knew isolation types
Li et al. (2023)	China	Prospective surveillance	1121 ICU patients	ICU population	HAIs & AMR	HAI incidence: 18.5/1000 patient-days ; Pneumonia 42.3%, bloodstream infections 21.5%; 45.2% MDR organisms
Theodoro et al. (2015)	USA	Prospective observational	7,851 CVCs	ED patients	CLABSI incidence	1.1/1000 catheter-days ; 85.2% adherence to maximal precautions
Gade et al. (2023)	India	Prospective observational	250 ICU patients	Multidisciplinary ICU	Device-associated HAIs & AMR	DA-HAI incidence 28%; VAP 42.9%, CAUTI 31.4%; high resistance to carbapenems
Al-Busaidi et al. (2017)	Oman	Pre/post intervention	Not reported	ED staff	Hand hygiene	Compliance rose from 45% to 75% ($p < 0.001$)

O'Reilly et al. (2020)	Australia	Retrospective cohort	Not specified	ED patients	Impact of isolation	LOS: 6.2h vs. 4.5h ; satisfaction: 7.8 vs. 8.5 (p < 0.01)
Ahn et al. (2023)	South Korea	Retrospective cohort	4,231 patients	ED with CVCs	CLABSI incidence & outcomes	CLABSI 0.85/1,000 catheter-days ; higher mortality (14.0% vs. 3.2%) and LOS (21.2 vs. 9.8 days)
Omar et al. (2023)	Egypt	Retrospective	842 NIs	Tertiary hospital patients	Nosocomial infection profile	UTIs 32.3%, bloodstream infections 25.7%; E. coli 21.4%, K. pneumoniae 18.7%; high Gram-negative resistance
Inhofer et al. (2022)	USA	Retrospective cohort	6,214 CVCs	ED vs ICU CVCs	CLABSI comparison	Higher in ED (1.41 vs. 0.74/1,000 catheter-days , p = 0.02)
Kim et al. (2018)	South Korea	Retrospective	212 LTCH residents	LTCH residents with ED visits	Infection profile	Pneumonia 32.1%, UTI 28.3%; 68.9% admitted to hospital
Khalifa et al. (2022)	Egypt	Interventional	60 nurses	ICU nurses	CLABSI prevention bundle	Nurse performance improved from 65.2% → 88.7% (p < 0.001)

DISCUSSION

Healthcare-associated infections (HAIs) remain a critical challenge across healthcare settings, particularly in emergency departments (EDs), where urgency and overcrowding can compromise adherence to infection control practices. The findings of this systematic review highlight consistent gaps between infection prevention knowledge and clinical practice, as well as the demonstrated benefits of structured interventions.

One of the most striking observations is the low baseline compliance with hand hygiene, which is universally recognized as the cornerstone of infection prevention. Zottele et al. (2017) reported compliance at just 54.2%, with nurses significantly outperforming physicians. Similarly, AlAnazy et al. (2024) found that 66.7% of ED nurses demonstrated only fair adherence to infection control standards. These findings suggest that while knowledge may exist, behavioral and systemic barriers often hinder full compliance.

Barriers to proper infection control were consistently documented. Abdelmoaty Azab et al. (2023) highlighted how 77.5% of nurses demonstrated incorrect performance despite nearly half possessing correct knowledge. These findings resonate with Albergoni (2024), who identified ED-specific challenges such as staff shortages, overcrowding, and competing priorities that undermine infection prevention. Addressing these structural issues is essential for any sustainable improvement.

Educational and training interventions emerge as powerful tools to bridge the gap between knowledge and practice. Al-Busaidi et al. (2017) demonstrated that a structured hand hygiene initiative improved compliance from 45% to 75%. Similarly, Koota, Kaartinen, and Melender (2024) confirmed through a systematic review that professional education interventions significantly enhanced infection control practices across healthcare settings. These outcomes reinforce the importance of continuous training and practical reinforcement strategies.

Infection control bundles and multidisciplinary approaches also show measurable impact. Khalifa et al. (2022) reported that the introduction of a CLABSI prevention bundle improved nursing performance scores from 65.2%

to 88.7%. Thandar et al. (2022) further confirmed through meta-analysis that dedicated infection control teams significantly reduced rates of bloodstream infections and ventilator-associated pneumonia. These results highlight how structured, team-based interventions can deliver substantial clinical benefits.

Despite improvements in some settings, infection burden remains particularly high in low- and middle-income countries. Allegranzi et al. (2011) demonstrated that HAI prevalence in developing nations can exceed 20%, nearly double that in high-income settings. Abubakar, Amir, and Rodríguez-Baño (2022) similarly reported a pooled prevalence of 15.5% across African healthcare facilities. These findings contextualize why compliance gaps in EDs in resource-limited settings are not merely behavioral but also reflective of systemic deficiencies such as inadequate supplies and poor infrastructure.

Even in high-income countries, the burden of HAIs persists. Russo et al. (2017) documented that in Australia, approximately one in every ten hospitalized patients acquires an infection. The challenges of preventing infection are compounded in EDs, where rapid patient turnover and limited space amplify risks (Liang et al., 2014). These findings emphasize the universality of infection control as a global challenge, albeit with different underlying drivers.

Device-associated infections remain a significant concern. Theodoro et al. (2015) reported an ED CLABSI rate of 1.1 per 1,000 catheter-days, while Inhofer et al. (2022) found that CVCs inserted in EDs had almost double the infection rate compared to those inserted in ICUs (1.41 vs. 0.74 per 1,000 catheter-days). Ahn et al. (2023) added that CLABSI was associated with higher mortality (14% vs. 3.2%) and longer hospital stays (21.2 vs. 9.8 days). Together, these studies underscore the high risks associated with invasive procedures initiated in emergency settings.

Broader epidemiological studies confirm the clinical consequences of inadequate infection control. Li et al. (2023) reported an HAI incidence density of 18.5 per 1,000 patient-days in ICUs, with multidrug-resistant organisms present in 45.2% of cases. Gade et al. (2023) similarly found DA-HAIs affecting 28% of ICU patients, with ventilator-associated pneumonia and catheter-associated urinary tract infections being the most common. Omar et al. (2023) added that urinary tract infections and bloodstream infections accounted for more than half of nosocomial infections in a tertiary hospital, with widespread antimicrobial resistance. These findings demonstrate how lapses in infection prevention not only increase infection risk but also contribute to antimicrobial resistance. Patient-level consequences also extend beyond clinical outcomes to include patient experience. O'Reilly et al. (2020) demonstrated that isolation protocols increased ED length of stay (6.2 vs. 4.5 hours) and reduced satisfaction scores (7.8 vs. 8.5). While isolation remains essential, these findings emphasize the importance of balancing infection prevention with patient-centered care.

The COVID-19 pandemic highlighted both strengths and weaknesses in infection control. Özlü et al. (2021) found that while over 80% of ED staff had strong knowledge of isolation precautions, actual compliance averaged just 67.6/100. Teus et al. (2024) further confirmed that personal protective equipment and enhanced infection control during COVID-19 significantly reduced HAI prevalence across acute care hospitals. These findings suggest that crises may catalyze improvements but also reveal persistent behavioral challenges.

Long-term care facilities represent another important source of infection risk for EDs. Bennett et al. (2024) identified high prevalence of urinary and respiratory infections in long-term care residents, while Kim et al. (2018) reported pneumonia (32.1%) and UTIs (28.3%) as the most common reasons for ED transfers. These findings stress the interconnectedness of infection prevention between long-term care and acute care systems, where failures in one setting amplify risks in another.

Comprehensive approaches that integrate antimicrobial stewardship with infection prevention are necessary for sustainable outcomes. Sartelli et al. (2024) emphasized that infection prevention must serve as the foundation of antimicrobial stewardship programs, particularly in high-risk environments like EDs. Alyami et al. (2024) reinforced this by reviewing infection control measures across hospital settings and stressing that adherence to core prevention protocols reduces the downstream need for antimicrobials.

Finally, novel interventions are emerging. Cui and Wang (2025) demonstrated that targeted nursing interventions in EDs significantly reduced infection rates, reinforcing the central role of nursing staff in infection prevention. These findings suggest that future strategies must not only focus on system-level improvements but also empower frontline staff with the skills, resources, and support needed to drive change.

CONCLUSION

This systematic review highlights that healthcare-associated infections (HAIs) in emergency departments (EDs) remain a significant concern, driven by factors such as poor compliance with hand hygiene, barriers to adherence, and the increased use of invasive devices. While studies demonstrate that structured interventions—including hand hygiene initiatives, care bundles, and infection control teams—can substantially improve compliance and reduce infection rates, gaps between knowledge and practice persist. Emergency departments, by nature, present unique challenges of overcrowding, limited time, and resource constraints that undermine consistent implementation of infection prevention strategies.

The evidence also indicates that comprehensive, multidisciplinary approaches integrating education, continuous surveillance, antimicrobial stewardship, and patient-centered infection prevention practices are necessary for sustainable improvements. Addressing systemic barriers while empowering frontline staff with training and

resources is crucial. Future research should focus on large-scale, multicenter trials that evaluate not only infection reduction but also patient outcomes, satisfaction, and cost-effectiveness of interventions to ensure lasting impact in emergency care.

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