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Exploring the Impact of Nurse-Led Early Intervention on Preventing Hospital-Acquired Infections in Intensive Care Units

Nouf Atieeg Aljohani[1], Hajar Bakr Baqri[2], Sanaa Muosa Bakr Hawsawi[2], Mohammad Ahmad Alzahrani[2], Afaf Ali Al-Ghamdi[2], Rua Ibrahim Bukhari[2], Reem Mohammed Alqarni[3], Fahad Mastour Althobaiti[4], Yasser Eid Al-Mohammadi[5], Alhan Ali Hashim Barubayq[6]

[1]Al-Noor Specialist Hospital, Burn ICU
[2]Al-Noor Specialist Hospital
[3]East Jeddah Hospital, Emergency Department (ER)
[4]Mina Al-Jisr Hospital
[5]Makkah Health Cluster, Infectious Diseases and Vector Control
[6]Executive Administration for the Control of Infectious Diseases and Disease Vectors

ABSTRACT

HAIs remain among the main sources of morbidity, mortality, extended length of stay, and increased cost in health care in ICUs. Nurses are important in the prevention of infection because they provide bedside care and handle the maintenance of invasive devices. This study aims to assess the impacts of early intervention by nurses in the prevention of HAIs in ICUs through the use of secondary research. The literature between 2020 and 2025 will be reviewed to identify practices that can reduce CLABSI, VAP, and CAUTI. Interventions by nurses, such as hand hygiene monitoring, infection prevention bundles, device removal bundles, educational interventions, oral care interventions, and nurse empowerment interventions are very significant in decreasing the infection rate. From various studies, it was found out that there were reductions in the rates of device-associated infections due to the implementation of nurse bundles and education intervention. Technology-enabled monitoring also improved the hand hygiene compliance rates and decreased infection rates. However, some barriers, including understaffing, workload, knowledge and organizational barriers, still continue to be barriers for the effective implementation of interventions. This literature review proposes that there should be proper education, audits, leadership, and patient safety culture in order to have successful outcomes.

Keywords:-Nurse, Infection, ICU, Hospital-Acquired Infections (HAIs), Prevention, Compliance, Education, Care Bundles, Hand Hygiene, Catheter-Associated Urinary Tract Infection (CAUTI).

1. INTRODUCTION

Hospital acquired infections have remained an important threat to patient safety in the intensive care units of many countries around the world. The results of the study known as EPIC III carried out in 88 different countries revealed that 54% of patients admitted in hospitals were infected or suspected of having infections (Vincent et al., 2020). Out of these patients with infections, 22% had ICU acquired infections and 30% of patients had died (Vincent et al., 2020). Notably, 65% of the infected patients had a positive microbiological culture (Vincent et al., 2020). Healthcare associated infections impact 7% to 10% of all patients admitted in hospitals, while in ICUs, this figure increases to 30% (Mazzeffi et al., 2021). Infection rates in ICUs are 2 to 20 times greater in the low and middle-income countries (Teixeira et al., 2025). The infections lead to increased mortality, stay duration, and costs of health care services (Todo Bom et al., 2025).

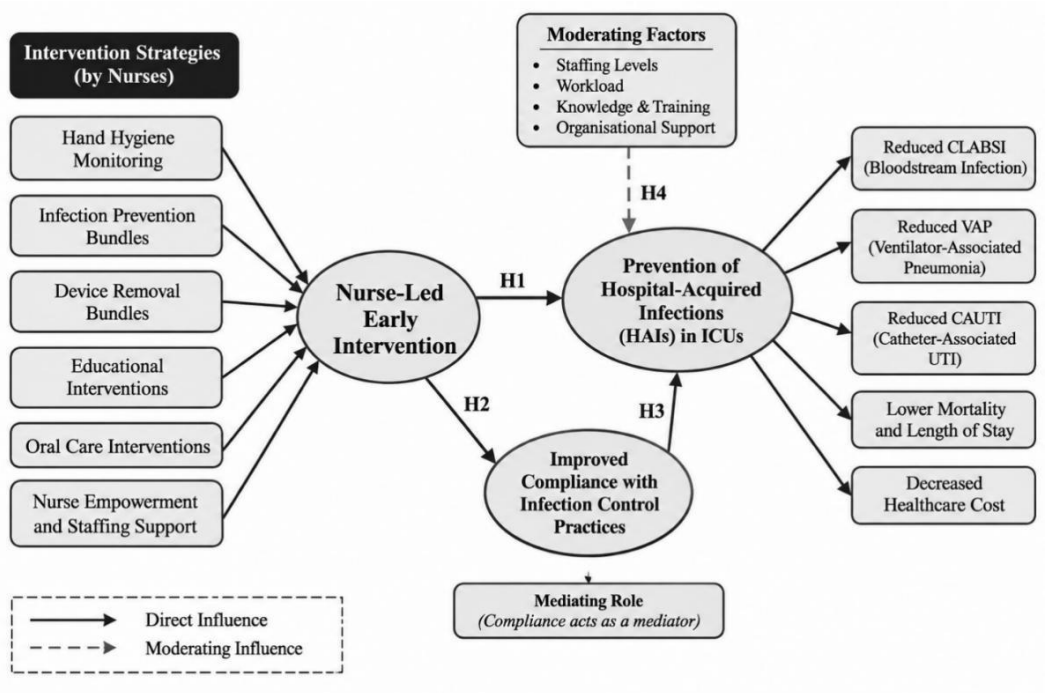
Hand washing practices have been found to be associated with a reduction of up to 40% in infections (Todo Bom et al., 2025). According to a systematic review done by Teixeira et al. (2025), nurse-led interventions have been found for bloodstream infections, ventilator-associated pneumonia, and urinary catheter infections. It was found out that there is a gap between the infection-prevention strategies suggested and the actual situation on the ground (Teixeira et al., 2025). Neonatal ICU line bundle strategy has been found to reduce bloodstream infections from 29.1 to 2.2 per 1,000 catheter days (Sala et al., 2025). Thandar et al. (2022) explored infection control teams with a link nurse system through randomized trials. In all the studies that they used, there was a high risk of bias. Consequently, there is need for stronger evidence in infection control in intensive care settings. There is not enough evidence about nurse-led

early intervention in intensive care units. Through nurse-led intervention, the infection chain may be interrupted before the infection becomes apparent in a critical care setting. This study aims to explore the effects of nurse-led early intervention on preventing hospital-acquired infections in the intensive care unit

2. RELATED WORK

The nurse always avoids infection, and scientific studies reveal the effect of their skill level on outcomes. According to Rae et al. (2021), the inverse correlation between ICU nurse staffing and infection probability was established. Infection probability varied from 3.28 to 3.60 times. This can be linked to the issue of the nurse's inability to focus, as every missed action impacts hygiene, equipment, and monitoring. Alanazi et al. (2023) performed the survey among 314 nurses from 8 ICUs and found that infection increased due to increased workload. Nurses' missed actions were quite common; 73.11% of nurses missed at least one action (Almenyan et al. 2021). Elmdni (2025) states that 20 studies have proven the effectiveness of staffing which results in the decrease of infection control efforts up to 20%. Nonetheless, only staffing is not sufficient as nurses' compliance with infection control strategies on the bedside should be ensured. Work environment barrier was found by Al-Tamimi et al. (2023) to be the main obstacle in nurses' compliance with VAP guidelines. In Bangladesh, well-educated nurses who have used a VAP bundle in treatment of 347 patients have reduced the frequency of developing VAP (Akhter et al., 2025). Consequently, education turns knowledge into actions and provides safety for critically ill patients. Catheter removal protocol conducted by nurses has also been considered an efficient approach, which is supported by 11 out of 13 studies conducted by Jones et al. (2023) and proving the low rate of infections. Despite the low evidence level, policy makers need to invest in staffing, education and nurses' authority for early interventions (Jones et al., 2023).

Conceptual Framework



3. METHOD

Proposed research project uses secondary research approach that is grounded on literature review on nurse-led early interventions in intensive care units. This methodology is relevant to the topic since performing primary studies on the problem of infection prevention is rather a costly and long process that raises ethical questions. Given the prevalence of ICU infections, there is plenty of information that can be synthesized. Moreover, it is possible to identify patterns between different ICUs and not only one particular ICU. Using secondary research, it is possible to analyze different interventions, including bundles, hand hygiene, and catheter removal protocols in different countries. According to Teixeira et al. (2025), synthesis of the best evidence will assist in the creation of the latest guidelines. Moreover, it will be cost and time-

efficient and provide reproducibility in the selection of sources. Studies between 2020 and 2025 will be selected according to PRISMA principles and analyzed narratively.

4. RESULTS

Persistent Burden of Device Infections in Indian ICUs

However, the findings of the surveillance in ICU from India on the issue of infection reveal the presence of a considerable burden of infection. The surveillance carried out in 8 ICUs, in which there were 121,051 patient days, resulted in 832 cases of infections, with incidence being 6.9%. Lohiya & Deotale (2023) also revealed the device rates of 10.6 and 13.4 per 1,000 device days for CLABSI and possible VAP, respectively

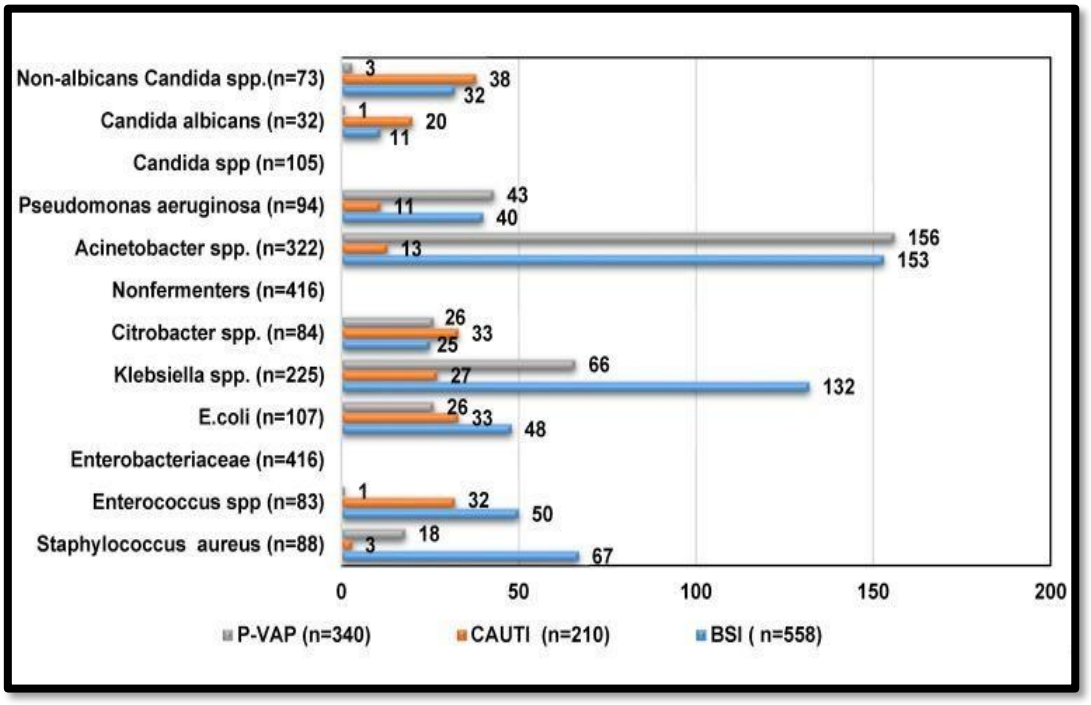


Figure 1: Distribution of HAI pathogens in the ICUs (n=1,108).

(Source: Lohiya & Deotale, 2023)

As for CAUTI, it was less frequent and was equal to 2.1 per 1,000 device days. However, such a rate requires special attention of nurses. Nurses had to visit the patients in their beds and obtain necessary data for surveillance. The rate of 12, 9.8, and 8.5 per 1,000 catheter days for VAP, CLABSI, and CAUTI, respectively, was observed by Mathur et al. (2021).

Hand Hygiene Compliance and Monitoring Technology

Hand washing is regarded as the best technique of avoiding infections (Clancy et al., 2021). Clancy et al. (2021) indicated that there were 332 articles; 57 articles were included in the review with a period ranging from 2014 to 2020; 36 articles had the World Health Organization multimodal strategy or similar techniques. The single and multimodal intervention improved the compliance of healthcare workers at moderate levels. Zhang et al. (2023) reviewed 36 articles where the compliance was increased by a risk ratio of 1.56 through the use of intelligent technology, and the healthcare associated infections were reduced by a risk ratio of 0.25 through intelligent technology. Reminder, electronic counting, feedback, and education were the functions of these technologies. However, the evidence is not robust since 34 out of 36 articles have quasi experimental design. ICU nurses are advised to combine regular observation with reminders, feedback, and technological monitoring.

Nurse Compliance in CLABSI Prevention

Line care is a dependent nursing procedure; hence, any lack of compliance will inevitably result in the development of bloodstream infections. According to the findings of Alqalah's (2024) study, 470 intensive

care nurses working in eight hospitals in Sana'a, Yemen, had poor knowledge of preventive guidelines even though the level of compliance was acceptable. The main factors that predicted compliance in the neural network model were knowledge and barriers

		Knowledge (5.3 ± 1.6)	Compliance (12.5 ± 3.4)	Attitude (21.1 ± 3.1)	Barriers (38.4 ± 9.9)
Knowledge	Pearson Correlation	1			
	Sig. (2-tailed)				
Compliance	Pearson Correlation	.781[b]	1		
	Sig. (2-tailed)	<.001			
Attitude	Pearson Correlation	.868[b]	.784[b]	1	
	Sig. (2-tailed)	.000	.000		
Barriers	Pearson Correlation	-.639[b]	-.861[b]	-.610[b]	1
	Sig. (2-tailed)	<.001	<.001	<.001	

Figure 2: Correlation matrix between critical care nurses' knowledge, compliance, attitudes, and barriers (n = 470)

(Source: Alqalah's, 2024)

Knowledge and attitude were positively associated with compliance while barriers negatively affected both knowledge and compliance. In the study by Bijarania et al. (2025), which aimed to evaluate the effect of using a multimedia-based approach on line care in the cardiac surgery intensive care unit of Chandigarh, India, the authors observed 6,043 ventilator procedures and 1,957 central lines practices before and after an intervention. There was an increase in the compliance with 11 ventilator procedures and 2 central lines procedures including chlorhexidine baths and hub scrubbing. Thus, increasing knowledge and visibility of reminders could prevent CLABSIs.

Ventilator Care Bundles Reduce VAP

It has been shown that ventilator care bundles belong to the most researched nurse-led interventions which target prevention of VAPs. Martinez-Reviejo et al. (2023) performed a meta-analysis which included 36 papers and 116,873 patients on mechanical ventilation. The authors concluded that care bundles decreased the risk of development of VAP; the odds ratio was 0.42 and 95% confidence interval was 0.33-0.54. Furthermore, care bundles reduced the length of mechanical ventilation but not mortality rates which were still unclear. A combination of care bundles and educational interventions appears to be more effective in the pooled analysis. Mastrogianni et al. (2023) performed a review of 38 pre-post papers focused on the usage of care bundles in adult ICUs. The most common elements of care bundles include sedation and weaning protocols, semi-recumbent position, oral hygiene and hand hygiene. There is considerable diversity of care bundle elements because there is no internationally recognized care bundle. The role of nurses in these care bundles involves positioning, oral care and cuff pressures.

Nurse Empowerment and Bundles Reduce CAUTI

The CAUTI can be easily prevented through limiting catheter days and adherence to strict aseptic technique. According to Gupta et al. (2023), in the cardiac ICU, the automatic stop order regarding catheters was delegated to the nurses. In addition, insertion and maintenance bundles were done through monthly audits and compliance feedback.

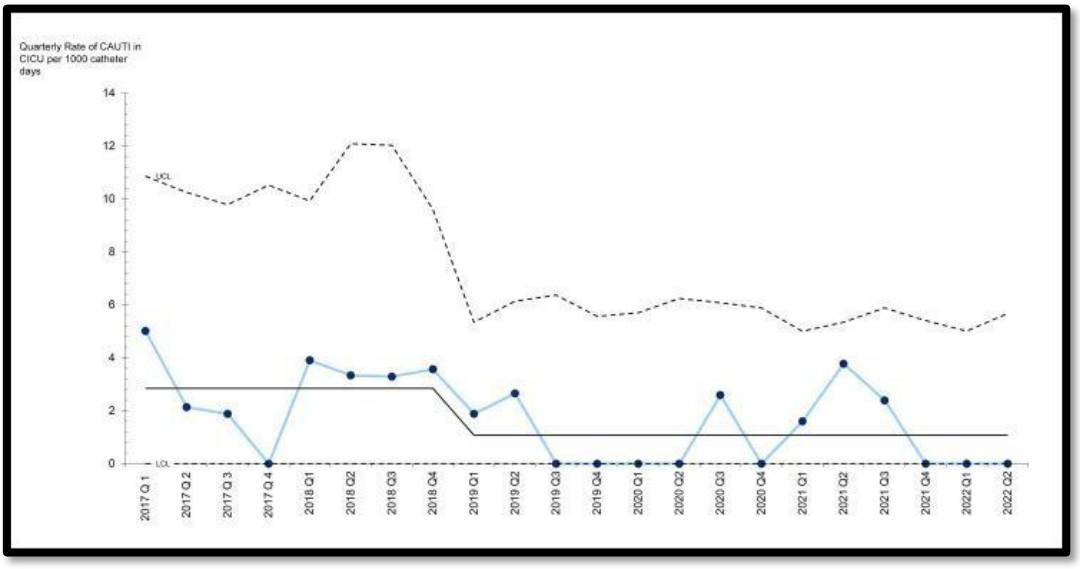


Figure 3: U chart—quarterly rate of CAUTI in CICU per 1000 catheter days. CAUTI, catheter-associated urinary tract infection; CICU, coronary intensive care unit.

(Source: Gupta et al. 2023)

The number of CAUTIs was reduced from 7.6 per 1,000 catheter days in January 2017 to zero by October 2021. Moreover, the ICU did not have any CAUTI for 280 consecutive days up to August 2022. In the case of Shadle et al. (2021), a bundle-based strategy was applied in an intensive care unit. The hospital reported 13 infections in 2018 which were more than its benchmark of 4 infections or less. No infection occurred in the process of implementation while the documentation compliance was raised from 50.0% to 83.3%. In addition, the catheter days were increased by 10.5%, which was insignificant; hence, the intervention must have contributed through better care practices.

Structured Education Improves Nurse Competence

Knowledge attained in the guidelines is converted to safe practices in the ward through education of the nurses. Nevertheless, the outcomes that have been recorded from the education programs have been inconsistent. Gupta et al. (2025) conducted a 3 month education program among 30 nurses where their performances were compared with those of other 30 nurses who did not undergo the program. The results showed an increase in the performance of the nurses who had undergone the program in terms of knowledge, attitude and practices with moderate to large effect size ($p<0.05$). All the subjects in this research were nurses working in the medical, surgical, neonatal and trauma ICUs in five tertiary hospitals in Uttar Pradesh, India. Elsheikh et al. (2025) carried out an education program among 106 health workers who included 84 nurses for two months in an Egyptian ICU. The mean knowledge score increased from 76.93% to 82.29% following the education program ($p=0.0112$). In addition, the program improved the compliance with infection control practices in the ICU, thus promoting sustainable ICU infection control.

Oral Care Education and VAP Outcomes

Oral care is an important aspect of VAP prevention; nevertheless, compliance among ICU nurses is low (Li & Wang, 2024). As it was found in the comparison of a micro course and standard oral care training done by Li and Wang (2024), both methods raised the level of compliance, although the latter managed to do it faster and more effectively. To be precise, during the third follow-up after training, the mean level of compliance increased by 0.281 ($p = 0.032$). As it was seen in the study of 60 ICU nursing staff trained for 12 weeks in Colombia by Sánchez Peña et al. (2021), the frequency of conducting oral care for patients raised from 29.6% to 92.8%. Also, VAP occurrence decreased from 8.9% to 2.8%, or from 9 to 3.5 per 1,000 intubation days. However, none of the changes were statistically significant.

Implementation Barriers and Sustainability

From the literature, the bundles and training are effective under supportive implementation conditions for the nurses. As per Goldman et al. (2021), 74 individuals were interviewed, and 50 hours of

observation was carried out across 3 clinical units. The perceptions about the bundle as a priority of quality were different based on individuals' role and unit. The nursing leaders had concerns about CLABSI being just another priority among other excessive priorities of improvements. The initial phase of implementation process was focused on education by nurses at the unit level, and the auditing varied as per people's individual approach. The transition from central to unit level in implementing the strategies explains the success in this case. According to the study conducted by Kakkar et al. (2021), one educational module related to infection control was implemented for 105 nurses. The knowledge and attitudes of the nurses improved; however, there was no change in practice and hospital-acquired infections.

5. DISCUSSION

In the light of this review, the results suggest that an early intervention approach by nurses is an important factor in decreasing hospital-acquired infections in intensive care units. As seen in the studies analyzed, infections associated with medical device utilization like CLABSI, VAP, and CAUTI remained a concern despite having infection prevention guidelines. Infection prevalence in Indian ICU settings because of prolonged utilization of the medical devices was a factor that highlighted the importance of nursing monitoring, early assessment, and removal of the devices. This is similar to what has been found in past literature where continuous bedside monitoring by nurses becomes vital for breaking infection transmission processes before it becomes complicated.

Hand hygiene became one of the most effective preventive measures but with low adherence. It was evident from the results that a combination of multimodal approaches like education, reminder, feedback, and technological monitoring increased hand hygiene adherence. Thus, it could be suggested that knowledge alone was not enough but needs to be combined with continuous monitoring and behavioral changes. Likewise, CLABSI patients showed that nurses who possessed higher knowledge and positive attitudes towards infection control practices had compliance.

Furthermore, the review found strong literature support for care bundles for ventilators and catheters. Though care bundles for preventing VAP have been found associated with significant reduction in the frequency of pneumonia, nurse-led catheter management interventions were shown to result in significant reduction in CAUTI frequency, with long periods of time with no cases of infection being reported. In addition, educational interventions improved infection prevention by modifying nurses' knowledge, attitude, and practices. Focused and short educational interventions on oral care were found associated with increased compliance and reduction in VAP frequency.

However, there are still certain challenges in the implementation of the above-described interventions. The overload of nurses, shortage of staff, conflicting priorities, and lack of continuous support from the leadership often prevented the sustainability of interventions. Moreover, according to several studies, the single education session had only a temporary effect, thus, continuous improvement was necessary and could be achieved through audits and coaching, among other methods. Hence, in summary, the reviewed evidence base indicates that the implementation of nurses-led intervention should involve the integration of several elements.

6. CONCLUSION

HAI still ranks among the greatest issues in ICUs as it causes morbidity and mortality, high expenses, and extended hospitalization periods. In this paper, the significance of nurse-led early interventions in preventing CLABSI, VAP, and CAUTI is revealed. There are several methods mentioned, including the necessity to adhere to the hand hygiene guidelines, using infection prevention bundles, training, device removal policy, compliance monitoring, and empowering nurses' programs. As it can be seen from the literature review, using these interventions is not only helpful in achieving the infection control practices adherence but also helps prevent the infections. Nevertheless, it should be stressed that there are several factors which influence the success of these interventions, such as adequate staffing, good leadership, proper education, auditing and, most importantly, a strong safety culture. The issues associated with the workload and other organizational barriers should be solved in order to enhance the efficacy of the interventions

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