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The Effectiveness Of An Educational Intervention On Nursing Staff And Nursing Technicians' Practices Toward The Prevention Of Health Care–Associated Infections In Critical Care Unit

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ABSTRACT

Background: HCAIs remain one of the biggest challenges facing critical care units in terms of increased mortality and high healthcare and morbidity cost. Nursing staff can play a vital role in infection prevention; however, there are still a number of knowledge gaps and inconsistencies in adhering to evidence-based practice.
The aim of this study, therefore, will be to establish whether a structured educational intervention can affect the practices of nursing staff in relation to the prevention of HCAI within a critical care unit.
Methods: A quasi-experimental pre-test/post-test design was used that included a sample of 110 nursing personnel (68 registered nurses and 42 nursing technicians) caring for patients in the medical-surgical intensive care unit. Data collection was through a validated knowledge assessment tool and observational checklist at baseline, immediately post-intervention, and at 3-month follow-up. HCAI rates were also monitored across the study period.
Results: Significant improvements were seen in nursing knowledge scores: pre-intervention, 60.1 ± 9.4; post-intervention, 82.3 ± 7.1; $p < 0.001$. Knowledge gains were consistent across both professional roles. Observed compliance with infection prevention practices increased from 54.2% to 87.5% ($p < 0.001$). At 3-month follow-up, knowledge retention remained high: 82.1 ± 7.4, and practice compliance sustained at 83.4%. HCAI incidence decreased from 12.4 to 6.8 per 1,000 patient-days ($p = 0.002$).
Conclusions: A structured educational intervention significantly improved nursing knowledge and compliance with HCAI prevention practices in critical care settings. These improvements in knowledge and practice were sustained at 3-month follow-up and were associated with infection reduction. Regular targeted education should be included in ongoing quality improvement activities within intensive care units.

Keywords: health care–associated infections, nursing education, critical care, infection prevention, hand hygiene, patient safety

INTRODUCTION

Health care-associated infections rank among the most important patient safety issues in contemporary healthcare facilities worldwide. These infections are acquired during the course of receiving treatment and affect millions of patients every year throughout the world, thereby increasing the morbidity, mortality, and economic expenditure of the patients to a large extent. Critical care units record a disproportionately high incidence of such infections because of the presence of invasive devices, immune compromised patients, frequent use of antimicrobials, and complexity associated with care.

The Centers for Disease Control and Prevention estimate that there are around 1.7 million HCAIs in the United States annually, causing approximately 99,000 deaths and excess healthcare costs of more than $28 billion. In ICUs, it is estimated that the incidence of HCAI is 5 to 10 times higher compared with general medical-surgical wards. The main device-associated infections include central line-associated bloodstream infections, catheter-associated UTIs, and ventilator-associated pneumonia.

Nurses are the first line of defense against HCAI because they provide care to patients constantly and conduct so many procedures that tend to either reduce or increase the possibility of infection (Mitchell et al., 2019). While evidence-based practices for infection prevention are available, several studies still show poor knowledge among nurses and inappropriate implementation of recommended practices (Abad et al., 2020). Factors that contribute to gaps in knowledge include previous training that was incomplete, a lack of refresher courses, high demands related to workload, and organizational barriers (Graveto et al., 2018).

Therefore, educational interventions have emerged as the core strategy for improving infection prevention practices among healthcare workers (Burnett, 2020). Evidence on optimal design, methods of delivery, and how best to ensure the sustainability of such interventions is incomplete. Although previous studies have shown short-term improvement in knowledge and behaviors in response to such education, long-term retention and possible impact on infection rates in the ICU remain poorly documented (Valim et al., 2019).

A further explanation of how educational interventions can facilitate change in nursing practices is the Theory of Planned Behaviour by Ajzen (1991). The theory postulates that the intention to perform a certain behavior is usually determined by attitude, subjective norms, and perceived behavioral control. Therefore, educational interventions should be effective in bringing about continued behavior change through enhancement of knowledge, instillation of positive attitudes, establishment of supportive norms, and building confidence among individuals (Sax et al., 2020).

Purpose and Research Questions

This study was designed to establish the efficacy of a comprehensive multimodal educational intervention on nursing staff practices concerning the prevention of HCAI in a critical care unit. The study aimed at answering the following research questions:

1. What is the impact of an educational intervention on nursing staff knowledge in terms of HCAI prevention practices?
2. What is the impact of an educational intervention on the compliance of nursing staff to best practice in infection prevention?
3. Do the improvements in knowledge and practices persist at the 3-month follow-up?
4. How does the educational intervention affect the incidence rates of HCAI in the critical care unit?

LITERATURE REVIEW

Burden of Health Care–Associated Infections in Critical Care

Health care-associated infections cause a high burden among patients, health systems, and society. About 30% of patients, especially in the ICU setting, develop at least one HCAI during the admission period. The most frequent types of infection include bloodstream infections, pneumonia, urinary tract infections, and surgical site infections, many of which are associated with invasive devices. These different types of infection extend the stay of the patient in the hospital, extend hospitalization by an average of 10-15 days, increase antibiotic use and increase healthcare costs, adding approximately $35,000-$45,000 extra per episode, and result in mortality rates up to 25% in severe cases.

This concern for the microbiology of HCAIs in ICUs has evolved because there is a continued increase in the prevalence of MDROs such as MRSA, VRE, and CRE (Antimicrobial Resistance Collaborators, 2022). These pathogens not only complicate treatment but also enhance the transmission risks in the environment of an ICU.

Evidence-Based Practices for Prevention of HCAI

The evidence to prove that some interventions are effective in reducing HCAIs is strong. Appropriate hand hygiene remains the single most important measure to prevent the spread of pathogens; however, compliance rates among healthcare workers are generally poor, ranging between 40-60% in most settings (Lotfinejad et al., 2020).) World Health Organization's "Five Moments for Hand Hygiene" is a conceptual framework for appropriate hand hygiene practice (WHO, 2021).

These bundling strategies have been very successful in reducing device-associated infections because they compiled multiple evidence-based practices into one bundle. According to Buetti et al. (2022), many studies have reported that central line insertion bundles that include maximum sterile barrier precautions, chlorhexidine skin antisepsis, optimal catheter site selection, and daily review of the necessity of the line reduce the rates of CLABSI by 40-70%.

Others are appropriate use of personal protective equipment, aseptic technique in invasive procedures, cleaning and disinfection of the environment, and antimicrobial stewardship. Substantial variability in knowledge and adherence among nursing staff regarding these practices is noted.

Educational Interventions in Infection Prevention

Educational interventions, therefore, are one of the cornerstones of infection prevention programs. Education programs, in a systematic review by Gould et al. (2017), were noted to enhance knowledge and compliance with infection control practices among healthcare workers, having moderate-to-large effect sizes. Interventions incorporating multiple teaching modalities-such as didactic lectures, hands-on demonstrations, and simulation training, including feedback mechanisms-yield the best outcomes.

Multimodal strategies tend to be more effective than single-intervention approaches. Education in combination with performance feedback, reminders, and administrative support has been shown by Luangasanatip et al., 2015 to sustain improvement in compliance with hand hygiene. Abbate et al. (2019) also found that interactive educational sessions coupled with audit and feedback yielded better results compared to education alone.

Timing of, and repetition of, educational interventions: it was demonstrated that short, frequent sessions were more effective than those that were long and infrequent (Powers et al., 2020). Secondly, just-in-time training—delivering education immediately prior to practical application—enhances the transfer of knowledge to clinical practice (Chopra et al., 2020).

Gaps in Current Knowledge

Despite accumulating evidence to support such educational interventions, there are a number of gaps in the literature. First, few have examined whether knowledge and behavior change are sustained beyond 1-2 months after an intervention. Second, there has been inconsistent evidence in the literature that improved nursing and nursing Technicians' practices translate into reductions in the rates of HCAI. Third, there is a need for further exploration of the influence of contextual factors such as unit culture, staffing levels, and organizational support on the effectiveness of interventions.

METHODS

Design

This was a quasi-experimental design involving one group with a 3-month follow-up in regard to the effectiveness of an educational intervention on the practice of integrated nursing team and in relation to preventing HAIs in the critical care unit. The study was approved by the institutional review board and the participants signed written informed consent.

Setting and Sample

The setting is a 24-bed medical-surgical intensive care unit within a 600-bed, tertiary care academic medical center in the Northeastern United States. This unit cares for a diverse population of critically ill patients with complex medical diagnoses requiring mechanical ventilation, hemodynamic monitoring, and multiple invasive devices.

Sample: The sample included a convenience sample of 110 nursing personnel was recruited, consisting of:

- **Registered Nurses (RNs):**n=68 (Responsible for clinical management and invasive device monitoring).
- **Nursing Technicians:**n=42 (Responsible for direct bedside care, patient hygiene, and environmental maintenance).

Inclusion Criteria: 1. Currently employed as an RN or Nursing Technician in the study ICU for at least 6 months.
2. Providing direct patient care.
3. Willingness to participate in all three phases of the study.

The exclusion criteria included the following: (a) nurses who would be on extended leave during the intervention period; (b) temporary or float staff; and (c) nurse managers or educators whose primary role does not include direct patient care.

Educational Intervention
It involved the creation of the educational intervention based on CDC guidelines, the WHO Multimodal Hand Hygiene Improvement Strategy, and literature on infection prevention in critical care (CDC, 2019; WHO, 2021). The intervention was designed as four 90-minute sessions, once a week for one month.
The "Infection-Free ICU" program was developed based on CDC and WHO guidelines. To ensure effectiveness across different educational backgrounds, the content was modularized:

- **For RNs:** Focused on device bundles (CLABSI/CAUTI/VAP), sterile techniques, and clinical surveillance.
- **For Technicians:** Focused on high-touch surface disinfection, proper PPE sequences (donning/doffing), and the "Five Moments for Hand Hygiene" during bedside care.

Structure:
Session 1: Hand Hygiene Basics
• WHO Five Moments for Hand Hygiene
Session 2: Aseptic Techniques and Device Care
• Principles of aseptic technique
Session 3: Personal Protective Equipment and Isolation Precautions
•Donning and doffing procedures
• Managing patients with MDROs
Session 4: Environmental Cleaning and Emerging Issues
• High-touch surface disinfection
• Emerging pathogens and infections

Data Collection Instruments
A 40-item multiple-choice questionnaire (validated by expert review, CVI = 0.91) adapted from previously validated tools of Al-Rawajfah et al. (2019) and Moureau et al. (2017) updated to reflect current guidelines from the CDC. The content validity was established by expert review by three infection preventionists and two critical care nurse specialists, with a Content Validity Index of 0.91. The internal consistency reliability was ensured by Cronbach's alpha, which was 0.87.
Observational Compliance Checklist: A 25-item observational checklist (inter-rater reliability k = 0.89) that rated nursing compliance with infection prevention practices during routine care activities. The checklist assessed behaviors of hand hygiene, aseptic technique, PPE use, and device maintenance. Items were classified as either compliant or non-compliant. Adaptation of the WHO Hand Hygiene Observation Tool and other prior reliable observational tools (WHO, 2021). Inter-rater reliability was obtained at 0.89 (Cohen's kappa) by employing simultaneous observation by two trained observers.
Surveillance data on HCAI were provided from the Infection Prevention and Control department based on prospective surveillance using definitions and methodology of the National Healthcare Safety Network, or NHSN (CDC, 2023). Rates of CLABSI, CAUTI and VAP as well as overall rates for HCAI in the form of total number of infections per 1,000 patient-days were included in the data.

Procedure

Baseline Measurement (Week 0): All nurses participating in the study completed the knowledge assessment questionnaire. Trained observers conducted direct observations of nursing practices in patient care activities. Each nurse was observed for a minimum period of 60 minutes across multiple interactions in care. The baseline data on HCAI were collected for the past 3 months.

The intervention phase consisted of weekly educational sessions from weeks 1 through 4. Several sessions were held each week to accommodate all shifts so that all participants could attend. Attendance was mandatory and supported by nursing administration through protected time and backfill staffing.

One week after completion of all educational sessions, all participants repeated the knowledge assessment (immediate post-intervention evaluation at week 5). The observational measurements of the practice compliance were also repeated using the same method as that at baseline.

Follow-up Measurement (Week 17): Three months post-intervention, the participants took the knowledge test for the third time and practice observations were repeated. The HCAI surveillance data were collected for the 3-month follow-up period.

Data Analysis

Analyses were performed using SPSS version 28.0. In addition to descriptive statistics, independent t-tests were used to compare baseline knowledge between RNs and Technicians. Repeated measures ANOVA was utilized to track the improvement and retention rates for both groups across the three time points (Baseline, Week 5, and Week 17). HCAI incidence rates were calculated as infections per 1,000 patient-days and analyzed via Chi-square.

RESULTS

Sample Characteristics

A total of 110 nursing personnel participated in the study, consisting of 68 registered nurses (RNs) and 42 nursing technicians. The sample was characterized by a 100% retention rate across all assessment points. The majority of participants (87.2%) were female with a mean age of 31.4 years (SD = 7.2). RNs had significantly more ICU experience (6.4 \pm 4.2 years) compared to technicians (4.1 pm 3.5 years, $p = 0.003$). Baseline training was limited, with 68.2% of the total sample reporting that their only prior infection prevention training was during initial hospital orientation.

Research Question 1: Impact on Staff Knowledge

Knowledge scores improved significantly for both professional groups (Table 1). While RNs maintained higher absolute scores, Nursing Technicians demonstrated a larger relative percentage increase from baseline to post-intervention (41.1% increase for technicians vs. 35.7% for RNs).

Research Question 1: Impact on Nursing Knowledge

Table 1 presents the means and standard deviations of knowledge scores at baseline, immediately post-intervention, and at 3-month follow-up. The knowledge scores increased significantly from baseline to immediate post-intervention, rising from M = 62.4%, SD = 8.3, to M = 84.7%, SD = 6.2, $t(67) = 18.42$, $p < 0.001$, Cohen's d = 2.98. This represents a 35.7% increase in the knowledge scores.

The mean knowledge scores at the 3-month follow-up were significantly higher than baseline, M = 82.1%, SD = 7.4, $t(67) = 16.28$, $p < 0.001$, Cohen's d = 2.64, though somewhat lower compared to immediate post-intervention, $t(67) = 2.31$, $p = 0.024$, Cohen's d = 0.37. This slight decline from immediate post-intervention to follow-up would indicate minor knowledge attrition but overall retention.

Table 1: Comparison of Knowledge Scores (%) Between RNs and Technicians

Professional Role	Baseline (Mean ± SD)	Post-Intervention	3-Month Follow-Up	p-value*
Registered Nurses (n=68)	62.4 ± 8.3	84.7 ± 6.2	82.1 ± 7.4	< .001
Nursing Technicians (n=42)	56.4 ± 10.2	79.6 ± 8.1	77.2 ± 8.5	< .001
Total Sample (N=110)	60.1 ± 9.4	82.3 ± 7.1	80.2 ± 7.9	< .001

Note. M = mean; SD = standard deviation; CI = confidence interval. *Comparisons with baseline.

Research Question 2: Compliance with Infection Prevention Practices

Overall compliance with infection prevention practices increased significantly from a baseline of 54.2% to 87.5% post-intervention for the combined team ($p < 0.001$).

Table 2: Practice Compliance Rates by Category and Role

Practice Category	Baseline (%)	Post-Intervention (%)	3-Month Follow-Up (%)
Hand Hygiene (All Staff)	49.8%	90.2%	86.4%
- Registered Nurses	55.9%	94.1%	91.2%
- Nursing Technicians	41.2%	85.3%	81.0%
PPE Use (All Staff)	67.5%	94.1%	90.4%
Device Care (RNs primarily)	62.4%	91.8%	88.2%
Env. Cleaning (Techs primarily)	54.4%	85.3%	79.4%

Note. PPE = personal protective equipment

Research Question 3: Sustainability and Retention

Retention rates at 3 months were high across both groups. Subgroup analysis revealed no significant difference in knowledge retention between RNs (88.3%) and Technicians (86.1%, $p = 0.45$). This suggests that the multimodal intervention was equally effective in cementing long-term behavioral changes across different educational levels.

Research Question 4: Impact on HCAI Rates

Following the inclusion of technicians in the training, the overall HCAI incidence decreased by 45.2%, falling from 12.4 to 6.8 per 1,000 patient-days ($p = 0.002$). Notably, CLABSI and CAUTI rates (which involve both device maintenance by RNs and hygiene care by Technicians) showed the most dramatic reductions.

Table 3: Retention of Knowledge and Practice Improvements at 3-Month Follow-Up ($N = 110$)

Outcome Measure	Improvement* (%)	Retained** (%)	Retention Rate (%)
Overall Knowledge Score	22.2%	19.8%	89.2%
- Registered Nurses (n=68)	22.3%	19.7%	88.3%
- Nursing Technicians (n=42)	23.2%	20.8%	89.6%
Overall Practice Compliance	33.3%	29.2%	87.7%
- Registered Nurses (n=68)	31.3%	26.9%	85.9%
- Nursing Technicians (n=42)	36.4%	32.8%	90.1%

Note. PPE = personal protective equipment. *Improvement = difference between baseline and immediate post-intervention. **Retained = difference between baseline and 3-month follow-up.

Table 4: Health Care–Associated Infection (HCAI) Rates ($N = 110$)

Infection Type	Pre-Intervention Rate*	Post-Intervention Rate*	Reduction (%)	χ^2	p-value
CLABSI	4.2	1.5	64.3%	4.82	.028
CAUTI	3.1	1.0	67.7%	3.76	.052
VAP	2.6	1.5	42.3%	1.43	.232
Total HCAIs	12.4	6.8	45.2%	9.76	.002

Note. CLABSI = central line-associated bloodstream infection; CAUTI = catheter-associated urinary tract infection; VAP = ventilator-associated pneumonia; HCAIs = health care–associated infections. *Rate = infections per 1,000 patient-days.

DISCUSSION

The importance of this trial is that it shows a significant increase in the knowledge as well as practice of both RNs and Technicians in preventing HCAIs, following an educational intervention that involved both professionals in both their knowledge and practice. It is important to note that these changes in practice not only led to significant changes but these changes remained significant even at the end of three months with a reduced infection rate of 45.2%. This clearly emphasizes that interventions need to target the whole team, not just RNs, in attempting to ensure patient safety in critical care settings.

Interpretation of Findings

The overall scores on knowledge increased by 37.1% (60.1 ± 9.4 to 82.3 \pm 7.1). This finding is similar to those obtained by Kim \& Oh (2020). Another interesting finding emerged in terms of reducing or shrinking the "knowledge-gap" between RNs and Technicians, where though Technicians began with lower scores (56.4%), their relative score improvement is higher (41.1%) than RNs. This highlights that "Technician-focused" education in terms of environmental and patient bed hygiene is most effective with these members, possessing only a diploma level of education.

Adherence with practices in infection control increased by 61.4% (54.2% to 87.5%). Closing this "gap between knowledge and practice" is of great importance (Erasmus et al., 2022). Specifically, hand hygiene compliance inTechnicians increased from 41.2% to 85.3%, exceeding "worldwide" norms (WHO, 2021). These changes in practice might be justified based on "Theory of Planned Behavior" because by encouraging these members with "why" and not just "how," their perceived behavioral control is heightened, thus their professional efficacy (Sax et al., 2020).

Impact on HCAIs Rates

A reduction in HCAIs infection rates by 45.2% is significant, both clinically and economically. CLABSI infection rates and CAUTIs reduced by 64.3% and 67.7%, respectively, which clearly emphasizes their combined effect of both professional groups in preventing infections in critical care settings. Since RNs are responsible for patient care in terms of device placement and infection control, most members, Technician, perform patient repositioning and hygiene practices. Therefore, these practices simultaneously reduced infections in both groups by preventing direct exposure and contact infection, thus providing protection in terms of "the shield effect" (Furuya et al., 2019).

Sustainability and Team Working

Unlike previous attempts where practices remained significant just for weeks (Bakaeen et al., 2019), in this trial, significant changes in practice remained significant even at three months with low infection rates. It is our belief that these differing rates of completion are the result of the multimodal educational approach and the fact that unit champions gave peer feedback to both RNs and Technicians on their work tasks. The high completion rate of 89.2% on the knowledge and 87.7% on the practice questions suggests that simulation-based education is, by necessity, more of a 'big tent' experience, where all of the nursing personnel, regardless of agenda or educational platform, have a more lasting educational opportunity.

, consistent with findings from other structured educational interventions. In fact, a similar increase in knowledge, 38.2%, was reported by Kim & Oh (2020) following a simulation-based infection control program for ICU nurses. Long-term retention at 3-month follow-up was 88.3%, suggesting that the multimodal approach-through the use of different modes of presenting information along with reinforcement materials-enhanced learning over a longer period.

Of most importance, however, is the fact that compliance to practice significantly improved by 53.7%, as this is a long-standing challenge in healthcare, considered crucial to be overcome: the bridging of the knowledge-practice gap (Erasmus et al., 2022). In fact, compliance with hand hygiene increased from 58.3% to 89.6%, thus attaining levels higher than international benchmarks and reported to prevent pathogen transmission effectively (WHO, 2021). This is founded on the idea that comprehensive education about knowledge, attitude, and self-efficacy can lead to changes in behavior reflected in the Theory of Planned Behavior framework.

This represents a 45.2% reduction in combined HCAI rates over the post-intervention period and is both clinically and economically significant. These findings are supported in other studies, such as by Moureau et al. (2017) and Furuya et al. (2019), where education was combined with system improvements, reaching reductions in infections of 40-50%. The large reductions seen in CLABSI, 64.3%, and CAUTI, 67.7%, probably reflect the emphasis of the intervention on bundles of care for devices and aseptic technique, where nursing practice directly impinges on infection risk.

Theoretical Implications

Success of this intervention further justifies the application of behavior change theories in infection prevention education. Because the intervention addressed the three most important components of the Theory of Planned Behavior-attitudes, through evidence-based rationale; subjective norms, through unit-based champions and peer support; and perceived behavioral control, through hands-on practice and skill development-it succeeded in changing behavior over the long term (Ajzen, 1991).

Such would go further in supporting how principles of adult learning, such as multiple teaching modalities and practical application opportunities, helped in enhancing educational effectiveness. Knowledge transfer from the classroom into clinical practice would be said to be better realized through such methodologies as simulation, case study, and immediate feedback. Hence, the theory-practice gap, which often limits the full benefit of didactic education, is minimized (Kolb, 2014).

Comparison with Existing Literature

This indicates that the improvement in compliance with hand hygiene,from 55.9% before patient contact to 94.1% post-intervention, is greater than what many previous studies found. According to Lotfinejad et al. (2020), who performed a systematic review, the percentage increase in compliance in the case of multimodal hand hygiene interventions was in general 35-40%, while in this paper there was a relative improvement of 63%. The better outcome may well be because of the more intense nature of the educational program, the use of unit-based champions, and strong administrative support.

These gains, sustained at 3-month follow-up, contrast with the rapid decay of intervention effects described in several previous studies. For example, Bakaeen et al. (2019) suggested that hand hygiene compliance returned to baseline within 6 weeks of an educational intervention. The fact that the effects were sustained in the present study might be explained by the continuous delivery of visual reminders, easy access to reference materials, and continued availability of trained champions reinforcing best practices and providing peer feedback.

These kinds of infection rate reductions are consistent with those from broad, multicomponent strategies to prevent infections. Saint et al. (2021) described a 60-70% reduction in CAUTI rates using bundled interventions that included education, reminders, and system changes. Buetti et al. (2022) also reported a 50-65% reduction in CLABSI rates with bundles for central line insertion and maintenance. The similarity in results of the current study, which applied primarily an educational intervention, would suggest that improvement of nursing knowledge and practice is the most important element of any infection prevention strategy.

Strengths and Limitations

Its strong points include a comprehensive assessment of the intervention effect on both cognitive and behavioral outcomes, given that knowledge assessment and direct observation were combined; it provided a 3-month follow-up, thus enabling examination of sustainability-a well-recognized gap in the literature; it included actual infection rate data, hence providing evidence for real-world impact beyond process measures; and it reported a 100% retention rate, with no attrition bias, which may have strengthened internal validity.

Nevertheless, several limitations should be considered: the quasi-experimental design without a control group has the obvious limitation in causal inference since temporal trends, concurrent initiatives, or Hawthorne effects may explain improvements observed. Single-site settings have a limitation for generalizability to ICUs with different organizational cultures, resources, or patient populations. The relatively short follow-up time of 3 months cannot establish whether any improvement would be maintained over longer time periods. Assessment of compliance through direct observation, although considered the gold standard, may introduce observer bias or reactivity and thus artificially inflate compliance rates. Finally, although infection rates decreased significantly, the number of individual infection types was small, such as VAP, and thus the statistical power to detect differences within specific infection categories was limited.

Some selection biases could occur with the convenience sampling and the voluntary participation, as nurses self-selecting into this study were more motivated or had a higher baseline interest in infection prevention. Measures of several variables that might moderate intervention effectiveness, such as measures of workload, staffing ratios, or organizational culture factors, are not measured in this study. Lastly, the current study did not include any form of cost-effectiveness analysis, one of the major considerations that health administrators would review while contemplating the implementation of similar programs.

Practice Implications

Investigators in this study considered unit-based champions to be a very valuable asset and recommend them as part of the implementation strategies because peer-to-peer education and modeling often exert a strong influence on practice norms.

Third, educational interventions need to be coupled with environmental supports to facilitate compliance. That is, adequate availability of supplies needs to be assured for hand hygiene, PPE, and necessary equipment to conduct aseptic procedures. Also, required is administrative support through protected time to train, staffing adjustments enabling proper execution of evidence-based practices, and visible leadership commitment to infection prevention.

Fourth, measurement and feedback are critical to maintaining improvement. Ongoing monitoring of process measures, such as compliance with practices, and outcome measures, such as infection rates, identifies areas that need further intervention and provides data to reinforce the value of nurses' efforts. Sharing unit-specific data with staff in a nonpunitive way can motivate continued adherence to best practice.

Educators and managers should avoid generalizations that one size of infection prevention education fits all.

Implications for Research

Where possible, studies should be designed as randomized controlled trials with concurrent control units in order to enhance causal inference. Tests of the sustainability of improvements gained and whether periodic booster sessions are required need longer follow-up than thus far adopted, such as 6-12 months or beyond. There is also a need for research to test the optimal timing, frequency, and intensity of educational interventions with a view to enhancing efficiency and cost-effectiveness.

This would suggest that several comparative effectiveness studies will be necessary to inform which specific components of the multimodal interventions lead most to improved outcomes, so leaner, less resource-intensive programs can be developed. Such studies may look at incremental benefit added by simulation training relative to video demonstrations or added value from unit-based champions beyond formal education sessions.

The search for such moderating variables would require further studies in exploring unit culture, leadership support, nurse-to-patient ratios, and baseline levels of compliance that may moderate the success of the interventions. Understanding such contextual factors could provide insights not just into the better targeting of interventions but also in the identification of units that might need additional support. Qualitative inquiries into nurses' perceptions of facilitators and barriers to implementing infection prevention practices would go a long way toward refining the interventions.

The educational interventions for such changes will need a cost-effectiveness analysis to further facilitate the business case to healthcare admini strators. A full economic evaluation will weigh all the costs of developing and delivering the intervention, including staff time and materials, against savings on reduced infections, length of stay, and antibiotic use, to support resource allocation decisions and demonstrate the return on investment for infection prevention education.

New modes of delivery, such as e-learning, mobile applications, virtual reality simulation, and gamification approaches, are required. These may confer advantages in terms of scalability, accessibility for shift workers, and levels of engagement-particularly in a cohort of younger nurses who are 'digital natives'. Comparison of traditional to technology-enhanced education would help inform future program designs.

Policy Implications

Organizational implications: These findings support policies providing frequent and comprehensive infection prevention education for the nursing staff in critical care settings. All healthcare organizations

should have standards that define the minimum frequency, such as quarterly refresher sessions, the content expectations, and the methods of competency assessment for infection prevention training.
Requirements for continuing education in infection prevention for license renewal underscore the central importance of this area.more specificity on the nature and frequency of educational interventions and evaluation might better stimulate improvement across health systems.Although the Joint Commission standards include infection prevention Competency testing for infection prevention included as part of the nursing license exams.
It is also important that funding agencies give high national priority to researching infection prevention strategies, including educational interventions. Given the high burden of HCAIs, large investments are justified in searching for effective methods of prevention. Further development of standardized evidence-based educational curricula, which could then be adapted and implemented in a wide range of settings, would allow consistent high-quality infection prevention education nationally.
Professional nursing organizations should develop standards for infection prevention education and associated continuing learning resources by nurses, including web-based learning modules and implementation toolkits for unit-based education. These resources would support certification programs that recognize advanced competency in infection prevention. Collaboration among the nursing organizations, infection prevention professional societies, and regulatory bodies would ensure that approaches to improvement of infection prevention practice are coordinated and comprehensive.

CONCLUSION

Conclusion of the study is that when there is an educational intervention that is structured and multi-modal, involving the registered nurse as well as the nursing technician, it has proven significantly useful in boosting knowledge levels and compliance regarding evidence-based practices related to the prevention of infection. The involvement of the whole team of nurses helped there be a clinically meaningful reduction in the HCAI rates, especially when it comes to CLABSIs and CAUTIs in the ICU. These findings support the "Total Team" method in the aspect of improving quality.
The fact that the intervention was successful underscores the fact that while RNs take care of the technical part of patient care, the role of the nurse technician in ensuring that the patient and the healthcare setting remain clean and free of contamination cannot be underestimated. Thus, healthcare facilities should move from the use of "one-size-fits-all" strategies to educating or training healthcare professionals for their specific roles. While the challenge of antimicrobial resistance continues to rise, educating the entire nursing workforce remains one of the most viable strategies for protecting severely ill patients and ensuring quality healthcare outcomes.
"Educational curricula should be adapted to the educational levels of various nursing personnel categories to ensure equitable knowledge gain."

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