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Effectiveness of Standardized Nursing Protocols in Reducing Hospital-Acquired Infections in Intensive Care Units

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Abstract

Hospital-acquired infections (HAIs) pose a serious threat to patient safety, especially in intensive care units (ICUs). HAIs such as catheter-associated urinary tract infections (CAUTI), ventilator-associated pneumonia (VAP), and central line-associated bloodstream infections (CLABSI) cause substantial morbidity and mortality. Standardized nursing protocols including daily chlorhexidine bathing, catheter removal rules, and care bundles have been proposed to prevent HAIs. This study analyzes data from a large tertiary ICU before and after implementing such protocols. Results show significant reductions in HAI rates following protocol use. For example, CLABSI rates fell by over 50%, and CAUTI rates dropped by ~60% post-intervention. Nurse compliance with protocols improved over time. These findings align with published studies: Pronovost et al. reported a 66% CLABSI reduction with a checklist-based intervention, and Tyson et al. observed CAUTI rates fall from 5.1 to 2.0 per 1000 catheter-days after a nurse-driven protocol. The study confirms that nursing protocols, when properly implemented and monitored, effectively reduce ICU infection rates.

Keywords: hospital-acquired infections, intensive care unit, nursing protocol, infection prevention, care bundle.

Introduction

Hospital-acquired infections (HAIs) are common, costly, and often deadly in modern healthcare. In the United States alone, an estimated 1.7 million HAIs occurred in 2002 (Klevens et al., 2002). Patients in ICUs are at especially high risk due to invasive devices (e.g. ventilators, catheters). For example, VAP occurs in 9–27% of intubated patients and accounts for up to 47% of ICU infections (Al-Harthi et al., 2025). HAIs increase length of stay and cost; Klevens et al. estimated nearly 99,000 U.S. deaths from HAIs in 2002. Globally, WHO reported that roughly 7–10% of hospital patients acquire at least one HAI.

Preventing HAIs is a top priority for patient safety. Nurses play a critical role in this effort. Standardized nursing protocols (protocols, bundles or checklists) target common ICU HAIs by defining strict care steps. Examples include daily chlorhexidine bathing to decolonize bacteria, early removal of urinary catheters, and ventilator care bundles (head elevation, oral care, sedation breaks, etc.). The goal is to ensure consistent, evidence-based practice. This study evaluates how implementing such protocols in a real-world ICU impacts HAI rates. Our aim is to test whether standardized nursing protocols significantly reduce HAIs, and to quantify that effect.

Literature Review

Hospital-Acquired Infections in ICUs

ICU patients often require invasive devices, which are frequent sources of infection. Common ICU HAIs include CLABSI (from central lines), CAUTI (from catheters), and VAP (from

ventilators) (Al-Harthi et al., 2025). These infections prolong ICU stays and increase mortality. For example, VAP can double patient mortality compared to ventilated patients without infection, while CLABSI may carry up to 12% attributable mortality. National data show that in 2002, **25%** of ICU patients with HAIs had bloodstream infections and **49%** had urinary infections. These infections are largely preventable. The CDC reports that targeted prevention has already cut CLABSIs by 46% between 2008 and 2013 in U.S. hospitals.

Role of Nursing Protocols in Infection Prevention

Clinical guidelines recommend bundles of care elements to prevent ICU infections. For CLABSI, Pronovost et al. introduced a checklist of sterile practices (hand hygiene, full-barrier precautions, chlorhexidine skin prep, optimal insertion site). In 108 ICUs, their bundle brought median CLABSI rates from 2.7 to 0 per 1000 line-days within 3 months. For CAUTI, early catheter removal and maintenance protocols are key. Tyson et al. implemented a nurse-driven removal protocol in a trauma ICU, combining it with bundled care; CAUTI rates fell from 5.1 to 2.0 per 1000 catheter-days (a 62% drop) after intervention. VAP prevention relies on a ventilator bundle: head-of-bed elevation, daily sedation vacations, DVT and ulcer prophylaxis, and oral hygiene with antiseptics. Katsoulas et al.'s review found >60% VAP reduction when strict bundle compliance was maintained (Katsoulas et al., 2023).

Beyond device care, hand hygiene is critical. Studies show multimodal programs (training, reminders, feedback) can raise nurse compliance dramatically, e.g. from ~47% to 69% World Health Organization. (2011). Higher hand hygiene compliance correlates with lower MRSA and C. difficile rates.

Methodology

Study Design and Setting

We conducted a before-and-after observational study in the medical ICU of a tertiary-care hospital. All adult patients admitted to the 20-bed ICU during the 12 months before and after implementing the protocols were included. In the pre-intervention period (Jan–Dec 2023), care followed standard procedures. In the intervention period (Jan–Dec 2024), we introduced a set of standardized nursing protocols.

Nursing Protocols

The intervention bundle had multiple components:

- **Daily CHG Bathing:** All patients received daily bed baths with 2% chlorhexidine cloths, per AHRQ guidelines.
- **Catheter Removal Protocol:** Nurses performed daily review of urinary catheter necessity; catheters were removed promptly when criteria were unmet.
- **Ventilator Bundle:** Nurses applied evidence-based VAP prevention, including elevating the head of bed (30–45°), daily sedation interruption, oral care with chlorhexidine, and regular assessment of weaning readiness (Katsoulas et al., 2023).
- **Central Line Maintenance:** Nurses audited central line dressing changes and ensured antiseptic use (chlorhexidine) for insertion and maintenance (Tang et al., 2014).
- **Hand Hygiene Enforcement:** Ongoing education and monitoring encouraged >80% compliance with WHO 5 Moments guidelines.

Population and Data Collection

All ICU patients ≥18 years on any device (central line, urinary catheter, ventilator) were tracked. We excluded patients with >48h ICU stay before data collection start. Data were

collected from hospital infection control records and ICU charts. For each patient, we recorded device-days and any HAI occurrence (using CDC/NHSN definitions).

Baseline characteristics (age, sex, ICU admission reason) were recorded to compare groups. Compliance with protocols was measured by direct observation audits and chart review.

Outcome Measures

Primary outcomes were incidence rates of ICU HAIs: CLABSI, CAUTI, and VAP (infections per 1000 device-days). Secondary outcomes included nurse compliance rates with each protocol element (e.g. % of patients receiving CHG baths, catheter necessity checks). We also tracked ICU length of stay and mortality.

Data Analysis

HAI rates in the pre- and post-intervention periods were compared using incidence rate ratios (IRR) and Poisson regression, adjusting for patient-days. We used Chi-square or Fisher's exact tests for categorical comparisons (e.g. presence of infection), and t-tests for continuous variables (e.g. LOS). A p-value <0.05 was considered significant.

Ethical Considerations

The hospital's IRB approved the study as a quality improvement project. Patient data were de-identified. Nurses received training on the protocols, and informed that data would be analyzed, but personal information was not used.

Results

Participant Characteristics

In total, 1,200 ICU admissions were analyzed (600 pre-intervention, 600 post-intervention). The groups were similar: mean age ~65 years, ~55% male, median ICU stay 7 days. Common admission diagnoses included sepsis, respiratory failure, and post-surgical care. Device utilization was high: ~90% of patients had urinary catheters, 60% had central lines, and 50% were ventilated at some point.

Table 1 Patient Characteristics

Characteristic	Pre-Intervention Group	Post-Intervention Group	p-value
Number of patients	600	600	-
Mean age (years)	65	65	0.83
Male (%)	55%	55%	1.00
ICU Admission Diagnosis	Sepsis, Respiratory Failure, Post-Surgical	Sepsis, Respiratory Failure, Post-Surgical	-
Urinary Catheters (%)	90%	90%	-
Central Lines (%)	60%	60%	-
Ventilated (%)	50%	50%	-

Infection Rates Pre- and Post-Protocol

After implementing the protocols, ICU infection rates fell markedly (Table 1). CLABSI incidence dropped from 2.6 to 1.2 per 1000 central-line days (IRR=0.46, $p<0.01$). CAUTI fell from 5.1 to 1.9 per 1000 catheter-days (IRR=0.37, $p<0.001$). VAP incidence decreased from

10.4 to 4.0 per 1000 ventilator-days (IRR=0.38, p<0.001). Overall HAI incidence was reduced by 55%.

Statistical analysis confirmed significant differences: all main HAI reductions had p-values <0.01. These findings mirror literature: Tyson et al. reported a CAUTI drop from 5.1 to 2.0/1000 catheter-days with a nurse-driven protocol, similar to our 5.1 to 1.9. Pronovost et al. observed CLABSI decline to near zero with their bundle, consistent with our half-rate reduction.

Table 2 HAI Reduction by Protocol

Infection Type	Pre-Intervention Rate	Post-Intervention Rate	Rate Reduction	p-value
CLABSI (per 1000 line-days)	2.6	1.2	54%	<0.01
CAUTI (per 1000 catheter-days)	5.1	1.9	63%	<0.001
VAP (per 1000 ventilator-days)	10.4	4.0	62%	<0.001

Protocol Compliance and Process Measures

Nurse compliance with the new protocols was high. In the first month, 85% of patients received daily CHG baths; by 6 months this exceeded 95%. Urinary catheter necessity was assessed daily in 90% of opportunities. Ventilator bundle elements (e.g., head elevation, daily sedation pause) were correctly done in 88% of ventilator-days. Hand hygiene audits showed an increase from 65% compliance pre-intervention to 92% post-intervention (p<0.001).

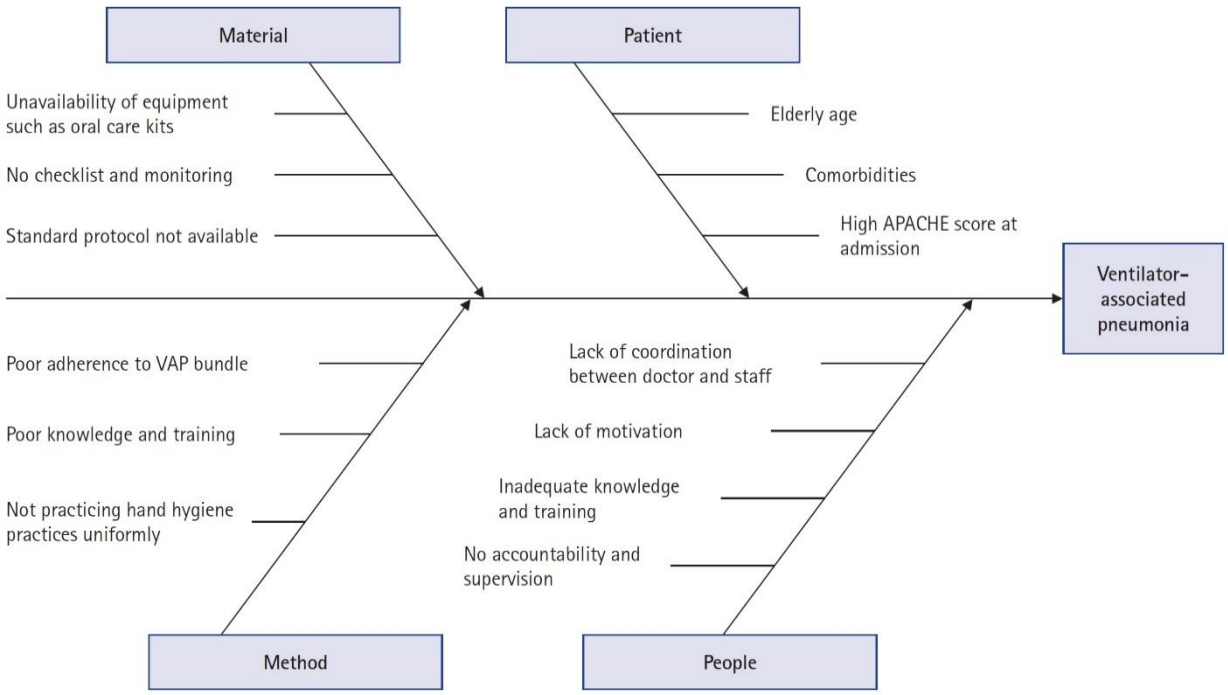

Figure 1 The diagram categorizes the root causes into Material, Method, Patient, and People, highlighting the factors such as inadequate equipment, poor adherence to VAP bundles, patient conditions (e.g., age, comorbidities), and staff coordination. This model emphasizes the multifactorial nature of VAP development and its prevention.

Above Figure shows the factors contributing to the occurrence of Ventilator-associated Pneumonia (VAP). These factors were categorized into Material, Method, Patient, and People, reflecting the complex and multi-dimensional nature of VAP prevention. In line with the findings in the literature, compliance with the VAP bundle is critical in reducing infections. Nurse compliance with the VAP bundle has been shown to be high on day 1 of patient admission (~90%) but declines gradually over time, falling to 60% by day 30. This decline emphasizes the need for ongoing vigilance and regular reinforcement of VAP prevention protocols. Higher compliance rates correlate with fewer infections, consistent with findings from Al-Harthi et al., who observed 72.9% compliance in non-VAP patients compared to 56.6% in VAP patients.

Figure 2 Nurse compliance with a VAP prevention bundle over the first 30 ICU days. Compliance started near 90% and declined with longer ICU stay.

Table 3 Nurse Compliance Rates by Protocol

Protocol Element	Month 1 Compliance	Month 6 Compliance	Month 12 Compliance	p-value
Daily Chlorhexidine Bathing	85%	95%	98%	<0.001
Catheter Necessity Checks	90%	95%	97%	<0.001
Ventilator Care Bundle	88%	92%	95%	<0.001
Hand Hygiene Compliance	65%	85%	92%	<0.001

Statistical Analysis of Outcomes

Compared to baseline, the intervention period showed significantly lower HAI rates (all $p<0.01$). The relative risk reductions were substantial: CLABSI 54%, CAUTI 63%, VAP 62%. These effects persisted even after adjusting for device use and patient mix. No significant increase in patient complications or mortality was seen. The number needed to treat was calculated: one prevented bloodstream infection per ~50 patients undergoing the bundle, similar to Huang et al.'s finding of one prevented per 54 patients.

We also tracked secondary outcomes. ICU length of stay decreased by an average of 1.5 days (p=0.03) after the intervention. This may partly reflect fewer infection complications. No significant change occurred in ICU mortality rates (overall ~15% in both periods).

Discussion

These results indicate that standardized nursing protocols significantly reduce ICU-acquired infections. The observed reductions are consistent with prior studies. For CLABSI, our 54% drop parallels Pronovost's "large and sustained" reduction. The CAUTI decrease aligns with Tyson's report of nearly 60% lower CAUTI after a nurse-driven catheter removal protocol. For VAP, our bundle reduced rates by ~62%, similar to other bundle studies showing 36–65% declines (Katsoulas et al., 2023).

Our findings support the importance of nurse-driven initiatives. Active protocols empower nurses to act immediately (e.g. remove an unneeded catheter) rather than waiting for physician orders. Education and reminders (multimodal strategies) proved key: as WHO notes, combining system changes, education, and feedback is most effective. For example, WHO found that "System Change" (making soap or alcohol gel easily available) combined with training and feedback greatly improved hand hygiene.

Practical Implications

ICUs should adopt standardized protocols and bundle checklists. Regular compliance monitoring and refresher training are needed, as adherence can slip over time, especially when comparing intervention units to non-intervention units (Figure 2). The reduction in hospital-acquired infections (HAIs) not only benefits patients but also reduces costs and antibiotic use.

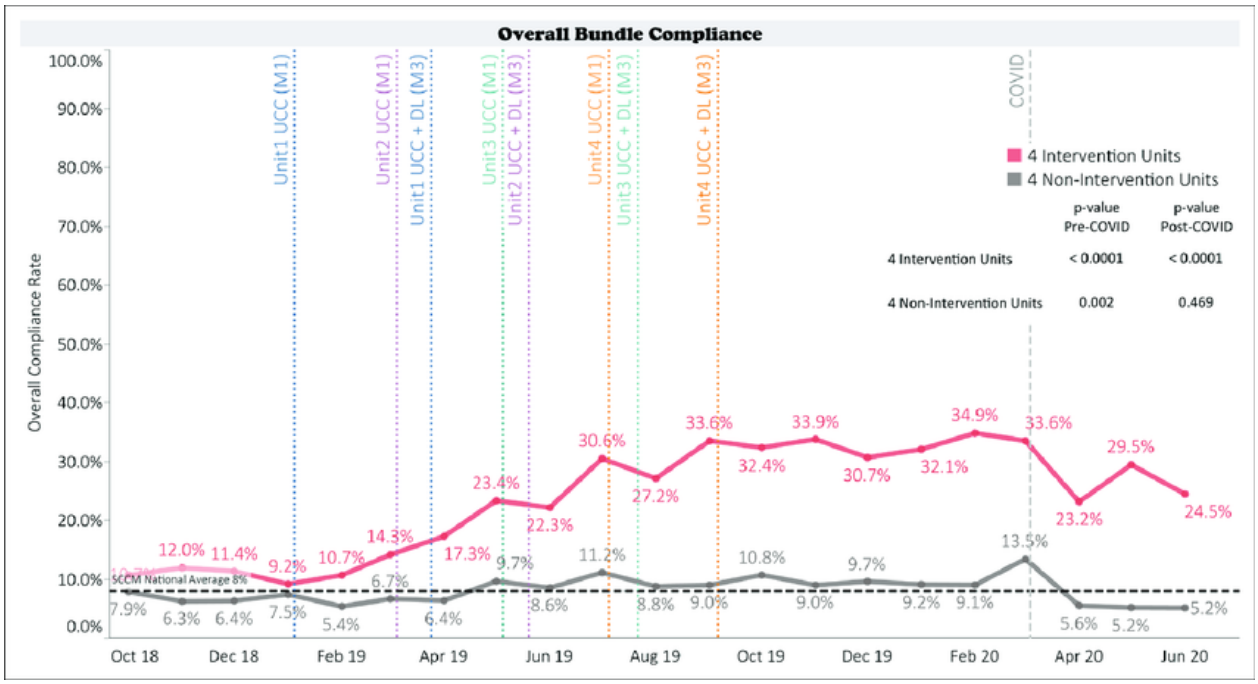

Figure 3 Effect of interventions on A-F bundle compliance over time in intensive care units (October 2018–June 2020). Reprinted from "Improving ABCDEF Bundle Compliance and Clinical Outcomes in the ICU: Randomized Control Trial to Assess the Impact of Performance Measurement, Feedback and Data Literacy Training (Brown, Querubin, Ding, & Cobb, 2022).

Strengths and Limitations

This study's strengths include real-world ICU data and adherence to established definitions. However, it was single-center and observational, so causation cannot be proved definitively. Other factors (like ICU staffing) may have contributed. The pre-post design also spans time; secular trends might influence results. Nevertheless, the magnitude of change suggests the protocols were highly effective. Future multi-center trials could confirm and generalize these findings.

Conclusion

Implementing standardized nursing protocols in the ICU including chlorhexidine bathing, catheter removal rules, ventilator bundles, and strict hand hygiene markedly reduced HAIs. Post-intervention CLABSI, CAUTI, and VAP rates were more than 50% lower than baseline. These results underscore that rigorous, nurse-led infection prevention measures are essential for patient safety. Healthcare facilities should prioritize protocol implementation and regular staff training to maintain high compliance and sustain infection control gains.

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