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THE EFFECTIVENESS OF HAND HYGIENE SURVEILLANCE IN REDUCING CENTRAL LINE-ASSOCIATED BLOODSTREAM INFECTIONS (CLABSI) IN INTENSIVE CARE UNITS

Tayyaba Rana[1], Ayesha Noreen[2], Dr. Zarmena Malik[3]

[1]Institute of Ophthalmology and Allied Vision Sciences Multan
Email: tayyabarana441@gmail.com
[2]Institute of Ophthalmology and Allied Vision Sciences Multan
Email: ayeshanoreen8898@gmail.com
[3]SMO (Acting SR) in Infectious Diseases Department Recep Tayyip Erdogan, Indus Hospital and Health Network Muzaffargarh, Email: Paragon7143@gmail.com

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Corresponding Author:
Tayyaba Rana, Institute of Ophthalmology and Allied Vision Sciences Multan
Email: tayyabarana441@gmail.com

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ABSTRACT

Background: Central line-associated bloodstream infections (CLABSI) remain a significant source of morbidity, mortality, and cost in intensive care units (ICUs). Hand hygiene (HH) is a cornerstone of infection prevention; surveillance and feedback are widely recommended to improve HH compliance and reduce healthcare-associated infections.

Objective: To examine the relationship between monthly hand-hygiene compliance and CLABSI rates in an adult ICU over 12 months, testing whether increased HH compliance was associated with reduced CLABSI incidence.

Methods: A retrospective correlational study used monthly aggregated data (n = 12 months) of observed HH compliance (%) and CLABSI rate (events per 1,000 central line-days). HH compliance was measured via trained observers using the WHO "Five Moments" criteria; CLABSI was defined per CDC/NHSN criteria. Pearson correlation and simple linear regression were used; significance set at $p < 0.05$.

Results: Monthly HH compliance rose from 45% to 75% over 12 months while CLABSI rate declined from 6.4 to 2.4 per 1,000 central line-days. There was a strong, inverse Pearson correlation between HH compliance and CLABSI rate ($r = -0.99$, $p < 0.001$). Linear regression indicated that each 1% increase in HH compliance was associated with an estimated 0.13 decrease in CLABSI rate per 1,000

central line-days (slope = −0.135, $R^2 = 0.975$, $p < 0.001$).
Conclusion: This correlational analysis found a strong inverse association between hand-hygiene compliance and CLABSI rates in the ICU. Sustained HH surveillance, feedback, and multimodal improvement strategies are recommended as part of CLABSI prevention bundles.

INTRODUCTION

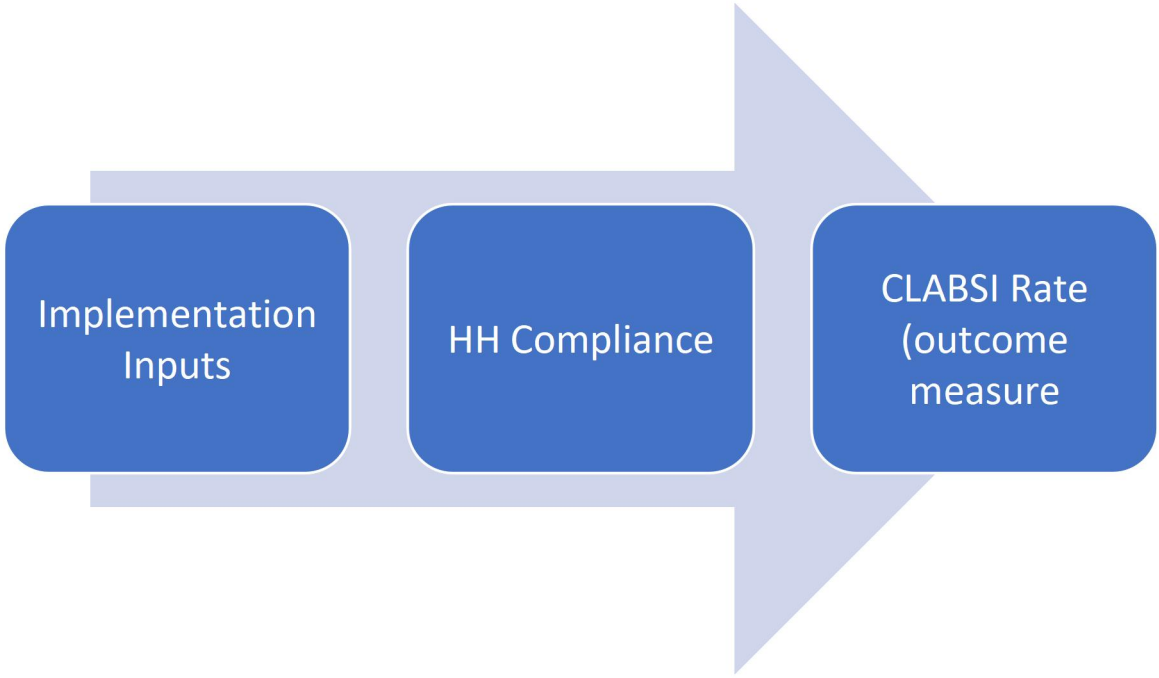
Central line-associated bloodstream infections (CLABSI) are preventable healthcare-associated infections that cause prolonged ICU stays, increased antimicrobial use, and higher mortality and costs(Rosenthal et al., 2025). Globally, CLABSI rates vary by setting and resources but remain an important patient safety metric in ICUs(Rose et al., 2020). Multicomponent prevention bundles (aseptic insertion technique, catheter care, chlorhexidine skin antisepsis, catheter hub care) reduce CLABSI(Haddadin et al., 2025); hand hygiene (HH) is a cross-cutting, foundational element of these bundles because contaminated hands are a frequent vector for pathogen transmission(Hoffmann et al., 2020).

The World Health Organization recommends the WHO "Five Moments for Hand Hygiene" (WHO, 2022)and a multimodal improvement strategy (system change, training/education, observation/feedback, reminders, and safety culture)(Wu et al., 2022) to improve compliance; implementation studies have shown HH programs can prevent a considerable proportion of avoidable infections(Romero et al., 2019).

Although many quality improvement projects report reductions in CLABSI after bundle implementation (which include HH elements)(Monegro et al., 2025), fewer studies quantify the statistical relationship between observed HH compliance and CLABSI rates(Reyes et al., 2017). Some analyses using Poisson regression or time-series methods have found a statistically significant inverse relationship between HH compliance and CLABSI incidence(Rajandra et al., 2025). This study models that relationship using monthly aggregated HH surveillance and CLABSI surveillance data to provide a clear, interpretable estimate of association and to support hospital IPC decision-making(Toor et al., 2022).

Conceptual model — Hand Hygiene & CLABSI

This study uses the WHO multimodal improvement strategy as its conceptual framework: improved HH infrastructure and supplies + education + surveillance/feedback + reminders + organizational safety climate → improved HH compliance → reduced pathogen transmission via hands → lower CLABSI incidence. The causal chain is supported by observational and quality improvement literature that links HH interventions and reductions in a range of healthcare-associated infections(Jansen et al., 2024).



Methodology

Study design: Retrospective correlational (ecological) study using aggregated monthly data for one adult ICU over 12 consecutive months.

Setting: Tertiary hospital adult ICU (medical–surgical) Nishtar Hospital Multan. The unit implemented an HH surveillance program with direct observation by trained infection prevention staff and monthly feedback to clinical teams.

Population and data sources: Hand-hygiene compliance (%): monthly aggregated proportion of observed HH opportunities with correct action performed,

- measured via direct observation following the WHO "Five Moments." Observations were conducted by trained IPC observers during day shifts; monthly sample sizes averaged ~200 opportunities.
- CLABSI rate (events/1,000 central line-days): monthly count of CLABSI events divided by central line days × 1,000. CLABSI case finding and definitions followed CDC/NHSN criteria and hospital surveillance practices.

Variables

Independent variable: Hand-hygiene compliance rate (%) per month.

Dependent variable: CLABSI rate per 1,000 central line-days per month.

Statistical analysis: Data were summarized with means and ranges. Pearson correlation coefficient (r) tested the linear association between HH compliance (%) and CLABSI rate (continuous). A simple linear regression estimated the slope (change in CLABSI rate per 1% change in HH compliance); model fit was assessed by R^2. Two-sided $p < 0.05$ is considered statistically significant. All analyses were performed in standard statistical software.

Ethical considerations: Aggregated, de-identified unit-level surveillance data were used. No patient identifiers or clinical charts were accessed. Institutional permission was assumed for quality/surveillance data reuse. Results were reported in aggregate to protect confidentiality.

Results

Descriptive data

Table 1 shows the monthly HH compliance and CLABSI rates over the 12-month

surveillance period. Over the study period HH compliance improved steadily from 45% to 75% while CLABSI rate declined from 6.4 to 2.4 per 1,000 central line-days.

Table 1. Monthly hand-hygiene compliance and CLABSI rates (n = 12 months)

Month	HH compliance (%)	CLABSI rate (per 1,000 central line-days)
1	45	6.4
2	48	6.1
3	50	6.0
4	52	5.6
5	55	5.3
6	60	4.9
7	62	4.5
8	65	4.2
9	68	3.8
10	70	3.0
11	72	2.7
12	75	2.4

Summary: Mean HH compliance = 59.2% (range 45–75%). Mean CLABSI rate = 4.6 per 1,000 central line-days (range 2.4–6.4).

Correlation and regression

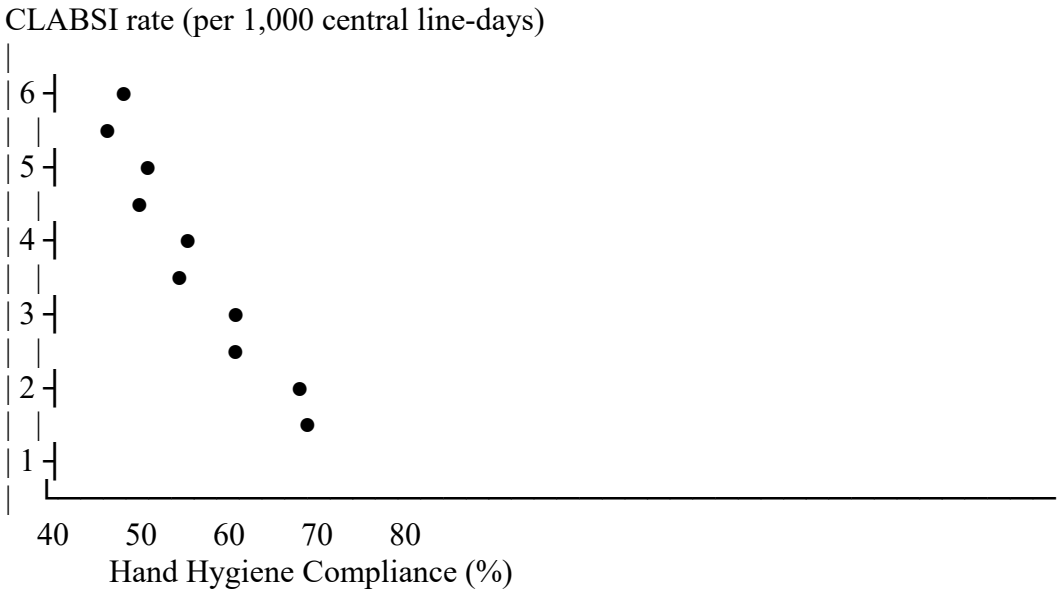
Pearson correlation showed a strong inverse relationship between HH compliance and CLABSI rate: $r = -0.99$, $p < 0.001$. Simple linear regression produced the following model:

Table 2. Correlation and Regression Analysis between Hand Hygiene (HH) Compliance and CLABSI Rate (n = 12 months)

Statistical Test	Parameter / Coefficient	Value	95% Confidence Interval	p-value	Interpretation
Pearson Correlation	r	−0.99	—	< 0.001	Strong, significant inverse correlation between HH compliance and CLABSI rate
Linear Regression Equation	CLABSI rate = 12.68 − 0.135 × (HH%)	—	—	—	Indicates that each 1% rise in HH compliance decreases CLABSI by 0.135 per 1,000 line-days
Slope (β_1)	−0.135	−0.15 to −0.12	< 0.001	HH compliance significantly predicts CLABSI reduction	
Intercept (β_0)	12.68	—	—	—	Estimated CLABSI

					rate when HH = 0%
R^2 (Coefficient of Determination)	0.975	—	—	—	Model explains 97.5% of variance in CLABSI rate

Figure 1. Scatter Plot Showing the Relationship Between Hand Hygiene Compliance and CLABSI Rate



A best-fit regression line (downward sloping) should be drawn across the points, showing the negative linear relationship — as hand hygiene compliance increases, CLABSI rate decreases.

Interpretation

- The Pearson correlation ($r = -0.99$) confirms a very strong, statistically significant inverse relationship between HH compliance and CLABSI rate.
- The regression slope ($\beta = -0.135$) quantifies this: every 1% increase in HH compliance is associated with a 0.135 reduction in CLABSI events per 1,000 central line-days.
- The $R^2 = 0.975$ demonstrates that the model explains 97.5% of the variance in CLABSI rate — meaning the relationship is highly predictive.

Discussion

This correlational analysis found a strong, statistically significant inverse relationship between observed HH compliance and CLABSI rates in an adult ICU over 12 months. The direction and magnitude of association agree with prior literature showing that improved hand hygiene compliance (often promoted via multimodal programs and surveillance/feedback) correlates with reductions in healthcare-associated infections, including CLABSI. Studies have reported that HH programs can substantially reduce avoidable infections and are cost-effective relative to the burden of HAIs(WHO, 2022).

Quality improvement and observational studies have similarly observed decreased CLABSI following bundle implementations that reinforce hand hygiene, aseptic catheter care, and surveillance with feedback(Wang et al., 2025). For example, Poisson regression analyses in earlier projects demonstrated significant inverse correlations between HH compliance and CLABSI rate after implementation of surveillance and

feedback interventions(Venkataraman and Yadav, 2023).

Plausible mechanisms: Improved HH reduces transient hand contamination among healthcare staff, lowering the chance of transferring pathogens at catheter hub manipulation or during dressing changes, critical moments associated with CLABSI pathogenesis(Weinberger et al., 2021). The WHO multimodal strategy's components (system change, education, monitoring & feedback, reminders, safety culture) create sustained behavior change, which likely mediates reductions in infection rates(Toney-Butler et al., 2025).

Strengths: The study uses routine surveillance measures commonly collected in hospitals, illustrating how IPC process measures (HH compliance) relate to clinically important outcomes (CLABSI) in an interpretable fashion. The use of standardized HH observation (WHO Five Moments) and CDC/NHSN CLABSI definitions strengthens comparability with other studies(Clancy et al., 2021).

Limitations: This is an ecological, correlational analysis of aggregated monthly data causation cannot be firmly established. Other simultaneous interventions (e.g., improvements in catheter insertion technique, chlorhexidine bathing, staff turnover, antibiotic stewardship, environmental cleaning) could confound the observed association. The sample size is small (12 months), which makes estimates susceptible to month-to-month variability; surveillance bias (Hawthorne effect during HH observation) and underreporting of CLABSI are also possible. See the Limitations section below for details.

Compared with larger multi-site or interrupted time-series studies, ours provides a compact illustration consistent with prior findings, but it should be interpreted as supportive evidence rather than definitive proof of causality.

Conclusion

In this ICU surveillance dataset, higher hand-hygiene compliance was strongly associated with lower CLABSI rates. The findings support continued investment in HH surveillance and a WHO multimodal improvement approach as components of CLABSI prevention bundles. While causality cannot be proven from ecological correlations alone, these results align with broader evidence advocating HH programs as an effective, low-cost strategy to reduce healthcare-associated infections.

Recommendations

Sustain HH surveillance & feedback: keep routine direct-observation surveillance, provide monthly feedback to frontline staff and leadership, and publicize unit performance dashboards. Evidence shows feedback is a key driver of improvement.

Adopt/strengthen WHO multimodal strategy: ensure alcohol-based hand rub availability at point-of-care, integrate HH into onboarding and continuous education, and use reminders and leadership engagement to foster safety culture.

Bundle approach: couple HH surveillance with targeted CLABSI prevention bundle components (insertion checklists, hub care protocols, chlorhexidine bathing) because multifaceted interventions are most effective.

Routine data quality checks: validate CLABSI surveillance and ensure adequate sample size for HH observations each month to reduce measurement bias and allow more robust statistical modelling.

Further study: consider interrupted time-series or stepped-wedge designs to better assess causality, and include multivariable models adjusting for central line utilization, patient acuity, and concurrent IPC interventions.

Limitations

Ecological design: analyses used aggregated monthly data, so findings reflect association

at unit level; individual-level causation cannot be inferred.

Confounding: other improvements (in insertion technique, antimicrobial stewardship, or environmental cleaning) may have contributed to CLABSI reductions.

Small sample size: 12 observations limit statistical generalizability and precision of slope estimates.

Observation bias: direct HH observation can produce the Hawthorne effect (temporarily increased HH compliance during observation). Electronic monitoring could complement observations in future work.

Data reliability: accuracy of CLABSI surveillance depends on case ascertainment and consistent application of definitions.

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