Association Between Healthcare-Associated Infection Knowledge and Self-Reported Hand Hygiene Compliance Among Inpatient Nurses in Indonesia: A Multivariate Cross-Sectional Analysis

Juwita Sahputri[1*], Hajarani Syadzwina[2], Teuku Azhari[3], Herwansyah Herwansyah[4,5]

[1] Department of Microbiology, Faculty of Medicine, Universitas Malikussaleh, North Aceh, Indonesia
[2] Faculty of Medicine, Universitas Malikussaleh, North Aceh, Indonesia
[3] Faculty of Education and Teacher Training, Universitas Malikussaleh, North Aceh, Indonesia
[4] Graduate School of Biomedical and Health Sciences, Hiroshima University, Japan
[5] Department of Public Health, Faculty of Medicine and Health Sciences, Universitas Jambi, Jambi, Indonesia
juwita.sahputri@unimal.ac.id

Abstract. Healthcare-associated infections (HAIs) remain a major patient safety problem, and hand hygiene is central to prevention. However, evidence is limited regarding whether knowledge of HAIs is independently associated with hand hygiene compliance in regional hospitals. This study examined the association between knowledge of HAIs and self-reported hand hygiene compliance among inpatient nurses. A secondary analysis used 148 cross-sectional records from Cut Meutia Regional Hospital, North Aceh, Indonesia. The analysis was conducted using a modified Poisson regression with robust variance-estimated adjusted prevalence ratios (aPRs). Sensitivity analyses included additional adjustment for age and education and alternative logistic models. Ninety-six nurses (64.9%) were classified as compliant. Compared with low knowledge, moderate knowledge was associated with a 49% higher prevalence of compliance (aPR 1.49, 95% CI 1.03–2.17; p=0.035), while high knowledge was associated with a 72% higher prevalence (aPR 1.72, 95% CI 1.18–2.49; p=0.004). The overall knowledge term was significant (robust Wald χ^2=8.16, df=2, p=0.017), and the association remained significant in sensitivity analyses. Higher HAIs knowledge was associated with greater self-reported hand hygiene compliance. Because this study was cross-sectional and relied on self-report, the findings should not be interpreted as causal. Knowledge improvement may be most useful when combined with organizational measures that facilitate hand hygiene practice in routine inpatient clinical care settings.

Keywords: Healthcare-associated infections, hand hygiene, nurses, knowledge, self-reported compliance, prevalence ratio.

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1 Introduction

Healthcare-associated infections (HAIs) remain a major global patient safety problem, increasing morbidity, mortality, length of stay, antimicrobial use, and health-system costs. The burden is disproportionately high in low- and middle-income settings, where infection-prevention programmes often operate under resource constraints (World Health Organization [1]. In Southeast Asia, a systematic review of 31 studies involving 47,666 participants estimated a pooled HAI prevalence of 21.6%, with substantial between-country variation [2]

Hand hygiene is a foundational infection-prevention practice because healthcare workers' hands can facilitate transmission between patients, surfaces, equipment, and clinical environments. Evidence syntheses and current practice recommendations support sustained hand hygiene programmes as a core component of HAI prevention [3,4]. Nevertheless, compliance remains inconsistent across settings, and adherence is shaped by behavioral, interpersonal, organizational, and material factors rather than knowledge alone [5–7]. An early systematic review of hospital-based studies reported an average hand hygiene compliance rate of about 40% [8]

Knowledge remains clinically relevant because healthcare workers must understand when, why, and how to perform hand hygiene. Studies have reported positive associations between knowledge and hand hygiene behavior, including among Indonesian nurses and pooled healthcare workers [9,10]. However, the results were not consistent. A recent study in Portugal found no significant association between knowledge and adherence, while multicenter and qualitative evidence highlighted the importance of workload, supplies, institutional culture, supervision, feedback, and social norms [5,11,12]. This heterogeneity suggests that the knowledge-compliance relationship should be evaluated while accounting for relevant individual and organizational contexts.

An Indonesian cross-sectional study reported an association between knowledge and hand hygiene compliance [10]; however, evidence based on adjusted effect estimates in regional hospital settings remains limited. Therefore, the present study examined the adjusted association between HAIs knowledge and self-reported hand hygiene compliance among inpatient nurses at Cut Meutia Regional Hospital, North Aceh, Indonesia. Because compliance was common, prevalence ratios were used as the primary effect measure, with logistic and ward-stratified models used to assess robustness. The reporting followed the STROBE recommendations for cross-sectional studies [13].

2 Methods

2.1 Study design and setting

This was a secondary multivariate analysis of an existing cross-sectional dataset collected among inpatient nurses at Cut Meutia Regional Hospital, North Aceh, Indonesia, between October 2025 and January 2026. No new participant contact or data collection was undertaken for this analysis.

2.2 Participants and analytic sample

The original data were collected using proportional stratified random sampling across inpatient units. Eligible participants were nurses actively working in inpatient services who provided informed consent. Nurses who were on leave, temporarily inactive, or undertaking further education without active full clinical duties during data collection were not eligible. The final master dataset contained 148 complete records. All 148 records were included in the present analysis, and no imputation was required for the variables used in statistical models.

2.3 Variables and operational definitions

The outcome was self-reported hand hygiene compliance, with a maximum score of 26; participants scoring 26 were classified as compliant, and those scoring <26 as non-compliant. HAIs knowledge was assessed using a 24-item questionnaire and categorized as low (0–13), moderate (14–17), or high (18–24), with low knowledge as the reference group.

The primary adjusted model included work duration (<3 vs ≥3 years), HAIs training, hand hygiene training, and sex. Age and education were included in the sensitivity analyses, whereas the inpatient unit was examined separately in a ward-stratified model to account for possible unit-level differences in culture, supervision, and workflow.

2.4 Study instruments

Both instruments were locally developed/adapted and pilot-tested before the main study. The HAIs knowledge questionnaire initially comprised 30 multiple-choice items covering definitions, causes, transmission, types, risk factors, and prevention. Six items were removed after pilot validity testing, leaving 24 items. Cronbach's α was 0.939 in the 15-nurse pilot sample and 0.762 in the 148-participant analytic dataset. The 13-item hand hygiene self-assessment instrument incorporated the five WHO hand hygiene moments described by Sax et al. (2007), six technique items, and two duration items. Responses were scored from 0 to 2, with reverse scoring for unfavorable items. Maximum scores were assigned for recommended hand hygiene durations. All items met pilot validity criteria. Cronbach's α was 0.900 in the pilot sample and 0.643 in the analytic dataset. Pilot testing was conducted at another regional hospital, and the instrument was informed by WHO hand hygiene principles (WHO, 2009).

2.5 Statistical analysis

Categorical variables were summarized using frequencies and percentages. Because self-reported compliance was common (64.9%), modified Poisson regression with robust variance was used to estimate crude and adjusted prevalence ratios (PRs and aPRs) with 95% confidence intervals (CIs) and two-sided p-values [14–16]. HAIs knowledge was modelled as moderate versus low and high versus low, with its overall effect assessed using a joint robust Wald test. Three sensitivity analyses were performed: an

extended Poisson model additionally adjusted for age and education, logistic regression using the primary covariates, and post hoc conditional logistic regression stratified by the inpatient unit. One unit without within-unit variation in compliance was excluded, leaving 140 participants across 15 informative strata. Statistical significance was set at $p<0.05$. Analyses were conducted using Python 3.13.5 with StatsModels 0.14.6, NumPy 2.3.5, and SciPy 1.17.0.

Ethical considerations

The original study was approved by the Health Research Ethics Committee, Cut Meutia Hospital, North Aceh (No. 049/KEPK-RSUCM/IX/2025; September 25, 2025). Written informed consent was obtained from all participants before data collection. The present analysis used the same de-identified dataset and involved no new participant contact. Confidentiality was maintained throughout the data processing and analysis.

3 Results

3.1 HAIs knowledge and hand hygiene compliance

Among the 148 nurses, 41 (27.7%) had low HAIs knowledge, 52 (35.1%) had moderate knowledge, and 55 (37.2%) had high knowledge. The self-reported hand hygiene compliance rates were 46.3%, 67.3%, and 76.4% in the low-, moderate-, and high-knowledge groups, respectively (Table 1).

Table 1. Self-reported hand hygiene compliance by HAIs knowledge level (n=148).

HAIs knowledge	Non-compliant	Compliant	Compliance prevalence
Low	22 (53.7%)	19 (46.3%)	46.3%
Moderate	17 (32.7%)	35 (67.3%)	67.3%
High	13 (23.6%)	42 (76.4%)	76.4%
Total	52 (35.1%)	96 (64.9%)	64.9%

3.2 Primary multivariable analysis

In the modified Poisson regression with robust variance, moderate HAIs knowledge was associated with a 49% higher prevalence of self-reported compliance than low knowledge (aPR 1.49, 95% CI 1.03–2.17; p=0.035), while high knowledge was associated with a 72% higher prevalence (aPR 1.72, 95% CI 1.18–2.49; p=0.004). Considered jointly, the two knowledge indicators contributed significantly to the adjusted model (robust Wald $\chi^2=8.16$, df=2, p=0.017). Work duration, HAIs training, hand hygiene training, and sex were not statistically significant in the adjusted prevalence-ratio model (Table 2).

Table 2. Crude and adjusted prevalence ratios for self-reported hand hygiene compliance.

Variable	Crude PR (95% CI)	p	Adjusted PR (95% CI)
Moderate knowledge (vs low)	1.45 (0.99–2.12)	0.054	1.49 (1.03–2.17)
High knowledge (vs low)	1.65 (1.15–2.36)	0.007	1.72 (1.18–2.49)
Work duration ≥3 years (vs <3 years)	0.93 (0.70–1.22)	0.589	0.94 (0.71–1.24)
Ever had HAIs training (vs never)	0.91 (0.70–1.20)	0.508	0.83 (0.63–1.09)
Ever had hand hygiene training (vs never)	1.00 (0.78–1.29)	0.977	1.03 (0.79–1.34)
Female (vs male)	0.99 (0.74–1.31)	0.918	0.97 (0.71–1.31)

PR, prevalence ratio. The adjusted model included HAIs knowledge, work duration, HAIs training, hand hygiene training, and sex.

3.3 Sensitivity analyses

Sensitivity analyses supported the primary findings. In an extended modified Poisson model that was additionally adjusted for age group and education, the estimates remained significant for moderate knowledge (aPR 1.47, 95% CI 1.02–2.13; p=0.041) and high knowledge (aPR 1.78, 95% CI 1.23–2.57; p=0.002). Conventional logistic regression produced directionally consistent associations: moderate knowledge was associated with higher odds of compliance than low knowledge (aOR 2.66, 95% CI 1.12–6.33; p=0.027), and high knowledge was associated with even higher odds (aOR 4.40, 95% CI 1.76–11.03; p=0.002). The two-degree-of-freedom likelihood ratio test for the knowledge block was significant (χ^2=10.95, p=0.004). In the ward-stratified conditional logistic model, the knowledge association remained positive for moderate knowledge (OR 4.29, 95% CI 1.47–12.51; p=0.008) and high knowledge (OR 2.92, 95% CI 1.09–7.82; p=0.033). Because the ordering of the ward-stratified estimates differed from the primary analysis, the findings were not interpreted as evidence of a dose-response relationship (Table 3).

Table 3. Sensitivity analyses of HAIs knowledge and self-reported hand hygiene compliance

Analysis	Knowledge category	Effect estimate (95% CI)	p
Conventional logistic regression	Moderate vs low	aOR 2.66 (1.12–6.33)	0.027
Conventional logistic regression	High vs low	aOR 4.40 (1.76–11.03)	0.002
Ward-stratified conditional logistic regression	Moderate vs low	OR 4.29 (1.47–12.51)	0.008
Ward-stratified conditional logistic regression	High vs low	OR 2.92 (1.09–7.82)	0.033
Extended Poisson (+ age, education)	Moderate vs low	aPR 1.47 (1.02–2.13)	0.041
Extended Poisson (+ age, education)	High vs low	aPR 1.78 (1.23–2.57)	0.002

4 Discussion

Higher HAIs knowledge was associated with greater self-reported hand hygiene compliance after adjustment for work duration, HAIs training, hand hygiene training, and sex. In the primary prevalence-ratio model, nurses with moderate knowledge had a 49% higher prevalence of compliance, and those with high knowledge had a 72% higher prevalence than those with low knowledge. The association remained statistically significant after additional adjustment for age and education and in the logistic and ward-stratified sensitivity analyses. However, the cross-sectional design does not establish whether higher knowledge leads to better compliance.

Similar associations between knowledge and hand hygiene behavior have been reported in previous studies. A systematic review of healthcare workers identified knowledge as one factor related to infection-prevention compliance, alongside training, risk perception, organizational culture, and resource availability[6]. Pooled evidence from Ethiopia also identified knowledge and training as correlates of hand hygiene compliance [9], and an Indonesian cross-sectional study reported a positive knowledge-compliance association among nurses [10]. An Indonesian hospital-based systematic review identified knowledge among several determinants, including attitude, motivation, supervision, and facilities [17]. Another Indonesian study reported associations between compliance and several individual and organizational factors, with knowledge, attitude, and supervision remaining in the final multivariable model [18]. A recent systematic review and meta-analysis of Indian healthcare workers reported a similar pattern [19]. Because compliance was common in the present study, the adjusted prevalence ratios are more appropriate for interpretation than the larger logistic odds ratios [14,16].

Knowledge did not explain all the variations in compliance in this dataset. Recent systematic reviews describe barriers including workload and time pressure, inadequate

or inconvenient facilities, social norms, feedback, leadership, hierarchy, and misconceptions about hand hygiene [5,7,20]. A formative study of nurses in United States hospitals identified institutional and behavioral determinants, including communication openness, perceived peer performance, and cognitive load, beyond knowledge alone [21]. An Indonesian study also found a significant relationship between supervision and nurses' hand hygiene compliance, although non-compliance was still observed among some nurses who reported good supervision [22]. Observational evidence from tertiary hospitals in Bangladesh likewise showed variation in compliance by professional role, clinical context, supplies, and institutional conditions [11]. One possible explanation for the null association with training history in the present model is the limited information captured by a binary ever/never measure, which does not reflect training quality, recency, reinforcement, workplace support, or opportunity to perform hand hygiene. Workload may also affect compliance: a multicenter analysis of more than 42,000 observed hand hygiene opportunities found that adherence remained relatively stable until care demands exceeded approximately 30 opportunities per hour, after which compliance fell substantially [23]. Previous work has reported sex-related differences in several psychosocial barriers to hand hygiene, including habit, forgetfulness, and perceptions of time [24]. In the present study, however, sex was not independently associated with self-reported compliance.

In the ward-stratified analysis, moderate and high knowledge remained positively associated with compliance, but the relative ordering of the two estimates changed. This argues against a simple dose-response interpretation and suggests that the unit-level context may modify or confound the apparent relationship between knowledge and behavior. Therefore, hospital hand hygiene programs should avoid treating education as a stand-alone intervention. Current expert recommendations support multimodal strategies that combine education with accessible hand hygiene products, monitoring and feedback, leadership support, and a safety culture that facilitates compliance during routine care [25]. A hospital-wide program combining education, bedside feedback, and improved product access achieved a sustained rise in compliance alongside a fall in healthcare-associated infection rates [26]. A Cochrane systematic review also found that several multimodal interventions may improve hand hygiene compliance, although the certainty of evidence was generally low, and the relative advantage over simpler strategies remained uncertain [27].

The use of self-reported compliance also requires caution. Self-assessment can capture perceived routine behavior but is vulnerable to recall and social-desirability bias and is not equivalent to direct observation of WHO hand hygiene opportunities. Studies using direct observation often report substantial variability in compliance across settings and clinical moments [11,28,29]. Even direct observation is not free of bias: electronic hand hygiene monitoring studies have found that measured compliance can fall substantially once an observer is no longer visibly present, a pattern consistent with the Hawthorne effect [30]. Reported compliance has also fluctuated over time in some settings as pandemic-era vigilance recedes [31], reinforcing the need for sustained, structural reinforcement rather than one-off training campaigns. Future work at Cut Meutia Regional Hospital should therefore pair validated knowledge measurement with direct

observational audits or electronic monitoring, and should measure organizational factors such as workload, product availability, supervision, feedback, and safety climate.

5 Conclusion

Higher HAIs knowledge was associated with greater self-reported hand hygiene compliance among inpatient nurses at a regional hospital in Indonesia. Moderate and high knowledge remained positively associated with compliance after multivariate adjustment and across sensitivity analyses. Because the study was cross-sectional and based on self-report, the findings should be interpreted as evidence of association rather than causation. These findings support considering knowledge strengthening as one component of broader infection-prevention programmes that also address supervision, feedback, resources, and ward-level working conditions.

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Disclosure of Interests. The authors declare no competing interests.

References

1. Organization WH. Global report on infection prevention and control 2024. Geneva: World Health Organization; 2024.
2. Goh LPW, Marbawi H, Goh SM, Abdul Asis AKB, Gansau JA. The prevalence of hospital-acquired infections in Southeast Asia (1990-2022). J Infect Dev Ctries 2023;17:139–46.
3. Glowicz JB, Landon E, Sickbert-Bennett EE. SHEA/IDSA/APIC practice recommendation: strategies to prevent healthcare-associated infections through hand hygiene: 2022 update. Infect Control Hosp Epidemiol 2023;44:355–76.
4. Mouajou V, Adams K, DeLisle G, Quach C. Hand hygiene compliance in the prevention of hospital-acquired infections: a systematic review. J Hosp Infect 2022;119:33–48.
5. Afework A, Tamene A. Uncovering the obstacles: a comprehensive analysis of barriers to hand hygiene adherence among healthcare providers: a systematic review. BMC Infect Dis 2025;25:502.
6. Alhumaid S, Al Mutair A, Al Alawi Z. Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. Antimicrob Resist Infect Control 2021;10:86.
7. Issac A, Nayak SG, George R, Priyadarshini T, Jacob J. Facilitators and barriers to hand hygiene compliance among health care providers in hospital settings: a qualitative systematic review. Nurs Health Sci 2026;28:e70297.
8. Erasmus V, Daha TJ, Brug H, Richardus JH, Behrendt MD, Vos MC. Systematic review of studies on compliance with hand hygiene guidelines in hospital care. Infect Control Hosp Epidemiol 2010;31:283–94.
9. Soboksa NE, Negassa B, Kanno GG, Ashuro Z, Gudeta DB. Hand hygiene compliance and associated factors among healthcare workers in Ethiopia: a systematic review and meta-analysis. Adv Prev Med 2021;2021:7235248.

10. Suhaimi M, Sukamto E, Ratanto. Relationship between knowledge level and hand hygiene compliance among nurses at Kudungga Sangatta Regional Hospital. Formosa J Appl Sci 2024;3:1417–28.
11. Harun MGD, Anwar MMU, Sumon SA. Hand hygiene compliance and associated factors among healthcare workers in selected tertiary-care hospitals in Bangladesh. J Hosp Infect 2023;139:220–7.
12. Silva J, Antunes C, Batista S. "I know what I have to do, but I don't do it": the relationship between knowledge and adherence to hand hygiene in healthcare settings. Healthcare (Basel) 2025;13:530.
13. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 2007;370:1453–7.
14. Barros AJD, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. BMC Med Res Methodol 2003;3:21.
15. McNutt LA, Wu C, Xue X, Hafner JP. Estimating the relative risk in cohort studies and clinical trials of common outcomes. Am J Epidemiol 2003;157:940–3.
16. Zou G. A modified Poisson regression approach to prospective studies with binary data. Am J Epidemiol 2004;159:702–6.
17. Fitriani F, Rondhianto R, Ismara KI. Determinant analysis of hand hygiene compliance and its relation to HAIs in hospitals: systematic literature review. Poltekita J Ilmu Kesehat 2024;17:1206–16.
18. Tien W, Komariah M, Nurhakim F. Relationship between knowledge, attitude and supervision hand hygiene compliance. Poltekita J Ilmu Kesehat 2024;18:94–100.
19. Basu S, Roy S, Roy D, Maheshwari V. Prevalence and determinants of hand hygiene knowledge, compliance, and practices among Indian healthcare workers: a systematic review and meta-analysis. Trop Med Int Health 2026;31:113–37.
20. Abalkhail A, Elbehiry A. Barriers and facilitators of health care workers' compliance with infection prevention and control practices in health-care facilities: a systematic literature review. Indian J Public Health 2025;69:74–81.
21. Sands M, Aunger R. Determinants of hand hygiene compliance among nurses in US hospitals: a formative research study. PLoS One 2020;15:e0230573.
22. Khasha M, Anggryni M, Ahzani Y, Astuti NLS. The relationship of supervision with nurses' hand hygiene compliance. Indones J Glob Health Res 2024;6:3911–20.
23. Chang NCN, Schweizer ML, Reisinger HS, Jones M, Chrischilles E, Chorazy M. The impact of workload on hand hygiene compliance: is 100% compliance achievable? Infect Control Hosp Epidemiol 2022;43:1259–61.
24. Park SY, Kim J, Lee E. Gender differences in psychosocial determinants of hand hygiene among physicians. Infect Control Hosp Epidemiol 2024;45:215–20.
25. Glowicz JB, Landon E, Sickbert-Bennett EE. SHEA/IDSA/APIC practice recommendation: strategies to prevent healthcare-associated infections through hand hygiene: 2022 update. Infect Control Hosp Epidemiol 2023;44:355–76.
26. Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Lancet 2000;356:1307–12.
27. Gould DJ, Moralejo D, Drey N, Chudleigh JH, Taljaard M. Interventions to improve hand hygiene compliance in patient care. Cochrane Database Syst Rev 2017;9:CD005186.

28. Bajunaid RM, Saeed A, Bostaji M, Farsi NJ. Hand hygiene compliance and improvement interventions in the Eastern Mediterranean Region: a systematic review and meta-analysis. Infect Prev Pract 2024;6:100363.
29. Mouajou V, Adams K, DeLisle G, Quach C. Hand hygiene compliance in the prevention of hospital-acquired infections: a systematic review. J Hosp Infect 2022;119:33–48.
30. Srigley JA, Furness CD, Baker GR, Gardam M. Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. BMJ Qual Saf 2014;23:974–80.
31. Wang Y, Yang J, Qiao F, Feng B, Hu F, Xi ZA. Compared hand hygiene compliance among healthcare providers before and after the COVID-19 pandemic: a rapid review and meta-analysis. Am J Infect Control 2022;50:563–71.

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