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Evaluation of hand hygiene adherence following multimodal hand hygiene strategies in a tertiary care hospital – a quasi-experimental pre–post study

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ABSTRACT

Introduction and aim. Although hand hygiene (HH) is a simple and inexpensive way to prevent healthcare-associated infections (HAI), adherence among healthcare workers (HCW) remains suboptimal. Few studies distinguish whether HH is performed from whether it is performed correctly in HCW categories, clinical areas, and WHO moments. Therefore, we compared total, complete, and partial adherence to HH before and after a WHO multimodal HH improvement program.

Material and methods. We conducted a quasi-experimental pre-post observational study in a tertiary care teaching hospital between May 2024 and April 2025. The study comprised a 5-month baseline, a 2-month intervention and a 5-month post-intervention phase; the intervention comprised the five components of the WHO multimodal strategy. HH opportunities in intensive care units (ICU) and general wards were assessed by unannounced direct observation of all categories of HCW, and 1,370 opportunities were included in the pre–post comparison (685 baseline and 685 post-intervention; intervention-phase observations from the intervention phase were not included). Total adherence (any HH action) consisted of complete adherence (all six WHO steps for the recommended duration) and partial adherence. The proportions were compared with Pearson's chi-square test, without adjustment for clustering.

Results. The total adherence rate to HH (HHTAR) was 48.61% in the initial phase and 72.85% in the post-intervention phase ($p<0.001$). Complete adherence rose from 2.48% to 22.34% ($p<0.001$) and partial

adherence from 46.13% to 50.51%; therefore, fewer than one third of post-intervention HH actions met the full WHO technique and duration criteria. Descriptively, adherence was higher after the intervention in the ICU and general wards and in all WHO Moments, and unit-wise audits showed higher adherence after education in each audit unit.

Conclusion. The post-intervention period was associated with higher observed HH adherence; however, this uncontrolled pre–post design does not establish causality. Complete adherence remained low, indicating that improving the HH technique, not only the frequency of HH actions, is a priority. Whether these gains persist and the lower HAI rates require longer follow-up.

Keywords. guideline adherence, hand hygiene, infection control

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Introduction

Healthcare-associated infections (HAI) are a major threat to patient safety worldwide, adding to morbidity, mortality, length of stay, costs, and antimicrobial resistance. This burden falls most heavily on low- and middle-income countries, in which infection prevention and control (IPC) resources and infrastructure are often constrained.[1-3] Robust IPC practices are therefore needed to prevent avoidable transmission in hospitals.

In healthcare settings, pathogens spread through direct and indirect contact, respiratory droplets, contaminated equipment, and the inanimate environment.[4] The hands of healthcare workers (HCW) are a major route of spread, as they can pick up organisms when touching patients, body fluids, devices, and nearby surfaces.[4] Hand hygiene (HH) breaks this chain and ranks among the simplest and most cost-effective ways of preventing transmission in healthcare facilities.[4]

The World Health Organization (WHO) framework "My Five Moments for Hand Hygiene" specifies when HH is required: before touching a patient, before a clean or aseptic procedure, after a risk of body fluid exposure, after touching a patient, and after touching the patient's surroundings.[5,6] The WHO Multimodal Hand Hygiene Improvement Strategy combines five elements (system change, training and education, evaluation and feedback, workplace reminders, and an institutional safety climate) to tackle both structural and the behavioural obstacles to good HH practice.[7] Current guidance further stresses that HH facilities should be readily accessible and that appropriate HH should be performed at the point of care.[8,9]

Even with clear recommendations and proven interventions, HH adherence among HCWs is inconsistent. Systematic reviews show that interventions can increase compliance, but the size and durability of the gains depend on the type of intervention, the setting, and how it is implemented.[10,11] In a large international quasi-experimental study, the WHO multimodal strategy improved HH compliance in facilities in high-income as well as low and middle-income countries.[2] However, the evidence on implementation and sustainability is mixed, especially when different professional groups and clinical environments are compared.

Measuring HH adherence is essential to any improvement program. Direct observation is the accepted method for recording HH opportunities and allows analysis by professional category, clinical area, and WHO Moment.[12-14] It is, however, labor intensive and prone to observer-related bias. Furthermore, a single aggregate compliance figure can conceal differences between HCW cadres, clinical areas, and individual HHH opportunities.

The WHO multimodal strategy, direct observation, and pre–post evaluation have been studied extensively,[2,5,14] and are not novel in themselves. However, most evaluations report only whether an HH action was performed at an indicated opportunity and not whether it was performed correctly. Data that simultaneously examine professional categories, intensive care units (ICUs) and general wards, and individual WHO moments, while distinguishing complete from partial adherence, remain limited, particularly from resource-constrained tertiary care hospitals. Nonclinical personnel, such as housekeeping, kitchen, and security personnel, are also rarely included in HH audits, although they frequently handle patient surroundings, linen, food trays, waste and shared surfaces, and may contribute to indirect transmission through the healthcare environment.[4] The contribution of the present study therefore lies not in the multimodal strategy itself, but in its combined assessment of total, complete, and partial adherence across HCW categories (including nonclinical personnel), clinical areas, and WHO Moments.

Aim

The primary objective of this study was to compare the total adherence rate (HHTAR) between the baseline and postintervention phases following implementation of a WHO multimodal HH strategy in the ICU and general wards of a tertiary care hospital. Secondary objectives were to describe HH by professional category, clinical area, and WHO Moment, and to evaluate the quality of HH performance by distinguishing complete from partial adherence.

Material and methods

Study design and setting

This was a quasi-experimental, pre–post observational study conducted over a 12-month period (May 2024–April 2025). The study consisted of three predefined phases. During the first 5 months (May 2024 to September 2024), baseline HH observations were performed in intensive care units (ICUs) and general wards under routine infection control surveillance. During the subsequent 2-month intervention phase (October-2024), the five components of the WHO multimodal HH strategy were implemented simultaneously as a bundled intervention. During the final 5 months (December 2024–April 2025), postintervention observations were conducted using the same surveillance approach. The preintervention and postintervention phases contributed 685 observations each (1,370 observations in total) to the primary pre–post analysis. Routine surveillance during the intervention phase was used to support implementation

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and monitoring and was not treated as a separate pre–post comparison group. Observation data were anonymized at the time of collection. The intervention and surveillance were carried out prospectively as part of routine IPC activities, while the present analysis was performed retrospectively using these routinely collected surveillance records.

The intervention was implemented in participating ICUs and general wards; the postintervention evaluation used the same rotating surveillance approach.

Study population and sampling

HCWs were defined as all personnel involved in direct or indirect patient care, including consultants, resident physicians, nurses, ward attendants, allied health professionals (laboratory technicians and physiotherapists), housekeeping personnel, kitchen personnel, and security personnel. A total of 1,370 HH opportunities were observed across all categories during the study period, contributed by 443 individual workers (158 doctors, 205 nurses, and 80 other workers). Observations followed a rotating monthly sampling design, in which an ICU or general ward was audited intensively each month before moving to the next clinical area, so that all main clinical areas and HCW categories were represented throughout the 12-month study period. The same clinical areas were evaluated in both the baseline and post-intervention phases; however, the number of observations contributed by each clinical area, the HCW category, and the WHO Moment could not be recovered, so differences in their relative contribution between phases may have influenced overall adherence rates. No a priori sample size calculation was performed; the number of opportunities reflects the routine surveillance records available for the baseline and post-intervention phases. Additionally, 1,767 opportunities with 808 HH actions (45.73%) were recorded in all audits. Category-wise adherence for all combined audits, and unit-wise adherence was recorded as within-unit audits before and after an education session in each unit; these data are reported descriptively (Fig. 1 and 3).

Multimodal intervention

The intervention comprised five components aligned with the WHO multimodal HH improvement strategy:

(i) System change: ensuring the availability of alcohol-based hand rub (ABHR), soap, water and hand-drying facilities.

(ii) Staff education and training: cadre-specific HH and IPC training was delivered through weekly nursing staff meetings, PowerPoint-based teaching sessions, and dedicated HH/IPC classes held every Friday for doctors, nurses, technicians, students, support staff, kitchen personnel, and security staff; HH posters were displayed at point-of-care locations as a continuous visual reminder.

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(iii) Continuous evaluation and monitoring: daily rounds of the ward were conducted in each ICU and general ward by a team of six trained infection control nurses (ICN), who performed direct observation of the HH practice as part of routine IPC surveillance.

(iv) Performance feedback: quarterly 'lapse meetings' were held, at which department-wise antimicrobial resistance (AMR), surgical site infection (SSI) and HH adherence data were presented to identify departments with performance gaps and reinforce accountability; feedback to physician groups also included peer-comparison data.

(v) Institutional engagement and workplace reminders: an annual celebration and awareness activities of Hand Hygiene Day, including a nukkad natak (street theater) performance, were conducted to maintain institution-wide engagement with HH practice, in addition to standardized WHO HH posters and point-of-care signals in all areas of contact with patients.

The baseline phase represented routine surveillance before the implementation of the multimodal program. The intervention phase comprised the implementation and reinforcement of all five components, while the final 5-month phase represented the post-intervention evaluation. Daily ICN surveillance rounds were part of routine IPC practice throughout the three phases. During the intervention phase (October to November 2024), the five components were introduced and reinforced together as a structured bundle; education, quarterly feedback, and workplace reminders continued during the post-intervention phase. Training sessions and attendance were recorded only cumulatively across all institutional teaching schedules, so the number of sessions and the proportion of staff trained specifically for the HH intervention could not be separately quantified.

Observation protocol, observer training, and minimization of bias

Direct observation was performed by the six trained ICNs described above, who were routinely assigned to surveillance activities in different clinical areas. ICNs identified HH opportunities in their routine IPC rounds, following the rotating monthly sampling scheme described above. Each ICN used the standard WHO HH observation form to record HCW category, clinical area (ICU or ward), the WHO Moment triggered and whether the indicated HH action was performed. When an HH action was performed, the ICN also recorded whether the six WHO steps were completed and whether the action met the recommended duration. The duration was visually estimated by the observer, and the consistency between the observers was supported by common training and periodic review of the observation records.

To limit observer bias and the Hawthorne effect, observations were unannounced and nonparticipatory and took place during routine rounds at unpredictable times. All ICNs received standardized training in WHO HH observation methodology before the study and attended periodic refresher sessions, including weekly recurring training sessions. Adherence data were reviewed at quarterly IPC (lapses) meetings; comparing observation patterns between ICNs and departments at these meetings helped to keep observation methods

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uniform. Observers knew which study phase they were observing, and inter-rater reliability was not formally measured; both points are acknowledged as limitations.

Adherence definitions

HH opportunities were recorded according to the five WHO moments: before patient contact (M1), before an aseptic procedure (M2), after risk of exposure to body fluids (M3), after patient contact (M4), and after contact with patient surroundings (M5). When multiple indications occurred simultaneously, a single HH opportunity was recorded. HH actions included washing hands with soap and water or the use of ABHR. Three adherence categories were defined: complete adherence (HHCAR), defined as the correct performance of all six WHO HH steps for ≥20 seconds with ABHR or ≥40 seconds with soap and water; partial adherence (HHPAR), omission of one or more steps and/or inadequate duration; and nonadherence, no HH action performed. The total HH adherence rate (HHTAR) was calculated as the sum of HHCAR and HHPAR, representing the proportion of HH opportunities in which any HH action was performed. HHTAR was used as the primary measure of any HH action throughout the manuscript. Each observation encounter was additionally coded for HCW category, clinical area, WHO moment and HH action performed (1) or not performed (0), and entered into a structured database in Microsoft Excel (Microsoft Corp., Redmond, WA, USA). The five WHO moments represent the clinical indications that trigger an opportunity for HH, while complete, partial and non-adherence describe the quality of the HH action performed at each opportunity.[6,13,15,16] The complete and partial adherence categories are study-specific operational definitions based on WHO technique and duration recommendations (20–30 seconds for hand rubbing and 40–60 seconds for handwashing).[9] The standard WHO observation-based compliance measure, which records only whether an HH action was performed at an indicated opportunity, corresponds to HHTAR in this study.

Statistical analysis

HH adherence rates were summarised using descriptive statistics (frequencies and percentages). The differences in HHTAR, HHCAR, and HHPAR between the pre- and post-intervention phases were assessed using Pearson's chi-square test, with exact χ^2 values of 2 and p-values reported; These analyzes were unadjusted and is presented as exploratory because the observation level data were clustered within HCW, clinical areas, months, and observers. Adherence by professional category, clinical area, and WHO moment is descriptively reported because phase-wise subgroup denominators were not available. For the overall comparison before - after HHTAR, for which the full analytic sample size (N=1,370) was known, the effect size was additionally calculated as the phi coefficient ($\varphi=\sqrt{[\chi^2/N]}$) and interpreted using conventional benchmarks (small 0.10, medium ≈0.30, large ≈0.50). A p-value <0.05 was considered statistically significant. Data were analyzed using IBM SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA).

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Pearson's chi-square test assumes independent observations. Because the 1,370 HH opportunities in this dataset are clustered within individual HCWs, professional categories, wards/ICUs, months, and observers, this assumption is not strictly met, and the reported p-values and effect size may be optimistic; this is discussed further as a limitation below. The p-value reported for HHCAR was derived from a separate 2×2 comparison of complete versus non-complete adherence between phases.

Results

Pre-post comparison included 1,370 HH opportunities (685 in each phase) observed in ICU and general wards, involving all categories of HCW. Category-wise adherence was available only for all combined audits (1,767 opportunities) and is presented first.

Adherence by category of healthcare worker

Across all audits recorded (1,767 opportunities; 808 HH actions; 45.73%), adherence was 44.27% (317/716) among physicians, 46.17% (458/992) among nurses, and 55.93% (33/59) among other health workers (Fig. 1). Category counts were not recorded separately for the pre- and post-intervention phases; phase-wise adherence by HCW category was recorded only as percentages for each WHO moment (Fig. 5). These results are descriptive.

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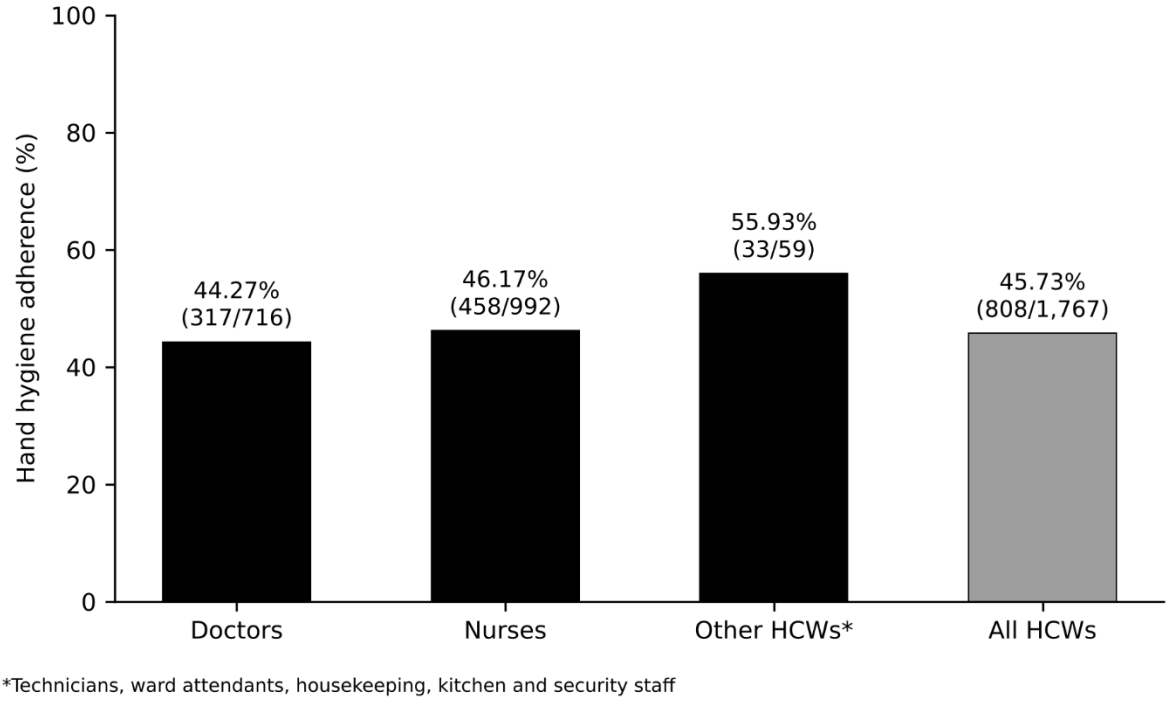

Fig. 1. HH adherence (%) by category of healthcare workers

Total HH adherence (HHTAR)

HHTAR increased after implementation of the multimodal intervention, from 48.61% during the preintervention phase to 72.85% during the postintervention phase, an absolute difference of 24.23 percentage points (95% CI, 19.22–29.24 percentage points; $\chi^2(1)=84.34$, $p<0.001$; $\varphi=0.25$, small-to-medium effect). Consequently, the proportion of HH opportunities without any HH action decreased from 51.39% to 27.15% (Fig. 2).

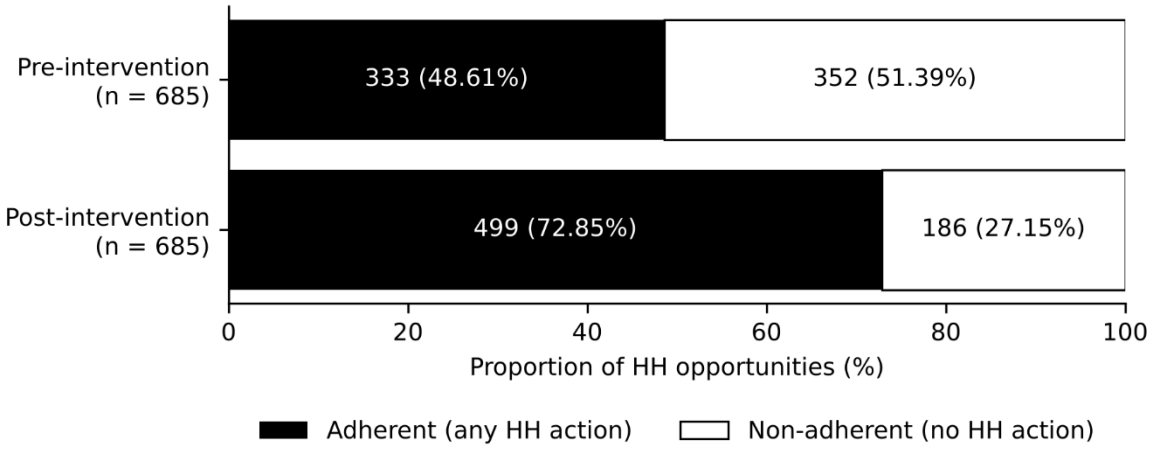

Fig. 2. Total adherence rate (HHTAR) before and after the intervention

Each phase contributed 685 HH opportunities. The number of adherent observations rose from 333 (48.61%) before the intervention to 499 (72.85%) after it, while nonadherent observations fell from 352 (51.39%) to 186 (27.15%) (Table 1).

Table 1. Distribution of HH opportunities by phase, with adherent and nonadherent counts

Phase	HH opportunities (n)	Adherent, n (%)	Non-adherent, n (%)
Pre-intervention	685	333 (48.61)	352 (51.39)
Post-intervention	685	499 (72.85)	186 (27.15)
Total	1,370	–	–

Complete adherence to HH (HHCAR) increased from 2.48% (17/685) to 22.34% (153/685) ($\chi^2(1)=124.21$, $p<0.001$), whereas partial HH adherence (HHPAR) changed from 46.13% (316/685) to 50.51% (346/685) ($\chi^2(1)=2.63$, $p=0.105$) (Table 2). Thus, although any HH action was performed in 72.85% of post-intervention opportunities, only 22.34% met the full criteria for complete adherence.

Table 2. HH pre and postintervention adherence parameters

HH parameter	Pre-intervention, n/N (%)	Post-intervention, n/N (%)	$\chi^2(1)$	p	Effect size/95% CI
Total HH adherence rate (HHTAR)	333/685 (48.61)	499/685 (72.85)	84.34	<0.001	φ=0.25 (small–medium)
Complete HH adherence rate (HHCAR)	17/685 (2.48)	153/685 (22.34)	124.21	<0.001	–
Partial HH adherence rate (HHPAR)	316/685 (46.13)	346/685 (50.51)	2.63	0.105	–

Unit-wise adherence before and after education

In the unit-wise audits, in which each unit was observed before and after an education session, adherence was higher after education in every unit audited (Fig. 3): NHMICU 46.03% to 58.45%, CTVS 38.48% to 51.10%, TICU 40.35% to 53.10%, Ward 2 40.91% to 56.18%, SICU (February) 45.69% to 60.19% and ECSMICU 50.91% to 65.88%. These unit-level results are descriptive.

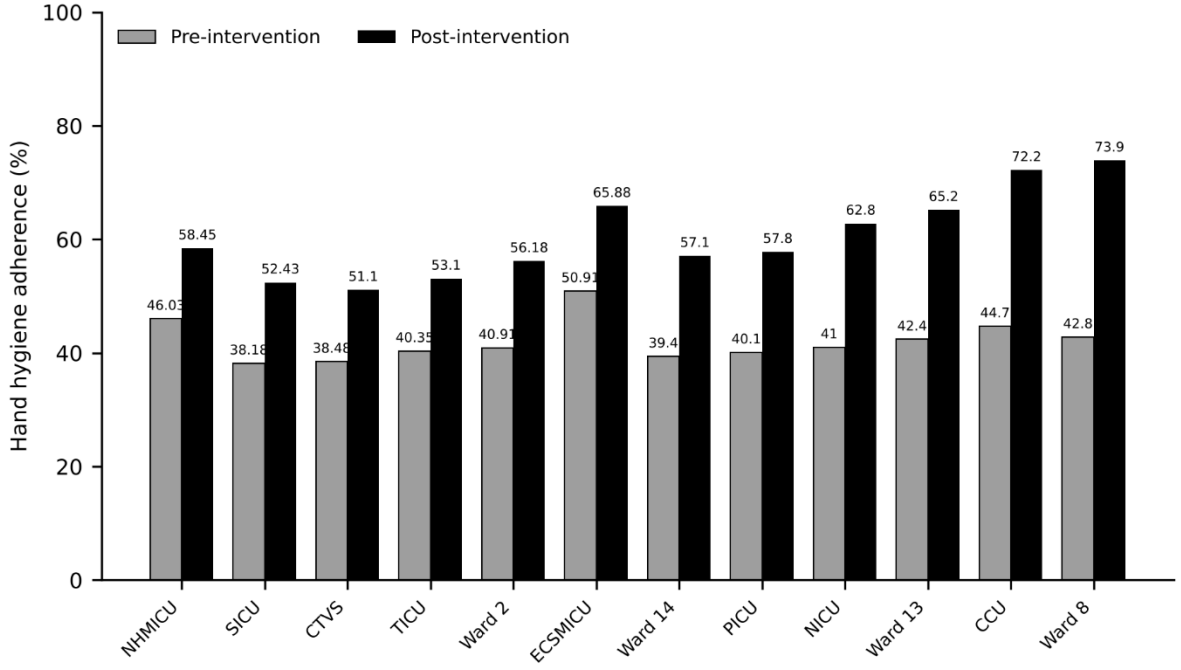

Fig. 3. HH adherence (%) before and after interventions in different units (Ward 13: neurosurgery; Ward 14: orthopedics; Ward 2: burns and plastic surgery; Ward 8: medicine; PICU pediatric ICU, NICU –

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neonatal ICU, SICU – surgical ICU of SICU, trauma ICU, CCU – cardiac care unit CCU, CTVS – cardiothoracic ICU, NHMICU nursing home medical ICU, ECSMICU emergency medicine ICU)

Adherence by clinical area

The ICUs showed higher adherence to HH than general wards in both the preintervention (54.3% vs. 36.2%) and post-intervention (74.8% vs 62.1%) phases (Fig. 4), and adherence was higher after the intervention in both settings (by 20.5 percentage points in ICUs and 25.9 percentage points in the general wards). Because phase-wise denominators for clinical areas were not available, these comparisons are reported descriptively.

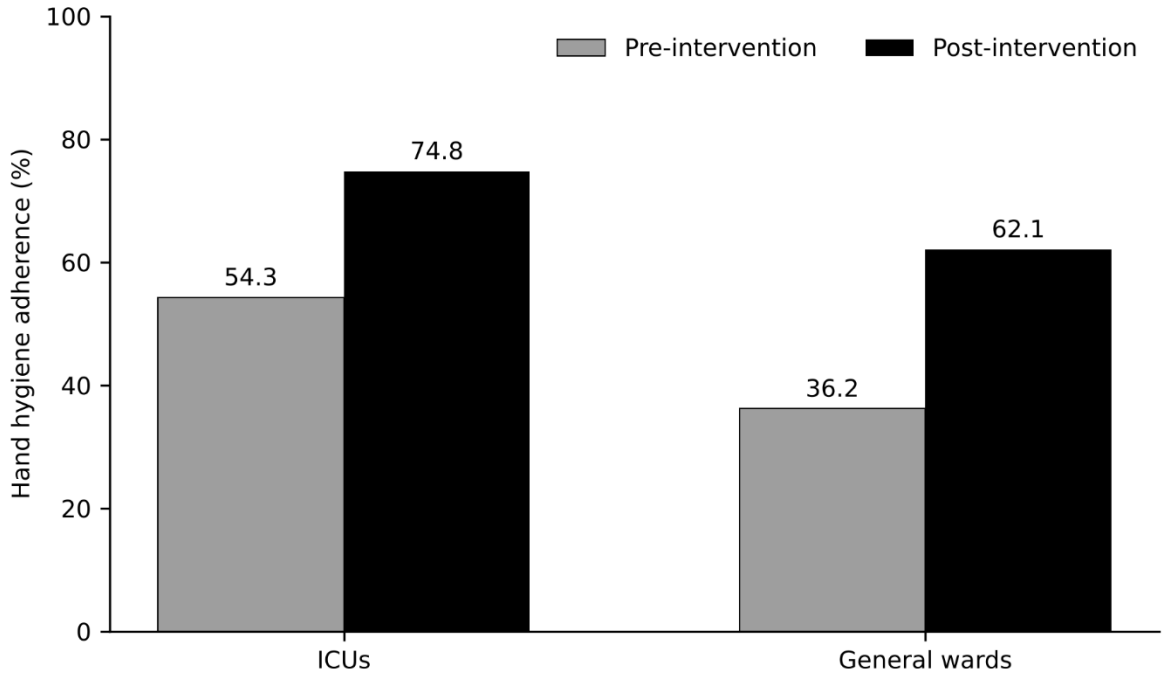

Fig. 4. Comparison of HH adherence (%) between the ICU and the general wards

WHO five moments for hand hygiene

Baseline HH adherence was highest after risk of exposure to body fluids (Moment 3, 52%) and after patient (Moment 4, 49%), whereas the lowest adherence was observed before patient contact (Moment 1, 36%) and before aseptic procedures (Moment 2, 38%). After the intervention, observed adherence was higher across all five WHO moments (Fig. 5): 63% for Moment 1, 65% for Moment 2, 74% for Moment 3, and 71% for Moment 4; adherence after touching patient surroundings (Moment 5) also increased in every category of HCW (Fig. 5). The largest increases were for Moments 1 and 2 (27 percentage points each). Because phase-wise denominators for individual moments were not available, these results are reported descriptively.

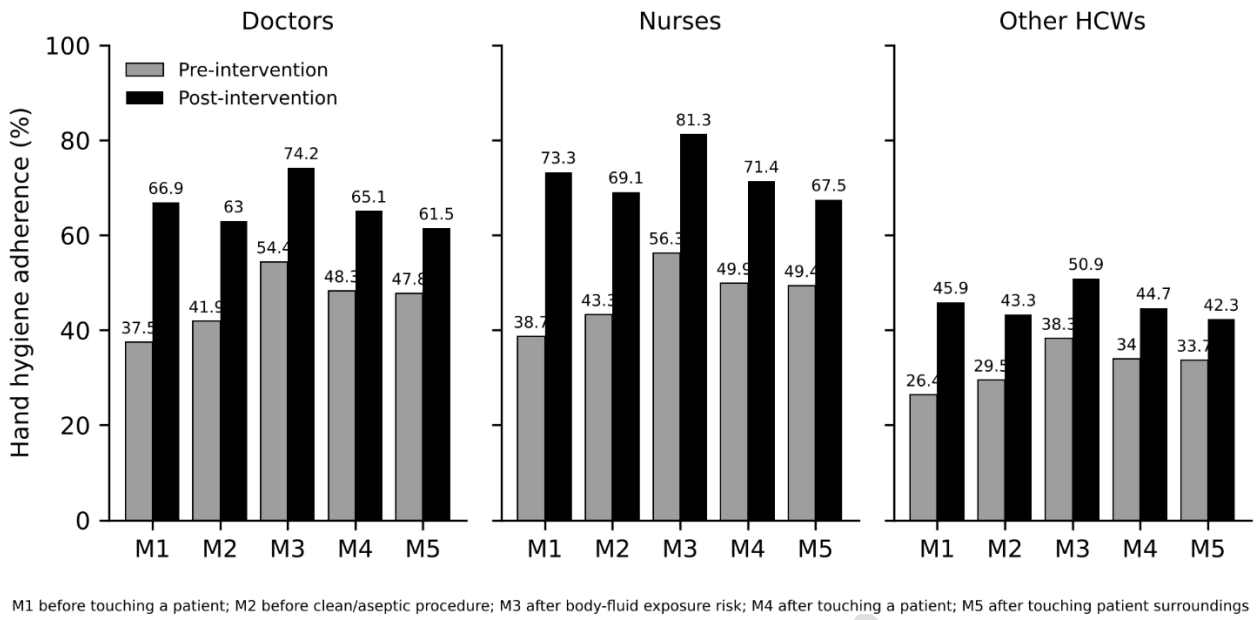

Fig. 5. HH adherence (%) by the five WHO Moments among different HCW

Monthly trend in adherence to HH

The HHTAR increased from 38% in May 2024 to 71% in April 2025 during the 12-month study period (Fig. 6). Because a different clinical area was audited each month, this trend reflects changes in the clinical areas observed, as well as over time, and should not be interpreted as continuous improvement within the same HCW population or clinical area.

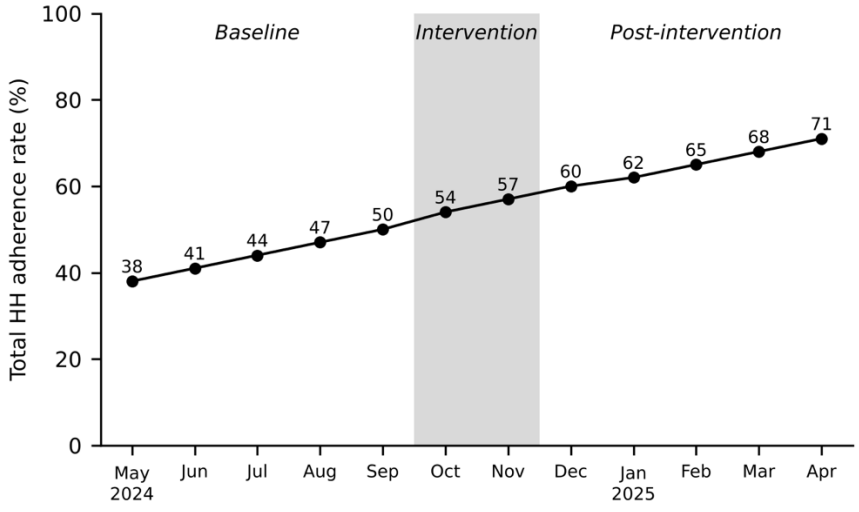

Fig. 6. Month-by-month trend in total HH adherence rate (HHTAR)

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Discussion

In this pre–post study, the total adherence rate increased from 48.61% in the baseline phase to 72.85% in the post-intervention phase, an absolute increase of 24.23 percentage points. However, complete adherence reached only 22.34%, so fewer than one-third of post-intervention HH actions met the full WHO technique and duration criteria. These process findings are relevant because HAIs carry substantial excess mortality; International Nosocomial Infection Control Consortium (INICC) surveillance reported in-hospital mortality of 30.15% among ICU patients who acquired an HAI compared with 17.12% among those who did not.[17] The increase in HHTAR is consistent with previous reports of improved HH adherence after multimodal interventions.[18,19]

The gap between total and complete adherence is one of the most informative findings of this study. It suggests that, after the intervention, the HH was performed more often but did not consistently follow the complete recommended technique and duration. An incomplete technique may reduce the effectiveness of hand rubbing to remove transient flora,[11] so an increase in the frequency of HH actions should not be assumed to provide an equivalent increase in protection. Possible explanations, such as time pressure, workload, and training that emphasized indications for HH more than the technique, are hypotheses that were not tested in this study. Therefore, future training should explicitly address technique and duration, for example through demonstration, supervised practice, and feedback on technique as well as on whether HH was performed.

Chaudhary and Gupta[5] reported an increase from 46.1% to 67.3%, while Rao et al.[20] observed an improvement from 40.9% to 68.4%. Laskar et al.[14] similarly demonstrated significant gains after a multimodal intervention in intensive care units. The present findings also demonstrate the feasibility of manual, paper-based direct observation and audit feedback in a resource-constrained tertiary care setting. However, because this was a quasi-experimental before-and-after study without a concurrent control group, the observed improvement may also reflect temporal or institutional factors not related to the intervention. Direct comparison with these studies is also limited because they differed in intervention content, observation methods, baseline adherence, duration of follow-up and healthcare setting; for example, Chaudhary and Gupta reported observations over 2 years,[5] Laskar et al. focused on intensive care units,14, and Allegranzi et al. evaluated implementation in multiple countries.[2] Moreover, most previous studies reported only whether HH was performed, so their compliance figures correspond to HHTAR rather than complete adherence in the present study.

Across all groups, adherence was similar between physicians (44.27%) and nurses (46.17%) and higher between other nurses (55.93%), although the last group provided few opportunities (n=59). Bredin et al. reported generally higher compliance among nurses than among physicians.[19] Because category-wise counts were not recorded by study phase, changes within professional categories could only be described from the Moment-specific percentages (Fig. 5) and could not be tested statistically. In this study, the reasons

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for the differences between categories were not examined in this study; possible explanations, such as differences in the frequency and type of contact with the patient, the workload and the exposure to training, should be considered hypotheses. However, the inclusion of support staff supports institution-wide HH programs rather than programs restricted to physicians and nurses.

The ICUs had higher adherence than the general wards in both the preintervention phases (54.3% vs 36.2%) and post-intervention phases (74.8% vs. 62.1%), consistent with Hoffmann et al.[12] The general wards nonetheless demonstrated a greater absolute improvement, suggesting that lower performing clinical areas may also benefit from structured HH improvement programs. Therefore, expanding surveillance and audit feedback beyond critical care areas can support more consistent institution-wide HH practice.[21]

Moment-specific analysis showed that baseline adherence was highest after exposure to body fluids (52%) and lowest before patient contact (36%). Lakoh et al.[22] reported a similar pattern, with greater adherence after body fluid exposure (78.3%) and patient contact (76.1%) than before patient contact (55%) and before aseptic procedures (38%). Adherence increased in all five WHO Moments in the present study, consistent with previous evaluations of multimodal HH strategies.[1,2] This pattern highlights the continuing need to reinforce HH indications that occur before patient contact and before aseptic procedures. This finding is clinically important because Moments 1 and 2 are the indications that protect the patient from colonization with healthcare-associated organisms and from infection during invasive procedures, while adherence after body-fluid exposure and patient contact also protects the HCW. Therefore, less adherence before patient contact may reflect greater attention to self-protection than to patient protection. Future training could specifically target these indications through point-of-care ABHR at the bedside, simulation of aseptic procedures such as line and catheter care, and moment-specific audit feedback.

Month-wise, HHTAR increased from 38% in May 2024 to 71% in April 2025. This increase should be interpreted as a trend observed during the 12 month study period rather than evidence of sustained improvement beyond the study period. Similar improvements have been reported by Laskar et al.[14] and Chaudhary and Gupta.[5] Conversely, Stangerup et al.[23] reported declining adherence after discontinuation of regular feedback meetings, supporting the potential importance of continued education, monitoring, and feedback. Because different clinical areas were evaluated in different months, the monthly trend cannot be interpreted as a direct measure of continuous improvement within the same HCW population or clinical area, and the follow-up of 5 months does not establish long-term sustainability, which requires further evaluation.

A strength of the study was the assessment of HH practice across all categories of HCW, ICUs, and general wards, and the five WHO Moments. The inclusion of nonclinical support staff and separate assessment of total, complete and partial adherence provided a more detailed assessment of HH practice than studies reporting only whether HH was performed and showed that performing HH and performing it correctly are distinct outcomes.

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The findings have practical implications for institutional IPC programs. The improvement observed across professional groups and clinical areas supports an institutional-wide approach that combines system change, education and training, monitoring, feedback, and institutional participation5,6 However, because the intervention was implemented as a multimodal package, the relative contribution of individual components cannot be determined. Similarly, the study demonstrates changes in a process indicator (observed adherence to HH) and does not establish whether improved adherence translates into reductions in HAI or other patient-safety outcomes; Improvements in process indicators should not be equated with demonstrated improvements in clinical outcomes.

Study limitations

This study has several limitations. First, without a concurrent control group, the changes observed in this before-and-after design may partly reflect secular trends or other institutional factors. Second, although the same clinical areas were evaluated in both phases, the relative contribution of each clinical area, the HCW category, and the WHO Moment to the observed opportunities may have differed between phases. Third, although observations were nested within HCWs, clinical areas, months, and observers, they were treated as independent in the analysis; Without observation-level data or subgroup denominators, neither multivariate models nor subgroup confidence intervals could be produced, and subgroup results should be read as exploratory. Fourth, because observers were aware of the study phase and interrater agreement was not tested, observer bias and the Hawthorne effect may have influenced the findings. Fifth, the fidelity data was sparse, and delivering the components as a bundle meant that their separate effects could not be estimated. Finally, as a single-center study without patient-level HAI or outcome data, its generalizability and clinical implications are limited.

Conclusion

In this uncontrolled pre–post study, the implementation of a WHO multimodal HH strategy was associated with higher observed adherence to HH in the post-intervention phase (HHTAR 48.61% to 72.85%). However, complete adherence reached only 22.34%, indicating that most HH actions still did not meet the WHO technique and duration criteria. Therefore, improving the quality and consistency of the HH technique, and not only the frequency of HH actions, remains an important priority. Future studies should evaluate sustained adherence and technique over longer follow-up, measure intervention fidelity, use analyses that account for clustering, and examine the relationship between HH adherence and HAI rates.

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Declarations

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Author contributions

Conceptualization, S.D. and S.M.; Methodology, J.M.R.; Software, S.D..; Validation, S.M., S.D., J.M.R. and A.K.; Formal Analysis, S.D. and J.M.R.; Investigation, S.D., J.M.R. and A.K.; Resources, S.M. and A.K.; Data Curation, S.D. and J.M.R.; Writing – Original Draft Preparation, S.D.; Writing – Review & Editing, S.D.; Visualization, S.M.; Supervision, S.M.; Project Administration, S.M.

Conflicts of interest

The authors declare no competing interests.

Data availability

The datasets analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval

This study was conducted as a retrospective analysis of routinely collected, de-identified IPC surveillance and audit data. As the project involved routine quality assurance activities using anonymised observational data without any intervention beyond standard infection prevention and control practices, it was determined to be exempt from formal Institutional Ethics Committee review in accordance with institutional policy. The exemption was based on the applicable institutional policy for routine infection prevention and control quality-assurance activities; no separate written confirmation of exemption was obtained.

Use of AI and AI-assisted technologies

During the preparation of this work, the authors used ChatGPT (OpenAI) solely to assist with grammar, language editing, and improving the clarity of the manuscript. After using this tool, the authors carefully reviewed and edited the content as appropriate and take full responsibility for the content of the published article.

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