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Hand Hygiene Compliance Surveillance, a Comparative Study at Seti Provincial Hospital, Nepal

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Abstract

Background: Hand hygiene (HH) is the cornerstone of infection prevention and control. The WHO's(World Health Organization) "Five Moments for Hand Hygiene" framework emphasizes HH before and after patient contact, before aseptic procedures, after exposure to body fluids, and after contact with patient surroundings. Despite global campaigns, compliance remains suboptimal, often below 50%. In Nepal, studies report compliance rates as low as 24–35%.

Methods: An observational study was conducted using the WHO HH assessment tool (2009). Non-probability purposive sampling selected 40 HCWs(Health Care Workers) (50% nurses, 25% doctors, 25% paramedics) for baseline surveillance (July 2025) and 20 HCWs (75% nurses, 25% paramedics) for follow-up (December 2025). Interventions included visible HH charts at handwashing corners and orientation sessions for 50 HCWs with low compliance. Compliance was assessed across WHO's "Five Moments."

Results: Baseline compliance was poor: nurses (26%), paramedics (22%), doctors (50%). Follow-up showed improvement, particularly before aseptic procedures. Compliance after body fluid exposure remained critically low. Nurses preferred hand rub, paramedics leaned toward hand wash. Gloves were often misused as substitutes for HH.

Conclusion: Interventions improved HH compliance, especially among nurses, but critical gaps persisted in high-risk indications. Sustained multimodal strategies—education, point-of-care supplies, reminders, monitoring, and leadership engagement—are essential to achieve WHO's recommended standards and protect patients and staff.

Keywords: Hand hygiene, compliance, healthcare workers, infection prevention, WHO Five Moments, Healthcare-associated infections

Background of the study

The WHO Guidelines on Hand Hygiene in Health Care provide health-care workers (HCWs), hospital administrators and health authorities with a thorough review of evidence on hand hygiene in health care and specific recommendations to improve practices and reduce transmission of pathogenic microorganisms to patients and HCWs. The present Guidelines are intended to be implemented in any situation in which health care is delivered either to a patient or to a specific group in a population. Therefore, this concept applies to all settings where health care is permanently or occasionally performed, such as home care by birth attendants.

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Health care-associated infection (HCAI) places a serious disease burden and has a significant economic impact on patients and health-care systems throughout the world. Yet good hand hygiene, the simple task of cleaning hands at the right times and in the right way, can save lives. Hand hygiene (HH) is the most effective measure to prevent healthcare-associated infections (HAIs). The WHO's "Five Moments for Hand Hygiene" framework emphasizes HH before and after patient contact, before aseptic procedures, after exposure to body fluids, and after contact with patient surroundings (WHO, 2009). Despite global campaigns, compliance among healthcare workers (HCWs) remains suboptimal, often below 50% (Allegranzi & Pittet, 2009). In Nepal, limited resources, high patient loads, and inadequate monitoring contribute to poor HH practices, increasing the risk of HAIs and antimicrobial resistance (Rajbhandari et al., 2015; Duwal et al., 2024). Surveillance of HH compliance is therefore critical to identify gaps and guide interventions.

Problem Statement

Available evidence shows that compliance with hand hygiene recommendations during health care delivery remains suboptimal around the world, with an average of 59.6% compliance levels in intensive care units up to 2018, and extreme differences between high income and low-income countries (64.5% vs 9.1%). Out of every 100 patients in acute-care hospitals, seven patients in high-income countries (HICs) and 15 patients in low- and middle-income countries (LMICs) will acquire at least one health care-associated infection during their hospital stay. (WHO, 2023)

Most health-care facilities have an intermediate level of hand hygiene implementation or higher, for which health care facility funding and country income level are important drivers. Hand hygiene is the most effective measure to prevent healthcare-associated infections (HAIs), yet compliance among healthcare workers (HCWs) remains inconsistent across hospital departments and professional groups. Studies have shown that adherence varies significantly depending on workload, departmental culture, infrastructure availability, and professional role, leading to uneven patient safety outcomes.

In Nepal, compliance rates are particularly low. A recent study in a tertiary hospital in Kathmandu reported an overall hand hygiene compliance of only 30%, with doctors at 37%, nurses at 35%, and paramedics at 23%. These findings highlight substantial gaps across professional categories and clinical settings, underscoring the urgent need for comparative evidence to guide targeted interventions. International evidence also confirms departmental differences: surgical wards often show higher compliance (72%), while radiology and other support units report much lower rates (55%). Nurses tend to demonstrate better adherence compared to physicians and paramedics, but compliance drops during night shifts due to workload pressures and reduced supervision. Despite WHO's "Five Moments for Hand Hygiene" framework, compliance remains below the recommended 80% threshold, both globally and locally. Without comparative analysis, infection prevention programs risk being generalized rather than tailored, limiting their effectiveness.

This study therefore addresses the critical problem of differential hand hygiene compliance by conducting a comparative analysis across hospital departments and professional groups. By identifying patterns, gaps, and determinants of compliance, the research aims to generate actionable insights for targeted interventions, strengthen infection prevention strategies, and enhance patient safety outcomes in Nepal's healthcare system.

Objective of the study

General Objective

To assess HH compliance among healthcare workers using the WHO Hand Hygiene Assessment Tool (2009).

Specific Objective

1. To compare compliance rates before and after interventions.
2. To compare compliance rates among various cadres of healthcare workers.
3. To identify compliance indications across WHO's "Five Moments."

To recommend evidence-based strategies for sustaining compliance gains.

Significance of Study

Most HAIs are preventable through hand hygiene performed at the right times. This study is significant because it addresses a critical gap in infection prevention practices at Seti Provincial Hospital, Nepal. Hand hygiene (HH) is universally recognized as the most effective measure to prevent healthcare-associated infections (HAIs) (WHO, 2009), yet compliance among healthcare workers (HCWs) remains suboptimal globally, often below 50% (Allegranzi & Pittet, 2009). In Nepal, published studies report compliance rates as low as 24–35%, with systemic barriers such as limited resources, high patient loads, and inadequate monitoring (Rajbhandari et al., 2015; Duwal et al., 2024). By conducting structured surveillance using the WHO HH assessment tool, this study provides empirical evidence on compliance patterns among nurses and paramedics, highlighting both strengths (e.g., improved compliance before aseptic procedures) and weaknesses (e.g., poor compliance after body fluid exposure, glove misuse). The findings are directly relevant for hospital administrators, infection control committees,

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and policymakers, as they demonstrate the impact of simple interventions—such as visual reminders and orientation sessions—on improving HH compliance. Furthermore, the study contributes to the national evidence base on HH practices in provincial hospitals, where published data remain scarce. It underscores the importance of multimodal strategies (education, monitoring, leadership engagement, and point-of-care supplies) to sustain compliance gains and reduce HAIs. Ultimately, this research supports Nepal's broader efforts to strengthen infection prevention and control, reduce antimicrobial resistance, and align with WHO's global patient safety challenge, Clean Care is Safer Care.

Literature Review

According to WHO, 2009, 2020, Hand hygiene refers to any action of cleaning hands to reduce the risk of transmitting microorganisms. This includes both handwashing with soap and water when hands are visibly dirty or contaminated, and hand rubbing with alcohol-based formulations when hands are not visibly soiled. Hand hygiene is not just handwashing it is a structured infection prevention practice defined by WHO, combining soap-and-water washing and alcohol-based hand rubs, performed at the five critical moments of patient care. WHO's "Five Moments for Hand Hygiene"

Hand hygiene must be performed at these critical points:

1. Before touching a patient
2. Before clean/aseptic procedures
3. After body fluid exposure risk
4. After touching a patient
5. After touching patient surroundings

Hand hygiene (HH) is universally recognized as the most effective measure to prevent healthcare-associated infections (HAIs). The WHO launched the *Clean Care is Safer Care* initiative in 2005, emphasizing the "Five Moments for Hand Hygiene" framework (WHO, 2009). Despite this, global compliance rates remain suboptimal, often below 50% (Allegranzi & Pittet, 2009). In Nepal, compliance rates are consistently low. A study in rural Makwanpur district found overall HH compliance at 24.25%**,** with barriers including lack of time, poor role modeling by seniors, and inadequate institutional protocols (Rajbhandari et al., 2015). Similarly, a tertiary hospital study in Kathmandu observed 30% overall compliance, with doctors at 37%, nurses at 35%, and paramedics at 23%. Compliance was highest after body fluid exposure (83%) but critically low before patient contact (11%) (Duwal et al., 2024).

Professional Role Differences

Comparative studies consistently show variation in compliance across healthcare worker categories. Nurses generally demonstrate higher adherence compared to physicians, while paramedics and support staff often report the lowest rates. For example, in a tertiary hospital in Kathmandu, compliance was 37% among doctors, 35% among nurses, and 23% among paramedics (Duwal, Budhathoki, Dhaubanjar, Rijal, & Acharya, 2024). International evidence echoes this pattern, with nurses achieving compliance rates above 80% compared to physicians at 72.6% and support staff at 39.3% (Li, Guan, Zhang, Liu, & Li, 2026). These findings highlight the need for role-stratified interventions.

Departmental Variations

Compliance also differs across hospital departments. Surgical wards often report higher adherence due to stricter infection control protocols, while radiology and outpatient units show lower rates (Erasmus et al., 2010). In Nepal's rural healthcare facilities, overall compliance was only 24.25%, with significant variation depending on workload and infrastructure availability (Rajbhandari, Sagtani, & Baral, 2018). Such disparities suggest that departmental culture and resource allocation strongly influence hand hygiene practices.

Intervention Outcomes

Comparative intervention studies demonstrate that multimodal strategies—combining education, feedback, and infrastructure improvements—significantly improve compliance. A CFIR-guided intervention in China raised overall compliance from 72.6% to 85.4%, with the largest gains among support staff (Li et al., 2026). Similarly, WHO's multimodal approach has been shown to reduce bacterial load and improve compliance across diverse hospital settings (Pittet, Allegranzi, & Boyce, 2009).

Global Standards and Local Gaps

The WHO "Five Moments for Hand Hygiene" framework sets a compliance threshold of 80% for effective infection prevention (WHO, 2009). However, both global and Nepal-specific studies show rates well below this benchmark, particularly before patient contact and after touching patient surroundings (Duwal et al., 2024). Comparative evidence underscores the importance of tailoring interventions to specific roles and departments rather than applying generalized strategies.

Hand Hygiene Compliance According to WHO's Five Moments

1. Before Touching a Patient

Compliance is consistently lowest before patient contact, as healthcare workers often underestimate the risk of transmitting pathogens at this stage. In a Kathmandu tertiary hospital, compliance was only 11% before patient contact (Duwal, Budhathoki, Dhaubanjar, Rijal, & Acharya, 2024). Similar findings are reported globally, with rates below 20% in many settings (Erasmus et al., 2010).

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2. Before Aseptic Procedures

Moderate compliance is observed before aseptic tasks such as IV insertion or wound dressing. Nepalese studies report rates around 40–50%, reflecting partial adherence but still below WHO's recommended threshold (Rajbhandari, Sagtani, & Baral, 2018). International reviews confirm that compliance improves when procedures are perceived as high-risk (Pittet, Allegranzi, & Boyce, 2009).

3. After Body Fluid Exposure

This moment shows the highest compliance, often exceeding 80%, because healthcare workers perceive direct personal risk. In Nepal, compliance reached 83% after body fluid exposure (Duwal et al., 2024). Global systematic reviews also confirm this trend, with rates consistently higher than other moments (Erasmus et al., 2010).

4. After Touching a Patient

Compliance after patient contact is moderate, typically between 50–70%. While better than pre-contact compliance, it remains below WHO's recommended 80%. Studies attribute this gap to time pressure and lack of reinforcement (WHO, 2009).

5. After Touching Patient Surroundings

This moment is often neglected, with compliance rates below 30% in Nepal and internationally (Rajbhandari et al., 2018; Erasmus et al., 2010). Healthcare workers frequently underestimate the risk of transmission from surfaces such as bed rails, infusion pumps, or tables. Most HAIs are preventable through hand hygiene performed at the right times.The WHO Guidelines on hand hygiene in health care outline hand hygiene recommendations and are complemented by the WHO Multimodal hand hygiene improvement strategy, the Guide to implementation, and an implementation toolkit, which contains many ready-to-use practical tools. The WHO multimodal improvement strategy has been shown as the most effective approach leading to practices improvements. Hand hygiene improvement programmes can prevent up to 50% avoidable infections acquired during health care delivery and generate economic savings on average 16 times the cost of implementation.

Study Methods

Study Design

This research adopts a comparative cross-sectional design, enabling the systematic observation of hand hygiene compliance among healthcare workers at a single point in time. The comparative approach is central to the study, as it highlights differences across professional roles (doctors, nurses, paramedics), five moments of hand hygiene and hospital departments (surgical, medical, outpatient). This design is appropriate because it provides a snapshot of current practices while allowing meaningful comparisons that inform targeted interventions.

Study Setting and Population

- **Setting:** A tertiary care hospital in Nepal, selected for its diverse clinical departments and high patient turnover.
- **Population:** Healthcare workers directly involved in patient care, including physicians, nurses, paramedics.
- **Inclusion criteria:** All healthcare workers present during the study period who consent to observation.
- **Exclusion criteria:** Administrative staff and workers not directly engaged in patient care.

Sampling Technique

For the baseline study, the non-probability purposive sampling technique was used and the 40 health care workers was selected from different departments. Among the 40 samples, the 50% was nurses working in inpatient department, 25% was medical doctors working in OPD, OT and IPD and 25% was paramedics including lab personnels. For the follow up study, the non-probability purposive sampling technique will be used and the 20 health care workers was selected from different departments. Among the 20 samples, the 75% will be nurses working in inpatient department and 25% will be paramedics including lab personnels.

Data Collection Methods

- **Observation Tool:** WHO's "Five Moments for Hand Hygiene" framework was used as a data collection tool.
- **Procedure:** Trained observers monitor healthcare workers during routine patient care, recording whether hand hygiene is performed at each critical moment.
- **Minimizing bias:** Observers was trained to reduce subjectivity, and discreet observation minimized the Hawthorne effect (behavior change due to awareness of being observed).

Results

This report examines hand hygiene (HH) compliance among Nurses, Doctors, and Paramedics based on the provided observational data. The data follow WHO's "5 Moments" framework (before patient contact, before aseptic task, after body fluids, after patient contact, after patient surroundings). WHO guidelines recommend cleaning hands at each of these moments. Overall, HCWs often fall short of perfect compliance in practice.

Baseline Compliance (July 2025)

At baseline, hand hygiene compliance varied across professional groups. Nurses demonstrated 26% compliance,

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which was substantially below the 100% target. Doctors achieved 50% compliance, meeting the set benchmark, while paramedics showed only 22% compliance, falling short of the 50% target. These findings highlight significant gaps in adherence, particularly among nurses and paramedics.

Professional Group	Baseline Compliance (%)	Target (%)	Status
Nurses	26	100	Below target
Doctors	50	50	Met target
Paramedics	22	50	Below target

Follow-up Compliance (December 2025)

Follow-up observations revealed more detailed patterns of compliance across the WHO "Five Moments."

- **Nurses (n=15):**
  - High compliance before aseptic procedures (**13/15**).
  - Moderate compliance before patient touch (**12/15**).
  - Poor compliance after body fluid exposure (**1/15**).
- **Paramedics (n=5):**
  - Good compliance before patient touch and aseptic procedures.
  - Poor compliance after body fluid exposure (**0/5**).

Group	Before Aseptic Procedures	Before Patient Touch	After Body Fluid Exposure
Nurses (n=15)	13/15 (High)	12/15 (Moderate)	1/15 (Poor)
Paramedics (n=5)	Good	Good	0/5 (Poor)

At baseline in July 2025, hand hygiene compliance varied across professional groups, with nurses demonstrating only 26% compliance, well below the 100% target, doctors achieving 50% compliance and thereby meeting their target, and paramedics showing 22% compliance, which fell short of the 50% benchmark. By the follow-up in December 2025, more nuanced patterns emerged. Among nurses (n=15), compliance was high before aseptic procedures (13/15), moderate before patient touch (12/15), but poor after body fluid exposure (1/15). Paramedics (n=5) showed good compliance before patient touch and aseptic procedures, yet similarly demonstrated poor adherence after body fluid exposure (0/5). Behavioral preferences were also evident: nurses favored the use of alcohol-based hand rubs (21 instances), while paramedics leaned toward handwashing with soap and water (6 instances). Although gloves were frequently used, they were often incorrectly substituted for proper hand hygiene, indicating a persistent gap in practice despite awareness of infection prevention protocols.

Overall, the comparative findings demonstrate that while doctors initially met compliance targets, nurses and paramedics lagged behind. Follow-up observations revealed that compliance was strongest before aseptic procedures and weakest after body fluid exposure, suggesting that perceived personal risk strongly influences adherence. Behavioral preferences further highlight differences in practice, with nurses relying more on hand rubs and paramedics on handwashing. The substitution of gloves for proper hand hygiene remains a critical issue requiring targeted educational interventions.

Distinct preferences in hand hygiene practices were observed:

- Nurses favored alcohol-based hand rubs, recorded in 21 instances.
- Paramedics leaned toward handwashing with soap and water, noted in 6 instances.
- Gloves were frequently used but often incorrectly substituted for proper hand hygiene, reflecting a persistent gap in practice despite awareness of infection prevention protocols.

Discussion

Interventions produced measurable improvement, particularly in aseptic procedure compliance. However, critical gaps remain after body fluid exposure, a high-risk moment for pathogen transmission. Misconceptions about glove use persist, echoing WHO's caution that gloves do not replace HH (WHO, 2009). Sustained multimodal strategies—education, point-of-care supplies, reminders, monitoring, and leadership engagement—are essential to close compliance gaps. Similar findings have been reported globally, where compliance after exposure remains weakest (Erasmus et al., 2010). In Nepal, small-scale studies mirror these trends, with paramedics consistently underperforming compared to nurses (Khadka et al., 2021). Interventions improved compliance, especially among nurses, but critical gaps persisted in high-risk indications. Misconceptions about glove use and poor HH after body fluid exposure highlight systemic challenges. Sustained multimodal strategies—education, point-of-care supplies, reminders, monitoring, and leadership engagement—are essential to achieve WHO's recommended standards.

This comparative study highlights persistent gaps in hand hygiene compliance among healthcare workers, with notable differences across professional groups and specific moments of patient care. At baseline, nurses and paramedics demonstrated low compliance (26% and 22%, respectively),

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while doctors achieved 50%, meeting their target. These findings align with previous research in Nepal, where overall compliance rates have been reported as low as 30% in tertiary hospitals (Duwal et al., 2024) and 24.25% in rural facilities (Rajbhandari et al., 2018). Such results underscore the challenge of achieving WHO's recommended threshold of 80% compliance across all five moments (WHO, 2009).

Follow-up observations revealed more nuanced patterns. Nurses showed high compliance before aseptic procedures (87%), moderate compliance before patient contact (80%), but poor compliance after body fluid exposure (7%). Paramedics demonstrated good compliance before patient touch and aseptic procedures, yet none adhered after body fluid exposure. This discrepancy reflects a common trend noted in international studies: healthcare workers are more likely to perform hand hygiene when they perceive direct personal risk (e.g., aseptic tasks), but adherence declines when the risk is perceived as patient-centered (Erasmus et al., 2010). The poor compliance after body fluid exposure is particularly concerning, as this moment represents a critical point for preventing cross-contamination and HAIs. Behavioral preferences further illustrate professional differences. Nurses favored alcohol-based hand rubs, consistent with WHO recommendations that hand rubs are the preferred method when hands are not visibly soiled (Pittet et al., 2009). Paramedics leaned toward handwashing, which may reflect either training gaps or resource availability. The frequent substitution of gloves for proper hand hygiene indicates a misconception that glove use alone provides adequate protection, a finding echoed in prior studies where glove misuse contributed to reduced compliance (Erasmus et al., 2010).

Comparatively, these results suggest that compliance is influenced not only by professional role but also by departmental culture and perceived risk. Nurses demonstrated stronger adherence to aseptic protocols, while paramedics showed better compliance before patient contact but failed after fluid exposure. Such variations emphasize the need for role-specific and moment-specific interventions. Educational programs should address misconceptions about glove use, reinforce the importance of hand hygiene after body fluid exposure, and promote consistent use of alcohol-based hand rubs.

Implications

- **Targeted interventions** are required for nurses and paramedics, focusing on moments with lowest compliance.
- **Behavioral reinforcement** should emphasize that glove use does not replace hand hygiene.
- **Departmental culture** must be strengthened through leadership support, supervision, and continuous monitoring.
- **Comparative evidence** provides actionable insights for tailoring infection prevention strategies rather than applying generalized approaches.

Conclusion

This comparative study examined hand hygiene compliance among healthcare workers in a tertiary hospital in Nepal, focusing on differences across professional groups and specific moments of patient care as defined by the WHO's "Five Moments for Hand Hygiene." The findings revealed significant gaps in adherence, with nurses and paramedics demonstrating low compliance at baseline (26% and 22%, respectively), while doctors achieved 50% compliance, meeting their target. Follow-up observations provided deeper insights, showing high compliance before aseptic procedures, moderate compliance before patient contact, but poor compliance after body fluid exposure. These results underscore the influence of perceived personal risk, departmental culture, and professional role on compliance behavior. The literature review confirmed that such disparities are consistent globally, with nurses generally outperforming doctors, but compliance remaining weakest before patient contact and after touching patient surroundings (Erasmus et al., 2010; Pittet et al., 2009). Nepal-specific studies further highlighted systemic challenges, including resource limitations, misconceptions about glove use, and inadequate institutional protocols (Duwal et al., 2024; Rajbhandari et al., 2018). Together, these findings emphasize that compliance is not uniform but varies across roles, departments, and contexts, making comparative analysis essential for designing effective interventions.

The discussion highlighted that while healthcare workers are more likely to perform hand hygiene when they perceive direct personal risk (e.g., before aseptic procedures), adherence declines when the risk is patient-centered, particularly after body fluid exposure. Behavioral preferences also differed, with nurses favoring alcohol-based hand rubs and paramedics leaning toward handwashing, reflecting both training influences and resource availability. The substitution of gloves for proper hand hygiene remains a critical issue requiring urgent correction. Based on these findings, the study recommended role-specific training, departmental interventions, improved infrastructure, behavioral reinforcement, and institutional policy support. These measures are necessary to address the lowest compliance moments, correct misconceptions, and align practices with WHO's global standards. Importantly, comparative evidence provides actionable insights for tailoring infection prevention strategies rather than applying generalized approaches.

In conclusion, this study demonstrates that hand hygiene compliance in Nepal's hospital settings remains below international benchmarks, with significant variation across

professional groups and care moments. By adopting targeted, evidence-based interventions, hospitals can strengthen infection prevention, reduce healthcare-associated infections, and improve patient safety outcomes. The comparative design of this study ensures that recommendations are grounded in observed differences, offering a practical roadmap for hospital management, policymakers, and the Nepal Health Research Council to advance national standards of care.

Recommendations

Based on the comparative findings of this study, several targeted recommendations are proposed to strengthen hand hygiene compliance among healthcare workers in Nepal's tertiary hospital settings:

1. Role-Specific Training Programs

- Nurses should receive refresher training emphasizing the importance of hand hygiene after body fluid exposure, where compliance was weakest.
- Paramedics require structured sessions to reinforce adherence across all five WHO moments, with particular focus on correcting misconceptions about glove use.
- Doctors, though meeting baseline targets, should be engaged in continuous professional development to sustain compliance levels and serve as role models for other groups.

2. Departmental Interventions

- Surgical and medical wards should implement moment-specific reminders (visual cues, posters, electronic alerts) to reinforce compliance before patient contact and after touching patient surroundings.
- Outpatient departments should adopt workflow adjustments to reduce time pressure, thereby improving adherence during high patient turnover.

3. Infrastructure and Resource Provision

- Ensure adequate availability of alcohol-based hand rubs at all points of care, as nurses demonstrated preference for hand rubs.
- Maintain functional handwashing stations in paramedic work areas to support their practice preference, while reinforcing that hand rubs are the WHO-recommended method when hands are not visibly soiled.

4. Behavioral Reinforcement and Monitoring

- Introduce real-time feedback mechanisms through direct observation and peer monitoring to sustain compliance.
- Address glove misuse by integrating educational modules that clarify gloves are not substitutes for hand hygiene.
- Incorporate leadership-driven accountability, where department heads regularly review compliance data and encourage adherence.

5. Policy and Institutional Support

- Hospital management should establish clear compliance targets aligned with WHO's 80% benchmark across all five moments.
- Integrate hand hygiene compliance into performance evaluation systems, linking adherence to professional appraisal and recognition.
- Collaborate with the infectious disease control division to develop national guidelines for comparative monitoring of hand hygiene across hospitals.

Declaration of Competing Interest

The authors declare that they have no known competing interests or personal relationships that could have influenced the work reported in this manuscript. The study was conducted independently, and no institutional pressures affected the design, data collection, analysis, or interpretation of results. All authors affirm that the research was undertaken solely to advance scientific understanding of hand hygiene compliance in healthcare settings.

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