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Evaluating the Compliance of Hand Hygiene Intervention Among Healthcare Workers in Mitigating Healthcare-Associated Infections in Cancer Patients

Dr. Rubina Mulla[1], Dr Ranjeeta[2], Surabhi Sharma[3], Dr Mohd. Aadam Bin Najeeb[4]*, Dr Narayan Kamath[5]

[1]Assistant Professor, Department of Microbiology, Jawaharlal Nehru Medical College, KAHER, Belagavi, Karnataka, India.

[2]Associate professor, L N Medical college & J K Hospital, Bhopal, Madhya Pradesh, India.

[3]Research Fellow, Teerthanker Mahaveer Medical College & Research Centre Moradabad, UP India.

[4]Assistant Professor, Department of Microbiology, NAMO Medical Education and Research Institute, Silvassa, DNH, India.

[5]Professor, Department of Microbiology, NAMO Medical Education and Research Institute, Silvassa, DNH, India.

***Corresponding Author:**

Dr Mohd. Aadam Bin Najeeb,

Assistant Professor, Department of Microbiology, NAMO Medical Education and Research Institute, Silvassa, DNH-396230

Email ID : aadamnajeeb@gmail.com

ABSTRACT

Background: Immunocompromised cancer patients are highly susceptible to hospital-acquired infections (HAIs), making hand hygiene (HH) a critical intervention for infection prevention. This study evaluates the effectiveness of a multimodal HH program in a tertiary care oncology hospital in Mumbai, western India

Methods: A prospective pre-post interventional study was conducted from January 2023 to December 2024. The study involved 150 healthcare workers (HCWs) across oncology wards, hematopoietic stem cell transplantation units, and intensive care units, with 12,500 HH opportunities observed. The intervention included infrastructure improvements (alcohol-based hand rub dispensers), monthly training on WHO's "Five Moments for Hand Hygiene," real-time feedback, workplace reminders, and leadership engagement. HH compliance (total, partial, and complete) was assessed using WHO observation forms, and HAI incidence was monitored as per CDC criteria. Data were analysed using chi-square tests ($p<0.05$).

Results: Pre-intervention HH compliance was 48.2% (total), 32.1% (partial), and 16.1% (complete), improving post-intervention to 72.5%, 48.7%, and 23.8%, respectively (all $p<0.01$). Nurses showed the highest compliance (76.4% post-intervention). HAI incidence decreased by 28%, from 15.4 to 11.1 per 1,000 patient-days ($p<0.05$), with a 35% reduction in neutropenic patients ($p<0.01$). Bloodstream infections and pneumonia saw the most significant declines.

Conclusion: The multimodal HH intervention significantly improved compliance and reduced HAIs among immunocompromised cancer patients, demonstrating its value in resource-limited settings. Sustained training and infrastructure support are crucial for maintaining these gains.

Key Words: Hand hygiene, hospital-acquired infections, immunocompromised patients, cancer care, infection prevention, India

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1. INTRODUCTION

Infections pose a significant threat to immunocompromised cancer patients; whose weakened immune system make them highly vulnerable to hospital-acquired infections (HAIs). These patients, often undergoing treatment such as chemotherapy, hematopoietic stem cell transplantation (HSCT), or radiation therapy, face heightened risks due to conditions like

neutropenia, which severely impair their ability to fight pathogens [1]. In oncology settings, HAIs contribute to substantial morbidity and mortality, with reported incidence rates ranging from 20% to 30% in tertiary care hospitals [2]. The consequences are particularly severe in resource-constrained healthcare settings, such as in developing countries, where infection control measures may be inconsistent due to limited infrastructure and training [3].

Hand hygiene (HH) is widely recognized as the most effective and cost-efficient strategy to prevent HAIs, as emphasized by the World Health Organization (WHO) in its guidelines on hand hygiene in healthcare [4]. By interrupting the transmission of pathogens, proper HH practices can significantly reduce infection rates, particularly for multidrug-resistant organisms (MDROs) and viral infections common among cancer patients [5]. However, achieving consistent HH compliance among healthcare workers (HCWs) remains a challenge globally, with studies in India reporting adherence rates as low as 20–40% in high-risk settings like oncology wards [6]. Factors such as heavy workloads, inadequate access to HH facilities, lack of awareness and lack of motivation often contribute to suboptimal compliance [7].

In the context of Indian tertiary care hospitals, where patient volumes are high and resources may be stretched, implementing effective HH interventions is critical yet complex. Previous studies in similar settings have shown that multimodal interventions—combining education, infrastructure improvements, and regular monitoring—can improve compliance and reduce infection rates [8]. However, there is limited research specifically addressing HH interventions tailored to immunocompromised cancer patients in India, despite their unique vulnerability. This gap is particularly relevant in western India, where tertiary care centres like those in Mumbai serve large populations of cancer patients from diverse socioeconomic backgrounds.

This study aims to evaluate the effectiveness of a multimodal HH intervention in a tertiary care oncology hospital in a tertiary care hospital in western India, conducted from January 2023 to December 2024. The intervention targeted HCWs in high-risk areas, including oncology wards and intensive care units (ICUs), with the goal of improving HH compliance and reducing HAI incidence among immunocompromised cancer patients. By addressing local challenges such as resource limitations and cultural attitudes toward infection control, this research seeks to contribute to evidence-based practices for infection prevention in vulnerable populations.

2. MATERIALS AND METHODS

Study Design and Setting

This prospective, pre-post interventional study was conducted from January 2023 to December 2024 at a 500-bed tertiary care oncology hospital in tertiary care hospital in western India. The hospital is a leading centre for cancer care, equipped with specialized units for immunocompromised patients, including oncology wards, hematopoietic stem cell transplantation (HSCT) units, and intensive care units (ICUs). These areas were selected due to their high-risk patient population, particularly those with severe immunosuppression, such as neutropenia (absolute neutrophil count <500 cells/mm^3). The study aimed to assess the impact of a multimodal hand hygiene (HH) intervention on compliance rates among healthcare workers (HCWs) and hospital-acquired infection (HAI) incidence in immunocompromised cancer patients.

Participants

The study included 150 HCWs with direct patient contact in the selected units. This comprised 45 doctors, 85 nurses, and 20 support staff (e.g., housekeeping and technicians). Inclusion criteria required HCWs to work in oncology ICUs, HSCT units, or general oncology wards for at least 20 hours per week. Exclusion criteria included HCWs on temporary assignments or those not involved in direct patient care. For HAI surveillance, 450 immunocompromised cancer patients were monitored, defined by active chemotherapy, HSCT, or confirmed neutropenia during their hospital stay. Patients under 18 years or those in palliative care without active treatment were excluded to maintain focus on high-risk groups.

Intervention

The intervention was designed based on the World Health Organization's multimodal HH strategy [4]. It was implemented from July 2023 to December 2024, following a six-month pre-intervention phase (January–June 2023) to establish baseline data. The intervention components were:

System Change: Installation of alcohol-based hand rub (ABHR) dispensers at every patient bed, ward entry/exit points, and nursing stations. Soap dispensers and single-use paper towels were ensured at all sinks to address infrastructure barriers common in Indian hospitals [6].

Training and Education: Monthly workshops were conducted for HCWs, focusing on the WHO's "Five Moments for Hand Hygiene": before touching a patient, before clean/aseptic procedures, after body fluid exposure risk, after touching a patient, and after touching patient surroundings [4]. Training included hands-on demonstrations and videos tailored to oncology settings.

Evaluation and Feedback: Trained infection control nurses conducted direct observation audits using standardized WHO

HH observation forms. Audits were performed unannounced during day and night shifts to minimize bias. Weekly feedback sessions provided HCWs with compliance data and actionable insights.

Reminders in the Workplace: Visual cues, such as posters and digital screens displaying HH protocols, were placed in high-traffic areas. Reminders emphasized the link between HH and patient safety in immunocompromised patients.

Institutional Support: Hospital leadership, including department heads, participated in regular ward rounds to promote a culture of infection prevention. Incentives, such as recognition awards for high-compliance teams, was introduced to sustain engagement and motivation among healthcare providers.

Data Collection

A total of 12,500 HH opportunities were observed over the 24-month study period (5,000 pre-intervention and 7,500 post-intervention). Compliance was categorized as:

Total HH Adherence Rate (HHTAR): Any attempt at HH, regardless of technique.

Partial HH Adherence Rate (HHPAR): HH performed with incomplete technique or duration.

Complete HH Adherence Rate (HHCAR): HH performed with correct technique and duration (e.g., 20–30 seconds for handwashing, 15–20 seconds for ABHR) as per WHO guidelines [4].

Observations were conducted by six infection control nurses trained to ensure inter-rater reliability (Cohen's kappa >0.85). Data was recorded for each of the "Five Moments" across different HCW categories and units.

HAI surveillance followed the Centres for Disease Control and Prevention (CDC) National Healthcare Safety Network criteria [9]. Infections monitored included bloodstream infections (BSIs), urinary tract infections (UTIs), ventilator-associated pneumonia (VAP), and surgical site infections (SSIs). Patient records were reviewed daily by the infection control team, and laboratory data (e.g., blood cultures, urine cultures) were used to confirm HAIs. Incidence was calculated as infections per 1,000 patient-days.

Statistical Analysis

Descriptive statistics summarized HH compliance and HAI rates. Pre- and post-intervention compliance rates were compared using chi-square tests, with a significance threshold of $p<0.05$. HAI incidence was analysed similarly to assess reductions post-intervention. Subgroup analyses explored compliance by HCW role (doctors, nurses, support staff) and unit type (ICU vs. wards). Data were analysed using SPSS version 26.0.

Ethical Considerations

The study was approved by the hospital's Institutional Review Board (IRB approval number: ONCO-2022-147). Informed consent was obtained from all participating HCWs, and patient data was anonymized to protect privacy. No identifiable patient information was used in the analysis, and the study adhered to the Declaration of Helsinki principles.

3. RESULTS

Hand Hygiene Compliance

During the pre-intervention phase (January–June 2023), a total of 5,000 hand hygiene (HH) opportunities were observed across oncology wards, hematopoietic stem cell transplantation (HSCT) units, and intensive care units (ICUs). The total HH adherence rate (HHTAR) was 48.2%, with a partial HH adherence rate (HHPAR) of 32.1% and a complete HH adherence rate (HHCAR) of 16.1%. Among healthcare worker (HCW) groups, nurses demonstrated the highest compliance at 52.3%, followed by doctors at 47.8%, and support staff at 38.5%. Compliance was notably higher in ICUs (55.4%) compared to general oncology wards (42.6%). The "before clean/aseptic procedures" moment showed the lowest adherence (41.2%), while "after touching a patient" had the highest (50.8%).

Following the implementation of the multimodal HH intervention (July 2023–December 2024), 7,500 HH opportunities were observed. The HHTAR significantly improved to 72.5% ($p<0.001$), with HHPAR increasing to 48.7% ($p<0.001$) and HHCAR to 23.8% ($p<0.01$). Nurses maintained the highest compliance post-intervention at 76.4%, followed by doctors at 70.9%, and support staff at 62.1% (all $p<0.001$). The most substantial improvement was observed for the "after touching patient surroundings" moment, which rose from 45.0% to 68.0% ($p<0.001$). Compliance in ICUs reached 78.2%, while wards improved to 66.8% ($p<0.001$). The table below summarizes key compliance metrics.

Table No. 1 Summary of Compliance Metrics.

Category	Pre-Intervention (%)	Post-Intervention (%)	p-value
HHTAR	48.2	72.5	<0.001

HHPAR	32.1	48.7	<0.001
HHCAR	16.1	23.8	<0.01
Nurses	52.3	76.4	<0.001
Doctors	47.8	70.9	<0.001
Support Staff	38.5	62.1	<0.001
ICU Compliance	55.4	78.2	<0.001
Ward Compliance	42.6	66.8	<0.001

Infection Rates

Among the 450 immunocompromised cancer patients monitored, the pre-intervention hospital-acquired infection (HAI) incidence was 15.4 per 1,000 patient-days. Bloodstream infections (BSIs) accounted for 45% of HAIs, followed by pneumonia (30%), urinary tract infections (UTIs) (20%), and surgical site infections (SSIs) (5%). Post-intervention, the HAI incidence decreased to 11.1 per 1,000 patient-days, representing a 28% reduction ($p<0.05$). The most significant decline was observed in BSIs, which dropped from 6.9 to 4.3 per 1,000 patient-days ($p<0.05$). Neutropenic patients, a particularly vulnerable subgroup, experienced a 35% reduction in infection rates, from 18.2 to 11.8 per 1,000 patient-days ($p<0.01$). Pneumonia rates also decreased significantly, from 4.6 to 3.1 per 1,000 patient-days ($p<0.05$), while UTIs and SSIs showed modest improvements ($p>0.05$) as shown in table 2.

Table 2: Infection Rates

Infection Type	Pre-Intervention (per 1,000 patient-days)	Post-Intervention (per 1,000 patient-days)	p-value
Total HAIs	15.4	11.1	<0.05
Bloodstream Infections	6.9	4.3	<0.05
Pneumonia	4.6	3.1	<0.05
Urinary Tract Infections	3.1	2.8	0.12
Surgical Site Infections	0.8	0.7	0.31
Neutropenic Patients	18.2	11.8	<0.01

Additional Observations

No significant adverse events related to the intervention, such as skin irritation from ABHR use, were reported among HCWs. Subgroup analysis revealed that compliance improvements were most pronounced among nurses in the HSCT unit, where HHCAR increased from 18.2% to 27.5% ($p<0.01$). The intervention's impact was less pronounced among support staff, likely due to lower baseline training levels. Seasonal variations in compliance were minimal, though a slight dip was noted during peak patient admission periods (November–December), possibly due to increased workload.

4. DISCUSSION

This study demonstrates the significant impact of a multimodal hand hygiene (HH) intervention on improving compliance among healthcare workers (HCWs) and reducing hospital-acquired infections (HAIs) among immunocompromised cancer patients in a tertiary care hospital in Mumbai, western India. The observed increase in total HH adherence rate (HHTAR) from 48.2% to 72.5% aligns with findings from similar studies in Indian healthcare settings, where multimodal interventions have boosted compliance from 46% to 67% [6]. The 28% reduction in HAI incidence, particularly the 35% decrease among neutropenic patients, underscores the critical role of HH in protecting highly vulnerable populations [1]. These results are especially relevant in oncology settings, where patients compromised immune systems amplify the consequences of infections [2].

The intervention's success can be attributed to its comprehensive approach, addressing key barriers to HH compliance identified in resource-limited settings. The installation of alcohol-based hand rub (ABHR) dispensers at every bed and

entry point directly tackled infrastructure gaps, a common issue in Indian hospitals [3, 6]. Training sessions focusing on the WHO's "Five Moments for Hand Hygiene" were instrumental in improving technique, particularly for the previously low-performing "after touching patient surroundings" moment, which rose from 45% to 68% [4]. This improvement suggests that targeted education can bring behavioural changes in healthcare workers even in high-pressure environments like oncology, ICUs. Additionally, real-time feedback and leadership involvement fostered a culture of accountability, consistent with global evidence that institutional support enhances HH adherence [7, 10].

The significant reduction in bloodstream infections (BSIs) and pneumonia aligns with studies highlighting HH's role in interrupting pathogen transmission, particularly for multidrug-resistant organisms (MDROs) prevalent in cancer care settings [5, 11]. However, the modest impact on urinary tract infections (UTIs) and surgical site infections (SSIs) may reflect their association with device-related factors, such as catheters, which require additional interventions beyond HH [9]. The pronounced benefit for neutropenic patients emphasizes the need for tailored infection prevention strategies in this subgroup, where even minor infections can lead to severe outcomes [1].

Despite these achievements, challenges persisted. Support staff showed the lowest compliance improvement, likely due to limited baseline training and less frequent patient interaction, which may reduce their perceived need for HH [6]. This finding suggests the need for role-specific educational strategies in future interventions. Additionally, compliance dipped slightly during peak admission periods, reflecting the impact of workload on adherence, a common issue in Indian tertiary care hospitals [8]. The study's single-centre design and potential Hawthorne effect from direct observation are limitations that may affect generalizability. However, the large sample of 12,500 HH opportunities and rigorous surveillance using CDC criteria strengthen the reliability of the findings [9].

The results have important implications for infection control in resource-constrained settings. While ABHR was effective for most scenarios, the persistence of spore-forming pathogens like *Clostridium difficile* in oncology settings highlights the need for soap and water in specific cases [5, 11]. Future research could incorporate molecular epidemiology to track pathogen transmission and assess the intervention's impact on specific MDROs. Additionally, longitudinal studies could evaluate the sustainability of compliance gains and explore cost-effectiveness, given the resource constraints in Indian healthcare systems [3].

In conclusion, this study highlights the efficacy of a multimodal HH intervention in improving compliance and reducing HAIs among immunocompromised cancer patients. By addressing local challenges like infrastructure and awareness, the intervention offers a replicable model for other tertiary care hospitals in India and similar settings. Sustained efforts, including continuous training and monitoring, are essential to maintain these gains and further enhance patient safety.

5. CONCLUSION

This study highlights the transformative impact of a multimodal hand hygiene (HH) intervention in a tertiary care oncology hospital in western India, conducted from January 2023 to December 2024. By implementing a comprehensive strategy that included infrastructure enhancements, targeted training, real-time feedback, workplace reminders, and leadership engagement, HH compliance among healthcare workers improved significantly from 48.2% to 72.5%, with complete adherence rising from 16.1% to 23.8%. This increase translated into a 28% reduction in hospital-acquired infections (HAIs) among immunocompromised cancer patients, with a notable 35% decrease in infection rates among neutropenic patients, underscoring the intervention's efficacy in protecting the most vulnerable.

These findings affirm that structured HH programs, grounded in WHO guidelines, can overcome common barriers in resource-constrained settings, such as limited access to hygiene facilities and high workloads. The intervention's success in reducing bloodstream infections and pneumonia highlights its potential to mitigate the burden of HAIs in oncology settings, where patients face heightened risks from multidrug-resistant organisms. However, sustained efforts are critical to maintain these gains, particularly for support staff, who showed lower compliance improvements, and during high-pressure periods when adherence dipped.

The study provides a replicable model for other Indian tertiary care hospitals and similar settings globally, emphasizing the importance of combining education, infrastructure, and institutional support. Future efforts should focus on long-term sustainability, integrating advanced pathogen surveillance, and addressing device-related infections like urinary tract infections, which showed limited improvement. By prioritizing consistent HH practices, healthcare facilities can significantly enhance patient safety and outcomes for immunocompromised cancer patients.

6. LIMITATIONS

While this study provides valuable insights into the effectiveness of a multimodal hand hygiene (HH) intervention, several limitations must be acknowledged. First, the study was conducted at a single tertiary care oncology hospital in, western India, which may limit the generalizability of findings to other healthcare settings with different patient populations, resources, or cultural practices. Second, the use of direct observation to assess HH compliance may have introduced the Hawthorne effect, where healthcare workers (HCWs) altered their behavior due to awareness of being observed, potentially

inflating compliance rates. Third, the study did not account for seasonal variations in patient acuity or pathogen prevalence, which could influence HAI rates, particularly during high-admission periods when compliance slightly declined. Additionally, while the intervention significantly reduced bloodstream infections and pneumonia, its limited impact on urinary tract infections and surgical site infections suggests that device-related factors, such as catheter care, were not fully addressed. Finally, the study's 24-month duration may not fully capture the long-term sustainability of the intervention's effects, especially in the face of staff turnover or resource constraints common in Indian hospitals.

Future Prospects

The success of this multimodal hand hygiene intervention opens promising pathways for advancing infection prevention in oncology settings. Expanding the intervention to other tertiary care hospitals across India, particularly in rural or resource-limited regions, could help validate its effectiveness in diverse contexts. Exploring the use of technology, such as automated hand hygiene monitoring systems, could reduce observer bias and provide real-time compliance data, enhancing scalability. Targeted training programs for support staff, who showed lower compliance, could further strengthen outcomes. Additionally, integrating pathogen-specific surveillance, such as tracking multidrug-resistant organisms, would deepen our understanding of transmission dynamics in immunocompromised populations. Long-term studies are needed to assess the sustainability of compliance gains and explore cost-effective strategies to maintain these improvements, ensuring lasting benefits for patient safety in high-risk settings.

No Conflict of Interest

The authors declare no conflicts of interest. This study was conducted without financial or personal relationships that could have influenced the design, implementation, or interpretation of the research. No funding was received from commercial entities, and all resources were provided by the hospital's research department or internal grants.

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