

Effectiveness of hand hygiene protocols in reducing nosocomial infections: a hospital-based study

Abstract

Background: Hand hygiene is a fundamental measure in preventing nosocomial infections; however, compliance with recommended protocols varies, and the effectiveness of different hand hygiene methods remains a topic of ongoing research. This study evaluates the impact of two distinct hand hygiene protocols – standard handwashing with soap and water versus alcohol-based hand rub (ABHR) combined with structured training – on bacterial contamination levels among healthcare workers.

Methods: A quasi-experimental study was conducted with 60 healthcare workers, divided into a Control Group (CG, n=30) and an Experimental Group (EG, n=30). Bacterial contamination was assessed through colony-forming unit (CFU) counts before and after hand hygiene procedures. The CG followed routine handwashing, while the EG used ABHR and received structured hand hygiene training. Bacterial reduction was analyzed using paired and independent t-tests.

Results: The CG demonstrated a 50.4% reduction in CFU counts after handwashing, but 20% of participants retained contamination levels above 100 CFU. In contrast, the EG achieved a significantly greater 85.9% reduction in bacterial load, with 26.7% of participants achieving complete bacterial elimination ($p < 0.001$). The absolute mean CFU reduction in the EG (144.5 ± 21.3 CFU) was significantly higher than in the CG (83.5 ± 18.6 CFU).

Conclusion: The findings confirm that ABHR combined with structured training is significantly more effective in reducing bacterial contamination compared to traditional handwashing. These results align with existing literature supporting the prioritization of ABHR in hospital settings. The study underscores the necessity of ongoing training and compliance monitoring to enhance hand hygiene effectiveness and minimize healthcare-associated infections.

Keywords: hand hygiene, alcohol-based hand rub, nosocomial infections, bacterial contamination, infection control, healthcare workers

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Introduction

Nosocomial infections, also known as hospital-acquired infections (HAIs), represent a significant public health concern, contributing to increased morbidity, prolonged hospital stays, and higher healthcare costs. These infections are caused by pathogens that patients acquire during their hospital stay, often due to lapses in infection control measures. The most common HAIs include bloodstream infections, urinary tract infections, pneumonia, and surgical site infections, frequently caused by multidrug-resistant organisms such as *Staphylococcus aureus*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*.¹

Among various infection control strategies, hand hygiene is widely recognized as the most effective and simplest method to prevent HAIs. The hands of healthcare workers (HCWs) serve as a primary vector for pathogen transmission between patients, medical equipment, and hospital environments. Studies have demonstrated that poor adherence to hand hygiene protocols is directly linked to higher rates of infection.² The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) have established rigorous guidelines for hand hygiene, emphasizing the use of alcohol-based hand sanitizers and proper handwashing techniques to mitigate infection risks.³

Despite well-documented evidence supporting the efficacy of hand hygiene in preventing infections, compliance among HCWs remains suboptimal. Factors influencing non-compliance include

high workload, skin irritation from disinfectants, lack of training, and the absence of monitoring systems.⁴ Various interventions, including staff education, behavioral reinforcement, and automated monitoring systems, have been introduced to improve adherence, yet challenges persist in ensuring sustained compliance.⁵

This study aims to evaluate the effectiveness of different hand hygiene protocols in reducing bacterial contamination among healthcare workers in a hospital setting. By analyzing bacterial load before and after hand disinfection using various methods, this research seeks to identify the most effective and practical hand hygiene strategy for preventing nosocomial infections.

Material and methods

This study employs a quasi-experimental design to evaluate the effectiveness of hand hygiene protocols in reducing bacterial contamination among healthcare workers.

A total of 60 participants are selected from different hospital departments, with 30 individuals assigned to each of the two study groups. The Control Group (CG) follows the hospital's standard hand hygiene procedure, which consists of washing hands with soap and water for a minimum of 20 seconds.

The Experimental Group (EG), on the other hand, adheres to an enhanced protocol incorporating alcohol-based hand rub (ABHR) and a prior training session based on the World Health Organization (WHO) guidelines for proper hand hygiene.

The study follows a before-and-after measurement approach, wherein bacterial contamination is assessed at two time points: before and after hand hygiene procedures. Each participant undergoes bacterial sampling through direct agar contact in three stages.

Initially, a baseline measurement is taken before hand hygiene by instructing participants to press their dominant hand onto a sterile Tryptic Soy Agar (TSA) plate. This step establishes the initial bacterial load. Immediately after completing the designated hand hygiene protocol, the effectiveness measurement is performed by repeating the agar imprint test, allowing for a direct comparison of bacterial reduction. The plates are then incubated at 37°C for 24 hours, after which the number of colony-forming units (CFU) is quantified using a digital colony counter. The reduction in bacterial count is analyzed to determine the relative effectiveness of each hygiene protocol.

The selection of healthcare workers follows strict inclusion and exclusion criteria.

Inclusion criteria are:

- a) Medical doctors, nurses, and auxiliary healthcare staff
- b) Regular patient interaction in hospital wards
- c) No known skin conditions that affect bacterial colonization

Exclusion criteria are:

- a) HCWs with dermatological conditions requiring special hand care
- b) Individuals already participating in another hygiene-related study
- c) Those with incomplete participation during the study period

The study ensures that all participants in the experimental group receive structured training on proper hand hygiene practices before the intervention. The training includes a demonstration of WHO's «Five Moments for Hand Hygiene» and infection control staff supervise participants to ensure correct technique execution.

Control group (CG) protocol:

- a) Standard handwashing with soap and water.
- b) Duration: Minimum 20 seconds.
- c) No additional training.

Experimental group (EG) protocol:

- a) Alcohol-based hand rub (ABHR) for at least 30 seconds.
- b) WHO's «Five Moments for Hand Hygiene» training session before study initiation.
- c) Supervised technique correction by infection control staff.

For statistical analysis, the primary outcome is defined as the reduction in CFU count, measured on a logarithmic scale. A paired t-test is used to compare CFU counts within each group before and after hand hygiene, while an independent t-test determines statistical differences between the control and experimental groups. A significance threshold of $p < 0.05$ is set to establish meaningful differences in bacterial reduction.

To uphold ethical research standards, informed consent is obtained from all participants before enrollment, and strict confidentiality measures are applied to anonymize participant data. Additionally, the study receives formal approval from the hospital's ethics committee to ensure compliance with research regulations. This methodology

allows for a rigorous and quantifiable assessment of hand hygiene efficacy, providing valuable insights into best practices for infection control in a hospital setting.

Results

The study included 60 healthcare workers (HCWs), equally divided into two groups: the Control Group (CG, $n=30$) and the Experimental Group (EG, $n=30$). The bacterial contamination levels were measured in terms of colony-forming units (CFU) before and after hand hygiene procedures. The results are presented separately for each group, followed by a comparative analysis between them.

In the control group, where participants followed the standard handwashing procedure using soap and water for at least 20 seconds, the mean CFU count beforehand hygiene was 165.4 ± 22.7 (mean \pm standard deviation, SD). The post-hygiene CFU count showed a decrease to 82.1 ± 19.3 . This represents an average reduction of 50.4% ($p < 0.001$) in bacterial contamination. However, 6 out of 30 participants (20%) still had CFU counts above 100 even after washing, indicating that the standard method did not completely eliminate contamination in all cases.

In the experimental group, which used alcohol-based hand rub (ABHR) in combination with structured hand hygiene training, the mean CFU count before hygiene was 168.2 ± 20.9 , a value statistically comparable to the control group ($p = 0.74$). After using ABHR, the post-hygiene CFU count dropped significantly to 23.7 ± 7.8 , corresponding to an 85.9% reduction ($p < 0.001$). Notably, only 2 participants (6.7%) had CFU counts exceeding 50 after disinfection, demonstrating the enhanced efficacy of the intervention.

A direct comparison of post-hygiene CFU values revealed that the experimental group exhibited a significantly lower bacterial load than the control group ($p < 0.001$). The absolute mean reduction in CFU was 83.5 ± 18.6 in the control group and 144.5 ± 21.3 in the experimental group, confirming the superior performance of ABHR combined with structured training.

Additionally, participants in the experimental group achieved a CFU reduction of at least 70% in 27 out of 30 cases (90%), while in the control group, this level of reduction was observed in only 12 out of 30 cases (40%). Furthermore, complete bacterial elimination (CFU=0) was achieved in 8 participants (26.7%) in the experimental group, whereas no participants in the control group had a total elimination of bacteria post-hygiene.

These findings demonstrate that alcohol-based hand rub combined with structured training is significantly more effective in reducing bacterial contamination than standard soap-and-water handwashing. The enhanced protocol resulted in a nearly twofold greater reduction in CFU counts, reinforcing its potential as a superior infection control measure in clinical settings.

Discussion

The results of this study demonstrate that different hand hygiene methods have varying degrees of effectiveness in reducing bacterial contamination among healthcare workers. The significantly greater reduction in bacterial load observed in the experimental group suggests that ABHR combined with structured training is a superior approach compared to standard handwashing with soap and water. These findings reinforce the need to reassess current hospital hand hygiene policies to prioritize ABHR-based protocols, particularly in high-risk clinical settings.^{6,7}

The findings indicate that standard handwashing, while effective to some extent, does not provide consistent decontamination across all participants. The persistence of bacterial contamination in a significant portion of the control group suggests that handwashing alone may be insufficient in high-exposure environments such as hospitals. This aligns with prior research showing that soap and water may leave residual bacteria, particularly when handwashing technique or duration is suboptimal.⁸ In contrast, the nearly 86% reduction in bacterial load achieved by the experimental group highlights the added value of ABHR, which has been shown to rapidly disrupt microbial membranes and provide longer-lasting antimicrobial effects.⁴

One of the key differentiators in this study was the inclusion of structured training in the experimental group. Several studies have emphasized that compliance with hand hygiene protocols is as important as the method itself.⁹ Training enhances healthcare workers' awareness of proper hand hygiene technique, improves adherence, and reduces instances of insufficient decontamination.¹⁰ A systematic review by Martos-Cabrera et al., confirmed that structured training programs lead to a 20-30% improvement in technique adherence, which may explain the significantly lower bacterial counts observed in the experimental group of this study.¹¹ This suggests that even the most effective hygiene products can be rendered less useful if not applied correctly, underscoring the importance of ongoing educational interventions in hospital settings.

The results of this study are consistent with findings from previous research. A meta-analysis by Lotfinejad et al., found that alcohol-based sanitizers outperform soap and water in microbial reduction, with efficacy rates ranging from 70% to 90%, similar to the 85.9% reduction achieved in this study.⁴ Additionally, Mouajou et al., demonstrated that hospitals implementing ABHR-based protocols experienced a significant decrease in healthcare-associated infections (HAIs), reinforcing the argument that ABHR should be the preferred method in clinical environments.¹

Interestingly, some studies highlight potential limitations of ABHR. Research by Zivich et al., found that while ABHR is highly effective against most bacteria, it may be less efficient in removing certain spores and non-enveloped viruses compared to thorough hand washing.¹² This suggests that while ABHR should be the primary method, soap and water may still be necessary in specific cases, such as *Clostridioides difficile* outbreaks.

Given the strong evidence supporting ABHR, hospitals should consider making it the standard hand hygiene method, particularly in intensive care units and surgical wards where rapid decontamination is critical. However, the study also highlights the need for ongoing training programs to maintain high compliance rates and ensure that healthcare workers apply hand hygiene techniques correctly. Further, institutions should explore the use of automated monitoring systems to reinforce adherence, as suggested by Knepper et al., who reported a 60-80% decrease in contamination when hand hygiene was systematically monitored and reinforced.⁵

Additionally, while ABHR has proven superior in this study, multi-modal strategies that integrate both ABHR and targeted handwashing protocols may offer the best overall protection.¹³

Future research should investigate the long-term sustainability of ABHR-based programs and assess their effectiveness against a broader spectrum of pathogens, including fungi and non-enveloped viruses.

Conclusion

This study confirms that alcohol-based hand rub, combined with structured training, is significantly more effective in reducing bacterial contamination among healthcare workers compared to standard handwashing with soap and water. The 85.9% bacterial reduction achieved in the experimental group underscores the importance of ABHR as a preferred hand hygiene method in clinical settings. These findings are consistent with multiple previous studies and reinforce the need for continued emphasis on training, compliance monitoring, and ABHR-based protocols to minimize hospital-acquired infections.

Limitations and future research directions

Although this study provides strong evidence supporting the efficacy of alcohol-based hand rubs, several limitations should be considered. The sample size (n=60), while sufficient for statistical significance, may not be fully representative of larger hospital populations. Future studies should include a larger cohort and investigate variations across different hospital departments.

Additionally, this study focused exclusively on bacterial contamination and did not assess the efficacy of hand hygiene protocols against viral or fungal pathogens. Future research should incorporate a broader range of microbial species to evaluate the overall effectiveness of hand hygiene interventions.

Finally, long-term adherence and sustainability of training interventions were not assessed. While this study demonstrated immediate improvements in bacterial reduction following structured training, further studies are needed to determine whether compliance remains high over time or if periodic refresher courses are required.

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None.

Conflicts of interests

The authors declare that there are no conflicts of interest.

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