



REVIEW

Role of hand hygiene in healthcare-associated infection prevention

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KEYWORDS

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Summary Healthcare workers' hands are the most common vehicle for the transmission of healthcare-associated pathogens from patient to patient and within the healthcare environment. Hand hygiene is the leading measure for preventing the spread of antimicrobial resistance and reducing healthcare-associated infections (HCAIs), but healthcare worker compliance with optimal practices remains low in most settings. This paper reviews factors influencing hand hygiene compliance, the impact of hand hygiene promotion on healthcare-associated pathogen cross-transmission and infection rates, and challenging issues related to the universal adoption of alcohol-based hand rub as a critical system change for successful promotion. Available evidence highlights the fact that multimodal intervention strategies lead to improved hand hygiene and a reduction in HCAI. However, further research is needed to evaluate the relative efficacy of each strategy component and to identify the most successful interventions, particularly in settings with limited resources. The main objective of the First Global Patient Safety Challenge, launched by the World Health Organization (WHO), is to achieve an improvement in hand hygiene practices worldwide with the ultimate goal of promoting a strong patient safety culture. We also report considerations and solutions resulting from the implementation of the multimodal strategy proposed in the WHO Guidelines on Hand Hygiene in Health Care.

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Introduction

Numerous studies document the pivotal role of healthcare workers' (HCWs) hands in the propagation of micro-organisms within the healthcare environment and ultimately to patients.¹ As recently described, patient-to-patient transmission of pathogens via HCWs' hands involves five sequential steps.² Patients' skin can be colonised by transient pathogens that are subsequently shed onto surfaces in the immediate patient surroundings, thus leading to environmental contamination.² As a consequence, HCWs contaminate their hands by touching the environment or patients' skin during routine care activities, sometimes even despite glove use.² It has been shown that organisms are capable of surviving on HCWs' hands for at least several minutes following contamination.² Thus, if hand hygiene practices are suboptimal, microbial colonisation is more easily established and/or direct transmission to patients or a fomite in direct contact with the patient may occur.²

Based on this evidence and the demonstration of its effectiveness, optimal hand hygiene behaviour is considered the cornerstone of healthcare-associated infection (HCAI) prevention.²⁻⁴ Furthermore, not only is it a key element of standard and isolation precautions, but its importance is emphasised also in the most modern 'bundle' approaches for the prevention of specific site infections such as catheter-related bloodstream infection (CRBSI), catheter-related urinary tract infection (CRUTI), surgical site infection (SSI), and ventilator-associated pneumonia (VAP).⁵⁻⁹

Together with other specific prevention measures, environmental cleaning is another essential measure to prevent the spread of some pathogens, particularly *Clostridium difficile*, vancomycin-resistant enterococci (VRE), norovirus, *Acinetobacter* spp. and methicillin-resistant *Staphylococcus aureus* (MRSA), and should not be neglected.¹⁰⁻¹²

Over the past few years, scientific evidence to support the role of hand hygiene in the improvement of patient safety has increased considerably, but some key controversial issues still challenge care practitioners and researchers. This review summarises the key themes on the role of hand hygiene in preventing HCAI. Interpretations and solutions based on the evidence and experience available through the work of the First Global Patient Safety Challenge of the WHO World Alliance for Patient Safety are suggested.

Factors influencing hand hygiene compliance

It has been known for many years that HCWs encounter difficulties in complying with hand hygiene indications at different levels.⁴ Insufficient or very low compliance rates have been reported from both developed and developing countries.^{1,4} Reasons which explain suboptimal practices are multiple and may vary according to the setting and the resources available. For example, the lack of appropriate infrastructure and equipment to enable hand hygiene performance, the cultural background, and even religious beliefs can play an important role in hindering good practices.¹³⁻¹⁵ The most frequently observed factors determining poor hand hygiene compliance are: (i) belonging to a certain professional category (i.e. doctor, nursing assistant, physiotherapist, technician); (ii) working in specific care areas (i.e. intensive care, surgery, anaesthesiology, emergency medicine); (iii) understaffing and overcrowding; and (iv) wearing gowns and/or gloves.¹ Unfortunately, hand hygiene indications at higher risk of being neglected are the ones that prevent pathogen transmission to the patient (i.e. before patient contact and clean/aseptic procedures).¹ This is also in concordance with the fact that care activities with a higher risk of cross-transmission lead to a higher risk of poor compliance.¹

Individual factors such as social cognitive determinants may provide additional insight into hand hygiene behaviour.^{3,16-18} Many factors play a role in eventually determining either a hand hygiene action or lack of compliance: perception and knowledge of the transmission risk and of the impact of HCAI; social pressure; HCWs' conviction of their self-efficacy; the evaluation of perceived benefits against the existing barriers; the intention to perform the hand hygiene action. For instance, intention to wash hands did not predict observed hand-washing behaviour in one study, whereas it did in another.^{19,20} Hence, hand hygiene behaviour appears not to be homogeneous and can be classified into at least two types of practice.²¹ Inherent hand hygiene practice, which drives most community and HCW hand hygiene actions, occurs when hands are visibly soiled, sticky or gritty. On the other hand, elective hand hygiene practice represents those opportunities for hand cleansing not encompassed in the inherent category. Among HCWs, this component of hand hygiene behaviour is similar to many common social interactions, such as shaking hands. During healthcare, it would include touching a patient (e.g. taking a pulse or blood pressure) or

having contact with an inanimate object in the patient's surroundings. As they recall a common social behaviour, these contacts do not necessarily trigger an intrinsic need to cleanse hands, although they do involve the risk of cross-transmission. According to behavioural theories, this is the component of hand hygiene most likely to be omitted by busy HCWs and it has been repeatedly confirmed by field observations.

Impact of hand hygiene promotion on HCAI

Given the complexity of hand hygiene behaviour and the influence of numerous external factors, promotion of good practices is complex and its potential for success depends on the delicate balance between evaluation of benefits and existent barriers. Demonstration of the effectiveness of recommendations and strategies to improve hand hygiene on the ultimate outcome, i.e. the HCAI rate, is crucial in both motivating HCWs' behavioural change and securing an investment in this preventive measure by policy-makers and health-care managers. However, research in this field represents a very challenging activity since methodological and ethical concerns make it difficult to conduct randomised controlled trials with appropriate sample sizes that could establish the relative importance of hand hygiene in the prevention of HCAI. In addition, HCAI surveillance is a very resource- and time-consuming activity requiring rigorous and standardised methods, and therefore is seldom available on a regular and reliable basis.

Nevertheless, there is convincing evidence that improved hand hygiene can reduce infection rates. More than 20 hospital-based studies of the impact of hand hygiene on the risk of HCAI have been published between 1977 and 2008 (Table I).^{22–45} Of these, some were conducted hospital-wide and report long-term follow-up to demonstrate sustainability.^{29,30,38,42} Despite study limitations, almost all reports showed a temporal association between improved hand hygiene practices and reduced infection and cross-transmission rates. Most investigations were conducted in adult or neonatal intensive care units (ICUs) and the large majority introduced the use of alcohol-based hand rubs in association with other promotional components in a multimodal implementation strategy (Table I). Three studies failed to show HCAI reduction following hand hygiene promotion.^{24,41,44} In one study, the intervention did not succeed in significantly increasing hand hygiene compliance.²⁴ In another, the methods and definitions used to detect HCAI were not described and therefore the data

reliability cannot be assessed.⁴⁴ In a prospective, controlled, cross-over trial, Rupp and colleagues observed no substantial change in device-associated infection rates and infections due to multidrug-resistant pathogens, despite a significant and sustained improvement in hand hygiene adherence.⁴¹ Nevertheless, although the study was well designed, it was criticised for lack of screening for cross-transmission, lack of statistical power, and use of an alcohol-based hand rub that failed to meet the EN 1500 standards for antimicrobial efficacy.^{46–48}

In many countries, the evidence from studies on hand hygiene effectiveness has been convincing enough to motivate governments to invest resources in hand hygiene national and subnational campaigns.⁴⁹ However, this evidence mainly reflects findings from interventions implemented in healthcare settings in developed countries. Further research is needed to evaluate the relative efficacy of each key element of multimodal strategies, to assess their implementation feasibility in settings with limited resources, and to gather information on successful solutions allowing adaptation. Among its main objectives, the First Global Patient Safety Challenge, launched by the WHO World Alliance for Patient Safety, intends to make available implementation tools for field use and to assess their validation and adoption in countries at different income levels.⁴⁹

Another controversial issue is how significant should be the hand hygiene compliance increase following the intervention in order to be considered satisfactory. No data are available yet to answer this question. Among all the above-mentioned studies, increased compliance rates at follow-up did not exceed 81% (Table I). One study with a follow-up of eight years showed a sustained compliance increase of up to a maximum of 66% and succeeded in parallel to maintain the achieved reduction in HCAI rates of <10%.^{29,30} To achieve 100% compliance is not strictly necessary to determine improvement of patient safety at the bedside. On the other hand, the goal of sustained 100% compliance appears unlikely to be achieved because of the complex range of factors influencing HCWs' behaviour related to hand hygiene performance. Thus, there is a need for careful consideration before setting a goal of zero tolerance to hand hygiene non-compliance to avoid failure and frustration.

Challenging issues related to the adoption of alcohol-based hand rubs

The adoption of alcohol-based hand rubs is considered the gold standard for hand hygiene in most

Table I Most relevant studies assessing the impact of hand hygiene promotion on HCAI (1977–2008)

Year	Hospital setting	Intervention	Impact on hand hygiene compliance	Impact on HCAI	Duration of follow-up	Reference
1977	Adult ICU	Promotion of hand washing with a chlorhexidine hand cleanser	NA	Significant reduction ($P < 0.001$) in the percentage of patients colonised/infected by <i>Klebsiella</i> spp.	2 years	22
1989	Adult ICU	Education on hand washing, hand hygiene observation, performance feedback	Compliance increase from 14% to 73% (before patient contact) and from 28% to 81% (after patient contact)	Significant reduction ($P = 0.02$) in HCAI rates (from 33% to 12% and from 33% to 10%, respectively, after two intervention periods 4 years apart)	6 years	23
1990	Adult ICU	Hand-washing promotion	Compliance increase from 22% to 29.9%	No impact on HCAI rates	11 months	24
1992	Adult ICUs	Prospective multiple cross-over trial on hand hygiene with either chlorhexidine soap or 60% isopropyl alcohol with optional hand washing with plain soap	NA	Significant reduction ($P < 0.02$) in HCAI rates using hand washing with chlorhexidine soap	8 months	25
1994	NICU	Introduction of hand washing with triclosan 1% (w/v)	NA	Elimination of MRSA, when combined with multiple other infection control measures. Significant reduction ($P < 0.02$) in nosocomial bacteraemia (from 2.6% to 1.1%) using triclosan compared with chlorhexidine for hand washing	9 months	26
1995	Newborn nursery	Introduction of HCWs' hand washing and neonates' bathing with triclosan 0.3% (w/v)	NA	Control of MRSA outbreak	3.5 years	27
2000	MICU/NICU	Organisational climate intervention	NA	Significant (85%) relative reduction ($P = 0.02$) in VRE rate in the intervention hospital; statistically not significant (44%) relative reduction in control hospital; no significant change in MRSA	8 months	28

2000	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, training, performance feedback, posters	Significant increase in compliance from 48% to 66%	Significant reduction ($P = 0.04$ and $P < 0.001$) in the annual overall HCAI prevalence (42%) and MRSA cross-transmission rates (87%). Active surveillance cultures and contact precautions implemented during same period. A follow-up study showed continuous increase in hand rub use, stable HCAI rates and cost savings.	8 years	29,30
2003	Orthopaedic surgical unit	Alcohol-based hand rub introduction, posters, feedback on HCAI rates, patient education and involvement	NA	36% decrease (P value, NA) in HCAI (mainly urinary tract infection and SSI) rates (from 8.2% to 5.3%)	10 months	31
2004	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, posters, performance feedback, informal discussions	No significant increase in compliance before and after patient contact	Significant reduction ($P = 0.03$) in hospital-acquired MRSA cases (from 1.9% to 0.9%)	1 year	32
2004	Adult intermediate care unit	Hand hygiene electronic monitoring at exit from patient rooms, direct observation and voice prompts	Compliance increase from 19.1% to 27.3% by electronic monitoring	Reduction in HCAI rates (not statistically significant, P value, NA)	2.5 months	33
2004	NICU	Alcohol-based hand rub introduction, hand hygiene observation, training, hand-hygiene protocols, posters	Compliance increase from 40% to 53% (before patient contact) and from 39% to 59% (after patient contact)	Reduction ($P = 0.14$) in HCAI rates (from 11.3 to 6.2 per 1000 patient-days)	6 months	34
2004	NICU	Education, written instructions, hand hygiene observation, posters, performance feedback, financial incentives	Compliance increase from 43% to 80%	Significant reduction ($P = 0.003$) in HCAI rates (from 15.1 to 10.7 per 1000 patient-days), in particular for respiratory infections	2 years	35

(continued on next page)

Table I (continued)

Year	Hospital setting	Intervention	Impact on hand hygiene compliance	Impact on HCAI	Duration of follow-up	Reference
2005	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, training, posters	Compliance increase from 62% to 81%	Significant reduction ($P = 0.01$) in hospital-associated rotavirus infections	4 years	36
2005	Adult ICUs	Hand-washing observation, training, guideline dissemination, posters, performance feedback	Compliance increase from 23.1% to 64.5%	Significant reduction ($P < 0.001$) in HCAI rates (from 47.5 to 27.9 per 1000 patient-days)	21 months	37
2005	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, training, posters, promotional gadgets	Compliance increase from 21% to 42%	Significant reduction (57%, $P = 0.01$) in MRSA bacteraemia	36 months	38
2007	Neurosurgery	Alcohol-based hand rub introduction, training, posters	NA	Reduction (54%, $P = 0.09$) in overall incidence of SSI. Significant reduction (100%, $P = 0.007$) in superficial SSI rates	2 years	39
2007	Neonatal unit	Posters, focus groups, hand hygiene observation, HCWs' perception assessment, feedback on performance, perception and HCAI rates	Compliance increase from 42% to 55%	Reduction (P value, NA) in overall HCAI rates (from 11 to 8.2 infections per 1000 patient-days) and 60% decrease (P value NA) in risk of HCAI in very low birth weight neonates (from 15.5 to 8.8 episodes per 1000 patient-days)	27 months	40
2008	ICU	Prospective, controlled, cross-over trial in two units with education, posters and alcohol-based hand rub introduction	Compliance increase from 38–37% to 68–69%	No impact on device-associated infection and infections due to multidrug-resistant pathogens	2 years	41

2008	(1) Six pilot hospitals	Alcohol-based hand rub introduction, hand hygiene observation, training, posters, promotional gadgets	(1) Compliance increase from 21% to 48%	(1) Significant reduction ($P=0.035$) in MRSA bacteraemia (from 0.05 to 0.02 per 100 patient discharges per month) and of clinical MRSA isolates ($P=0.003$)	(1) 2 years	42
	(2) All public hospitals in Victoria (Australia)		(2) Compliance increase from 20% to 53%		(2) Reduction in MRSA bacteraemia (from 0.03 to 0.01 per 100 patient discharges per month, $P=0.09$) and of clinical MRSA isolates ($P=0.043$)	
2008	Urology Unit	Alcohol-based hand rub introduction, hand hygiene observation, training, posters, patient education	Compliance increase from 0% (estimation) to 28.2%	Significant reduction ($P < 0.001$) in HCAI rates from 13.1% to 2.1%	6 months	43
2008	NICU	Alcohol-based hand rub introduction, training, posters	NA	Significant reduction ($P=0.009$) in HCAI incidence (4.1 vs 1.2 per 1000 patient-days)	18 months	44
2008	NICU	Alcohol-based hand rub introduction, hand hygiene observation, training, posters, performance feedback, focus groups	Compliance increase from 6.3% to 81.2%	No impact on HCAI rates (9.7 vs 13.5 per 1000 patient-days) (P -value NA)	7 months	45

HCAI, healthcare-associated infection; ICU, intensive care unit; NICU, neonatal intensive care unit; MICU, medical intensive care unit; VRE, vancomycin-resistant enterococcus; MRSA, methicillin-resistant *Staphylococcus aureus*; SSI, surgical site infection; NA, not available.

clinical situations. This recommendation, promoted by the CDC and WHO and embraced by many national hand hygiene guidelines, is based on the evidence of better microbiological efficacy, less time required to achieve the desired effect, point of patient care accessibility and a better skin tolerance profile.^{1,29,50–56}

The WHO Guidelines on Hand Hygiene in Health Care have been conceived to catalyse hand hygiene improvement in any setting regardless of the resources available and the cultural background.^{1,49,57} Since there is a strong emphasis in the Guidelines and in their implementation tools on the availability of alcohol-based hand rubs as a key factor for hand hygiene improvement, the issue of the procurement and cost of these products, especially in developing countries, challenges the recommendation feasibility. Indeed, global sales of commercially produced, alcohol-based hand rubs in 2007 were as high as US \$3 billion, corresponding to 295 million L in volume, with an overall 16.3% increase compared with 2003 (WHO, unpublished data), mostly observed in Europe and North America (27% and 23% increase, respectively). Looking at procurement opportunities, these products are available only in South Africa in the African continent and in China, India, and Japan in the Asia–Pacific region (WHO unpublished data). The most important issue curbing the purchasing power in these regions is the high cost of these products. Market prices vary from US \$2.50 to 8.40 per 100 mL dispenser and are clearly unaffordable for many developing countries. The WHO multimodal hand hygiene improvement strategy offers a possible solution to this obstacle: the local production of either of two WHO-recommended hand rub formulations.¹ The implementation toolkit accompanying the WHO Guidelines on Hand Hygiene in Health Care includes a Guide to Local Production to manufacture alcohol-based hand rubs in hospital pharmacies or other facilities for local use.¹ Two formulations are proposed: one based on ethanol 80% v/v, and one based on isopropyl alcohol 75% v/v; both include hydrogen peroxide 0.125% v/v and glycerol 1.45% v/v. Local production has been carried out in many healthcare settings worldwide and was carefully monitored and evaluated by WHO in several sites (WHO unpublished data). No major procurement, production, and storage obstacles were encountered and long-term stability at tropical temperatures was shown (up to 19 months). The final products complied with quality control standards and had good skin tolerability at very low cost (less than US \$0.50 per 100 mL).

Controversial issues related to the use of alcohol-based hand rubs and *Clostridium difficile* spread

Following the widespread use of alcohol-based hand rubs as the gold standard for hand hygiene in healthcare, concern has been raised about their lack of efficacy against spore-forming pathogens. Indeed, apart from iodophors, albeit at a concentration remarkably higher than the one used in antiseptics, no hand hygiene agent (including alcohols, chlorhexidine, hexachlorophene, chloroxylenol, and triclosan) is reliably sporicidal against *Clostridium* or *Bacillus* spp.^{1,58} Mechanical friction while washing hands with soap and water may help physically remove spores from the surface of contaminated hands.^{59–61} As a consequence, contact precautions are highly recommended during *C. difficile*-associated outbreaks, in particular, glove use and hand washing with a non-antimicrobial or antimicrobial soap and water following glove removal after caring for patients with diarrhoea.⁵

The widespread use of alcohol-based hand rubs in healthcare settings has been blamed repeatedly for the increase in *C. difficile*-associated disease rates, although this has not been demonstrated by any study to date.^{62,63} On the contrary, the observed increase in *C. difficile*-associated disease began in the USA long before the wide use of alcohol-based hand rubs.^{64,65} Furthermore, one large outbreak with the epidemic strain REA-group B1 (equivalent to ribotype 027) was managed successfully by introducing alcohol-based hand rub for all patients other than those with *C. difficile*-associated disease.⁶⁶ In addition, several studies recently demonstrated a lack of association between the consumption of alcohol-based hand rubs and the incidence of clinical isolates of *C. difficile*.^{67–69} In conclusion, discouraging the widespread use of alcohol-based hand rubs for the care of patients other than those with *C. difficile*-associated disease will only jeopardise overall patient safety in the long term.

Discussion

From the available evidence it appears that multimodal interventions are the most suitable strategy to determine behavioural change leading to improved hand hygiene compliance and reduction in HCAI rates. Introduction of alcohol-based hand rubs and continuous educational programmes are key factors to overcome infrastructure barriers and to build solid knowledge improvement. Support by

healthcare administrators and commitment by national and local governments are essential to make hand hygiene an institutional and national priority for patient safety and to ensure long-term sustainability of promotional programmes. Higher priority should also be given to hand hygiene as a research topic, through good-quality, randomised, controlled trials to determine definitively its impact on HCAI and the relative effectiveness of the different components of multimodal strategies.

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