

**Standard Infection Control Precautions Literature Review:  
Hand Hygiene:  
Hand washing, hand rubbing and indications for  
hand hygiene.**

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Version History:			
This literature review will be updated in real time if any significant changes are found in the professional literature or from national guidance/policy.			
Version	Date	Summary of changes	Changes marked
1.0	13 July 2020	<p>Three reviews (Hand washing V2.0 2016, Indications for Hand Hygiene V2.0 2016, and Use of Alcohol Based Hand Rub V2.0 2016) were amalgamated into one review using the two-person NIPCM methodology.</p> <p>Addition of the following recommendations:</p> <p><b>When should hand hygiene be performed?</b> Hand hygiene should be carried out using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) following contact with the patient's immediate surroundings;</p> <p><b>How should hands be dried after hand washing?</b> Air-dryers, including high speed air-dryers, should not be used in the clinical setting or other health and care settings because they are noisy and may disperse microorganisms via the airborne (aerosol) route;</p> <p><b>What is the evidence regarding the wearing of jewellery in relation to hand hygiene, including Jewellery worn for religious reasons?</b> Bracelets or bangles such as the Kara which are worn for religious reasons should be able to be pushed higher onto the arm and secured in place for all patient care activities. This is to enable effective hand hygiene (which includes the wrists);</p>	

		<p><b>What are the requirements for sink design, provision and types of tap for clinical hand wash?</b> Sinks should be large enough to contain most splashes and enable the correct hand washing technique to be performed without excessive splashing of the user and the surrounding area. In high risk units and low-use situations, the use of sensor operated, automated 'non-touch' taps is not recommended as the complexity of the internal mechanisms can result in a greater risk of contamination by microorganisms and biofilms. For new installation and planned replacements or refurbishments in intensive care units, taps should be removable and easily dismantled for cleaning and disinfection. Infrequently used water outlets should be identified and assessed as per the local Water Safety Plan and incorporated into a flushing regime or removed from use;</p> <p><b>Is the use of alcohol based hand rubs suitable for individuals who abstain from alcohol for religious reasons?</b> The use of ABHR by persons with religious beliefs that forbid the consumption of alcohol is permissible as external application of the synthetic alcohol in these solutions is not considered intoxicating.</p>	
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**Approvals – this document requires the following approvals (in cases where signatures are required add an additional 'Signatures' column to this table)::**

Version	Date Approved	Name	Job Title	Division
1.0	July 2020	National Policies and Guidance Group (Steering and Consensus)		

<b>HPS ICT Document Information Grid</b>	
<b>Description</b>	This literature review examines the available professional literature on Hand Hygiene – hand washing, hand rubbing and indications for hand hygiene in health and care settings.
<b>Purpose:</b>	To inform the Standard Infection Control Precaution (SICP) Hand Hygiene section of the National Infection Prevention and Control Manual.
<b>Target audience:</b>	All NHS staff involved in the prevention and control of infection in NHSScotland.
<b>Circulation list:</b>	Infection Control Managers, Infection Prevention and Control Teams, Public Health Teams.
<b>Update/review schedule:</b>	Updated as new evidence emerges with changes made to recommendations as required.
<b>Update level:</b>	Practice – <b>No change to practice</b>  Research – <b>No change to evidence.</b>
<b>Cross reference:</b>	National Infection Prevention and Control Manual <a href="http://www.nipcm.hps.scot.nhs.uk/">http://www.nipcm.hps.scot.nhs.uk/</a>  SICP Literature Review: Surgical Hand Antisepsis in the Clinical Setting <a href="http://www.nipcm.hps.scot.nhs.uk/web-resources-container/standard-infection-control-precautions-sicp-literature-review-hand-hygiene-surgical-hand-antisepsis-in-the-clinical-setting/">http://www.nipcm.hps.scot.nhs.uk/web-resources-container/standard-infection-control-precautions-sicp-literature-review-hand-hygiene-surgical-hand-antisepsis-in-the-clinical-setting/</a>

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## 1. Objectives

The aim of this review is to examine the extant professional literature regarding effective hand washing, hand rubbing and indications for hand hygiene. The specific objectives of the review are to determine:

- When should hand hygiene be performed?
- What is the evidence for each of the five key moments as indications for hand hygiene?
- Are there any additional key moments where hand hygiene (hand washing or alcohol based hand rub (ABHR) use) should be performed?
- What is the correct process and technique to ensure that all surfaces of the hands are covered during washing?
- What is the recommended water temperature for hand washing?
- How should hands be dried after hand washing?
- What is the evidence for infection risk from finger nails to enable effective hand hygiene?
- What is the evidence regarding the bare below the elbows policy?
- What is the evidence regarding the wearing of jewellery in relation to hand hygiene, including jewellery worn for religious reasons?
- Where should hand washing products be placed in the care environment?
- What are the requirements for sink design, provision and types of taps for clinical hand wash basins?
- Where should clinical hand wash basins be placed in health and care settings?
- Is the use of alcohol based hand rubs suitable for individuals who abstain from alcohol for religious reasons?
- What is the correct process and technique when using alcohol based hand rub for hand hygiene?
- Where should alcohol based hand rub products be placed in the care environment?

## 2. Methodology

This systematic literature review was produced using a defined methodology as described in the [National Infection Prevention and Control Manual: Methodology](#).

## 3. Discussion

### 3.1 Implications for practice

#### When should hand hygiene be performed?

The World Health Organization's (WHO) '5 moments for hand hygiene' concept is based on an evidence-based hand transmission model and aims to provide reference points for when hand hygiene should be performed in order to interrupt the transmission of microorganisms during delivery of care. The five key moments are defined as:

- **Moment 1:** Perform hand hygiene using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before touching a patient.
- **Moment 2:** Perform hand hygiene using antimicrobial liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before carrying out a clean/aseptic procedure such as handling an invasive device.
- **Moment 3:** Hand hygiene should be carried out using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) after contact with body fluids, mucous membranes or wound dressings.
- **Moment 4:** Perform hand hygiene using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) after touching a patient.<sup>1-4</sup>
- **Moment 5:** Hand hygiene should be carried out using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) following contact with the patient's immediate surroundings.

#### What is the evidence for each of the five key moments for hand hygiene?

**Moment 1:** Perform hand hygiene using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before touching a patient.<sup>4</sup> There is consensus in the literature that hand hygiene should be performed using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before touching a patient.<sup>1, 2, 5</sup> Observational studies have demonstrated the risk of transmission to patients following contact with contaminated hands of healthcare workers.<sup>6-9</sup>

**Moment 2:** Perform hand hygiene using antimicrobial liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before carrying out a clean/aseptic procedure such as handling an invasive device.<sup>3, 5</sup> There is a consensus of evidence that hand hygiene should be performed before carrying out a clean/aseptic procedure such as handling an invasive device;<sup>1-3</sup> performing hand hygiene at this moment has been associated with fewer complications occurring in peripheral venous catheters.<sup>10</sup>

**Moment 3:** Hand hygiene should be carried out using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) after contact with body fluids, mucous membranes or wound dressings.<sup>4</sup> Visibly dirty hands or hands contaminated with blood, other body fluids or excretions must first be washed with liquid soap and water if alcohol based hand rub is going to be used for hand hygiene subsequently.<sup>2, 5</sup> There is a substantial volume of evidence indicating that hand hygiene should be performed using liquid soap or an alcohol based hand rub (if hands are not visibly soiled) immediately after contact with body fluids, mucous membranes or wound dressings.<sup>1-3</sup> Performing hand hygiene at this indication is necessary to reduce the risk of infection to healthcare workers, as microorganisms can be isolated from infected wounds, but also to reduce the risk of transfer of microorganisms from a colonised to a clean site during different care activities on the same patient.<sup>1</sup>

**Moment 4:** Perform hand hygiene using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) after touching a patient.<sup>1-4</sup> Healthcare worker hand contamination has been demonstrated following contact with patients in a number of studies.<sup>6-9, 11-14</sup>

**Moment 5:** Hand hygiene should be carried out using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) following contact with the patient's immediate surroundings.<sup>1-3, 5, 9</sup> The fifth moment of the WHO hand hygiene guidelines is defined as "after touching patient surroundings" and indicates that hand hygiene must occur after exposure to any surface in the patient zone.<sup>4</sup> In terms of the hospital environment the patient zone encompasses "...all inanimate surfaces that are touched by or in direct physical contact with the patient such as the bed rails, bedside table, bed linen, infusion tubing or other medical equipment" and "...surfaces frequently touched by HCWs while caring for the patient...".<sup>3, 4</sup> A number of studies have demonstrated that hands can become contaminated after contact with contaminated surfaces such as the patient's bed, bedside table or equipment within the patient's surroundings.<sup>6-9, 15-17</sup> A recent study has identified contamination of medical charts as a risk for transmission of HAI.<sup>18</sup>

The World Health Organization published guidance on the application of the 'five moments' in outpatient settings in 2012,<sup>19</sup> in some settings 'moment 5' is removed as it is typically combined with 'moment 1' e.g. in care homes, in these settings the indications for hand hygiene may be referred to as the 'Four Moments'.



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## Are there any additional key moments where hand hygiene should be performed?

The WHO Guidelines on Hand Hygiene in Healthcare and the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force recommend that hand hygiene is performed using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before handling medication or preparing food and after visiting the toilet.<sup>1, 3-5</sup>

There is some evidence from an observational study showing the potential for microorganisms to be transferred from sites on patients' skin to clean sites.<sup>8</sup> As such, hand hygiene should be performed using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) between carrying out different care activities on the same patient.<sup>2-4</sup> In addition, hand hygiene should be performed after removing sterile or non-sterile gloves.<sup>1-5</sup>

## What is the correct process and technique to ensure that all surfaces of the hands are covered during washing?

It is recommended that all cuts and abrasions should be covered with a waterproof dressing before hand hygiene, including hand washing, is commenced.<sup>2</sup>

There is consensus in the literature regarding the recommended method for hand washing in the healthcare setting, which can be summarised as follows:

- Wet hands under running warm/tepid water;
- Apply the manufacturers recommended quantity of liquid soap;
- Rub hands together for at least 15 seconds, ensuring all surfaces of the hands are covered;
- Rinse hands well under running water;
- Dry hands thoroughly using a disposable paper towel;
- Turn off the tap using elbow or a paper towel to prevent contamination of clean hands.<sup>2-4, 20, 21</sup>

There is not a consistent evidence base to inform how all surfaces of the hands should be covered during hand washing. Ayliffe *et al* published the first description of a technique in 1978<sup>22</sup> and despite the fact that it was not designed for application in clinical practice the WHO recommend this technique as best practice and it has been adopted internationally.<sup>4</sup> The six step technique is as follows (see [Appendix 1 of National Infection Prevention and Control Manual](#)):

- Rub hands palm to palm.
- Rub right palm over the back of the other hand with interlaced fingers and vice versa.
- Rub palm to palm with the fingers interlaced.

- Rub the backs of fingers to opposing palms with fingers interlocked.
- Use rotational rubbing of the left thumb clasped in the right palm and vice versa.
- Use rotational rubbing, backwards and forwards with clasped fingers of the right hand in the left palm and vice versa.<sup>1-4, 20</sup>

While there is consensus within guidelines, one systematic review<sup>23</sup> and one cross-over trial<sup>24</sup> comparing bacterial reduction when using the technique described or modified techniques were identified in this review. The systematic review found that some modifications of the technique were more effective at reducing bacterial loads.<sup>23</sup> However, the cross-over trial found a shortened repeated version of the six step technique was not significantly superior to the six step technique at reducing *Clostridioides difficile*.<sup>24</sup> The heterogeneity of identified studies means that it is difficult to draw definitive conclusions however the varying results suggest a need for further research to determine the optimal technique for reducing the bacterial load on hands of healthcare workers.

### **What is the recommended water temperature for hand washing?**

A limited volume of evidence was identified by this review which examines water temperature for hand washing. One study found no significant effects on bacterial reduction associated with water temperatures ranging from 15 to 38 °C when using plain or antimicrobial soap.<sup>25</sup> While little evidence was identified on the reduction of contamination, there is consensus that hands should be washed using warm or tepid water because repeated exposure to hot water may lead to the development of dermatitis and staff may be intolerant to cold water and not perform hand washing adequately.<sup>1, 2, 4, 5, 26</sup>

Furthermore, it is possible that extremes of water temperature could have a detrimental effect on hand washing compliance of healthcare workers or the rigour of their hand washing technique; although no evidence was identified by this review to support this assertion.

### **How should hands be dried after hand washing?**

Thorough drying of hands is important as wet surfaces have been shown to transfer microorganisms more readily than dry surfaces<sup>27</sup> and wet hands have been shown to harbour more bacteria than dried hands.<sup>28</sup> Furthermore, failure to adequately dry hands can, over time, lead to skin damage or irritation.<sup>20</sup>

A number of recent studies have compared various hand drying methods including warm air-dryers, high speed (or jet) air-dryers, and paper towels.<sup>27, 29-33</sup> A systematic review found that warm air-dryers may be unsuitable for hand drying due to proposed dispersal of microorganisms via the airborne route and the potential to increase bacterial counts on hands.<sup>27</sup> Similarly, high speed air-dryers have been found to produce significantly more droplets which were dispersed over a larger area compared with use of paper towels.<sup>30, 31, 34</sup> High-speed air-dryers have been associated with significantly higher microbial contamination of equipment and

environmental surfaces compared to paper towels.<sup>29, 34</sup> Also, recovery of bacteria from surfaces of high speed air-dryers has been found to be significantly higher than the recovery from the surface of paper towel dispensers.<sup>29</sup>

There is mixed evidence for the effectiveness of various hand drying methods for removing bacteria from washed hands. One study found no significant differences in the efficiency of various hand drying methods (including air drying and use of paper towels) for removing bacteria from washed hands.<sup>32</sup> However, one study found that hand drying with paper towels resulted in a greater reduction on mean colony forming units (CFUs) than drying with a warm air-dryer or high speed air-dryer;<sup>33</sup> and another found the opposite i.e. hands dried with a high-speed air-dryer had significantly fewer bacterial contaminants than those dried with paper towels.<sup>28</sup>

A degree of risk has been identified in the literature relating the use of air-dryers, including high speed air-dryers, in the clinical setting. A potential for warm air dryers to result in red, sore and dry hands has been identified.<sup>27</sup> In addition, reduced drying efficacy compared to use of paper towels and the potential for excessive noise in clinical areas was also reported.<sup>27</sup> Therefore air-dryers are not recommended for use in health and care settings.

The use of paper towels is recommended in most national and international guidelines.<sup>1, 2, 4, 21</sup> Recommendations include the use of good quality, disposable paper towels for hand drying.<sup>1, 2</sup> It is also recommended that hands should be dried using a method that avoids recontamination and that the same towel(s) should not be used multiple times or by multiple individuals.<sup>1, 3, 4</sup>

There is consensus that cloth towels (both hanging and roll type), represent a contamination risk and are therefore unsuitable for use in health and care settings.<sup>1, 3, 4, 27</sup>

Based on the identified evidence, it is recommended that soft, absorbent, disposable paper towels are used across NHSScotland for hand drying following hand washing in the healthcare environment.

### **What is the evidence for infection risk from finger nails to enable effective hand hygiene?**

The Scottish Government's Chief Executive Letter CEL42(2010) on dress code across NHSScotland, states that staff should keep their nails short and clean when providing patient care.<sup>35</sup>

There is agreement across the literature that nails should be kept short in the healthcare setting with the specific recommendation that finger nails should not exceed ¼ inch (approximately 0.5 cm) in length beyond the end of the finger tip.<sup>1-4, 21, 36, 37</sup> However, it is not clear how this length was determined and one cross sectional study found a correlation between nails fingernails longer than 2 mm and the presence of *Staphylococcus aureus*.<sup>38</sup> The recommendation that nails be kept short is intended to facilitate thorough cleaning underneath finger nails and is in part based on evidence which demonstrates that larger numbers of microorganisms can be found under longer nails when compared to short nails.<sup>36</sup> Therefore, in

order to help ensure correct and thorough hand hygiene and to mitigate against the potential risks associated with longer nails, healthcare workers across NHSScotland and other health and care settings should have short nails.

CEL42(2010) also states that NHSScotland healthcare workers should not wear false/artificial nails when providing patient care.<sup>35</sup> This requirement is consistent with the evidence identified from the extant professional literature by this review. Studies demonstrate that wearing false/artificial nails of any kind should not be permitted in the healthcare setting and this has been adopted by evidence-based guidelines.<sup>2</sup> While one piece of international guidance states that artificial nails or extenders should not be worn when having direct contact with patients at higher risk of infection,<sup>1</sup> others suggests they should not be worn during any patient contact.<sup>2-4</sup> The evidence suggests that the wearing of artificial nails is inappropriate in the clinical setting due to various demonstrated detrimental effects; including an increase in subungual (underneath the nail) bacteria and hand microflora associated with wear,<sup>36, 39</sup> which is exacerbated by gradual nail lifting at the edges and results in further microbial growth;<sup>36</sup> and the inefficiency of hand hygiene in comparison to individuals with natural nails as well as the possibility of glove tearing or interference with the donning of gloves.<sup>36, 39</sup> There is also evidence to link artificial nails with outbreaks of infection.<sup>37, 40</sup> An investigation of an outbreak of *Klebsiella pneumoniae* infections in a neonatal intensive care unit identified an association of infection with care from a healthcare worker wearing artificial nails contaminated with ESBL-producing *K. pneumoniae*.<sup>40</sup> Therefore healthcare workers should not wear any form of artificial nail as they inhibit hand hygiene and pose an infection risk.

The evidence regarding the wearing of nail products (i.e. polish/varnish and gel nails) is unclear, leading to conflicting recommendations in the literature. Some of the identified literature and practice recommendations advise that the wearing of nail products should be prohibited in the clinical setting, as chipped nail products may harbour microorganisms and thus represent an infection risk.<sup>2, 36</sup> However, one cross-sectional study found that nail polish had no impact on the bacterial loads of hands.<sup>38</sup>

Although evidence is conflicting, it is acknowledged that chipped nail products may act as a reservoir for microorganisms and thus pose an infection risk,<sup>20</sup> in addition to looking unprofessional. Therefore, it is recommended that nail products should not be worn by NHSScotland healthcare workers.

### **What is the evidence regarding the bare below the elbows policy?**

Current policy states that clinical staff should be “bare below the elbows”.<sup>35</sup> Staff who wish to cover their forearms for religious reasons may wear disposable over-sleeves, these must be removed and disposed of before performing hand hygiene and replaced with a new set after.<sup>35</sup>

The evidence base which currently underpins the policy is not comprehensive, with the majority of studies being of low level evidence, based on professional opinion or on small scale studies. A cohort study was identified which found that medical staff who were “bare below the elbow”

and those that were not did not have significantly different bacterial loads on their hands following hand washing.<sup>41</sup>

### **What is the evidence regarding the wearing of jewellery in relation to hand hygiene, including jewellery worn for religious reasons?**

Limited evidence was identified for the wearing of watches or bracelets within this review.<sup>2, 36</sup> A non-systematic review states that wearing of jewellery, including watches, inhibits correct hand hygiene.<sup>36</sup> Multiple pieces of guidance recommend that watches and wrist jewellery should be removed to ensure hands can be decontaminated throughout the duration of clinical work.<sup>2-4</sup>

One cohort study which examined contamination of hands and wrist watches concluded that wearing a watch does not contribute to higher levels of bacteria on hands unless they are physically manipulated or touched.<sup>42</sup> However, a cross-sectional study recovered more than three times as many bacteria from healthcare workers wearing watches than those without watches.<sup>38</sup>

CEL42(2010) states that NHSScotland healthcare workers should not wear any wrist or hand jewellery (other than a plain band ring) when providing patient care.<sup>35</sup> The consensus of the identified literature is that the wearing of jewellery (i.e. rings, watches and/or bracelets) prevents effective hand cleansing.<sup>2, 36</sup> A number of studies report that healthcare workers who wore jewellery, predominantly but not exclusively rings, exhibited greater bacterial counts on their hands, even following hand hygiene.<sup>38, 43, 44</sup> Further studies also suggest that jewellery can harbour microorganisms and thus pose an infection risk.<sup>36, 45</sup> It should be noted that plain rings have been shown to harbour lower numbers of bacteria in comparison to ornate rings.<sup>45</sup> Recommendations from a number of guidance and documents state that jewellery should not be worn when providing clinical care<sup>3, 4, 36</sup> or should at least be removed prior to hand hygiene.<sup>2, 21, 26</sup> This recommendation is emphasised in settings where risk of infection is high, such as the operating theatre or intensive care units.<sup>3</sup> However, one piece of international guidance states that the wearing of rings is an unresolved issue and as such no recommendations can be made.<sup>1</sup> Furthermore, the practicality of wearing rings in the clinical setting has also been cited as an issue, with a non-systematic review suggesting that wearing rings may make donning gloves more difficult as well as having the potential to breach glove integrity.<sup>36</sup>

Jewellery worn for religious reasons such as Kara bangles worn by initiated Sikhs do not require to be removed for hand decontamination, however, they should be pushed up the arm and secured in place to enable effective hand decontamination.<sup>46</sup>

Based on the majority consensus from the evidence; healthcare workers should not wear jewellery, including wrist watches, bracelets and rings (excluding a plain band ring), because they inhibit effective hand hygiene and may pose an infection risk. It is also recommended in UK guidance that hand and wrist jewellery should be removed to allow effective hand decontamination.<sup>2, 21</sup>

## Where should hand washing products be placed in the patient care environment?

The placement of hand hygiene products is crucial to encourage and assist staff to comply with correct hand hygiene practices.<sup>3, 4</sup> In terms of liquid soap and disposable paper towels the current NHSScotland guidance states that these must be wall mounted and placed near sinks allowing for easy operation.<sup>4, 47</sup>

One observational study examining two different layouts of hand hygiene products at hand wash basins observed the rates of hesitation and error when applying hand hygiene products, including soap, ABHR and moisturiser. No significant difference was found between the two different layouts used. The authors suggest that standardising the layouts of products at sinks in health and care settings may reduce errors in hand hygiene.<sup>48</sup>

## What are the requirements for sink design, provision and types of tap for clinical hand wash basins?

Sink design, provision and types of tap are important factors to consider when making an assessment of hand washing facilities. Health Facilities Scotland (HFS) guidance states that sinks located in the clinical area need to be fit for purpose (e.g. designed to prevent splashing, enable effective cleaning, not be able to have a plug or overflow, include a splash-back).<sup>47</sup>

The adequate provision of sinks in clinical areas is important as this should encourage staff to comply with hand hygiene protocols. In a cross-sectional study, adequate sink visibility was found to correlate with increased hand washing frequency by healthcare staff.<sup>49</sup> Another cross-sectional study found that direct visualisation and distance to sink from the patient care area was strongly associated with hand washing compliance.<sup>50</sup> In addition, a further observational study found that hand hygiene compliance increased following the installation of additional sinks, the design of which focused on increased visibility.<sup>51</sup> However, it is recommended that the number of sinks varies dependant on the clinical area.<sup>47</sup> Infrequently used water outlets should be identified and assessed as per the local Water Safety Plan and incorporated into a flushing regime or removed from use as per the HPS *Pseudomonas aeruginosa* guidance.<sup>52</sup> Acute, elderly and long-term care settings should ideally have one sink between four patients. Furthermore it is recommended that sinks used for hand washing should be used solely for this purpose.<sup>47</sup> The use of hand washing facilities has also been discussed in a Department of Health letter which states that hand washing facilities should only be used for the purpose of hand washing; not for the disposal of body fluids.<sup>53</sup>

In terms of taps, HFS guidance states that both hot and cold running water should be available for employees where they are expected to wash their hands.<sup>47</sup> In healthcare settings mixer taps should be used as high water temperatures are used to control microorganisms such as *Legionella* spp.<sup>47</sup> The operation of the taps should allow them to be easily turned on and off without recontamination of the operator's hands. As such, the taps should be operated either by the elbow, or knee.<sup>47</sup> Although, the use of non-touch taps can also aid this, there are known issues associated with the cleaning and flushing of these. In high risk units the use of sensor

operated, automated taps is not recommended as the complexity of the internal mechanisms can result in a greater risk of contamination by microorganisms and biofilms.<sup>54, 55</sup> In addition, they are therefore not recommended for low-use situations.<sup>55</sup> The placement of the tap is crucial to prevent splashes and contaminated aerosols. It is therefore recommended that taps are placed in such a way that they do not point directly into the sink outlet. In addition, the use of a shallow sink will also cause splashing and therefore should be avoided. Swan-neck tap outlets must not be used due to them not emptying fully, creating potential for stagnant water. Strainers and anti-splash devices for sink outlets should not be used as they can become easily contaminated.<sup>47</sup> New guidance for intensive care units recommend that taps should be removable and easily dismantled for cleaning and disinfection. Whilst there is no requirement to change existing taps this recommendation applies for planned replacements, refurbishments, and new installations.<sup>55</sup>

### **Where should clinical hand wash basins should be placed in health and care settings?**

In areas where clinical procedures or examinations are undertaken (e.g. outpatient departments) the sink should be located close to the procedure.<sup>5, 47</sup> There is limited evidence to inform the minimum distance required between clinical hand wash basins and the patient and/or preparation area to prevent spread of contamination by splash or spray; expert opinion suggests that this should be between 3 and 6 feet; clinical procedures that require sterile fields should not be in the vicinity of sinks or clinical hand wash basins.

### **Is the use of ABHR suitable for individuals who abstain from alcohol for religious reasons?**

There is no scientific literature available to inform recommendations on the use of alcohol based hand hygiene products by persons who abstain from alcohol for religious reasons. Expert advice formed in consultation with religious leaders is available and highlights that although alcohol consumption is forbidden (haram) in the Islamic faith, alcohol is permitted as a medicinal agent e.g. in perfumes and cleaning agents.<sup>56</sup> Guidance from the Department of Health produced on behalf of the Muslim Spiritual Care Provision (now archived) provides the following guidance on accommodating religious requirements in relation to hand hygiene:

*'External application of synthetic alcohol is considered permissible within the context of infection control because it is not an intoxicant (i.e. it has not been derived from fermented fruit). Concerns among the community are likely to be in perception rather than principle within Islam.'*<sup>57</sup>

Provision of guidance for faiths other than Islam which also do not permit the consumption of alcohol such as Hinduism and Sikhism are lacking, however, it is recommended that the impact of religious faith and cultural beliefs are considered when promoting the use of ABHR.<sup>58</sup>

Therefore, the use of ABHR by persons with religious beliefs that forbid the consumption of alcohol is permissible as external application of the synthetic alcohol in these solutions is not considered intoxicating.

### **What is the correct process and technique when using ABHR for hand hygiene?**

As with hand washing, it is recommended that all cuts and abrasions should be covered with a waterproof dressing prior to commencing hand hygiene.<sup>2</sup>

It is recommended that hand rubbing should be performed until hands are dry, typically for a minimum of 20-30 seconds.<sup>1, 3, 4, 20, 21, 59-62</sup> Several experimental studies have tested ABHR application at short times ( $\leq 15$  seconds) and yielded mixed results in terms of antimicrobial activity and hand coverage.<sup>62-66</sup> Application times of longer than 30 seconds have not been associated with greater microbial reduction.<sup>64</sup>

In practice, the time taken for hands to dry is affected by the volume of ABHR product applied to the hands,<sup>67, 68</sup> it has been suggested that the optimal volume of ABHR is that which is sufficient to keep the hands wet for 30 seconds and that this will vary by product type and individual hand size.<sup>61, 69</sup> Larger volumes of ABHR typically have better microbicidal efficacy.<sup>59, 67, 70</sup> This is likely because larger volumes provide greater hand coverage.<sup>69, 71</sup> The volume of ABHR required for adequate hand coverage is directly related to hand size;<sup>5, 72, 73</sup> and microbial reduction by ABHR has been shown to be inversely related to hand size.<sup>72</sup> A number of identified studies indicate that relatively large volumes (approximately 3 mL) are required to ensure full coverage and associated increased antimicrobial activity.<sup>20, 59, 71, 73</sup> The volume of ABHR required for optimum efficacy is likely to vary for different formulations and so manufacturer's instructions regarding the volume that will provide adequate coverage of the hands should be followed.<sup>1, 3-5, 20, 69</sup> There is evidence that the volumes of ABHR likely to be used in practice may not be optimum because drying times of appropriate volumes may exceed 30 seconds.<sup>74</sup> In the absence of manufacturer's instructions, WHO suggests that a palmful of product is enough to cover all surfaces of the hands.<sup>3, 4</sup>

The technique for hand rubbing recommended by the WHO is the same as that recommended for hand washing and ensures a methodological approach is taken. The technique is:

- Dispense ABHR into the cupped palm of one hand.
- Rub hands palm to palm.
- Rub right palm over the back of the other hand with interlaced fingers and vice versa.
- Rub palm to palm with the fingers interlaced.
- Rub the backs of fingers to opposing palms with fingers interlocked.
- Use rotational rubbing of the left thumb clasped in the right palm and vice versa.
- Use rotational rubbing, backwards and forwards with clasped fingers of the right hand in the left palm and vice versa.<sup>3, 4</sup>



A modified version of the WHO technique which added a fingertip decontamination before rubbing hands palm to palm found a significantly greater bacterial reduction compared to the original technique.<sup>75</sup> A recent RCT also demonstrated that this six-step technique was superior to use of the three-step Centers for Disease Control and Prevention (CDC) recommended technique,<sup>76</sup> which provides less procedural detail. In contrast, a smaller RCT found a three-step method was found to be more effective.<sup>77</sup> UK guidance recommends that the process should ensure ABHR comes into contact with all surfaces of the hand and that particular attention should be paid to the fingertips, thumbs and areas between the fingers.<sup>2, 21</sup>

There is some limited evidence that a 'responsible application' technique i.e. one in which there are no prescribed steps may result in superior coverage to a prescribed technique.<sup>63, 78</sup> However, there is consensus within the literature that a technique that ensures that all surfaces of the hands are covered should be utilised.<sup>1-3, 20, 21, 63</sup>

### **Where should alcohol based hand rub products be placed in the care environment?**

Adequate placement of hand hygiene products is crucial to encourage and assist staff in complying with correct hand hygiene practices.<sup>4</sup> The Chief Nursing Officer (CNO) circulated a letter in February 2005, which detailed the Executive's proposal for establishing widespread use of ABHRs in NHSScotland.<sup>79</sup> A Health Technology Assessment (HTA) published by NHS Quality Improvement Scotland in the same year stated that the potential benefit of the provision of ABHRs for use by all NHSScotland staff in clinical areas was likely to outweigh the costs.<sup>80</sup>

There is evidence to demonstrate that higher rates of hand hygiene compliance are associated with ABHR dispensers which are easily visible upon entry to the clinical area;<sup>81, 82</sup> that are near to the point of patient care;<sup>83</sup> and are placed close to an entrance or exit.<sup>81</sup> It is recommended that ABHR should be made available to staff as near to each individual patient as possible.<sup>2-5, 47, 84</sup> Products may be placed on a wall mounted dispenser, or attached to the end of each bed.<sup>79, 84, 85</sup> A personal dispenser may also be carried by staff on the belt or in the pocket, in certain clinical situations (i.e. when caring for very young patients).<sup>79, 84, 86</sup> It is also recommended that ABHRs should be made available for use by visitors, particularly where hand washing facilities are limited. Visitor use of ABHR is also improved by placing dispensers in locations with increased visibility.<sup>87</sup> HFS guidance states that local risk assessments should be undertaken to guide the placement of ABHR dispensers and the number of these required within clinical areas.<sup>47</sup> In addition, risks related to fire, ingestion or unintended use should also be considered.<sup>79, 84</sup>

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### 3.2 Implications for research

There is an extensive body of literature which examines hand washing, rubbing and indications for hand hygiene in healthcare settings. Much of this literature is in the form of expert opinion and consequently, when assessed, yields a low quality level of evidence. The identified literature on techniques for hand washing and rubbing, and methods for hand drying presented some conflicting results and further research is required in these areas, ideally with larger numbers of participants and in clinical settings.

There has been some research conducted with the aim of determining how hands become contaminated during patient care and the potential for transmission of microorganisms. However, additional good quality experimental and epidemiological studies are required in order to gain a complete understanding of the various aspects of microbial transmission, colonisation and infection, in particular the role of casual contact and environmental contact in the transmission of microorganisms.

The studies identified in this review were heterogeneous in design, typically had a small number of participants and were often confounded by factors such as hand size, volume of product used, differences in drying times and training of participants. These factors are often not adequately controlled in the published literature, for example one study reported a significant difference in compliance with technique between ABHR and non-antimicrobial soap and water which could have explained the difference in efficacy observed. It is challenging to synthesise strong recommendations from these heterogeneous studies, the evidence base would benefit from larger studies with better controls for variables such as volume, hand size, drying time, formulation and compliance with technique. The evidence base would also benefit from further microorganism-specific research, particularly relating to ABHR efficacy against a wider range of viruses, fungi and parasites.

## 4. Recommendations

This review makes the following recommendations based on an assessment of the extant professional literature on hand washing, rubbing and indications for hand hygiene for standard infection control purposes:

### When should hand hygiene be performed?

The World Health Organization's '5 moments for hand hygiene' should be used to highlight the key indications for hand hygiene.

**Moment 1:** Hand hygiene using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) should be performed before touching a patient.

**Moment 2:** Perform hand hygiene using antimicrobial liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before carrying out a clean/aseptic procedure such as handling an invasive device.

**Moment 3:** Hand hygiene should be carried out using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) after contact with body fluids, mucous membranes or wound dressings.

If hands are visibly dirty or contaminated with blood, other body fluids or excretions they must be washed with liquid soap and water.

**Moment 4:** Perform hand hygiene using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) after touching a patient.

**Moment 5:** Hand hygiene should be carried out using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) following contact with the patient's immediate surroundings.

**(Category B recommendation)**

**Are there any additional key moments where hand hygiene (hand washing or alcohol based hand rub (ABHR) use) should be performed?**

Hand hygiene should be performed using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) before handling medication or preparing food and after visiting the toilet.

**(Category B recommendation)**

Hand hygiene should be performed using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) after removing personal protective equipment (e.g. sterile or non-sterile gloves).

**(Category B recommendation)**

Hand hygiene should be performed using liquid soap and water or an alcohol based hand rub (if hands are not visibly soiled) between carrying out different care activities on the same patient.

**(Category B recommendation)****What is the recommended water temperature for hand washing?**

Hands should be washed with warm/tepid water to mitigate the risk of dermatitis associated with repeated exposures to hot water and to maximise hand washing compliance. Compliance may be compromised where water is too hot or too cold.

**(Category B recommendation)**

### **What is the correct process and technique to ensure that all surfaces of the hands are covered during washing?**

Cuts and abrasions should be covered with a waterproof dressing before commencing hand washing.

Hands should be washed as follows:

- Wet hands under running warm/tepid water.
- Apply the manufacturers recommended quantity of liquid soap – normally via a measured dispenser.
- Rub hands together for at least 15 seconds, ensuring all surfaces of the hands are covered with lather.
- Rinse hands well under running water.
- Dry hands thoroughly using a disposable paper towel.
- Turn off the tap(s) using elbow or a paper towel to prevent contamination of clean hands.

The following technique should be used to ensure that all surfaces of the hands are covered during hand washing (see [Appendix 1](#)):

- Rub hands palm to palm.
- Rub right palm over the back of the other hand with interlaced fingers and vice versa.
- Rub palm to palm with the fingers interlaced.
- Rub the backs of fingers to opposing palms with fingers interlocked.
- Use rotational rubbing of the left thumb clasped in the right palm and vice versa.
- Use rotational rubbing, backwards and forwards with clasped fingers of the right hand in the left palm and vice versa.

**(Category B recommendation)**

### How should hands be dried after hand washing?

Hands should be dried thoroughly following hand washing by drying with a soft, absorbent, disposable paper towel from a dispenser which is located close to the sink but beyond the risk of splash contamination.

- Cloth towels – either roll or hanging type – pose a contamination risk and therefore should not be used in the clinical/hospital setting and other care settings.
- Air-dryers, including high speed air-dryers, should not be used in the clinical setting or other health and care settings because they are noisy and may disperse microorganisms via the airborne (aerosol) route.

#### **(Category B recommendation)**

Soft, absorbent, disposable paper towels should be used to dry each area of the hands thoroughly following the steps included in the hand washing process.

#### **(Category B recommendation)**

Drying should be achieved by patting dry each part of the hand avoiding rubbing, which may lead to skin irritation/damage.

#### **(Category C recommendation)**

### What is the evidence relating to finger nails to enable effective hand hygiene?

When providing patient care, nails should be kept short and clean and staff should not wear false nails.

#### **(Category B recommendation)**

Finger nails should not exceed  $\frac{1}{4}$  inch (approx. 0.5 cm) beyond the end of the finger tip to prevent the accumulation of debris under nails and to facilitate effective hand hygiene.

Artificial nails should not be worn as they inhibit hand hygiene and pose an infection risk.

Nail products should not be worn as chips may harbour bacteria and thus represent an infection risk.

#### **(Category B recommendation)**

**What is the evidence regarding the bare below the elbows policy?**

The Scottish Government in line with the Department of Health recommendation, and as part of the development of a new national NHSScotland uniform policy, have recommended that staff providing care in NHSScotland should be “bare below the elbows”.

**(Mandatory)**

**What is the evidence regarding the wearing of jewellery in relation to hand hygiene, including jewellery worn for religious reasons?**

Jewellery, including wrist watches, bracelets and rings (excluding a plain metal finger ring), should not be worn when providing care because they can inhibit effective hand washing, may increase bacterial load on the hands and thus pose an infection risk. Jewellery also interferes with the provision of care.

**(Category B recommendation)**

Bracelets or bangles such as the Kara which are worn for religious reasons should be able to be pushed higher onto the arm and secured in place for all patient care activities. This is to enable effective hand hygiene (which includes the wrists).

**(Category C recommendation)**

**Where should hand washing products be placed in the care environment?**

Liquid soaps and paper towels must be wall mounted and placed near sinks allowing for easy operation.

**(Category B recommendation)**

## What are the requirements for sink design, provision and types of tap for clinical hand wash?

Sinks located in the clinical area need to be fit for purpose (e.g. designed to prevent splashing, enable effective cleaning, designed not to have a plug or overflow, include a splash-back). Sinks should be large enough to contain most splashes and enable the correct hand washing technique to be performed without excessive splashing of the user and the surrounding area. The use of a shallow sink should therefore be avoided.

In healthcare settings mixer taps should be used as high water temperatures are used to control *Legionella* spp. The operation of the mixer tap should allow them to be easily turned on and off without recontamination on the operator's hands (the elbow, wrist or knee should be used). The mixer tap should be placed in such a way that they do not point directly into the sink outlet.

In high risk units and low-use situations, the use of sensor operated, automated 'non-touch' taps is not recommended as the complexity of the internal mechanisms can result in a greater risk of contamination by microorganisms and biofilms.

For new installation and planned replacements or refurbishments in intensive care units, taps should be removable and easily dismantled for cleaning and disinfection.

Strainers and anti-splash devices for sink outlets should not be used as they can become easily contaminated.

In areas where clinical procedures or examinations are undertaken (e.g. outpatient departments), the hand washing basins should be located close to the procedure.

In low dependency settings, one sink between six patients is recommended. Acute, elderly and long-term care settings, one sink between four patients is recommended. Infrequently used water outlets should be identified and assessed as per the local Water Safety Plan and incorporated into a flushing regime or removed from use

Hand washing facilities should:

- Only be used for the purpose of hand washing.
- Not be used for disposal of any body fluids.

**(Mandatory)**



**Is the use of alcohol based hand rubs suitable for individuals who abstain from alcohol for religious reasons?**

The use of ABHR by persons with religious beliefs that forbid the consumption of alcohol is permissible as external application of the synthetic alcohol in these solutions is not considered intoxicating.

**(Category C recommendation)**

**What is the correct process and technique when using ABHR for hand hygiene?**

Application of a sufficient volume of ABHR to cover all surfaces of the hands is important to ensure effective hand hygiene.

Manufacturer's instructions should be followed for the volume of ABHR required to provide adequate coverage of the hands. In the absence of manufacturer instructions, volumes of approximately 3 mL are recommended to ensure full coverage.

**(Category B recommendation)**

Hands should be rubbed together to ensure that the ABHR solution covers all surfaces of the hands.

**(Category B recommendation)**

Hand rubbing should be performed until the hands are dry, typically for a minimum of 20-30 seconds.

**(Category B recommendation)**

**Where should ABHR products be placed in the patient care environment?**

ABHR should be made available to staff as near to each individual patient as possible.

A risk assessment should be carried out considering aspects such as location, visibility, dispenser size and whether the use of personal dispensers is required. This assessment should also take into account the risk in relation to fire, ingestion or unintended use.

**(Mandatory)**

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## References

1. Boyce JM and Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Infection Control & Hospital Epidemiology* 2002; 23: S3-40.
2. Loveday H, Wilson J, Pratt R, et al. epic3: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. 2014; 86: S1-S70.
3. Pittet D, Allegranzi B, Boyce J, et al. The World Health Organization guidelines on hand hygiene in health care and their consensus recommendations. 2009; 30: 611-622.
4. World Health Organization. WHO Guidelines on Hand Hygiene in Healthcare: First Global Patient Safety Challenge Clean Care is Safer Care. Geneva: World Health Organization,, 2009.
5. Ellingson K, Haas JP, Aiello AE, et al. Strategies to Prevent Healthcare-Associated Infections through Hand Hygiene. *Infection Control & Hospital Epidemiology* 2014; 35: 937-960. DOI: 10.1086/677145.
6. Pessoa-Silva CL, Dharan S, Hugonnet S, et al. Dynamics of bacterial hand contamination during routine neonatal care. *Infection Control & Hospital Epidemiology* 2004; 25: 192-197.
7. Hayden MK, Blom DW, Lyle EA, et al. Risk of hand or glove contamination after contact with patients colonized with vancomycin-resistant enterococcus or the colonized patients' environment. 2008; 29: 149-154.
8. Duckro AN, Blom DW, Lyle EA, et al. Transfer of vancomycin-resistant enterococci via health care worker hands. 2005; 165: 302-307.
9. Creamer E, Dorrian S, Dolan A, et al. When are the hands of healthcare workers positive for methicillin-resistant *Staphylococcus aureus*? *Journal of Hospital Infection* 2010; 75: 107-111. Research Support, Non-U.S. Gov't.
10. Hirschmann H, Fux L, Podusel J, et al. The influence of hand hygiene prior to insertion of peripheral venous catheters on the frequency of complications. 2001; 49: 199-203.
11. Kac G, Podglajen I, Guerneret M, et al. Microbiological evaluation of two hand hygiene procedures achieved by healthcare workers during routine patient care: a randomized study [corrected] [published erratum appears in J HOSP INFECT 2006 Jan;62(1):129]. *Journal of Hospital Infection* 2005; 60: 32-39.
12. McBryde E, Bradley L, Whitby M, et al. An investigation of contact transmission of methicillin-resistant *Staphylococcus aureus*. 2004; 58: 104-108.

13. Lam RF, Hui M, Leung DY, et al. Extent and predictors of microbial hand contamination in a tertiary care ophthalmic outpatient practice. 2005; 46: 3578-3583.
14. Pittet D, Allegranzi B, Sax H, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. 2006; 6: 641-652.
15. Bhalla A, Pultz NJ, Gries DM, et al. Acquisition of nosocomial pathogens on hands after contact with environmental surfaces near hospitalized patients. 2004; 25: 164-167.
16. Grabsch EA, Burrell LJ, Padiglione A, et al. Risk of environmental and healthcare worker contamination with vancomycin-resistant enterococci during outpatient procedures and hemodialysis. 2006; 27: 287-293.
17. Boyce JM, Johi. Environmental contamination makes an important contribution to hospital infection. 2007; 65: 50-54.
18. Chen K-H, Chen L-R and Wang Y-K. Contamination of medical charts: an important source of potential infection in hospitals. 2014; 9: e78512.
19. World Health organization. Hand Hygiene in Outpatient and Home-based Care and Long-term Care Facilities. A Guide to the Application of the WHO Multimodal Hand Hygiene Improvement Strategy and the 'My Five Moments for hand Hygiene' Approach.: World Health Organization, 2012.
20. Gould D and Drey N. Hand hygiene technique. *Nursing Standard* 2008; 22: 42-46.
21. National Institute for Health and Care Excellence. Healthcare-associated infections: prevention and control in primary and community care (CG139). . National Institute for Health and Care Excellence, , 2012.
22. Ayliffe G, Babb J and Quoraishi AJ. A test for 'hygienic' hand disinfection. 1978; 31: 923-928.
23. Price L, Melone L, McLarnon N, et al. A systematic review to evaluate the evidence base for the World Health Organization's adopted hand hygiene technique for reducing the microbial load on the hands of healthcare workers. *American Journal of Infection Control* 2018; 46: 814-823. DOI: 10.1016/j.ajic.2018.01.020.
24. Deschênes P, Chano F, Dionne L-L, et al. Efficacy of the World Health Organization–recommended handwashing technique and a modified washing technique to remove *Clostridium difficile* from hands. *American Journal of Infection Control* 2017; 45: 844-848. DOI: 10.1016/j.ajic.2017.04.001.
25. Jensen DA, Macinga DR, Shumaker DJ, et al. Quantifying the effects of water temperature, soap volume, lather time, and antimicrobial soap as variables in the removal of *Escherichia coli* ATCC 11229 from hands. 2017; 80: 1022-1031.
26. Firanek C and Guest S. Hand hygiene in peritoneal dialysis. 2011; 31: 399-408.

27. Huang C, Ma W and Stack S. The hygienic efficacy of different hand-drying methods: a review of the evidence. *Mayo Clinic Proceedings* 2012; 87: 791-798. DOI: 10.1016/j.mayocp.2012.02.019.
28. Mutters R and Warnes SL. The method used to dry washed hands affects the number and type of transient and residential bacteria remaining on the skin. *Journal of Hospital Infection* 2019; 101: 408-413. DOI: 10.1016/j.jhin.2018.12.005.
29. Best E, Parnell P, Couturier J, et al. Environmental contamination by bacteria in hospital washrooms according to hand-drying method: a multi-centre study. *Journal of Hospital Infection* 2018; 100: 469-475. DOI: 10.1016/j.jhin.2018.07.002.
30. Best EL, Parnell P and Wilcox MH. Microbiological comparison of hand-drying methods: The potential for contamination of the environment, user, and bystander. *Journal of Hospital Infection* 2014; 88: 199-206.
31. Best EL and Redway K. Comparison of different hand-drying methods: the potential for airborne microbe dispersal and contamination. *Journal of Hospital Infection* 2015; 89: 215-217. DOI: 10.1016/j.jhin.2014.11.007.
32. Gustafson DR, Vetter EA, Larson DR, et al. Effects of 4 hand-drying methods for removing bacteria from washed hands: a randomized trial. *Mayo Clinic Proceedings* 2000; 75: 705-708.
33. Pitt SJ, Crockett SL and Andreou GM. The contribution of hand drying in prevention of transmission of microorganisms: Comparison of the efficacy of three hand drying methods in the removal and distribution of microorganisms. *Journal of Infection Prevention* 2018; 19: 310-317. DOI: 10.1177/1757177418789485.
34. Margas E, Maguire E, Berland C, et al. Assessment of the environmental microbiological cross contamination following hand drying with paper hand towels or an air blade dryer. 2013; 115: 572-582.
35. Scottish Government. National uniform policy, dress code and laundering policy CEL 42. Edinburgh: Scottish Government, 2010.
36. Ward DJ. Hand adornment and infection control. *British Journal of Nursing* 2007; 16: 654-656.
37. Moolenaar RL, Crutcher JM, San Joaquin VH, et al. A prolonged outbreak of *Pseudomonas aeruginosa* in a neonatal intensive care unit: did staff fingernails play a role in disease transmission? *Infection Control & Hospital Epidemiology* 2000; 21: 80-85.
38. Fagernes M and Lingaas E. Factors interfering with the microflora on hands: a regression analysis of samples from 465 healthcare workers. 2011; 67: 297-307.

39. McNeil SA, Foster CL, Hedderwick SA, et al. Effect of hand cleansing with antimicrobial soap or alcohol-based gel on microbial colonization of artificial fingernails worn by health care workers. 2001; 32: 367-372.
40. Gupta A, Della-Latta P, Todd B, et al. Outbreak of extended-spectrum beta-lactamase-producing *Klebsiella pneumoniae* in a neonatal intensive care unit linked to artificial nails. 2004; 25: 210-215.
41. Burger A, Wijewardena C, Clayson S, et al. Bare below elbows: does this policy affect handwashing efficacy and reduce bacterial colonisation? 2010; 93: 13-16.
42. Jeans A, Moore J, Nicol C, et al. Wristwatch use and hospital-acquired infection. 2010; 74: 16-21.
43. Yildirim M, Sahin I, Oksuz S, et al. Hand carriage of *Candida* occurs at lesser rates in hospital personnel who use antimicrobial hand disinfectant. *Scandinavian Journal of Infectious Diseases* 2014; 46: 633-636. DOI: 10.3109/00365548.2014.922694.
44. Trick WE, Vernon MO, Hayes RA, et al. Impact of ring wearing on hand contamination and comparison of hand hygiene agents in a hospital. 2003; 36: 1383-1390.
45. Fagernes M and Nord RJV. A study of microbial load of different types of finger rings worn by healthcare personnel. 2007; 27: 21-24.
46. Department of Health. Uniforms and workwear: Guidance on uniform and workwear policies for NHS employers. Department of Health,, 2010.
47. Health Facilities Scotland (HFS). SHFN 30 Part A: Manual Information for Design Teams, Construction Teams, Estates and Facilities and Infection Prevention and Control Teams.: Health Facilities Scotland,, 2014.
48. Stackelroth J, Sinnott M and Shaban RZ. Hesitation and error: Does product placement in an emergency department influence hand hygiene performance? *American Journal of Infection Control* 2015; 43: 913-916.
49. Cloutman-Green E, Oya K, Hedieh W, et al. The important role of sink location in handwashing compliance and microbial sink contamination. *American Journal of Infection Control* 2014; 42: 554-555. DOI: 10.1016/j.ajic.2013.12.020.
50. Deyneko A, Cordeiro F, Berlin L, et al. Impact of sink location on hand hygiene compliance after care of patients with *Clostridium difficile* infection: a cross-sectional study. 2016; 16: 203.
51. Zellmer C, Blakney R, Van Hoof S, et al. Impact of sink location on hand hygiene compliance for *Clostridium difficile* infection. 2015; 43: 387-389.
52. Health Protection Scotland. *Guidance for neonatal units (NNUs) (levels 1, 2 & 3), adult and paediatric intensive care units (ICUs) in Scotland to minimise the risk of *Pseudomonas aeruginosa* infection from water.* 2018. Health Protection Scotland.

53. Department of Health. Water Sources and Potential for Infection from Taps and Sinks. *Department of Health*, 2010.
54. Health Facilities Scotland (HFS). Scottish Health Technical Memorandum (SHTM) 04-01: Water safety for healthcare premises Part A: Design, installation and testing. Health Facilities Scotland, 2014.
55. Health Facilities Scotland (HFS) HPSHaPaaWSG. Guidance for neonatal units (NNUs) (levels 1, 2 and 3), adult and paediatric intensive care units (ICUs) in Scotland to minimise the risk of *Pseudomonas aeruginosa* infection from water. Health Protection Scotland, 2018.
56. Ahmed QA, Memish ZA, Allegranzi B, et al. Muslim health-care workers and alcohol-based handrubs. *Lancet* 2006; 367 North American Edition: 1025-1027.
57. Department of Health. Supplement to Uniforms and Workwear: An evidence base for developing local policy: Statement on behalf of the Muslim Spiritual Care Provision (Accommodating religious requirements in relation to dress and hand hygiene). Department of Health, 2009.
58. Allegranzi B, Memish ZA, Donaldson L, et al. Religion and culture: potential undercurrents influencing hand hygiene promotion in health care. *American Journal of Infection Control* 2009; 37: 28-34. DOI: 10.1016/j.ajic.2008.01.014.
59. Goroncy-Bermes P, Koburger T and Meyer BJJohi. Impact of the amount of hand rub applied in hygienic hand disinfection on the reduction of microbial counts on hands. 2010; 74: 212-218.
60. Kampf G. How effective are hand antiseptics for the postcontamination treatment of hands when used as recommended? *American Journal of Infection Control* 2008; 36: 356-360.
61. Wilkinson MAC, Ormandy K, Bradley CR, et al. Dose considerations for alcohol-based hand rubs. *Journal of Hospital Infection* 2017; 95: 175-182. DOI: 10.1016/j.jhin.2016.12.023.
62. Suchomel M, Kundi M, Pittet D, et al. Testing of the World Health Organization recommended formulations in their application as hygienic hand rubs and proposals for increased efficacy. 2012; 40: 328-331.
63. Kampf G, Reichel M, Feil Y, et al. Influence of rub-in technique on required application time and hand coverage in hygienic hand disinfection. *BMC Infectious Diseases* 2008; 8: 149-149.
64. Pires D, Soule H, Bellissimo-Rodrigues F, et al. Hand Hygiene With Alcohol-Based Hand Rub: How Long Is Long Enough? *Infection Control & Hospital Epidemiology* 2017; 38: 547-552. DOI: 10.1017/ice.2017.25.

65. Dharan S, Hugonnet S, Sax H, et al. Comparison of waterless hand antiseptics agents at short application times: raising the flag of concern. 2003; 24: 160-164.
66. Paula H, Becker R, Assadian O, et al. Wettability of hands during 15-second and 30-second handrub time intervals: A prospective, randomized crossover study. *American Journal of Infection Control* 2018; 46: 1032-1035. DOI: 10.1016/j.ajic.2018.02.015.
67. Macinga DR, Shumaker DJ, Werner H-P, et al. The relative influences of product volume, delivery format and alcohol concentration on dry-time and efficacy of alcohol-based hand rubs. 2014; 14: 511.
68. Suchomel M, Leslie RA, Parker AE, et al. How long is enough? Identification of product dry-time as a primary driver of alcohol-based hand rub efficacy. 2018; 7: 65.
69. Girard R, Aupee M, Erb M, et al. Hand rub dose needed for a single disinfection varies according to product: A bias in benchmarking using indirect hand hygiene indicator. *Journal of Epidemiology and Global Health* 2012; 2: 193-198.
70. Li X, Xu C-J and Zhao S-JJJoNS. Experimental study on disinfection effect of different dose of rapid hand disinfectant. 2014; 1: 212-214.
71. Macdonald DJM, McKillop ECA, Trotter S, et al. One plunge or two?--hand disinfection with alcohol gel. *International Journal for Quality in Health Care* 2006; 18: 120-122. DOI: intqhc/mzi109.
72. Bellissimo-Rodrigues F, Soule H, Gayet-Ageron A, et al. Should alcohol-based handrub use be customized to healthcare workers' hand size? 2016; 37: 219-221.
73. Zingg W, Haidegger T and Pittet DJAjoic. Hand coverage by alcohol-based handrub varies: volume and hand size matter. 2016; 44: 1689-1691.
74. Kampf G, Marschall S, Eggerstedt S, et al. Efficacy of ethanol-based hand foams using clinically relevant amounts: a cross-over controlled study among healthy volunteers. 2010; 10: 78.
75. Pires D, Bellissimo-Rodrigues F, Soule H, et al. Revisiting the WHO "How to Handrub" Hand Hygiene Technique: Fingertips First? *Infection Control & Hospital Epidemiology* 2017; 38: 230-233. DOI: 10.1017/ice.2016.241.
76. Reilly JS, Price L, Sue L, et al. A Pragmatic Randomized Controlled Trial of 6-Step vs 3-Step Hand Hygiene Technique in Acute Hospital Care in the United Kingdom. *Infection Control & Hospital Epidemiology* 2016; 37: 661-666. DOI: 10.1017/ice.2016.51.
77. Tschudin-Sutter S, Sepulcri D, Dangel M, et al. Simplifying the WHO protocol: Three steps versus six steps for performance of hand hygiene-a cluster-randomized trial. 2018.
78. Chow A, Arah OA, Chan S-P, et al. Alcohol handrubbing and chlorhexidine handwashing protocols for routine hospital practice: A randomized clinical trial of protocol efficacy and

- time effectiveness. *American Journal of Infection Control* 2012; 40: 800-805. DOI: 10.1016/j.ajic.2011.10.005.
79. Scottish Government. Alcohol Based Handrubs and Infection Control, CNO (2205) 1. Edinburgh: Scottish Government,, 2005.
  80. Ritchie K. IK, . Macpherson K,. Riches E. and Stout A. Health Technology Assesement 7: The provision of alcohol-based products to improve compliance with hand hygiene. NHS Quality Improvement Scotland, 2005.
  81. Cure L and Van Enk RJAjoic. Effect of hand sanitizer location on hand hygiene compliance. 2015; 43: 917-921.
  82. Thomas BW, Berg-Copas GM, Vasquez DG, et al. Conspicuous vs customary location of hand hygiene agent dispensers on alcohol-based hand hygiene product usage in an intensive care unit. 2009; 109: 263-267.
  83. Munoz-Price LS, Patel Z, Banks S, et al. Randomized crossover study evaluating the effect of a hand sanitizer dispenser on the frequency of hand hygiene among anesthesiology staff in the operating room. 2014; 35: 717-720.
  84. National Patient Safety Agency. Patient safety alert: clean hands save lives. London: National Patient Safety Agency, 2008.
  85. Kendall A, Landers T, Kirk J, et al. Point-of-care hand hygiene: Preventing infection behind the curtain. *American Journal of Infection Control* 2012; 40: S3-S10. DOI: 10.1016/j.ajic.2012.02.009.
  86. Haas JP and Larson EL. Impact of Wearable Alcohol Gel Dispensers on Hand Hygiene in an Emergency Department. *Academic Emergency Medicine* 2008; 15: 393-396.
  87. Hobbs MA, Robinson S, Neyens DM, et al. Visitor characteristics and alcohol-based hand sanitizer dispenser locations at the hospital entrance: Effect on visitor use rates. 2016; 44: 258-262.



## Appendix 1: Grades of recommendation

Grade	Descriptor	SIGN levels of evidence
<b>Mandatory</b>	A mandatory recommendation (recommendations that are directives from government policy, regulations or legislation)	N/A
<b>Category A</b>	Based on high to moderate quality evidence	SIGN level 1++, 1+, 2++, 2+, AGREE strongly recommend
<b>Category B</b>	Based on low to moderate quality of evidence which suggest net clinical benefits over harm	SIGN level 2+, 3, 4, AGREE recommend
<b>Category C</b>	Expert opinion, these may be formed by the NPGO groups when there is no robust professional or scientific literature available to inform guidance.	SIGN level 4, or opinion of NPGO group
<b>No recommendation</b>	Insufficient evidence to recommend one way or another	N/A