Health and Safety Executive

A review of the data on efficacy of handcleaning products in industrial use as alternatives to handwashing

Prepared by the **Health and Safety Laboratory** for the Health and Safety Executive 2014

RR1007
Research Report

HSE

Health and Safety Executive

A review of the data on efficacy of handcleaning products in industrial use as alternatives to handwashing

Helena Senior, Catherine Makison Booth and **Alan Beswick**
Health and Safety Laboratory
Harpur Hill
Buxton
Derbyshire SK17 9JN

The aim of the project was to review available data on the efficacy of currently available alternatives to soap and water for hand washing in the context of removal of contamination typical of that experienced in a range of outdoor activities, workplaces and related environments. Consideration to include commercial waste and recycling activity, agriculture including animal visitor attractions, outdoor events, construction sites and other work away from permanent welfare facilities.

The use of soap and warm running water for hand washing remains an effective method for reducing the levels of hand borne microbiological contamination. The use of soap and cold running water has also been shown as effective for hand decontamination, though is likely to be marginally less effective than soap and warm water.

Alcohol preparations based on either gels or liquid hand rubs can offer a significant reduction in microbiological hand contamination, with some studies claiming multi-log reductions under specified conditions that are greater than hand washing approaches. However, there are important limitations to how alcohol rubs and gels should be used, and these may introduce uncertainties regarding their efficacy.

Little published data exists on the performance of hand hygiene methods in the context of variable to heavy organic loading.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE Books

EXECUTIVE SUMMARY

Aim

To review available data on the efficacy of currently available alternatives to soap and water for hand washing in the context of removal of contamination typical of that experienced in a range of outdoor activities, workplaces and related environments. Consideration to include commercial waste and recycling activity, agriculture including animal visitor attractions, outdoor events, construction sites and other work away from permanent welfare facilities.

Objectives

1. To conduct a structured literature search against agreed search terms on the available evidence of performance of hand cleansers using soap and water as a benchmark for comparison with alternative hand cleansing methods. To include examining data from in 'field conditions' if possible. It is anticipated the largest body of data will be healthcare related and so likely to provide a benchmark for comparison with other, less well studied sectors.

2. To consider the following questions in relation to waste and recycling, but where relevant to agriculture, construction, and members of the public visiting farm (and similar) attractions and outdoor events:

- What information is available on the efficacy of hand washing *vs*. hand gels and/or hand wipes, especially in the presence of organic soiling?
- What information is available on the most effective way for operatives to wash their hands and/or for operatives to use wipes or gels for hand hygiene purposes?
- What differences in terms of overall efficacy are there between different types of wipes and gels used, compared to hand washing?
- Do all considered methods ensure a minimum standard of hygiene that would be acceptable regardless of the method used?
- Does credible read-across exist for data from the healthcare settings to other sectors of interest?

3. Report findings and highlight any gaps in knowledge, with recommendations as to how those gaps may be filled; including if necessary, by further research.

Main findings and evidence-based conclusions

A large number of potentially relevant publications were identified by the various search strategies employed, though the number of highly relevant, robustly designed studies was found to be small (<10). However, these, and supportive information provided by a larger number of publications with some relevant data, did provide pertinent information that helps address a number of the questions asked of this review.

The majority of data were derived from studies of efficacy applicable to the healthcare sector, rather than for agriculture, waste or leisure applications. This bias was expected, since the market for most hand hygiene products has historically been within the healthcare sector. While some of this information was not directly relevant, there are aspects of hand hygiene approaches that allow read across to the work environments that were the focus of this review. From these, it is possible to make evidence based statements related to the use of either a conventional hand wash approach, or an alternative method using hand gels/rubs/wipes, as follows:

- The use of soap and warm running water for hand washing remains an effective method for reducing the levels of hand borne microbiological contamination. This need not involve specialist medicated soaps, though these have been shown to enhance decontamination effects in some studies. Multi-log reductions in microbiological hand contaminants have been repeatedly demonstrated using this approach;

- The use of soap and cold running water has also been shown as effective for hand decontamination, though is likely to be marginally less effective than soap and warm water. Although not proven, it is reasonable to assume that the availability of cold water alone might deter some individuals from washing their hands during cold winter conditions, e.g., at remote facilities on farms or on construction sites;

- Alcohol preparations based on either gels or liquid hand rubs can offer a significant reduction in microbiological hand contamination, with some studies claiming multi-log reductions under specified conditions that are greater than hand washing approaches. However, there are important limitations to how alcohol rubs and gels should be used, and these may introduce uncertainties regarding their efficacy, for example:

    - There is evidence to show that any active alcohol content in a hand rub, gel or foam can be neutralised by the presence of visible organic soiling, especially proteinacious residues. Alcohol based gels and rubs should therefore only be used when the hands are visibly (i.e. physically) clean. This constraint may have implications for the use of such products in work sectors where hand soiling is unavoidable;

    - In particular, the levels of soiling on the hands of workers may vary considerably for builders, farm workers, waste recycling operatives and for similar activities where hand soiling is likely. Hand rubs, gels and foams will not physically remove soiling from the hands of such workers and may render antimicrobial products ineffective;

    - Any variation in the levels of skin soiling is likely to result in variation in hand contamination with microorganisms – the so-called ‘microbial loading’. This will have additional implications for the ability of a water free hand sanitisers to effectively remove microorganisms from the skin of the hands, as their removal will be influenced by microbial loading levels an associated organic soiling;

    - The ‘dose’ of alcohol based product used per application is critical to the success of its use. Studies show that at least 3 ml of product should be applied to the hand. More than 4 ml is not likely to improve efficacy providing that at least 3 ml is normally applied. This should equate to sufficient alcohol based product to fully lubricate both hands, so that a film of liquid product can be felt to cover the skin of the hands;

    - Hand soiling may include chemical contamination of the skin, not just organic soiling and microorganisms. Basic cleansing principles mean that hand rubs and foams alone – whether alcohol based or alcohol free – will relocate but not effectively remove chemical contamination. Only the effect of wash-off using soap and running water will reliably remove chemical contamination;

- Hand wipes impregnated with alcohol and/or some additional disinfectant products – such as quaternary ammonium compounds or chlorhexidine – have been shown to reduce hand contamination, but the mechanism for this is not always clear. Physical removal of contaminants is thought to be possible using hand wipes, and this may be helpful when soap and water are unavailable. However, the degree of skin disinfection from a wipe is likely to be highly dependent on the concentrations, type of active chemicals present on the wipe and the way the wipe is used. These are often present at levels far lower than liquid or gel hand hygiene products;

Evidence based statement

Little published data exists on the performance of hand hygiene methods in the context of variable to heavy organic loading. Direct and indirect data that do exist suggests that the following hierarchy of choice of hand hygiene methods should be applied:

- Washing hands with soap and warm water;
- Washing hands with soap and cold water;
- Rinsing hands with water alone;
- Wiping hands with moistened wipes;
- Using hand rubs or gels.

CONTENTS PAGE

SUMMARY OF DATA SUPPORTING HIERARCHY OF HAND HYGIENE EFFICACY

HAND HYGIENE METHOD	SUPPORTING EVIDENCE ON PAGE	SUPPORTING REFERENCE
Antibacterial soap with warm water > wipe > alcohol based hand rub (ABHR)	17	D'Antonio *et al*, 2009, 2010
ABHR > wipe	18	CDC
ABHR > wash	18	Girou *et al*, 2002
Wash = rub. Effective hand wash time = 15 sec	18	Hubner *et al*, 2006
Soap & warm water > soap & cold water > wipe > ABHR (*Clostridium difficile* challenge)	19	Oughton *et al*, 2009
Soap & water 10 sec = Soap & water 30 sec = soap & water 60 sec > ABHR	20	Weber *et al*, 2003
Soap & water > ABHR	21	Savolainen-Kopra *et al*, 2012b
Soap & water > wipe = ABHR (animal visitor attractions)	21	Steinmuller *et al*, 2006
Hibiclens surgical scrub = high alcohol content ABHR > low alcohol ABHR – large volume of ABHR no more efficient than low volume	21	Kampf , 2008
Antibacterial soap & water > non antibacterial soap & water – 30 sec > 15 sec	21	Fuls *et al*, 2008
High alcohol ABHR > low alcohol ABHR	22	Do Prado *et al*, 2012
Wipes physically remove bacterial contamination but have little sporicidal activity.	22	Siani *et al*, 2011
ABHR > soap & water	24	Kampf & Loffler (review) 2010
ABHR + rubbing > ABHR without rubbing – but contact time needed for bactericidal efficacy greater than in-use contact time	25	Cheeseman *et al*, 2011
Alcohol hand rinse > ABHR	26	Dharan *et al*, 2003
ABHR 60 sec > ABHR 30 sec	26	Suchomel *et al*, 2012
Soap & water > water alone > wipe > ABHR	26	Sickbert Bennett *et al*, 2005
Soap & water then ABHR > degreasing cream then ABHR > hand wipe then ABHR > ABHR alone with heavy/moderate bacterial contamination; soap & water then ABHR = degreasing cream then ABHR = hand wipe then ABHR = ABHR alone with low bacterial contamination.	27	Racicot *et al*, 2013

1. INTRODUCTION

1.1 BACKGROUND

The microbial flora of hands consists of more than 150 species, the exact composition of which is largely host specific (Fierer *et al*., 2008). These flora fall into two categories; the resident and the transient microbiological species. The resident flora consist of permanent inhabitants of the skin and are not typically pathogenic, with the most dominant species being *Staphylococcus epidermidis*. The transient flora consist of bacteria, virus and fungi that may be found on the skin at certain times following contact with contaminated surfaces or fomites (contaminated objects of transmission). Equally, microorganisms can migrate from the hands to other fomites or to orifices of the host or a patient. Generally, they do not multiply on the skin but certain microbial species can grow and cause disease where an available niche allows.

1.1.1 UK Legislation on hand hygiene

The main legal requirements for the provision of adequate welfare facilities, including hand washing facilities, are outlined in the Workplace (Health, Safety and Welfare) Regulations 1992 (the Workplace Regs.) HSE guidance INDG293 (rev1; 09/11) states that there should be provision of, "..*facilities with hot and cold running water" and "enough soap or other washing agents*". However, regulation 25 of the Workplace Regs does not apply to waste and recycling collection activities - by virtue of Regulation 3 which specifically excludes means of transport/vehicles.

1.2 HEALTHCARE SECTOR

The benefits of hand washing to reduce the transmission of disease have been appreciated in the healthcare sector for over 150 years. The first effective programme of hand hygiene promotion to reduce hospital acquired infection was implemented by the Hungarian obstetrician Ignaz Semmelweis in 1847 and since then hand hygiene has been a key factor in reducing the spread of infection in healthcare (Stewardson *et al*., 2011). Although Semmelweis's original approach involved the use of 'chlorine water' to cleanse the hands of medical and nursing staff before treatments, the more recent traditionally approach to hand hygiene has involved washing hands with soap and warm water. However, in the last decade there has been a move towards the use of hand gels and impregnated wipes to render the hand decontamination process less time consuming. An additional benefit is that these modern products do not require the presence of running water nor hand drying facilities, as the active ingredients are volatile and so evaporate quickly. In order to be used in hospitals, each product has to undergo a series of tests to prove its efficacy against a variety of hospital microorganisms, with one of the most common internationally recognised tests being BS EN 1500 (BSI, 1997). The efficacy of many hand hygiene products has been the focus of peer reviewed research, and has relevance to infection control across the developed and developing world.

1.3 WORKPLACES INVOLVING OUTDOOR ACTIVITY

The provision of hand wash facilities for workers undertaking outdoor activities is sometimes challenging, especially if the activity is mobile or some distance from a mains water source. With this in mind, the following work sectors were considered during the course of this study.

1.3.1 Waste and Recycling

The collection of waste and recyclables has the potential for exposing collection operatives to a range of hazardous substances, particularly foodborne pathogens such as *Salmonella* sp. Data relating to the resultant ill-health effect of such exposure is imprecise, but early findings and on-going research into sickness absence within the waste and recycling industry suggests that 30% of employees engaged in collection activities have at least one stomach related absence spell per annum, compared with 21% for all workers and 13% for office workers (Source: on-going HSE sickness absence survey in the industry). A good standard of personal hygiene is therefore an important and basic control measure within this industry sector, which must be used to prevent unnecessary infection that may otherwise lead to ill-health.

The current agreed industry guidance states, "*Provide adequate hand-washing facilities, including mild soap and towels on collection vehicles. Cleansing wipes alone should only be provided on vehicles where there is minimal health risk of exposure*" (Waste 15). Furthermore, "*Hand-washing provision should be provided where there is a risk of contact with corrosives, acids, biohazards etc. This may include warm water, mild soap and towels. Cleansing wipes alone should only be provided on vehicles where there is a minimal health risk and no hand washing facilities*." (Waste 04). See supporting information at:
http://www.hse.gov.uk/foi/internalops/sims/manuf/03_12_11.htm.

The amount of soiling of workers hands in the waste and recycling industry is likely to be task specific and therefore requires assessment in order to identify methods of best practice for hand hygiene.

1.3.2 Agriculture

There may be practical difficulties for employers in providing hot and cold running water and soap in this industry. For example, vegetable picking gangs need to be supplied with 'plastics' (i.e. plastic portable appliances) to provide their welfare requirements when working at a distance from fixed (toilet) facilities on the farm. The effectiveness of these facilities is highly dependent on an employer's maintenance of the portable appliance(s). Although the provision of basic mobile toilet facilities is not so dependent on high levels of maintenance, the availability of clean water for hand washing is, as it requires adequate preparation of feeder tanks, with regular replenishment in order to maintain hygiene standards. Within this high turnover, intensive working environment, where large groups of non-UK nationals often make up much of the work force, this is a responsibility that may be overlooked.

Adequate hand washing facilities are also of paramount importance on open farms and at similar animal contact visitor attractions where there may be the potential for animal faecal contamination on hands. Following a major outbreak of gastro-intestinal infections caused by the bacterium *E. coli* O157 at an open farm in 2009, the official enquiry (Independent Investigation Report; www.griffininvestigation.org.uk) made a number of recommendations to HSE. In response, Agriculture Information Sheet 23 'Avoiding ill health at open farms - advice to farmers' (AIS23) was subsequently replaced by an Industry Code of Practice 'Preventing or Controlling Ill Health from Animal Contact at Visitor Attractions' (available from Farming & Countryside Education web site at http://www.face-online.org.uk/resources/preventing-or-controlling-ill-health-from-animal-contact-at-visitor-attractions-industry-code-of-practice). The Industry Code of Practice emphasises the importance of providing suitable hand wash facilities and provides examples of good practice contrasted with examples of facilities that would be unacceptable. Whilst these are likely to be permanent hand wash stations, they may need to be supplemented at peak activity times by temporary facilities, and examples of these are also illustrated in the Code of Practice.

Choice of hand hygiene facilities is therefore important, even for temporary arrangements. A review of outbreaks of intestinal infectious diseases associated with animal contact visitor attractions in USA (Steinmuller *et al.*, 2006) emphasised the importance of hand hygiene.

1.3.3 Leisure

In addition to open farms, temporary events such as music concerts, country fairs and agricultural shows will require the provision of adequate toilet and hand washing facilities for use by members of the public. There may also be an additional risk factor where the event is held in fields previously used for animal grazing. An outbreak of *E coli* O157 was recorded at the Glastonbury festival, and was brought about by the predominant wet weather at the time of the festival and the presence of cattle on the site immediately before its use for entertainment purposes (Crampin *et al*., 1999).

Public health matters at events are generally regulated by licensing, food safety and environmental legislation, rather than health and safety law (though the general duties of Section 3 of the HSWA and COSHH apply); for which the local authorities and other Government departments take the lead. By way of example, the Scottish Executive Health Department provides guidance on recreational use of agricultural pasture (http://www.scotland.gov.uk/Resource/Doc/47102/0013825.pdf) though if asked, HSE refers organisers to the general guidance in AIS23(rev).

The number of workers routinely exposed to pathogens in agriculture, entertainments and waste and recycling is large. There is potential exposure to food poisoning organisms such as *E coli* O157 and *Salmonella* sp. as well as zoonotic organisms such as *Cryptosporidium parvum*.

1.3.4 Construction

Hot and cold water is required on construction sites for hand washing regardless of whether this is for personal hygiene reasons, e.g., following using the toilet, or as a control measure to prevent unnecessary exposure of a worker's skin to chemicals. These requirements are clearly described within document CIS59: Provision of welfare facilities during construction work, available at: http://www.hse.gov.uk/pubns/cis59.pdf and SIM02/11/01).

Although not immediately obvious, some construction sites may contain biological hazards that workers will come in to contact with during routine work activity. These can include sites where groundwork, refurbishment or demolition work is taking place. Common hazards do not just include contact exposure; some may relate to other exposure routes such as inhalation. However, most of the microorganisms described below can be transmitted by hand, on surfaces etc., leading to potential for exposure to biological hazards that could cause disease include:

- Discarded needles: for example from recreational drug use. Needlestick injuries can lead to exposure to blood borne viruses including Hepatitis B and C and HIV.
- Rat infestation and exposure to rat urine: rat urine or water contaminated with it can cause Leptospirosis / Weil's disease if it enters a cut or gets into the nose, mouth or eyes.

- Contamination of the site with sewage or animal faeces: this can lead to infection with *E. coli*, a bacterium that can cause gastro-intestinal problems or more serious ill health, such as kidney failure.
- Human sewage: this can be contaminated with Hepatitis A, which can cause serious liver disease if ingested.
- Water systems that have not been drained or disinfected for long periods: these may contain stagnant water. This could contain *Legionella pneumophila*, a bacterium that can cause serious lung disease if spray or fine droplets contaminated with the bacteria are inhaled.

Some work activities have similarities with, but may be deemed peripheral to the core industries described above. For example, workers at outdoor events may undertake most of their activities at non-permanent sites, but be exposed to health risks that have strong links to the sectors described above. These workers include scaffolders and riggers who build stages, and waste management operatives who clean up grounds after events are ended. Workers at temporary events such as agricultural shows may be at risk from biological agents and other hazardous substances. Where an event is held on a greenfield site, the challenges associated with providing adequate temporary welfare facilities (including a water supply) are often no different to those experienced by workers on construction sites and/or in the waste industry.

1.3.5 Summary

In each of the above sectors there is evidence from industry and from some publications of an increasing trend towards the provision of alcohol based hand gels or hand wipes instead of soap and water. Before accepting these as alternatives it is important to review the evidence to ensure that they can provide adequate hand cleansing performance; at least equivalent to that achievable with soap and water. Because hand gels/wipes do not usually involve running water, their efficacy may be influenced by the degree of soiling present on the user's hands, as this will not be readily removed with rubbing alone and in the absence of running water that would normally carry the soilant away to drain.

Following earlier HSL research into the label claims made in respect of commercially available antibacterial hand gels and wipes, HSE has concerns about the use of these products for routine hand-washing. Amongst other things:

- Efficacy claims are often not supported by any laboratory data or testing of specific organisms.
- Where data are available on the efficacy of hand cleanser, in many cases it has not been independently tested, having being undertaken on behalf of the manufacturer.
- There is fundamental and widespread misunderstanding about the meaning of phrases such as "kills 99.9% of bacteria". The phrase does not mean that the product will kill a vast array of bacteria but rather that, if it has been tested under controlled conditions, it has shown a 1000-fold reduction in the concentration of a limited range of test bacteria.

In sectors such as waste handling, where potentially high exposure to microorganisms may occur, this means that large numbers of live may still remain. By way of example, a 1000-fold reduction from one million bacteria still leaves 1000 bacteria remaining. In some cases e.g. *E. coli* O157, illness can result from exposure to fewer than 100 bacteria, so serious infection risk may remain, even if 99.9% of bacteria are killed. A number of important points need to be considered before using hand gels/wipes within sectors other than healthcare:

- Most performance data are based on use in healthcare or domestic settings where soiling with organic material is less likely to be a confounding factor.
- Hand gels used in the healthcare sector are rigorously tested to much higher standards and against specific named organisms found in that sector. Therefore, published research will not necessarily translate to other work sectors. The US Food and Drug Administration (FDA) and the Centre for Disease Control (CDC) report that their guidelines for the use of hand gels in hospitals do not translate from the healthcare sector to other settings e.g. food handling. They recommend that products meeting specific efficacy criteria may be used only after and in addition to proper hand-washing.

The reasons they cite include:

- Differences in the type of pathogens present: Pathogens commonly transmitted in healthcare differ from those in other worker sectors, such as agriculture and waste recycling.
- Efficacy of the products: Products used in healthcare are rigorously tested against pathogens associated with healthcare acquired infections. The US quite rightly believes the efficacy of products in general settings needs to be reviewed.
- The type and level of soiling on the hands differs between healthcare workers and those in other sectors and this can influence the efficacy of the hand gel.

These US Government findings are consistent with HSE's concerns and support the need for further research in these areas. It is proposed therefore that a review of data relevant to the workplace situations (described above) be undertaken to identify the gaps in current knowledge. Further research may be required to inform practical solutions and to help develop appropriate enforcement benchmarks.

The aim and objectives at the outset of this work were as follows:

Aim

To review available data on the efficacy of currently available alternatives to soap and water for hand washing in the context of removal of contamination typical of that experienced in a range of outdoor activities, workplaces and related environments. Consideration to include commercial waste and recycling activity, animal visitor attractions, outdoor events, construction sites and other work away from permanent welfare facilities.

Objectives

1. To conduct a structured literature search against agreed search terms on the available evidence of performance of hand cleansers using soap and water as a benchmark for comparison with alternative hand cleansing methods. To include examining data from in 'field conditions' if possible. It is anticipated the largest body of data will be healthcare related and so likely to provide a benchmark for comparison with other, less well studied sectors.

2. To consider the following questions in relation to waste and recycling, but where relevant to agriculture, construction, and members of the public visiting farm (and similar) attractions and outdoor events:

- What information is available on the efficacy of hand washing *vs*. hand gels and/or hand wipes, especially in the presence of organic soiling?
- What information is available on the most effective way for operatives to wash their hands and/or for operatives to use wipes or gels for hand hygiene purposes?
- What differences in terms of overall efficacy are there between different types of wipes and gels used, compared to hand washing?
- Do all considered methods ensure a minimum standard of hygiene that would be acceptable regardless of the method used?
- Does credible read-across exist for data from the healthcare setting to other sectors of interest?

3. Report findings and highlight any obvious gaps in knowledge, with recommendations as to how those may be filled; including if necessary, by further research.

In order to address the above objectives, a series of formalised questions were devised by HSL and HSE staff, in order to obtain as much relevant information as possible from the scientific and industrial literature. The questions were designed using topic-focused search terms and are discussed in further detail in the Methods section below. It should be noted that the ability to answer any key review questions is totally dependent on the quality of the data available from published literature. So while it was always anticipated that relevant data would be available from healthcare sector studies, the body of information from other sectors was unknown at the start of this review. The relevance of healthcare findings, and its read across to sectors such as agriculture and waste and recycling, was also uncertain prior to data retrieval.

2. METHODOLOGY

2.1 AGREED APPROACH AND SCOPE OF THE REVIEW

Following initial discussions with HSE, it was agreed that a structured, narrative review of the available literature would be the most appropriate method to retrieve and summarise the published evidence. This type of approach would allow a thorough assessment of the efficacy data of hand cleaning products in industrial use, as alternatives to hand washing, but without the time intensive demands of a full systematic review. The use of systematic review methodology was an option at the outset of work, and can ensure greater consistency and less bias than a narrative review, but a full systematic approach was not appropriate here given the limited budget and time available. However, what the HSL team did choose to do, in order to ensure a high degree of structure to the search and sift process for available papers, was to implement a systematic approach to the 'front end' of the review process. To achieve this the development of review questions, sifting out of good, average and poor quality search results by group consensus, and final assessment of papers by data extraction form were all undertaken. These are processes normally used only for systematic reviews, but were used successfully here and the extracted data then incorporated in to the final report.

2.2 DEVELOPMENT OF REVIEW QUESTIONS

Key questions to be asked of the literature were agreed with the HSE customer. These applied systematic review principles based on PICO-based approach (Population of interest; Intervention; Control Group; Outcome). From the key questions below, specific search terms were also then developed and agreed with HSE, and these are listed in detail in section 2.3:

> Q1. For the specified worker populations** (P), how does hand washing with soap and water (I) compare to the use of alternatives such as gels and wipes [C], in order to achieve effective hand cleansing (O)?
> **As described in section 2.3 Table below

An additional sub-question (consideration) under Q1 (above) is:

> Q1a) When specifically considering waste and recycling operatives (P), do hand cleansing data (I) from other well studied sectors, e.g. healthcare (C), allow estimation of hand cleansing efficacy for the less reported groups (O)

> Q2. What quantitative information is available for work operatives (P), who wash their hands or use wipes or gels (I and C), to demonstrate whether a minimum standard of acceptable hand hygiene is achievable, regardless of the approach used (O)?

2.3 SEARCH TERMS AND CRITERIA

Table 1. Search terms used by HSE Infocentre

Population	Intervention	Control	Outcome
Waste / garbage / refuse disposal/ recycling workers/operative/ collection Agriculture/farm/open farm workers Visitors to animal visitor attractions Construction workers Leisure event (e.g., open air festival; country fair) visitors Leisure event workers Healthcare workers	Soap and water Hot and cold running water Hand wash(ing) Hand gel Hand cleanser Hand wipe Hand sanitiser/ sanitizer	Control study Unexposed control group Unwashed	Pathogen/micro-organism/bacteria/virus removal efficiency/ effectiveness/ efficacy Hand hygiene efficiency/ effectiveness/ efficacy Hand hygiene standard Comparable efficacy/effectiveness (Q2) Equivalent efficacy/ effectiveness (Q2)

Data search timescale – last 10 years initially, and then if the number of useful papers was disappointing, to extend further back if necessary.

2.4 SEMI-SYSTEMATIC LITERATURE SEARCH

2.4.1 Agreed search boundaries

Given that the use of alternative biocidal/biostatic hand hygiene products is relatively recent for the disinfection of contaminated hands using products such as hand gels, foams and wipes, it was agreed that the literature gathering would be confined to an initial ten-year retrospective search (see footer, Table 1). However, no 'earliest date' restriction was rigidly imposed and consequently any relevant papers found that pre-dated the ten-year initial search were included in this review. In order to initially qualify for review the articles had to be published in English and be of a quality standard comparable to that of the UK, i.e. most likely a study based on a developed country's research.

2.4.2 The search process

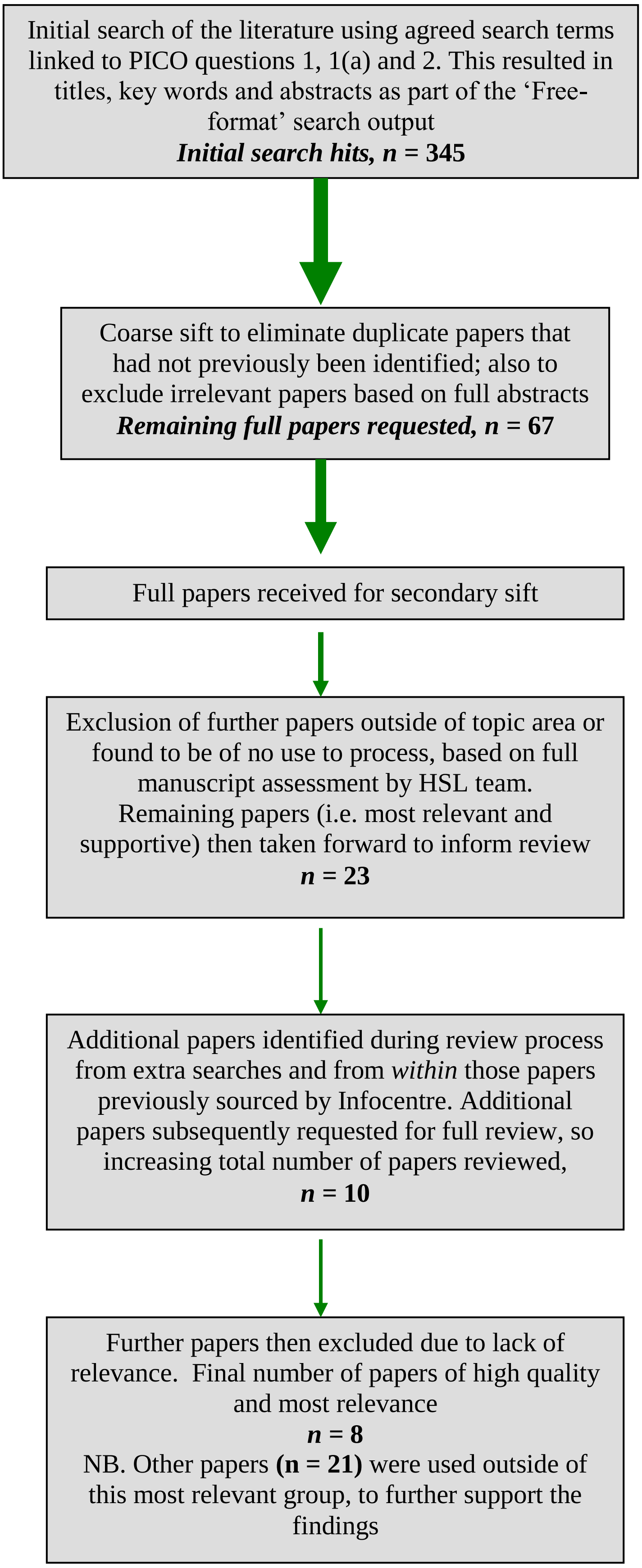
The agreed review questions and search terms (sections 2.2 and 2.3) were developed and provided for the HSE Infocentre, which offers a dedicated library and information retrieval service for HSL and HSE staff. Search algorithms were subsequently prepared by the HSE Infocentre to accommodate all search terms requested, whilst being sufficiently selective to exclude papers outside of the topic areas and where possible eliminate duplication. Database searches were undertaken by the HSE search team and included the Web Of Knowledge, EMBASE and MEDLINE databases. Although this review was of a structured narrative design, the use of two comprehensive search engines is consistent with recommendations given in a recent discussion paper about systematic reviews for occupational health research (Nicholson, 2011).

Additional searches were also undertaken by the HSL team where required, such as when additional references were of interest within an existing paper, using on-line databases Google Scholar and Pubmed. Additional Industry information was sought via Google searches. Copies of any additional relevant papers not identified by the HSE Infocentre searches were then ordered and assessed. A final approach was used in an attempt to obtain information on some of the more popular hand hygiene products used for healthcare; the hand hygiene section of the NHS supply chain database was searched. All products in this database are understood to have been reviewed and accepted by the Rapid Review Panel. Where possible, data were sought from web sites linked to 'approved' products from that listing in order to identify active ingredients as well as the concentrations at which they are used. It was thought this would be of benefit where further testing of products may be required so as to enable the most common actives and concentrations to be studied. This would then allow such analysis to cover the maximum number of products currently on the market.

2.5 REVIEW OF ABSTRACTS AND OTHER RELATED OUTPUT

The HSE Infocentre initially provided 'Free Format' printed summaries of the publications, including title, key words and in most cases abstracts. The HSL team sifted these papers to identify those most relevant to the review topics, and the primary consideration for the first course sift was that the paper content fell within those core topic areas. For example, a number of initial papers retrieved by the search included those focused on frequency or incidence of infection, and gave little or no product efficacy data. Retrieved papers also had to fall within additional agreed criteria for the review; published in English, of any year, relevant to modern healthcare systems and, as mentioned above, relevant to the PICO questions key topics. Abstracts of relevant papers were then requested. Following a further sift of the abstracts, based on the same broad criteria above, full copies of the relevant papers were requested. This process, and the distillation of publications from the initial search to the paper reviewed is summarised in Figure 1. Full papers were allocated to individual team reviewers, assessed, and data extracted independently of one another. Resulting data extraction forms were then considered by the team to agree which papers were of most relevance to the final reporting process. The data extraction forms therefore provided a useful and concise resource, to inform subsequent decisions on which data to include in the report.

Figure 1. Search and sift procedure undertaken for papers relating to PICO questions 1, 1(a) and 2.



2.6 CRITICAL APPRAISAL OF PAPERS

The requirements for the effective, systematic appraisal of published papers have previously been summarised for HSE where a systematic review approach is used (Beswick *et al.*, 2011). Although a full systematic methodology was not applied here that earlier study highlighted that the criteria used to design clinical studies (e.g., for drugs or medical devices) often cannot be applied easily to consider the risks to workers in their work setting. This has been previously acknowledged by others and does have an impact on the quality of peer-reviewed publications available for review within the occupational setting (Nicholson and Llewellyn, 2010; Tuma and Sepkowitz, 2006).

During this review it was noted that many of the published studies focussed on small worker populations – if indeed populations were involved at all - in order to carry out practical interventions. Another limitation was that many studies relied heavily on experimental testing of interventions, or extrapolated conclusions based on the work of others or expert opinion, and were not undertaken in a real workplace. These characteristics are reflected in the relatively small number of high quality papers eventually available for inclusion in the final review process (Fig. 1). Despite this constraint, the HSL review team recognised that many of the sifted papers employed studies that *could* be evaluated to some degree. A small number of these were confirmed as high quality in terms of their relevance and the quality of study design (n=8), and numerous other documents provided useful supportive information for this report.

2.7 EVIDENCE-BASED CONCLUSIONS

The nature and strength of any evidence-based conclusions were assessed in terms of their relevance to questions asked of the review; for example, their use in any future decision-making. This rule has particular relevance for the current review, where high quality papers were in short supply. Where there is insufficient information to support an evidence-based conclusion within this review, a knowledge gap (KG) has been identified. Further detail on the formulation of evidence-based conclusions is available elsewhere (Beswick *et al.*, 2011).

2.8 REVIEW OF ADDITIONAL PAPERS

Despite a thorough initial search of the published literature, with professional library support from the HSE Infocentre, the authors subsequently identified a small number of other published studies when individual papers were reviewed and scrutinised. These new papers were checked to ensure that their content fell within the agreed criteria for the review (i.e., published in English, any year, relevant to modern healthcare systems and relevant to the review questions). If these studies met these criteria, they were reviewed on the same basis as the previous studies.

3. FINDINGS

3.1 PRIMARY SEARCH OUTPUT AND PAPER EXCLUSIONS

Data were successfully obtained on the main review topic, the efficacy of hand cleaning using soap and water, hand wipes and hand gels, using the agreed set of key words which were used by HSE's Info Centre to search published literature.

The quality of data obtained was then assessed using an initial data extraction approach based on systematic review methodology, i.e. assessing data using agreed criteria but not using the full systematic review process, which is more labour intensive and therefore costly. For each paper a data extraction form was completed, summarising the data, which was then used to prepare the final report. These forms alone provide a useful resource that concisely summarises the author(s), title, context and data from each publication assessed.

Using this method the HSL team initially sifted all full papers into 3 categories - highly relevant, not relevant data and requiring further assessment. A consensus team approach (4 staff) was then used to peer review and complete the assessment which confirmed the short list of high quality papers, rejected the 'no relevant data' papers and retained other 'supportive data' papers that were worth including in the final review process.

In summary, there were few (less than 10) highly relevant papers i.e. where data related to industrial application. Some of these and the majority of other (supportive) papers and reports were based on the efficacy of hand cleaning within the healthcare context. Some read-across data were evident and therefore useful to the process, but a limitation will always be that in the healthcare situation hands are essentially clean in terms of organic load that might compromise cleaning efficacy. This is not typically the case in sectors such as agriculture and construction.

3.2 FINDINGS OF THE STRUCTURED LITERATURE REVIEW

Of the articles collected spanning the ten-year search period, many were of use for supportive information only and most related to the healthcare sector as described above. This was an expected outcome of the review process. In addition, many articles did not support scientific, rigorous analysis or were based upon expert opinion, which meant that they could not be classified as highly relevant or reliable (e.g. without bias). From the most significant articles we attempted to address the original questions asked of the literature. These are considered in the sections below, with key findings from the related studies presented.

3.2.1 Efficacy (i.e. reduction in contamination) of hand washing *vs.* hand gels *vs.* hand wipes, especially in the context of confounding factors such as organic soiling:

There is compelling and recently reported evidence to support the fact that the effectiveness of alcohol-based hand hygiene compounds depends on how much soil (bioburden) is present on the hands of the user (Todd *et al.,* 2010). This same review states that, '…*each formulation must be evaluated against the target pathogens in the environment of concern before being considered for use*'.

One study was found to be of particular relevance within the current review, and compared all three methods of hand hygiene i.e. hand washing, use of hand gel or foam, and hand wiping.

However, other related studies are also reported within this section because they were of good quality and also allowed a comparison between some form of hand wash approach as well as another (water free) form of hand cleansing.

This most complete comparative study used alcohol hand wipes (65.9% ethanol), alcohol gel rubs (62% ethanol) and antimicrobial foam soap containing 0.75% Ticlosan, (D'Antonio *et al.*, 2009). In this study, volunteers' hands were seeded with the bacterium *Serratia marcescens,* followed by disinfection treatment. Washing using antimicrobial soap gave the greatest bacterial reduction, which reduced the numbers of viable bacteria by 4.44 logs. Alcohol gel rub reduced the bio-burden least, by 2.32 logs; the alcohol wipe reduced the load by 3.44 logs. The authors concluded that the use of alcohol-based hand sanitizers by patients and healthcare workers effectively reduces the carriage of potential pathogens; however hand wipes were significantly more effective. A follow on study was carried out from this using the same three antimicrobial hand hygiene wipes, gels and soap as noted above against a *Geobacillus stearothermophilus* spore challenge (D'Antonio *et al*, 2010). The wipes reduced the numbers of spores by 0.5 logs, the gel by -0.8 logs i.e. an increase over the base line recovery, and the soap reduced the numbers of viable spores by 1.72 logs. This highlights the effectiveness of soap and water, but also suggests that hand wipes are more effective than gels for reducing the bio-burden on hands. Interestingly the CDC guidelines (Boyce and Pittet, 2002) state that alcohol wipes are not as effective as hand rubs, however this is based on wipes containing 30% alcohol rather than the 65.9% contained within the wipes used in the studies of D'Antonio *et al* (2009 and 2010).

Overall this study showed that, while soap and water was most effective, as an alternative hand wipes may be a way forward for hand hygiene in the industry as they mechanically remove contamination as well as disinfecting the skin surface. This study did not, however, use a soiling agent prior to hand hygiene, which may alter the efficacy of each hand hygiene method.

A randomised study by Girou *et al* (2002) describes how 23 staff used either medicated hand soap (chlorhexidine gluconate; Hibiscrub) or a hand rub containing 45% 2-propanol, 30% 1-propanol, 0.2% mecetronium ethyl sulphate, averaging 3-5ml volume application (Sterillium, Germany). During the study the participants performed 114 patient care activities; 55 of these were in the hand washing group, 59 in hand rubbing group. Gloves were worn with similar frequency during most activities between groups. Contamination of hands was lower for both groups after both types of hand hygiene treatment. Median reduction in bacterial contamination was 58% for hand washing and 83% for hand rubbing, confirming that here, hand rubbing more effective than hand washing. Time spent hand washing was usually less than 30s, which is insufficient for hand washing. Time spent hand rubbing was also 30s, so generally more acceptable for the alcohol based application. A notable factor within this study is that associated soiling levels was deemed low, as gloves were often worn during patient treatment and the work activity was routine ward based. In addition, the study was funded by the German manufacturer of the gel rub.

A before and after study undertaken by Davis *et al* (2006) is considered here and elsewhere in this review, (section 3.2.6). The study was designed to test efficacy of hand gel in the context of animal handling, but also made a useful comparison with hand washing using soap and water. Participants were identified at a ruminant animal show and all participants initially asked to wash their hands with soap and water (lather for 10s) to remove transient bacterial flora. Although subsequent animal handling did take place, it is possible that this initial hand wash procedure – designed to set a start baseline - did reduce soiling and prevent this confounding factor from being fully considered. Despite this, some useful data were obtained: exhibitors then handled their stock as normal during the show. They then returned to the hand washing station and were asked to rub their hands together to reduce hand contamination bias. Further details on experimental approach are provided in section 3.2.6, below, but in summary there was no significant difference in log reduction of coliform counts between the two groups. Many participants did not have coliforms present on hands either pre or post cleaning. Among all participants 14 were positive for presence of *E. coli* pre-cleaning: 7 in the hand gel group, 7 in soap and water group. All those in the hand gel group had no *E. coli* present post cleaning, but 3 from the soap and water group had low counts of *E. coli* after cleaning. A major bias of this study related to whether participants were left or right handed; the authors conceded that rubbing hands together was inadequate for preventing potential bias from 'handedness'. The authors conclude that hand sanitizers (gels and rubs) will remain only part of the solution for hand hygiene procedures of this type.

A study by Hubner *et al* (2006) has relevance for this hand wash *vs*. alternative approaches section of the review but is also cited elsewhere (section 3.2.4). The study was based on the healthcare (surgical) environment of a hospital and used 20 volunteers to evaluate hand rubs and to compare their use to hand washing/scrubbing. The log reduction of naturally occurring hand flora and seeded levels of *Geobacillus stearothermophilus* spores was assessed. Overall log reduction values, based on immediate measured effect on natural hand flora, were as follows: Propan-1-ol (60%) most effective with a mean log reduction of 2.11 ± 1.3; ethanol (80%) with a mean log reduction of 1.76 ± 1.2; propan-2-ol (60%) with a mean log reduction of 0.57 ± 0.6. After artificial contamination of hands with bacterial spores a 15 second hand wash reduced levels by 2.0 logs10 ± 0.51 logs. This study did not consider high soiling levels and only considered pre-alcohol hand washing and hand washing for spore removal separately. However, it does present some useful findings. Effective hand washing was shown to take only 15 seconds, with longer periods of washing with soap and running water having no additional benefit for hand hygiene. The authors also stress that hand washing is really only needed when the hands are visible soiled, e.g. if a glove punctures and contamination enters and coats the skin. At all other times the authors state that an alcohol-based preparation, preferably with brushing during application, should be just as effective. The efficacy of hand wash was neither significantly improved nor impaired by preceding application with a 1 minute hand wash with soap and water. However, there was a trend towards greater efficacy with alcohol hand rub when the user's hands were dry and not overly hydrated. Using a brush for 1 minute during disinfection enhanced the efficacy of all the alcohol hand rubs tested.

Oughton *et al* (2009) employed ten volunteer lab workers in crossover test fashion, so all were exposed to the various hand hygiene approaches and sampling methods used. Participants were used to simulate healthcare workers whose hands might become contaminated with *C. difficile*. Each worker's hands were exposed to *C. difficile* at levels in the order of 10^5 cfu per hand (62% spores). After this the volunteers undertook various methods of hand cleaning at controlled intervals, including: warm water and plain soap; cold water and plain soap; warm water and antibacterial soap; antiseptic hand wipe; alcohol based hand rub or, no intervention (control). The mean log reduction for *C difficile* was measured for each cleansing treatment (cfu/ml *C difficile* left on the hands). Warm water and plain soap gave the greatest reduction in *C. difficile*, closely followed by cold water and plain soap. Both gave slightly greater than a 3-log reduction in bacteria. Warm water and antibacterial soap provided just under a 3-log reduction, with antiseptic hand wipes providing < 2-log reduction. Of all the active interventions, alcohol hand rub alone (70% vol/vol isopropanol) gave the worst outcome, with slightly > 1-log reduction. This latter result was only marginally better than the no intervention control. This study is one of the few reported that allows a direct comparison of a range of hand cleansing approaches. The challenge organism – *C. difficile* – provides a substantial challenge for any hand hygiene approach and emphasises the inability of alcohol-based hand rubs and wipes to remove this bacterium effectively. Under such circumstances the effect of hand washing appears more beneficial. Within this study, antiseptic hand wipes were generally more effective against this particular bacterial challenge than alcohol hand rub. This is an important consideration for the current review, where hand wipes, as opposed to gels or rubs, are an option. The authors do acknowledge certain weaknesses in the study, such as the fact that this was an *In Vitro* study that might not extrapolate to clinically important outcomes such as HCAI. In addition, all of the hand wash/rub studies were performed for less time than recommended in Canadian hygiene guidance, but the durations used were applied following real life observation, with the cleaning steps designed to better mimic real life hand hygiene, rather than guidance stipulated hand hygiene periods

The detailed findings described above represent some of the more robust study data available from the peer reviewed literature, where studies have been well designed and have either limited bias, or are open about any bias/confounding factors. Other study reports exist that provide useful data, but these investigations may not have been undertaken in as controlled a manner, or may be based on expert opinion with little original data. These studies can still provide supportive information on hand washing compared with other means of sanitizing the hands (rubs/gels/wipes), and the most relevant of these papers are considered in brief below:

- Boyce and Pittet (2002) summarise some relevant data in their literature review article, though no original data are presented by the authors themselves. Hand washing with soap and water, antiseptic hand wash and hand cleansing with alcohol-based hand rubs are all considered as part of the review. The reduction in bacterial and viral colonization of the hands following various hand hygiene interventions is reviewed. The paper cites multiple data sources that list examples of biocidal efficacy for various products, and provides a number of conclusions, including a table of relative efficacy between different products tested by others over a 33 year period. One review recommendation is that alcohol rubs and gels are not appropriate when hands are visibly dirty or otherwise heavily contaminated. However, the authors also state that available data show that if low levels of proteinacious material such as blood are present, then ethanol and isopropanol may be more effective than antimicrobial hand soap. This review again underlines the importance of hand rub volume in terms of overall efficacy (3ml applied is more effective than 1 ml). A useful practical tip is provided, namely that the hands should feel slippery after a 10-15 sec product application. The authors offer a note of caution on frequent use of alcohol-based preparations, concluding that these may lead to drying of the skin unless an emollient is added.

- Weber *et al* (2003) used a small group of 6 volunteers of unspecified occupation and compared the efficacy of soap and water hand washing, 2% chlorhexidine based medicated soap and also the use of chlorine-containing hand towels. A bacterial inoculum (10^7) of *Bacillus atrophaeus* spores was spread on hands then washed with one or other of the products, using chlorine release impregnated hand towels. The results were compared to waterless 61% alcohol based cleanser. Against a baseline control value of 10^5 bacteria per ml recovered from hands, washing with soap and water showed ~2-log reduction. Chlorhexidine soap showed a similar effect. The study found no appreciable benefit of washing hands for longer (30 and 60 sec) compared to a shorter 10 second period. Both soap and chlorhexidine were significantly better than chlorine release towel after 10 sec but after 60 sec these were superior to chlorhexidine and similar to soap. Alcohol hand rub showed almost no log reduction in numbers, with the authors concluding that this was ineffective in removing or inactivating spores for all contact times.

- Savolainen-Kopra *et al* (2012a) undertook a Randomised trial of 683 office workers in 21 distinct office work units (clusters) in Helsinki. Three groups were established: 257 workers trained to use soap and water correctly, 202 workers trained to use hand gel correctly, 224 workers control group (no intervention). A trial was then performed over 16 months, during which pandemic flu occurred. All groups were influenced by a national hand hygiene campaign and participants were assessed for the number of sick days taken due to respiratory or gastro-intestinal infection. The number of reported infection episodes in a cluster per total reported weeks was, Soap = 1451, Gel= 1288, control group = 1214. The number of sick leave episodes in a cluster per total reported weeks was, Soap = 625, Gel = 418, Control = 405. A 6.7% reduction in infection episodes was observed when using soap; 16.7% less cases than control group during flu pandemic period. Despite conflicting results the authors concluded that intensified hand hygiene using water and soap, together with behavioural recommendations, can reduce the occurrence of self-reported acute illnesses in the office environment.

- Savolainen-Kopra *et al* (2012b) conducted a comparison of ethanol based hand rub with soap and water hand washing in order to remove human rhinovirus (common cold) from the hands. Eight adult volunteers were employed to use liquid soap (Erisan Nonsid) and LV alcohol hand rub (with 80% alcohol active). Volunteers first cleaned their hands with soap and water, then alcohol hand rub. Hands were then inoculated with10µl of quantified human rhinovirus 2 prototype, placed on back of both clean hands in the area of the middle fingers tendon. Pre-test cleaning swab samples were collected from skin of right hand, then following swabbing each volunteer washed their hands with soap and water or the alcohol hand rub. The process repeated so each volunteer trialled both products. The Rhinovirus was detected by a molecular (PCR-based) method. Pre-hand washing swabs were all PCR positive for virus, as would be expected. Following use of soap and water 3/9 left hands were positive, 1/9 right hands. After use of alcohol rub, virus was detected on all hands. This study reported that viral reduction on the hands for soap and water was statistically significant, but not so for alcohol rub. *In vitro* efficacy testing at 30 sec (as used in hand trials) was poor for both soap and alcohol hand rub.

- Steinmuller *et al* (2006) reviewed infectious disease associated with direct or indirect animal contact at visitor attractions in USA. Although only observational data, this paper and cross reference to data from US Communicable Diseases Centre (Anon, 2005) showed differences in efficacy between hand washing and use of alternatives. Washing hands with soap and water was consistently demonstrated to reduce visitors' incidence of illness, especially when reinforced by use of advisory signs (see also Anon, 2001). This was also tied into good practice, however, as drying hands on clothes led to increased illness, suggesting that washing hands with soap and water and drying hands with paper towels are necessary for preventing illness. In other reported outbreaks use of hand gels had inconsistent efficacy, leading to lower incidence of infection in one instance but making no difference in another.

3.2.2 Availability of quantitative information on the most effective way (i.e., in-use performance data) for operatives to wash their hands

Whilst the previously mentioned study by D'Antonio (2009) highlighted the use of wipes being efficacious over alcohol rubs, many operatives may wish to use gels over wipes. A study by Kampf (2008) showed that hand rub preparations containing 60-62% (w/w) alcohol were less effective at removing $1x10^8$ *Serratia marcescens* from hands (1.9-2.6 logs) than that of Hibiclens (containing 4% chlorhexidine gluconate), which was used as a reference hand rub and reduced bacterial numbers by 2.39 log. Hand rub containing 85% ethanol was, however, more effective than that of the Hibiclens reference preparation reducing bacterial counts by 2.79 log. This study investigated the differences in efficacy of hand rubs when using volumes of 2.4 ml and 3.6 ml. Use of the higher 3.6 ml gel application did not necessarily yield a higher rate of complete coverage of hands and increased efficacy of bacterial kill by a maximum of 0.5 log. This study showed that whilst the application of 2.4 ml of an alcohol-based hand rub was sufficient to wet both hands, it was not necessarily sufficient to meet the FDA efficacy requirements of a 2 log reduction in viability of bacteria after the first application when used as recommended by the manufacturers. This study therefore highlighted the requirement for hand rubs with high alcohol content in order to be as efficacious as Hibiclens – an agent often used in the healthcare sector. An important finding here was that the volume of alcohol was not a significant factor of overall efficacy i.e. a smaller volume of 2.4 ml was sufficient. This may differ depending on the type of microbial contamination, but is relevant given that dispensers are likely to differ in their output volumes.

Fuls *et al* (2008) evaluated hand washing techniques using an adaptation of the ASTM E1174 method in which volunteers' hands were contaminated with bacteria. Parameters examined were wash time and soap volume for antimicrobial and non-antimicrobial soap. Antimicrobial soap consistently performed better than non-antimicrobial soap, but for each increasing the wash time led to better reduction in residual bacterial contamination. For example, the antimicrobial soap increasing the wash time from 15 to 30 seconds led to an improvement from 2.90 $\log_{10}$ count reduction of bacteria on hands to 3.33 $\log_{10}$ count reduction. Increasing soap volume used for both led to better reduction in residual bacterial contamination, again with better reduction for non-antimicrobial soap. In a separate experiment, they also tested the potential for subsequent transfer of bacteria from hands to inanimate objects after washing. Following a 15 second wash, significant numbers of residual bacteria were transferred from hands onto plastic balls subsequently handled. The better reduction in numbers achieved with antimicrobial soap meant fewer were transferred.

Messina *et al* (2008) provide useful comments on the available approaches to hand cleansing as part of their mini-review. Although no original data are presented by the authors, the findings of others are usefully discussed. The importance of hand washing with soap and water is stressed, based on published evidence, where visible soiling is present. As with other reports, the authors also emphasise that washing the hands for anything > 2 min offers no additional benefit for removing microbes from the hands. This paper usefully summarises the activity spectrum of some alcohol hand rubs and recommends their use only on physically clean hands only. The review of Messina *et al* (2008) describes how some studies have shown comparable, or even improved hygiene performance of hand rub (compared with medicated soap), though the paper emphasises the importance of hand rub technique, e.g. the use of at least 3ml of alcohol hand rub liquid to achieve good effect. Finally, the authors describe how the success of hand hygiene techniques, especially hand rub approaches, are reliant on good educational programmes to ensure the product is used to best effect.

3.2.3 Most effective hand hygiene methods for operatives to implement

The research carried out by D'Antonio *et al* (2009) and also noted above, showed that where hand washing facilities were not available alcohol hand wipes were more effective than alcohol hand gels where alcohol concentrations were similar. More recent studies have evaluated alcohol hand gels where higher concentrations of alcohol have been used. Do Prado *et al* (2012) for example tested 12 alcohol-based gels each containing 70-85% alcohol against *E. coli* K12. The level of bacterial kill achieved by these products ranged from 2.91-3.8 logs after 30 seconds of exposure, thus indicating that increasing the levels of alcohol does not appear to significantly increase the anti-microbial efficacy of the product.

Hand gels and foams are rubbed on to the skin, which means that the active antimicrobial agents contained within them need to be efficient enough to kill microorganisms present on the skin surface. Jobs such as refuse collection will likely result in the hands being coated in organic material. This is a tough challenge for hand gel/foam products because the active ingredients need to penetrate the organic material to reach and affect the viability of the microbial contamination within or beneath it. It appears that hand wipes physically remove organic material and therefore assist the removal of microbial contamination from hands (Siani *et al.,* 2011), which may be a more suitable option for hand hygiene practices in sectors where hands are heavily soiled and where hand washing facilities are unavailable.

Based on the possible benefits of hand wipes where hand washing facilities are unavailable, it was important to find appropriate studies support this principle. One study tested nine commercially available wipes that claimed to be sporicidal against two strains of *C. difficile*: NCTC 12727 and R20291 (ribotype 027) respectively (Siani *et al.,* 2011). The product names of these wipes were not detailed, but the active ingredients mostly contained quaternary ammonium compounds or biguanides that are sporistatic, rather than sporicidal. Clinell unmedicated wipes were soaked with sodium hypochlorite (5000 ppm chlorine) and used as a positive control, with unsoaked wipes used as a negative control. This investigation utilised a three stage approach looking at i) the efficacy of wipes in removing spore contamination from surfaces; ii) bacterial transfer from wipes and; iii) sporicidal activity of wipes by direct inoculation.

The efficacy of wipes in removing spore contamination from surfaces was studied by mechanically rotating wipes attached to a steel rod (for 10 seconds at 60 rpm, exerting 500 g weight) against a steel disc inoculated with 20 µl of spore suspension containing ~10^7 spores, which had been left to air dry for an hour prior to wiping. The numbers of spores remaining on the disc post wipe were then assessed via culture on agar plates. The wipes from this test were then used to inoculate five agar plates consecutively by pressing the wipe on the surface, exerting a weight of ~500 g. These adpression tests indicated any bacterial transfer from the wipes. The ability of the sporicidal wipes to remove *C. difficile* spores from a surface ranged from 0.22 to 4.09 logs within a 10-second period. Wipe A, which contained peroxygen and tetra acetyl ethylenediamine, removed significantly more spores from steel discs than all other wipes including the positive control. Interestingly, the negative control wipe removed 90% of the spores from the surface of the steel disc compared with 99% for the positive control wipe. The R20291 (ribotype 027) strain was more resilient than that of the NCTC 12727 strain.

The sporicidal activity of the wipes was assessed via direct inoculation with 20 µl of spore suspension (~10^7 spores). After a set time of 10 seconds or 5 minutes, wipes were neutralized with buffer and the numbers of remaining viable spores identified via culture on agar plates. With the exception of the control wipe, which was soaked in 5000 ppm sodium hypochlorite solution none of the wipes demonstrated high sporicidal activity (i.e. >4 logs) within a 5-minute contact time. Only one wipe demonstrated some sporicidal activity, which reduced the numbers of spores by 1.5-3.74 logs. Only wipe A prevented spore transfer to sequential agar plates from the adpression tests. Of the remaining eight wipes, four showed an increased release of spores with each subsequent transfer. The authors suggested that this correlated well with the breakup of aggregates within the wipes.

This study also looked at the association of spores with wipe fibres using scanning electron microscopy and the release of spore aggregates via dynamic light scattering. Differences in spore binding were identified. Wipe A and the control showed uniform coverage of spores, whilst large loosely bound aggregates were observed for two other wipes.

The authors concluded that on the whole the inclusion of a sporicide in impregnated wipes was more appropriate for the safe disposal of wipes post use than spore inactivation on the wiped surfaces and recommended a one wipe, one application with a unidirectional approach to the wiping itself. The authors also concluded that current efficacy tests might be inadequate to reflect the activity of such wipes in practice.

It appears therefore that wipes might be more appropriate than hand gels or foams in terms of physically removing organic material from the hands, but the active ingredients impregnated into the wipe material may need to be assessed further to ensure sufficient biocidal activity against microbial contaminates on skin, which will likely vary between industry sectors.

3.2.4 Differences in terms of overall effect (efficacy and effectiveness) between different types of wipes and gels used, also compared to hand washing

The impact of hand washing alone on seeded spore levels on hands as well as the effect of a combination of hand pre-washing, hand scrubbing or hand rub alone for various applications of alcohol hand rub has been investigated (Hubner *et al*., 2006).

It was found that effective hand washing with soap and running water took only 15 seconds, with longer periods of washing having no additional benefit for hand hygiene. The authors suggested that hand washing with soap and water is only required when hands are visibly soiled, e.g. if a glove punctures and contamination enters and coats the skin. At all other times the authors indicate that an alcohol-based preparation is appropriate. Using a brush for one minute during disinfection enhanced the efficacy of all the alcohol hand rubs.

The efficacy of hand washing was neither significantly improved nor impaired by preceding application with a 1 minute hand wash with soap and water. However, there was a trend towards greater efficacy with alcohol hand rub when the users' hands were dry and not overly hydrated. Of the hand rubs tested one containing 60% propan-1-ol was found to be most effective at reducing *Geobacillus stearothermophilus* spores seeded on hands with a mean log reduction of 2.11±1.3. This was followed by 80% ethanol, which reduced the numbers of spores by 1.76±1.2. Propan-2-ol (60%) followed this with a mean log reduction of 0.57±0.6. Comparatively, a 15 second hand wash with soap and running water reduced levels of spores by 2.0±0.51 logs.

Supportive information on this topic also includes a review by Sickbert-Bennett *et al* (2004) who looked effects of test variables on the efficacy of hand hygiene. The authors undertook their own research on alcohol based hand rubs but also conducted a Medline based literature review of efficacy testing methods for hand hygiene agents from 1964 to 2002. Interestingly, this assessment of many other study data identified a number of variables that influenced hand decontamination, but which were not necessarily related to the type of product (though product type was confirmed as an influential factor). Other influences included, the method of use of the hand hygiene agent, the duration of application of the hand hygiene product and the volume of product applied. The study also confirmed that for products used during washing (water based) hand hygiene procedures, log reduction was linked to both the physical action of washing as well as chemical inactivation of the contaminant. For alcohol based products the level of efficacy was solely due to chemical inactivation.

Kampf and Loffler (2010) undertook a mini-review that considered the efficacy of soap and water hand washing compared to alcohol skin disinfection. The investigation was undertaken within the healthcare context, so it must be assumed that hands were not heavily soiled at the time of alcohol product use. Hand washing with soap and water was reported to reduce *E. coli* by ~2.6 log; *Bacillus globigii* by 2 log and *S. aureus* 2 log, following s 30 s exposure to the hand wash product. Alcohol hand rub disinfection was found to have a greater effect, though test challenges were not all identical; reducing *E. coli* by 4.6 log, *Enterococcus faecalis* and *S. aureus* by ~6.5 log, and *Ps. aeruginosa* by 6.7 log. (30s product exposure).

Bloomfield *et al* (2007) considered hand hygiene within a range of occupational settings, including healthcare, food preparation, community setting and childcare. This review document makes an interesting observation relating to the difficulties of studying hand hygiene within the workplace. Namely that, '*By definition, observational studies are not randomized and must utilize careful methods to preserve internal validity*.' During the preparation of the current review this was found to be the case, with many of the studies being observational in nature. Bloomfield *et al* usefully compare different types of hand hygiene product and their biocidal efficacy. Specifically, they show that hand washing can reduce naturally contaminated *E. coli* on the hands by anything from 0.5 log (10s hand wash) to 3.37 log (3 min hand wash) whereas 50% 1-propanol, 60% 2-propanol and 70% ethanol can reduce *E. coli* levels on artificially contaminated hands by up to 4.9 log, 4.4 log and 5.1 log respectively. The maximum alcohol based efficacy was achieved only after 1-2 min product application. Hand washing was shown to reduce naturally contaminated hands of *S aureus* by up to 3 log, (30s hand wash) with reduction of the same bacterium with 70% ethanol on artificially contaminated hands as high as 3.7 log.

Boyce and Pittet (2002) undertook a review that reported on hand washing with soap and water, hand washing with antiseptic hand wash and hand cleansing with alcohol-based hand rubs. Within Table 3 of this review the authors summarise a large number of studies – conducted over a 34 year period - that have compared soap and water hand washing with other forms of hand hygiene. Although too extensive to reproduce in detail here, relative product performance can be summarised as follows: in most cases, though not all, hand washing with soap and water gave less microbiological reduction on the hands than other forms of hand hygiene treatment, including ethanol, alcoholic chlorhexidine gluconate, propidium iodide and propanol-based products. To balance these data, which often indicated 65-70% ethanol is superior to other products, the review provides important reminders on the application of alcohol hand hygiene products. These notably include the statement that alcohols are not appropriate when hands are visibly dirty or otherwise heavily contaminated. However, the authors conclude from analysed data that if low levels of proteinacious material such as blood are present, then ethanol and isopropanol may be more effective than antimicrobial hand soap. Hand rub volume is seen as important to overall efficacy (3ml applied is more effective than 1 ml). The authors state that hands should feel slippery after a 10-15 sec application. Importantly, the authors also state that frequent use of alcohol-based preps may lead to drying of the skin, unless an emollient is added.

3.2.5 Do all hand hygiene approaches ensure a minimum standard of hygiene that would be deemed acceptable under COSHH?

A critical comparison of the health care personnel hand wash (ASTM E1174) and the hygiene hand rub (EN1500) test methods was carried out by Arbogast *et al* (2011). It was found that neither standard provided a realistic method for contaminating hands. It also found that they used unrealistic volumes of hand rub and implemented excessive contact times that would not be used in practice. It was found that a recently approved ASTM E2755-10 standard included the use of *Staphylococcus aureus*, which is more representative of a hand-transmitted pathogen than the standardly used Gram-negative organisms. This standard also employs lower contamination levels, lower volumes of hand rub to be applied and reduced exposure times. This allows for more realistic results to be attained using this standard method. It was noted that none of the standards mentioned has criteria based on evidence of the benefit or prevention of pathogen transmission and that a globally recognised standard test method was required for such products.

Cheeseman *et al* (2011) evaluated three different alcohol hand rubs (AHR) against *S. aureus* to mimic use in a clinical setting. Manufacturers use standard *in-vitro* tests (EN1500 and EN12054) to assess efficacy of AHRs, but they found that these over-estimated efficacy compared to in-use conditions. Using an *ex-vivo* carrier test, sterile pig skin was inoculated with the bacteria then coated with AHR for 5, 10 and 20 minutes before determining survival of bacteria. In further tests, rubbing of the skin was mimicked following AHR application. Much longer contact time (10-20 minutes) was needed compared to *in-vitro* tests. Greater efficacy was achieved with mechanical rubbing, but it was concluded that contact times greater than the evaporation rate of the AHR was needed for bactericidal effect, therefore the AHRs would be unlikely to achieve a significant (>4 log) reduction in practice in healthcare.

An earlier study (Dharan *et al.*, 2003) looked at alcohol based hand rubs (three hand rinses and a gel) using the EN1500 test method but with shorter contact time. According to the standard, a contact time of 30-60 seconds is applied, but this is longer than is usually achieved in practice. All met the standard in terms of log reduction with a 15 – 30 second contact time, but the hand rinses performed significantly better than the gel. They concluded that at contact times which more closely matched clinical practice they could not recommend the use of the gel.

Suchomel *et al* (2012) also tested the efficacy of alcohol based hand gels using a modification of the EN1500 test method but with shorter contact times. They found 30 seconds contact time to be significantly inferior in removing *E coli* K12 compared to 60 seconds contact, although increasing alcohol content in the formulation meant that each gel tested met the requirements of the test within 30 seconds.

Sickbert-Bennett *et al* (2005) used an adaptation of the ASTM E1174 method in which they reduced contact time from 30 seconds to 10 seconds. They tested 2 gels, 2 lotions and 1 foam waterless hand rub and 1 hand wipe (all alcohol based), 1 antimicrobial chemical based hand wipe, and 5 antimicrobial chemical (mainly chlorhexidine) liquid hand washes. Controls were non antimicrobial soap and water and tap water alone. They were tested for log reduction of repeated episodes of contamination of volunteers' hands with bacteria. Even most efficacious treatments were close to the minimum acceptance criteria for the method. Antimicrobial hand washing agents and even the controls (soap and water and water alone) were more efficient and more consistent at bacterial removal that wipes and rubs.

3.2.6 Extent with which biological agents used to generate efficacy data is relevant to non-healthcare settings

Organisms commonly used for testing the efficacy of antimicrobial hand hygiene products include *S. aureus, Pseudomonas aeruginosa, Enterococcus faecalis, E. coli (K12), S. marcescens, Influenza virus H1N, Enterococcus* sp. The reasons for these choices reflect the fact that many such products are designed with healthcare in mind. We can also extrapolate from this theme when we reflect on the context within which most antimicrobial hand hygiene data are published; the majority are linked to healthcare and for this reason much of the data below are linked to that sector.

A study by Maliekal *et al* (2005) identified the presence of specific bacteria from 204 untreated hands of HCW working in an ICU. These bacteria included *Staphylococcus* sp, Group-D *Streptococci, E. coli, Klebsiella* sp, NLF Gram-Negative Bacilli (GNB), and spore-forming *bacilli.* Of those tested, 16 HCW samples were regarded as having scant or no growth (<20

CFU), 136 moderate growth (20-100 CFU) and 52 were categorised as having heavy growth (>100 CFU). Although these values do reflect counts from healthcare workers, they also provide a useful indication of the variation in hand flora that can be seen across a large group of workers, all doing a similar type of work.

A study by Kac *et al* (2005) found that specimens collected from healthcare workers prior to hand hygiene procedures included *S. aureus* (of which 25% were MRSA) and *A. baumanii*. Despite absence prior to hand hygiene procedure *Enterobacter cloacae* and *Stenotrophomonas maltophila* were recovered from one HCW post hand wash.

A study by Lucet *et al* (2002) noted that the predominant bacteria present on the hands of HCW were *Corynebacterium* sp, coagulase-ve *Staphylococcus, Micrococcus* sp, and *Bacillus* sp. Potential pathogens identified on some hands were *S. aureus, A. baumanii, P. aeruginosa* and enterococci sp.

One of the small number of non-healthcare related articles obtained during this review had relevance for animal exhibition settings (Davis *et al*., 2006), and has already been summarised above for its comparison of alcohol and soap and water based strategies. This study was designed to test the efficacy of hand gel in the context of handling ruminant animals. Animals exhibited included horses, sheep, steer, and swine. Participants of the study were exhibitors half of which utilised a soap and water method to wash their hands with a 10-20 second lathering time, whilst the other half were allocated 1-3ml of 62% ethanol-based hand gel to apply followed by a 60-second air drying time. Pre and post wash/rub sampling of alternate hands was carried out by rinsing in 100ml of buffer, which was then serially diluted and plated out onto various agar types and incubated. The numbers of coliforms, generic *E. coli* and total bacterial counts were enumerated thereafter. The results of this study showed that the distribution of bacterial reduction after using hand rub was similar to that of soap and water hand washing. Total bacterial log reduction ranged between 1.4 and 6 for both groups. It is important to note that coliforms were not detected on many of the participants either pre or post hand rub/wash procedures. Of those participants that did have coliforms present on their hands prior to hand hygiene, the difference in log reduction post hand hygiene was not significant between the two groups. Among all of the study participants, 14 had *E. coli* on their hands after handling their animals. Post hand hygiene *E. coli* was not detected on any of the participants (seven) in the hand-gel group. Three of the seven participants from the hand washing group had low counts of *E. coli* detected on their hands post hand hygiene. This article also highlighted that in 44 cases (26 from the soap and water group, 18 from the hand rub group), the total numbers of bacteria isolated post hand hygiene was greater than the numbers recovered prior to the hand hygiene activity. Overall the study demonstrated that the effectiveness of ethanol-based (62%) hand-rub was not detectibly different to that of soap and water for reducing microbial counts on the hands of livestock exhibitors.

A more recent publication retrieved after the main literature search assessed protocols for sanitising hands of workers in poultry catching crews (Racicot *et al*, 2013). In this study, it was acknowledged that hands will be heavily contaminated with organic material and considered protocols using different combinations of hand hygiene methods to reduce levels of total bacteria and coliforms as well as to neutralise *Salmonella* bacteria. Protocols included soap and water, degreasing cream or hand wipes each combined with alcohol based hand gel, or hand gel only. The authors concluded that when bacterial contamination levels were low there was no significant difference between any of the protocols, but that when hands were moderately to highly contaminated hand gel alone was least effective, and that soap and water followed by hand gel was more effective than hand wipes followed by hand gel. In summary, they found it necessary to reduce levels of bacterial contamination on hands using soap and water of a degreasing cream before hand gels could sanitise hands, but also that catching crew members preferred using warm water and soap compared to using a degreasing cream.

3.2.7 Products from the NHS Supply Chain

The NHS Supply Chain data were difficult to access and work with. Hand hygiene products come under a disinfectant products category and included several hundred entries. The search terms used on the NHS Supply Chain website and numbers of products identified within that category were as follows:

- Disinfectants: 590 products found
- Hand gel: 80 products found
- Hand foam: 220 products found
- Hand rub: 230 products found

Not all products listed were of relevance to this review and information on the active ingredients contained in some products was not always available from the NHS Supply Chain website. Manufacturers' websites of such products were visited in an attempt to gain this information. Unfortunately not all manufacturers' listed the active ingredients of their disinfectant products. The following table highlights the common and relevant products found, the search term used, the brand, the product type (where the information was noted), and where possible the active ingredients they contain and the concentrations at which they are present.

Table 2. Summary of hand hygiene products listed on the NHS-Supply Chain website

Search Term Used	**Brand**	**Product Type**	**Active Ingredient(s)**
Disinfectants	Ecolab	Spray	0.5% Chlorhexidine, 70% ethanol
Disinfectants	Sterets Swabs	Swab	70% Isopropanol
Disinfectants	Ecolab	Liquid	2% Chlorhexidine, 70% Isopropanol
Disinfectants	PDI	Swab	70% Isopropanol
Hand gel	Desderman gel (aka SandM)	Gel	78.2% Ethanol, 10% Propan-2-ol
Hand gel	Durable	Travel kit including gel	
Disinfectants	Sanicloth	Wipe	2% Chlorhexidine gluconate, 70% IPA
Disinfectants	Tuffie	Wipe	Cocoalkyl Dimethylbenzyl Ammonium Clhoride (0-0.5%)
Disinfectants	Clinell	Wipe	<1% Benzalkonium chloride, 1-5% Propane-1,2-diol
Disinfectants	Durr HD410?	?	?
Disinfectants	Sanicloth Active	Wipe	0.01-1% N, N-didecyl-N, N-dimethylammonium chloride, 0.01-1% Propan-2-ol, 0.01-1% Monoethanolamine
Disinfectants	Wipex	Wipe	<0.5% Alkyl dimethylbenzyl

Search Term Used	Brand	Product Type	Active Ingredient(s)
			ammonium chloride, <0.2% Polymeric biguanide hydrochloride, <4% Propan-2-ol
Disinfectants	Softcare Sensisept	Liquid soap	<5% Chlorhexidine digluconate, <5% Sodium cocoamphopropionate, <5% Alkyl alcohol ethoxylate,
Hand gel	Clensa	Wipes	50-70% Propan-2-ol
Hand gel	VF481	Gel	70% Isopropanol, 2% Chlorhexidine gluconate
Hand foam	Alkapharm	Foam soap	?
Hand foam	Gojo Purell	Foam hand rub	50-75% Ethanol, 1-5% Propan-2-ol
Hand foam	Seraman sensitive	Liquid soap	?
Hand foam	Cutan foaming soap	Liquid foam	
Hand foam	HIBI Wash+	Foam wash	4% Chlorhexidine gluconate, 1-5% Propan-2-ol, 1-5% Lauryldimethylamine oxide
Hand foam	Gojo	Foam soap	1-5% 1-Propanaminium, 3-amino-N-(carboxymethyl)-N,N-dimethyl-, N-coco acyl derives., hydroxides, inner salts
Hand foam	Assure	Foam mousse	?
Hand foam	DEB	Foam	?
Hand foam	Kleenex	Foam	0.36% Didecyldimethyl ammonium chloride, 0.14% Chlorhexidine digluconate
Hand foam	Tork premium	Soap	?
Hand foam	DEB	Foam	65% Ethanol, 10% Propanol, <0.1% Propan-2-ol
Hand foam	Cutan	Foam hand rub	Propylalcohol?
Hand foam	Gojo Purell	Foam	62% Ethanol, <5% Isopropanol
Hand foam	Gojo	Foam soap	?
Hand foam	Deb cleanse inastant foam	Liquid soap	?
Hand rub	Spirigel	Hand rub	65-75% Ethannol, <1% of 85% Triethanolamine
Hand rub	Softalind 999	Gel	<55% Ethanol, <25% Propanol
Hand rub	B Braun (same as Softalind 999)	Gel	<55% Ethanol, <25% Propanol
Hand rub	GOJO NXT	Gel	?
Hand rub	Soft care med	Hand rub	>30% Propanol, 15-30% Propan-2-ol,
Hand rub	Soft care Des E	Hand rub	>30% Propanol, <5% 2-methylpropan-2-ol,
Hand rub	Spirigel Complete	Hand rub	50-100% Ethanol

Search Term Used	Brand	Product Type	Active Ingredient(s)
Hand rub	Gojo Purell 85		80% Ethanol, <5% Isopropanol
Hand rub	Biosure	Hand rub	70% Propan-2-ol, 0.5% 1,6-(4-Chlorophenyl diguanido) hexane digluconate
Hand rub	HiBi Liquid Hand Rub+	Hand rub	30-60% Propan-2-ol, 0.5% Chlorhexidine gluconate
Hand rub	Hydrex	Hand rub	50-70% Ethanol, <1% Chlorhexidine gluconate

This highlights that many products contain more than one active ingredient and that the groups of active ingredients as well as the concentrations with which they are present vary considerably. On the whole where alcohol is used as the active ingredient, it is generally ethanol or propanol based and is present at concentrations normally ranging between 50 and 75%. Chlorhexidine was another commonly used active ingredient of these products at concentrations ranging from 0.14 to 5%. From the literature reviewed in this report, most published articles have based their research on hand gels, foams or wipes containing propanol or ethanol based alcohols and/or chlorhexidine as the active ingredient(s). As is evident by the lack of published literature, it is likely that most of the products identified from the NHS supply chain website will not have been tested against microorganisms commonly found on the skin of workers hands in sectors other than those identified within the healthcare sector. Moreover, they will not have been analysed in the presence of soilant that would be akin to the amounts and varieties likely to be present on the hands of workers in these alternative sectors. This may therefore be a good starting point for testing purposes where further analysis of hand hygiene products outside the healthcare sector is deemed necessary.

4. CONCLUSIONS AND KNOWLEDGE GAPS

4.1 RELEVANCE OF REVIEWED DATA TO INDUSTRY

An important and early motivator for the current work rested on the experience of HSE's agriculture and waste and recycling inspectors. These professional enforcers possess first-hand knowledge of the challenges faced by some workers within various industries, in order to gain access to acceptable hand hygiene facilities. In part, these challenges have come about because of changing working patterns, but also because our knowledge of disease prevention has improved and places a new onus on employers to 'break the chain of infection' that may be linked to worker hand contamination. This is a wide topic area that has received much attention within the healthcare sector, as reflected by the findings here, but much less so within other sectors such as agriculture, waste handling and construction.

Examples of the evolution of working patterns can be well illustrated by refuse workers, who once, quite recently, had only black bags to collect, or latterly grey wheelie bins to empty, in order to complete their work. They are now faced with multi-coloured collection vessels of all shapes and sizes, catering for all aspects of waste recycling. This can include decomposing foodstuffs that may be less contained at the point of collection than was once the case, with many of these residues capable of harbouring infectious microorganisms. In addition, bin collection has been reduced from weekly to fortnightly collection. The level and variety of microorganisms present may therefore have changed over that time period as organic material contained within the bins decomposes. Discussions of vehicle based hand wash facilities, and their actual implementation by some councils, is perhaps not so unexpected then, given the increasing demands on waste collection operatives and our increasing knowledge of disease transmission.

In parallel to this, many waste handlers are now unseen by the public, working in large processing plants where recyclables must be sorted for end processing. Although these systems are often highly mechanised, human intervention is still required, either during breakdown, routine maintenance, or for aspects of the production line where human assessment is still essential. All of these activities present an opportunity for exposure to pathogenic microorganisms, and require PPE to be worn. This will invariably include hand protection comprising gloves that may prevent sharps injury or major soiling, but these items may themselves become soiled, sweaty and so leave the hands of the worker contaminated at the end of a long, highly physical shift.

Similarly, the means by which home grown crops are brought to market have changed, with the UK work force now often consisting of overseas nationals, often those who do not have English as a first language. Fruit and vegetable crop collection still often requires hard manual labour – unlike more mechanised arable – and field teams may have to spend many hours in remote locations, with limited access to toilet and hygiene facilities. Workers' hands will therefore become heavily soiled, and the physical nature of the work may induce workers to discard gloves and other PPE as they become hot, especially during the warmer months when many crops are harvested. The availability of effective hand hygiene facilities for such groups therefore becomes a basic human requirement, but also one that can break the chain of potential infection, e.g. prior to eating a sandwich box lunch.

The subject of hand wash basins for waste collection operatives remains an important one, but is clearly only one aspect of a wider requirement for several non-healthcare sectors that require hand hygiene facilities. Just as important though is the fact that the provision of wash basins in various occupational settings is being challenged by those who feel other, more practical and possibly less expensive options may be sufficient. Underlying these challenges within the waste collection context are *ad hoc* reports suggesting that wash basins on the vehicles, by the nature of their location and design, are difficult to maintain in good working order and that collection operatives do not like using the wash basins; preferring instead to use wipes. These issues will almost certainly have carry over to other sectors, such as agriculture and construction, where similar challenges exist at remote work sites. For waste collection, these issues could be tackled by exploring redesign of wash basins with manufacturers and reinforcing good management practices. These might logically include systems of work to ensure wash basins are checked and cleaned regularly, and operatives trained and properly supervised in their use. It is acknowledged, however, that this would be resource intensive and would need constant attention, as would also be the case within the other work sectors mentioned above.

4.2 EVIDENCE BASED STATEMENTS

There are aspects of hand hygiene approaches that allow read across from the (majority) healthcare sector publications identified from this review, and application to other work environments. From these, it is possible to make evidence based statements related to the use of either a conventional hand wash approach, or an alternative method using hand gels/rubs/wipes:

- The use of soap and warm running water for hand washing remains an effective method for reducing the levels of hand borne microbiological contamination. This need not involve specialist medicated soaps, though these have been shown to enhance decontamination effects in some studies. Multi-log reductions in hand contaminants have been repeatedly demonstrated using this approach;

- The use of soap and cold running water has also been shown as effective for hand decontamination, though is likely to be marginally less effective than soap and warm water. Although not proven, it is also logical to assume that the availability of cold water alone might deter some individuals from washing their hands during cold winter conditions, e.g. at remote facilities on farms, on construction sites, or children visiting open farms;

- There is some evidence that water alone provides physical removal of contamination that is superior to hand wipes or alcohol based hand rubs;

- Alcohol preparations based on either gels or liquid hand rubs can offer a significant reduction in microbiological hand contamination, with some studies claiming multi-log reductions under specified conditions that are greater than hand washing approaches. However, there are important limitations to how alcohol rubs and gels should be used:

    - Any active alcohol content can be neutralised by the presence of visible hand soiling, especially proteinacious residues, so alcohol based gels and rubs should only be used when the hands are visibly (i.e. physically) clean. This constraint may have implications for the use of such products in work sectors where hand soiling is unavoidable;

    - The 'dose' of alcohol based product used per application is critical to the success of its use. Studies show that at least 3 ml of product should be applied to the hand. More than 4 ml is not likely to improve efficacy providing that at least 3 ml is normally applied. This should equate to sufficient alcohol based product to fully lubricate both hands, so that a film of liquid product can be felt to cover the skin of the hands.

- Hand wipes impregnated with alcohol and/or some additional disinfectant products – such as quaternary ammonium compounds or chlorhexidine – have been shown to reduce hand contamination, but the mechanism for this is not always clear. Physical removal of contaminants is thought to be possible using hand wipes, and this may be helpful when soap and water are unavailable. However, the degree of skin disinfection from a wipe is likely to be highly dependent on the concentrations and type of active chemicals present on the wipe. These are often present at levels far lower than liquid or gel hand hygiene products.

4.3 SUMMARY

Given the lack of rigorous data related to hand hygiene within non-healthcare sector industries, there are some notable gaps in knowledge evident from this assessment of the literature performed here. Little published data exists on the performance of hand hygiene methods in the context of variable to heavy organic loading. Direct and indirect data that do exist suggests that the following hierarchy of choice of hand hygiene methods should be applied:

- Washing hands with soap and warm water;
- Washing hands with soap and cold water;
- Rinsing hands with water alone;
- Wiping hands with moistened wipes;
- Using hand rubs or gels.

5. REFERENCES

5.1 GENERAL REFERENCES NOT RELATED TO SPECIFIC KEY WORD SEARCHES

British Standards Institutions (BSI). (1997). BS EN 1500:1997. Chemical disinfectants and antiseptics. Hygienic handrub. Test method and requirements (phase 2/step 2). At: http://shop.bsigroup.com/ProductDetail/?pid=000000000001220898.

Crampin, M, Willshaw, G, Hancock, R, Djuretic, T, Elstob, C, Rouse, A, Cheasty, T and Stuart J. (1999). Outbreak of *Escherichia coli* O157 infection associated with a music festival. Eur J Clin Microbiol Infect Dis. 18(4): 286-8.

Fierer, N, Hamady, M, Lauber, CL and Knight R. (2008). The influence of sex, handedness, and washing on the diversity of hand surface bacteria. Proc Natl Acad Sci USA. 105(46): 17994-9.

Nicholson, P.J. and Llewellyn, D. (2010). Occupational contact dermatitis and urticaria. British Occupational Health Research Foundation (BOHRF). London, 2010. ISBN 978-0-9564979-0-1.

Stewardson, A, Allegranzi, B, Sax, H, Kilpatrick, C and Pittet D. (2011). Back to the future: rising to the Semmelweis challenge in hand hygiene. Future Microbiol. 6(8): 855-76.

Tuma S. and Sepkowitz K.A. (2006) Efficacy of safety-engineered device implementation in the prevention of percutaneous injuries: a review of published studies. Clinical Infectious Disease. 42; 1159-1170.

5.2 REFERENCES OBTAINED THROUGH AGREED KEY WORD SEARCHES

Anon (2001) Outbreaks of E.coli 0157:H7 infections among children associated with farm visits- Pennsylvania and Washington, 2000 MMWR; 50:293–7.

Anon (2005) Outbreaks of E.coli 0157:H7 associated with petting zoos: North Carolina, Florida and Arizona MMWR 54 (50) 1277-1280

D'Antonio N, Rihs JD, Tosiano MA, Stout JE, Yu VL. (2009). Efficacy of alcohol-based hand sanitizers (ABHS): A hand wipe (65.9% ethanol) exceeds the killing capacity of a gel rub (62% ethanol). American Journal of Infection Control. 37: E116-E11.

D'Antonio N, Rihs JD, Stout JE, Yu VL. (2010). Revisiting the hand wipe versus gel rub debate: is a higher ethanol content hand wipe more effective than an ethanol gel rub? American Journal of Infection Control. 38(9): 678-682

Arbogast JW, Okeke B, Brill F, Bradley T, Fraise A, Wilkinson M, Macinga D. (2011). Advancement of the standard in vivo hand rub test methods: a critical comparison of the health care personnel hand wash (ASTM E1174) and the hygiene hand rub (EN1500). BMC Proceedings (2011). Poster presentation.

Bloomfield S, Aiello A, Cookson B, O'Boyle C, Larson EL. (2007). The effectiveness of hand hygiene procedures in reducing the risk of infections in home and community settings…etc. Am. J. Inf. Contr. 35(10); suppl. I, S27-S64.

Boyce JM, Pittet D (2002). Guidelines for hand hygiene in healthcare settings: recommendations of the healthcare Infection Control Practices Advisory Committee etc. Inf. Con. Hosp. Epidemiol. 23(12) suppl. S3 – S40.

Cheeseman KE, Denyer SP, Hosein IK, Williams GJ, Maillard J-Y. (2011) Evaluation of the bactericidal efficacy of three different alcohol hand rubs against clinical isolates of *Staphylococcus aureus* using *ex vivo* carrier test. Journal of Hospital Infection. 77:21-24.

Davis MA, Sheng H, Newman J, Hancock DD, Hovde CJ. (2006). Comparison of waterless hand-hygiene preparation and soap-and-water hand washing to reduce coliforms on hands in animal exhibit settings. Epidemiol. Infect. 134: 1024-1028.

Dharan S, Hugonnet S, Sax H, Pittet D. (2003). Comparison of waterless hand antisepsis agents at short application times: raising the flag of concern. Infection Control and Hospital Epidemiology. 25(3): 160-164.

Do Prado MF, Coelho ACC, de Brito JPB, Ferreira DO, Junior AW, da Silva Menecucci C, de Queiroz AB, Garcia LB, Cardoso CL, Tognim MCB. (2012). Antimicrobial efficacy of alcohol-based hand gels with a 30-s application. Letters in Applied Microbiol. ISSN 0266-8254.

Fuls JL, Rodgers ND, Fischler GE, Howard JM, Patel M, Weidner PL, Duran MH (2008) Alternative hand contamination technique to compare the activities of antimicrobial and nonantimicrobial soaps under different test conditions. Applied and Environmental Microbiology 74; 3739–3744

Girou E, Loyeau S, Legrand P, Oppein F, Brun-Buisson C. (2002). Efficacy of hand rubbing with alcohol based solution versus standard handwashing with antiseptic soap: randomised clinical trial. BMJ. 325(7360): 362-365.

Hübner NO, Kampf G, Löffler H, Kramer A. (2006). Effect of a 1 min hand wash on the bactericidal efficacy of consecutive surgical hand disinfection with standard alcohols and on skin hydration. Int. J. Environ. Hlth. 209; 285-291.

Kac G, Podglajen I, Gueneret M, Vaupre S, Bissery A, Meyer G. (2005). Microbiological evaluation of two hand hygiene procedures achieved by healthcare workers during routine patient care: a randomized study. JHI. 60: 32-39.

Kampf G. (2008) How effective are hand antiseptics for the post-contamination treatment of hands when used as recommended? AMJIC. 36(5):356-60

Kampf G, Loffler H. (2010). Hand disinfection in hospitals – benefits and risks. JDDG. 8: 978-983.

Lucet JC, Rigaud MP, Mentre F, Kassis N, Deblangy C, Andremont A, Bouvet E. (2002). Hand contamination before and after different hand hygiene techniques: a randomized clinical trial. JHI. 50: 276-280.

Maliekal M, Hernvani N, Ukande U, Geed S, Bhattacherjee M, George J, Chitnis DS. (2005). Comparison of traditional hand wash with alcohol hand rub in ICU setup. Indian Journal of Critical Care Medicine. 9(3):141-144.

Messina MJ, Brodell LA, Brodell RT, Mostow EN. (2008). Hand hygiene in the dermatologists's office: To wash or to rub? J. Am. Acad. Dermatol. 59(6): 1043-1049.

Oughton MT, Loo VG, Dendukuri N, Fenn S, Libman MD. (2009). Hand hygiene with soap and water is superior to alcohol rub and antiseptic wipes for removal of *Clostridium difficile*. Inf. Contr. and Hosp. Epidemiol. 30(10): 939 – 944.

Racicot M, Kocher A, Beauchamp G, Letellier A, Vaillancourt JP (2013). Assessing most practical and effective protocols to sanitise hands of poultry catching crew members. Prev. Vet. Med. 111: 92-99.

Savolainen-Kopra C, Haapakoski J, Peltola PA, Ziegler T, Korpela T. (2012a). Hand washing with soap and water together with behavioural recommendations prevents infections in common work environment: an open cluster-randomized trial. Trials. 13: 10-21.

Savolainen-Kopra C, Korpela T, Simonen-Tikka M-L, Amiryousefi A, Ziegler T. (2012b) Single treatment with ethanol hand rub is ineffective against human rhinovirus-hand washing with soap and water removes the virus efficiently Journal of Medical Virology 84: 543-547.

Siani H, Cooper C, Maillard J-Y. (2011). Efficacy of "sporicidal" wipes against *Clostridium difficile*. Am J Infect Control. 39: 212-8.

Sickbert-Bennett EE, Weber DJ, Gergen-Teague MF, Rutala WA. (2004). The effects of test variables on the efficacy of hand hygiene agents American Journal of Infection Control. 32(2); 69-83.

Sickbert-Bennett EE, Weber DJ, Gergen-Teague MF, Sobsey MD, Samsa GP, Rutala WA. (2005). Comparative efficacy of hand hygiene agents in the reduction of bacteria and viruses. American Journal of Infection control. 33(2); 67-77.

Steinmuller N, Demma L, Bender JB, Eidson M, Angulo FJ (2006) Outbreaks of enteric disease associated with animal contact: not just a foodborne problem anymore. Clinical Infectious Diseases; 43:1596–602

Suchomel M, Kundi M, Pittet D, Weinlich M, Rotter ML (2012) Testing of the World Health Organisation recommended formulations in their application as hygienic hand rubs and proposals for increased efficacy. American Journal of Infection Control 40: 328-331

Todd EC, Michaels, BS, Holah, J, Smith, D, Greig, JD and Bartleson, CA. (2010). Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 10. Alcohol-based antiseptics for hand disinfection and a comparison of their effectiveness with soaps. J Food Prot. 73(11):2128-40

Weber DJ, Sickbert-Bennett E, Gergen MF, Rutala WA. (2003) Efficacy of hand hygiene agents used to remove *Bacillus atrophaeus* (a surrogate of *Bacillus anthracis*) from contaminated hands. JAMA 289: 1274 – 1277.

Published by the Health and Safety Executive 04/14

Health and Safety Executive

A review of the data on efficacy of handcleaning products in industrial use as alternatives to handwashing

The aim of the project was to review available data on the efficacy of currently available alternatives to soap and water for hand washing in the context of removal of contamination typical of that experienced in a range of outdoor activities, workplaces and related environments. Consideration to include commercial waste and recycling activity, agriculture including animal visitor attractions, outdoor events, construction sites and other work away from permanent welfare facilities.

The use of soap and warm running water for hand washing remains an effective method for reducing the levels of hand borne microbiological contamination. The use of soap and cold running water has also been shown as effective for hand decontamination, though is likely to be marginally less effective than soap and warm water.

Alcohol preparations based on either gels or liquid hand rubs can offer a significant reduction in microbiological hand contamination, with some studies claiming multi-log reductions under specified conditions that are greater than hand washing approaches. However, there are important limitations to how alcohol rubs and gels should be used, and these may introduce uncertainties regarding their efficacy.

Little published data exists on the performance of hand hygiene methods in the context of variable to heavy organic loading.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

RR1007

www.hse.gov.uk