



---

## Parallel Group Comparison of the Effects on Skin Condition of Two Antimicrobial Hand Wash Products

J. Djokic-Gallagher<sup>1\*</sup>, P. Rosher<sup>1</sup>, J. Walker<sup>1</sup>, K. Sykes<sup>1</sup> and V. Hart<sup>2</sup>

<sup>1</sup>Dermal Laboratories Ltd, Hitchin SG4 7QR, UK.

<sup>2</sup>Reading Scientific Services Ltd, Reading RG6 6LA, UK.

### Authors' contributions

All authors contributed to study design and reporting. All authors also read and approved the final manuscript. Author JDG drafted the manuscript. Author VH directed the implementation of the study. Authors PR, JW, KS have made substantial contributions to acquisition of data, and analysis and interpretation of data.

Original Research Article

Received 29<sup>th</sup> June 2013  
Accepted 12<sup>th</sup> November 2013  
Published 23<sup>rd</sup> December 2013

---

### ABSTRACT

**Aims:** The aim of this study was to compare the effects on skin condition of a hand cleansing protocol comprising repeated use of alcohol rub supplemented with one of two different antimicrobial hand washes, Dermal Wash (DW) and Hibiscrub (HS) when used for 5 consecutive days.

**Methodology:** Forty females applied the alcoholic rub 24 times and used their allocated antimicrobial wash product 13 times on test days (Days 1, 3 and 5) and applied the alcoholic rub 12 times and used the antimicrobial wash 7 times on intervening days. On test centre visit days, an investigator made visual assessments of skin condition and performed corneometry and pH measurements. Transepidermal water loss (TEWL) was measured at baseline and day 5. Subjects also assessed how their skin felt compared to baseline.

**Results:** Investigator visual assessments of skin dryness barely changed for DW but significantly deteriorated by the end of each test day for HS. Subjects' assessments of how their skin felt significantly deteriorated for HS, with five withdrawals. There was one withdrawal in the DW group. Corneometry measurements significantly improved for DW by 19% over the study, compared to a significant deterioration by 18% for HS. Apparent skin surface pH tended to increase for HS only. TEWL increased in both groups.

---

\*Corresponding author: Email: [jasmina.gallagher@dermal.co.uk](mailto:jasmina.gallagher@dermal.co.uk);

**Conclusion:** The use of an appropriate hand wash product, such as DW, even in conjunction with ubiquitous alcohol rubs, can achieve significant benefits- assessed in terms of subjects' own assessments of how their skin feels, investigator visual assessments of skin dryness and skin hydration measured by corneometry.

*Keywords: Dermol; Hibiscrub; hand wash; comparison; hydration; skin.*

## ABBREVIATIONS

DW : Dermol Wash  
 HS : Hibiscrub  
 TEWL : Transepidermal Water Loss

## 1. INTRODUCTION

Frequent and diligent hand cleansing by healthcare professionals is an important measure to help reduce microbial carriage and transmission between patients [1]. Hand cleansing protocols typically combine repeated use of alcohol-based hand rubs supplemented with washing with soap or liquid products, often antiseptic, when hands are visibly dirty [2].

Intensive hand cleansing can be drying, irritating to the skin [3] and lead to occupational hand dermatitis. Routine handwashing has been reported to be practiced by only about 40% of doctors [4].

Several studies have compared the bactericidal effects of antiseptic hand washes [5-9] but few have compared their effects on skin condition [10;11].

This single-centre, randomized, parallel-group, assessor-blind study compared the effects on skin condition of washing with Dermol Wash (DW, Dermal Laboratories Ltd, UK) and Hibiscrub (HS, Regent Medical Ltd, UK) with repeated use of an alcohol cleansing rub containing 70% denaturated ethanol with emollient (Spirigel Alcohol Hand Gel, Ecolab Ltd, UK) in circumstances mimicking semi intensive professional hand cleansing (Table 1). HS antimicrobial wash was chosen as the comparator in this study because it is commonly used for antiseptic hand washing in the clinical setting.

**Table 1. Composition of Dermol Wash and Hibiscrub**

<b>Dermol Wash</b>	<b>Hibiscrub</b>
Benzalkonium Chloride 0.1%	Chlorhexidine Gluconate 4%
Chlorhexidine Dihydrochloride 0.1%	Polyoxyethylene-polyoxypropylene block copolymer
Liquid Paraffin 2.5%	Lauryl dimethyl amine oxide
Isopropyl Myristate 2.5%	Glycerol
Cetostearyl Alcohol	Macrogol 7 glycerol cocoate
Macrogol Cetostearyl Ether (Cetomacrogol 1000)	Ponceau 4R (E124)
Phenoxyethanol	Isopropyl alcohol
Purified Water	Herbacol 015393 TB
	D-gluconolactone
	Sodium hydroxide
	Purified water

## **2. MATERIAL AND METHODS**

Performed in accordance with Good Clinical Practice, the study involved forty healthy female volunteers, aged 20-63, recruited from general public, with self-perceived normal skin. Ethical approval was obtained from Reading Independent Ethics Committee, Reading, UK. Written informed consents were witnessed. Exclusion criteria were: known allergies to the test products or ingredients; use of any medication likely to affect skin response; concurrent skin disease; history of relevant skin disease or allergy; significant visible skin abnormality; excessive hair growth; irritation, tattoos, scars etc. on measurement sites; breastfeeding or pregnancy; participation in any other hand test in the previous month; and any medical condition which in the judgment of the Investigator would preclude participation.

Screening was performed 7 days prior to commencement when subjects were asked to refrain from using moisturisers on the test sites. Subjects were assigned to treatment group according to pre-determined randomization prepared by statistician. For 5 days, hand and forearm cleansing involved using either DW or HS in combination with the alcohol rub (20 subjects per group).

On day 1, the subjects were shown how to wash their hands. The hand cleansing technique employed in this study was in accordance with the recommendations produced by the National Patient Safety Agency, UK [12]. The subjects washed their hands for 1 min (timed by the clock near the sink), employing a unit dose of approximately 5 ml. Although the two washes looked different, subjects and the assessing investigator were not told which had been allocated. The subjects were also shown how to use the alcohol rub and this was performed in accordance with the manufacturer's recommendations.

On days 1,3 and 5 at the test centre, subjects used their allocated wash 13 times at approximately half-hourly intervals and the alcoholic rub 10 and 20 minutes after each wash (24 times in total) (Table 2). All washes/rubs on these days were supervised by trained study center personnel and independently of study sponsor. On days 2 and 4, subjects used their wash 7 times, at hourly intervals, and the rub on 12 occasions at home (prompted by text messages). An earlier pilot test indicated this semi intensive cleansing regimen was likely to elicit only mild deleterious skin effects, however to avoid more serious dermatitis subjects were advised to discontinue cleansing in case of unacceptable irritation.

Prior to the first wash of the day on days 1, 3 and 5, and approximately 1 hour after the final wash of the day, the investigator made visual assessments of skin erythema and dryness under standard conditions of illumination, using a hand-held lamp fitted with an incandescent blue daylight bulb. Occurring signs were assessed individually using a 0 to 3 scoring system: 0 = 'none', 1 = 'slight', 2 = 'moderate', and 3 = 'severe'.

On the same occasions, subjects assessed how their skin felt compared to before the study: -2 = 'feels much worse', -1 = 'feels slightly worse', 0 = 'feels the same as', 1 = 'feels slightly better', and 2 = 'skin feels much better'.

**Table 2. Daily order of events**

<b>At the test centre (Days 1, 3 and 5)</b>				<b>At home (Days 2 and 4)</b>			
<b>Handwash No:</b>	<b>Target time for handwashing</b>	<b>Gel Application No:</b>	<b>Target time for alcohol hand rub</b>	<b>Handwash No:</b>	<b>Target time for handwashing</b>	<b>Gel Application No:</b>	<b>Target time for alcohol hand rub</b>
1	10:00	1	10:10	1	10:00	1	10:20
		2	10:20			2	10:40
2	10:30	3	10:40	2	11:00	3	11:20
		4	10:50			4	11:40
3	11:00	5	11:10	3	12:00	5	12:20
		6	11:20			6	12:40
≈	≈	≈	≈	≈	≈	≈	≈
12	15:30	23	15:40	6	15:00	11	15:20
		24	15:50			12	15:40
13	16:00	-	-	7	16:00	-	-

Secondary end points were measured using a Multiprobe Adapter MPA5 fitted alternately with a Corneometer CM825 probe (for hydration), a PH905 probe (for pH) and a Tewameter TM300 open chamber probe (for transepidermal water loss (TEWL)) from Courage and Khazaka, Germany. Corneometer is a well-established method for accurate determination of skin hydration, with skin dryness being commonly observed as an early sign of the deleterious effects of frequent and diligent skin cleansing. Regarding the pH, irritated skin is associated with higher values. Similarly, TEWL is reported to be an indicator of skin barrier function or leakiness, with higher values pointing to compromised skin barrier. These tests were performed at room temperature of 18.3°C to 20.4°C, with relative humidity between 23% and 27%.

Triplicate corneometry and single pH determinations were made at sites on the hands and forearms on the same occasions as the subjective assessments. Single TEWL measurements were taken at the start of day 1 and the end of day 5. These measurements were performed by experienced, trained personnel in accordance with the manufacturer's instructions.

At the end of day 5, subjects were asked how much they liked the products overall: 1 = 'dislike very much', 2 = 'dislike moderately', 3 = 'dislike slightly', 4 = 'neither like nor dislike', 5 = 'like slightly', 6 = 'like moderately' and 7 = 'like very much'.

The primary end points erythema, dryness and subjects' assessments of skin condition were analysed in SAS software using Wilcoxon's rank-sum test conducted using PROC NPAR1WAY (for differences between wash groups) and PROC UNIVARIATE (for differences from baseline).

The remaining parameters were analysed in SAS software using Student's t-tests conducted using PROC GLM with an estimate statement (for differences between wash groups) or using PROC UNIVARIATE (for differences from baseline). Significance is declared at the 5% level.

### **3. RESULTS**

Unacceptable skin irritation prompted six withdrawals: five subjects using HS and one subject using DW. For these subjects their last recorded assessments were carried forward for all later analyses. Results for the forearms were very similar to those for the hands, although generally less marked, and so for succinctness only the hand data are presented.

#### **3.1 Investigator Assessments of Skin Erythema and Visual Dryness**

All mean erythema scores were less than 1 (slight) (Table 3). For the HS group only, mean scores showing slight but statistically significant ( $P \leq 0.039$ ) deterioration from baseline were seen by the end of day 3 and thereafter. Visual dryness scores were also generally less than 1 (slight). They barely changed for DW, but significantly deteriorated by the end of each assessment day for HS. Statistically significant differences ( $P < 0.05$ ), in favour of DW with respect to these dryness changes from baseline, were evident at the end of days 1 and 5.

### **3.2 Subjects' Assessments of How Their Skin Felt**

For HS, scores showed a highly statistically significant ( $P<0.0001$ ) deterioration from baseline (generally "slightly worse than") for 75% of subjects by the end of day 1, and by the end of treatment more than half of the subjects assessed their skin as feeling "much worse than before the study", and 5 (25%) had actually withdrawn from the study (Table 4). For DW, by the end of treatment 10% assessed their skin condition as "much worse than before the study", and 1 had withdrawn. Differences in favour of DW were increasingly statistically significant over the three measurement days ( $P<0.001$  by the end of day 5).

### **3.3 Measurements of Skin Hydration and pH**

For DW, highly statistically significant ( $P<0.009$ ) skin hydration improvements from baseline were recorded at all time points (Table 3). For HS, skin hydration levels showed stepwise and highly significant deterioration at the end of days 1, 3 and 5 ( $P=0.0023$  by the end of day 5).

Apparent skin surface pH tended to increase slightly by the end of day 1 for DW and then returned to baseline by the end of day 5. For HS, pH increased markedly by the end of day 1 ( $P=0.0009$ ), and then showed a return towards baseline as treatment progressed, but with elevated levels at the end of days 3 and 5.

### **3.4 Measurements of TEWL**

For both DW and HS, TEWL measurements showed highly statistically significant ( $P\leq 0.0026$ ) increases by the end of day 5, and there were no statistically significant differences between the groups (Table 5).

### **3.5 Questionnaire Responses**

When asked "Considering everything about your wash, how much do you like it overall?" DW performed significantly better than HS, scoring 4.4/7 versus 2.2/7 respectively ( $P=0.001$ ).

**Table 3. Investigator assessments of skin erythema, skin dryness and measurements of skin hydration (corneometry) and pH**

		Dermol Wash			Hibiscrub			Wilcoxon test (Dermol Wash-Hibiscrub difference from baseline)
Skin erythema		Mean	Std Dev	Wilcoxon test P Value	Mean	StdDev	Wilcoxon test P Value	P Value
Day 1	Start	0.45	0.51	-	0.53	0.55	-	-
	End	0.60	0.68	0.500	0.53	0.55	-	0.311
Day 3	Start	0.53	0.60	0.625	0.63	0.58	0.500	0.957
	End	0.65	0.61	0.125	0.78	0.44	0.031	0.487
Day 5	Start	0.63	0.53	0.125	0.85	0.54	0.039	0.281
	End	0.60	0.50	0.375	0.85	0.40	0.023	0.350
<b>Skin dryness</b>								
Day 1	Start	0.28	0.44	-	0.55	0.60	-	-
	End	0.33	0.47	1.000	1.00	0.73	0.004	0.004
Day 3	Start	0.33	0.47	0.813	0.70	0.78	0.371	0.545
	End	0.48	0.50	0.094	0.98	0.80	0.020	0.204
Day 5	Start	0.45	0.51	0.125	0.75	0.79	0.219	0.768
	End	0.33	0.47	0.813	0.95	0.69	0.008	0.031
Corneometry		Mean	StdDev	Paired Student's t test P Value	Mean	StdDev	Paired Student's t test P Value	Student's t test (Dermol Wash-Hibiscrub difference from baseline)
Day 1	Start	27.2	7.8	-	28.0	6.0	-	-
	End	31.0	7.5	<0.0001	25.6	5.9	0.0582	<0.0001
Day 3	Start	31.0	6.2	0.0089	31.1	5.5	0.0014	0.6933
	End	33.5	6.1	<0.0001	26.4	5.2	0.1855	<0.0001
Day 5	Start	33.4	7.4	<0.0001	28.6	6.5	0.5048	0.0006
	End	32.4	8.3	0.0015	22.9	6.9	0.0023	<0.0001
<b>pH</b>								
Day 1	Start	5.3	0.4	-	5.3	0.5	-	-
	End	5.5	0.3	0.2669	5.7	0.2	0.0009	0.0768
Day 3	Start	5.4	0.5	0.4093	5.5	0.5	0.2103	0.8346
	End	5.4	0.3	0.6086	5.6	0.3	0.0688	0.2917
Day 5	Start	5.5	0.3	0.1532	5.4	0.5	0.4723	0.7424
	End	5.2	0.3	0.4063	5.5	0.3	0.2180	0.1351

Table 4. Subjects' assessments of how their skin felt

	Day 1		Day 3		Day 5	
	Dermol Wash Freq	Hibiscrub Freq	Dermol Wash Freq	Hibiscrub Freq	Dermol Wash Freq	Hibiscrub Freq
-2: Skin feels much worse than before study	1	4	1	6	2	11
-1: Skin feels slightly worse than before study	8	11	13	11	10	3
0: Skin feels the same as before study	9	5	5	1	7	2
1: Skin feels slightly better than before study	1	0	0	0	0	0
2: Skin feels much better than before study	1	0	0	0	0	0
Missing (withdrawn)	0	0	1 (-2)	2 (-2,-2)	1 (-2)	4 (-2,-2,-2,-1)**
All	20	20	20	20	20	20
Wilcoxon rank-sum test for difference from baseline P Value	0.1465	<0.0001	<0.0001	<0.0001	0.0002	<0.0001
Wilcoxon rank-sum test of difference between treatment groups P Value	0.028		0.013		0.001	

\*Numbers in brackets denote the withdrawal score, (-2) 'skin feels much worse than before the study', (-1) 'skin feels slightly worse than before the study'

\*\* One subject withdrawn at Day 5, but completed the assessment



**Table 5. Measurements of TEWL (g.m-2.h-1)**

	Dermol Wash				Hibiscrub Wash				Student's t test (Day5 End-Baseline) Probt
	No	Mean	StdDev	P value	No	Mean	StdDev	P value	
Baseline	19	10.9	3.3	-	16	10.0	2.3	-	-
Day 5	19	14.8	5.6	0.0026	16	14.5	4.1	<0.0001	0.6607

#### 4. DISCUSSION

Increasingly, healthcare professionals are experiencing skin drying and irritation as a result of repeated and combined hand washing with plain soaps and alcohol-based hand rubs. It is believed that anionic detergents present in the soaps damage the epidermal barrier, whilst the use of alcohol-based products on such skin causes an unpleasant, burning sensation [13,14]. As a result, healthcare professionals tend to reduce the use of alcohol hand rubs and increase the frequency of hand washing, thus further causing skin barrier damage and, as a result, eventually experiencing skin irritation [15].

Current wisdom recommends routine use of alcohol-based rubs in most clinical settings, reserving hand washing with plain soaps for instances when the hands are visibly soiled or contaminated with proteinaceous material or visibly soiled with blood or other body fluids [1,15,16]. Hand washing should not be performed immediately before or after the use of alcohol-based hand rubs [14]. However, this requires a significant change in professional behavior, because historically hand washing has been enforced as the mainstay of hand hygiene protocols.

A more acceptable strategy may be to recommend hand washing with a detergent-free soap substitute, particularly one such as DW which was specifically developed for use on problem skin. Its cleansing action relies on cetomacrogol 1000, which is non-ionic surfactant and so avoids the irritancy problems of ordinary anionic soaps and detergents. DW also contains two emollient ingredients, liquid paraffin and isopropyl myristate, and the synergistic combination of two antimicrobial agents, benzalkonium chloride and chlorhexidine dihydrochloride, present at low concentrations of 0.1%. The formulation satisfies the requirements of EN 1499 when used as a hand wash and leave-on skin conditioner, performing significantly better than reference soap in reducing the *E. coli* load from the fingertips of artificially contaminated hands [17], and is reported to be equally effective against normal and antibiotic resistant strains of *S. aureus* [18].

HS antimicrobial wash is a liquid containing the antiseptic chlorhexidine, in this case 4% as the gluconate salt, and two surface active cleansers polyoxyethylene-polyoxypropylene block copolymer and lauryl dimethyl amine oxide. HS is reported, by its manufacturer, to be gentle on the skin by inclusion of macrogol 7 glycerol cocoate and glycerol as skin friendly moisturisers. Its antimicrobial activity has been demonstrated against a variety of microorganisms [19;20].

The washing/rub cleansing schedule used in this study was less intensive than often required in the clinical setting, which can be up to 30 times per day [1]. Also, to allow a direct comparison between the effects of DW and HS, both were used only for hand washing

whereas DW is also recommended to be used as a leave-on conditioner reapplied after hand washing.

In this study erythema was scarcely evident at all and consequently there were no discernible differences between the two treatments. Some dryness, with mean scores generally less than "slight", was observed, with statistically significant deterioration only in the HS group particularly at the end of the more intensive days 1, 3 and 5.

Subjects' own assessments of how their skin felt compared to baseline showed that the DW/alcohol rub regimen was appreciably less detrimental to the skin than the regimen involving HS/alcohol rub. This parameter is arguably the most relevant to hand cleansing adherence because it directly influences individuals' willingness to persevere with the regimen. Indeed, this is reflected by the fact that the 6 withdrawals from the study included 5 in the HS group and only 1 in the DW group. Notably, whereas in the DW group subjects recorded some deterioration, generally "slightly worse than baseline", in their skin condition by the end of day 3, with no further deterioration thereafter, in the HS group the skin deterioration was first evident by the end of day 1 and steadily worsened over the treatment period such that, by the end of day 5, more than 70% of the HS subjects recorded their skin condition as being "much worse than before the study".

Regarding the skin hydration measurements (corneometry), highly statistically significant improvements in skin hydration, compared to baseline, were recorded in the DW group at all time points, reaching a 19% mean improvement by the end of day 5. This hydrating effect of DW is likely attributable to its two emollients, and supports the findings of other researchers that regular use of moisturising products can mitigate irritant contact dermatitis caused by regular use of hand cleansing products [21-23]. By contrast, in the HS group, after a slight improvement in skin hydration measured at the start of day 3, stepwise deteriorations, compared to baseline, occurred thereafter, and by the end of day 5 the mean hand measurement showed 18% deterioration in skin hydration.

The 'apparent' skin surface pH is often reported as a measure of the protective acid mantle of the skin, which is thought to have several beneficial effects including regulation of the skin's normal bacterial flora, as well as maintenance of the structure and function of the lipid barrier and stratum corneum homeostasis [24,25]. This property is known to be compromised by skin cleansers, especially anionic detergents, and irritated skin can be associated with higher, less acid pH values. In this regard, no statistically significant trends were observed, but HS group showed a clearer tendency towards higher values.

For the other secondary parameter, TEWL, significant increases were evident in both groups, with no appreciable differences between them. Skin research groups generally interpret higher TEWL values as a subclinical indicator of impaired skin barrier function [26]. TEWL measurements in particular are notoriously sensitive to environmental interference and can show marked temporal fluctuations [27]. Accordingly, when designing future studies of this sort, it may be advisable to include appropriate internal controls such as, measuring TEWL at untreated skin sites rather than relying on just the pre-study baseline.

Regarding subjects' questionnaire responses, neither semi-intensive regime was particularly popular, which is to be expected. Nevertheless, the overall liking score of 4.4 for the DW group (4 = 'neither like nor dislike') was significantly better than the score of 2.2 for the HS group (2 = 'dislike moderately').

A possible limitation of the study was the omission of an ordinary soap/alcohol rub comparator. However, this was considered unnecessary because the deleterious effects on the skin of this combination have been reported [14,16]. Also DW was used solely as a hand washing soap substitute, excluding its use as a leave on skin conditioner; whereas this dual application of the product is routinely recommended by the manufacturer.

## **5. CONCLUSION**

This study has demonstrated a sparing effect of DW when used as a soap substitute in conjunction with alcoholic rub. This is consistent with previous reports demonstrating the skin protectant effect of emollients in preventing dermatitis induced by rigorous use of detergent washes [21,23]. As such, DW could be regarded as a 'skin friendly' antiseptic soap substitute for professional use by healthcare workers.

## **CONSENT**

Not applicable.

## **ETHICAL APPROVAL**

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## **COMPETING INTERESTS**

This study was carried out independently by Reading Scientific Services Ltd, Reading, UK, and was funded by Dermal Laboratories Ltd, Hitchin, UK. The authors are employees of these two companies.

## **REFERENCES**

1. Boyce JM, Pittet D. Guideline for Hand Hygiene in Health-Care Settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Infect Control Hosp Epidemiol.* 2002;23:S3-40.
2. Cookson B, Mathai E, Allegranzi B, Pessoa-Silva CL, Bagheri NS, Schneider A, Tschopp C, Wendt C, Pittet D. Comparison of national and subnational guidelines for hand hygiene. *J Hosp Infect.* 2009;72:202-210.
3. Canham L. The first step in infection control is hand hygiene. *Dent Assist.* 2011;80:42-46.
4. Cohen HA, Kitai E, Levy I, Ben Amitai D. Hand washing patterns in two dermatology clinics. *Dermatology.* 2002;205:358-361.
5. Lowbury EJ, Lilly HA. Use of 4 per cent chlorhexidine detergent solution (Hibiscrub) and other methods of skin disinfection. *Br Med J.* 1973;1:510-515.
6. Larson EL, Laughon BE. Comparison of four antiseptic products containing chlorhexidine gluconate. *Antimicrob Agents Chemother.* 1987;31:1572-1574.
7. Lee MG, Hunt P, Felix D. A comparison of two bactericidal handwashing agents containing chlorhexidine. *J Hosp Infect.* 1988;12:59-63.

8. Ayliffe GA, Babb JR, Davies JG, Lilly HA. Hand disinfection: a comparison of various agents in laboratory and ward studies. *J Hosp Infect.* 1988;11:226-243.
9. Bulus N, Kaleli I. Comparison of antibacterial effects of different antiseptics after hand washing. *Mikrobiyol Bul.* 2004;38:137-143.
10. Scott D, Barnes A, Lister M, Arkell P. An evaluation of the user acceptability of chlorhexidine and wash formulations. *J Hosp Infect.* 1991;18Suppl B:51-55.
11. Grove GL, Zerweck CR, Heilman JM, Pyrek JD. Methods for evaluating changes in skin condition due to the effects of antimicrobial hand cleansers: two studies comparing a new waterless chlorhexidine gluconate/ethanol-emollient antiseptic preparation with a conventional water-applied product. *Am J Infect Control* 2001;29:361-369.
12. Anonymous. Hand cleaning techniques. Accessed 10<sup>th</sup> July 2013. Available: <http://www.npsa.nhs.uk/cleanyourhands/resource-area/nhs-resources/nhs-materials/download-artwork/>.
13. Whitefield M. Infection control, hand washing and irritant dermatitis - a possible solution. *NHS Journal of Healthcare Professionals*; 2004.
14. Kampf G, Loffler H. Dermatological aspects of a successful introduction and continuation of alcohol-based hand rubs for hygienic hand disinfection. *J Hosp Infect.* 2003;55:1-7.
15. Kampf G, Loffler H, Gastmeier P. Hand hygiene for the prevention of nosocomial infections. *Dtsch Arztebl Int.* 2009;106:649-655.
16. Kampf G, Loffler H. Prevention of irritant contact dermatitis among health care workers by using evidence-based hand hygiene practices: a review. *Ind Health.* 2007;45:645-652.
17. Gallagher J, Rosher P, Rees K. Bactericidal activity of a new 'skin friendly' combined hand wash and leave on skin conditioner. A poster presented at the 20th EADV Congress in Portugal; 2011.
18. Gallagher J, Rosher P, Temple S, and Dixon A. Routine infection control using a proprietary range of combined antiseptic emollients and soap substitutes - their effectiveness against MRSA and FRSA. A poster presented at the 18th EADV Congress in Berlin; 2009.
19. Marchetti MG, Kampf G, Finzi G, Salvatorelli G. Evaluation of the bactericidal effect of five products for surgical hand disinfection according to prEN 12054 and prEN 12791. *J Hosp Infect.* 2003;54:63-67.
20. Wootton M, Walsh TR, Davies EM, Howe RA. Evaluation of the effectiveness of common hospital hand disinfectants against methicillin-resistant *Staphylococcus aureus*, glycopeptide-intermediate *S. aureus*, and heterogeneous glycopeptide-intermediate *S. aureus*. *Infect Control Hosp Epidemiol.* 2009;30:226-232.
21. Kampf G, Ennen J. Regular use of a hand cream can attenuate skin dryness and roughness caused by frequent hand washing. *BMC Dermatol.* 2006;6:1.
22. Crowther JM, Sieg A, Blenkinsop P, Marcott C, Matts PJ, Kaczvinsky JR, Rawlings AV. Measuring the effects of topical moisturizers on changes in stratum corneum thickness, water gradients and hydration in vivo. *Br J Dermatol.* 2008;159:567-577.
23. Williams C, Wilkinson SM, McShane P, Lewis J, Pennington D, Pierce S, Fernandez C. A double-blind, randomized study to assess the effectiveness of different moisturizers in preventing dermatitis induced by hand washing to simulate healthcare use. *Br J Dermatol.* 2010;162:1088-1092.
24. Cork MJ, Danby S. Skin barrier breakdown: a renaissance in emollient therapy. *Br J Nurs.* 2009;18:872-877.

25. Hachem JP, Crumrine D, Fluhr J, Brown BE, Feingold KR, Elias PM. pH directly regulates epidermal permeability barrier homeostasis, and stratum corneum integrity/cohesion. *J Invest Dermatol.* 2003;121:345-353.
26. Williams C, Wilkinson M, McShane P, Pennington D, Fernandez C, Pierce S. The use of a measure of acute irritation to predict the outcome of repeated usage of hand soap products. *Br J Dermatol.* 2011;164:1311-1315.
27. Tupker RA, Pinnagoda J. Measurement of Transepidermal Water Loss by Semiopen Systems; in: Serup J, Jemec G, Grove G (eds): *Handbook of Non-Invasive Methods and the Skin.* Taylor and Francis.

---

© 2014 Gallagher et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<http://www.sciencedomain.org/review-history.php?iid=380&id=12&aid=2807>