Effect of topical treatments on irritant hand dermatitis in health care workers

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Background: Irritant contact dermatitis (ICD) from repetitive hand hygiene is the primary reason for compliance failure among health care workers (HCWs). Chronic ICD has implications for infection control because higher bacterial counts are associated with increased skin compromise. Guidelines recommend lotions/creams to lessen irritation. We evaluated the effects of 5 to 10 daily applications of a test cream (A, glove and chlorhexidine gluconate compatible) and current lotions/creams (B) compared with a control of normal skin care.

Methods: Outcomes were visual skin erythema and dryness, excess erythema (quantitative image analysis), and hydration among 80 HCWs in an intensive care unit.

Results: Knuckle dryness was lower for both treatments than the no treatment control ($P < .02$) after 2 weeks. Skin treated with A had lower knuckle erythema ($P = .03$) than B and control. HCWs using A had lower excess erythema (right) than B and control ($P < .04$). Excess erythema was lower for A and B versus control ($P = .003$).

Conclusion: Reduction in erythema suggests that frequent use of cream A may mitigate the damaging effects of repetitive hand hygiene and allow the skin to recover. Intensive treatment of HCW ICD may be required to counteract the skin compromise and minimize the negative impact on infection control.

Key Words: Skin; stratum corneum; irritant contact dermatitis; skin condition; irritation; erythema; dryness; image analysis; hydration; hand hygiene; topical treatment; lotion; cream.

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Routine hand hygiene is effective for preventing health care-associated infections, yet compliance rates are only 30% to 57%.[1,2] Irritant contact dermatitis is the primary reason for compliance failure.[3] Irritant contact dermatitis arises from the deleterious effects of repetitive procedures and specific products.[3-11] Up to 85% of nurses had histories and 25% reported symptoms of dermatitis.[2] Fifty-five percent of inpatient nurses and 65% of intensive care unit (ICU) nurses had observable hand dermatitis.[12] Irritant contact dermatitis may predispose development of allergic contact dermatitis.[13] Chronic skin compromise has implications for infection control because total bacteria counts were higher as skin damage increased.[11] Irritated hands had significantly more colony-forming units than normal hands.[14] Higher frequencies of colonization with *Staphylococcus hominis*, *Staphylococcus aureus*, gram-negative bacteria, *Enterococci*, and *Candida* were found in nurses with hand dermatitis.[15] Soap and water washing was ineffective for reducing microorganism contamination of damaged hands.[14] We previously found health care workers (HCW) skin to be appreciably compromised in spring and winter compared with non-HCW subjects.[10] Erythema, dryness, and reduced hydration were seen at the start of sequential work shirts. The stratum corneum (SC) did not recover from the effects of repetitive exposure during time off, especially in winter, indicating substantial, chronic SC barrier compromise.[16]

Use of lotions or creams to mitigate irritation is recommended.[2,17,18] Hand lotions and creams can increase skin hydration and replace SC lipids.[19-21] Because petrolatum may compromise the integrity of protective gloves, such as those based on latex,[22] caution is exercised with hand treatments containing petrolatum and/or mineral oil.[23] Information on the effectiveness of glove-compatible (ie, free of petrolatum) lotions/creams in clinical settings is sparse. We examined the effects of 2 treatments on hand skin condition of HCWs in an ICU. We hypothesized that frequent lotion/cream application would facilitate repair of the epidermal barrier damage from high-frequency hand hygiene. We used a single-blind parallel group design to assess exaggerated use of a test cream (commercially available, designed for use on compromised skin, petrolatum free, compatible with chlorhexidine gluconate [CHG][24]) and HCW

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current lotions/creams (representing the current standard) over 2 weeks. Both were applied 5 to 10 times daily and compared with skin condition for a control period of normal skin care.

METHODS

Subjects

HCWs from the Regional Center for Newborn Intensive Care (59-bed, level III, neonatal ICU) at Cincinnati Children's Hospital Medical Center participated from March to June of 2008. The research was approved by the Institutional Review Board, and subjects provided written informed consent. Exclusions were fewer than 2 consecutive 12-hour shifts, more than 14 days between work shifts, and fewer than 20 hand hygiene procedures over 8 hours at work. The subjects provided information about histories of allergies, asthma, atopic dermatitis, dry skin, pruritus, flexural rash, and childhood dermatitis and classified as to classify them as atopic dermatitis, general atopic, or nonatopic.[25] The skin was evaluated at approximately weekly intervals over 2 weeks to obtain control data. Treatments were assigned, and the skin was assessed weekly for 2 to 4 weeks.

Treatment assignment

Subjects were assigned to the test product or the current hand care products based on right-hand knuckle dryness score (ie, in categories of 0.5 grade increments from 0 to 5) to stratify and balance the groups for initial skin condition. Groups were not stratified for specific type of hand hygiene as described in the experimental procedure.

Outcomes

The primary outcome was hand skin condition measured as visual erythema, visual dryness, and excess erythema from digital image analysis over 2 weeks of treatment. Secondary outcomes were hydration (dorsum) and skin condition after 4 weeks of treatment for the test cream group.

Sample size

A sample size of 40 subjects per group was determined from our previous evaluations of the effects of 2 hand hygiene treatments (cleansers, hand sanitizers) during exposure (work) and regression (time off). The treatment difference for quantitative erythema (mean [μ] + standard deviation [σ]) during regression was 9.7 ± 7.6, requiring a sample size of 39 per group.

Skin measurements

The knuckles and dorsum were scored individually for erythema on validated scales for erythema (0-4) and dryness (0-5) by judges blinded to treatment.[10,26] High-resolution digital images of each hand were taken with a Fuji Camera (S2-Pro, 6.1 Megapixel, SLR; Fujifilm, Tokyo, Japan), a Nikon Flash (SB-29s Macro Speedlight; Nikon, Melville, NY), and a Macro Lens (AD Micro-Nikkor 60 mm f/2.8; Nikon).[16] Lighting was controlled and standardized for white balance and color. Images were converted from RGB to Lab mode. Means (μ) and standard deviations (σ) from the a* channel Lab histogram data were calculated with ImageJ (National Institutes of Health, Washington, DC) to generate $\mu + \sigma$. Pixels with redness higher than $\mu + \sigma$, to 188, were considered to represent excess redness.[16] The skin hydration was determined from capacitive reactance with the NOVA Dermal Phase Meter 9003 (NOVATechnology, Portsmouth, NH) and reported as capacitive reactance units (CRU). The reading 5 seconds after probe contact is the measure of SC hydration because of residual surface moisture, evaporative moisture from the dermis, and water bound to SC corneocyte proteins. The subjects recorded the daily times of treatment application in a diary.

Experimental procedure

HCWs used the hospital products (cleansers, handrubs) throughout the trial according to hospital policies for hand hygiene technique, indications, handwashing, ie, soap or antimicrobial soap and water for visibly soiled or contaminated hands, versus hand antisepsis, and others. The type of hand hygiene per shift during the study period was not recorded because of time constraints. Differences among subjects regarding specific practices (handwashing vs hand antisepsis) contributed to the study variability. Differences in hand skin condition as a result of specific practices was accounted for to some extent in the randomization procedure. For 2 to 4 weeks prior to the treatment, their skin was assessed 3 times at the start of work cycles of 2 to 3 consecutive 12-hour shifts after 3 to 4 days off. Subjects followed their normal routine of lotion/cream use at work and home. The skin evaluations served as the study control, ie, typical lotion usage. The measurements (each hand) were as follows: digital image, visual grading (erythema, dryness) of knuckles and dorsum, and skin hydration (3 sites midway between knuckles and wrist). At the last control period visit, subjects were assigned to 1 of 2 treatments (A or B) based on the right knuckle dryness score. To provide *intensive treatment*, they were instructed to apply the assigned treatments at least 10 times daily when off work and 5 times on work days. Higher application rates were requested during time off to maximize treatment exposure during periods of less frequent handwashing. During work shifts, the treatment exposure periods (between hand hygiene events) tend to be shorter. Group A

used the test cream only at home and work. Group B used their current products at home and the hospital lotion at work because they represented the ''current standard of care.'' The subjects were instructed to apply the treatments after towel drying their hands. Product information was recorded for group B lotions and creams. HCW skin condition was evaluated again at weeks 1 and 2 of treatment at the start of a work cycle. They did not apply treatments for 8 hours before the evaluations. Group A continued treatment application for 2 additional weeks with evaluations at week 4.

The hospital cleansers were Endure 50 (potassium cocoate, SD alcohol 40-B, potassium stearate, cocoamidopropyl PG-dimonium chloride phosphate; Ecolab, St. Paul, MN) and Endure 420 (CHG 2%, cocamide DEA, cocamine oxide, fragrance, gluconic acid, gluconolactone, hydroxymethyl cellulose, isopropyl alcohol 4%, PEG-75 lanolin, PEG-150 distearate, propylene glycol, quaternium-60, water; Ecolab). The handrub was Endure 320 (ethyl alcohol 62%, water, cetyl alcohol, PEG-32, glycerin, cyclomethicone, limanthes alba (medofoam) seed oil, panthenol, cerylates/C10-30 alkyl acrylate crosspolymer, tetrahydroxypropyl ethylendiamine, isopropyl palmitate, dimethicone, tocopheryl acetate, titanium dioxide, fragrance, aloe barbadensis leaf juice; Ecolab). The hand lotion was Clean*Care* Amino + Derm® Everyday Emulsion (purified water, glycerin, isopropyl palmitate, stearic acid, butylene glycol, lysine HCL, Arginine HCL, aspartic acid, glutamine, proline, glycine, alanine, glyceryl stearate, stearyl alcohol, polysorbate 60, cetyl alcohol, carbomer, triethanolamine, methylparaben, propylparaben, diazolidinyl urea, fragrance; Cardinal Health, McGaw Park, IL). The test cream (Remedy; dimethicone, aloe barbadensis [aloe vera] leaf juice, ascorbic acid, ascorbyl palmitate, canola oil, cetyl alcohol, cholecalciferol, citric acid, citrus aurantium dulcis peel oil, citrus grandis peel oil, citrus tangerina peel oil, diazolidinyl urea, glycerin, glyceryl stearate SE, glycine, hydroxytyrosol, l-proline, l-taurine, methylparaben, methylsulfonylmethane, n-acetyl-l-cysteine, niacinamide, olea europaea [olive] fruit oil, PEG-8, PEG-100 stearate, propylene glycol, propylparaben, pyridoxine HCL, retinyl palmitate, stearic acid, stearyl alcohol, tetrasodium EDTA, tocopherol, triethanolamine, vanillin, water, zea mays [corn] oil; Medline Industries, Inc., Mundelein, IL) was selected from commercially available products that could be purchased by health care institutions. The products selection criteria were CHG and glove compatibility (ie, free of petrolatum and mineral oil), designed for use on compromised skin, and absence of known skin irritants.

Statistical analyses

Treatment effects for the test cream (A), current products (B), and the control (usual skin care) were assessed for baseline, week 1, and week 2 using linear mixed models repeated measures procedures with week as the repeat (F statistic, $P < .05$) (SPSS Version 16.0, 2007; SPSS, Inc., Chicago, IL). The covariance type was diagonal. Treatment comparisons were based on estimated marginal means and made with the least significant difference (LSD) method ($P < .05$). Covariates included starting skin condition (eg, erythema, dryness, excess erythema), skin hydration, interaction terms, and fixed and random effects. The analyses were also conducted for the A versus B (control not included) for verification. Univariate analysis of variance was used to evaluate the effects over 4 weeks for A and historical control data ($P < .05$). Skin hydration data were normalized ($\log_{10}$).

RESULTS

Subjects

Eighty-four HCWs participated. Eighty took part in the control phase. Three withdrew prior to the treatment phase because of scheduling difficulties, and 4 HCWs were enrolled to replace them. No participant reported a history of eczema in flexural areas or of recurrent dermatitis beginning in childhood. Approximately 73% were classified as general atopic, primarily from a personal history of allergies, hay fever, or asthma, and the remainder were nonatopic. Forty-three HCWs were assigned to the test cream (A) and 38 to their current lotions/creams (B). No adverse reactions occurred. All of the subjects were right-hand dominant.

Baseline skin condition

Mean values (± standard error of the mean) are provided in Table 1. No significant differences were observed for right knuckle dryness for the control, test cream (A), and current lotions/creams (B) (ANOVA, $P < .05$) indicating that groups A and B were balanced by the assignment procedure. Dryness and erythema scores were significantly higher for the knuckles versus dorsum (both hands), consistent with our previous findings. Higher dryness (knuckle, dorsum) and erythema (knuckle) scores were found for the control period ($P < .05$) for the right hand (Table 1). Excess erythema was significantly higher for the right hand at baseline for the control period and the treatment phase (Table 1). There were no significant differences in baseline skin parameters for the general atopic versus the nonatopic subjects.

Treatment usage

Mean lotion/cream application frequency during week 1 was 7.3 per day (range, 1.7-15.4) for A and 6.8 (range, 2.1-8.8) for B. Mean frequencies for the

Table 1. Baseline skin condition for the control period and at the start of treatment

Measurement	Control (n=80)	Test cream (group A) (n=43)	Current lotion/cream (group B) (n=38)
Dryness			
Left knuckle	1.0 ± 0.07	0.9 ± 0.09	0.84 ± 0.10
Right knuckle	1.1 ± 0.08*	0.9 ± 0.09†	1.0 ± 0.09†
Left dorsum	0.4 ± 0.04	0.5 ± 0.06	0.4 ± 0.07
Right dorsum	0.5 ± 0.05*	0.4 ± 0.06	0.4 ± 0.07
Erythema			
Left knuckle	1.0 ± 0.07	1.0 ± 0.09	1.0 ± 0.10
Right knuckle	1.2 ± 0.07*	0.9 ± 0.09	1.0 ± 0.08
Left dorsum	0.5 ± 0.03	0.5 ± 0.06	0.5 ± 0.06
Right dorsum	0.5 ± 0.04	0.5 ± 0.04	0.5 ± 0.05
Excess erythema ($\mu + \sigma$)			
Left hand	50.0 ± 1.8	45.8 ± 2.9	44.0 ± 2.6
Right hand	57.0 ± 1.9*	57.1 ± 2.8*	58.2 ± 2.5*
Skin hydration (CRU)			
Left hand	—	128.1 ± 12.2	120.8 ± 6.7
Right hand	—	130.8 ± 14.8	124.2 ± 8.7

NOTE. Values represent mean ± standard error of the mean.
*Indicates significant difference between the left and right hands at baseline.
†Indicates directional difference ($P = .07$) between hands at baseline.

2-week period were 7.3 per day (range, 1.6-14.6) for A and 7.0 (range, 2.1-8.6) for B. Mean frequencies were not different for A and B (*t* test, $P < .05$). For group A, 8 of 43 HCWs reported that lotion use was not part of their normal hand skin care. Two of 38 group B subjects did not use lotions or creams for normal care.

Group B lotions/creams

HCWs in group B used a combination of the petrolatum-free (glove compatible) Clean*Care* Amino + Derm® Everyday Emulsion at work and their current lotions/creams encompassing 19 brands at home (percent per brand, Table 3). Water was the first ingredient (ie, in the highest amount) for 79% of brands, 5% were anhydrous, and 8% had another material as the first ingredient (Table 3). Seventy-nine percent contained petrolatum and/or mineral oil. Compositions are provided in Supplementary Table 1, which can be accessed at www.ajicjournal.org. Approximately 74% of group B HCWs used lotions containing water, glycerin, and petrolatum or mineral oil.

Outcome measures: Treatment effects

Both the test cream and the current lotions/creams resulted in lower knuckle (left, right) dryness than the no treatment control ($P < .02$) (Fig 1). Right dorsum dryness was lower for B than control ($P = .03$) and directionally lower for A ($P = .06$) (Table 2). A, B, and control were not different for left dorsum dryness. Skin treated with cream A had lower left and right knuckle erythema than lotions/creams B and the control ($P \leq .03$) (Fig 2). Left dorsum erythema was lower for A than both B and the control ($P < .01$), with values of 0.37±0.03 (A), 0.42±0.03 (B), and 0.47±0.02 (control), respectively. Right dorsum erythema was lower for A than the control ($P = .01$) (Table 2). HCWs using A had lower excess hand erythema (right) than those using B and the no treatment control ($P < .04$) (Fig 3). Excess erythema was lower for both A ($P = .003$) and B ($P = .000$) versus the control values.

Skin hydration increased from baseline values for A and B at week 1 (paired *t* tests) ($P < .05$). Values for A were as follows: left, 128±12 baseline and 164±16 week 1; and right, 131±15 baseline and 171±18 week 1. Values for B were as follows: left, 121±7 baseline and 147±12 at week 1; and right, 124.2±8.7 at baseline and 150.0±13.8 at week 1. Similar values were observed for week 2. Treatments A and B were comparable for skin hydration. Atopic classification (ie, general atopy or nonatopic) was examined as a covariate in the analysis, but it did not have an effect on the outcomes.

Group A continued the application for another 2 weeks to determine the effects of longer term treatment. Right knuckle erythema scores at weeks 2 and 4 were lower than at baseline and week 1 (ANOVA, $P < .001$). Scores were lower at week 4 than at all other times (Fig 4). Skin dryness was lower than baseline at weeks 1, 2, and 4 (ANOVA, $P < .05$). Knuckle erythema and dryness remained unchanged over a comparable 4-week period among a similar group of HCWs under conditions of normal (nonexaggerated) lotion/cream use (Fig 4).[10] For A, excess erythema (left hand) was lower at week 4 (40.4±16.7) than at baseline (45.8±18.3) and week 1 (46.3±16.3) (ANOVA, $P < .05$).

DISCUSSION

Intensive treatment of chronic irritant dermatitis with 2 treatments for 2 weeks significantly reduced skin dryness compared with a no treatment control period. Significantly lower erythema was observed for the petrolatum-free, CHG compatible test cream (A) compared with the HCW current lotions/creams (B) and no treatment. Further improvement occurred with continuing use of test cream (A) compared with historical data on HCWs with normal (nonexaggerated) lotion use. Reduction in skin erythema suggests that intensive use of the test cream (A) may mitigate the damaging effects of repetitive hand hygiene procedures and allow the skin to recover.

Our findings are consistent with previous reports on treatment of irritant hand dermatitis. Skin condition improved over 4 weeks (liberal application) for both a barrier cream (aluminum chlorohydrate in water, paraffinum liquidum, behenyl alcohol, glycerin, octyl palmitate, buxus chinensis, ceteth-10, steareth-20,

Table 2. Linear mixed model analysis details

Outcome measure	Covariates	Model statistics (F, P value)	Post hoc paired comparisons
Dryness			
Left knuckle	None	5.2, $P = .002$	A and B –s- vs control, $P < .02$
Right knuckle	None	9.6, $P < .001$	A and B –s- vs control, $P \leq .001$
Left dorsum	None	Not significant	NA
Right dorsum	None	3.2, $P = .04$	B –s- vs control, $P = .03$ A dir vs control, $P = .06$
Erythema			
Left knuckle	Random: treatment *baseline excess erythema, baseline RK erythema	6.6, $P = .002$	A –s- vs B, control, $P \leq .02$
Right knuckle	Random: treatment*baseline RK erythema	6.4, $P = .002$	A –s- vs B, $P = .03$ A –s- vs control, $P < .001$
Left dorsum	Random: treatment*baseline LD erythema	4.1, $P = .02$	A –s- vs control, $P = .005$
Right dorsum	Random: treatment*baseline R excess erythema	3.1, $P = .05$	A –s- vs control, $P = .01$
Excess erythema			
Left	Treatment*baseline LK erythema, treatment *baseline LD erythema, baseline LD dryness	8.3, $P < .001$	A –s- vs control, $P = .003$ B –s- vs control, $P < .001$
Right	Baseline R excess erythema	5.8, $P = .004$	A –s- vs. control, $P = .04$ A –s- vs B, $P = .001$

A, test cream; *B*, current products; *LD*, left dorsum; *LK*, left knuckle; *R*, right; *RK*, right knuckle.
*Indicates interaction between two parameters in the model.

Table 3. Health care workers' current lotions/creams

Brand	No. subjects per brand	% Subjects per brand	Formulation type	Percent by type
Aquaphor*	1	2.6	A	
Petrolatum*	1	2.6	A	5.3
Arbonne Intelligence	1	2.6	C	
Biotone	1	2.6	C	
Burt's Bees	1	2.6	C	7.9
Aveda Cream	1	2.6	NA	
Mary Kay	1	2.6	NA	
Victoria's Secret	1	2.6	NA	7.9
Aveeno*	1	2.6	W	
Bath and Body Works*	8	21.1	W	
Curel*	5	13.2	W	
Gold Bond*	4	10.5	W	
Jergens	1	2.6	W	
Johnson Soft Lotion*	1	2.6	W	
Keri*	1	2.6	W	
Lubriderm*	1	2.6	W	
Neutrogena	1	2.6	W	
Olay Quench*	1	2.6	W	
Vaseline Intensive Care*	6	15.8	W	78.9
Total	38 subjects 19 brands	100	NA	100

A, indicates anhydrous; *C*, indicates water not first ingredient on label; *NA*, not available; *W*, indicates water listed first on label.
*Indicates contains petrolatum or mineral oil (based on label ingredient list).

dimethicone) and the vehicle control (no aluminum chlorohydrate).[17] The reduction in damage versus baseline was significant at week 1, similar to our results. Among 54 HCWs with skin irritation, a lotion (Lubriderm [Johnson & Johnson Consumer Companies, Inc, Skillman, NJ]: mineral oil, petrolatum, lanolin, sorbitol, stearic acid, and others in water) provided greater improvement than a cream (Hand Sense [North American Safety Products, Los Angeles, CA]: glycerin, isopropyl myristate, triethanolamine, stearic acid, dimethicone, and others in water) after 4 weeks (4× daily) and both decreased damage at week 1.[18] A petrolatum-based lotion (Locobase [Astellas Pharma Europe Ltd, Staines, UK]: mineral oil, petrolatum, and others) reduced irritation versus the untreated control (crossover design).[27] Decreased dryness and increased hydration versus no treatment were seen for a cream (Baktolan [Bode Chemie, Hamburg, Germany]: water, liquid paraffinum, petrolatum, liquid paraffin, wax, and others) (4× daily, 2 weeks).[28] Use of hand cream (3× daily) reduced erythema and transepidermal water loss (TEWL) and increased hydration at week 2 versus no treatment in factory workers.[29] Hand eczema improved equally with a skin lipid formulation (ceramide 3, oleic and palmitic fatty acids, cholesterol with glycerin, petrolatum, and others) and a petrolatum-based cream at week 8.[30] This result was inconsistent with previous reports of greater effectiveness for the skin lipid cream, leading to the conclusion that treatment efficacy may depend on the type of skin compromise (ie, solvent, tape stripping, surfactant) and underlying conditions, eg, atopy, essential fatty acid deficiency, ichthyosis, and others.[30]

Treatment effects have also been investigated using models of skin irritation. Skin erythema from repetitive irritation (10%, sodium lauryl sulfate [SLS] patch) was reduced by each of 4 treatments: (1) petrolatum, (2) a water-in-oil cream (with polydimethylsiloxane and dimethyltrimethylmethylpolysiloxane), (3) glycerin-based cream A (water, glycerin, octyl dodecanol, stearic acid, PEG-100 stearate, cetostearyl alcohol,

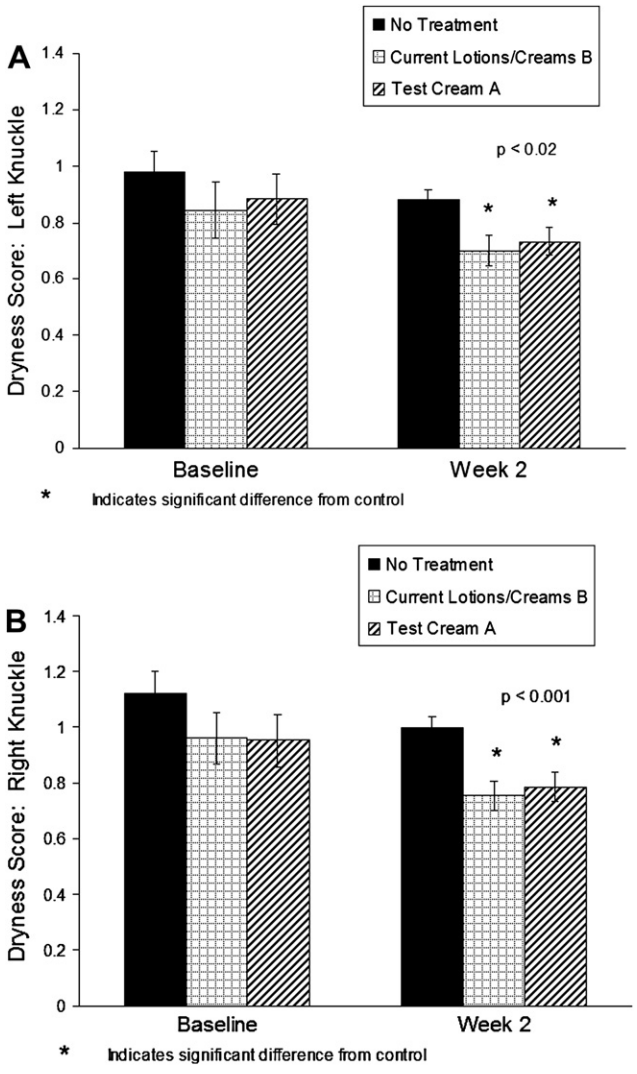

Fig 1. (A and B) Both test cream (A) and the current lotions/creams (B) resulted in significantly lower knuckle (left, right) dryness than no treatment control ($P < .02$) after 2 weeks of exaggerated use.

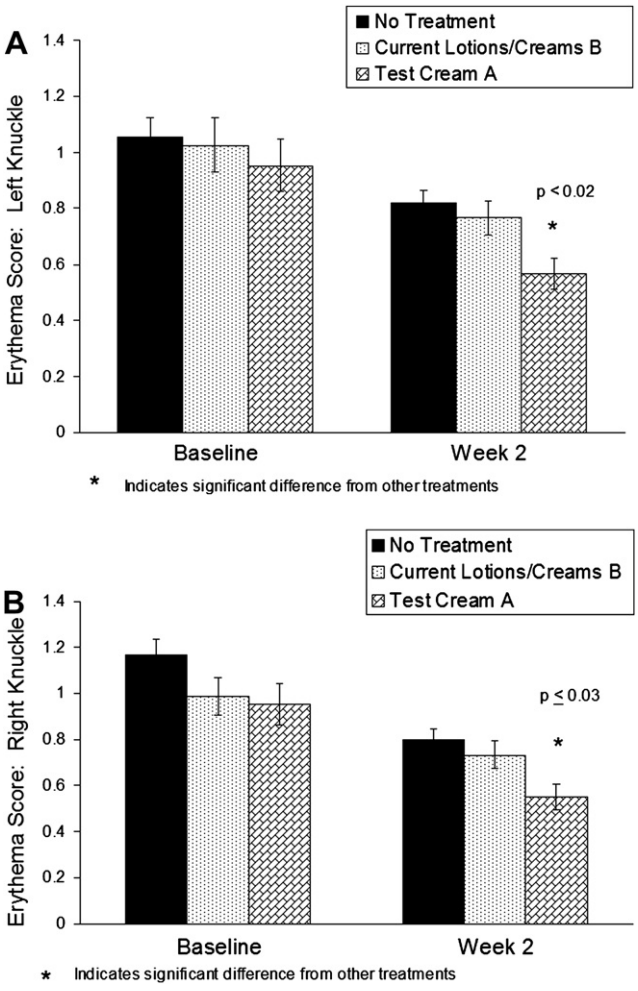

Fig 2. (A and B) Hand skin treated with cream A had significantly lower knuckle erythema ($P \leq .03$) than current products (B) and the control after 2 weeks of exaggerated application.

steareth-10, mineral oil, dimethicone, and others), and (4) glycerin-based cream B (water, glycerin, caprylic/capric triglycerides, cetyl dimethicone copolyol, isocetyl stearate, C12-15 alkyl benzoate, stearic acid, hydrolyzed almond protein, and others).[31] The effects of the individual ingredients glycerin (20%), nifedipine (1%), canola oil (40%), and (−)-a-bisabolol (0.5%) in a vehicle (90% paraffin oil, 10% polyethylene) were evaluated. Whereas each ingrediant protected the skin against repetitive irritation compared with no treatment, glycerin was significantly more effective than the vehicle alone.[32] The extent of protection from chemical (SLS patch) and mechanical irritation varied for test lotions (of specific compositions) compared with the mineral oil, petrolatum, and mineral oil + petrolatum-based formulations.[33] Recovery from skin irritation (SLS) was directly related to the lipid content (21%-100%) for 6 treatments based on petrolatum and/or mineral oil or isopropyl myristate and lanolin.[34]

Reports indicate that treatments can vary substantially in their effects on SC irritation and barrier integrity and, therefore, in the utility for chronic irritant dermatitis. Moisturizers were evaluated for their protective effects 7 weeks after daily application (normal skin). Those based on isohexadecane with paraffin (total 4%), canola oil (4%), canola (4%) plus urea (5%), and polymer gel (emulsifier only) *increased TEWL and susceptibility to irritation.*[35] The changes were associated with increases in messenger RNA (mRNA) for involucrin, transglutaminase 1, and SC proteolytic enzymes, indicating activation of barrier repair.[36] In contrast, a complex mixture (ie, triglyceride, canola oil, cetearyl alcohol, paraffin, glycerol stearate, and

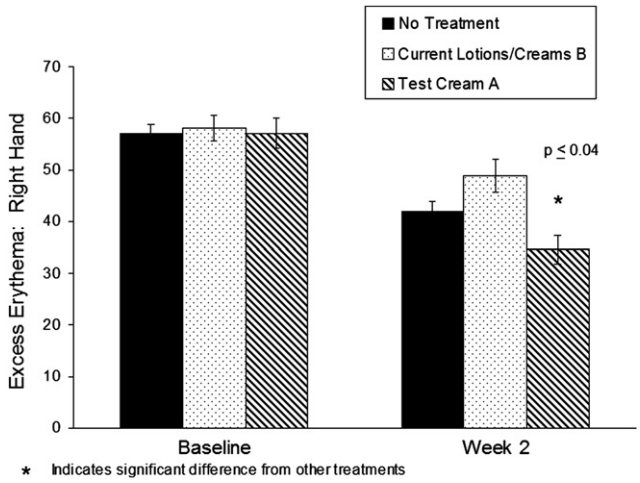

Fig 3. HCWs using cream A had lower excess erythema (right hand) than those using cream B and the no treatment control ($P < .04$). Excess erythema was lower after 2 weeks for both creams A and B compared with the control ($P \leq .003$).

urea) *decreased TEWL and irritant susceptibility*. The findings suggest that moisturizers vary in their effects on SC integrity. An examination of the effects of long-term moisturizer application found differing effects on skin (some positive and some negative).[35] Yokota and Maibach suggested that moisturizers are not necessarily effective against all irritants, models need efficacy determination, and formulations should be targeted at the causes of irritation and barrier compromise.[37] Xhauflaire-Uhoda and Pierard propose that the effectiveness of barrier creams is not particularly well studied or reported.[38]

The 2 treatments differed in their effects on skin erythema (visual scores, excess erythema from quantitative analysis of images). We anticipate that the observed differences were due to multiple factors, such as the presence and effectiveness of specific ingredients, the ingredient combination, and the amount applied per area. Test cream (A) contains linoleic, a fatty acid involved in epidermal barrier repair and has been implicated in the reduction of inflammation.[39] In culture systems, it triggered keratinocyte differentiation and synthesis of free and covalently bound lipids.[40] Cream A includes the water soluble amino acids L-proline, L-cysteine, and glycine that are components of natural moisturizing factor generated from proteolysis of stratum SC filaggrin. The group B hospital lotion contains the natural moisturizing factor amino acids lysine, arginine, aspartic acid, glutamine, proline, glycine, and alanine. Water exposure removes natural moisturizing factor from the SC, and treatments that supply amino acids to the SC may facilitate skin hydration.[41,42]

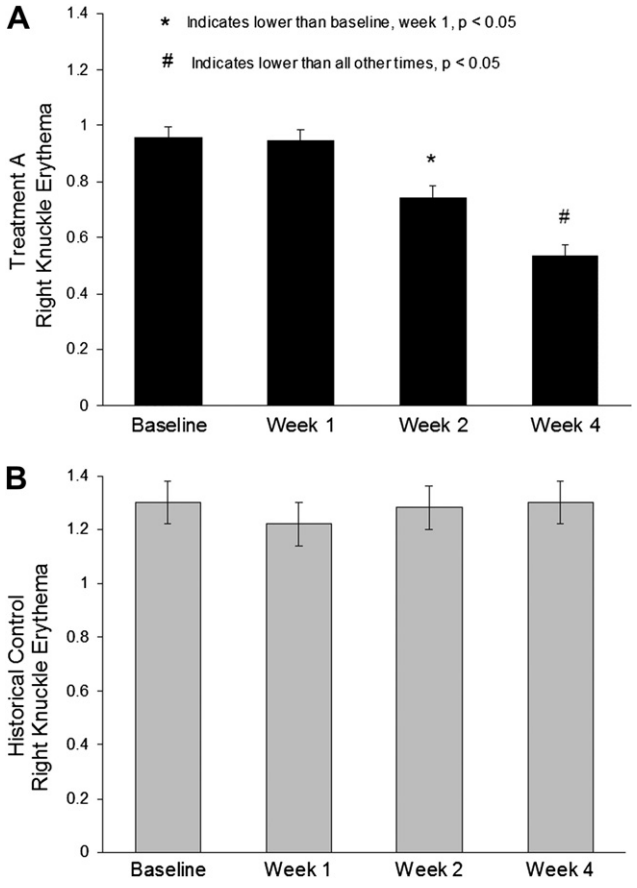

Fig 4. (A and B) Group A continued the cream application for 2 additional weeks. Erythema continued to decrease. Right knuckle scores were lower at weeks 2 and 4 than at baseline and week 1 (ANOVA, $P < .001$). Erythema was lower at week 4 than at baseline, week 1, and week 2. Knuckle erythema remained unchanged over a comparable 4-week period (spring conditions) with normal lotion use.[10]

Limitations of the study include the relatively short duration of the 2-week treatment period for comparison of A and B. The 4-week data for A indicates that additional changes occur and that longer durations of treatment are warranted. In addition, the study was limited in size to 80 subjects. The starting skin condition for this HCW population may not include the entire range of severity of skin compromise, eg, more extensive fissuring and inflammation. HCWs can also have atopic dermatitis, and the effects of both treatments in this condition would be of interest, given the inflammatory component of the disease. Furthermore, group B used a mixture of product with the hospital lotion at work and their own at home. The hospital lotion is also petrolatum free, and a direct comparison of test cream A with the hospital lotion would provide a

comparison of currently available products for use by this population. We did not measure SC barrier integrity by the standard measure of TEWL ($g/m^2/hr$) based on previous findings that it did not differentiate the effects of repetitive hand hygiene procedures within this clinical setting.

The findings from the present study suggest that aggressive application of hand lotions/creams is necessary to mitigate the epidermal barrier compromise that occurs with repetitive hand hygiene procedures. Such an approach might be appropriate in a health care setting where the risk of infection must be minimized. Currently, the choice of creams or lotions to alleviate chronic irritant hand dermatitis in the health care setting is somewhat limited because they must be free of petrolatum and/or mineral oil to maintain the integrity of protective gloves. Both utilization and development of treatments that are effective for the type of epidermal barrier compromise experienced by HCWs is a clear need for the safety of patients and care providers alike.

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Appendix.

Supplementary Table 1. Current lotions/creams ingredient list

No. per Brand	%		Brand	Ingredients
1	2.6	A	Aquaphor	Petrolatum, mineral oil, ceresin, lanolin alcohol, panthenol, glycerin, bisabolol
1	2.6	C	Arbonne Intelligence	Bio-Hydria® Complex (comfrey root extract; cucumber extract; birch leaf extract; watercress extract; clover blossom extract; ginseng extract; and St. John's wort) liposomes; phospholipids; α-hydroxy acids; antioxidant vitamins A, C, and E
1	2.6		Aveda Cream	Not available
1	2.6	W	Aveeno (intense relief)	Water, glycerin, distearyldimonium chloride, petrolatum, isopropyl palmitate, cetyl alcohol, aluminum starch octenylsuccinate, dimethicone, avena sativa kernel flour (oat), benzyl alcohol, sodium chloride
8	21	W	Bath and Body Works hand cream	Major ingredients: Water, mineral oil, glycerin, butylene glycol, cetyl alcohol, stearyl alcohol, triethanolamine, paraffin, cyclomethicone, microcrystalline wax, and others
			Bath and Body Works lotion	Major ingredients: water, glycerin, petrolatum, cetyl alcohol, cetearyl alcohol, dimethicone, fragrance, and others
1	2.6	C	Biotone	Key ingredients: apricot oil, sesame oil, grape seed oil, vegetable glycerin, grape seed extract
1	2.6	C	Burt's Bees (almond milk beeswax cream)	Sweet almond oil, water, beeswax, aloe barbadensis leaf juice, kaolin (natural clay), fragrance, citrus grandis seed extract (grapefruit), stearic acid (vegetable fat), glucose, tocopherol (vitamin E), carrageenan extract, sodium borate (natural borax), glucose oxidase, lactoperoxidase (natural enzymes)
			Burt's Bees Shea Butter Hand Repair	Rose water, sunflower oil, stearic acid (vegetable fat), beeswax, vegetable glycerin, seasame oil, shea butter, macadamia nut oil, glucose, rose hip seed oil, lavender oil, willow bark extract, calendula flower extract, plantain leaf extract, lady's mantle leaf extract, rose oil, neroli oil, borage oil, sucrose stearate (sugar emulsifier), retinyl palmitate (vitamin A), rosemary extract, vegetable oil, β-carotene, xanthan gum (natural thickener), sodium borate (natural borax), glucose oxidase, lactoperoxidase (natural enzymes)
5	13	W	Curel*	Water, glycerin, petrolatum, isopropyl palmitate, cetearyl alcohol, behentrimonium chloride, paraffin, stearyl alcohol, tocopheryl acetate (vitamin E), magnesium ascorbyl phosphate (vitamin C), retinyl palmitate, *Cocos nucifera* oil (coconut), *Gardenia tahitensis* flower extract, soy milk, *Prunus amygdalus* dulcis oil (sweet almond), dimethicone, DMDM hydantoin, aluminum starch, octenyl succinate, propylene glycol, cetearyl glucoside, lecithin, alcohol, methylparaben, propylparaben, fragrance
4	10.5	W	Gold Bond (ultimate)	Water, hydroxyethyl urea, glycerin, dimethicone, jojoba esters, petrolatum, cetyl alcohol, distearyldimonium chloride, *Aloe barbadensis* leaf juice, stearyl alcohol, cyclopentasiloxane, cetearyl alcohol, methyl gluceth-20, behentrimonium methosulfate, glyceryl stearate, *Butyrospermum parkii* (shea butter) extract, tocopheryl acetate, dimethicone/vinyl dimethicone, crosspolymer, bisabolol, *Zingiber officinale* (ginger) root extract, *Boswellia serrata* resin extract, *Avena sativa* (Oat) kernel extract, panthenol, magnesium ascorbyl phosphate, retinyl palmitate, *Chamomilla recutita* (Matricaria) flower extract, polysorbate 60, stearamidopropyl PG-dimonium chloride phosphate, propylene glycol, steareth-21, diazolidinyl urea, methylparaben, hydrolyzed jojoba esters, EDTA, propylparaben, potassium hydroxide, dipropylene glycol
1	2.6	W	Jergens Renew daily moisturizer	Water, glycerin, glyceryl stearate, myristyl myristate, glycine soja (soybean) oil, hydrogenated palm kernel glycerides, glycerides, cetearyl alcohol, jojoha esters, cyclopentasiloxane, *Vitis vinifera* (grape) seed oil, *Vaccinium angustirolia* (blueberry) fruit extract, *Punica granatum* extract, *Helianthus annuus* (sunflower) seed oil, *Simmondsia chinesis* (jojoba) seed oil, hydrolyzed jojoba esters, *Camellia sinesis* leaf extract, *Aloe barbadensis* leaf extract, *Chelidonium majus* extract, *Rosa cania* fruit extract, ascorbic acid, retinyl plamitate, polyglycerin-10, PEG-100 stearate, cetearth-20, carbomer, hydrogenated cottonseed oil, hydrogenated palm glycerides, sodium hydroxide, fragrance, DMD hydantoin, phenoxyethanol, ethylhexylglycerin, caramel
1	2.6	W	Johnson Soft Lotion	Water, glycerin, distearyldimonium chloride, petrolatum, isopropyl palmitate, cetyl alcohol, dimethicone, phenoxyethanol, titanium dioxide, fragrance, mineral oil, methylparaben, propylparaben, tetradibutyl pentaerithrityl hydroxyhydrocinnamate, tetrasodium EDTA, sodium chloride, glyceryl oleate, squalane, red 4, yellow 10
1	2.6	W	Keri Long-lasting hand cream with vitamin E	Water purified, cetearyl alcohol (and), polysorbate 60, mineral oil, cetyl alcohol, caprylic/capric triglycerides, propylene glycol, dimethicone, methylparaben, tocopheryl acetate (vitamin E acetate), propylparaben, disodium EDTA
1	2.6	W	Lubriderm Advanced therapy hand cream	Water, glycerin, distearyldimonium chloride, petrolatum, isopropyl palmitate, cetyl alcohol, aluminum starch octenylsuccinate, dimethicone, *Avena sativa* (Oat) kernel flour, benzyl alcohol, methylparaben, sodium chloride, tocopherol acetate, lecithin (and), retinyl palmitate
1	2.6		Mary Kay	Not available
1	2.6	W	Neutrogena Fast absorbing hand cream	Water, glycerin, isononyl isononanoate, dimethicone, cyclopentasiloxane, cetearyl alcohol, petrolatum, cyclohexasiloxane, behenyl alcohol, panthenol, tocopheryl acetate, xanthan gum, xylitylglucoside, anhydroxylitol, xylitol, cetyl alcohol, glyceryl stearate, PEG 75 stearate, ceteth 20, steareth 20, cetearyl glucoside, VP/hexadecene copolymer, disodium EDTA, methylparaben, phenoxyethanol, propylparaben, fragrance

(Continued)

Supplementary Table 1. (Continued)

No. per Brand	%		Brand	Ingredients
1	2.6	W	Olay Quench therapy hand cream	Water, glycerin, niacinamide, petrolatum, *Butyrospermum parkii* (shea butter), isopropyl isostearate, caprylic/capric triglycerides, *Olea europaea* fruit oil (olive), *Aloe barbadensis* leaf juice, *Chamomilla recutita* flower extract (*Matricaria*), *Elaeis guineensis* oil (palm), panthenol, hydrogenated vegetable oil, tocopheryl acetate, dimethicone, aluminum starch octenylsuccinate, propylene glycol, sodium PCA, betaine, sorbitol, glycine, alanine, proline, serine, threonine, arginine, lysine, glutamic acid, cetearyl glucoside, polyethylene, methylparaben, sodium acrylates copolymer, dimethiconol, ethylparaben, disodium EDTA, PEG 100 stearate, propylparaben, sodium hydroxide, cetearyl alcohol, cetyl alcohol, stearyl alcohol, behenyl alcohol, benzyl alcohol, C12 13 pareth 3, laureth 7, fragrance
1	2.6	A	Petrolatum	Petrolatum
6	16	W	Vaseline Intensive Care Healthy hand and nails	Water, potassium lactate, sodium hydroxypropyl starch phosphate, glycerin, stearic acid, mineral oil, dimethicone, lactic acid, glycol stearate, PEG 100 stearate, keratin, glycine soja sterol (soybean), tocopheryl acetate (vitamin E acetate), retinyl palmitate (vitamin A palmitate), *Helianthus annuus* seed oil (sunflower), sodium PCA, sodium stearoyl lactate, urea, collagen amino acids, ethylhexyl methoxycinnamate, petrolatum, mineral water, cetyl alcohol, stearamide AMP, cyclomethicone, magnesium aluminum silicate, glyceryl stearate, fragrance, xanthan gum, corn oil, BHT, disodium EDTA, methylparaben, DMDM hydantoin
1	2.6		Victoria's Secret	Not available

A, indicates anhydrous; *C*, indicates water not first ingredient on label; *W*, indicates water listed first on label.