

Revisiting the hand wipe versus gel rub debate: Is a higher-ethanol content hand wipe more effective than an ethanol gel rub?

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Background: The Centers for Disease Control and Prevention's guidelines for hand hygiene state that the use of alcohol-based hand wipes is not an effective substitute for the use of an alcohol-based hand rub or handwashing with an antimicrobial soap and water. The objective of this study was to determine whether a hand wipe with higher ethanol content (65.9%) is as effective as an ethanol hand rub or antimicrobial soap in removing bacteria and spores from hands.

Methods: In two separate experiments, the hands of 7 subjects were inoculated with a suspension of *Serratia marcescens* or *Geobacillus stearothermophilus*. Subjects washed with each of 3 different products: 65.9% ethanol hand wipes (Sani-Hands ALC), 62% ethanol gel rub (Purell), and antimicrobial soap containing 0.75% triclosan (Kindest Kare).

Results: A total of 56 observations were analyzed for *S marcescens* removal and 70 observations were analyzed for *G stearothermophilus* removal. The rank order of product efficacy for both bacteria and spore removal was antibacterial soap > 65.9% ethanol hand wipes > 62% ethanol hand rub. Mean *S marcescens* log reductions (\pm SD) for the 65.9% ethanol alcohol wipe, 62% ethanol alcohol rub, and antimicrobial foam soap were 3.44 ± 0.847 , 2.32 ± 1.065 , and 4.44 ± 1.018 , respectively ($P < .001$). Mean *G stearothermophilus* log reductions for the 65.9% ethanol wipe, 62% ethanol rub, and antimicrobial foam soap were 0.51 ± 0.26 , -0.8 ± 0.32 increase over baseline, and 1.72 ± 0.62 , respectively ($P < .001$).

Conclusion: The alcohol-based hand wipe containing 65.9% ethanol was significantly more effective than the 62% ethanol rub in reducing the number of viable bacteria and spores on the hands.

Key Words: Hand hygiene; waterless; hand sanitizer; alcohol; antimicrobial.

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INTRODUCTION

The 2002 Centers for Disease Control and Prevention (CDC) guidelines for hand hygiene stated that alcohol-based hand wipes are not as effective as alcohol-based hand rubs.¹ This pronouncement was based on previous

research that used 30% vol/vol alcohol-impregnated wipes, a 50% lower alcohol concentration than contained in currently available alcohol-based hand wipes.² As a result, uncertainty exists regarding the effectiveness of alcohol-based hand sanitizers, specifically the efficacy of wipes versus rubs. In addition, antiseptic hand wipes and antiseptic hand rub preparations are not effective against bacterial spores.¹ Handwashing with soap and water has been shown to be more effective in physically removing spores from the surface of contaminated hands.³

The purpose of this study was to reassess the efficacy of alcohol-based hand wipes and rubs in removing bacteria and spores. We compared a hand wipe with a 65.9% ethanol alcohol content to a gel rub containing 62% ethanol alcohol. The study had two objectives: (1) to determine whether the 65.9% ethanol alcohol hand wipe is equally or more effective than a 62% ethanol alcohol-based hand rub in eliminating bacteria from hands, and (2) to determine whether the ethanol alcohol hand wipe is equally or more

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effective than the ethanol alcohol-based hand rub or soap and water in physically removing spores from the surface of contaminated hands.

METHODS

Seven subjects fulfilled the following requirements before commencing each handwashing exercise: no known compromising illness or disorder; no cuts, burns, or dermatoses visible to the eye on the hands or wrists; no artificial nails; nail length no greater than 2 mm; no rings or other wrist adornments to be worn during testing; no use of medicated soaps, shampoos, strong acids or bases, or antimicrobial products for the 1 week before product testing; no use of topical or systemic antimicrobial agents or any other medication that might affect the microbial flora of the skin for the 1 week before product testing; and no recent body art that required antimicrobial care. In addition, all subjects were instructed in standard handwashing technique and were required to demonstrate proficiency in this technique before initiation of the study.

Inoculum preparation

Serratia marcescens. Preparation of *S marcescens* (ATCC #14756) inoculum included overnight incubation of *S marcescens* in trypticase soy broth at 35-37°C (Remel, Lenexa KS) and dilution with sterile saline solution to yield a 0.5 McFarland suspension (approximately $1.5E + 08$ cfu/mL).⁴ A 5-mL aliquot of the inoculum was applied to each hand per cycle.

Geobacillus stearothermophilus. *G stearothermophilus* (ATCC #7953) was the test organism for evaluation of spore removal from the hands. The use of ProSpore ampoules (Raven Labs, Omaha, NE), containing a viable spore suspension of *G stearothermophilus*, ensured that the nonvegetative form of the bacteria was applied to the hands for product testing. Preparation of hand inoculum included dilution of the ampoule spore suspension with deionized water to yield an approximate spore concentration of $2.0E + 05$ cfu/hand. A 4-mL aliquot of the inoculum was applied to each hand during each cycle.

Study design

The handwashing experiments were performed in accordance with the method cited in the *Federal Register*.⁴ Three hand-cleansing products were chosen to compare efficacy of disinfection: Sani-Hands ALC antimicrobial alcohol gel hand wipes (65.9% ethanol alcohol; PDI, Orangeburg, NY), Purell ethanol alcohol gel hand rub (62% ethanol alcohol; GOJO, Akron, OH), and Kindest Kare antimicrobial foaming hand wash (0.75% triclosan; Steris, Mentor, OH). Subjects washed with each of the 3 products following the

manufacturer's instructions. A standard handwashing technique was used for the antimicrobial soap and water.^{5,6} The product evaluations were separated by at least 1-week intervals.

Product efficacy of bacterial removal was assessed using a 5-mL/hand inoculum of *S marcescens* suspension. Subject testing comprised a baseline cycle, a mechanical degerming cycle, and 10 product usage cycles. Each cycle involved inoculating the subject's hands with 5 mL of the *S marcescens* bacterial suspension, applying the product for bacterial removal, and collecting viable bacteria from the hands via the glove juice recovery method.⁴ The recovery liquid from test cycles 1, 3, 7, and 10 was plated on trypticase soy agar (Remel, Lenexa, KS) and enumerated. Serial dilutions of the recovery liquids were performed using deionized water to guarantee accurate colony counts.

Product efficacy for spore removal was assessed using a 4-mL/hand inoculum of *G stearothermophilus* suspension. Subject testing involved a baseline cycle and 5 product usage cycles. The product testing and plating procedures were similar to those used for *S marcescens*, but with deionized water used for collection fluid instead of glove juice, in accordance with instructions from Raven Labs. (The glove juice contains diphosphates that inhibit *G stearothermophilus* growth.) The recovery liquid from test cycles 1-5 was plated on trypticase soy agar (Remel) and enumerated. Serial dilutions of the recovery liquids were performed using deionized water to guarantee accurate colony counts.

Product usage. One ethanol alcohol gel wipe per washing was used for each test cycle. The wipe was used according to the manufacturer's instructions, with particular attention to the backs of the hands, the areas between the fingers, around the wrist, and under the nails. Each subject used the wipe until he or she was satisfied that all of these areas were covered.

One pump volume of the ethanol alcohol gel product (approximately 0.72 g) per washing was applied to the subject's hands. According to the manufacturer's instructions, the subject was to use a sufficient amount of the product to cover the entire surface of the hands and to massage the product into the hands until the hands felt dry.⁵ The subject's hands had to "feel dry" before continuing with the experiment.

Similarly, one pump volume of the antibacterial foam soap (approximately 1.47 g) per washing was applied to the subject's hands, using a standard handwashing technique that included rubbing the surfaces of the hands together with soap (the fronts, backs, wrists, and nails), rinsing with water, and drying with paper towels. Product usage and drying typically took 30-60 seconds.

Baseline cycle. Nitrile gloves (High Five Products, Chicago IL) were first placed on the subject's hands,

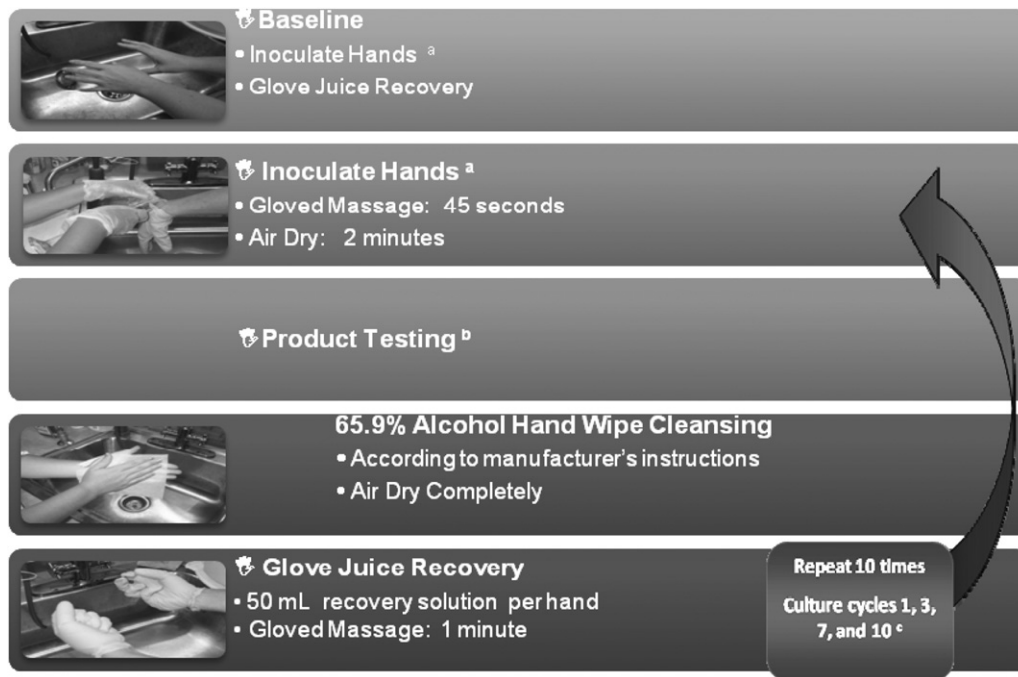


Fig 1. Handwashing method used for product testing. ^aInoculum: 5 mL/hand of $\sim 1.5E + 08$ cfu/mL *S marcescens* suspension and 4 mL/hand of $\sim 2.0E + 05$ cfu/hand *G stearothermophilus* suspension. ^b65.9% ethanol alcohol hand wipe, 62% ethanol alcohol rub, and antimicrobial soap. ^cCulture recovery solution of cycles 1, 3, 7, and 10 for *S marcescens* and cycles 1-5 for *G stearothermophilus*.

and the appropriate amount of inoculum suspension was dispensed into each gloved hand. Rubber bands secured the gloves at each wrist, and the inoculum was spread over the hands for 45 seconds by gently massaging the hands and forming loose fists. The gloves were then removed and discarded, and the hands were air-dried for 2 minutes. The subject then donned another pair of nitrile gloves, and 50 mL of glove juice recovery solution (containing monobasic potassium phosphate, dibasic sodium phosphate, and Triton X-100) was added to each hand. Rubber bands secured the gloves at the wrists, and the recovery solution was spread over the hands for 1 minute by gently massaging the hands and forming loose fists. The gloves were then carefully removed and emptied into a collection container. Collection fluid was serially diluted, and viable bacteria were plated and enumerated. The baseline data were used to calculate bacterial log reduction for each product test cycle.

Product testing cycles. Each product testing cycle consisted of bacterial inoculation and drying as described previously. Once the hands were dry, the subject used a product according to the manufacturer's instructions. The hands were then thoroughly air-dried. Next, viable bacteria were recovered from the hands using the glove juice recovery method as described previously. The product testing cycle was repeated (Fig 1). These product testing cycles measured

each product's efficacy at removing bacteria and spores.

Statistical analysis

Sample size for the evaluation was estimated for equivalence testing with equivalence at $P = .05$ and a power of 0.8, assuming that difference of $<20\%$ [0.6 log] was equal. This identified a sample size of 7 subjects for each test product.

Data were collected and analyzed for 56 handwashings for *S marcescens* and for 70 handwashings for *G stearothermophilus*. Statistical analysis conducted on all data included a two-sample t test with equal variances and mean bacterial log reduction from the baseline over the cycles for each product. Mean bacterial log reduction per product cycle was calculated by subtracting the mean bacteria recovered at each cycle from the mean bacteria recovered at the baseline.

RESULTS

Efficacy of hand hygiene products

S marcescens. The 65.9% ethanol alcohol hand wipe showed a significantly greater log reduction of *S marcescens* than the 62% ethanol alcohol rub ($P < .001$). Specifically, the overall mean bacterial log reduction was 3.44 ± 0.847 for the 65.9% ethanol alcohol

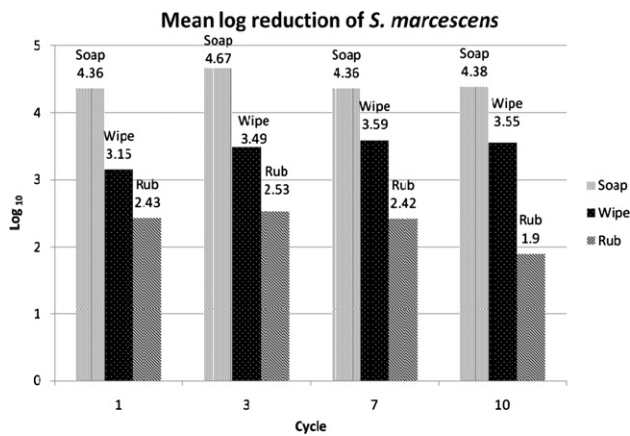


Fig 2. Mean log reduction of *S. marcescens*. At each test cycle, the 65.9% ethanol alcohol wipe was significantly more effective in removing *S. marcescens* compared with the 62% ethanol alcohol rub.

wipe, 2.32 ± 1.065 for the 62% ethanol alcohol rub, and 4.44 ± 1.018 for the antimicrobial foam soap. The rank order of product efficacy was antibacterial soap > 65.9% ethanol alcohol hand wipe > 62% ethanol alcohol hand rub (Fig 2).

***G. stearothersophilus*.** Comparing the alcohol-based products for effectiveness of spore removal, the 65.9% ethanol alcohol hand wipe showed a significantly greater log reduction of *G. stearothersophilus* than the 62% ethanol alcohol rub ($P < .001$). Specifically, the overall mean bacterial spore log reduction was 0.51 ± 0.26 for the 65.9% ethanol alcohol wipe, -0.8 ± 0.32 increase over baseline for the 62% ethanol alcohol rub, and 1.72 ± 0.62 for the antimicrobial foam soap. The rank order of product efficacy was antibacterial soap > 65.9% ethanol alcohol hand wipe > 62% ethanol alcohol hand rub (Fig 3).

DISCUSSION

The importance of hand hygiene in the health care settings is uncontested. Alcohol-based hand sanitizers have been recommended by the CDC for routine decontamination of hands when soap and water are unavailable.¹ In 2002, the CDC stated that alcohol-based hand wipes were not an effective substitute for alcohol-based hand rubs or washing hands with an antimicrobial soap and water.¹ Since then, the ethanol alcohol content of hand wipes has increased from 30% to 65.9%, but the perception persists that the higher-ethanol content wipe is less effective than the gel.

Of the literature reviewed, our study is the first to compare an ethanol wipe with an ethanol rub. The higher-ethanol content wipe (65.9% vol/vol) was more effective than the lower-ethanol content rub (62%) in the removal of vegetative bacteria and spores

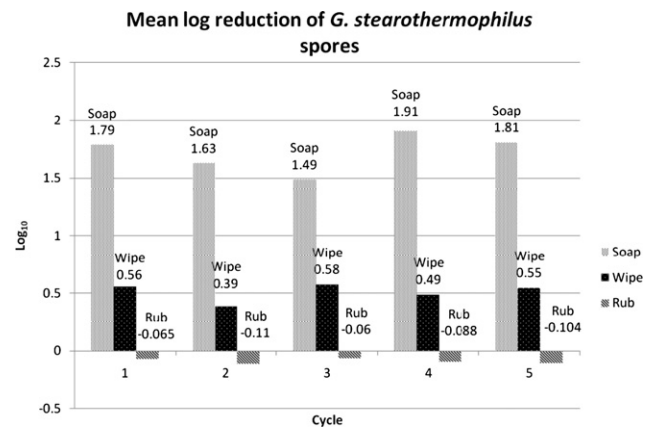


Fig 3. Mean log reduction of *G. stearothersophilus* spores. The 65.9% ethanol alcohol wipes demonstrated significantly greater reduction of *G. stearothersophilus* spores compared with the 62% ethanol alcohol rub across all 5 cycles. Little or no reduction in spore recovery was observed with the rub. Handwashing with soap and water demonstrated the greatest log reduction.

from hands. The rank order of product efficacy for both bacteria and spore removal was antibacterial soap > 65.9% ethanol hand wipe > 62% ethanol hand rub. Specifically, the ethanol wipe demonstrated greater removal of *S. marcescens* from hands (3.44 mean bacterial log reduction) than the ethanol rub (2.32 mean bacterial log reduction). In addition, the ethanol wipe was more effective in removing *G. stearothersophilus* spores from hands (0.51 mean bacterial spore log reduction) than the ethanol rub (-0.8 mean bacterial spore log reduction). Oughton et al³ reported that a hand wipe containing 40% ethanol and 0.5% parachlorometazulenol was more effective than an alcohol rub, but less effective than traditional soap and water, in removing *Clostridium difficile*.³ In addition, Weber et al⁸ also found that a waterless 61% ethanol-based hand rub was ineffective in removing spores compared with a hypochlorite wipe.

The handwipe's superior efficacy in removing vegetative bacteria is attributed to the higher ethanol concentration, whereas its effectiveness in removing spores is due to the mechanical wiping action used during product usage. Kampf et al⁷ reached a similar conclusion about the association between alcohol concentration and vegetative bacteria when they compared 4 ethanol-based hand rubs with alcohol concentrations of 85%, 62%, 61%, and 60%. They found greater bacterial log reduction with increasing ethanol concentration.

Our study has several limitations. We evaluated 7 individuals per organism, for a total of 56 observations for *S. marcescens* and 70 observations for *G.*

stearothermophilus. Although similar previous studies used between 5 and 16 individuals, a larger sample size would enable a more robust calculation and comparison of product effectiveness. In addition, no neutralizing agent was used in the 0.75% triclosan foaming soap collection. Consequently, our data possibly might overstate the effectiveness of the soap. Future studies may include other organisms commonly encountered in health care settings, such as methicillin-resistant *Staphylococcus aureus* (MRSA) and *Escherichia coli*.

In summary, our results demonstrate that an ethanol hand wipe is more effective than an ethanol hand rub, as long as the alcohol content is at least 65.9%. Although the wipes were less effective than antibacterial soap and water, they may be used as an alternative when handwashing is impractical. Use of the wipes reduces the potential for transmission of pathogens due to hand carriage.

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