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Comparative Efficacy of Commercially Available Alcohol-Based Hand rubs and WHO-Recommended Hand rubs: Which Is More Critical, Alcohol Content or Product Formulation?

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ABSTRACT

Background / Objectives

Alcohol-based hand rubs (ABHR) are the primary form of hand hygiene in healthcare settings globally. Alcohol level in many products outside the U.S. tends to be higher than those in the U.S. The formulations provided in the World Health Organization (WHO) Guidelines on Hand Hygiene contain either 80% ethanol or 75% isopropanol. Recent studies have further suggested that foaming alcohol-based products deliver inferior efficacy compared to other product formats (i.e. gels / liquids). The objective of this study was to determine the relative importance of alcohol concentration alone versus product formulation and format as drivers for antimicrobial efficacy.

Methods

Three commercial products were evaluated: two recently introduced novel ABHR, Product A (70% v/v ethanol gel) and Product B (70% v/v ethanol foam); and Product C, an ABHR gel (85% w/w ethanol (90% v/v)). WHO-recommended hand rub formulations were included as benchmarks: WHO-EtOH (80% v/v ethanol) and WHO-IPA (75% v/v isopropanol). Test articles were evaluated on the hands of adult subjects at a 2 ml dose using the Health Care Personnel Handwash (HCPHW) method according to US FDA requirements. Log reductions from baseline were calculated after one and ten product applications. Statistical analysis was conducted using one-way ANOVA (α=0.05).

Results

Log reductions for Products A, B, C, WHO-EtOH, and WHO-IPA were 3.58, 3.55, 3.12, 3.07, and 3.12, respectively after one application; and were 3.50, 4.00, 1.80, 2.39, and 2.04 respectively after the tenth application. After one application Product A was statistically superior to Product C, WHO-EtOH, and WHO-IPA; and Product B was superior to WHO-EtOH ($p<0.05$). After ten applications Products A and B were statistically superior to Product C, WHO-EtOH, and WHO-IPA ($p<0.001$).

Conclusions

Products A and B were the only test articles to meet the FDA HCPHW requirement of a 3 log reduction after the tenth application. Product formulation was found to be the key determinant of product efficacy, as well-formulated 70% ethanol formulations were statistically superior to products with higher alcohol levels. These results demonstrate that alcohol concentrations in excess of 70% are neither necessary nor sufficient for efficacy. Finally, these results demonstrate that product format (foam vs. gel or rub) is not a key determinant of efficacy; when properly formulated, ABHR foams can meet efficacy requirements.

INTRODUCTION

Alcohol-based hand rubs (ABHR) are recommended for use in healthcare settings by the CDC and WHO, and are recognized as one of the most important interventions for the prevention of illness[1-2]. Additionally, numerous studies have demonstrated the clinical effectiveness of these products[3-4]. ABHR are typically evaluated using standard methods, either ASTM standards or European Norms[5-6]. The U.S. FDA specifies using ASTM E 1174, the Health Care Personnel Handwash (HCPHW) Method. Products are required to achieve a minimum of a 2 $\log_{10}$ reduction from baseline after one application and a 3 $\log_{10}$ reduction from baseline after ten applications[6].

The U.S. FDA and others have determined that 60% to 95% ethanol is safe and effective for disinfecting hands[1,2,6]. However, publications have raised questions regarding both the level of alcohol required for ABHR efficacy and the appropriateness of certain product formats[7-9]. These publications speculate that concentrations of at least 75% to 80% ethanol are necessary to meet global efficacy requirements and that gel and foam products are less efficacious than rinses. In addition the WHO guidelines contain recipes for ABHR, that are intended for use as surgical scrubs or routine hand hygiene when commercially available ABHR is inaccessible. The WHO recommended hand rub formulations are based on 75% isopropanol and 80% ethanol[2].

Studies were conducted to determine the influence of alcohol concentration, product format and product formulation on the ability to meet U.S. FDA HCPHW efficacy standards.

MATERIALS AND METHODS

Health Care Personnel Hand Wash (HCPHW) Study

Products A, B, C, WHO-EtOH, and WHO-IPA were evaluated according to the ASTM E 1174 "Standard Test Method for Evaluation of the Effectiveness of Health Care Personnel Handwash Formulations", as described by the U.S. FDA[6]. A neutralization study per ASTM E 1054-08 was performed to ensure the neutralizer employed in this study was effective. Subjects hands were contaminated with *Serratia marcescens* (ATCC #14476). Test product was applied to the hands with a volume of 2 ml, and was rubbed in until dry. A total of 12 subjects were evaluated for each test product for a series of 10 applications, with samples taken after applications 1, 3, 7, and 10. Log_{10} reductions from baseline were calculated and statistical analysis was conducted utilizing an ANOVA (α=0.05). U.S. FDA requires a 2 $\log_{10}$ reduction after the first application and a 3 $\log_{10}$ reduction after the tenth application.

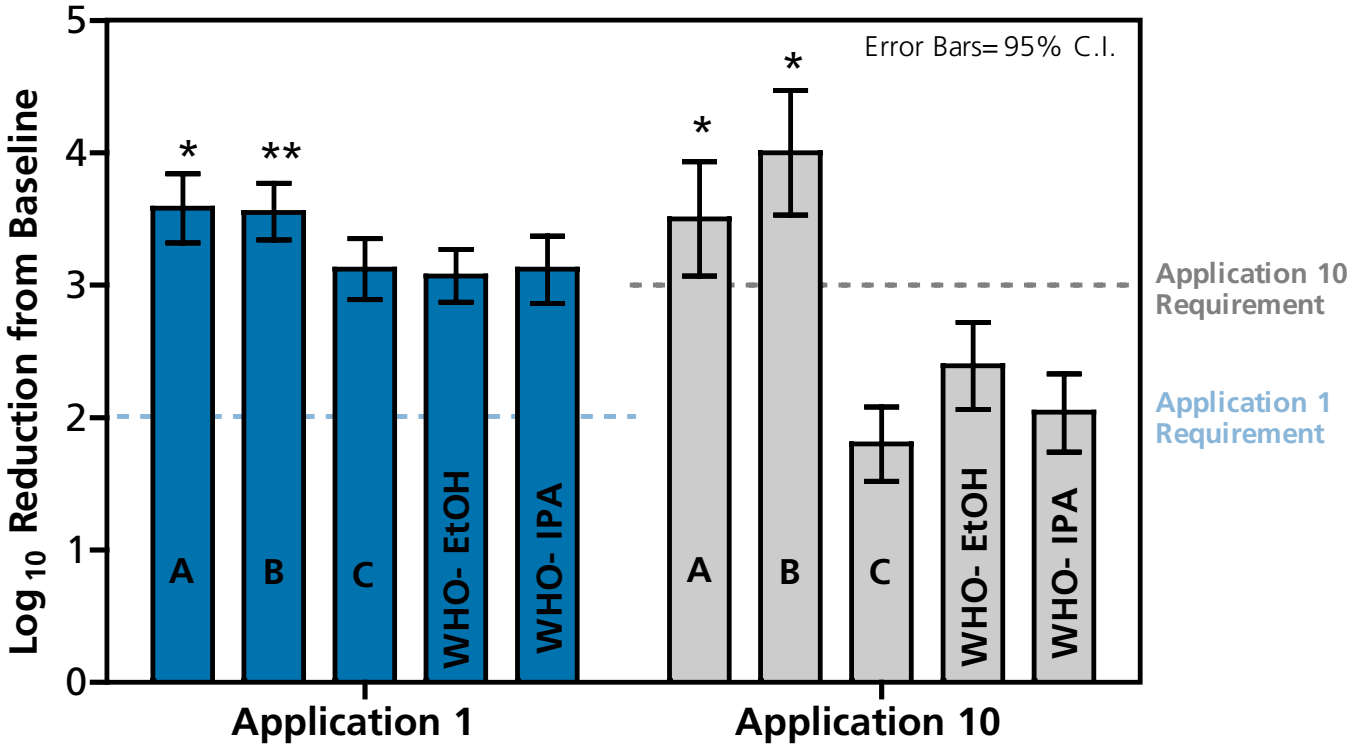
Test Products

Code	Product	Active Ingredient	Manufacturer
A*	PURELL® Advanced Instant Hand Sanitizer	70% ethanol (v/v)	GOJO Industries
B*	PURELL Advanced Instant Hand Sanitizer Foam	70% ethanol (v/v)	GOJO Industries
C	Bode Sterillium Comfort Gel	85% ethanol (w/w); 90% ethanol (v/v)	Bode Chemie Hamburg
WHO-EtOH	WHO-recommended hand rub formulation with ethanol	80% ethanol (v/v)	n/a
WHO-IPA	WHO-recommended hand rub formulation with isopropanol	70% isopropanol (v/v)	n/a

*Products A and B are patent pending formulations that optimize the antimicrobial performance of alcohol without the need for additional antimicrobial ingredients.

RESULTS

Only well formulated, novel 70% ethanol products meet FDA HCPHW requirements



***Indicates statistical superiority to product C, WHO-EtOH, and WHO-IPA**

****Indicates statistical superiority to WHO-EtOH**

When tested with a 2 ml application volume, only the novel 70% ethanol products (A and B) met U.S. FDA HCPHW requirements for a ≥3 log reduction after 10 applications, whereas Product C, WHO-EtOH, and WHO-IPA failed to meet FDA requirements after 10 applications.

SUMMARY

- **Alcohol concentration in excess of 70% is not required for high efficacy:**
  - **Novel 70% ethanol gel and foam ABHR (A and B) met both FDA HCPHW requirements, whereas products containing 75% to 90% alcohol did not meet the application 10 requirement.**
- **Product formulation is a critical determinant of ABHR efficacy:**
  - **Products A and B were statistically superior to Product C, WHO-EtOH, and WHO-IPA, after ten applications, despite having a lower concentration of alcohol.**
  - **With repeated use, Products A and B exhibited an increase in efficacy (whereas the other products decreased in efficacy), highlighting the importance of evaluating products after multiple uses.**
- **Product format does not influence efficacy:**
  - **Products in both gel and foam formats met FDA HCPHW efficacy requirements.**

CONCLUSIONS

- **Formulation matters. Increasing alcohol concentration alone is not sufficient to guarantee efficacy according to FDA standards.**

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