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This is the peer reviewed version of the following article which has been published in final form at <https://doi.org/10.1017/ice.2019.251>.

Martinello, R., Arbogast, J., Guercia, K., Parker, A., & Boyce, J. (2019). Nursing preference for alcohol-based hand rub volume. *Infection Control & Hospital Epidemiology*, 40(11), 1248-1252. doi:10.1017/ice.2019.251

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Nursing Preference for Alcohol-Based Hand Rub Volume

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Short Title: Nursing Preference for ABHR Volume

Key words: hand hygiene; alcohol-based hand rub; hand sanitizer; hand disinfection; health personnel; hand size

Word Count: 2,018

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Abstract

Background: The effectiveness of alcohol-based hand rub (ABHR) is correlated with contact time, which depends on the volume applied. Evidence suggests that there is considerable variation in the amount of ABHR used by health care providers. We sought to identify the volume of ABHR preferred for use by nurses.

Methods: A prospective observation study was performed in 8 units at a single tertiary hospital. Nurses were provided with pocket-sized ABHR bottles with caps to record each bottle opening for hand hygiene (HH). Nurses were instructed to use the volume of ABHR which they felt was best. The average ABHR volume used per HH event was calculated using cap data and changes in bottle mass.

Results: Fifty-three nurses participated and 140 nurse-shifts were analyzed. The average ABHR dose was 1.09 mL. It was greater for non-ICU nurses (1.18 mL) than ICU nurses (0.96 mL), but this difference was not significant. There was no significant association between hand surface area and preferred average dose volume. ABHR dose volume was 0.006 mL less per use as the number of applications per shift increased ($p=0.007$).

Conclusions: The average dose of ABHR used was similar to the dose provided by the hospital's automated dispensers, which deliver 1.1 mL/dose. The volume of ABHR dose was inversely correlated with the number of applications of ABHR per shift and not correlated with hand size. Further research to understand differences and drivers of ABHR volume preferences and whether automated ABHR dosing may create a risk for people with larger hands is warranted.

Introduction

The effectiveness of alcohol-based hand rub (ABHR) is known to be closely correlated with the amount of time it takes for the product to dry on the hands (dry-time), which depends primarily on the volume applied.^{1,2} One recent study found a linear relationship between dry-time and the log reduction of bacteria on hands that was independent of application volume.³ Limited evidence suggests that there is considerable variation in the amount of ABHR that is used per application by health care providers. This variability in volume applied may be due to dispenser malfunction, or more likely, due to user preference.⁴⁻⁶ A recent study found that healthcare professionals (HCPs) frequently applied amounts of ABHR that took less than 5 seconds to less than 15 seconds to dry, also suggesting that the volume of ABHR that HCPs applied was quite variable.⁷ Some healthcare personnel believe that the amount delivered by some dispensers is excessive and takes too long to dry, and as a result, they apply doses lower than those recommended.^{2,5,8} This issue is of concern since it has been suggested that application of small amounts of ABHR may not be sufficient to cover all surfaces of the hands and reduce bacteria on hands to the degree recommended by regulatory agencies.⁹⁻¹² We sought to identify the volume of ABHR preferred for use by nurses.

Methods

A prospective, observational study was conducted in the inpatient setting at a single large academic medical center. Nurses working in eight hospital units, five adult and pediatric inpatient wards and three intensive care units, were invited to participate in the study. All participating nurses were providing hands-on patient care. Nurses who volunteered to

participate were each given pocket-sized, 125mL ABHR bottles with a flip-top electronic memory cap (model, manufacturer) that recorded the number of times the bottle was opened. Nurses were instructed in the safe use of these personal ABHR bottles to prevent cross contamination. The ABHR product used was a commercially-available gel containing 70% ethanol. A similar product is used in the hospital but is dispensed as a foam rather than as a gel. Each unit was observed on 3 separate days. During each shift, nurses were instructed to use ABHR from the electronic-cap bottle for all hand hygiene opportunities where they would normally use ABHR. The electronic cap recorded the number of bottle openings. Nurses were repeatedly instructed to use the volume of ABHR which they felt was best and were blind to the objectives of the study. The investigation was approved by the Yale Human Investigations Committee.

Volume of ABHR used. At the beginning of each shift, each nurse was provided with a new electronic cap bottle containing 125mL ABHR. The bottles were collected at the end of the shift after use. The mass of ABHR used from each bottle was determined by weighing each bottle before and after being used by nurses, and the number of uses was interrogated from the electronic cap at the end of each shift. The volume (mLs) of ABHR used from each bottle was calculated by dividing the mass of ABHR used by the density of the product (0.8698 gm/mL). For each nurse, the average volume of ABHR used per application was calculated by dividing the volume used from each bottle by the number of times the electronic bottle cap had been opened.

Hand size measurement. Participants' hand surface area was estimated using a validated method as an average of both left and right hands.¹³ Hand sizes were classified as either small (≤ 375 cm²), medium (375 – 424 cm²), or large (≥ 425 cm²).¹¹

Survey. A brief, self-administered survey was distributed and collected from all study participants. The survey obtained 9 point Likert-scale responses regarding subject perception of the ABHR and open-ended questions were used to collect participants' thoughts regarding the appropriate volume of ABHR, ABHR drying time and the participants' understanding of the rationale for recommended ABHR volume and use.

Statistical analysis. Linear mixed effects models were used to analyze the dose volumes with a random effect for nurses that accounted for the repeated doses measured on different days from the same nurse; and a second random effect for unit that accounted for the possible correlation among nurses that work in the same hospital unit. Covariates for hand surface area and the number of applications were included. Fixed effects were also included to compare doses between ICUs versus non-ICUs, and to compare doses among small, medium and large hand sizes.

Results

A total of 53 nurses participated in the study, with 5 to 13 nurses from each of 8 hospital units. Two units were ICUs and employed 22 (42%) of the 53 participating nurses. Each nurse participated in the study from 1-3 days for a total of 140 nurse-shifts of ABHR use. Seven nurse-shifts were excluded because the electronic devices used to count ABHR uses malfunctioned. Seventy-four percent of volunteers provided three shifts of ABHR use data. The overall average volume ABHR used was 1.09 mL per application (STD 0.61mL). The middle 95% ranged from 0.19 to 2.34 mL (Figure 1). The average hand surface area was 417 cm² (STD 46 cm²) and 9 (17%), 24 (45%), and 20 (38%)

participants had small, medium, and large hands, respectively. There was a statistically significant negative correlation ($p=0.007$) between dose volume and the number of applications (Figure 2 gives a graphical representation) although the ABHR dose volume decreased by only 0.006 mL ($\pm SD = \pm 0.002$) per use as the number of applications increased (based on a mixed effects regression of dose volume vs number of applications). There was no significant correlation between hand surface area and preferred average dose size in aggregate ($p=0.569$) or when each hand size group was analyzed independently ($p=0.246$) (Figure 3).

The average volume of ABHR per hand hygiene event was greater among non-ICU versus ICU staff, but the difference was not significant (1.18 versus 0.96 mL/application, $p=0.251$). The majority of the variation in ABHR dose volume was shown between nurse subjects and less due to differences between units or within individual subject use across shifts. The variation in the doses was large ($SD = 0.61$ ml/dose) compared to the average dose differences among hospital units. The largest average difference of 0.73 ml/dose was between 2 non-ICU medicine units. The unit using the greatest average volume/dose specializes in the care of patients with infectious diseases. Fifty-six percent of the variability in dose volume was related to nurse-to-nurse differences, 37% was related to day-to-day differences (e.g., differences in the application technique employed by the same nurse on different days), and 6% was related to unit-to-unit differences. There were no statistically significant differences, on the average, among units with respect to either the number of applications ($p = 0.4297$) or hand size ($p = 0.4421$).

Survey results showed that nursing staff were generally not aware that the volume of ABHR used is correlated with the proportion of bacteria killed and were not concerned that if a greater volume of ABHR was used, it would interfere with their duties. The participants were slightly concerned that applying a greater volume of ABHR would impact the condition of their skin. The participants noted that sometimes ABHR takes too long to dry, agreed that cost does not influence their dose, and disagreed that the scent of the ABHR product used at the institution had influence on the preferred volume of ABHR used (Figure 4). Responses from the open-ended questions (data not shown) showed an understanding that the volume of ABHR used should be sufficient to cover both the front and back of the hands to the wrists and an assumption that the standard, touch-free dispensers used throughout the hospital provided an evidence-based amount of ABHR.

Discussion

Given the belief of some nurses that the amount of ABHR routinely delivered by dispensers is excessive and takes too long to dry, there is a need to identify the amount of ABHR per application that meets United States Food and Drug Administration (FDA) criteria for effectiveness and has a dry-time that is acceptable to most healthcare staff. We found that the average dose of ABHR used by nurses (1.09 mL per application) was similar to the dose provided by the hospital's standard touch-free dispensers, which deliver 1.1 mL/dose. The extent to which the automated dispensers used in the hospital influenced nurses' choices on ABHR volume could not be determined by the study design utilized. Of interest, a small study by Leslie et al. involving 19 nurses was

conducted in another hospital where ABHR was routinely obtained from manual, as opposed to automated, dispensers.⁵ The investigators used the same type of bottle with an electronic cap to assess nurses' preferences for the volume of ABHR to apply to hands. On average, the volume of a liquid formulation containing 80% (v/v) ethanol applied by nurses was 0.73 mL (range, 0.27 – 1.61 mL), which was lower than that recommended by the manufacturer. In contrast to our study, the average volume used per application in that study varied significantly among the five participating wards.⁵ Another recent study by Dalziel et al. determined that the median volume of ABHR used in a survey of Scottish hospitals was a median volume of 1.0 ml, similar to findings in the present study.⁶ Of note, the Scottish study used a more indirect method of determining the median volume of ABHR used per hand hygiene event.

Males used somewhat larger volume of ABHR/day than females, as reported in at least one earlier study.¹⁵ Although this may have been related to hand size, frequency of use could not be excluded as an alternate explanation. We found that the amount of ABHR used slightly but significantly decreased as hand hygiene was performed more frequently. This finding supports the use of automated dispensers of ABHR rather than manual pumps to ensure the provision of a proper amount. Our study was not designed to explore the reasons for this. Future assessment of the drivers of ABHR dose should consider hand hygiene frequency and the inverse relationship with dose.

One of the other major findings of our study was that nurses with large hands did not use significantly more ABHR per application than those with small hands. This finding was in alignment with a recent study showing the volume of ABHR selected by HCPs with large hands and those with small hands, from an offering of 1, 2 or 3mL, was

similar.¹² This finding raises the question of whether or not those with large hands were able to apply ABHR to all surfaces of their hands for effective decontamination.

However, whether it is necessary to cover all surfaces of the hands in order to adequately reduce the number of bacteria on the hands has not been established with certainty.^{11,14}

Likewise, the maximum safe level of pathogenic microbes on or transferred by healthcare staff hands also remains uncertain.

Limitations of the study include that the study was conducted in a single large academic medical center in the United States, involved only inpatient units, and enrolled only nurses. We did not assess hand hygiene technique, the degree to which nurses covered all surfaces of their hands, or antimicrobial efficacy and the survey was not tested to determine its reliability or validity. Finally, we were not able to assess time as a variable as the electronic caps solely recorded bottle openings and only assessed HH performed using ABHR from the special bottle. Therefore, we were unable to measure the density of HH or episodes of HH where soap and water was used, the distribution of hand hygiene episodes over the shifts, or how these variables may have affected the volume of ABHR used.

Conclusions

Our findings suggest that there is substantial variability among nurses in the volume of ABHR used per application. Of concern, we found no correlation between hand surface area and preferred volume of ABHR applied. The volume of ABHR dose preferred was shown to be inversely correlated with the number of applications of ABHR per shift on most units. Further research to understand differences and drivers between wards (e.g.

ICUs compared with non-ICUs) and factors that influence nurses' hand hygiene behaviors and preferred volume of ABHR is needed. Based on earlier studies and our findings, the preferred ABHR dose volume may or may not be sufficient to provide appropriate reduction of bacteria on hands, depending in part on the product formulation used.^{11,16} These findings should contribute to future considerations for product formulation and the design of automated dispensers of ABHR.

Acknowledgements. We thank the nurses who participated in this project, and Yale New Haven Hospital nurses and Nursing leadership for their support. We would also like to thank GOJO technical personnel Dave Macinga and Rachel Leslie for their input on study design and Jackson Wegelin for engineering the bottle with counting cap.

Financial support. ABHR, electronic cap bottles and other materials necessary for the study were provided by GOJO Industries, Inc.

Conflict of interest. JMB is a consultant to Diversey, Global Life Technologies and GOJO Industries, and has received honorarium from Sodexo Healthcare. JMB has also received travel support from Diversey and GOJO Industries.

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FIGURES

Figure 1. Frequency histogram of the average ABHR dose by nursing shift

Figure 2. Dose volume as a function of the number of ABHR uses per nursing shift

Figure 3. Dose as a function of the nurse participants' hand surface area (cm²). Hand size is classified as small (≤ 375 cm²), medium (375 – 424 cm²), or large (≥ 425 cm²). The line represents the correlation between average dose and hand size by hand surface area strata.

Figure 4. Box-and-whisker plots illustrating the nurses Likert scale responses where the bar shows the range, the box shows the inter-quartile range, and the vertical mark inside the box shows the median.