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Major Article

Product dose considerations for real-world hand sanitiser efficacy

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Background: Alcohol based hand rubs (ABHR) are extremely effective at reducing microbial contamination and have an essential role in best practice hand hygiene described by the World Health Organization.

Methods: We determined ABHR drying time when performing hand hygiene in a laboratory setting. Which was followed by identifying the amount of ABHR needed for complete hand coverage. When the aforementioned was analyzed real-time data were gathered to examine the amount used for hand hygiene in a hospital setting. In parallel hands of healthcare workers (HCWs) were monitored for drying time and perception on ABHR use.

Results: In 86% (24,446,397/28,280,383) of the events a single dose of ABHR was used on clinical wards. Twenty-four HCWs expected hand hygiene to take 7.5 seconds (median; range 3-30 seconds). Forty-three HCWs show that 1.5 mL ABHR dose achieves the desired drying time according to World Health Organization guidelines (av. median 26 seconds), but is consistently perceived to have a longer drying time than expected (av. median 18 seconds). In-vivo results (n = 10) indicate that 2.25 mL ABHR is required for adequate coverage (82%-90%) of both sides of the hand.

Conclusions: Results indicate that set standards for the use of ABHR do not match "in-vivo" behaviour of HCWs. Perceived drying times are shorter than actual drying time. The needed drying time to reach acceptable antimicrobial efficacy of ABHRs should be revisited.

Use of alcohol based hand rub (ABHR) is believed to be the most (cost-)effective method to reduce microbiological contamination on hands of healthcare workers (HCWs) and consequent health care acquired infections.[1-5] It is estimated that nurses have an average of 55-74 hand hygiene opportunities a day, with >90% of those moments needing hand disinfection rather than handwashing.[4,5]

Much research has been directed at improving hand hygiene compliance in health care settings. In addition, for hand hygiene to be successful, other factors are important such as the tolerability and acceptability of ABHRs, as well as the correct technique in applying these products at an effective dose. With regard to the latter, the actual use of ABHRs in health care settings frequently differs from the laboratory methods used to evaluate and licence the products.[6]

We undertook a series of studies aimed at gaining a better understanding of the optimal dose of ABHR for use in health care settings.

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IRB/ethics committee: No medical ethics review was required because using alcohol based hand rub is common practice for hand hygiene and available throughout the hospital. Participants took part in the study on a voluntary base and consented to participate. The study was exempted from IRB.

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Table 1
Summary of testing sites and brief methods

Type of test	Location (s)	Brief methods
ABHR drying time as function of dose	CWH, Nijmegen, NL	Drying time of different volumes of ABHR were examined in a laboratory setting.
Establishing hand coverage for ABHRs	CWH, Nijmegen, NL RDH, Birmingham, UK	HCWs were asked to disinfect their hands with 4 different volumes.
Dispenser usage	CWH, Nijmegen, NL MSH, Toronto Ontario, CA	A system was installed to measure the events of hand hygiene in 2 hospitals.
Real-world user evaluation of ABHR	GMH, Greenville, United States RDH, Birmingham, UK	Evaluation of drying time and user perceptions was carried out with 2 volumes.

ABHR, alcohol based hand rub; *CA*, Canada; *CWH*, Canisius Wilhelmina Hospital; *HCWs*, Healthcare workers; *MSH*, Mount Sinai Hospital; *NL*, the Netherlands; RDH, Royal Derby Hospital; *UK*, United Kingdom.

METHODS

This project included 4 components: (1) establishing ABHR drying time as function of dose; (2) establishing hand coverage for ABHRs; (3) dispenser usage; and (4) real-world evaluation of ABHR use. The data of this study consist of consolidated data from various testing sites (see Table 1).

Laboratory evaluation of ABHR drying time as function of dose

HCWs were recruited via email that was sent by the infection control expert. The HCWs were asked to participate on voluntary basis and asked to reply to the email if they would like to participate in the study. Nine HCWs, 3 males and 6 females, of Canisius-Wilhelmina Hospital (CWH), Nijmegen, the Netherlands agreed to participate. Through this mixture, we hoped to mimic a reflection of the actual distribution of sex and hand-sizes of HCWs in the clinical setting. The HCWs were trained to the World Health Organization (WHO) hand hygiene method[7] by an infection control expert. Measured volumes (0.75 mL, 1.5 mL, 2.25 mL, and 3 mL) of the same formulation (Deb InstantFoam, 65% ethanol, and 10% n-propanol alcohol) in liquid, gel, and foam form were placed in the palm of one hand to examine drying time. The study took place over a time period of 2 weeks and all tests were performed in duplicate. The products were randomized and all 3 forms were tested per person per day. There was at least a 24-hour break in-between testing using the same person. The HCWs were observed and timed by the infection control expert while using the products. Drying time was recorded as the time when each HCW reported that their hands felt dry.

Establishing hand coverage for ABHRs

Ten HCWs from CWH and Royal Derby Hospital (RDH), Birmingham, United Kingdom were recruited. The HCWs were recruited via e-mail of the local infection control teams. When HCWs agreed to participate they were trained to the WHO hand hygiene method[7] by the local infection control team. After training, they were asked to apply measured doses of ABHR in gel and foam format at 4 different volumes: 0.75 mL, 1.5 mL, 2.25 mL, and 3 mL. The ABHR products were mixed with a 2% concentration UV marker (Visirub) to enable hand coverage assessment via image analysis. Once the HCWs completed ABHR application according to WHO guidelines, hands were photographed under a standard UV light source to assess coverage. The images were analysed by 2 blinded investigators to estimate coverage. Scanning Probe Image Processor image analysis software was used to analyze the percentage of the hands covered by ABHR. To ensure consistency the same protocol was followed on both study sites.

Dispenser usage

ABHR dispensers were fitted with an electronic sensing and data communication system (DebMed GMS Hand Hygiene Monitoring System). By sensing each button press using a magnetic switch and by detecting each usage event, the system is capable of determining the number of button presses and hence ABHR dosage per hand hygiene event. For this element of the study, we collated anonymous system-wide data from CWH, and from Mount Sinai Hospital (MSH), Toronto Ontario, Canada. Deb wall-mounted ABHR dispensers were used with Deb foam providing 1.5 mL per button press in CWH and 0.75 mL per button press in Greenville Memorial Hospital (GMH) and MSH. In both institutions, hand hygiene education for HCW was to WHO guidelines including recommended 20-30 drying time.

Real-world user evaluation of ABHRs

Two evaluations of drying time and user perceptions were carried out at health care facilities in GMH, Greenville, United States (n = 19) and RDH in the United Kingdom (n = 24). Locations in the United States and United Kingdom were selected to understand any attitudinal differences. GMH and RDH were selected as suitable locations using the same formulation for daily hygiene as that presented in the study and of sufficient size to provide participant cohorts without undue inconvenience. The infection control teams of both hospitals recruited participants through emails, asking HSCs to voluntary participate in the study. The recruited volunteers were asked to use ABHR products in foam format dispensed in 2 pump sizes: 0.75 mL and 1.5 mL. Participants were first asked their expectation of drying time in seconds for ABHR, then asked to estimate the drying time of the product they were using. Actual drying time was recorded in parallel with a timer. At the end of the test, participants from the United Kingdom were asked for their perceptions of the volume used; too little, about right, or too much. To ensure consistency in both test locations a protocol was provided and followed.

RESULTS

Laboratory evaluation of ABHR drying time as function of dose

Results of the CWH study on ABHR drying time as function of dose are shown in Figure 1. In general, drying time was shorter for the gel form and longer for the foam. Data from the 9 volunteers (n = 18) show that 0.75 mL foam, 0.75 mL liquid, 1.5 mL foam, 1.5 mL gel, and 2.25 mL gel have a perceived drying time within the WHO recommended 20-30 seconds drying time for ABHRs.[7] For none of the used product forms the perceived drying time was within 30 seconds when using 3 mL of the product, but ranged from 37 seconds (gels) to 56 seconds (foams).

Establishing hand coverage for ABHRs

The results on average hand coverage from the volunteers (n = 10) at CWH and RDH is presented in Figure 2. When using 0.75 mL of ABHR the coverage is very low; foam covering 49% and gel covering 47% on average. When using 1.5 mL ABHR the coverage of the palms

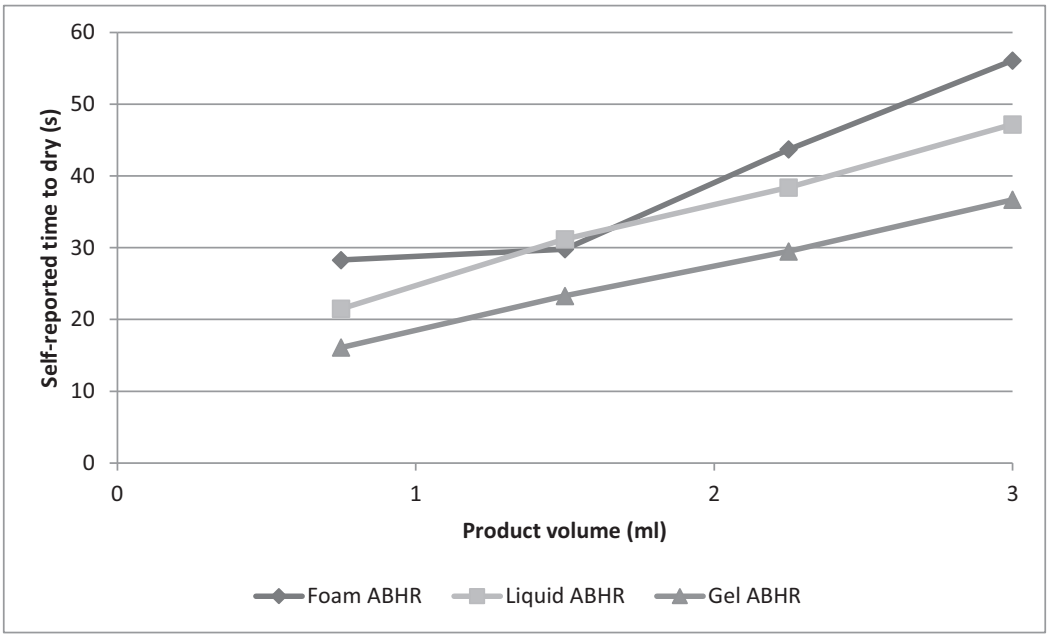

Fig 1. Laboratory evaluation of alcohol based hand rub drying time as a function of volume and format.

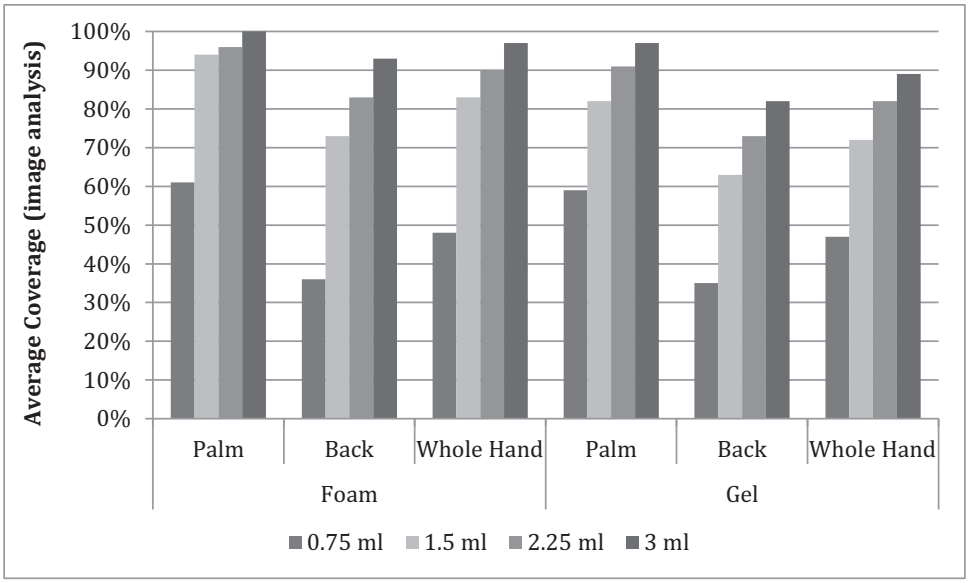

Fig 2. Hand coverage as a function of product dose.

and fingers is achieved more readily (foam covering 84% and gel covering 73%) than for the back of the hands (foam covering 73% and gel covering 63%). At least 2.25 mL ABHR is required for the optimal coverage of both the front and back of the hand, foam covering 90% and gel 82%.

Dispenser usage

Table 2 shows system-wide DebMed GMS data, totalling 28,280,383 events taking place at CWH and MSH. In 86% (24,446,397/28,280,383) of events a single dose of ABHR was used. At CWH, where 1,5 mL was dispensed 93% (261,896/282,223) a single dose was used. MSH where dispensers gave 0,75 mL per dose 86% (24,184,501/27,998,160) of the events were single dosed by HCWs.

Real-world user evaluation of ABHRs

HCWs from RDH (n = 24) expected hand hygiene to take 7.5 seconds (median; with a range from 3 to 30 seconds). The perceived time performing hand hygiene using 1.5 mL of ABHR foam was 15 seconds (median; with a range from 3 to 60 seconds), and an actual time of 25.5 seconds (median; range from 10 to 45 seconds).

The HCWs from the GMH in the United States (n = 19) expected hand hygiene with the amount of 1.5 mL to take 10 seconds (median; with a range from 5 to 25 seconds), the perceived time when hand hygiene was performed was 21.7 seconds (median; with a range from 10 to 45 seconds) and the actual time to disinfect hands was 27 seconds (median; with a range of 20-65 seconds).

Table 2
The number of doses per hand hygiene event

Doses per event	No. of events NL	Total %	No. of events CA	Total %
1	261,896	92.8	24,184,501	89.6
2	16,758	5.9	3,359,494	8.7
3 or more	3,569	1.3	454,165	1.7

In both settings 1.5 mL ABHR dose achieves the actual drying time according to WHO guidelines (n = 43). In both studies perceived and actual drying time are moderately correlated ($R^2 = 0.51$, consolidated).

When the RDH in the United Kingdom (n = 24) used 0.75 mL of ABHR the perceived time was 10 seconds (median; with a range from 3 to 20 seconds) and the actual time was 12 seconds (median; with a range of 8-20 seconds).

HCWs at RDH in the United Kingdom (n = 24), when their opinion was asked on the volume, 0.75 mL dose as "just right" (84%) while rating the 1.5 mL dose as "too much" (80%). Only 16% of the HCWs found 0.75 mL "too little" and 20% found that 1.5 mL was "just right".

DISCUSSION

While compliance with hand hygiene has received a lot of attention over the past decade, less effort has been directed to adequate technique or required volume. International norms (NEN) recommend the use of 3 mL ABHR which in our study was considered too much for many hands.[8] The WHO tried to correlate the needed volume with the hand-size by recommending to fill up the palm of your hand with alcohol, but resulting volumes and effect of hand coverage were not measured.[9] In this study we aimed to address key questions about dose control, wetting and coverage characteristics of ABHR.

HCWs in the United States and United Kingdom expect hand sanitizing to be a rapid event, on average lower than 20 seconds. They described 1.5 mL of ABHR as "too much." While ABHR's are a faster and better alternative than hand-washing in the busy hospital setting,[10] users must be aware of the volume and dry time that are required to provide sufficient coverage of hands and antimicrobial efficacy.[11,12] Our Dutch and Canadian testing site indicated that more than 86% of users used a single pump of product, whether it is set at 0.75 mL or 1.5 mL. Dispensers should be designed to provide the desired volume of ABHR in a single pump, in line with WHO recommendations.[11] Suchomel et al suggests customising the dose needed to each individual, however this might be difficult to implement in health care settings.[13]

Our results demonstrate that the recommended 20-30 seconds of drying time[11] in controlled and real-world settings is achieved with volumes of 1.5-2.25 mL ABHR. For the gel form of ABHR, 1.5 mL of product was not sufficient to cover over 80% of the hand surface, whereas it was possible with 1,5 mL of foam. While it seems logical to ask for 100% coverage, even with 2.25 and 3 mL of product a full (100%) coverage was not achieved in all cases. Based on the data, we would recommend a minimum of 2.25 mL for gels ABHR and 1.5 mL for products in foam form. As higher product volumes lead to an increased drying time, the ideal volume to use would be according to hand-size of the individual HCW. While the attempt of WHO to correlate volume and hand-size by recommending "a palm-full" of product, optimal hand hygiene might only be achieved if we have intelligent dispensers, recognizing the HCW in question and delivering the perfect amount of volume, based on the product form used.

In addition, as higher volumes of ABHR are needed to achieve maximum hand coverage, expectations of HCWs with regard to drying times of <30 seconds need to be adjusted. While the efficacy of different application methods (gel, foam and liquid) with regard to microbial load reduction showed no significant differences in an in-vivo study,[14] drying time and hand coverage did. Depending on the form of ABHR used a >80% coverage in less than 30 seconds should be aimed at.

The objective at the outset was to identify an "optimal" dose meeting all requirements. While this remains our aim, we were faced with some challenges and potentially the recognition that in reality there is no readily acceptable optimum. In health care facilities today, the effectiveness of many hand hygiene events is lower than understood because users self-titrate the dose to "acceptable" drying times of less than or equal to 15 seconds. It is unknown what antimicrobial efficacy is needed to reduce hospital acquired infection effectively. The acceptable duration of a hand hygiene moment for HCWs seems to be 15-20 seconds. Formulation changes might have an impact on the duration needed for a hand hygiene moment, for example increasing the alcohol concentration. Currently through education and training aligned to properly metered products, we must re-establish that proper hand hygiene takes 20-30 seconds to complete.

CONCLUSIONS

In conclusion, our results indicate that modifying the dispenser volume to achieve 20-30 seconds of drying time as per WHO recommendations, may result in volumes that are perceived as "too much" by HCWs. In part this expectation may have been driven by prevailing small pump sizes. It may therefore be overcome once correct pump volumes are deployed. The needed drying time to reach acceptable antimicrobial efficacy of ABHRs should be revisited. Furthermore, research to investigate needed efficacy in relation to reducing health care acquired infections is needed.

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