Estimating the volume of alcohol-based hand rub required for a hand hygiene program

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Background: Providing alcohol-based hand rub (ABHR) at the point of care is a key success factor in enabling health care providers to achieve optimal hand hygiene practices. There are few tools available for health care organizations to assess the number of points of care, estimate the number of hand hygiene indications at each point of care, and estimate the anticipated volume of ABHR required to support a hand hygiene program.

Methods: We developed an assessment tool to systematically evaluate the environmental hand hygiene needs in diverse care settings across a multisite health care organization.

Results: We identified 1,103 points of care in 34 clinical units, of which only 53% had ABHR at point of care. There are an estimated 171,468,240 (95% confidence interval: 146,844,406-191,871,179) hand hygiene indications per year in our in-patient and emergency areas. If 100% compliance with hand hygiene is achieved, 240,056 L of ABHR will be required each year.

Conclusions: Our environmental assessment was invaluable in estimating the number of hand hygiene indications by unit and the logistical and financial requirements to implement a hand hygiene program. Other health care organizations may find this a useful framework to estimate their own environmental hand hygiene needs.

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identify the number and location of the points of care throughout our hospital and determine the availability of ABHR at each identified point of care.

Setting

This study was conducted at The Ottawa Hospital (TOH), the sole tertiary adult care referral center for Eastern Ontario, serving a population of 1.2 million people. At the time of this study (calendar year 2008), TOH was a 1,172-bed hospital with 126,850 emergency department visits, 46,426 admissions, and an annual operating budget of $1.080 billion (Canadian). TOH includes 2 in-patient acute care sites, a cardiac care center, an ambulatory care center, a rehabilitation center, and a regional cancer center. This study involved 1,023 beds and 40,476 patient admissions in 2008 because the cardiac center and ambulatory care settings were not included.

Definitions and assumptions

Patient environment was defined as the immediate space around a patient that may be touched by the patient and may also be touched by the health care worker when providing care. Health care environment was defined as the care environment (eg, medical equipment, staff) of a hospital, clinic, or ambulatory setting outside the patient environment. Point of care was defined as any place where the following 3 elements occur together: the patient, the health care provider, and care or treatment involving patient contact. ABHR was considered to be at point of care if it was available within an arm’s reach or without the provider leaving the patient’s environment. This was almost always the patient’s bedside, treatment table or chair. A hand hygiene indication was defined as a point in a patient care activity during which hand hygiene is considered necessary. These are (1) before initial patient or patient environment contact, (2) before an aseptic procedure, (3) after body fluid exposure risk, or (4) after patient or patient environment contact. The term portal entry system describes the method of placing ABHR dispensers on the right-hand side of doorways into patient rooms. The hospital occupancy rate was calculated as the total number of patients in residence as of midnight each day, divided by the total number of patient beds.

We made several assumptions to estimate the number of hand hygiene indications, and the volume of ABHR required at each point of care. We assumed our hospital occupancy rate to be 100% at all times, consistent with our median occupancy rates over the past 5 years. Based on observer audits and the literature, we assumed that 80% of hand hygiene indications would involve the use of ABHR and 20% the use of soap and water and that only ABHR was available, not soap and paper towel use, would increase after the implementation of a hand hygiene program. Finally, we assumed that health care providers would action 1 "pump" or application per hand hygiene indication and that each "pump" would yield 1.4 mL of product, as per supplier’s estimates which we verified on-site. In measuring the ABHR volume of 351 pumps from 16 different dispensers in different areas by different personnel, the mean volume dispensed per pump was 1.4 mL (range, 1.2-1.5 mL).

Methods

The methods involved 4 key steps: (1) developing an assessment tool to conduct an environmental scan, (2) identifying all points of care within the patient environment and assessing the current availability of ABHR at each point of care, (3) estimating the number of hand hygiene indications in each in-patient and emergency unit and at each point of care, and (4) developing a formula to calculate the volume of ABHR required.

Step 1: developing an assessment tool to conduct an environmental scan

An environmental tool was developed to assess the number of points of care within the patient environment, the location of each point of care, and the availability of ABHR at each point of care. Guiding principles used in the environmental scan included the definition of point of care, the key hand hygiene indications, the distinction between the patient environment and the health care environment, and the effectiveness of ABHR as the preferred method to clean hands in an acute care setting. The most suitable place to provide ABHR at the point of care is the care environment. Information collected included the hospital site, name and type of patient care area, number and types of points of care, number of points of care where ABHR was not accessible, current accessibility of hand hygiene stations (including sinks, wall mounted ABHR dispensers, and free-standing ABHR bottles), and suggestions for improving access to ABHR at point of care (eg, location, the feasibility of placing wall-mounted ABHR dispensers, and any unique requirements for that area).

Step 2: identifying points of care and availability of ABHR at each point of care

Hospital administrative records were used to identify the number and location of patient beds on each inpatient and emergency unit. A multidisciplinary team, including the hand hygiene coordinator, infection control, occupational health and safety, and facilities management and nursing, visited each in-patient and emergency unit with the environmental assessment tool to identify all points of care and determine whether or not ABHR was available at each point of care.

Step 3: estimating the number of hand hygiene indications

We estimated the number of hand hygiene indications in a 24-hour period for each point of care from the results of hand hygiene audits and front-line staff interviews. Hand hygiene audits were conducted by trained auditors over 20-minute observation periods, distributed over the 24 hours of the day, and included all types of health care workers. We conducted random interviews of front-line nurses between the hours of 8 AM and 5 PM. The coordinator explained the 4 hand hygiene indications and asked staff to estimate how many times in 1 hour each patient is touched by all health care providers, including physicians and support workers (eg, patient transporters).

Step 4: estimating the required volume of ABHR

The estimated volume of ABHR required per year to support a hand hygiene program was calculated based on the number of hand hygiene indications identified in step 3, using a formula modified from the World Health Organization, as follows:

Total volume (liters) = number of points of care × estimated number of hand hygiene indications per hour at each point of care × 24 hours × 365 days × 0.0014 L of product used per indication × occupancy rate.

For example, to calculate the total volume of ABHR in 1 of our critical care units: Number of points of care on the unit (25) × estimated number of hand hygiene indications per hour at each point of care (30) × 24 hours × 365 days × 0.0014 L of product used per indication × occupancy rate (1) = 9,198 L required per year at 100% occupancy.

To assess the robustness of our estimates, a 1-way sensitivity analysis was conducted to assess the impact that changes in individual parameters would have on the outcome, assuming all other variables remain constant. The following key parameters were changed across the whole range of possible values observed in the literature and from our organization: (1) number of points of care, (2) number of hand hygiene indications at each point of care in
The number of points of care in our organization varied from 942 to 1,023 because of bed closures for holiday periods or construction. The range of possible hand hygiene indications observed in the literature for each clinical area is shown in Table 1. The possible range of hand hygiene indications for in-patient units as reported in the literature accounted for the largest variations in this analysis.

**RESULTS**

The assessment tool was used to conduct an environmental scan in 34 in-patient and emergency care units across three sites. We identified 1,103 points of care, including at patient bedsides, in isolation rooms, open treatment and assessment areas, and in in-patient rehabilitation areas (Table 2). Of the 1,103 points of care, 53% had ABHR at point of care. Although purchasing records showed that our facility had installed 3,850 wall-mounted ABHR dispensers throughout the organization, many were located according to the portal entry system and were not at point of care. To provide ABHR at each point of care, an additional 520 wall-mounted dispensers were required.

The number of hand hygiene indications from hand hygiene audits, front-line staff interviews, and previously published studies are presented in Tables 1 and 3. Clinical units were categorized based on similar numbers of hand hygiene indications as follows: (1) critical care units, (2) in-patient rehabilitation units, (3) all other in-patient units, and (4) emergency departments. Services providing care to patients with higher acuity illnesses tended to have more hand hygiene indications per hour (Table 3).

We identified an estimated 171,468,240 hand hygiene indications per year in the in-patient and emergency units of our organization (Table 2). To provide ABHR at point of care requires an estimate of 240,056 L of ABHR product per year, with a median of 171,486,240 (95% confidence interval: 146,844,406-191,871,179). The total estimated volume of ABHR required ranged from 124,558 to 355,553 L per year, with a median of 237,976 (95% confidence interval: 202,778-267,400) L per year. The median was slightly lower than our point estimate of 240,056 L per year. As expected, the wide range of hand hygiene indications for in-patient units as reported in the literature accounted for the largest variations in this analysis.

**DISCUSSION**

An environmental assessment tool facilitated the systematic evaluation of hand hygiene needs across a multisite health care organization. We were able to estimate the volume of ABHR required to supply point of care ABHR for each individual unit. This method can be used to calculate required ABHR volumes for different numbers of points of care, hand hygiene indications per hour, volume of product used per indication, and occupancy rates. There are few other studies to assist health care organizations in estimating the resources required to implement point of care ABHR to support a hand hygiene program.

The World Health Organization provides one of the few tools available to calculate the amount of ABHR required. This tool, based on the number of health care workers, the number of hours per shift per health care worker per day, and the number of working days per month, presented a challenge for our large health care organization because of variability in staffing levels. Staffing levels vary by type of health care workers (eg, physicians, nurses, trainees, allied health care workers, patient transportation, environmental services), all of whom work different numbers of hours per shift, and by the transient nature of some workers (eg, medical and nursing students, casual staff, and contract workers). Furthermore, hand hygiene indications are driven by patient care needs, not by the number of health care workers. Therefore, we modified the tool to base our ABHR volume requirements on the number of points of care. This also allowed us to calculate unit-specific requirements because many health care workers move from unit to unit, whereas points of care remain fixed.

Although ABHR has been available in our organization for nearly 10 years, our environmental assessment found an insufficient number of dispensers, suboptimal placement of existing dispensers, and widespread reliance on free-standing ABHR bottles, which could rarely be found at point of care. Emphasis on the importance of ABHR at point of care is relatively recent. In the past, health care facilities often placed dispensers in hallways as a way to enhance

### Table 1

<table>
<thead>
<tr>
<th>Clinical setting</th>
<th>Number of hand hygiene opportunities</th>
<th>Observation time</th>
<th>Average number of indications per hour</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital wide</td>
<td>2,834</td>
<td>105 Hours</td>
<td>26.9</td>
<td>Pittet et al. Ann Int Med 1999</td>
</tr>
<tr>
<td>Hospital wide</td>
<td>20,082</td>
<td>2,629 20-Min periods</td>
<td>22.9</td>
<td>Pittet et al. Lancet 2000</td>
</tr>
<tr>
<td>Hospital wide</td>
<td>6,948</td>
<td>1,353 1-Hour periods</td>
<td>5.1</td>
<td>Trick et al. Infect Control Hosp Epidemiol 2007</td>
</tr>
<tr>
<td>Intensive care</td>
<td>On average, 350 contacts per patient per 24-hour period</td>
<td>598 (not including before patient contact)</td>
<td>14.6</td>
<td>McArdle et al J Hosp Infect 2006</td>
</tr>
<tr>
<td>Intensive care</td>
<td>3,678</td>
<td>300 Hours</td>
<td>12.2</td>
<td>Rupp et al. Infect Control Hosp Epidemiol 2006</td>
</tr>
<tr>
<td>Intensive care</td>
<td>1,575</td>
<td>120 Hours</td>
<td>13.1</td>
<td>Bischoff et al. Arch Int Med 2009</td>
</tr>
<tr>
<td>Neonatal intensive care</td>
<td>314</td>
<td>20 Hours</td>
<td>15.7</td>
<td>Creedon et al. J Adv Nurs 2005</td>
</tr>
<tr>
<td>Pediatric emergency</td>
<td>5,568</td>
<td>306 Hours</td>
<td>18.2</td>
<td>Larson et al. Am J Crit Care 2005</td>
</tr>
<tr>
<td>department</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rehabilitation center</td>
<td>952</td>
<td>38 Hours</td>
<td>25.0</td>
<td>Girou et al. Infect Control Hosp Epidemiol 2006</td>
</tr>
<tr>
<td>Post-anesthesia care unit</td>
<td>1,091 High- or medium-risk indications</td>
<td>39 Hours</td>
<td>28.0</td>
<td>Pittet et al. Anesthesiology 2003</td>
</tr>
</tbody>
</table>

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general hand cleanliness or in areas where installation of sinks was otherwise impractical or inaccessible. In an effort to standardize placement, one earlier approach was to use the portal entry system to encourage hand hygiene on entering and exiting the patient room. However, 2 studies found no change in hand hygiene rates after installing ABHR according to the portal entry system.\(^{15,16}\) In our organization, approximately half of all ABHR dispensers were installed according to the portal entry system. Among acute care facilities in our region, only 23% of all ABHR dispensers were located at point of care.\(^{15}\) Similarly, Suresh et al found that only 33% of ABHR dispensers were within easy reach of bedside, and only 35% had unobstructed access.\(^{16}\)

The main limitation of this study is the uncertain accuracy of front-line health care providers in estimating the number of hand hygiene indications. Interviews were conducted with nursing staff and in the day time only; workflow patterns were not independently observed to verify interview responses. However, our estimates were verified by hand hygiene audits of all health care workers over 24-hour periods and were comparable with the number of indications in previously published studies, although methodologic differences limit direct comparison. Our estimates will be further verified after implementing a full-scale hand hygiene program with auditing on each unit to confirm total usage and cost in each area. Second, our tool provides a daily average of ABHR volume requirements at the unit level. We recognize that hand hygiene indications will vary from hour to hour and at different points of care. Finally, this is a single center study; additional research is needed to assess the generalizability of these findings to other centers.

Our assumptions may have led to an underestimate of the true ABHR requirements. We assumed no increase in soap or paper towel use because our previous pilot study,\(^{17}\) as well as experience in other centers, found that soap and paper towel use decreased after introduction of ABHR.\(^{2,8,15}\) although the UK National Health Service noted an increase in soap use 3 years after the launch of their hand hygiene campaign.\(^{20}\) For calculation purposes, we assumed 1 pump per indication, which may underestimate the volume of ABHR required because multiple pumps may be required, depending on hand size and type of dispenser. We focused on points of care within the patient environment where the majority of care is provided; thus, we did not account for hand hygiene indications in other areas within the health care environment (eg, shower rooms, kitchens). Finally, we did not account for wastage because wall-mounted units may be changed before they are completely empty, and free-standing or pocket-sized units may be lost or prematurely replaced. The World Health Organization recommends factoring in a 10% allowance for wastage when determining ABHR volume requirements.\(^{19}\)

In summary, we found a systematic environmental assessment to be invaluable in planning the implementation of a hand hygiene program and identifying the administrative requirement required for ABHR at point of care. These steps have been identified as crucial to the success of a hand hygiene program,\(^{1,4}\) but few resources are available to enable health care organizations to conduct an environmental assessment, estimate the number of hand hygiene indications that represent an improved level of compliance, and plan accordingly. Given the lack of currently available environmental assessment tools, we believe our experience offers a valuable framework for other health care organizations to conduct a similar assessment (using their own estimates, assumptions, and measures of clinical activity) prior to implementing a hand hygiene program.

References

16. Trick WE, Vernon MO, Welbel SF, Demarais P, Hayden MK, Weinstein RA. Multicenter intervention program to increase adherence to hand hygiene


