



Major Article

Use patterns and frequency of hand hygiene in healthcare facilities: Analysis of electronic surveillance data



Jessica Albright PhD ^{a,*}, Bruce White MS ^a, Daniel Pedersen BS ^a, Pete Carlson BA ^b,
Lisa Yost MPH ^c, Cheryl Littau PhD ^a

^a Research, Development and Engineering, Ecolab, Eagan, MN

^b Regulatory Affairs, Ecolab, St. Paul, MN

^c Environment and Health, Ramboll, Arlington, VA

Key Words:

Hand hygiene
Healthcare
Monitoring
Alcohol-based handrub
Infection prevention
Occupational exposure

Background: Healthcare workers perform hand hygiene much more frequently than workers in other fields. As a result, healthcare workers have a higher exposure to topical antiseptic products.

Methods: Five tertiary care facilities were equipped with an electronic hand hygiene compliance monitoring system. Alcohol-based handrub (ABHR) and handwash use was recorded on a worker-specific basis for 6 months. Total hand hygiene product use and total hours worked were calculated for each worker to determine use frequency.

Results: A detailed, descriptive analysis of hand hygiene practices was performed. All facilities demonstrated high hand hygiene compliance rates (>85%). ABHR use was more frequent (9.1 uses/hour, 95th percentile) than handwashing (2.1 uses/hour, 95th percentile). This study identified a relationship between hand hygiene frequency and job function. Nursing and nonclinical support staff demonstrated higher usage rates than other healthcare workers. For these workers with high hand hygiene frequency, 95th percentile usage rates for ABHR use and handwashing were 9.6 and 2.2 uses/hour, respectively.

Conclusions: This extensive dataset, monitoring nearly 4000 healthcare workers and more than 6 million data points, provides a detailed description of current hand hygiene practices of hospital staff. ABHR was used more frequently than handwashing. Job function was found to affect hand hygiene frequency, with nonclinical staff and nursing staff demonstrating elevated rates of hand hygiene.

© 2021 The Author(s). Published by Elsevier Inc. on behalf of Association for Professionals in Infection Control and Epidemiology, Inc. This is an open access article under the CC BY-NC-ND license. (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

BACKGROUND

Hand hygiene of healthcare personnel is recognized as a crucial factor in limiting healthcare-associated infections. The World Health Organization (WHO)¹ and the Centers for Disease Control and Prevention (CDC)² recommend that healthcare workers wash their hands with soap and water when visible soil is present. When hands are not visibly soiled, hand hygiene with an alcohol-based handrub (ABHR) is recommended. The use of ABHR is faster, more effective, and less damaging to the skin, and it is the hand hygiene modality most frequently used by healthcare workers in the United States.³ WHO¹ introduced the concept of “My Five Moments for Hand

Hygiene,” which includes the following hygiene opportunities: 1) before touching a patient; 2) before a clean/aseptic procedure; 3) after body fluid exposure risk; 4) after touching a patient; and 5) after touching a patient’s surroundings. In complying with these clinical guidelines, healthcare workers often have a higher exposure to hand hygiene product ingredients than workers in most other fields. Furthermore, workers with more frequent patient contact require an even higher frequency of hand hygiene to comply with clinical guidelines. To demonstrate the safety of hand hygiene product ingredients, the U.S. Food and Drug Administration⁴ has requested data from repeated-exposure safety studies using human subjects and representative usage patterns. To create an accurate exposure model, it is necessary to assess current hand antiseptics practices and frequency of use in actual healthcare facilities.

Several observational and self-reported studies have evaluated compliance with the recommendations from the WHO¹ report. Some studies reported that the average number of hand hygiene opportunities for nurses in an intensive care unit was as high as 30 events/hour.^{5,6} Although such studies estimated the hypothetical

* Address correspondence to Jessica Albright, PhD, Research, Development and Engineering, Ecolab, 655 Lone Oak Dr, Eagan, MN 55121.

E-mail address: Jessica.Albright@Ecolab.com (J. Albright).

Conflicts of interest: Jessica Albright, Bruce White, Daniel Pedersen, Pete Carlson, and Cheryl Littau are employees of Ecolab. Lisa Yost received compensation from Ecolab.

number of hand hygiene events based on job responsibilities, the authors reported on hygiene opportunities, not on actual measured hand hygiene events. Limitations noted in observational studies of hand hygiene frequency have included inconsistent observational methods, small sample sizes, and potentially biased observers.^{7–11} The Hawthorne effect has also been noted with observational studies, repeatedly showing that the presence of observers alters behavioral practices of the test population during the observation period. This effect results in a temporary upsurge of hand hygiene events during the direct surveillance period.¹² The net result is that this influence misrepresents long-term hand hygiene patterns. If healthcare facilities have an inaccurate understanding of actual hand hygiene practices, they may not devote the proper resources to continuous improvement of these essential intervention practices, potentially increasing the risk of costly hospital-acquired infections.

In contrast to observational studies, electronic data gathering has a major advantage in that it eliminates the bias and subject influence that is inherent in observational studies.¹³ Electronic monitoring also allows 24-hour monitoring, which would be arduous at best with a direct observational study.¹⁴

The analysis reported in this article draws from extensive, highly accurate data—measurements of hand hygiene events gathered unobtrusively through electronic monitoring in 5 hospitals over 6 months, generating a dataset of more than 1.4 million person-hours from 4208 healthcare workers. This study used the Ecolab Hand Hygiene Compliance Monitoring System (HHCMS). In this system, each employee has a unique identification badge that communicates with the monitoring system. Monitoring is done without interruption, on a 24-hour basis, 7 days per week. The Ecolab HHCMS was developed to ensure hand hygiene compliance, but it is uniquely valuable for providing near real-time data on hand hygiene frequency that is highly relevant for understanding current hand hygiene practices and determining occupational exposure levels to hand hygiene products.

Study objective

The objective of this study was to employ direct measurement data to perform a highly accurate descriptive analysis detailing how frequently healthcare workers use hand hygiene products in an occupational setting.

METHODS

Data were gathered over a 6-month period spanning July 1, 2016, to December 31, 2016, in 5 medium-sized healthcare facilities ranging from 200 to 500 beds per hospital. All 5 facilities had general medical-surgical units as well as multiple specialty services, which varied by hospital. Examples of specialty services included orthopedics, maternity care, and cardiac care. Each facility was equipped with the Ecolab HHCMS, which employs monitoring beacons that communicate with each dispenser and with the badge of each employee. Therefore, each recorded or logged product dispense is associated with an individual, the individual's job description, the dispensing location, and a time and date record of the specific product being dispensed. When a hand hygiene product is dispensed (ie, either an ABHR or a handwash product), the event is communicated to a central database by wireless connection. During the 6-month surveillance period considered in this study, more than 6.65 million (6,652,474) dispensing events were recorded, and a total of approximately 1.4 million person-hours were tracked for product use. All healthcare workers employed directly by the hospitals were monitored.

Hand hygiene product usage data were collected from locations where workers would have a high frequency of patient contact. The Ecolab HHCMS does not include hand hygiene dispensers in public restrooms, and dispensers in surgical scrub sink areas were also not included in this analysis. Further excluded were products such as hand-conditioning lotions and creams, which were available to the staff in the facilities but are not used for hand hygiene.

A few healthcare workers at these 5 hospitals were employed on a contractor or consultant basis. Individuals not employed directly by the hospital were not monitored and were not included in the analyses. Across all of the hospitals, many medical specialists worked on a consulting physician basis and were not employed directly by the facility. Physicians have repeatedly been shown to have significantly lower hand hygiene product use and compliance rates than other healthcare workers,^{2,9,15} so the effect of having this group underrepresented in the dataset in this analysis would overestimate hand hygiene frequency for healthcare workers as a whole. Other positions were staffed by contractors on an ad-hoc basis at individual facilities. This factor was not expected to have any significant effect on the analysis.

The 5 healthcare facilities selected for this evaluation were identified as having a high degree of compliance with hand hygiene clinical guidelines. Specifically, their compliance rates were higher than 85%, whereas the average compliance rate for most hospitals is lower than 50%,¹⁶ and mean baseline rates as low as 5% have been reported by WHO.¹ For this reason, the individuals monitored for this analysis would be expected to provide an accurate and representative dataset for estimating occupational exposure for healthcare workers. Moreover, the study population, which comprised 3927 individuals, would be expected to be representative of hand hygiene practices in diverse settings where these products are used.

Data preparation

The dataset analyzed included all dispensing data for ABHR and a nonmedicated handwash product used in 5 hospitals. The data collection period was July 1, 2016, to December 31, 2016, for 4 of the hospitals and July 4, 2016, to December 31, 2016, for the fifth. The initial overall dataset consisted of 6,652,474 dispensing events, representing 4208 hospital workers.

Since the unprocessed data did not have a shift designation for a given dispensing event, time between dispenses for each individual was used to parse the data into separate shifts and calculate the length of each shift. Specifically, if more than 6 hours passed between dispensing events for a given worker, these events were assumed to occur in 2 different shifts. The time between the first dispense on a shift and the last dispense on a shift was used as a proxy for shift length.

All workers who logged a total time of less than 1 hour at a given hospital over the entire 6-month period were excluded from the analysis. After this exclusion criterion was applied, there were 6,651,438 dispensing events from 3927 hospital workers. Thus, this evaluation was able to retain more than 99.9% of dispensing events and 93.3% of workers.

Use by product

Usage rates for ABHR and handwash were evaluated separately to allow for a more detailed understanding of hand hygiene patterns and practices.

Calculation of Hand Hygiene Frequency per Hour: As mentioned previously, the goal of this study was to describe healthcare worker usage rates of the individual hand hygiene products. Exposure estimates were derived as applications per hour, for each

Table 1

Frequency of dispenses per hour for alcohol-based handrub and for handwash—all worker categories combined.

All Worker Categories	Frequency per Hour	
	Alcohol-Based Handrub	Handwash
95th Percentile	9.1	2.1
Average	3.6	0.7
Median	2.9	0.4

respective product. This value was calculated in the following manner for each worker:

$$\frac{\text{Frequency}}{\text{Hour}} = \frac{\text{Total Dispenses}}{\text{Total Hours Worked}}$$

In this calculation, *Total Dispenses* includes all dispensing events for the product of interest that were recorded for a given employee during the 6-month period. *Total Hours Worked* includes all hours for a given employee recorded during the same 6-month period.

RESULTS

Table 1 shows the frequency of dispenses per hour for ABHR and for handwash. As an overall finding, the percentage split between dispenses of product types was 84.3% for handrub compared to 15.7% for handwash. The 95th percentile for ABHR usage for all hospitals overall was 9.1 dispenses/hour, whereas the 95th percentile for handwash usage for all hospitals overall was 2.1 dispenses/hour.

The dataset was used to interrogate levels of occupational exposure to topical antiseptics among healthcare workers. The 95th percentile was employed in this study as a health-protective means of evaluating population exposures with the intent of not underestimating exposure. We recognize, however, that focusing on the 95th percentile will overestimate exposures for most individuals.

The following analyses provided findings for all facilities combined. In some cases, statistically significant differences were observed between the 5 hospitals because of the very large dataset. Overall, however, the differences between hospitals were small and were detectable only because of the large volume of data being analyzed. Hence, these factors suggest that this dataset offers a reasonable approximation of hand hygiene usage in hospitals as a whole.

Frequency of hand hygiene across all workers included in analysis

The data for all workers in all hospitals were analyzed first as a single dataset (**Fig 1**). Additional analyses of hand hygiene by job function followed.

Figure 1 is a histogram of ABHR and handwash dispenses for all workers at all 5 hospitals combined. For purposes of plotting these data to fit the lognormal curve, zero values were excluded, but these data were included in all analyses. Reference lines for the mean and 95th percentile values are included.

Effect of job function on hand hygiene frequency

The literature has suggested that among healthcare workers, job function may affect hand hygiene compliance.^{1,6,15} Previous studies largely focused on nurses and physicians and excluded nonclinical staff. Because the Ecolab HHCMS data included detailed job position descriptions, we were able to investigate whether any job functions were associated with unusually high hand hygiene usage rates. To determine whether any relationship could be found between job type and hand hygiene usage rates, 474 free-text job titles were

Table 2

Job types, number of individuals in that job type, and examples of job titles.

Category	Employees	Examples
Coordinator	156	Case Management Coordinator, EEG Coordinator, Sepsis Coordinator
Dietician	10	Clinical Dietician
EMT	53	EMT, Paramedic
LPN/CNA	363	LPN, CNA, Nursing Assistant
MD	104	MD, Physician, DO
Nonclinical Support Staff	369	Guest Relations Associate, Environmental Services Associate, Food and Nutrition Services Clerk
Pharmacy	10	Pharmacist, Pharmacy Technician
RN	1569	RN, Registered Nurse, RN Med/Surg, RN Pediatrics
Supervisor/Director	43	Manager Diagnostic Imaging, Director of Patient Safety
Tech	279	Ultrasound Technologist, Phlebotomist, Radiology Technician
Therapist	276	Physical Therapist, Occupational Therapist, Social Worker
Transport	42	Transport, Transporter
Undefined	15	Intern, Default

classified into 12 categories (**Table 2**). For example, any job titles that included “RN” or “Registered Nurse” were placed in the registered nurse (RN) category. Job position description was not identified for a fraction of the workers; however, because analyses provided in this study did not suggest unusual hand hygiene frequency for these workers, they were included in the overall analyses.

Figure 2 is a boxplot showing the distribution of average ABHR and handwash dispenses per hour for all workers at all 5 hospitals, categorized by job function. The reference line is the 95th percentile for all hospitals.

Of the 12 job categories identified, only 3 had more than 25 workers who exceeded the 95th percentile level usage rate. The 3 categories with an increased number of high-frequency hand hygiene users were licensed practical nurse/certified nursing assistant (LPN/CNA), RN, and nonclinical support staff. Across all facilities, these 3 positions consistently exhibited the highest number of workers exceeding the 95th percentile for hand hygiene frequency. **Figure 3** shows boxplots of the distribution of ABHR and handwash dispenses for the top 3 worker categories versus those for workers in all categories. As indicated in **Figure 3**, for the positions with the highest hand hygiene usage rates, the 95th percentile rates were 9.6 and 2.2 dispenses/hour for ABHR and handwash, respectively. These rates were only slightly higher than the usage rates for healthcare workers as a whole across all job types (9.1 and 2.1).

DISCUSSION

This descriptive analysis of the frequency of hand hygiene in healthcare settings provides a detailed understanding of hand hygiene practices. This information has important implications for infection prevention efforts and for determining the occupational exposure of healthcare workers to hand hygiene products. Although previous studies have estimated exposure based on hand hygiene opportunities or on short-term observational findings, the current measured dataset is large and comprehensive, representing more than 6 million dispensing events from nearly 4000 hospital workers measured in 5 hospitals over 6 months.

The facilities included in this evaluation have hand hygiene compliance rates higher than 85%. These rates are significantly higher than those typically observed in hospitals; for most facilities, compliance rates have been reported to be lower than 50%.¹⁶ For this reason, the data in this study are expected to provide an

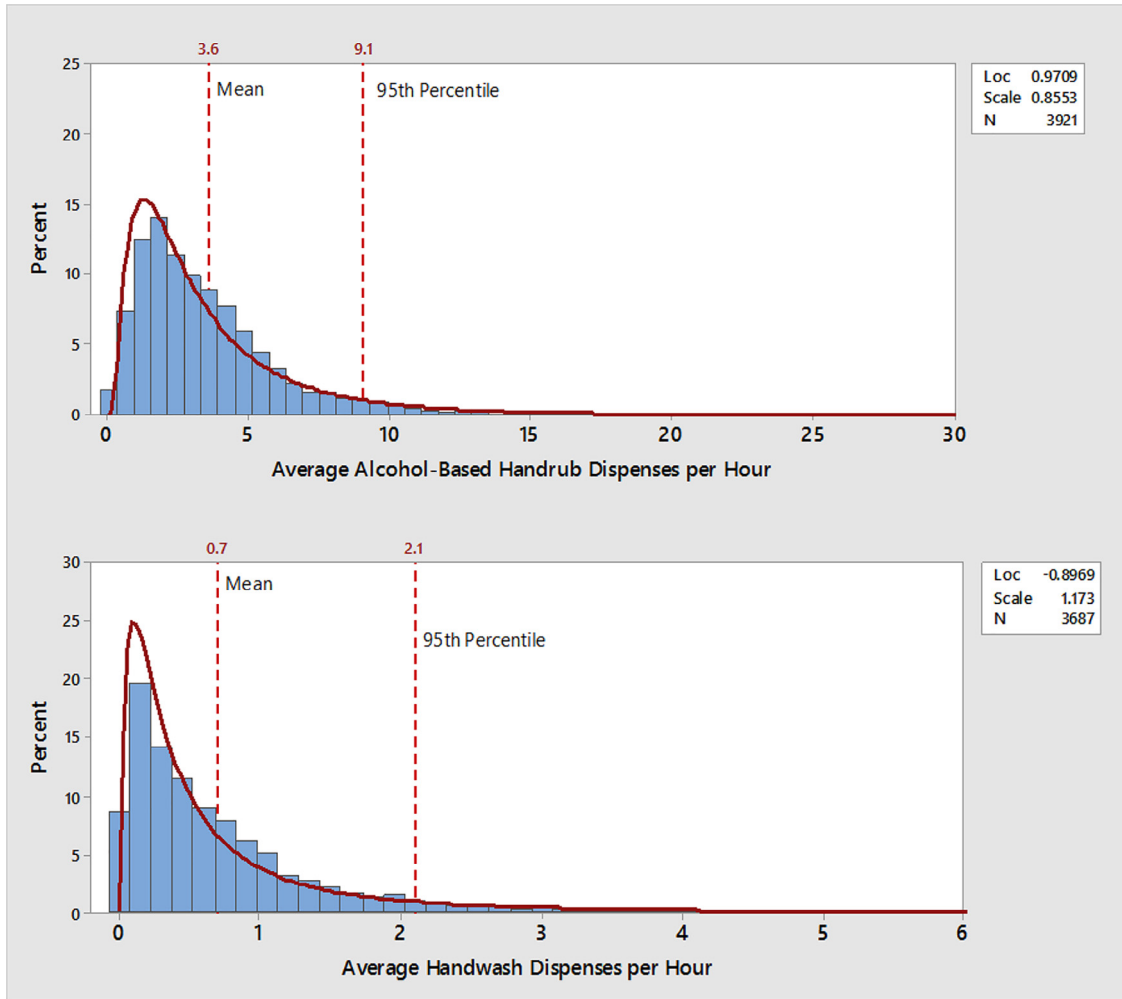


Fig 1. Distribution of average alcohol-based handrub dispenses per hour (top) and average handwash dispenses per hour (bottom).

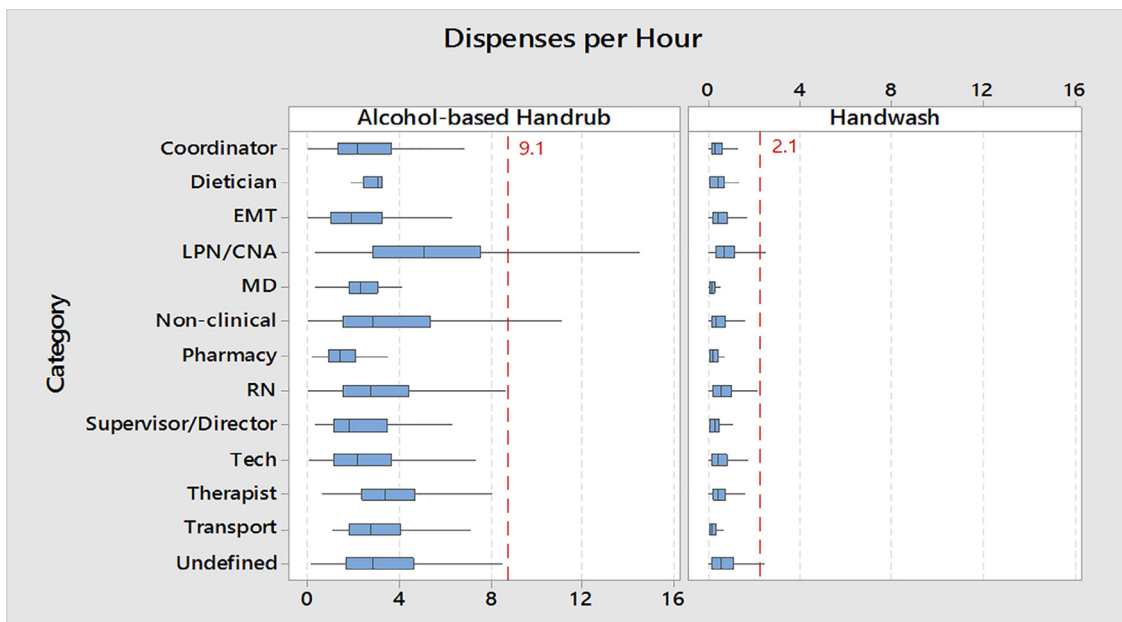


Fig 2. Distribution of average alcohol-based handrub dispenses per hour and average handwash dispenses per hour by job function.

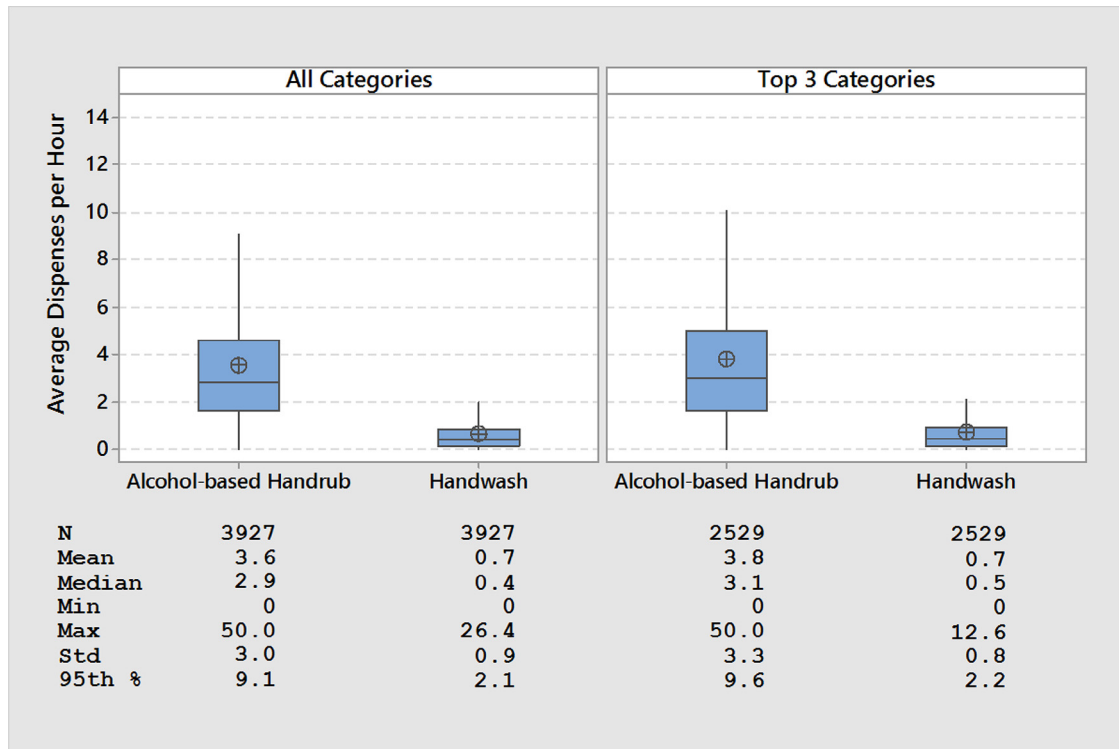


Fig 3. Distribution of average dispenses per hour of alcohol-based handrub and handwash for all workers and for workers in only the 3 highest-frequency job functions.

upper-end estimate of hand hygiene frequency in the healthcare setting.

Several key findings were noted. ABHRs were dispensed at a higher frequency than handwashes, with 95th percentile rates of 9.1 dispenses/hour versus 2.1 dispenses/hour across all hospitals. This finding is consistent with WHO¹ and CDC² recommendations for hand hygiene with handwashing when hands are visibly soiled, with the fact that handwashing frequency is also limited by time considerations, and with the need to maintain healthy skin. The finding of a higher frequency of dispenses for ABHRs is also consistent with WHO and CDC recommendations for use of these products at other hygiene opportunities. Moreover, ABHRs are widely available and are conveniently placed throughout healthcare facilities, while WHO¹ guidelines only require facilities to provide at least 1 handwashing sink for every 10 patient beds. The use of properly formulated ABHRs also leads to significantly less skin irritation and dryness among healthcare professionals than handwashing.¹⁷ Overall, ABHRs are an efficient and popular hand hygiene mode, and the observed ratio in this study was consistent with literature reports and agency guidelines.³

Another important finding was that hand hygiene frequency varied by job function. Specifically, of the 12 main job categories for healthcare workers, 3 groups demonstrated higher hand hygiene rates: RNs, LPNs/CNAs, and nonclinical support staff. Regarding the elevated frequency observed with nursing staff, this finding is consistent with and builds upon the findings of other more limited studies^{18,19} and is likely a function of the number of times a worker enters and leaves a patient zone per hour. For example, LPNs/CNAs generally perform less complex tasks than RNs. As a result, on average they spend less time with a given patient and thus are entering and leaving the patient zone more frequently. Every time they enter or leave the patient zone, they are prompted to perform a hand hygiene event. This finding is consistent with the observed usage rates of LPNs/CNAs being higher than those of RNs.

Nonclinical support staff also demonstrated elevated hand hygiene usage rates. Workers categorized in this job function included workers in the areas of food and nutrition services as well as environmental services. These employees may enter a high number of patient rooms per hour to perform short-duration tasks such as delivering meal trays or emptying refuse bins. The high frequency of hand hygiene among nonclinical staff has important implications. It suggests that this group is likely entering the patient zone on a very frequent basis. Importantly, clinical staff who treated a given patient will generally be recorded in the electronic medical record. Nonclinical staff, such as environmental services workers, likely would not create a record showing that they entered a patient room. This fact could have important implications for investigating infectious outbreaks in a healthcare facility. In the absence of a compliance monitoring system, nonclinical staff may be overlooked as a potential vector for microbial transmission. Frequent, specialized training on the importance of hand hygiene may be warranted for this group of employees and merits further study.

In evaluating the exposure of healthcare workers to hand hygiene products, even for the 3 job categories with elevated hand hygiene usage rates, the 95th percentile frequency levels were only slightly higher than those for all healthcare workers monitored in this study. ABHR and handwash usage rates were 9.1 dispenses/hour and 2.1 dispenses/hour for the entire dataset, compared to 9.6 dispenses/hour (ABHR) and 2.2 dispenses/hour (handwash) for the 3 highest-use groups. Although clear correlations were found between job function and hand hygiene frequency, usage rates for the entire dataset were only slightly lower than those for high-frequency job categories. This finding was likely due to the fact that subgroups with lower hand hygiene usage rates, such as physicians, represented a relatively small proportion of the dataset, whereas nurses and nonclinical support staff, who are high-frequency users, were a very large proportion of the workers in this study. Overall, this situation makes it even more likely that the usage rates presented

in this study do not underestimate usage rates for even high-frequency hand hygiene subgroups of workers.

CONCLUSIONS

Findings for this large dataset, which measured nearly 4000 highly compliant healthcare workers at 5 hospitals, provide a detailed analysis of hand hygiene frequency across multiple tertiary care facilities. Having a confident understanding of current hand hygiene practices has implications for both patients and healthcare workers. Through this analysis, job function was found to have a significant effect on hand hygiene frequency. Nonclinical staff had elevated hand hygiene frequencies, suggesting they are entering patient rooms on a very frequent basis. This finding merits further study to ensure that these employees are not underappreciated as a vector for infection. With respect to occupational exposure, even job functions with higher-than-average hand hygiene frequency rates produced upper-level estimates of less than 10 uses/hour for ABHR and less than 3 uses/hour for handwash. These data-driven estimates provide a hand hygiene frequency rate that can, and should, be used to design a realistic and representative repeated-use study to evaluate the safety of ABHRs and handwashes used by healthcare workers.

References

- World Health Organization. WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care is Safer Care. Geneva: World Health Organization; 2009 Available from: http://apps.who.int/iris/bitstream/10665/44102/1/9789241597906_eng.pdf. Accessed May 10, 2018
- Boyce JM, Pittet D. Guideline for hand hygiene in healthcare settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/ SHEA/APIC/IDSA Hand Hygiene Task Force. *MMWR Morb Mortal Wkly Rep* 2002;51:1–45.
- Kirk J, Kendall A, Marx JF, Pincock T, Young E, Hughes JM, et al. Point of care hand hygiene—where's the rub? A survey of US and Canadian health care workers' knowledge, attitudes, and practices. *Am J Infect Control* 2016;44:1095–101.
- Food and Drug Administration. Proposed Rule. 21 CFR Part 310 [Docket No. FDA–2015–N–0101] (Formerly Docket No. FDA–1975–N–0012) RIN 0910–AF69 Safety and Effectiveness of Health Care Antiseptics; Topical Antimicrobial Drug Products for Over-the-Counter Human Use; Proposed Amendment of the Tentative Final Monograph; Reopening of Administrative Record. 2015.
- Hugonnet S, Perneger TV, Pittet D. Alcohol-based handrub improves compliance with hand hygiene in intensive care units. *Arch Intern Med* 2002;162:1037–43.
- Pittet D, Mourouga P, Perneger TV. Compliance with handwashing in a teaching hospital. *Ann Intern Med* 1999;130:126–30.
- Boyce J. Measuring healthcare worker hand hygiene activity: current practices and emerging technologies. *Infect Control Hosp Epidemiol* 2011;32:1016–28.
- Haas JP, Larson EL. Measurement of compliance with hand hygiene. *J Hosp Infect* 2007;66:6–14.
- Conway LJ. Challenges in implementing electronic hand hygiene monitoring systems. *Am J Infect Control* 2016;44:7–12.
- Morgan DJ, Pineles L, Shardell M, Young A, Ellingson K, Jernigan JA, et al. Automated hand hygiene count devices may better measure compliance than human observation. *Am J Infect Control* 2012;40:955–9.
- Hagel S, Reischke J, Kesselmeier M, Winning J, Gastmeier P, Brunkhorst F, et al. Quantifying the Hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. *Infect Control Hosp Epidemiol* 2015;36:957–62.
- Eckmanns T, Bessert J, Behnke M, Gastmeier P, Rüden H. Compliance with antiseptic hand rub use in intensive care units: the Hawthorne effect. *Infect Control Hosp Epidemiol* 2006;27:931–4.
- Srigley JA, Furness CD, Baker RG, Gardam M. Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. *BMJ Qual Saf* 2014;23:974–80.
- Almeida M, Filho O, Marra AR, Magnus TP, Rodrigues RD, Prado M, et al. Comparison of human and electronic observation for the measurement of compliance with hand hygiene. *Am J Infect Control* 2014;42:1188–92.
- Larson E, McGinley KJ, Grove GL, Leyden JJ, Talbot GH. Physiologic, microbiologic, and seasonal effects of handwashing on the skin of health care personnel. *Am J Infect Control* 1986;14:51–9.
- Chassin MR, Mayer C, Nether K. Improving hand hygiene at eight hospitals in the United States by targeting specific causes of noncompliance. *Jt Comm J Qual Patient Saf* 2015;41:4–12.
- Larson EL, Cimiotti J, Haas J, Parides M, Nesin M, Della-Latta P, et al. Effect of antiseptic handwashing vs alcohol sanitizer on health care-associated infections in neonatal intensive care units. *Arch Pediatr Adolesc Med* 2005;159:377–83.
- Erasmus V, Daha T, Brug H, Richardus J, Behrendt M, Vos M, et al. Systematic review of studies on compliance with hand hygiene guidelines in hospital care. *Infect Control Hosp Epidemiol* 2010;31:283–94.
- Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Lancet* 2000;356:1307–12.