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Environmental Factors and their Association with Emergency Department Hand Hygiene Compliance: an Observational Study

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Abstract

Objectives—Hand hygiene is effective in preventing healthcare-associated infections.

Environmental conditions in the emergency department (ED), including crowding and the use of nontraditional patient care areas (i.e. hallways), may pose barriers to hand hygiene compliance.

We examined the relationship between these environmental conditions and proper hand hygiene.

Methods—This was a single-site, observational study. From October 2013 to January 2014, trained observers recorded hand hygiene compliance among staff in the ED according to the World Health Organization “My 5 Moments for Hand Hygiene.” Multivariable logistic regression was used to analyze the relationship between environmental conditions and hand hygiene compliance, while controlling for important covariates (e.g., hand hygiene indication, glove use, shift, etc.).

Results—A total of 1,673 hand hygiene opportunities were observed. In multivariable analyses, hand hygiene compliance was significantly lower when the ED was at its highest level of crowding than when the ED was not crowded and lower among hallway care areas than semi-private care areas (OR=0.39, 95% CI 0.28-0.55; OR= 0.73, 95% CI 0.55-0.97).

Conclusions—Unique environmental conditions pose barriers to hand hygiene compliance in the ED setting and should be considered by ED hand hygiene improvement efforts. Further study is needed to evaluate the impact of these environmental conditions on actual rates of infection transmission.

Keywords

handwashing; infection control; guideline adherence; emergency medical services

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INTRODUCTION

Hand hygiene is a leading means to prevent healthcare-associated infections.[1-3] Proper hand hygiene is particularly important in the emergency department (ED) as the ED is a major site of healthcare delivery, admitting approximately half of all hospital inpatients,[4] and is a frequent setting of the placement of invasive devices, which are subject to infection. While studies have consistently found that environmental conditions,[5] such as the availability of sinks and alcohol-based hand sanitizers impact hand hygiene compliance in the inpatient setting, little is known of the role of environmental factors on hand hygiene practices in the ED.[6]

Environmental conditions unique to the ED may pose barriers to recommended infection prevention practices. To expedite patient care when treatment rooms are full, EDs provide care in nontraditional areas such as hallways,[7] a practice found to be predictive of lower hand hygiene compliance.[6] Crowding, “a situation in which the identified need for emergency services outstrips available resources in the ED”[8, 9] is another common condition of EDs.[10] While ED crowding is associated with several aspects of poor care quality,[11] its relationship with hand hygiene compliance is unknown. To adequately address the challenge of ED crowding, it is important to understand ED crowding's consequences, not only in terms of efficiency of care processes, but also on clinical quality and outcomes of care. Using observational methods, we examined the relationship between environmental factors and hand hygiene compliance in the ED.

METHODS

This was part of a single-site observational investigation examining the relationship between ED crowding and healthcare workers' compliance with infection prevention practices (i.e. hand hygiene during routine patient care and aseptic technique during the insertion of urinary catheters, central venous catheters and peripheral venous catheters). Here, we report hand hygiene compliance findings. Prior to study commencement, we informed staff of the research via email and shift huddles and reported that we were examining the relationship between ED crowding and different processes of care.

This investigation was conducted from October 2013 to January 2014 in a high-volume ED in the New York metropolitan area of the United States. Hand hygiene compliance was observed during 20-60 minute observation periods through direct observation. Four trained research associates observed hand hygiene compliance according to the World Health Organization's (WHO) “My 5 Moments for Hand Hygiene.”[12]. Research associates were trained using publicly available WHO hand hygiene training materials[12] and engaged in inter-rater reliability testing prior to data collection and monthly over the course of the study period, in which a series of hand hygiene practices were co-observed in the study ED. Inter-rater agreement was formally tested using Cohen's Kappa and disagreements were discussed and resolved according to WHO hand hygiene training tools.[1]

Research associates observed hand hygiene compliance among nurses, physicians, nursing assistants, and “other,” defined as respiratory therapists, radiology technicians, security, and

environmental service personnel in the adult ED. Research associates only marked if hand hygiene was performed; hand hygiene technique was not evaluated. Observations were conducted unobtrusively from hallway vantage areas and research associates did not interfere with patient care to observe hand hygiene practices. Psychiatric and pediatric areas of the ED were excluded. No observations were conducted among healthcare workers providing care to psychiatric patients in the adult ED or among emergency situations (e.g. cardiac arrest). To limit the overrepresentation of individual practices, observers recorded a maximum of three hand hygiene opportunities per healthcare worker during an observation period.

Research associates recorded the following variables potentially associated with hand hygiene compliance: [1, 6] healthcare worker type, glove use, nursing staffing levels, day of the week, shift of observation (day or night), hand hygiene indication, location of patient receiving care and ED crowding. Variables were recorded using a modified WHO data collection tool (**Appendix**). Hand hygiene indications were specified according to the WHO “My 5 Moments for Hand Hygiene,” i.e. before patient contact, before an aseptic/clean procedure, after patient contact, after body fluid exposure, and after contact with the patient's environment.[12]

Patient care locations were recorded as ‘private,’ ‘semi-private’ or ‘hallway.’ We defined ‘private’ areas as patient care spaces equipped with doors, ‘semi-private’ areas as patient care spaces partitioned by curtains and ‘hallway’ areas as those located in corridors. To quantify ED crowding, we used the National Emergency Department Overcrowding Scale (NEDOCS),[13] a seven-item validated tool that takes into account census, timeliness of care, patient acuity and institutional constraint information. Crowding data were obtained from the ED tracking system and nurses in ED supervisory roles (e.g., nurse managers, charge nurses). Upon completion of an observation period, crowding data were entered into the NEDOCS calculator[14] to determine an overall ED crowding score for each observation period. No identifying information was collected among healthcare workers or patients over the course of the study and the medical center's institutional review board approved the study with a waiver of informed consent.

Data Analysis

Our outcome of interest was hand hygiene compliance for each hand hygiene opportunity. First, we linked ED crowding scores to the hand hygiene compliance data of its observation period, analyzed data using descriptive statistics and recoded continuous variables into categorical level data based on their distribution. We classified NEDOCS crowding scores, which range from 0-200, into categories designated by the NEDOCS instrument.[13] Specifically, we defined NEDOCS<100 as not crowded; 101 NEDOCS 140 as overcrowded; 141 NEDOCS 180 as severely overcrowded; and 181 NEDOCS as dangerously overcrowded. Second, we used simple logistic models to test each predictor variable on hand hygiene compliance. Using forward model selection, we included all variables with $p<0.20$ in simple logistic models into our multivariable logistic model.[15] Finally, using a multivariable logistic model, we tested interaction terms and assessed goodness of model fit. All statistical analyses were two-sided and conducted using SAS 9.4.

We performed sensitivity analyses to ensure the robustness of study results. We performed sensitivity analyses to determine the robustness of study results. To determine if results remained stable when a different ED crowding measure was used, we re-analyzed data using ED occupancy, a simple and commonly used measure of ED crowding. We also re-analyzed data using a multilevel model to account for clustering at the level of an observation period.

Sample Size Calculation

Based on a previous study that found the relative risk of hand hygiene compliance among hallway patient care locations was 0.89 compared to compliance among private patient beds, [6] we set out to calculate a 10% difference in hand hygiene compliance between high and low periods of ED crowding. To detect a 10% difference in hand hygiene compliance between high and low levels of ED crowding, with an alpha of 0.05 and a power of 0.80, a minimum number of 388 hand hygiene observations per high and low periods of crowding was needed.[16]

RESULTS

A total of 1,673 hand hygiene opportunities were observed over the course of 199 observation periods. Of the times hand hygiene was performed, alcohol-based rub and hand wash were used 93% and 7% of the time, respectively. Among observed hand hygiene opportunities: 925 (55%) were nurses, 538 (32%) were physicians, 159 (10%) were nurse assistants, and 51 (3%) were “other,” shown in **Table 1**. A majority of hand hygiene opportunities was observed among care provided in semi-private areas and during the day shift. Most hand hygiene opportunities were observed after patient contact (39%), followed by those before patient contact (23%), after body fluid exposure (19%), after contact with a patient's environment (12%), and before aseptic/clean procedure (7%). Inter-rater reliability was high throughout the course of data collection (Cohen's Kappa>0.86).

Hand hygiene compliance was highest during non-crowding periods (67%) and among patients in private areas (74%). Significant predictors of hand hygiene compliance in simple logistic regression ($p<0.20$) included: shift of observation, patient location, healthcare worker type, glove use, hand hygiene indication, and ED crowding, detailed in **Table 1**. Variables that were not significant predictors of hand hygiene compliance included day of week ($p=0.33$), number of registered nurses on duty ($p=0.25$), and number of nursing assistants on duty ($p=0.45$).

In our final multivariable logistic model, hand hygiene compliance was lower when the ED was overcrowded, severely overcrowded, and dangerously overcrowded, compared to times the ED was not crowded (OR=0.56, 95% CI, 0.42-0.75; OR=0.63, 95% CI, 0.46-0.86; OR=0.39, 95% CI 0.28-0.55) and lower among hand hygiene opportunities in hallways than those in semi-private areas (OR=0.73; 95% CI, 0.55-0.97). **Table 2**. Hand hygiene compliance was higher on the night shift than day shift (OR=1.37; 95% CI, 1.04-1.80), and physicians had higher compliance than nurses (OR=1.60; 95% CI, 1.25-2.04).

We also found that the interaction term for “hand hygiene indication and glove use” was highly significant ($p=0.004$), shown in **Table 3**. Hand hygiene was more likely to be

performed after body fluid exposure and after patient contact, regardless of glove use, when compared to hand hygiene before patient contact. Yet, hand hygiene was more likely to be performed after contact with a patient's environment if gloves were used, when compared to times gloves were not used. Our final model adequately fit the data (Hosmer and Lemeshow goodness-of-fit test, Chi-square 4.7; $p=0.79$; pseudo R^2 0.10). Sensitivity analyses supported the robustness of study results, with findings remaining consistent when ED occupancy was used as the measure of ED crowding and when a multilevel model was used to analyze the data.

DISCUSSION

This study builds upon the body of literature that finds environmental conditions impact hand hygiene compliance. To our knowledge, this is the first published study to evaluate the relationship between hand hygiene compliance and ED crowding. We found that crowding was associated with lower hand hygiene compliance in the ED, a finding consistent with studies that found crowding is a barrier to hand hygiene compliance in non-ED care settings. [1] Since ED crowding was associated with less hand hygiene, it is possible that increased transmission of infectious agents could occur as a result. While studies have found ED crowding is associated with care delays, decreased patient satisfaction, and increased patient mortality,[11] infection prevention practices have not been a focal area of ED crowding studies. This may reflect the magnitude of competing research priorities in the ED or difficulty in conducting this type of research. Further studies are needed to evaluate ED crowding's role in infection transmission and to determine the comparative effectiveness of interventions aimed at reducing ED crowding.[18]

We found that hallway care was associated with lower hand hygiene compliance, a finding consistent with published reports.[6] We likely lacked the power to demonstrate that compliance differed between semi-private and private areas as only 1.4% of all hand hygiene opportunities were observed among private locations. Hallway care areas are designed to facilitate the prompt assessment and treatment of ED patients,[7] yet care should be taken to ensure that modifications to the ED environment support infection prevention practices. In the process of designing and renovating EDs, hospital and ED leadership may consult with human factors engineers to ensure that the physical layout of the ED facilitates proper infection prevention practices.[19] To support hand hygiene compliance among existing hallway patient care areas, EDs may strategically place wall-mounted or free-standing alcohol based sanitizers in hallway care locations. EDs may also encourage the use of wearable alcohol gel dispensers[20] to help ensure the availability of hand sanitizer product regardless of a patient's care area in the ED.

While environmental modifications may help to support proper infection prevention practices, they are likely insufficient to drastically improve hand hygiene compliance. Studies show that median hand hygiene compliance among hospital inpatients is 40%[5] and that no simple evidence-based strategy effectively optimizes hand hygiene compliance.[21] Effective hand hygiene improvement programs are multimodal and have included interdisciplinary champions, ongoing education, hand hygiene audits, and real-time feedback, as well as improvement in the location and availability of hand sanitizer product.

[22] This ED recently implemented many of these evidence-based strategies as part of a multi-pronged hand hygiene improvement initiative.

This is one of the few studies to use all of the WHO “My 5 Moments for Hand Hygiene” to observe hand hygiene compliance in the ED. Other studies have used a subset of these criteria or alternative methods.[23] Published reports have found that staff is more likely to perform hand hygiene after patient care than before, and that the reported impact of glove use on hand hygiene compliance is varied.[1] We hypothesized that there may be an interaction effect between hand hygiene indication and glove use, which would help to explain varied findings. We found that healthcare workers were more likely to perform hand hygiene after patient care than before regardless of glove use. While early hand hygiene literature reported that gloves were perceived as an alternative to hand hygiene, our findings indicate that staff members are aware of the need for hand hygiene after glove use. We also found that healthcare workers who contacted a patient's environment and wore gloves were more likely to perform hand hygiene than those not wearing gloves, which suggests that gloves may be used when environmental exposures are considered more ‘dirty.’

Few studies conducted in the ED have examined hand hygiene compliance by staff shift schedules. We found that hand hygiene compliance was higher on the night shift than on the day shift, which suggests that the night shift may have certain characteristics that predispose them to have better hand hygiene compliance. For instance, night shift personnel may consist of more new graduates, whose training and education emphasize the importance of infection prevention. Alternatively, it is possible that fewer people (e.g. visitors, patients) were present during night shift observations, which increased staffs’ awareness that they were being observed. This increased awareness may have amplified the Hawthorne effect and led to higher rates of hand hygiene compliance. We found that physicians had higher hand hygiene compliance than nurses, which differs from published reports.[1] Variables that were not assessed in our study, including patient-to-nurse ratios, interruptions during patient care, and hand hygiene opportunities per hour may help to explain this finding.

This study has several limitations. First, we used a modest sampling frame, collecting data from one institution over four consecutive months, which limits the generalizability of study findings. Second, we did not evaluate relevant patient outcomes data (e.g. rates of healthcare-associated infection) in addition to hand hygiene compliance. Third, hand hygiene practices were evaluated through direct observation. While this is widely considered the gold standard to monitor hand hygiene practices,[1] staff may have changed hand hygiene practices as a result of being observed. The Hawthorne effect may also not have operated uniformly across hand hygiene observations. Fourth, while we adjusted for a number of covariates, as an observational study, residual confounders may have impacted study results. For instance, it is possible that the hand hygiene practices of regularly staffed ED personnel were different from non-regularly staffed personnel (e.g., rotating residents, travel nurses). Yet, we aimed to evaluate the impact of ED crowding on hand hygiene compliance in the ED, regardless of staff regularity.

CONCLUSIONS

Environmental conditions pose barriers to hand hygiene compliance in the ED and should be considered in ED hand hygiene improvement efforts. Further study is needed to evaluate the impact of these environmental conditions on actual rates of infection transmission.

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Table 1

Description of Variables and Bivariate Associations of Hand Hygiene Compliance

Variable	HH opportunity, no., % of sample	HH compliance, %	Unadjusted OR (95% CI)	P-value
Day of week				0.33
Monday	247 (15)	52.6	Reference	
Tuesday	310 (19)	53.9	1.05 (0.75-1.47)	
Wednesday	319 (19)	52.4	0.99 (0.71-1.38)	
Thursday	442 (26)	58.6	1.27 (0.93-1.74)	
Friday	304 (18)	52.6	1.00 (0.71-1.40)	
Weekend	51 (3)	62.8	1.52 (0.82-2.82)	
Shift				<0.005
Day (8:30am-8:30pm)	1371 (82)	53.0	Reference	
Night (8:30pm – 8:30am)	302 (18)	62.3	1.46 (1.13-1.89)	
Patient location				<0.005
Semi-private	1376 (82)	56.3	Reference	
Hallway	274 (16)	45.3	0.64 (0.50-0.83)	
Private	23 (1)	73.9	2.20 (0.86-5.61)	
Healthcare worker type				0.07
Nurse	925 (55)	52.5	Reference	
Physician	538 (32)	59.3	1.32 (1.06-1.63)	
Nurse assistant	159 (10)	53.5	1.04 (0.74-1.45)	
Other (security, housekeeping, etc.) ^a	51 (3)	49.0	0.87 (0.49-1.53)	
Glove use				0.02
No	1137 (68)	52.8	Reference	
Yes	536 (32)	58.8	1.28 (1.04-1.57)	
HH indication				<0.005
Before patient contact	383 (23)	42.0	Reference	
Before aseptic/clean procedure	124 (7)	39.5	0.90 (0.60- 1.36)	
After body fluid exposure	312 (19)	69.6	3.15 (2.30-4.32)	
After patient contact	653 (39)	62.6	2.31 (1.79-2.99)	
After patient environment	201 (12)	39.3	0.89 (0.63-1.27)	
ED crowding				<0.005
Not crowded (NEDOCS 100)	370 (22)	66.8	Reference	
Overcrowded (101 NEDOCS 140)	600 (36)	53.7	0.58 (0.44-0.76)	
Severely overcrowded (141 NEDOCS 180)	391 (23)	54.2	0.59 (0.44-0.79)	
Dangerously overcrowded (NEDOCS>180)	312 (19)	43.0	0.38 (0.28-0.51)	
Number of Registered Nurses				0.25
24	878 (52)	56.0	Reference	
> 24	795 (48)	53.2	0.89 (0.74-1.08)	
Number of Nursing Assistants				0.45
7	740 (44)	53.7	Reference	

Variable	HH opportunity, no., % of sample	HH compliance, %	Unadjusted OR (95% CI)	P-value
> 7	933 (56)	55.5	1.08 (0.89-1.31)	

Note.

^a security, housekeeping, respiratory therapists, and radiology department personnel; NEDOCS, National Emergency Department Crowding Scale; ED, emergency department

Table 2**Multivariable Model of Predictors of Hand Hygiene Compliance in the ED**

Variable	Adjusted OR (95% CI)	p-value
Shift		0.03
Day shift (8:30am-8:30pm)	Reference	
Night shift (8:30pm – 8:30am)	1.37 (1.04-1.80)	
Patient location		0.06
Semi-private	Reference	
Hallway	0.73 (0.55-0.97)	
Private	1.51 (0.56-4.06)	
Healthcare worker type		0.002
Nurse	Reference	
Physician	1.60 (1.25-2.04)	
Nurse assistant	1.27 (0.88-1.85)	
Other (security, housekeeping, etc.) ^a	1.51 (0.83-2.75)	
ED crowding		<0.0001
Not crowded (NEDOCS 100)	Reference	
Overcrowded (101 NEDOCS 140)	0.56 (0.42-0.75)	
Severely overcrowded (141 NEDOCS 180)	0.63 (0.46-0.86)	
Dangerously overcrowded (NEDOCS>181)	0.39 (0.28-0.55)	
Glove use * HH indication		0.004

Note.

^a security, housekeeping, respiratory therapists, and radiology department personnel; NEDOCS, National Emergency Department Crowding Scale; ED, emergency department;

* interaction term

Table 3

Stratum Specific Odds Ratios and Confidence Intervals of Interaction Term

Variable	Adjusted OR (95%)	p-value
Glove use * HH indication		0.004
HH before patient contact and no gloves	Reference	
HH before aseptic/clean procedure and no gloves	1.10 (0.54-2.30)	
HH after body fluid exposure and no gloves	3.22 (1.97-5.26)	
HH after patient contact and no gloves	2.42 (1.81-3.25)	
HH after patient surroundings and no gloves	0.70 (0.47-1.04)	
HH before patient contact and glove use	Reference	
HH before aseptic/clean procedure and glove use	1.10 (0.55-2.19)	
HH after body fluid exposure and glove use	4.63 (2.52-8.53)	
HH after patient contact and glove use	2.18 (1.17-4.08)	
HH after patient surroundings and glove use	4.64 (1.65-12.99)	
No gloves and same HH indication	Reference	
Glove use and HH before patient contact	0.83 (0.47-1.47)	
Glove use and HH before aseptic/clean procedure	0.82 (0.37-1.85)	
Glove use and HH after body fluid exposure	1.19 (0.71-2.00)	
Glove use and HH after patient contact	0.75 (0.51-1.10)	
Glove use and HH after patient surroundings	5.47 (2.13-14.09)	

Note.

* interaction term; HH, hand hygiene, shaded areas denote different reference groups