



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Contents lists available at ScienceDirect

## American Journal of Infection Control

journal homepage: [www.ajicjournal.org](http://www.ajicjournal.org)

## Major Article

## Compliance measurement and observed influencing factors of hand hygiene based on COVID-19 guidelines in China

Qian Zhou PhD<sup>a</sup>, Xiaoquan Lai MM<sup>b</sup>, Xinping Zhang PhD<sup>a,1,\*</sup>, Li Tan PhD<sup>b,2,\*\*</sup><sup>a</sup> School of Medicine and Health Management, Tongji Medical School, Huazhong University of Science and Technology, Wuhan, Hubei, China<sup>b</sup> Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei, China

## Key Words:

Criterion  
Moment  
Procedure  
Duration  
Hand drying

## A B S T R A C T

**Background:** Higher requirement is put forward in the measurement of hand hygiene (HH) during a pandemic. This study aimed to describe HH compliance measurement and explore observed influencing factors with respect to coronavirus disease 2019 (COVID-19) guidelines in China.

**Methods:** Compliance was measured as the percentage of compliant opportunities based on criteria for 17 moments. The criteria for compliance included HH behavior, procedure, duration, hand drying method, and the overall that counts them all. The observed influencing factors included different departments and areas and protection motivation. Descriptive analysis and logistic regression were performed.

**Results:** The compliance of overall criteria, HH behavior, procedure, duration, and hand drying method were 79.44%, 96.71%, 95.74%, 88.93%, and 88.42%, respectively, which were significantly different from each other ( $P < .001$ ). Meanwhile, the overall and hand drying method compliance in semi-contaminated areas (odds ratio [OR] = 1.829,  $P < .001$ ; OR = 2.149,  $P = .001$ ) and hygienic areas (OR = 1.689,  $P = .004$ ; OR = 1.959,  $P = .015$ ) were significantly higher than those in contaminated area. The compliance with HH behavior for the motivation of patient-protection (OR = 0.362,  $P < .001$ ) was lower than that for the motivation of self-protection.

**Conclusions:** HH compliance was firstly measured using different criteria for 17 moments according to COVID-19 guidelines in China. The measurement of HH compliance needs clearer definition and comprehensive practice. Contaminated areas and motivation of patient-protection contribute to lower compliance, which may be addressed by allocating more human resources and increasing supervision and education.

© 2020 Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.

Hand hygiene (HH) is considered an effective measure to prevent and control the spread of disease.<sup>1,2</sup> Both alcohol-based handrub and handwashing with soap and water are critical approaches to preventing and controlling health care-associated infection (HCAI) that are effective in combating enveloped viruses, like Ebola and coronaviruses.<sup>3</sup> Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2),

first detected in Wuhan, is the cause of a pandemic and has infected more than 1 million people across the world up to April 11, 2020. HH in health care workers (HCWs) is important to protect both themselves and prevent the spread of the virus during this pandemic.<sup>4</sup>

Using “moments” in HH is a standardized technique to formulate its practice.<sup>1</sup> The most frequently used moment-based systems include the “5 moments” suggested by the World Health Organization (WHO), while the Centers for Disease Control and Prevention (CDC) in the United States suggest 5 moments, particularly stressing the moments before moving from work on a soiled body site to a clean body site on the same patient and after glove removal.<sup>5</sup> Some studies observed HH using moments before or after patient contact, after a specific task and during entry or exit.<sup>6</sup> However, many studies omitted to explain the moments they used, which can greatly influence the compliance result.<sup>7</sup> Recent studies found that the observed compliance of HH varies between 5% and 89%, and the observed

\* Address correspondence to Xinping Zhang, PhD, School of Medicine and Health Management, Tongji Medical School, Huazhong University of Science and Technology, Wuhan, Hubei, China

\*\* Address correspondence to Li Tan, PhD, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei, China

E-mail addresses: [xpzhang602@hust.edu.cn](mailto:xpzhang602@hust.edu.cn), [xpzhang602@163.com](mailto:xpzhang602@163.com) (X. Zhang), [tanlidyx@126.com](mailto:tanlidyx@126.com) (L. Tan).

Conflicts of interest: All the authors declared no interest.

<sup>1</sup> Current address: No.13 Hangkong Rd, Wuhan, Hubei Province, China. Telephone number: +86-180-7150-9979

<sup>2</sup> Current address: No.1095 Jie Fang Av, Hankou, Wuhan 430030, China. Telephone: +86 159-9745-1097

influencing factors include profession, working department, wearing gowns or gloves, and contact with patient environment, among others.<sup>1,6</sup>

Previous published studies have several limitations. First, the studies were limited focused on HH during emerging infectious diseases, especially HH via direct observation. For example, Jieun<sup>8</sup> and Akinyinka<sup>9</sup> used self-report to measure HH compliance during outbreak of Middle East respiratory syndrome-related coronavirus and Ebola, respectively. However, HH is more difficult and higher medical quality is required during the outbreak of infectious diseases. Previous studies of the moments of HH were mostly confined to 5 moments,<sup>1,10</sup> which may not be applicable to the stricter hygienic requirements in a pandemic and lead to the ignorance of other moments of HH. For example, the standard implementation of donning and doffing protective equipment is the cornerstone of protection for HCWs, which occupies much time for HCWs in daily clinical work. Moreover, guidelines from the WHO and National Health Commission of China stress the importance of HH before putting on and after removing personal protective equipment (PPE).<sup>11,12</sup>

Second, most studies calculated compliance using the percentage of opportunities for which HCWs are compliant to HH guidelines, while the criteria for HH compliance are obscure and incomplete.<sup>6</sup> The WHO and CDC both highlighted that methods to define HH compliance vary considerably and detailed information concerning the methods and criteria for evaluating HH needs to be researched and provided.<sup>1,5</sup> Previous studies mainly included whether HH is performed as the only criterion of compliance.<sup>13</sup> However, some found that only 72% of HCWs have satisfactory HH that involved following the complete procedure, more than 90% of HCWs washed their hand for less than 15 seconds and hand drying was given the equal importance in HH.<sup>14–16</sup> This indicates that the compliance to the complete procedure, duration and hand drying are critical in preventing the transfer of microorganisms to the environment. Moreover, the evidence surrounding observed factors influencing HH compliance as assessed using different criteria was limited.

Therefore, this study aimed to explore the measurement (moment and criteria) of compliance and observed factors influencing HH during the coronavirus disease 2019 (COVID-19) pandemic via direct observation in Wuhan, China.

## METHOD

### Setting

The study was performed in a branch of Tongji Hospital. The HCWs included those from Tongji Hospital and 17 medical groups from other provinces in China. The 17 medical groups undertook responsibility or assisted in treatment and caring in 17 departments to solve human resource shortages. During the pandemic period, 828 beds were available. HCWs received education regarding HH and other infection control measures from department chiefs, head nurses and infection preventionists, given in the form of study meetings, learning materials, and supervision.

### Data collection

HH practices were directly observed in 17 departments from 5th to 7th March 2020. A standardized data collection tool was used, which contained 7 items: department, area (contaminated, semi-contaminated, or hygienic area), moment, HH behavior, procedure, duration, and hand drying method. HH duration was estimated by the observers counting seconds in their mind. Trained observers were asked to be at the patient's bedside or in front of glass outside the ward to perform covert observation; HCWs were not made aware of this observation in order to reduce the Hawthorne effect. Seventeen

staff members responsible for medical quality control who were experienced in HCAI control were trained by infection preventionists face to face (with PPE protection) to ensure the quality of covert observation. The definition of the criteria and method to perform were discussed and unified among all the observers. In one observation, the maximum number of observed HCWs should not exceed 3 and the duration of one observation should not exceeding 15 minutes based on the guidelines.<sup>17</sup>

## MEASUREMENT

### Dependent variable (compliance measurement of HH)

The dependent variable was the compliance of HH measured using different criteria based on moments.<sup>1,5</sup>

### Moments

According to the technical guidelines issued by the Chinese government,<sup>12</sup> we assessed 17 moments (Table 1).

### Criteria of compliance

According to the process recommended by the HH guidelines,<sup>11,12</sup> the criteria for compliance included HH behavior, procedure, duration, hand drying method, and the overall for all criteria.

### HH behavior

HH behavior was divided into handwashing with soap and water and then alcohol-based handrub, handwashing with soap and water, handwashing with alcohol-based handrub, handwashing with use of gloves, or no HH measures.<sup>13</sup> The use of gloves or no HH measures were considered to be noncompliant. The opportunity was defined as the occurrence of any moment during the observed period.

### Compliance of HH behavior

$$= \frac{\text{number of hand hygiene opportunities performed, excluding use of gloves}}{\text{total number of hand hygiene opportunities observed}}$$

### Procedure

Procedure of HH was measured by whether each procedure was completed. The complete procedure included rubbing hands palm to palm, right palm over left dorsum with interlaced fingers and vice versa, palm to palm with fingers interlaced, backs of fingers to opposing palms with fingers interlocked, rotational rubbing of left thumb clasped in right palm and vice versa, rotational rubbing, backward and forward with clasped fingers of right hand in left palm and vice versa, and rotational rubbing of left wrist clasped in right palm and vice versa.<sup>18</sup> HH following the complete procedure was considered

**Table 1**  
Categories of HH moments based on motivation

Motivation of HH	HH moments
Self-protection	After body fluid exposure risk; after touching a patient; after touching patient surroundings; before, after, and during removing all the PPE; after removing glove; leaving the ward; before drinking; before and after using the toilet
Patient-protection	Before touching a patient; before aseptic procedure; during work on a soiled body site to a clean body site on the same patient; before putting on PPE; before wearing gloves; arriving at the ward

HH, hand hygiene; PPE, personal protective equipment.

compliant. The observations with no handwashing were also defined to be noncompliant in this and the following calculation.

#### Compliance of HH procedure

$$= \frac{\text{number of hand hygiene opportunities with complete procedure}}{\text{total number of hand hygiene opportunities observed}}$$

#### Duration

When the duration of HH exceeded 15 seconds, the duration was determined to be compliant, according to the guidelines.<sup>17</sup>

#### Compliance of HH duration

$$= \frac{\text{number of hand hygiene opportunities with sufficient duration}}{\text{total number of hand hygiene opportunities observed}}$$

#### Hand drying method

The hand drying method was divided into use of hand drying paper near the handwash equipment, no use because of alcohol-based handrub, and other hand drying methods.<sup>19</sup> Compliant hand drying method was defined as a suitable hand drying method with respect to the specific HH behavior, including no use after alcohol-based handrub, and using hand drying paper near the handwash equipment after handwashing with soap and water. We defined the hand drying method after alcohol-based handrub (ie, handwashing with soap and water then alcohol-based handrub, and alcohol-based handrub) as compliant, because HH was promoted with alcohol-based handrub when there was no visible contamination. Previous studies showed that alcohol-based handrub promoted HH compliance and was more efficient when there was no visible contamination in the perspective of hand drying method.<sup>20–22</sup>

#### Compliance of HH drying method

$$= \frac{\text{number of hand hygiene opportunities with compliant hand drying method}}{\text{total number of hand hygiene opportunities observed}}$$

#### Overall criteria

If all 4 criteria above were considered compliant, the overall HH was determined compliant.

#### Overall HH compliance

$$= \frac{\text{number of compliant hand hygiene opportunities following all four criteria}}{\text{total number of hand hygiene opportunities observed}}$$

#### Independent variable

The independent variables included department (intensive care department or other general departments),<sup>23</sup> different areas (contaminated, semi contaminated, or hygienic area),<sup>24</sup> and motivation (self-protection and patient-protection)<sup>25</sup> (Table 1). Contaminated areas included areas where COVID-19 patients were treated or areas contaminated by the secretions and excretions of patients, such as wards, treatment rooms, and dirty rooms. Hygienic areas included areas free of aforementioned contaminations, such as staff lounges and catering room. In semi contaminated areas, the contaminated level is lesser than that of contaminated areas and greater than that of hygienic areas (eg, PPE removal room).<sup>26,27</sup> We divided the 17 moments into self-protection- and patient-protection-motivated according to the observers' perceived motivation for HH, which was based on the categories suggested by Lambe regarding the "5

moments" from WHO and unified among observers in training stage.<sup>25</sup> Exploration of influencing factors is important to identify the key factors to improve HH practice, and they have been investigated widely by other studies.<sup>6</sup> We selected 3 factors because they were accessible and important, while other factors, such as profession and gender, could not be distinguished in convert observation with HCWs wearing PPE.<sup>6</sup>

#### Statistical analysis

Categorical variables were described using percentages and frequency rates. The  $\chi^2$  tests, continuity correction, or Fisher exact tests were performed to compare proportions of categorical variables. Logistic regression was performed to estimate the observed factors influencing HH compliance. The 2-sided  $\alpha$  level was set at 0.05. All statistical analyses were performed using IBM SPSS Version 20.0 (IBM, New York, NY).

## RESULT

The overall compliance for 17 moments of HH was 79.44%. The highest overall compliance was for the moment before wearing gloves (91.67%), and the lowest was the moment after touching patient surroundings (65.56%); the highest compliance for HH behavior was the moment before putting on all the PPE, before removing all the PPE, leaving the ward, before drinking, and after using the toilet (100%); the lowest was for the moment, arriving at the ward (85.51%). The highest compliance of procedure were moments after body fluid exposure risk and after using the toilet (100%), and the lowest was the moment arriving at the ward (85.51%); the highest compliance for duration was for the moment when leaving the ward (96.15%), and the lowest was for the moment when arriving at the ward (78.26); the highest compliance for hand drying method was the moment before putting on all the PPE (96.69%), and the lowest was for the moment after touching patient surroundings (79.47%) (Table 2).

Most HCWs performed HH behavior (96.71%) and complete procedure (95.74%), whereas the compliance for duration (88.93%) and appropriate hand drying method (88.42%) were a bit lower, each of which were significantly higher than the overall compliance ( $P < .001$ ).

According to the univariate analysis, overall compliance ( $P < .001$ ), compliance of HH behavior ( $P = .003$ ) and hand drying method ( $P = .001$ ) were significantly different between contaminated, semi contaminated, and hygienic area. Self-protective HH was significantly higher than patient-protective HH in terms of compliance of HH behavior ( $P < .001$ ). No HH practice showed the difference between intensive care and nonintensive care departments (appendix). The overall compliance was 85% in the intensive care department, 79.18% in the nonintensive care department; 76.07% in contaminated area, 84.38% in semi contaminated area, and 84.21% in hygienic area; and 79.89% for self-protection-motivated behavior and 78.68% for patient-protection-motivated behavior.

According to the multivariable logistic analysis, the overall compliance in the semi contaminated (odds ratio [OR] = 1.829,  $P < .001$ ) and hygienic area (OR = 1.689,  $P = .004$ ) was significantly higher than that in the contaminated area. The compliance of HH behavior in semi contaminated (OR = 4.391,  $P = .015$ ) area was higher than that in contaminated area; and the compliance of patient-protection-motivated HH behavior was lower than that for self-protection-motivated behavior (OR = 0.362,  $P < .001$ ). The compliance for the hand drying method in semi contaminated area (OR = 2.149,  $P = .001$ ) and hygienic area (OR = 1.959,  $P = .015$ ) was also higher than that in contaminated area (Table 3).

**Table 2**  
The opportunity and compliance of HH and its criteria

	Overall observed HH compliance, n (%)	Observed HH behavior compliance, n (%)	Observed HH procedure compliance, n (%)	Observed HH time duration compliance, n (%)	Observed hand drying with paper compliance, n (%)	Total number of HH opportunities observed
Before touching a patient	173 (74.89)	217 (93.94)	215 (93.07)	199 (86.15)	199 (86.15)	231
Before aseptic procedure	100 (74.07)	128 (94.81)	125 (92.59)	115 (85.19)	115 (85.19)	135
After body fluid exposure risk	56 (81.16)	68 (98.55)	69 (100.00)	64 (92.75)	62 (89.86)	69
After touching a patient	214 (76.70)	275 (98.57)	271 (97.13)	250 (89.61)	243 (87.10)	279
After touching patient surroundings	99 (65.56)	141 (93.38)	137 (90.73)	119 (78.81)	120 (79.47)	151
During work on a soiled body site to a clean body site on the same patient	59 (81.94)	66 (91.67)	69 (95.83)	66 (91.67)	62 (86.11)	72
Before putting on PPE	109 (90.08)	121 (100.00)	119 (98.35)	113 (93.39)	117 (96.69)	121
Before removing all the PPE	120 (86.96)	138 (100.00)	136 (98.55)	132 (95.65)	125 (90.58)	138
During removing all the PPE	110 (83.97)	129 (98.47)	130 (99.24)	118 (90.08)	125 (95.42)	131
After removing all the PPE	85 (80.95)	104 (99.05)	102 (97.14)	93 (88.57)	96 (91.43)	105
Before wearing glove	22 (91.67)	23 (95.83)	23 (95.83)	23 (95.83)	22 (91.67)	24
After removing glove	58 (85.29)	67 (98.53)	66 (97.06)	65 (95.59)	61 (89.71)	68
Arriving at the ward	50 (72.46)	59 (85.51)	59 (85.51)	54 (78.26)	55 (79.71)	69
Leaving the ward	70 (89.74)	78 (100.00)	77 (98.72)	75 (96.15)	72 (92.31)	78
Before drinking	48 (82.76)	58 (100.00)	57 (98.28)	52 (89.66)	54 (93.10)	58
Before using the toilet	13 (76.47)	16 (94.12)	16 (94.12)	14 (82.35)	15 (88.24)	17
After using the toilet	13 (86.67)	15 (100.00)	15 (100.00)	14 (93.33)	14 (93.33)	15
Total	1399 (79.44)	1703 (96.71)	1686 (95.74)	1566 (88.93)	1557 (88.42)	1761

HH, hand hygiene; PPE, personal protective equipment.

**Table 3**  
Multivariate analysis of influencing factors and HH compliance

	Overall compliance		Compliance of HH behavior		Compliance of procedure		Compliance of time duration		Compliance of hand drying method	
	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)
<i>Department</i>										
Nonintensive		Reference								
Intensive care	.139	1.606 (0.857,3.008)	.992	1.006 (0.305,3.324)	.584	1.751 (0.236,13.009)	.351	1.551 (0.617,3.900)	.128	2.209 (0.795,6.134)
<i>Contaminated, semi contaminated or hygienic area</i>										
Contaminated		Reference								
Semi contaminated	<.001	1.829 (1.338,2.500)	.015	4.391 (1.333,14.467)	.305	1.622 (0.644,4.087)	.164	1.354 (0.884,2.074)	.001	2.149 (1.371,3.370)
Hygienic	.004	1.689 (1.180,2.419)	.370	1.398 (0.672,2.909)	.219	2.131 (0.637,7.130)	.328	1.284 (0.778,2.120)	.015	1.959 (1.140,3.368)
<i>Motivation for HH</i>										
Self-protection		Reference								
Patient-protection	.937	1.010 (0.789,1.293)	<.001	0.362 (0.207,0.635)	.651	0.848 (0.416,1.730)	.577	1.107 (0.774,1.585)	.155	1.291 (0.908,1.836)

CI, confidence interval; HH, hand hygiene; OR, odds ratio.

## DISCUSSION

In this study, HH compliance was measured based on criteria including HH behavior, procedure, duration and hand drying method, and overall based on 17 moments during the COVID-19 pandemic period. The HH compliance for the 17 moments ranged from 79.44% to 96.71%, and significantly differed between the different criteria. Area (contaminated, semi contaminated, and hygienic) and motivation (self-protection and patient-protection) for HH were identified as influencing factors.

The overall compliance for HH was 79.44%, which is relatively high with respect to previous observed HH studies,<sup>6</sup> this may be explained by the improvement in HH practices in situations with increased risk.<sup>28</sup> Phan found a high risk of not performing HH when doffing PPE and the compliance of HH after leaving patient room was 93.4%.<sup>29</sup> Kim observed that compliance was 4.8% when hands were exposed to a different body site in the same patient,<sup>30</sup> much lower than the compliance in our study, which may be associated with differences in education and context. Based on the differences in HH compliance regarding different moments in previous study and ours, it is necessary to take more moments into consideration to prevent HCAI. In addition, the compliance in HH behavior and procedure is

quite high, while the compliance for duration and hand drying method was a little lower, which may be associated with the conventional criteria that most HCWs only consider HH behavior as part of compliance, but ignore duration and hand drying method.<sup>31</sup> However, HH efforts would be in vain, with the absence of compliant duration and hand drying.<sup>15</sup> Thus, we recommend that the evaluated moments and criteria should be included and reported when measuring compliance, as recommended by the WHO and CDC.<sup>1,12</sup> Meanwhile, education targeting other moments and criteria, including duration and hand drying method, should be strengthened.<sup>14,15</sup> Similar to the previous study, the highest compliance for HH is HH after body fluid exposure and touching a patient, when considering the 5 moments of the WHO, which might be associated with the motivation of self-protection.<sup>25</sup>

Compliance in semi contaminated and hygienic area is higher than that in contaminated area. First, the workload of HCWs in contaminated area is higher than that in semi contaminated and hygienic area, which is a strong factor impeding high HH compliance.<sup>32</sup> Second, the reason why compliance in moments in semi contaminated area are higher is that they mostly involve the process of donning and doffing PPE, which is the cornerstone of hospital education during the pandemic period. Moreover, mutual supervision is typically

adopted during the process of donning and doffing PPE in investigated hospital, because of its importance in controlling HCAI among HCWs. Therefore, we believe that education and supervision are important tools to improve HH practice, with the adequate supplementation of human resources.<sup>33</sup> It is worth mentioning that education does not always translate into behavioral change. Clinical administrators should apply appropriate approaches to make education effective, such as education materials and behavioral change strategies.<sup>34,35</sup>

We found that the compliance for patient-protection-motivated HH behavior was lower than that for self-protection-motivated behavior. Previous studies found the same result, suggesting that better knowledge or awareness and stronger motivation may exist regarding self-protection HH moment among HCWs.<sup>25</sup>

The strength of our study is that covert observation could be performed with fewer limitations than typically expected because the observed HCWs were less likely to notice observers when they were in close as the observers used PPE and HCWs were usually surrounded by unknown staffs from other departments during the COVID-19 period. However, there are a few limitations to this study. First, we did not take sociodemographic characteristics of HCWs into consideration, due to the use of the gown and goggle. Second, HH duration was estimated by counting seconds in the observer's mind, which may lead to less accurate assessment of duration, although we set criteria and trained observers carefully to reduce the error as much as possible. Third, we measured the motivation of HH according to the observers' perceived motivation for HH, which might not be appropriate for every HCW observed, as the actual motivation of individual health care providers could not be assessed. Fourth, the study was only conducted over a 3-day period in one hospital, which may limit the generalizability of the findings. Fifth, the direct observation method of monitoring HH compliance only accounts for a very small fraction of HH events that could be observed.

This work raises implications for clinical administrators. First, the criteria for HH compliance, especially duration and hand drying method, need further attention and more detailed investigation to make compliance in different studies more comparable. Second, moments of HH, for example, donning and doffing PPE and other important moments, should be taken into consideration when higher quality medical care is required. Third, based on the lower compliance observed in contaminated area, greater allocation of human resources to share the workload is crucial to better handle emerging infectious diseases. Fourth, regarding the high compliance in the process of donning and doffing PPE with strengthened education and supervision, we recommend supervision and education using appropriate approaches as an effective tool to improve HH practice during emerging infectious diseases.

## CONCLUSIONS

HH compliance was measured using different criteria for 17 moments according to COVID-19 guidelines in China. As the compliance for HH varied based on the moments and criteria, we propose the measurement (moment and criteria) of HH compliance needs further attention to create a clear definition, especially when considering important moments, such as HH in the process of donning and doffing PPE, and criteria including duration and hand drying method. The area (contaminated, semi contaminated or hygienic area) and motivation are factors influencing HH practice, which indicates that the support of more human resources to share the workload in clinical department is crucial and the application of appropriate education and supervision may be an effective tool to improve HH practice during emerging infectious diseases.

## Acknowledgments

We thank the healthcare workers in Tongji hospital and the medical assistant groups coming to Wuhan from across the country for their help with data collection and their devotions to their patients.

## SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.ajic.2020.05.043>.

## References

- World Health Organization, World Alliance for Patient Safety. WHO guidelines on hand hygiene in health care. 2009.
- Assab R, Temime L. The role of hand hygiene in controlling norovirus spread in nursing homes. *BMC Infect Dis*. 2016;16:395.
- Adhikari SP, Meng S, Wu YJ, et al. Epidemiology, causes, clinical manifestation and diagnosis, prevention and control of coronavirus disease (COVID-19) during the early outbreak period: a scoping review. *Infect Dis Poverty*. 2020;9:29.
- World Health Organization. Infection prevention and control during health care when novel coronavirus (nCoV) infection is suspected. 2020.
- Boyce JM. Healthcare Infection Control Practices Advisory Committee; HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Society for Healthcare Epidemiology of America/Association for Professionals in Infection Control/Infectious Diseases Society of America*. 2002;51:1–45.
- Erasmus V, Daha TJ, Brug H, et al. Systematic review of studies on compliance with hand hygiene guidelines in hospital care. *Infect Control Hosp Epidemiol*. 2010;31:283–294.
- Jeanes A, Coen PG, Gould DJ, Drey N. Validity of hand hygiene compliance measurement by observation: a systematic review. *Am J Infect Control*. 2018;47:313–322.
- Jieun Y, Eun-Cheol P, Ah L S. Associations between hand hygiene education and self-reported hand-washing behaviors among Korean adults during MERS-CoV-outbreak. *Health Educ Behav*. 2018;46:157–164.
- Akinyinka M R, Bakare O Q, Oluwole E O. Hand hygiene practices in the context of Ebola virus disease: a cross-sectional survey of Lagos residents. *J Infect Prev*. 2019;20:179–184.
- Loftus MJ, Guitart C, Tartari E. Hand hygiene in low- and middle-income countries. *Int J Infect Dis*. 2019;86:25–30.
- World Health Organization. Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19). 2020. Available at: [https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE\\_use-2020.2-eng.pdf](https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE_use-2020.2-eng.pdf). Accessed March 25, 2020.
- National Health Commission of the People's Republic of China. Technical guidelines for protection of medical personnel during COVID-19 epidemic period (trial). 2020. Available at: [http://www.henanyz.com/uploadAttach/20200224/20200224095242\\_338.pdf](http://www.henanyz.com/uploadAttach/20200224/20200224095242_338.pdf). Accessed March 25, 2020.
- Thompson D, Bowdley L, Brett M, Cheek J. Using medical student observers of infection prevention, hand hygiene, and injection safety in outpatient settings: a cross-sectional survey. *Am J Infect Control*. 2016;44:374–380.
- Stahmeyer JT, Lutze B, von Lengerke T. Hand hygiene in intensive care units: a matter of time? *J Hosp Infect*. 2017;95:338–343.
- Gammon J, Hunt J. The neglected element of hand hygiene - significance of hand drying, efficiency of different methods and clinical implication: a review. *J Infect Prev*. 2019;20:66–74.
- Szilagyi L, Haidegger T, Lehotsky A, et al. A large-scale assessment of hand hygiene quality and the effectiveness of the "WHO 6-steps". *BMC Infect Dis*. 2013;13:249.
- National Health Commission of the People's Republic of China. Specification of hand hygiene for healthcare workers WS/T 313—2019. *Chin J Infect Control*. 2020;19:93–98.
- World Health Organization. Guideline on hand hygiene in health care in the context of filovirus disease outbreak response. 2014. Available at: [https://apps.who.int/iris/bitstream/handle/10665/144578/1/WHO\\_HIS\\_SDS\\_2014.15\\_eng.pdf?ua=1](https://apps.who.int/iris/bitstream/handle/10665/144578/1/WHO_HIS_SDS_2014.15_eng.pdf?ua=1). Accessed March 25, 2020.
- Suen LKP, Lung VYT, Boost MV. Microbiological evaluation of different hand drying methods for removing bacteria from washed hands. *Sci Rep*. 2019;9:13754.
- Mody L, McNeil SA, Sun RJ, Bradley SF, Kauffman CA. Introduction of a waterless alcohol-based hand rub in a long-term-care facility. *Control Hosp Epidemiol*. 2003;24:165–171.
- Grayson ML, Melvani S, Druce J, et al. Efficacy of soap and water and alcohol-based hand-rub preparations against Live H1N1 influenza virus on the hands of human volunteers. *Clin Infect Dis*. 2009;48:285–291.
- Mona M, Nanda H, Usha U, Sanjay G, Maitreyee B. Comparison of traditional hand wash with alcoholic hand rub in ICU setup. *Indian J Crit Care Med*. 2005;9:141–144.
- Lydon S, Power M, Mcsharry J. Interventions to improve hand hygiene compliance in the ICU: a systematic review. *Crit Care Med*. 2017;45:e1165.
- Namrata S, Neelima A, Atul K. Ocular infections: prophylaxis and management; 2018.

25. Lambe KA, Lydon S, Madden C, et al. Hand hygiene compliance in the ICU: a systematic review. *Crit Care Med*. 2019;47:1251–1257.
26. Wang J, Feng H, Zhang S, et al. SARS-CoV-2 RNA detection of hospital isolation wards hygiene monitoring during the Coronavirus Disease 2019 outbreak in a Chinese hospital. *Int J Infect Dis*. 2020;94:103–106.
27. Wei W, Zheng D, Lei Y, et al. Radiotherapy workflow and protection procedures during the Coronavirus Disease 2019 (COVID-19) outbreak: experience of the Hubei cancer hospital in Wuhan, China. *Radiother Oncol*. 2020;148:203–210.
28. Loh LC, Chelliah A, Ang TH. Change in infection control practices and awareness of hospital medical staff in the aftermath of SARS. *Med J Malaysia*. 2005;59:659–664.
29. Phan LT, Maita D, Mortiz DC, et al. Personal protective equipment doffing practices of healthcare workers. *J Occup Environ Hyg*. 2019;16:575–581.
30. Kim PW, Roghmann MC, Perencevich EN, Harris AD. Rates of hand disinfection associated with glove use, patient isolation, and changes between exposure to various body sites. *Am J Infect Control*. 2003;31:97–103.
31. Cheng VCC, Tai JWM, Li WS. Implementation of directly observed patient hand hygiene for hospitalized patients by hand hygiene ambassadors in Hong Kong. *Am J Infect Control*. 2016;44:621–624.
32. Zhang S, Kong X, Lamb KV, Wu Y. High nursing workload is a main associated factor of poor hand hygiene adherence in Beijing, China: an observational study. *Int J Nurs Pract*. 2019;25:e12720.
33. Tschudin-Sutter S, Pargger H, Widmer AF. Hand hygiene in the intensive care unit. *Crit Care Med*. 2010;38:S299–S305.
34. Seligman HK, Wallace AS, Wallace DA, et al. Facilitating behavior change with low-literacy patient education materials. *Am J Health Behav*. 2007;31:S69–S78.
35. Ghisi GLDM, Abdallah F, Grace SL, Thomas S, Oh P. A systematic review of patient education in cardiac patients: do they increase knowledge and promote health behavior change? *Patient Educ Couns*. 2014;95:160–174.