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Global Perspective Article

Compared hand hygiene compliance among healthcare providers before and after the COVID-19 pandemic: A rapid review and meta-analysis

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Funding/support: This work is supported by special fund of Beijing Key Laboratory of Indoor Air Quality Evaluation and Control (No. BZ0344KF20-02).

Conflicts of Interests: None to report.

Author Contributions: LL and YYF contributed to the study concept. WY and YJR drafted the manuscript. Acquisition, analysis, or interpretation of data: All authors. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: All authors. All authors approved the final version of the manuscript.

Ethics approval and consent to participate: Ethical approval or informed consent was not necessary for this meta-analysis because our study has not affected participants directly, and required data were extracted from previous published studies.

https://doi.org/10.1016/j.ajic.2021.11.030
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INTRODUCTION

Health care-associated infections (HAIs) have had a negative impact on insurers and health systems globally due to prolonged hospitalization days, as well as increased hospitalization expenses, disease burdens, and waste of health resources.1,2 The additional total medical expenditure per HAI-Antimicrobial resistance inpatient was US$15,557.25 compared with that of the non-HAIs, and the additional length of per hospital stay of the HAI-Antimicrobial resistance inpatient was 41 days compared with that of the non-HAIs in China.3 It has been well established that hand hygiene (HH) is a cost-effective measure to reduce HAIs.4 A 3 year observational study showed a 10% improvement in HH associated with a 6% reduction in overall HAIs.5 From the front-line experience, during the outbreak of COVID-19, many factors, such as heavy workloads,6 interruption by other auxiliary workers and the HH opportunity for “before contact with patients” should be strengthened. In the future, it will be necessary to develop standardized HH monitoring tools for practical work.

METHODS

This meta-analysis was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) checklist.21 We developed a protocol and used systematic methods to identify relevant studies, screen study eligibility and assess the quality.

Inclusion and exclusion criteria

Studies were considered to be eligible for further evaluation if they met the following inclusion criteria: (1) an original article with valid HHC data among health care providers during the COVID-19 pandemic with appropriate observation methods being used to monitor HHC. Appropriate observation methods referred to anonymous observation, openly observation and electronic instrument were used by a third party to monitoring HH practices among health care providers during the COVID-19 pandemic, but it also reduces the burden of HAIs and the spread of antimicrobial resistance. It is notable that there is a gap between the knowledge of HH and HH compliance (HHC) among health care providers.13-15 Previous studies have documented that the compliance of HH was affected by many factors, such as heavy workloads,6 interruption by other things,17 forgetting to wash hands, shortages of HH facilities,16 and intolerance to the hand skin disinfectant18 caused by frequent HH. From the front-line experience, during the outbreak of COVID-19, hospitals strengthened intervention measures for the HHC among health care providers, including strengthening education, increasing monitoring frequency, posting notices and warning signs, and other measures.20,21 In addition, health care providers may have had a higher self-awareness of and ability to perform HH compared with other daily working conditions in during the contingency status of COVID-19. However, it is not known whether HH behavior and compliance among health care providers changed and what kind of changes may have taken place after the outbreak.22 Therefore, the aim of this study was to evaluate the overall HHC rate and characteristics of HHC during the COVID-19 pandemic and conduct in-depth comparison with the situation before the epidemic so as to make evidence-based suggestions to improve the HHC in the future.

Data extraction

Each study was screened by 2 independent reviewers (WY and YJR) according to the study eligibility criteria and the retrieved data from all the publications meeting the inclusion criteria. The retrieved data were crosschecked to ensure accuracy, and any disagreements were resolved by consensus through discussion. The information extracted included: (1) publication data: name of first author, publication year, geographic location, literature types (randomized clinical trials; cross-sectional study or before-after study), and HH monitoring period; (2) social demographic characteristics of the study population: sample size, age, gender, department, years of work, and whether the hospital/ward was designated for COVID-19; (3) the HH characteristics: HHC rates, actual number of HH actions, and number of HH opportunities; (4) the subgroups divided according to...
control trial (RCT) study. All the studies were conducted and I² statistics, which quantified the heterogeneity of the studies was evaluated using the Cochrane Q test. Many, 1 in Italy, and 1 in India, including 3 cross-sectional studies were performed in designated COVID-19 hospitals or wards. Most of the studies (6/10) took the hospital as the whole unit to conduct the overall study. Among all the health care providers included, 64 (48.8%) worked in ICU, accounting for the vast majority, followed by 46 (35.1%) in surgery and 21 (16.0%) in internal medicine. A total of 1891664 HH actions and 3591681 HH opportunities were observed in 10 studies. For the observation method of HH compliance, the researchers adopted the secret observation method (3 groups), open observation method (6 groups), mixed secret and open observation method (one group), and automated monitoring system (one group) separately. Six studies reported the HH rate of different occupations, 6 studies reported the HH rate at different WHO 5 HH opportunities, and all 10 studies reported different observation methods of HH.

Risk of bias

As the extracted information was not affected by the intervention factors, the Newcastle-Ottawa quality assessment scale was used to evaluate the quality of the literature. Consequently, only 1 of 10 studies (10%) had a moderate risk of bias and 9 (90%) had a low risk of bias (Supplementary Table 1).

Meta-analysis outcome

More than 2 subgroups were observed in 5 studies, and finally 16 subgroups were included in the meta-analysis. The overall compliance rate of HH was 74% (P = 100%, P < 0.0001; 95% CI: 68%–79%). The highest and lowest HH compliance reports were 95% and 47%, respectively, which were all from the subgroup data of 3 COVID-19 pandemic periods in Germany. Of the data, 60% reported that HH was higher than 80%. The overall HH of the health care providers were at a high level during the COVID-19 pandemic.

Seven groups of studies reported the HH of health care providers for different occupations. The overall HH was 76% (P = 100%, P < 0.0001; 95% CI: 72%–79%). As shown in Figure 3, nurses had the highest HH (80%; 95% CI: 74%–87%), followed by doctors (76%; 95% CI: 71%–81%), and the lowest was for other staff (70%; 95% CI: 62%–77%). Among the other staff, the reported lowest HH was only 55%. The HH of nurses was 10% higher than that of other staff. There was a gap in the HH of different occupations in the hospital, so the education of HH should be strengthened for auxiliary workers in the hospital.

RESULTS

Study characteristics

The initial database search obtained 826 unique citations, of which 488 were removed for duplicates. 43 were retrieved based on their title and abstract content. Of the 43 retrieved articles, 4 articles reported incomplete data and 22 articles were excluded because they did not contain the primary objectives. Ten eligible studies were identified for the meta-analysis. The list of excluded studies and reasons for exclusion are shown in Figure 1. Among the 10 included studies, 6 studies were carried out in China, 1 in America, 1 in Germany, 1 in Italy, and 1 in India, including 3 cross-sectional surveys, 6 before-after studies, and 1 randomized controlled trial (RCT) study. All the studies were conducted between December, 2019 and April, 2021, and the HH rates ranged from 46% to 100% (Table 1).

According to the information in the literature, 2377 health care providers were included in the study. A total 1360 of nurses participated in the study, which was the main observation population accounting for 57.21%, followed by 833 doctors (35.04%) and 184 other health care providers (7.74%). Five studies were performed in designated COVID-19 hospitals or wards. Most of the studies (6/10) took the hospital as the whole unit to conduct the overall study. Among all the health care providers included, 64 (48.8%) worked in ICU, accounting for the vast majority, followed by 46 (35.1%) in surgery and 21 (16.0%) in internal medicine. A total of 1891664 HH actions and 3591681 HH opportunities were observed in 10 studies. For the observation method of HH compliance, the researchers adopted the secret observation method (3 groups), open observation method (6 groups), mixed secret and open observation method (one group), and automated monitoring system (one group) separately. Six studies reported the HH rate of different occupations, 6 studies reported the HH rate at different WHO 5 HH opportunities, and all 10 studies reported different observation methods of HH.

Quality assessment

We used the Newcastle-Ottawa quality assessment scale to assess the methodological quality and risk of bias for each included study. Studies received as many as 9 points based on participant selection (4 points), study comparability (2 points), and outcome of interest (3 points). Studies were classified as having high (≥3 points), moderate (4–6 points), and low (≥7 points) risk of bias. One of the authors (LL) evaluated study quality. RevMan software was used to perform a sensitivity analysis by excluding one study at a time to validate the stability of the results in our meta-analysis. Subgroup analyses were also performed by occupation, the WHO 5 moments of HH, or observation methods to analyze the sources of potential heterogeneity.

Statistics analysis

The HH compliance rates were chosen as the primary outcome, which were measured by the HH actions (X) and HH opportunities (N). To implement a non-contrast binary data meta-analysis, the DerSimonian and Laird model was used to yield a point estimate and a 95% CI for HH compliance rate; the data were processed to give the rate of HH compliance and standard error (SE); Rate of HH (P) = X/N × 100%; SE = √[P(1 − P)/N]. The heterogeneity of the studies was evaluated using the Cochrane Q test and I² statistics, which quantified the inconsistencies among the studies. Heterogeneity was considered significant if the P-value was less than 0.05, and the I² was greater than 50%. A random-effects model was used for comparisons when heterogeneity was observed; otherwise, a fixed-effects model was used. For comparisons across covariates (ie, occupations, the WHO 5 moments of HH, and observation methods), the study was treated as a random effect. The analyses were performed using the Review Manager software (version 5.4.1, The Cochrane Collaboration, Oxford, UK). Publication bias was assessed using funnel plots. A symmetrical inspection of the inverted funnel was regarded as having no significant publication bias. In contrast, skewed and asymmetrical funnels showed a bias.
The HHC of open monitoring combined with anonymous monitoring was 41.8% higher than that of anonymous monitoring. There was a gap in the compliance of the HH under different monitoring conditions.

**Sensitivity analysis**

After deleting the included studies 1 by 1, no significant changes in the effect value and confidence interval were found in the overall HHC rate and HHC in different occupations, hand washing moments, and observation methods, indicating that the results were relatively stable.

**Publication bias**

A funnel plot was performed to evaluate the potential publication bias of the 4 outcome indicators, including the overall HHC, HHC in occupation, hand washing moments, and observation methods. It can be seen that the distribution of each study was basically symmetrical, suggesting that the possibility of publication bias was small (Supplementary Fig 2-5).

**DISCUSSION**

During the COVID-19 pandemic, the compliance of HH among health care providers showed a significant increase compared with the situation before the outbreak. The HHC reported by the WHO, previous meta-analyses, and other research systems before COVID-19 was 5%-89%, and levels of HHC for high-income countries rarely exceed 70%. Among the studies included in this paper, a total of 6 studies researched the health care providers’ HHC rate changes before and after the pandemic, including 2 cross-sectional surveys and 4 time before-after studies. Zhang Xiangxiang found that during the non-COVID period from June 1, 2019 to November 30, 2019, the HHC rate of health care providers in the fever clinic was 70.67%, while during COVID-19, HHC rates increased to 90.52%. Liu Sidi found that from 2016 to 2019, the HHC rate of health care providers in a grade A class hospital increased year by year, from 71.65% in 2016, 73.27% in 2017, 75.94% in 2018, and 77.04% in 2019, while from January to August 2020, the compliance rates increased significantly to 84.16%. For the changes of HHC before and after the COVID of health care providers, Moore, Derksen, Zhao Tingting, and Ragusa reported that the HHC increased from 46% to 56%, 47% to 100%, 76% to 81%, and 62% to 66% respectively.
Moreover, 5 meta-analyses of HHC before COVID-19 were included. All the 5 literatures were comparative analysis focused on before and after HH intervention. The lowest HHC before intervention was 29%, and the highest HHC reported after intervention was 80.1% (Table 2). The research on HHC before the pandemic paid close attention on the exploration of intervention measures. The main intervention measures included information monitoring, education, training, encouragement, facility provision and so on. However, with

### Table 1
Basic information of studies

| Study                | Country          | Article type              | Study period                  | Main conclusions                                                                 |
|----------------------|------------------|---------------------------|-------------------------------|----------------------------------------------------------------------------------|
| Du Miao 2020         | Beijing, China   | Randomized controlled trial | Jan-May, 2020                 | Under Hawthorne effect, the HHC rate of health care provider in open observation (82.82%) was higher than that in secret observation (71.45%)(P < .05), and it was most obvious among doctors (Hawthorne effect = 16.33). |
| Zhang Xuan 2020      | Shandong, China  | Cross-sectional study     | Feb, 2020                     | The overall high HHC rate (81.46%) may be related to the professional training before supporting Wuhan and protection experience of the front line. |
| Zhang Xiangxiang 2020| Fujian, China    | Cross-sectional study     | Dec 1, 2019-May 31, 2020      | The HHC rate of health care provider was significantly higher (90.52%) than that in nonpandemic period (70.67%) (P < .001). |
| Liu Sidi 2020        | Hunan, China     | Before-after study        | Jan-Aug, 2020                 | Under the influence of COVID-19, health care providers have a strong sense of self-protection. Before and during pandemic, HHC rate was 71.65% vs 84.16% (P <.001). |
| Moore 2021           | Ohio, USA        | Before-after study        | Jan 5-Mar 14, 2020            | HHC rates increased from 46% to 56% in the months preceding pandemic-related school closures (P <.001), which was followed by a 6% upward shift at the time school closures occurred. |
| Derksen 2020         | Bremen, Germany  | Before-after study        | Jan 1-Jan 28, 2020            | Facing COVID-19 pandemic, health care providers adapt their HH behavior and the HHC were increased following 3 period: 47% in pre-COVID-19 pandemic period, 79% in heightened awareness period, and 100% in strict precautions period (P < .001). |
| Zhou Qian 2020       | Wuhan, China     | Cross-sectional survey    | Mar 5- Mar 7, 2020            | HHC rate was highest in HH behavior (96.71%), followed by HH procedure (95.74%), duration (88.93%), and hand drying method (88.42%) (P <.001). |
| Zhao Tingting 2021   | Hangzhou, China  | Before-after study        | Feb 1, 2019-May 31, 2019      | The psychological pressure brought by the spread of COVID-19 may promote the HHC rate of doctors and nurses from 75.93% to 81.14% (P < .001). |
| Ragusa 2021          | Catania, Italy   | Before-after study        | Jan 1, 2015-Dec 31, 2020      | Compared with the HHC rate of 62% in 2016 and 66% in 2020, the HHC rate has not increased greatly, which may be related to the shortage of medical materials and poor working environment, the health care providers probably already did the maximum. |
| Anguraj 2021          | Pondicherry, South India | Before-after study | Nov, 2020-Apr, 2021           | Auditing HH and providing timely feedback significantly improved HHC from 26.7% in November 2020 to 68.4% in April 2021. |

### Table 2
Social demographic characteristics of health care providers

| Study                | No. of health care providers | Occupation (Doctor/Nurse/Other*) | Working department | Observation method | HHC rate (HH actions/opportunities) | SE | Subgroup          |
|----------------------|------------------------------|----------------------------------|--------------------|-------------------|-------------------------------------|----|-------------------|
| Du Miao.a 2020       | 34                           | 5/25/4                           | ICU                | Secretly          | 0.71450 (468/655)                  | 0.01765 | 1①②③             |
| Du Miao.b 2020       | 34                           | 5/25/4                           | ICU                | Openly            | 0.86156 (641/744)                  | 0.01266 | 1①②③             |
| Zhang Xuan 2020      | 100                          | 0/100/0                          | ICU: 30; Surgery: 46; Internal: 21; Other: 3 | Openly            | 0.81405 (788/968)                  | 0.01251 | ③                |
| Zhang Xiangxiang 2020| 1189                         | 427/603/159                      | Fever clinic       | Secretly + Openly | 0.90524 (7604/8400)                | 0.00320 | ①②③             |
| Liu Sidi 2020        | NA                           | NA                               | One tertiary A-level hospital | Secretly          | 0.84161(28751/34162)              | 0.00198 | ①②③             |
| Moore 2021           | NA                           | NA                               | Nine hospitals     | Automated monitoring | 0.48477 (1044060/2153702)         | 0.00034 | ③                |
| Derksen 2020         | 115                          | 44/50/21                         | Two obstetric university hospitals | Openly            | 0.57989 (801707/1382512)           | 0.00042 | ①②③             |
| Zhou Qian 2020       | NA                           | NA                               | One tertiary A-level hospital | Secretly          | 0.47297 (70/148)                  | 0.04104 | ③                |
| Zhao Tingting 2021   | 939                          | 357/582/0                        | 45 clinical departments | Openly            | 0.81142 (3580/4412)               | 0.00089 | ①②③             |
| Ragusa 2021          | NA                           | NA                               | NA                 | Openly            | 0.66015 (2092/3169)               | 0.00084 | ①②③             |
| Anguraj 2021         | NA                           | NA                               | COVID ICUs         | Openly            | 0.65323 (1458/2232)               | 0.01007 | ①②③             |

Note:
*Designated hospital/ward for COVID-19.
*Other occupations include medical interns, regular training students, hospital cleaners, logistics personnel, etc.
①Subgroup for different occupations; ②Subgroup for WHO five moments of HH; ③Subgroup for differential observation methods.
the outbreak of COVID-19, medical personnel pay more attention to HH, which may be caused by the improvement of health care providers' self-protection awareness, the psychological pressure brought by the spread of the pandemic, etc. Consciousness of HH among health care providers were an unprecedented unity during the COVID-19. From the systematic review of this study, the literatures related to HH published during COVID-19 generally lack the research on the precise transmission path of hand as a media. In addition, there was a lack of direct quantitative research that HH caused environmental contamination of SARS-Cov-2 and population infected with COVID-19.

Notably, a series of characteristic changes have taken place in HH behavior among health care providers during the pandemic. Our study found that the concern about HH behavior during the pandemic period was based mainly in fever clinics, ICUs, and designated COVID-19 wards. Before the outbreak, the reporting departments of HH monitoring were carried out mainly in the ICU or the whole hospital, and targeted less on fever clinics and infectious disease-related departments. At present, given that HH needs to be carried out in any diagnosis and treatment situation, the actual implementation is difficult. The results of this study suggest that infectious disease-related diagnosis and treatment departments can be a breakthrough point to improve HH. Additionally, another change in HH was observed in the group. This study showed that during the COVID-19 pandemic, the HHC of other auxiliary staff was the lowest, except for doctors and

![Fig 2. Forest plot of HHC of health care providers during COVID-19 pandemic.](image1)

![Fig 3. Forest plot of HHC of health care providers among different occupations during COVID-19 pandemic.](image2)
nurses, while a 3-year HH monitoring report conducted in China from 2016 to 2019 showed that doctors were the group with the lowest HHC. It showed that while the HHC of doctors had improved greatly after the pandemic, the HH of other auxiliary staff may have been ignored. The observation from Novák indicated that the reasons for decreased compliance with hand washing protocols may have been related to forgetting to wash the hands or not being acquainted with hand washing protocols at

![Fig 4. Forest plot of HHC of health care providers among different washing opportunities during COVID-19 pandemic.](image-url)
all. It is generally accepted that the hand of the auxiliary staff, including the cleaning personnel, specimen transfer personnel, and logistics personnel, have carried pathogens and viruses easily. The WHO-5 opportunities of HH, showed that the compliance with HH was the lowest for "before contact with patients," and the highest for "after contact with patients' body fluids or blood," which was consistent with the relevant reports of HH before the epidemic. We speculated that obvious visible stains on the hands of health care providers after contacting the body fluids or blood of patients increased the frequency of hand washing. The behavior of "before contacting patients" occurs frequently in daily diagnosis, treatment and emergency rescue, which affects the implementation of HH to a certain extent.

It is important to highlight the monitoring mode of the HHC. The literature included in this study was mainly mentioned open monitoring and anonymous monitoring. Only one study has reported the use of an automatic monitoring system for supervising HHC. According to our study, there was significant differences in HH between manual and automatic monitoring. When we reviewed the literature, we found that there were many kinds of interventions to improve HHC. However, it is precisely that the observation and monitoring of HHC itself cannot achieve relative consistency and is affected by whether the monitors are professionally trained, the personal observation bias of the monitors.

The state of the World’s HAND HYGIENE documented that there is also growing interesting in electronic monitoring, focused on the point of care, as reliable systems are developed. In addition, the manual monitoring of HH also costs a certain amount of manpower, and it cannot be systematic and sustainable. Therefore, in the future, we will call for more artificial intelligence and AI technology to be used in HH monitoring.

This study had some limitations. The data of areas without reported HHC were not available during the time of the study; therefore, the assessment of HHC during the global pandemic was limited to the reported areas. However, we consider that the limitations of the present study cannot offset the main results of this study. To sum up, this was the first study to comprehensively and systematically analyze the compliance of HH during the pandemic, and compared with the situation before the pandemic. It provided a comprehensive evidence-based basis for us to comprehensively understand the situation of HH during the epidemic.

CONCLUSION

During the COVID-19 pandemic, the compliance of the health care providers’ HH showed a great improvement. The fever clinics have become the focused departments for monitoring HH. The HHC of auxiliary workers and the opportunity of “before contact with patients” should be strengthened. In the future, it will be necessary to develop standardized HH monitoring tools for practical work.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2021.11.030.

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