American Journal of Infection Control 000 (2023) 1–6

Contents lists available at ScienceDirect

American Journal of Infection Control

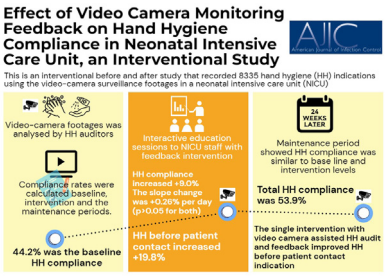
journal homepage: www.ajicjournal.org

Major Article

Effect of video camera monitoring feedback on hand hygiene compliance in neonatal intensive care unit, an interventional study

Huseyin Bilgin MD, MPH [a,*], Uluhan Sili MD, PhD [a], Nazli Pazar RN [b], Isil Kucuker RN [b], Eda Kepenekli MD [c], Meral Agirman Yanar RN [d], Asli Memisoglu MD [d], Eren Ozek MD [d], Neill KJ Adhikari MDCM, MSc [e,f], Ruxandra Pinto PhD [e], Volkan Korten MD [a]

[a] *Department of Infectious Diseases and Clinical Microbiology, Marmara University School of Medicine, Istanbul, Turkey*
[b] *Infection Prevention and Control, Marmara University Hospital, Istanbul, Turkey*
[c] *Department of Pediatric Infectious Diseases and Clinical Microbiology, Marmara University School of Medicine, Istanbul, Turkey*
[d] *Department of Neonatal Intensive Care Unit, Marmara University School of Medicine, Istanbul, Turkey*
[e] *Department of Critical Care Medicine, Sunnybrook Health Sciences Centre, Toronto, Canada*
[f] *Interdepartmental Division of Critical Care Medicine, University of Toronto, Toronto, Canada*



Key Words:
Video camera footage
Glove use
Hawthorne effect
Hospital acquired infections

A B S T R A C T

Background: The purpose of this study was to determine whether use of a video camera surveillance system for hand hygiene (HH) monitoring, video-based education, and feedback could improve the HH compliance in a neonatal intensive care unit (NICU).

Methods and materials: This was an interventional before-after trial conducted in a level-III NICU between July 2019 and June 2020. HH compliance was measured using randomly selected video-camera footage in the baseline, intervention, and maintenance periods. After the baseline, an intervention consisting of feedback and education with video scenarios was implemented. The primary outcome was change in HH compliance. The compliance rates were analyzed as an interrupted time series (ITS) with a segmented regression model adjusted for autocorrelation for each study period.

Results: We identified a total of 8335 HH indications. There were non significant increases in the total compliance rate (9.0%, 95% CI -2% to 20%) at the time of intervention and in the compliance rate after intervention (0.26%, 95% CI -0.31% to 0.84%) per day. The hand hygiene compliance before patient contact significantly increased (19.8%, 95% CI, 4.8%-34.8%). Incorrect glove use improved non-significantly with the intervention (-3.4%, 95% CI -13.4% to 6.7%).

Conclusion: In this study of HH monitoring using video-camera footage combined with an intervention including feedback and education, there were inconsistent improvements in HH compliance. However, these

* Address correspondence to Hüseyin Bilgin MD, MPH, Department of Infectious Diseases and Clinical Microbiology, Marmara University Hospital, Fevzi Cakmak Mah, Muhsinyazicioglu Cad No: 10 Pendik, Istanbul, Turkey.

E-mail addresses: husambilginer@gmail.com, husambilginer@hotmail.com (H. Bilgin).

Conflicts of interest: None to report.

https://doi.org/10.1016/j.ajic.2022.12.011

improvements were not sustained in the long term. Frequent feedback and education may be required to sustain high compliance.

Health care associated infections (HAI) cause significant mortality, morbidity, and excess health care expenses worldwide.[1] The estimated pooled prevalence of HAIs in developing countries is over 10%.[2] In Turkey, the burden of HAIs is around 13%. HAI is also a serious problem in patients admitted to neonatal intensive care units (NICU).[3,4] In a multicentre point prevalence study from Turkey, the total HAI prevalence was 7.6% in neonatal intensive care units (NICU).[5]

Compliance with World Health Organization's (WHO) 5 hand hygiene (HH) moments is a critical factor for prevention of HAIs.[6,7] Low HH compliance is a universal problem. In a systematic review of hand hygiene studies, the mean HH compliance rate was 40%.[8] In another systematic review of 16 clinical trials, the mean compliance rate was 34.1% which increased to 56.9% after an intervention.[1] To improve low compliance rates, several HH monitoring and improvement programs have been implemented.[9] The majority of these programs monitor HH compliance using direct observation, but this methodology has major drawbacks including being labor intensive, undercounting hand hygiene opportunities (HHO), Hawthorne effect and observer bias. The Hawthorne effect overestimates high compliance rates, which are not sustained after the audit ends.[10] To overcome these shortcomings, electronic devices can be used to assess HH compliance of health care workers (HCWs). Electronic HH monitoring includes video-camera monitoring, monitoring and feedback using employee badges with radiofrequency, and other wearable technology that provides HH reminders. The mean HHOs observed with electronic method is almost 800 times more compared to direct observation methodology.[9]

This study investigates the effect of a single intervention of HH monitoring with video-camera, education, and feedback on HH behavior of HCWs in NICU in a tertiary care center in Istanbul, Turkey.

METHODS AND MATERIALS

Setting

Marmara University Pendik Research and Training Hospital is 650-bed tertiary care center in Istanbul. The study was conducted in the 14-bed NICU of the hospital. All HCWs with direct patient contact or with the patient environment (physician, nurse, housekeeping) were included in the study. A video camera surveillance system was in place in all NICU rooms since 2018. Five cameras visualizing the whole room, sinks and alcohol-based hand rub dispensers (Fig 1).

Study design and participants

We designed an interventional quasi-experimental before-after study with interrupted time series analysis. The research took place in NICU from July 2019 to June 2020. We included nurses, attending physicians, resident physicians, environmental services staff, and medical assistants who work in NICU.

Data collection

Seven, trained HH observers participated in the study. These observers achieved at least 80% concordance before the study. The HH observers monitored the video footages by means of HH behavior according to WHO HH observation guideline.[11]

HH compliance data was collected using a mobile app (SpeedyAudit Version 89, HandyMetrics Corporation). HH monitoring was performed from randomly selected periods of 20 minutes of footage in three shifts consisting of morning (08:00 AM-04:59 PM), afternoon (05:00 PM-11:59 PM) and night (12:00 AM-07:59 AM) for each data collection period.

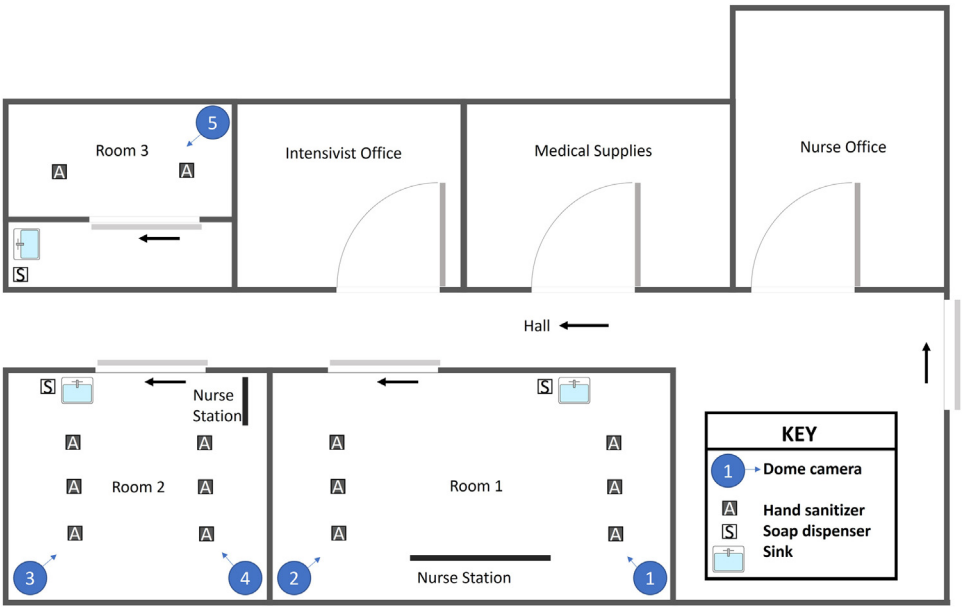


Fig 1. Location of the rooms, video cameras and hand hygiene materials in NICU.

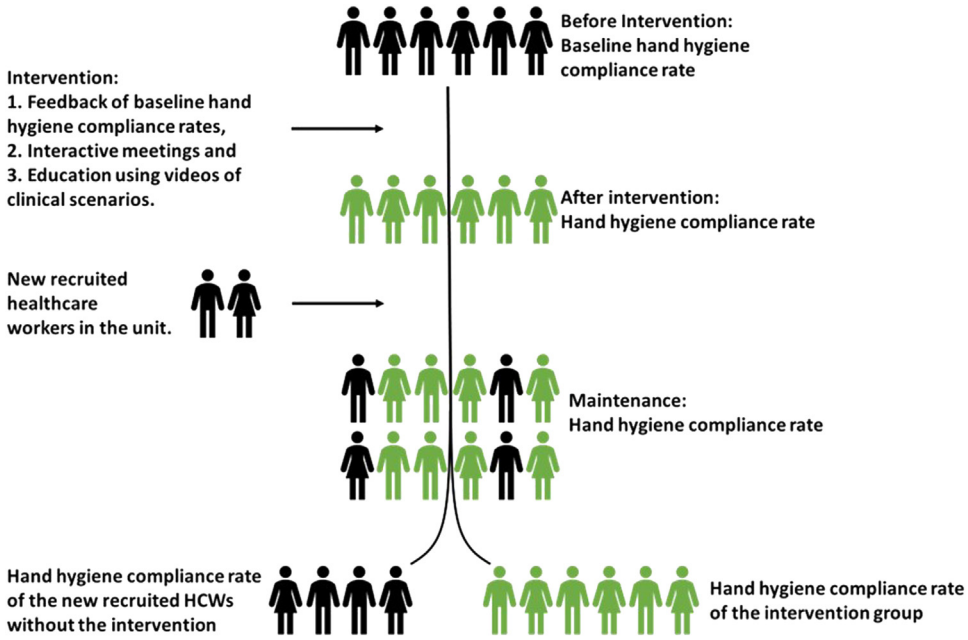


Fig 2. Flow diagram of the study.

All HCWs in the room during the 20 minute observation period were monitored for HHOs. Each HHO was stratified as compliant or noncompliant and was classified according to the three of WHO's My 5 Moments for HH: before touching a patient (moment 1), after touching a patient (moment 4), and after contact with the patient's environment (moment 5). HH moments before an aseptic task (moment 2) and after body fluid exposure risk (moment 3) were not included due to resolution of video camera surveillance system. HCWs could comply by using either soap and water or alcohol-based handrub solution. Presence of gloves in noncompliant moments were recorded. Due to low resolution of the video camera system, professions of HCWs could not be identified and recorded. All the data were automatically loaded into database organized chronologically by room and shifts of the day.

The HCWs in the unit were aware of the video camera surveillance system and were informed that video cameras were used to monitor HH behavior only, without violating any patient or employee privacy. The collected data did not include any patient or employee identifying information. A waiver of informed consent was issued by the Marmara University School of Medicine Institutional Ethical Review Board (IRB#: 09.2019.710).

Compliance was calculated as [(total number of compliant HHOs across all subjects) / (total HHOs for all subjects)] $\times$ 100. Missed HH with glove use was calculated as [(total number of missed HHOs with gloves on) / (number of missed HHOs)] $\times$ 100. Indications per minute was calculated as [(total number of HHOs/total minutes of observation)].

Baseline period (Preintervention)

We observed the HH behavior of HCWs using the video camera surveillance for four weeks starting on July 2019-August 2019. During this period no HH compliance feedback was given to the staff. This gave us the baseline HH compliance rates of NICU.

Intervention

The intervention took place in December 2019. We reported baseline HH compliance rates during meetings with NICU staff. All investigators, nursing, and physician leaders and environmental services staff of NICU were present in the meetings. During these meetings infection control measures, examples of common HH mistakes the team made were emphasized. For that purpose, we designed 6 scenarios explaining HH indications, glove use and the optimal workflow to increase HH compliance rates. Video recording of these scenarios were made. A pilot video was shown to a focus group of NICU workers to assess the clarity of the messages. These videos were shown to the HCWs during the meetings. Meetings were carried out in an interactive fashion with questions, answers and feedback from the HCWs and investigators. In addition to these HCWs, new staff were hired after the intervention period. However, these newly hired HCWs only received standard infection control education, not the intervention. This standard education program includes sessions regarding hand hygiene and glove use in the NICU, which is routine preemployment process for new NICU HCWs. Infection prevention nurses also carry out routine HH audits in NICU. However, during the study period, HH audit sessions were discontinued since it would produce observer bias. The investigators then conducted HH observation from December 2019 to February 2020, for 6 weeks after the intervention.

Sustainability of the intervention (Maintenance)

We measured HH compliance rates for 4 weeks from June to July 2020, 24 weeks after the intervention, to investigate the sustainability of the intervention. During these 24 weeks, newly recruited HCWs joined the NICU team. They received no intervention other than standard orientation education from the hospital infection prevention and control team. Figure 2 presents a flow diagram of the design and measurements of the study. The maintenance period coincided with the beginning of COVID-19 pandemic period in Turkey.

Sample size

We used G-power program for sample size calculation. With a power of 90%, 0.05 type I error rate and an anticipated 10% absolute

increase in HH compliance from a 40% baseline rate, we planned to record 538 HHOs for each period (1,614 HHOs total).

Outcomes

The primary outcome was change in total HH compliance rate, in the postintervention period compared to the before period, and in the maintenance period compared to the before period. The secondary outcomes were indications per minute, missed HH with gloves on, compliance before touching a patient, after touching a patient, and after contact with the patient's environment, with each comparison as per the primary outcome.

Statistics

To evaluate the impact of the intervention, HH compliance rates were tested as an interrupted time series with a segmented regression, and if the Durbin-Watson test for autocorrelation was significant, we used an autoregressive term for errors. The time series was divided in to three segments: before the intervention, after the intervention, and 24 weeks after the intervention. HH compliance rates of the non-intervention employee group were compared with the baseline period. The primary outcome and indications per minute were analyzed as rates per day. All other outcomes were analyzed using an average percentage over 4 days.

We analyzed the categorical variables using chi-square and Fisher-exact tests, and continuous variables using Mann-Whitney U test or t test based on distribution of the data. Statistical analyses were performed using SAS 9.4 (SAS Institute Inc.).

RESULTS

During the study, we performed 97 29 video monitoring sessions accounting for 1,940 minutes of video footage. Overall, we identified a total of 8335 HHOs. During the 4 preintervention weeks, we observed 3,127 HHOs, of which 1,383 (44.2%) were classified as compliant. In the postintervention phase there were 4,031 opportunities, of which 2,353 (58.4%) were compliant. Finally, in the maintenance phase we observed 760 opportunities, of which 410 (54.0%) were compliant. The compliance rate of HCWs who received the intervention was 53.9% in the maintenance period. Meanwhile the compliance rate of newly recruited HCWs who did not receive the intervention was 51.5% in the maintenance period.

Interrupted time series analysis of indications per minute showed no difference at the time of intervention (increase of 0.32, 95% CI [-0.12-0.76]) and no change in slope postintervention (-0.019, 95% CI [-0.044-0.005]) when compared to baseline. There was a statistically significant decrease in the indications per minute at the start of the maintenance period (-0.50, 95% CI [-0.99-0.02]), with no change in slope during the maintenance period (Fig 3). There were non-significant increases in the total daily compliance rate (9.0%, 95% CI [-2%-20%]) at the time of intervention and after the intervention (0.26%, 95% CI [-0.31%-0.84%]) (Fig 4). The hand hygiene compliance before patient contact significantly increased (19.8%, 95% CI [4.8%-34.8%]). Hand hygiene compliance of moments 4 and 5 did not change during the study period. Incorrect glove use rate did not significantly decrease at the time of intervention (-3.4%, 95% CI [-13.4%-6.7%]). Newly recruited HCWs compliance rates were compared with the maintenance rates of the intervention group. Overall compliance rate was similar to the intervention group (data not shown).

DISCUSSION

Summarizing the main results

In this interventional quasi-experimental study in a NICU, we observed a statistically nonsignificant improvement in the overall HH compliance after a scenario-based education intervention. Rate of missed HH with glove use did not change; however, HH moment 1 (before patient contact) and indications per minute significantly

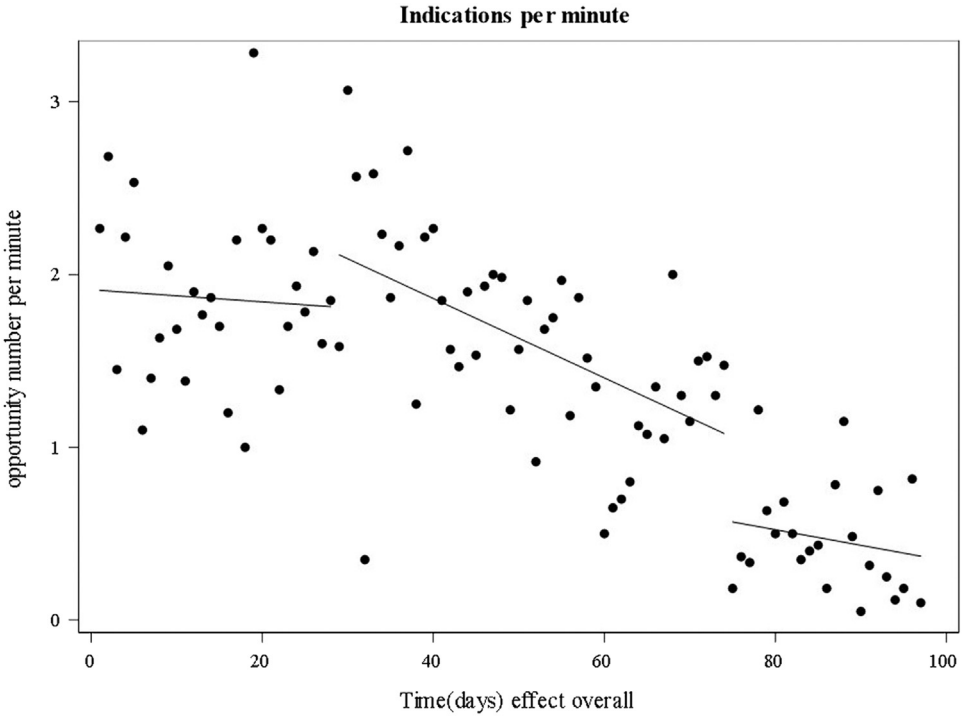


Fig 3. The indications per minute by study timeline. The colored shapes indicate the different phases of the study. Lines indicate the trend line of the indications per minute.

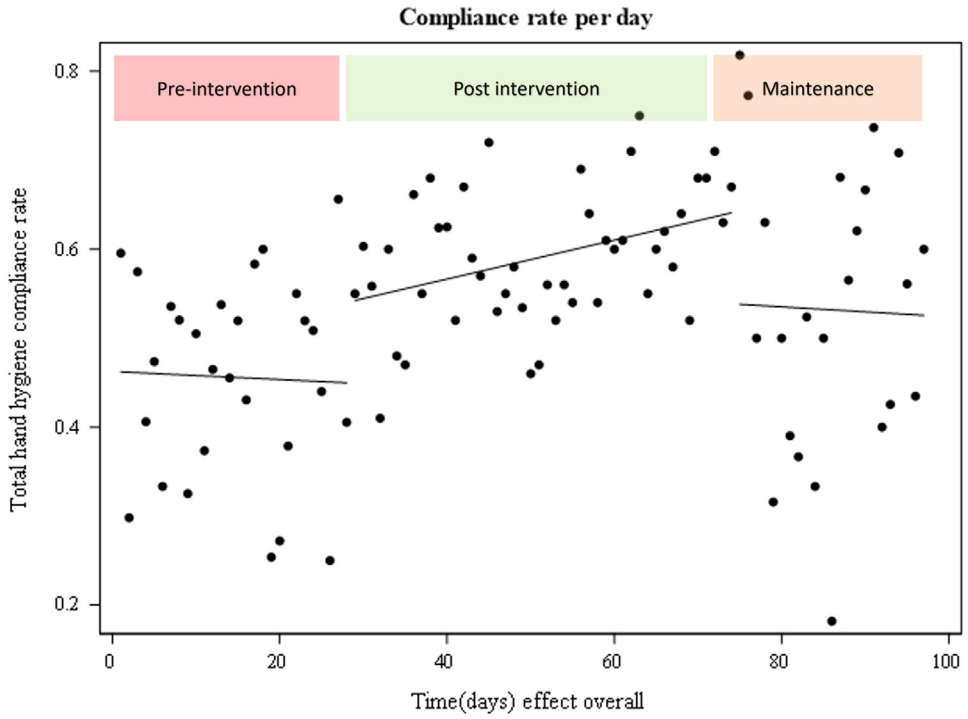


Fig 4. The hand hygiene compliance rates of the intervention group by study timeline. The colored shapes indicate the different phases of the study. Lines indicate the trend line of the hand hygiene compliance rates.

increased. Indications per minute decreased in the maintenance period. HH compliance and incorrect glove use were not different between baseline and the maintenance period.

Previous hand hygiene studies in our medical center

A study performed in adult intensive care units of our hospital showed that the overall HH compliance rate was 40.6%. This study revealed that despite regular HH trainings that HCWs received, they did not consistently implement HH moments in daily practice. While compliance is low, it still could be an overestimation since audits were done using direct observation, which is prone to the Hawthorne effect.[12] A study in our NICU in 2013 collected 704 HHOs, with and overall compliance rate of 37%.[13] Our baseline compliance rate was 44.1%, similar to previous measurements.

NICU studies on hand hygiene and electronic monitoring technologies

In a study conducted at a NICU in a tertiary care center, the baseline HH compliance rate was 46% and improved to 69%, using direct obsservation, after education, reminders, and audit and feedback.[14] Raskind et al showed that a high compliance rate of 89% before an intervention which increased up to 100% after the intervention.[15] In both studies, the authors suggested that improvements resulted from educational interventions and Hawthorne bias.[14,15] Video camera recordings were also previously used to assess hand hygiene compliance in NICUs. Brown et al showed that hand washing compliance was 23.6% using random video footage from nursing shifts for a 2-month period.[16] Shah et al used a motion activated video cameras above hand washing stations and found that 15% of the hand washing procedures were unacceptable according to WHO's hand hygiene protocol.[17] A meta-analysis of HH interventions in NICUs concluded that individual- or group-level performance feedback was crucial to improving HH compliance.[18]

Armellino et al showed improvement in HH compliance from 6.5% to 81.6% after real time feedback to HCWs using remote video camera monitoring.[19] This increase was maintained during the 75 week study period, with a compliance rate of 87.9%. Carillo et al measured HH compliance using video camera footage in a hemodialysis unit and designed an intervention with feedback and education using compliant and noncompliant video samples. The HH compliance increased by an average of 30.6% after the intervention.[20]

The effect of the intervention in our study

In the preintervention phase, HCWs were informed about the cameras and HH audits. However, during the preintervention phase there was no change in the HH behavior. The total compliance rate was low (44.1%), in line with other studies. After the intervention, overall HH compliance rates and incorrect glove use did not significantly improve, but compliance to moment 1 (before patient contact) showed a significant improvement. We believe that continuous feedback using and repeated education sessions would likely be necessary to achieve a sustained and clinically meaningful effect.[21]

Effect on glove use

Despite repetitive training, HCWs may misuse gloves when a hand hygiene indication arises, for example by removing them and not performing hand hygiene, thus increasing the risk of cross contamination. In our study, the rate of missed hand hygiene with gloves on declined from 11.8% to 8.0% after the intervention. However, in the maintenance period the rate increased back to baseline level. Similarly, a prospective observational study from France measured the misuse of gloves in ICUs as 64.4%.[22]

Strengths and limitations

Strengths of the study include analysis of a large volume of HH behavior, in line with other studies,[23,19] use of electronic monitoring to decrease the Hawthorne effect from direct personal observation;[24] and ability to design a focused intervention based on an appreciation of NICU workflow.

Limitations include lack of real-time feedback to HCWs and inability to evaluate HH compliance at moments 2 (before an aseptic task) and 3 (after body fluid exposure risk). However, studies suggest that moments 1, 4, and 5 provide the majority of HHOs and suffice for estimating total compliance.[25] We could not calculate HH compliance rates of different professions, which may differ, although studies have shown similar compliance levels among nurses, physicians and radiology technicians.[16] Another limitation is the impact of COVID-19 on the maintenance period, which may have confounded our findings if glove use increased and appropriate HH decreased. We were not able to measure the burden of COVID-19 patients in the unit during the maintenance period.

In summary, our study found that HH monitoring using video camera footage combined with an intervention including feedback, interactive meetings, and education improved hand hygiene compliance non-significantly. These small improvements were not sustained in the long term follow up. More frequent feedback and education may be required to sustain high HH compliance.

Acknowledgments

We would like to express our gratitude to the NICU team for their participation and collaboration.

References

1. Kingston L, O'Connell NH, Dunne CP. Hand hygiene-related clinical trials reported since 2010: a systematic review. *J Hosp Infect*. 2016;92:309–320.
2. World Health Organization. The burden of health care-associated infection worldwide. A Summary; 2010. Accessed January 01, 2022. https://apps.who.int/iris/bitstream/handle/10665/80135/9789241501507_eng.pdf. 2017.
3. Yapicioglu H, Satar M, Ozcan K, et al. A 6-year prospective surveillance of healthcare-associated infections in a neonatal intensive care unit from southern part of Turkey. *J Paediatr Child Health*. 2010;46:337–342.
4. Alp E, Orhan T, Kürkcü CA, Ersoy S, McLaws ML. The first six years of surveillance in pediatric and neonatal intensive care units in Turkey. *Antimicrob Resist Infect Control*. 2015;4:34.
5. Demirdağ TB, Koç E, Tezer H, et al. The prevalence and diagnostic criteria of healthcare associated infections in neonatal intensive care units in Turkey: A multicenter point-prevalence study. *Pediatr & Neonatol*. 2021;62:208–217.
6. Ellingson K, Haas JP, Aiello AE, et al. Strategies to prevent healthcare-associated infections through hand hygiene. *Infect Control Hosp Epidemiol*. 2014;35(S2): S155–S178.
7. Pittet D, Allegranzi B, Sax H, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. *Lancet Infect Dis*. 2006;6: 641–652.
8. 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.
9. Clancy C, Delungahawatta T, Dunne CP. Hand hygiene-related clinical trials reported between 2014 and 2020: a comprehensive systematic review. *J Hosp Infect*. 2021;111:6.
10. McLaws ML, Kwok YLA. Hand hygiene compliance rates: fact or fiction? *Am J Infect Control*. 2018;46:876–880.
11. World Health Organization. WHO Patient Safety. *Hand hygiene technical reference manual: to be used by health-care workers, trainers and observers of hand hygiene practices*. World Health Organization; 2009..https://apps.who.int/iris/handle/10665/44196. [Internet] 2009 [Accessed October 24, 2019]. Available from: https://apps.who.int/iris/bitstream/handle/10665/44196/9789241598606_eng.pdf;jsessionid=3C5CE7B3A298CE45C9D684C104087073?sequence=1.
12. Sili U, Ay P, Bilgin H, Hidiroglu S, Korten V. Hand hygiene knowledge, perception and practice of healthcare workers in a Turkish university hospital intensive care unit. *J Infect Develop Countries*. 2019;13:744–747.
13. Karaaslan A, Kepenekli Kadayifci E, Atıcı S, et al. Compliance of healthcare workers with hand hygiene practices in neonatal and pediatric intensive care units: overt observation. *Interdisciplin Perspect on Infect Dis*. 2014;5: 306478.
14. Chhapola V, Brar R. Impact of an educational intervention on hand hygiene compliance and infection rate in a developing country neonatal intensive care unit. *Int J Nurs Pract*. 2015;21:486–492.
15. Raskind CH, Worley S, Vinski J, Goldfarb J. Hand hygiene compliance rates after an educational intervention in a neonatal intensive care unit. *Infect Control Hosp Epidemiol*. 2007;28:1096–1098.
16. Brown J, Froese-Fretz A, Luckey D, Todd JK. High rate of hand contamination and low rate of hand washing before infant contact in a neonatal intensive care unit. *Pediatr Infect Dis J*. 1996;15:908–910.
17. Shah R, Patel DV, Shah K, Phatak A, Nimbalkar S. Video surveillance audit of handwashing practices in a neonatal intensive care unit. *Indian Pediatr*. 2015;52:409–411.
18. Shlomai NO, Rao S, Patole S. Efficacy of interventions to improve hand hygiene compliance in neonatal units: a systematic review and meta-analysis. *Eur J Clin Microbiol Infect Dis*. 2015;34:887–897.
19. Armellino D, Hussain E, Schilling ME, et al. Using high-technology to enforce low-technology safety measures: the use of third-party remote video auditing and real-time feedback in healthcare. *Clin Infect Dis*. 2011;54:1–7.
20. Sánchez-Carrillo LA, Rodríguez-López JM, Galarza-Delgado DÁ, et al. Enhancement of hand hygiene compliance among health care workers from a hemodialysis unit using video-monitoring feedback. *Am J Infect Control*. 2016;44:868–872.
21. Boyce JM, Cooper T, Yin J, Li FY, Arbogast JW. Challenges encountered and lessons learned during a trial of an electronic hand hygiene monitoring system. *Am J Infect Control*. 2019;47:1443–1448.
22. Girou E, Chai SHT, Oppein F, et al. Misuse of gloves: the foundation for poor compliance with hand hygiene and potential for microbial transmission? *J Hosp Infect*. 2004;57:162–169.
23. Brotfain E, Livshiz-Riven I, Gushansky A, et al. Monitoring the hand hygiene compliance of health care workers in a general intensive care unit: use of continuous closed circle television versus overt observation. *Am J Infect Control*. 2017;45:849–854.
24. Hagel S, Reischke J, Kesselmeier M, et al. Quantifying the Hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. *Infect Control Hosp Epidemiol*. 2015;36:957–962.
25. Stewardson A, Sax H, Longet-Di Pietro S, Pittet D. Impact of observation and analysis methodology when reporting hand hygiene data. *J Hosp Infect*. 2011;4:358–359.