Internet of things (IOT) to explore the moment 2 of "WHO My five moments" for hand hygiene

Sophia Boudjema, Olga Florea, Jeremy Gonin, Hervé Tissot-Dupont, Jean-Charles Dufour, Philippe Brouqui

Internet of things (IOT) to explore the moment 2 of “WHO My five moments” for hand hygiene

Sophia BOUDJEMA[1, 2*], Olga Florea[2, 1], Jeremy GONIN[1], Hervé TISSOT-DUPONT[1, 2, 3*], Jean-Charles DUFOUR[2, 4], Philippe BROUQUI[1, 2, 3]

[1]IHU Mediterranee Infection, France, [2]Faculté de Médecine, Aix Marseille Université, France, [3]Assistance Publique Hôpitaux de Marseille, France, [4]INSERM U912 Sciences Economiques et Sociales de la Santé et Traitement de l’Information Médicale (SESSTIM), France

Submitted to Journal:
Frontiers in Digital Health

Specialty Section:
Connected Health

Article type:
Original Research Article

Manuscript ID:
684746

Received on:
04 May 2021

Revised on:
16 Sep 2021

Journal website link:
www.frontiersin.org

Conflict of interest statement

The authors declare a potential conflict of interest and state it below

P. Brouqui owned part in the start-up company MedihandTrace SAS, which commercialized the electronic monitoring system. None of the other authors have conflicts of interest

Author contribution statement

PB, JCD, and SB conceived and designed the experiments. OF performed the experiments. OF, JG, and SB analysed the data. OF, JG, and PB wrote the manuscript. OF, JCD and SB edited the manuscript.

Keywords

Hand hygiene (disinfection), IoT - Internet of Things, Five Moments for Hand Hygiene, nosocomal infections, Catheter - complications

Abstract

Word count: 221

Background
Electronic hand hygiene surveillance systems are developing and are considered to be more reliable than direct observation for hand hygiene monitoring. However, none are in the capability to assess compliance in complex nursing care.
Materials & Methods
We combined two different technologies, a hand hygiene monitoring system (RFID) and a nursing care recorder at the bedside, and we merge their data to assess hand hygiene performance during nursing. Nursing tasks were classified as the standard task procedures or aseptic task procedures corresponding to moment 2 among the 5 moments for hand hygiene recommended by the WHO. All statistical analyses were performed using R, version 3.6.2. For the mixed models, the package “lme4” was used.
Results
From the merged database over the 2-year study period 30,164 nursing tasks were identified for analysis, 25,633 were classified as standard task procedures and 4,531 were classified as aseptic task procedures for nursing care. Hand disinfection with an alcohol-based solution was not detected with our system in 42.50% of all the recorded tasks, 37% of all the aseptic task procedures and 47.1% of all the standard task procedures for nursing (p= 0.0362), indicating that WHO moment 2 was not respected in 37% of the mandatory situations.
Conclusion
Using a combination of different technologies, we were able to assess hand hygiene performance in the riskiest circumstances.

Contribution to the field

Healthcare-associated infection (HCAI) in hospitals mainly results from unsolved but well-identified causes such as hand hygiene, overuse of catheters, and to a lesser extent, The risk of transmission of microbes from HCWs’ hands to patients has been studied extensively in peripheral venous catheters (PVCs) which have long been associated with infection. New technologies allow for the traceability of care and good practices reminders have been developed concomitantly to an anthropological approach, facilitating acceptability by healthcare workers. While the automated continuous monitoring system is validated and commercially available, some other technologies are still under clinical evaluation or in the early development phase. A model of transmission identifying moments at which health care workers (HCWs) are at risk for transmission has been suggested. This model was used to develop “My Five Moments for Hand Hygiene” (WHO). Moment 2 of the My five moment by WHO, is defined by hand disinfection before an aseptic task procedures. While Moment 2 appears as a very important clue to cross transmission, its monitoring by direct observation is difficult as events are relatively infrequent compared with moments 1 and 5. To bypass this difficulty we have developed a tool to record the nurse's task at patient’s bedside that we called PSR for patient smart reader. This barcode intelligent personal digital assistant allows to record most care at the bedside and to push data in a centralized database for nurse’s digital patient files. We aim to evaluate hand hygiene of nurses before an aseptic task procedure (moment 2) using merge data provided by our automatic hand hygiene monitoring system couple with the PSR.

Funding statement

This study was funded by ANR-15-CE36-0004-01 and by ANR “Investissements d’avenir”, Mediterranée infection 10-IAHU-03.

Ethics statements

Studies involving animal subjects

Generated Statement: No animal studies are presented in this manuscript.

Studies involving human subjects

Generated Statement: No human studies are presented in this manuscript.

Inclusion of identifiable human data

Generated Statement: No potentially identifiable human images or data is presented in this study.

Data availability statement

Generated Statement: The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Internet of things (IOT) to explore the moment 2 of “WHO My five moments” for hand hygiene.

Olga FLOREA[1] RNMS, Jeremy GONIN[2] MS, Hervé TISSOT DUPONT[1,2] MDPhD, Jean Charles DUFOUR[3] MDPhD, Philippe BROUQUI[1,2] MDPhD and Sophia BOUDJEMA[1] RNPhD

[1] Aix Marseille Université, IRD, MEPHI, IHU-Méditerranée Infection, Marseille, France

[2] AP-HM, IHU-Méditerranée Infection, Marseille, France

[3] Aix Marseille Univ, AP-HM, INSERM, IRD, SESSTIM, Hop Timone, BioSTIC, Marseille, France.

Main text word count: 2280

Abstract word count: 222

Tables: 2

Figures: 2

Supplementary file 2

Abstract:

Background

Electronic hand hygiene surveillance systems are developing and are considered to be more reliable than direct observation for hand hygiene monitoring. However, none are in the capability to assess compliance in complex nursing care.

Materials & Methods

We combined two different technologies, a hand hygiene monitoring system (RFID) and a nursing care recorder at the bedside, and we merge their data to assess hand hygiene performance during nursing. Nursing tasks were classified as the standard task procedures or aseptic task procedures corresponding to moment 2 among the 5 moments for hand hygiene recommended by the WHO. All statistical analyses were performed using R, version 3.6.2. For the mixed models, the package “lme4” was used.

Results

From the merged database over the 2-year study period 30,164 nursing tasks were identified for analysis, 25,633 were classified as standard task procedures and 4,531 were classified as aseptic task procedures for nursing care. Hand disinfection with an alcohol-based solution was not detected with our system in 42.50% of all the recorded tasks, 37% of all the aseptic task procedures and 47.1% of all the standard task procedures for nursing (p= 0.0362), indicating that WHO moment 2 was not respected in 37% of the mandatory situations.

Conclusion

Using a combination of different technologies, we were able to assess hand hygiene performance in the riskiest circumstances.

Introduction.

It is generally believed that hand hygiene reduces the prevalence of hospital-acquired infection (HAI) and an inadequate hand hygiene is one of the main risk factors for infection (1–4).

The risk of transmission of microbes from health care workers (HCWs) hands to patients has been studied extensively in peripheral venous catheters (PVCs) which have long been associated with infection (4–6).

Appropriate hand disinfection prior to PVC insertion significantly reduces the incidence of infection (5–8). Direct observation is the current gold standard to appreciate compliance to hand hygiene. A model of transmission identifying moments at which health care workers (HCWs) are at risk for transmission has been suggested (9). This model was used to develop "My Five Moments for Hand Hygiene" (10,11). Alcohol-Hand-Rub (AHR) with alcohol-based solution before moments 1 and 2 is suggested to prevent the transmission of infection to patients, whereas AHR after moments 3, 4, and 5 is suggested to protect patients' environment and the transmission of infection to other patients. Moment 2 of the My five moment by WHO, is defined by hand disinfection before an aseptic task procedures (12) . While Moment 2 appears as a very important clue to cross transmission, its monitoring by direct observation is difficult as events are relatively infrequent compared with moments 1 and 5.

To bypass this difficulty we have developed a tool to record the nurse's task at patient's bedside that we called PSR for patient smart reader (13) . This barcode intelligent personal digital assistant allows to record most care at the bedside and to push data in a centralized database for nurse's digital patient files.

Automated hand hygiene monitoring has recently been developed in the aim to replace direct observational monitoring, because it avoids the influence of the Hawthorne effect and appears to be more reliable (14–16). Since 2012, we have developed an automated hand hygiene monitoring

system and used it as a part of the HAI Management at the University Hospital Institute Méditerranée Infection (IHU-MI)(17–19). However, to our knowledge, there are no automated hand hygiene monitoring systems that allow the evaluation of hand hygiene before aseptic task procedure (moment 2), except remote video-based surveillance system, which is time consuming and not cost-effective (20,21) .

This study aimed to evaluate hand hygiene of nurses before an aseptic task procedure (moment 2) using merge data provided by our automatic hand hygiene monitoring system couple with the PSR. The hand hygiene monitoring system provided alcoholic hand rub use and entry/exit of the bedroom and the PSR provide the information on the nature of the nursing task recorded during care. This way we investigated if nurses used ARH during care and for which kind of care.

Materials & Methods.

Electronic survey: For this study, we used a combination of data from two different electronic data capture (EDC) systems (see functional schema in supplementary material). An EDC system is a computerized system designed for the collection of clinical data in electronic format for use mainly in human clinical trials. The first EDC system was a hand hygiene automated electronic system named MHT for MediHandTrace®, which is an RFID (13.56 MHz)-based personal identifying tracking system that records compliance to AHR for each identified HCW. This system was deployed in a 25-bed infectious disease ward in Marseille, France (22). MHT detects HCWs' movements by tracking chips that are placed in the shoes of HCWs; RFID signals are emitted by an antenna placed on the floor at the entrance of the bedroom. When a HCW enters in the room by opening the door, the device is triggered, and a set of signals are captured and stored in a server at the following time points: [0] when the door opens, [1] when the HCW walks near the antenna, [2] when the HCW walks out of the range of the antenna and [8] when an AHR is used within 8 seconds or [10] more than 8 seconds after the HCW enters the room. The second EDC system was a handily personal digital assistant with barcode reader named the Patient Smart Reader (PSR) a device allowing to record, at patient

bedside, the nursing tasks. This tool allows for integration of recorded data within the SQL database stored in the PSR and are then synchronized with a desktop- or server-based database. It allows nursing care tasks and patients' vital signs to be recorded by HCWs in real time during the provision of care (note that a HCW can record the action before or after he/she performs it) (23). This is an important limitation which explain that only the lack of compliance to AHR can be explored. If AHR is performed, we cannot identify if this is before (good) or after (bad) the task. To record a task, the HCW must identify himself or herself, identify the patient and identify the task by scanning the barcode affixed to the wall next to the bed. Both systems (MHT and the PSR) are time synchronized and send the collected data on the same server using a unique ID for each HCW. These two systems together allow of hand hygiene performed around the time of a specific nursing task.

Selection of variables: The nursing tasks that were explored are listed in **Table 1**. They were classified as standard task procedures (STPs) or aseptic task procedures (ATPs) corresponding to moment 2 for hand hygiene. Each act recorded in a designated aseptic task should be associated with one AHR (hand hygiene opportunity). The lack of compliance to AHR is define by the ratio of no AHR / Number of acts in the designated task.

Data analyses: The data used for the study were extracted from the raw data (MHT database and PSR database) collected from 01/11/2017 to 01/11/2019. The lack of compliance during ATPs was compared with the lack of compliance during STPs. Both systems have been used in the ward for years, and HCWs were invited to participate in the study as a part of their natural nursing routine. No specific training was given before the study.

Statistical analysis: All statistical analyses were performed using R, version 3.6.2. For the mixed models, the package "lme4" was used. For all statistical tests, the alpha risk level was set to 5%, and a bilateral alternative hypothesis (two-sided test) was used, except for when the Kolmogorov-Smirnov test was used, which was performed with a unilateral alternative hypothesis (one-sided test). Lak of compliance with hand hygiene was compared across durations with the chi-square test.

In a previous work, we reported that the use of an automated electronic surveillance system generated a large amount of data for which the bias in the relationship between HCW activity and HCW performance with AHR needed to be corrected by using a multilevel multivariate logistics model (18). To better control the link between hand hygiene compliance and the type of nursing care, the following generalized linear mixed models were built:

$$M_0 : logit\left(P(Y_{ij} = 1)\right) = \beta_0$$

$$M_{0r} : logit\left(P(Y_{ij} = 1)\right) = \beta_0 + b_{0i} \qquad b_{0i} \sim N(0, \sigma_0^2)$$

$$M_1 : logit\left(P(Y_{ij} = 1)\right) = \beta_0 + \beta_1 X_{ij}$$

$$M_{1r} : logit\left(P(Y_{ij} = 1 \backslash b_{0i})\right) = \beta_0 + \beta_1 X_{ij} + b_{0i} \qquad b_{0i} \sim N(0, \sigma_0^2)$$

where Y is the hand hygiene compliance variable (Y=0 if AHR is not used and Y=1 if AHR is used) and X is the nursing task risk variable (X=0 if the nursing task is an STP and X=1 if the nursing task is an ATP. The index i represents the HCW level, j represents the nursing care level, and Y_{ij} represents hand hygiene compliance. The different models were compared by several methods. The Akaike inference criterion (AIC) was used when the models were not nested. For the nested models, the comparisons were made with the likelihood ratio test corrected for the comparison between two mixed models. For the models with random effects, the intraclass correlation coefficient (ICC) was used to measure the percentage of variance in AHR use attributable to the HCW level. The ICC was estimated based on assumptions for binary variables, and the variance attributable to the HCW level was divided by the total estimate variance. For the models without random effects, the estimations were maximum-likelihood estimations, and for the mixed models (with random effects), the maximum-likelihood estimation method with Laplace approximation was used. Finally, to investigate when AHR occurred within the care sequence, the distribution of hand hygiene within the care sequences was compared between the STPs and ATPs for nursing. The duration of each care sequence was split into 100 intervals of the same length, and the significance was tested by using the Kolmogorov-Smirnov test

142 with a unilateral alternative hypothesis (Supplementary data). The Data set is available on demand to the corresponding author.

Ethics: To ensure the anonymity of the data analysed, a random number was assigned to the data from each participant included in the database. All the procedures for this study were approved by the ethics committee at our institution (N° 2016-018). Before the study, the HCWs were informed of the study details and gave their consent to be monitored by automated systems.

Results.

Among 39 nursing procedures, 24 were classified as Standard Task Procedures (STPs), and 15 aseptic task procedures (ATPs) for which ARH before the procedure is mandatory (Moment 2). The most frequent procedures, such as vital signs recording, per os medication or layer pose were STP. Among the ATPs, blood catheter monitoring, intravenous medication, and blood test collection were the most frequent. Our system identified the HCW in the patient room for 30,164 nursing tasks procedures during the 2-year study period. Of the 30,164 tasks, 25,633 were classified as requiring STPs for nursing and 4,531 were classified as requiring ATPs for nursing (Table 1)

No AHR was detected in 42.5% of all tasks, 37% of ATPs and 47.1% of STPs for nursing (p= 0.0362), indicating that moment 2 was not respected in 37% of the mandatory situations. For the ATPs, the nurses performed better than did the assistant nurses (35.9% versus 51.6% of lack of compliance to M2; p <0.001). The assistant nurses practising STPs did not perform AHR at all in 52% of these nursing tasks. The housekeeping workers only performed STPs, and AHR was not detected in 40.6% of the tasks. Among the nursing tasks performed, those with lower lack of AHR use was urinary catheter removal, blood catheter insertion, blood sample collection, intravenous medication and blood cultures (**Figure 1**). Interestingly, some tasks that were considered STPs for nursing, such as penile case assessments and per-os medication, were associated with higher AHR performance. **Figure 2**

shows the distribution of AHR events among 16,416 nursing tasks, 12,759 classified STPs (in grey) and 2,853 ATPs (in black) during the nursing task. Hand hygiene is more frequently performed at the end of the task when STPs nursing is performed (Kolmokorov-Sirnov 0.84 $p < 2.2$ E-16). In ATPs nursing the AHR is performed in a similar way at entry than at exit. Multilevel analysis showed that the variables associated with AHR were the HCW's behaviour itself and the nature of the tasks. AHR was slightly performed more often by any of the HCWs when the task recorded was an ATP [ORa 1.08 (95% CI) (1.01-1.17) p =0.036] (**Table 2**).

Discussion:

Electronic hand hygiene systems have been developed not only to record but also to promote compliance. These systems have been designed to ensure that HCWs perform hand hygiene before approaching the patient's bedside (M1) and to issue an alert for HCWs to do so (18). Despite the advantages of newer technologies, at this time, they are unable to differentiate the five moments for hand hygiene, but most of them can detect whether their hands have been disinfected before touching the patient (moment 1) and before leaving the patient zone (similar to moments 3, 4 and 5). Nevertheless, the level of risk of infection is associated with specific steps in the care process and the relative importance of hand hygiene at each of the five moments in preventing microbial transmission and infection outcomes is still unknown (24) . According to the WHO guidelines, it is assumed that "**an ideal indicator of hand hygiene performance would reliably capture each moment requiring hand hygiene, even during complex care activities** (20). In this study, by merging data obtained from two systems we successfully identified that in ATPs which are identified at high risk for cross-transmission of microbes to patient, no ARH was performed in 37% of the tasks. However, this lack of compliance may be underestimated. Among task for which we detect AHR it is possible that hand hygiene was performed after the aseptic procedure as reported in figure 2, and consequently considered as inefficient. This is the main limitations of our study.

The lack of AHR among the nurses practicing ATPs is likely be related to the fact that they have reduced the need for hand hygiene by wearing nonsterile gloves, which can make HCWs feel less exposed to dirt, microbes and be protected against blood borne disease (20). The overuse of gloves has been shown to be one major factor explaining poor hand hygiene compliance (25,26). There is currently increasing scientific evidence that glove disinfection is as effective in preventing infection in experiments as in routine care and that glove disinfection should be promoted (27) (28). Recently, Fehling et al. reported that allowing glove disinfection significantly improved hand disinfection, particularly at moment 2, and reduced the occurrence of severe infection considerably (29). Weakness of our system is that we detect the lack of AHR, but the technology available at this time is unable to detect AHR and when it occurs precisely withing the time of the nursing. Only video capture is capable to do it. New generation of hand hygiene monitoring should evolve to dematerialized video system with real time data analysis and feedback.

In conclusion assessing hand hygiene surveillance during complex care is feasible by combining different technologies. Although no perfectly responding to WHO requirements for an ideal indicator , this proof-of-concept study reveals that AHR is not performed in at least 37% of care situation for which it is mandatory. Focused interventions on the practice of Moments 2 for hand hygiene should be quicky implemented and then evaluated.

Acknowledgements: We would like to thank the nurses, assistant nurses and housekeeping personnel from the University Hospital Institute Méditerranée-Infection who kindly participated in the study. English was edited by an English native Maria Filannino.

The plagiarism rate was assessed by Magister by Compilatio.net to be 3%.

Contributors: PB, JCD, and SB conceived and designed the experiments. OF performed the experiments. OF, JG, and SB analysed the data. OF, JG, and PB wrote the manuscript. OF, JCD and SB edited the manuscript.

Financial support

This study was funded by ANR-15-CE36-0004-01 and by ANR “Investissements d’avenir”, Mediterranée infection 10-IAHU-03.

Conflicts of Interest

P. Brouqui owned part in the start-up company MedihandTrace SAS, which commercialized the electronic monitoring system. None of the other authors have conflicts of interest.

Reference List

1. Mathur P. Hand hygiene: back to the basics of infection control. Indian J Med Res. 2011 Nov;134(5):611–20.

2. Peters A, Palao VC, Lotfinejad N, Pittet D. WHO Year of the Nurse and Midwife: More clean and educated hands for all. J Infect Prev. 2020 Sep;21(5):166–9.

3. Loveday HP, Wilson JA, Pratt RJ, Golsorkhi M, Tingle A, Bak A, et al. epic3: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. J Hosp Infect. 2014 Jan;86 Suppl 1:S1-70.

4. Keleekai NL, Schuster CA, Murray CL, King MA, Stahl BR, Labrozzi LJ, et al. Improving Nurses' Peripheral Intravenous Catheter Insertion Knowledge, Confidence, and Skills Using a Simulation-Based Blended Learning Program: A Randomized Trial. Simul Healthc [Internet]. 2016 Dec [cited 2021 Feb 3];11(6):376–84. Available from: https://journals.lww.com/simulationinhealthcare/Fulltext/2016/12000/Improving_Nurses__Peripheral_Intravenous_Catheter.2.aspx

5. Zhang L, Cao S, Marsh N, Ray-Barruel G, Flynn J, Larsen E, et al. Infection risks associated with peripheral vascular catheters. J Infect Prev. 2016 Sep;17(5):207–13.

6. Gould CV, Umscheid CA, Agarwal RK, Kuntz G, Pegues DA, Healthcare Infection Control Practices Advisory Committee. Guideline for prevention of catheter-associated urinary tract infections 2009. Infect Control Hosp Epidemiol. 2010 Apr;31(4):319–26.

7. Kampf G, Reise G, James C, Gittelbauer K, Gosch J, Alpers B. Improving patient safety during insertion of peripheral venous catheters: an observational intervention study. GMS Hyg Infect Control. 2013;8(2):Doc18.

8. McCalla S, Reilly M, Thomas R, McSpedon-Rai D, McMahon LA, Palumbo M. An automated hand hygiene compliance system is associated with decreased rates of health care-associated infections. Am J Infect Control. 2018 Dec;46(12):1381–6.

9. Pittet D, Allegranzi B, Sax H, Dharan S, Pessoa-Silva CL, Donaldson L, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. Lancet Infect Dis. 2006 Oct;6(10):641–52.

10. Sax H, Allegranzi B, Uçkay I, Larson E, Boyce J, Pittet D. 'My five moments for hand hygiene': a user-centred design approach to understand, train, monitor and report hand hygiene. J Hosp Infect [Internet]. 2007 Sep 1 [cited 2021 Feb 3];67(1):9–21. Available from: http://www.sciencedirect.com/science/article/pii/S0195670107001909

11. Salmon S, Pittet D, Sax H, McLaws ML. The "My five moments for hand hygiene" concept for the overcrowded setting in resource-limited healthcare systems. J Hosp Infect. 2015 Oct;91(2):95–9.

12. Pittet D, Allegranzi B, Boyce J, Experts WHOWA for PSFGPSCCG of. The World Health Organization Guidelines on Hand Hygiene in Health Care and Their Consensus Recommendations. Infect Control Hosp Epidemiol. 2009 Jul;30(7):611–22.

13. Florea O, Dufour J-C, Magnin C, Brouqui P, Boudjema S. Improving health care workers compliance with traceability by recording the nursing process at the point of care using a personal digital assistant with a barcode. J Nurs Care. 2020 Jul 1;9:500.

14. McCambridge J, Witton J, Elbourne DR. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. J Clin Epidemiol. 2014 Mar;67(3):267–77.

15. Hagel S, Reischke J, Kesselmeier M, Winning J, Gastmeier P, Brunkhorst FM, et al. Quantifying the Hawthorne Effect in Hand Hygiene Compliance Through Comparing Direct Observation With Automated Hand Hygiene Monitoring. Infect Control Hosp Epidemiol. 2015 Aug;36(8):957–62.

16. Bruchez SA, Duarte GC, Sadowski RA, Custódio da Silva Filho A, Fahning WE, Belini Nishiyama SA, et al. Assessing the Hawthorne effect on hand hygiene compliance in an intensive care unit. Infect Prev Pract. 2020 Jun 1;2(2):100049.

17. Brouqui P, Boudjema S, Soto Aladro A, Chabrière E, Florea O, Nguyen H, et al. New Approaches to Prevent Healthcare-Associated Infection. Clin Infect Dis Off Publ Infect Dis Soc Am. 2017 Aug 15;65(suppl_1):S50–4.

18. Dufour J-C, Reynier P, Boudjema S, Soto Aladro A, Giorgi R, Brouqui P. Evaluation of hand hygiene compliance and associated factors with a radio-frequency-identification-based real-time continuous automated monitoring system. J Hosp Infect [Internet]. 2017 Apr [cited 2018 Sep 25];95(4):344–51. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0195670117300634

19. Boudjema S, Dufour JC, Aladro AS, Desquerres I, Brouqui P. MediHandTrace®: a tool for measuring and understanding hand hygiene adherence. Clin Microbiol Infect [Internet]. 2014 Jan [cited 2018 Sep 25];20(1):22–8. Available from: http://linkinghub.elsevier.com/retrieve/pii/S1198743X14601890

20. Boudjema S, Reynier P. Hand Hygiene Analyzed by Video Recording. J Nurs Care [Internet]. 2016 [cited 2021 Mar 4];05(02). Available from: http://www.omicsgroup.org/journals/hand-hygiene-analyzed-by-video-recording-2167-1168-1000338.php?aid=72184

21. Boudjema S, Tarantini C, Peretti-Watel P, Brouqui P. Merging video coaching and an anthropologic approach to understand health care provider behavior toward hand hygiene protocols. Am J Infect Control [Internet]. 2017 May [cited 2018 Sep 25];45(5):487–91. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0196655316311762

22. Dufour J-C, Reynier P, Boudjema S, Soto Aladro A, Giorgi R, Brouqui P. Evaluation of hand hygiene compliance and associated factors with a radio-frequency-identification-based real-time continuous automated monitoring system. J Hosp Infect. 2017 Apr;95(4):344–51.

23. Florea O, Dufour JC, Magnin C, Brouqui P, Boudjema S. Improving health care workers compliance with traceability by recording the nursing process at the point of care using a personal digital assistant with a barcode. [Internet]. Nursing; 2020 Jan [cited 2020 Aug 19]. Available from: http://medrxiv.org/lookup/doi/10.1101/2020.01.14.20017434

24. Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. Am J Infect Control. 2017 May 1;45(5):528–35.

25. Fuller C, Savage J, Besser S, Hayward A, Cookson B, Cooper B, et al. “The dirty hand in the latex glove”: a study of hand hygiene compliance when gloves are worn. Infect Control Hosp Epidemiol. 2011 Dec;32(12):1194–9.

26. Vikke HS, Vittinghus S, Giebner M, Kolmos HJ, Smith K, Castrén M, et al. Compliance with hand hygiene in emergency medical services: an international observational study. Emerg Med J EMJ. 2019 Mar;36(3):171–5.

27. Kampf G, Lemmen S. Disinfection of gloved hands for multiple activities with indicated glove use on the same patient. J Hosp Infect. 2017 Sep;97(1):3–10.

28. Vogel A, Boudjema S, Brouqui P. Disinfection of gloved hand during routine care. New Microb New Infect. in press. 2021;

29. Fehling P, Hasenkamp J, Unkel S, Thalmann I, Hornig S, Trümper L, et al. Effect of gloved hand disinfection on hand hygiene before infection-prone procedures on a stem cell ward. J Hosp Infect [Internet]. 2019 Nov 1 [cited 2021 Feb 3];103(3):321–7. Available from: http://www.sciencedirect.com/science/article/pii/S0195670119302580

Figure 1.TIF

Figure 1: Distribution of lack of compliance (%) to hand hygiene in aseptic task procedure (WHO Moment 2) versus standard task procedure nursing. Hand hygiene is better performed when the nursing is in the category aseptic task (yellow) compare to standard precaution (grey) that were 1678 (37%) /12070 (47.1%) p <2.2 e-16.

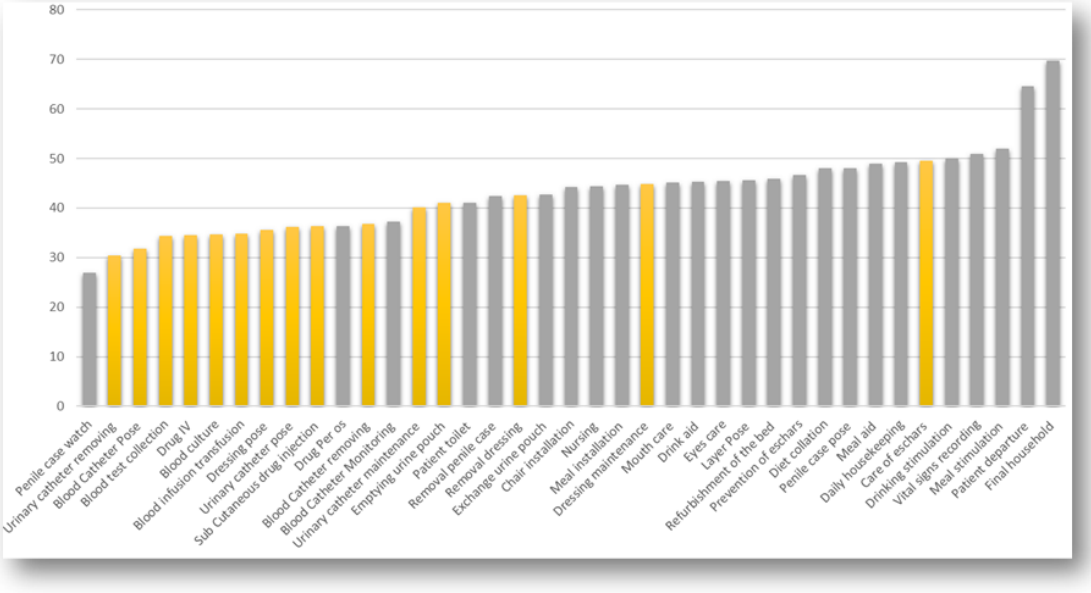

Figure 2.TIF

Figure 2: Distribution during the nursing task (from room entry to room exit) of alcoholic hand rub among 16,416 nursing tasks, 12,759 classified standard task procedures STP (in grey) and 2,853 aseptic tasks procedures ATP (in black). Hand hygiene is more frequently performed at the end of the task when standard task procedure nursing is performed (Kolmokorov-Sirnov 0.84 $p < 2.2$ E-16). In aseptic task procedure nursing the AHR is performed in a similar way at entry than at exit.