Pilot study of digital tools to support multimodal hand hygiene in a clinical setting

Article *in* American Journal of Infection Control · October 2017

DOI: 10.1016/j.ajic.2017.08.042

6 authors, including:

Gary Thirkell
The Christie NHS Foundation Trust

James Arbogast
GOJO Industries, Inc.

Gerard Lacey
National University of Ireland, Maynooth

American Journal of Infection Control 46 (2018) 261-5

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Pilot study of digital tools to support multimodal hand hygiene in a clinical setting

Gary Thirkell RN [a,*], Joanne Chambers RN [a], Wayne Gilbart RN [a], Kerrill Thornhill BEng [b], James Arbogast PhD [c], Gerard Lacey PhD [d,e]

[a] *The Christie NHS Trust, Manchester, UK*
[b] *MEG Support Tools, The Digital Depot, Dublin, Ireland*
[c] *GOJO Industries, Akron, OH*
[d] *SureWash, Trinity Enterprise Centre, Dublin, Ireland*
[e] *Computer Science and Statistics, Trinity College Dublin, Dublin, Ireland*

Key Words:
Hand hygiene
multimodal strategies
electronic monitoring
training and competence validation
patient engagement

Background: Digital tools for hand hygiene do not share data, limiting their potential to support multimodal programs. The Christie NHS Foundation Trust, United Kingdom, worked with GOJO (in the United States), MEG (in Ireland), and SureWash (in Ireland) to integrate their systems and pilot their combined use in a clinical setting.
Methods: A 28-bed medical oncology unit piloted the system for 5 weeks. Live data from the tools were combined to create a novel combined risk status metric that was displayed publicly and via a management Web site.
Results: The combined risk status reduced over the pilot period. However, larger and longer duration studies are required to reach statistical significance. Staff and especially patient reaction was positive in that 70% of the hand hygiene training events were by patients. The digital tools did not negatively impact clinical workflow and received positive engagement from staff and patients. The combined risk status did not change significantly over the short pilot period because there was also no specific hand hygiene improvement campaign underway at the time of the pilot study.
Conclusions: The results indicate that integrated digital tools can provide both rich data and novel tools that both measure impact and provide feedback to support the implementation of multimodal hand hygiene campaigns, reducing the need for significant additional personnel resources.

BACKGROUND

Health care–associated infections (HAIs) are a major focus of patient safety, and some studies place the annual burden of HAIs in the United States at 2 million infections and 100,000 related deaths.[1] Targeted hand hygiene initiatives have had a significant impact on reducing HAIs.[2] However, such hand hygiene initiatives can cost from $225-$4,669 per 1,000 bed days.[3]

Hand hygiene improvement interventions range from wide participation of staff as auditors[4,5] to the use of remote video observation and feedback.[6] The subjectivity of human assessments of hand hygiene is frequently reported,[7] and different strategies aim to control for the Hawthorne effect.[8] Culture and social dynamics on a unit can be a major factor in intervention success,[9] and Pincock et al[10] note the importance of a multimodal strategy that involves a range of a wide set of stakeholders and a coordinated set of intervention types, such as education, audits, visual reminders, multidisciplinary teams, and an explicit process improvement strategy. Conway[11] discusses the challenge of implementation and recommends that for maximum impact, feedback should be delivered directly to health care workers (HCWs), and prior to implementation a plan for using the data to drive improvement should be considered.

Banfield and Kerr[12] raised patient hand hygiene as an important link in the chain of infection prevention, and Srigley et al[13] reviewed a number of studies that aimed to improve patient hand

* Address correspondence to Gary Thirkell, RN, The Christie NHS Trust, Wilmslow Rd, Manchester, M20 4BX, United Kingdom.
E-mail address: Gary.Thirkell@christie.nhs.uk (G. Thirkell).
Author contributions: G.L., J.A., J.C., W.G., and G.T. worked on the study protocol. GOJO, MEG Support Tools and SureWash staff performed the technical implementation. G.T., W.G., and J.C. conducted data collection. G.L. worked on the data analysis. G.L., G.T., W.G., and J.C. worked paper drafts.
Conflicts of interest: None to report.

0196-6553/
https://doi.org/10.1016/j.ajic.2017.08.042

hygiene. Studies have reported that dedicated education resources have a significant impact on rates of patient hand hygiene[14,15] and showed that specific education encouraged patients to perform hand hygiene when approached by a HCW,[16] resulting in a positive impact on compliance.

The Christie NHS Foundation Trust, United Kingdom, examined the feasibility of implementing a multimodal hand hygiene intervention. However, the cost of implementation using additional infection prevention and control (IPC) staff was prohibitive; therefore, digital tools were examined. There are a range of digital tools available, such as tablet-based audit tools, smart dispensers, and hand hygiene training kiosks for both staff and patients, but no integrated solution existed. As a result, we challenged a number of vendors, GOJO (in the United States), MEG (in Ireland), and SureWash (in Ireland), to work together to develop an integrated digital framework for hand hygiene and support a pilot evaluation in a clinical setting.

Aims of the study

Our aims were to evaluate, in a live clinical setting, the ability of integrated digital tools to support a multimodal hand hygiene program, assess the reaction of staff and patients to real-time feedback of a combined risk status (CRS), and identify the design considerations for a larger-scale rollout.

METHODS

The intervention described in this article combined data from observational and electronic audits with live feedback and high availability training for staff and patients. The main technical work of the study was the integration of 3 core tools via a Web service, the development of the novel risk measure and the reporting and feedback system. Both subjective and objective measures were developed to understand the context and the impact of the intervention.

Core tools to be integrated

The 3 core systems are subsequently discussed.

Tool 1: MEG: tablet-based clinical support tools

MEG clinical support tools provide a range of software for frontline HCWs on mobile and tablet devices and provide real-time results and alerts for auditors and managers. This study used the hand hygiene auditing tool throughout the unit for recording direct observation of practice compliance scores.

Tool 2: SureWash: hand hygiene training and competence validation system

SureWash is an interactive kiosk that can be moved around the hospital to train and assess staff and patients in hand hygiene. The system uses camera-based augmented reality and gamified learning to ensure that the muscle memory of hand hygiene is learned correctly. In this study, a SureWash system was placed in the day room where it was visible and accessible to all.

Tool 3: GOJO: SMARTLINK activity monitoring system

The system captures soap and sanitizer dispenses (events) and room entries and exits (opportunities), and can be configured to monitor and measure hand hygiene performance by facility, floor, unit, or room. The data captured are not role specific and include health care personnel, doctors, patients, and visitors. In this study, 3 people counters were used, 1 4-bed bay and 2 in single rooms. There were 5 SMARTLINK dispensers (GOJO, Akron, OH) used, one for each of the side rooms and 3, 1 soap and 2 Purell (GOJO), associated with the 4-bed bay.

Novel technologies developed for the pilot study

Data integration and display via the cloud

All 3 systems used a Web database, and a new set of protocols were developed to allow them to share data. Data were gathered from the core tools into a common database at 15-minute intervals, and the analytics and dashboards were updated accordingly.

Signal processing and constructing time series data

To construct a time series dataset from asynchronous data sources, a number of algorithms were developed to be consistent with clinical practice. The tool 1 observational compliance score and tool 2 hand hygiene technique performance score were updated at each observation using a 24-hour moving average. The tool 3 people counter data were adjusted using a standard signal processing technique to mitigate false-positives because of staff hovering in doorways or quick entries or exits where actual hand hygiene was not required. The tool 3 activity metric score (total dispenser activations/people counting events) was updated every 15 minutes based on a cumulative count from midnight each day.

Calculating the CRS

One aim of the pilot study was to develop a novel CRS to indicate overall performance in hand hygiene and provide an easy to understand display. The CRS was calculated based on a combination of live data from each of the digital systems. To develop the algorithm, a couple of weeks of baseline data were gathered and used by the IPC team to develop the rules for the red-amber-green status for each of the tools. These rules were encoded into a set of finite state machines according to the rules in Table 1.

The CRS also used a red-amber-green rating scheme that was set based on a logical combination of the values from the data sources. Through consultation with the IPC team, the CRS was set to be green only if at most one of the data streams was in the amber zone but all others were green. It was determined to be red if ≥2 data streams were in the red zone; all other states were regarded as amber.

Risk management feedback system

It was important that the CRS be easily understood by staff and patients. The team favored a strong graphical format with a clear meaning and readable from a distance. The final design used an emoji-type icon on a germ-filled background to indicate risk status. The CRS was followed immediately by a screen indicating actions needed to improve the score; both the CRS states and the action screens are shown in Figure 1. The CRS and action screens were rotated every 4 seconds on the .53 m display of the tool 2 unit that was positioned in the day room as shown in Figure 2.

The CRS along with a detailed data visualization dashboard was provided on a Web site which could be accessed on a computer or on a mobile device as shown in Figure 3.

Table 1
Algorithm to set the RAG status for each data source

RAG status	Tool 1: DOP compliance	Tool 2: Performance	Tool 3: Activity metric
Green	$x \geq 80\%$	$x > 70\%$	$x > 30\%$
Amber	$80\% > x \geq 50\%$	$70\% > x \geq 40\%$	$30\% > x \geq 15\%$
Red	$x < 50\%$	$x < 40\%$	$x < 15\%$

DOP, direct observation of practice; *RAG*, red-amber-green.

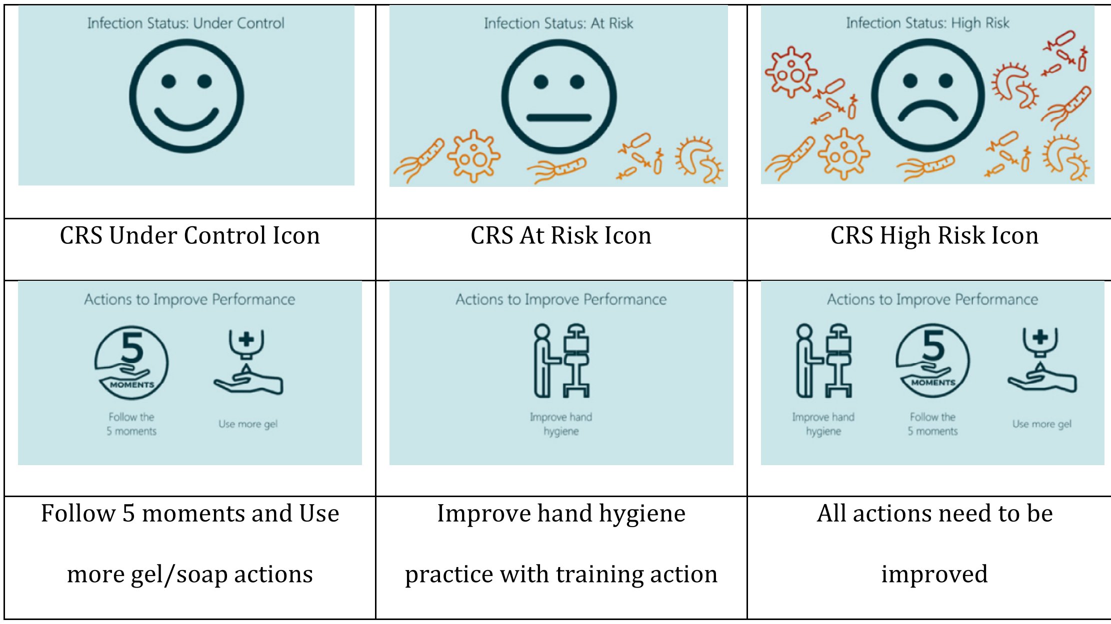

Fig 1. Icons used to provide feedback to staff and patients on the combined risk status and the associated actions. *CRS*, combined risk status.

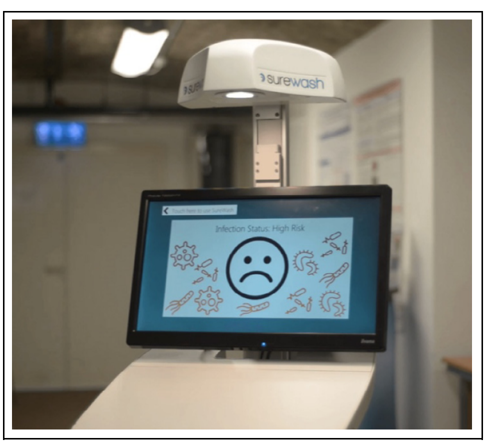

Fig 2. Combined risk status on tool 2 screen.

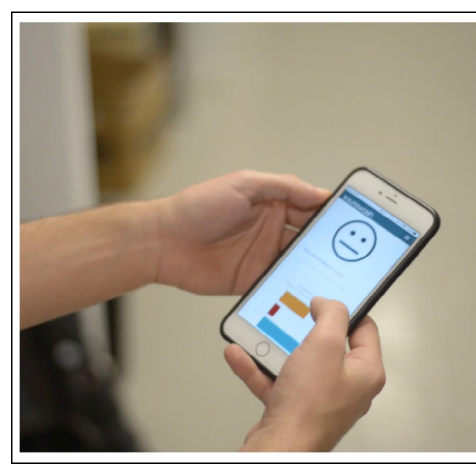

Fig 3. Combined risk status and detailed Web dashboards on a mobile device.

Implementation and evaluation

Setting and time scale

The pilot study was carried out over 5 weeks from the end of November to the end of December 2016 in a 28-bed unit in one of Europe's leading cancer centers, The Christie NHS Foundation Trust, United Kingdom. The unit is divided into five 4-bed bays and 8 single bedrooms (Fig 4). The nurse's station and a day room for patients are situated in the middle of the unit. Staffing levels on the unit were stable over the period; the only variation was a reduction of 10%-15% on weekend day staff.

The IPC team submitted the study proposal to the hospital ethics committee and received a determination that it did not require ethics approval but that the study should be registered with the audit department at the hospital.

Evaluation methodology

The cultural context in advance of the pilot study was assessed via a series of short questionnaires targeting clinical staff, hospital leadership, and patients. After the pilot study, clinical staff were surveyed again. Trend analysis over the pilot study was performed on the 24-hour averages of the data from the different systems.

RESULTS

Despite the short duration of the pilot study, a wealth of data was gathered on hand hygiene training, practice, and competence assessment in the unit over a 35-day period.

Pretrial survey results

Because the study was confined to a single unit over a short duration, the number of subjects is low (10 HCWs), but it represents 63% of the HCWs on duty during an entire 24-hour period and provides a snapshot of the cultural context of the study.

Clinical staff survey results

Seventy percent stated that their duty of care to patients was the primary motivator for hand hygiene, whereas 20% were driven

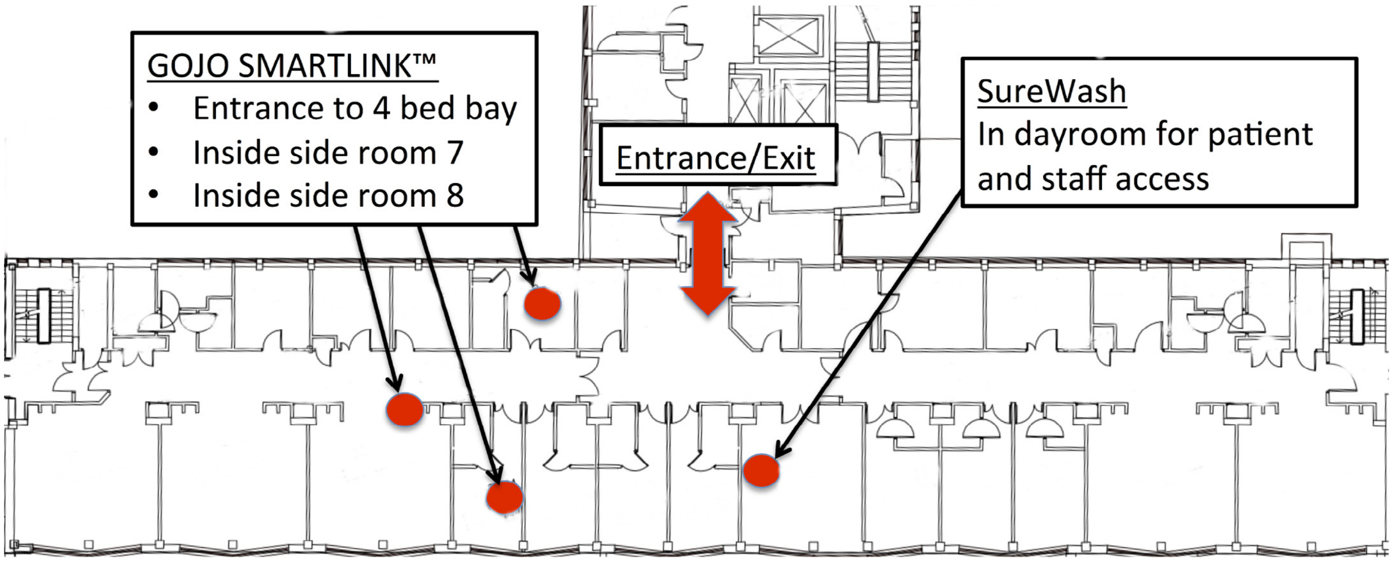

Fig 4. Layout of the systems used in the pilot study.

by the economic and patient consequences of infections, and 10% admitted that when they were busy they deprioritized hand hygiene. Fifty percent of staff felt that providing emergency care is more important than hand hygiene. The source of HAIs was felt to be poor hand hygiene (80%), contaminated surfaces (10%), and visitors bringing in infections (10%).

Hospital leadership survey

Five senior hospital leaders out of a total population of 11 were surveyed. Hospital leaders were confident in the accuracy of infection control audits and thought that hand hygiene and cleaning could be improved. They thought that infection control reduced overall operating costs and made a positive impact on patient safety.

Most hospital leaders (80%) thought that data from infection control was most useful for allocating resources, with 20% thinking it protected the reputation of the hospital. However, none felt that it was for satisfying external auditors or estimating the costs of HAIs. There was little consensus among hospital leaders on the main role of IPC: 20% thought it was outbreak management, 20% thought it was surveillance, 20% thought it was for advice provided to clinicians, and 40% thought it was hand hygiene training.

Patient survey

Ten patients were surveyed; this is 35% of the population of the unit at any time. Of the patients, 70% noted a lack of infection control information from the hospital, but there is a good general awareness of the importance of infection control (ie, the importance of hand hygiene activities and the potential for visitors to pick up infections). In the context of campaigns to promote patient empowerment, only 50% of patients would ask staff if had they cleaned their hands before caring for them.

Posttrial staff survey

After the pilot study, we surveyed 10 staff with 8 questions and ranked then in order of agreement. Training for staff and patients was seen as most important, and observational audits of both direct observation and electronic were ranked at a similar level. Although there was broad agreement on the positive impact of the study, the survey identified that more effort was needed on making the technology more accessible.

Results from the electronic systems

Observational audits

Observational audits using the tool 1 app were conducted each weekday for 5 weeks by members of the IPC team, with only 1 scheduled audit missed. Audits were kept short (10 observations or maximum of 10 minutes) to reduce the Hawthorne effect as in Chen et al.[8] The average compliance ± SD remained constant throughout the study at 76% ± 18%. The observational audits capture a range of additional data, including the range of professionals that make up the samples in the typical audit and their associated compliance level along with the different compliance rates with each of the My 5 Moments for Hand Hygiene.

Tool 2 interactive training data

There were 120 interactions, of which 75 were hand hygiene training sessions and the remainder were hand hygiene quizzes. The data showed that the system was unplugged for a number of days at different points in the middle of the trial period. Of the interactions, 30% (n = 36) were from staff and 70% (n = 84) were from patients. The average performance level achieved is pulled down by the number of missing days; however, we see a modest rise over the study.

Tool 3 data

Tool 3 produced a large number of data points in terms of dispenser activation and the associated activity sensor triggers. There were 2,781 dispenses tracked with approximately 80 dispenses per day, representing the output from 3 dispensers that cover 6 out of the 28 beds (21%) in the unit. The cumulative daily dispenser data are divided by the number of motion sensor events to provide an estimate of compliance. The daily aggregate status showed a modest rise in compliance over the period of the study from 16% to 17.5%.

Risk management system

The 3 data streams were combined to form a CRS based on a set of rules agreed with the IPC team. The data show that the risk status stayed pretty constant over the study duration with a modest fall in risk score over the pilot study.

Given the shortness of the pilot evaluation, the modest fall in the CRS was not statistically significant. The correlation between the different time series data streams was assessed using normalized cross correlation. Normalized cross correlation gives a score of 1.0 for highly correlated, 0.0 for uncorrelated, and –1.0 for negatively correlated. The data showed that tool 1 and tool 3 are weakly correlated (0.23), as was tool 2 and tool 3 (0.25). As would be expected, all 3 data streams are negatively correlated with risk, with tool 3 data having the strongest effect (–0.77), followed by tool 2 (–0.57) and tool 1 (–0.18).

DISCUSSION

The pilot study has demonstrated that it is possible to deliver a set of integrated digital tools and a novel risk assessment measure and feedback system that could support the implementation of multimodal hand hygiene programs for both staff and patients. This rich data set was gathered without impacting the workflow of either the clinical staff or the IPC team. The data showed nonstatistically significant improvement in the risk status over the pilot study period. However, this is unsurprising because the implementation of the system was not linked to an active hand hygiene improvement campaign and there was no management follow-up if HCWs did not undertake training or validate competence.

The data from the surveys highlighted a lack of resources for training patients in infection control. However, when patients are provided with training facilities they actively engaged, resulting in patients making up 70% of all training interactions.

The limitations of the study are that it was a short duration pilot study (35 days), with a low number of smart link dispensers[5] for a 28-bed unit. The gaps in the tool 1 and tool 2 data sets weaken the impact of the study and highlight operational issues that can be addressed by wall mounting tool 2 and having daily audits. Given recent results on the impact of hand hygiene technique on the efficacy of hand sanitization,[17] there is a case for incorporating the validation of technique competence into handwash stations.[18]

The algorithm used drive the CRS was based on a finite state machine that approximates the underlying risks, further work is required to accurately model the underlying risk probabilities and their impact on patient safety and the cost of care. Further research would help develop such a model. The public display of the CRS and the associated actions to improve the score was accepted by both staff and patients and shows that feedback on hand hygiene performance can be expanded beyond the clinical community to include patients and visitors.

Using integrated digital tools for hand hygiene creates an opportunity to use artificial intelligence to automatically cross-validate observational audit data with electronic audit data to ensure the overall system maintains accuracy and relevance in a dynamic clinical environment. It also creates an opportunity to use a range of hand hygiene data from past outbreaks to predict the potential for an outbreak to occur and automatically suggest prevention or mitigation strategies.

CONCLUSIONS

This article describes the first attempt to create integrated digital tools for infection control that support a multimodal approach to hand hygiene. The scale of the pilot study precludes drawing statistically significant findings. However, early results indicate that integrated digital tools can support the delivery of multimodal hand hygiene campaigns, including patient engagement, without the need for significant additional personnel.

Acknowledgments

We thank the staff and patients of The Christie NHS Foundation Trust and the staff of GOJO (UK), MEG Support tools(IRL) and SureWash(IRL) who contributed to this project.

References

1. Jarvis WR. The Lowbury lecture. The United States approach to strategies in the battle against healthcare-associated infections, 2006: transitioning from benchmarking to zero tolerance and clinician accountability. J Hosp Infect 2007;65(Suppl):3-9.
2. Shabot MM, Chassin MR, France AC, Inurria J, Kendrick J, Schmaltz SP. Using the targeted solutions tool(r) to improve hand hygiene compliance is associated with decreased health care-associated infections. Jt Comm J Qual Patient Saf 2016;42:6-17.
3. Luangasanatip N, Hongsuwan M, Limmathurotsakul D, Lubell Y, Lee AS, Harbarth S, et al. Comparative efficacy of interventions to promote hand hygiene in hospital: systematic review and network meta-analysis. BMJ 2015;351:h3728.
4. Walker JL, Sistrunk WW, Higginbotham MA, Burks K, Halford L, Goddard L, et al. Hospital hand hygiene compliance improves with increased monitoring and immediate feedback. Am J Infect Control 2014;42:1074-8.
5. Sickbert-Bennett EE, DiBiase LM, Schade Willis TM, Wolak ES, Weber DJ, Rutala WA. Reducing health care-associated infections by implementing a novel all hands on deck approach for hand hygiene compliance. Am J Infect Control 2016;44:e13-6.
6. Armellino D, Trivedi M, Law I, Singh N, Schilling ME, Hussain E, et al. Replicating changes in hand hygiene in a surgical intensive care unit with remote video auditing and feedback. Am J Infect Control 2013;41:925-7.
7. Srigley JA, Gardam M, Fernie G, Lightfoot D, Lebovic G, Muller MP. Hand hygiene monitoring technology: a systematic review of efficacy. J Hosp Infect 2015;89:51-60.
8. Chen LF, Carriker C, Staheli R, Isaacs P, Elliott B, Miller BA, et al. Observing and improving hand hygiene compliance: implementation and refinement of an electronic-assisted direct-observer hand hygiene audit program. Infect Control Hosp Epidemiol 2013;34:207-10.
9. Kwok YL, Harris P, McLaws ML. Social cohesion: the missing factor required for a successful hand hygiene program. Am J Infect Control 2017;45:222-7.
10. Pincock T, Bernstein P, Warthman S, Holst E. Bundling hand hygiene interventions and measurement to decrease health care-associated infections. Am J Infect Control 2012;40(Suppl):S18-27.
11. Conway LJ. Challenges in implementing electronic hand hygiene monitoring systems. Am J Infect Control 2016;44:e7-12.
12. Banfield KR, Kerr KG. Could hospital patients' hands constitute a missing link? J Hosp Infect 2005;61:183-8.
13. Srigley JA, Furness CD, Gardam M. Interventions to improve patient hand hygiene: a systematic review. J Hosp Infect 2016;94:23-9.
14. Cheng VC, Tai JW, Li WS, Chau PH, So SY, Wong LM, et al. Implementation of directly observed patient hand hygiene for hospitalized patients by hand hygiene ambassadors in Hong Kong. Am J Infect Control 2016;44:621-4.
15. Stewardson AJ, Sax H, Gayet-Ageron A, Touveneau S, Longtin Y, Zingg W, et al. Enhanced performance feedback and patient participation to improve hand hygiene compliance of health-care workers in the setting of established multimodal promotion: a single-centre, cluster randomised controlled trial. Lancet Infect Dis 2016;16:1345-55.
16. Rai H, Knighton S, Zabarsky TF, Donskey CJ. A randomized trial to determine the impact of a 5 moments for patient hand hygiene educational intervention on patient hand hygiene. Am J Infect Control 2017;45:551-3.
17. Reilly JS, Price L, Lang S, Robertson C, Cheater F, Skinner K, et al. A pragmatic randomized controlled trial of 6-step vs 3-step hand hygiene technique in acute hospital care in the United Kingdom. Infect Control Hosp Epidemiol 2016;37:661-6.
18. Ghosh A, Ameling S, Zhou J, Lacey G, Creamer E, Dolan A, et al. Pilot evaluation of a ward-based automated hand hygiene training system. Am J Infect Control 2013;41:368-70.