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Major Article

Scenario-based simulation health care education for performance of hand hygiene



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Background: Simulation health care education is widely used in medical education and has great potential. However, scenario-based simulation health care education for preventing health care–associated infections has not been described.

Methods: A single-center, prospective cohort study was conducted at Tokyo Medical University Hospital (1,015 beds), an acute care teaching hospital, from January 2011 to December 2014. Each training course was held every month and lasted 2 hours. Trainees put on and removed personal protective equipment under scenarios of standard precaution (2 scenarios) and contact precaution with methicillin-resistant *Staphylococcus aureus* (1 scenario), while considering the timing of hand hygiene. We determined the correlations between the participation rate in the simulation education and the use of alcohol-based hand disinfection and reduction of catheter-related bloodstream infection.

Results: There were 1,077 trainees. The total participation rate for hospital staff, which increased gradually during the study period, was 76% by the end of the study. The overall correlation between the use of alcohol-based hand disinfection in the hospital and the course participation rate was significant (correlation coefficient, 0.97). An inverse correlation (−0.94) was observed for the relation between the training course participation rate and the incidence of catheter-related bloodstream infection.

Conclusions: Our training course had a positive effect on hand hygiene. This study is the first effective scenario-based simulation health care education on hand hygiene and control of health care–associated infection.

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Proper hand hygiene among health care workers is an important component in efforts to prevent health care–associated infection (HAI). Performing appropriate hand hygiene is the most important measure to reduce the transmission of microorganisms from one person to another or from one site to another in the same patient.¹ For methods of hand

hygiene, alcohol-based hand disinfection has led to improved compliance and reduction in HAIs.^{2,3} However, although many educational interventions have been implemented worldwide, compliance of hand hygiene with recommended instructions is usually poor.³

Lecture-style education and reading, which seems to be linked to the traditional style of Japanese education, are likely to be less effective for the acquisition of knowledge and skill. Recently, it has been recognized that problem-based learning (PBL), known as active learning in Western countries, is more effective than the traditional style and is an effective method of interactive learning that can lead to lifetime retention of knowledge.^{4,5} Significant differences have been identified in the development of students' critical thinking dispositions between those who undertook PBL and those who undertook lecture courses.⁵ As an example of this active learning method, or PBL, simulation health care education is widely used in medical

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Conflicts of interest: None to report.

Availability of data and materials: The dataset supporting the conclusions of this article is included within the article.

Declarations: Ethical approval was not applicable to conduct this study since the data were collected as part of an educational program of hospital standard infection control. For this type of study, consent to participate is not required in Japan.

education and has great potential. Good efficacy of this education system has been reported in various types of clinical procedures, such as cardiac life support,^{6–9} laparoscopic surgery,^{10,11} endoscopy,¹² bronchoscopy,¹³ emergency airway management,¹⁴ trauma resuscitation,¹⁵ and radiology paracentesis procedures.¹⁶ However, the efficacy of simulation health care education for the prevention and control of HAIs is limited.^{17,18}

Reports on prevention and control of HAIs in health care education simulations involved videotaped lectures and practice on a computed simulator for second- and third-year internal medicine and emergency medicine residents.¹⁸ Furthermore, 1 study comparing scenario-based simulation training in infection control for nursing students with traditional small-group learning settings found that the students were more aware of the complexity of the scenarios after simulation-based training.¹⁹ Some recent studies of scenario-based trainings, which were related to working processes in caring for patients with possible Ebola virus disease, indicated that simulation training sessions were an integral component for disease outbreak preparedness and enabled medical professionals to garner information.²⁰

However, scenario-based simulation health care education similar to a cardiac life support course has not yet been described in the education of the prevention and control of HAIs. This study aimed to determine whether a scenario-based simulation health care education program on prevention and control of infection improves quality in hospital care, especially in hand hygiene, using the change in use of alcohol-based hand rub before and after participating in this simulation-based education course as an indicator for the effectiveness of the training.

METHODS

Study design and study population

A single-center, prospective cohort study was conducted. The selected study population was medical doctors and nursing staff who attended and completed the training courses. The medical staff voluntarily joined the training courses. The participation rate of the training course was calculated in a whole hospital and in each hospital ward. The study was performed from January 2011 to December 2014 at Tokyo Medical University Hospital (1,015 beds; Tokyo, Japan), which is a large, acute care teaching hospital.

Intervention

The training course was a scenario-based simulation health care education course, which aims for an accurate understanding and practice of hand hygiene and good practice of standard precautions and transmission-based precautions. In this course, a brief lecture on the appropriate method of hand hygiene and principles of both standard precautions and transmission-based precautions was provided in the first half of the course. After the lecture, a scenario-based simulation was performed in small groups of 4–5 trainees with 2–3 facilitators. Trainees considered the timing of hand hygiene and the selecting, putting on, and removing of personal protective equipment (PPE) under 3 scenarios of 2 standard precautions and a contact precaution with methicillin-resistant *Staphylococcus aureus* (Table 1). They needed to consider the simulation on their own and make their own decisions. Debriefings were held for the facilitators and team members after each scenario. The facilitators discussed the point of the scenario and attempted to ensure that the trainees understood it during the debriefings.

The training course was designed to last 2 hours and was held regularly every month. Certification of facilitators was performed after they had participated in the course once with trainees and acted

Table 1
Actual scenarios in our course

First scenario (standard precaution)
A 50-year-old homeless man is presenting with disturbance of consciousness and is transferred to the emergency room. He is contaminated with feces and urine. You must measure his blood pressure. You must consider the scenario on your own for 3–5 minutes and make your own decision.
Second scenario (standard precaution)
A 55-year-old man is hospitalized after surgery. No drug-resistant bacteria have been detected from the wound. Because there is a large amount of exudate from the surgical site, you should change the surgical gauze. You must consider the scenario on your own for 3–5 minutes and make your own decision.
Third scenario (contact precaution)
A 68-year-old man, from whom methicillin-resistant <i>Staphylococcus aureus</i> was detected in a fecal culture, is complaining of abdominal pain. You must perform a physical examination of the abdomen. You must consider the scenario on your own for 3–5 minutes and make your own decision.

as prefacilitators (apprenticeship) twice. Certified facilitators were able to control the scenario-based simulation and participate in leadership positions for prevention and control of infection in each of their hospital wards.

Study outcomes

Use of alcohol-based hand rub and the incidence of central venous catheter-related bloodstream infection (CV-CRBSI) were investigated to evaluate the educational outcome and improved clinical care. From January 2010 to December 2014, the amount of use of alcohol-based hand rub based on payout amounts in each hospital ward and in the whole hospital was estimated. In addition, this amount was compared with the proportion of participation in the training course in the whole hospital. The number of times that hand hygiene was performed per patient day (hand hygiene index) was calculated based on the total amount of alcohol-based hand rub and the total number of inpatient days in a year. The correlation between the proportion of participation and the hand hygiene index was estimated in 24 hospital wards.

In addition, the relation of CV-CRBSI with the participation rate of the training course was investigated from January 2010 to December 2014. Diagnosis of CV-CRBSI was defined according to the guideline of the Infectious Disease Society of America.²¹ All patients who had positive blood cultures for any organism were evaluated and examined by infectious disease specialists at our hospital to determine whether they had CV-CRBSI or other infections. The correlation coefficient of participation in the training course and the incidence rate of CV-CRBSI during the study period were evaluated.

Data analysis

The Pearson product-moment correlation coefficient was used for the estimation of correlations. All statistical analyses were performed using SPSS version 20 software (SPSS Inc, Chicago, IL).

RESULTS

There were 1,077 trainees (261 medical doctors and 816 nurses). By the end of the study, the total participation rate for hospital staff was 76%. The participation rate in the entire hospital gradually increased over time, with rates of 0%, 21.6%, 46.5%, 75.2%, and 75.9% in 2010, 2011, 2012, 2013, and 2014, respectively. The hand hygiene index in the entire hospital increased over time, with values of 2.57, 2.55, 5.60, 8.10, and 8.98 in 2010, 2011, 2012, 2013, and 2014, respectively. The

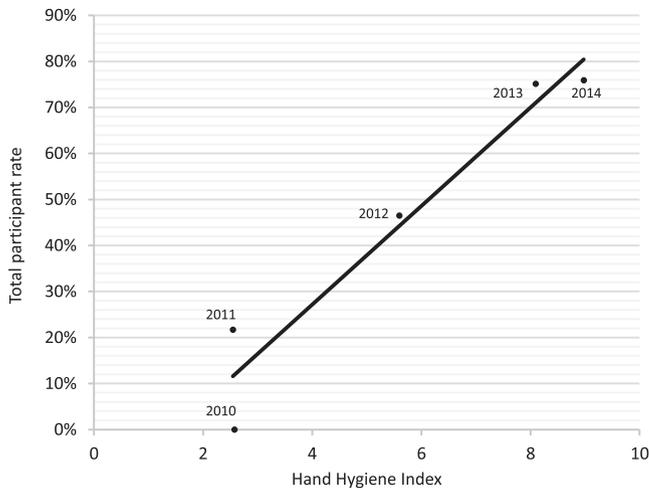


Fig 1. Correlation between the course participation rate and use of hand hygiene agents in the hospital.

correlation coefficient of the participation rate and the hand hygiene index was significant (correlation coefficient, 0.97; Fig 1). Additionally, the correlation between the course participation rate and the hand hygiene index in each hospital ward was significant for 19 of 24 hospital wards (correlation coefficient, 0.8–0.99). Three of 24 wards showed an intermediate correlation coefficient (0.45–0.67).

The incidence of CV-CRBSI from 2010 to 2014 in the entire hospital was 271 cases in 5 years. The number of CV-CRBSIs per year decreased over time, with 66, 66, 59, 43, and 37 cases in 2010, 2011, 2012, 2013, and 2014, respectively. The incidence of CV-CRBSI during 5 years and each causative organism of CV-CRBSI are shown in Table 2. *Staphylococcus* spp included 47 (27%) cases of *S aureus* and 125 (73%) cases of coagulase-negative *Staphylococcus*.

An inverse correlation (correlation coefficient, -0.94) was observed in the relation between the training course participation rate and the incidence of CV-CRBSI (Fig 2). In addition, a significant decrease in CV-CRBSI was observed with an increase in the hand hygiene index of the entire hospital (correlation coefficient, -0.98) (Fig 3).

We observed variation in reduction of CV-CRBSI among the causative organisms. CRBSI due to *Staphylococcus* spp and Enterobacteriaceae showed a significantly reduced incidence in accordance with an increase in participation rate of the training course (correlation coefficients, -0.96 and -0.69 , respectively). Additionally, CRBSI due to *Staphylococcus* spp and Enterobacteriaceae showed a significant reduction in accordance with an increase in the hand hygiene index (correlation coefficients, -0.95 and -0.83 , respectively). A reduction in CV-CRBSI due to *Candida* spp showed a low relation with the

Table 2
Incidence of CV-CRBSI during 4 years and each causative organism of CV-CRBSI

	2010	2011	2012	2013	2014	Total
<i>Staphylococcus</i> spp	47	40	37	27	21	172
Enterobacteriaceae	6	10	8	3	2	29
<i>Candida</i> spp	5	10	5	5	7	32
<i>Enterococcus</i> spp	3	1	3	1	1	9
Other Gram-negative organisms	3	3	3	3	2	14
Other Gram-positive organisms	2	2	3	3	5	15
Total	66	66	59	43	37	271

CV-CRBSI, central venous catheter-related bloodstream infection.

Other gram-negative organisms included *Pseudomonas aeruginosa*, *Pseudomonas putida*, *Acinetobacter* spp, and *Stenotrophomonas maltophilia*. Other gram-positive organisms included *Corynebacterium* spp, *Bacillus* spp, group B streptococcus, and group G streptococcus.

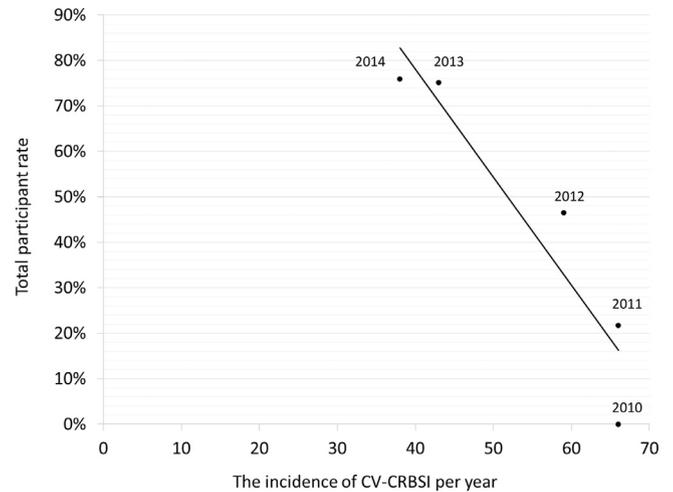


Fig 2. Correlation between the course participation rate and the incidence of catheter-related bloodstream infection.

participation rate of the training course and the hand hygiene index (correlation coefficients, -0.16 and -0.31 , respectively).

DISCUSSION

In our study, the correlation coefficient of the participation rate and the hand hygiene index was significant, and an inverse correlation was observed in the relation between the training course participation rate and the incidence of CV-CRBSI. Therefore, our study indicated the effectiveness of scenario-based simulation health care education in prevention and control of infection, especially in hand hygiene.

A previous study reported that traditional and lecture-based instructions result in somewhat effective behavioral changes.²² A previous report indicated that dissemination of guidelines alone does not change the behavior of medical staff.²³ However, the improvement of performance of hand hygiene by health care providers is a problematic aspect worldwide. Active learning style rather than lecture-based education, which is passive learning style, has been considered to be a more effective pedagogic method.^{4,5} Similarly, although some edu-

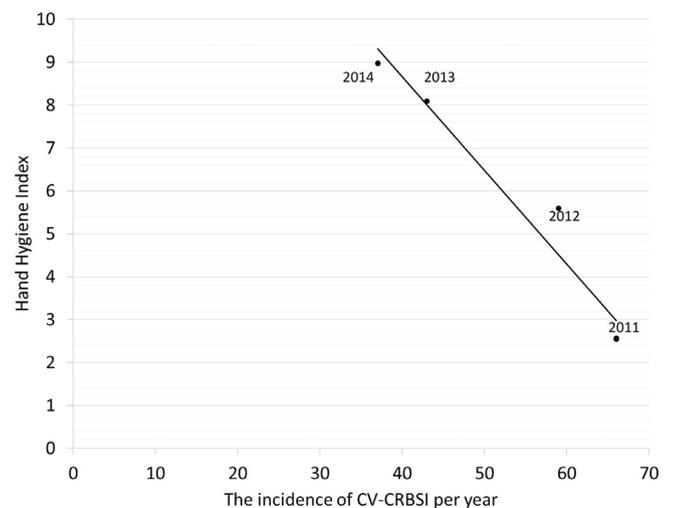


Fig 3. Correlation between use of hand hygiene agents and the incidence of catheter-related bloodstream infection.

cation by lectures was previously performed as a strategy for improving hand hygiene in our hospital, the performance of hand hygiene actually did not improve, as mentioned earlier (hand hygiene index was 2.55 and 2.57 in 2000 and 2010, respectively). In addition, our training course as an active learning style had a positive effect on hand hygiene and achieved a reduction in the incidence of CV-CRBSI.

Although numerous studies have reported the effectiveness of simulation training, few studies have examined the efficacy of simulation based-education for prevention of HAIs. These reports described that simulation-based training in central venous catheter insertion reduced central line-associated bloodstream infections using a computer simulator.¹⁸ However, whether scenario-based simulation training for HAIs is effective is unknown. To our knowledge, this study is a preliminary experience to demonstrate the effectiveness of scenario-based simulation education, which is similar to cardiac life support courses for prevention and control of HAIs.

Interestingly, a previous study reported that specific and informative feedback resulted in increasingly better skills performance in a controlled educational setting.²⁴ In the debriefings section of each scenario of our education course, facilitators discussed the point of the scenario of standard precaution or contact precaution and attempted to ensure that the trainees comprehended the correct choice while considering, and sharing, why they chose what they did. In addition to effective feedback, simulation education improves skills for all participants and leads to skill retention.²⁵ In scenario-based simulation training, when to perform hand hygiene or which PPE to select needs to be considered by the participants themselves against problems encountered in actual work duties, such as preventing infection and the need to move around the ward. Furthermore, participants receiving the training course become more effective leaders in hospital wards than after lecture-based training, because they can acquire practical skills and knowledge. These characteristics in our course might lead to behavior modifications, which are likely to be difficult to generate in lecture-based education or through reading textbooks.

Our study showed that scenario-based simulation health care education had a favorable effect on hand hygiene and reduced CV-CRBSIs. In our institute, maximal barrier precaution and hand hygiene are usually performed with every insertion technique of central venous catheters. According to Centers for Disease Control and Prevention guidelines for the prevention of intravascular catheter-related infection, hand hygiene is recommended at contact of the insertion site, exchange of the catheter, use of the access port, and with changing the dressing. Our training course presumes to improve hand hygiene in the situation of insertion of a central venous catheter or in changing the dressing for the insertion site of a central venous catheter.

An important finding in our study was that performing hand hygiene for preventing CV-CRBSI had a different effect on each causative organism. *Staphylococcus* spp is a microorganism that is found on the hands of medical staff. Therefore, improvement of hand hygiene is effective in preventing CRBSI of this microorganism. However, in CRBSI due to *Candida* spp, hand hygiene was of intermediate relevance. This finding suggests that effective measures for CRBSI due to *Candida* spp require not only hand hygiene but also other types of prevention. Although hand hygiene as a prevention care bundle has been reported to be an effective measure for the reduction of CV-CRBSI,²⁶ no studies have reported the difference in effect on the prevention of CRBSI with each causative organism. Our study showed different positive effects of hand hygiene on CRBSI due to *Staphylococcus* spp or Enterobacteriaceae than *Candida* spp. Hand hygiene had a different effect for each causative organism of CV-CRBSI.

Our study had some limitations. First, the performance of hand hygiene was evaluated quantitatively by the payout amount of alcohol-based disinfectors. Estimation via payout of alcohol hand rub as a primary outcome might be an innovative way of looking at this

problem and getting closer to an overall hand hygiene culture in the hospital, as well as avoiding the Hawthorne effect. However, it could be necessary for qualitative assessment of hand hygiene at the actual clinical setting in each health care worker who participated in this course or did not. Second, the direct relation of cause and effect between educational effects and hand hygiene performance is insufficient, because there were confounding factors, such as other educational interventions, which are related to overcoming the outbreak of drug-resistant organisms. Third, it is unclear whether other factors, such as “culture” and what “others” do around the individual staff member, strongly influence hand hygiene. The training course might have a positive and indirect effect on improvement of staff engagement and commitment of the department heads and hospital facilities, which have been previously reported as barriers to effective hand hygiene.^{27,28}

What we mainly learned from this study in practice is that simulation health care education is a favorable method because of its interactive learning of skills in following appropriate hand hygiene practice. Hospitals should try to improve hand hygiene performance not only through lecture-based education but also through simulation education.

CONCLUSIONS

Our scenario-based and task-oriented simulation education for prevention and control of infection had a positive effect on the education of hand hygiene and achieved a reduction in CV-CRBSI. Scenario-based education programs as active learning might be effective for changing the behavior of staff for preventing HAIs. Further expansion of scenario-based education programs on infection control is expected to enhance the quality of medical care in health care facilities.

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