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Web-Based Training Improves Knowledge about Central Line Bloodstream Infections

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Abstract

A Web-based training course with embedded video clips for reducing central line-associated bloodstream infections (CLABSIs) was evaluated and shown to improve clinician knowledge and retention of knowledge over time. To our knowledge, this is the first study to evaluate Web-based CLABSI training as a stand-alone intervention.

Central line-associated bloodstream infections (CLABSIs) are a significant cause of mortality and morbidity for critically ill patients. The 2011 Infectious Diseases Society of America–Centers for Disease Control and Prevention guidelines for the prevention of CLABSIs recommend implementing educational programs as well as periodic assessment of knowledge and adherence to the guidelines for those who insert and maintain catheters.¹

Conventional educational programs involve lecture formats, distributing materials, workshops, simulations, or some combination thereof.² Online or Web-based formats provide several advantages to conventional training formats, including unrestricted physical location, flexibility in training time, access to course information after completion, training individualization, and tools to automate assessment and documentation.³

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This study aimed to determine (a) the effect of a Web-based training course on clinicians' knowledge and perceived norms regarding prevention of CLABSIs in 5 hospital clinical education programs and (b) knowledge retention months after the training course. To our knowledge, this is the first study to examine Web-based CLABSI training as a stand-alone method of increasing infection-control knowledge.

METHODS

This study was approved by the institutional review boards at each study site. Five hospitals in the United States participated in the study. Each participating site identified a minimum of 20 clinicians who placed central venous catheters (CVCs) to take the training course described below. The 5 hospitals integrated the course into hospital-specific training activities targeted at those clinicians who might perform or assist in CVC placement. Study participants were registered nurses, nurse practitioners, physician assistants, residents, fellows, and attending physicians from hospital medicine, critical-care medicine, surgery, and radiology departments. Data were collected electronically via the training course's assessment tool.

The self-paced course, which provided video demonstration of common errors, aimed to educate clinicians in (a) outcomes and morbidity of CLABSIs and (b) methods to prevent CLABSIs. The content of the course was based on published systematic reviews.¹ The course was pilot tested previously in a prospective, randomized, controlled study in the admitting department of a university-based high-volume trauma center.⁴ In the pilot study, residents who had completed the CVC training course were significantly more likely to comply with sterile practices than were residents who took a paper-based training course or those who had not taken the training course ($P = .003$).

The CVC Knowledge and Attitude Questionnaire (CVCKAQ) was developed (see Figure 1) to assess knowledge on outcomes and morbidity of CLABSIs and methods to prevent CLABSIs (multiple-choice questions 1–17). Attitude toward sterile practices was assessed using the construct from the theory of planned behavior (Likert-scale questions 18–22), which asserts that people act according to their intentions and perceptions of command over the behavior, and their intentions are inspired by attitudes toward the behavior, subjective norms, and perceived behavioral control.⁵

The questionnaire was piloted in April 2008 on 10 residents at 1 participating institution and revised on the basis of the results and feedback from the residents. The revised version was piloted in a different participating institution but the questionnaire reliability was not specifically tested. The CVCKAQ was administered 3 times: (1) as a pretest, before the course, (2) as a posttest, immediately after the course, and (3) as a follow-up test, 3–4 months after course completion. The CVCKAQ was completed electronically. A dedicated course Web portal was used at each site (each at a different city) to reduce potential cross-influence among sites. Each participant was assigned a unique anonymous sign-in to allow within-subject comparison of test scores from the pretests, the posttests, and the follow-up tests while protecting anonymity.

Linear mixed models were used to analyze the change in test scores (posttraining minus pretraining). The models included random intercepts to account for within-subject and within-site correlation. Linear mixed models with random intercepts were also used to assess whether subjective norms of CVC infection prevention related to test scores. The statistical software R was used for analysis.⁶

RESULTS

There were 177 respondents from 5 hospitals. The mean score of the 17 knowledge questions was calculated for the pretest (baseline) questionnaires and the posttest questionnaires. The mean pretest score was 59.6% (standard error [SE], 0.9%) and the mean posttest score (test administered immediately after the course) was 77.9% (SE, 0.9%); this represents a significant increase of 18.3% (SE, 1.1%; $P < .001$). Pre- and posttest scores were examined for each of the 5 sites (Table 1). The mean posttest scores were significantly ($P < .001$) higher than the pretest scores for site 1 (81.6% vs. 58.6%; $P < .001$), site 2 (81.1% vs. 57.5%; $P < .001$), site 3 (73.6% vs. 59.6%; $P < .001$), site 4 (83.1% vs. 59.4%; $P < .001$), and site 5 (76.5% vs. 68.1%; $P = .044$). Site 4 had the largest change in mean score from the pretest to the posttest (23.7% [SE, 2.1%]), and site 5 had the smallest change (8.4% [SE, 3.9%]).

For site 4, the completion rate for the pretest, the posttest, and the follow-up test was 100%. The data from site 4 were analyzed to assess knowledge retention because it was only at this site that a sufficient number of participants finished the follow-up test. Table 2 shows that the mean follow-up test scores decreased by 12.2% from the posttest scores but they were still statistically higher ($P < .001$) than the baseline pretest scores. Responses to questions addressing attitude were not predictive of increased posttest scores when compared with pretest scores.

DISCUSSION

The goal of this study was to examine the effect of a Web-based training course about CVC placement on clinicians' knowledge as well as change in and retention of knowledge in multiple hospitals. We found that the training course did increase clinicians' knowledge about CVC-associated safety risks, and much of this knowledge was retained after 3–4 months, as scores decreased only about 12% over that time. The clinicians' attitude toward CLABSIs was not predictive of the knowledge score improvement.

Effective multicenter interventions addressing CLABSIs have utilized several different modalities in training programs.^{7,8} Interventions have included didactic lectures, self-study modules, checklists, simulations, and recommended procedures posted as reminders. Two other studies have incorporated Web-based CVC training as part of infection-control programs. Berenholtz et al included such training as 1 of 5 interventions that were designed to increase provider awareness.⁹ The training was paired and evaluated with 16 lectures and was successful in decreasing CVC bloodstream infections. Web-based CVC trainings were also derived from a 30-hour patient safety course at the University of California, San Francisco.¹⁰ The advantage of the Web-based training course we used was that it was self-directed and did not require additional staff to give lectures or perform assessments. At 1 site, incoming residents were required to complete the modules before starting their training. Such self-directed study carries the advantages of providing the learner with autonomy and flexibility.^{11,12}

All participants served as their own control to account for the expected differences in knowledge at the start of the course. We found no evidence that training targeting certain groups with certain pretraining attitudes would increase knowledge among clinicians who participated in the training course.

This study is limited in that only 1 site had sufficient participants in the 3–4-month follow-up test; thus, the study results may have been biased. Also, this study was not designed to assess whether a high level of knowledge translated to improved patient outcomes. Moreover, the study was not designed to stratify results by profession.

Future multicenter studies on effective ways to improve education training may include larger sample sizes with measures on behavioral changes and patient outcomes, such as CLABSIs or utilization of femoral sites. Also, researchers should determine ways to assess whether such a course has an effect on longer-term knowledge. Moreover, stratifying results by operator profession may provide further information about training targets.

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- Q1 How often do CVC-related blood stream infections occur in patients with central lines?
- More than 1/4
 - Between 2/100 and 1/4
 - Between 1/100 and 2/100**
 - Between 1/1,000 and 1/100
- Q2 What is the healthcare cost associated with each CVC-related blood stream infection?
- Between \$100 and \$1000
 - Between \$1000 and \$2500
 - Between \$2500 and \$30,000**
 - Between \$25,000 and \$30,000
- Q3 What is the mean additional hospitalization days attributable to CVC-related blood stream infection?
- < 1 day
 - Between 1-5 days
 - Between 5-10 days**
 - Between 10-20 days
- Q4 Which of the following is NOT a complication of CVC insertion?
- Pneumothorax
 - Bloodstream infection
 - Aspiration pneumonia**
 - Hemothorax
- Q5 Arterial puncture during a central line insertion is most common at the following site:
- Femoral**
 - Subclavian
 - Internal jugular
 - External jugular
- Q6 Using appropriate techniques, by what percentage can CVC-related blood stream infections be prevented?
- 100% completely
 - Between 25-75%**
 - Between 2-10 %
 - Between 10-25%
- Q7 Which of the following is the optimal skin preparation prior to CVC insertion?
- Povidone-iodine
 - Iodine
 - Chlorhexidine**
 - Alcohol-based scrub
- Q8 Which of the following does not decrease the risk of a CVC bloodstream infection?
- Maximal barrier precautions
 - Use of chlorhexidine skin preparation
 - Routinely changing a central line to a new site
 - Anti-infective coated central line catheters**
- Q9 When inserting a central line, after how many failed attempts should you seek help?
- 1
 - 3**
 - 5
 - 10
- Q10 When prepping the skin prior to CVC insertion, you should
- Not wear gloves
 - Wear non sterile gloves
 - Wear sterile gloves**
 - Ask the nurse to prep the area while you are putting on sterile gloves, gown, and mask
- Q11 When draping a patient, you should handle cardiac leads in the following way:
- Leave the leads where they are because the patient needs continued cardiac monitoring during insertion
 - Leads should be moved out of the area where the skin is being prepped**
 - Leads should be removed
 - Clean the leads with chlorhexidine skin prep and leave them where they are
- Q12 Chlorhexidine skin preparation should not be used in which patient population?
- Cancer patients
 - Trauma patients
 - Children less than 2 months of age**
 - Any children
- Q13 What is the attributable financial cost of using maximal barriers for each line placement
- < \$100
 - Between \$100 and \$1000
 - Between \$1000 and \$2500
 - Actually save between \$100 and \$1000**
- Q14 After you have placed how many CVCs does the rate of complications decrease by 50%?
- 100
 - 50**
 - 5
 - 1
- Q15 You are inserting a central line in a 55-year-old male admitted with cardiogenic shock. The patient has a normal PT, PTT, and INR. Which site is the preferred choice for central line insertion?
- Femoral line
 - Subclavian**
 - Internal jugular
 - External jugular
- Q16 You are taking care of a 55-year-old diabetic female admitted with acute renal failure. The nephrology team has decided that a dialysis catheter is needed. Which site is the preferred choice for central line dialysis catheter?
- Femoral line
 - Subclavian
 - Internal jugular**
 - External jugular
- Q17 You are taking care of a 30-year-old trauma patient with a chest tube on his left side. Which site is the preferred choice for central line dialysis catheter?
- Femoral line
 - Left subclavian**
 - Right subclavian
 - Internal jugular

FIGURE 1. Central venous catheter (CVC) knowledge and attitude questionnaire. INR, international normalized ratio; PT, prothrombin time; PTT, partial thromboplastin time. Bolded text indicates the “correct” answers. Attitude questions (18–22) not shown.

TABLE 1

Mean Knowledge Scores for All 5 Sites

Site	N	Pretest	Posttest	Posttest minus pretest	P
1	30	58.6 (2.3)	81.6 (2.3)	22.9 (2.6)	<.001
2	23	57.5 (2.8)	81.1 (2.8)	23.5 (2.7)	<.001
3	67	59.6 (1.2)	73.6 (1.2)	14 (1.7)	<.001
4	38	59.4 (1.7)	83.1 (1.7)	23.7 (2.1)	<.001
5	19	68.1 (2.9)	76.5 (2.9)	8.4 (3.9)	.044

NOTE. Data are mean % (standard error), unless otherwise indicated.

TABLE 2Mean Test Scores of Site 4 for 3 Time Periods ($N = 38$)

Variable	Mean	Mean difference	<i>P</i>	
			Versus pretest	Versus posttest 2
Pretest	59.4 (1.8)	Reference
Posttest	83.1 (1.8)	23.7 (2.1)	<.001	<.001
Posttest 2 ^a	71.6 (2)	12.2 (2.2)	<.001	...

NOTE. Data are % (standard error), unless otherwise indicated.

^a Performed 3–4 months after the course.