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Changing health care worker behavior in relation to respiratory disease transmission with a novel training approach that uses biosimulation

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Background: This pilot study was conducted to determine whether supplementing standard classroom training methods regarding respiratory disease transmission with a visual demonstration could improve the use of personal protective equipment among emergency department nurses.
Methods: Participants included 20 emergency department registered nurses randomized into 2 groups: control and intervention. The intervention group received supplemental training using the visual demonstration of respiratory particle dispersion. Both groups were then observed throughout their work shifts as they provided care during January-March 2005.
Results: Participants who received supplemental visual training correctly utilized personal protective equipment statistically more often than did participants who received only the standard classroom training.
Conclusion: Supplementing the standard training methods with a visual demonstration can improve the use of personal protective equipment during care of patients exhibiting respiratory symptoms. (Am J Infect Control 2007;35:14-9.)

Health care personnel are at risk for exposure to a variety of infections during the routine performance of their job responsibilities. Despite these risks, compliance with protective equipment has remained suboptimal.[1] The safety of emergency department (ED) personnel, often the first to encounter an ill patient, is an important area to target for improvement. The risk factors for those individuals include the emergent nature of the care provided and the unknown circumstances that initially led to the patient's utilization of health care.[2] Despite the emphasis on standard precautions training for health care workers (HCWs), the consistent use of personal protective equipment (PPE) remains poor.[3,4] Various descriptions and analyses of the 2002-2003 severe acute respiratory syndrome (SARS) outbreak reported lack of basic preemptive infection prevention and control strategies. As the outbreak grew, attention was paid to use of protective equipment, including respiratory protection, as symptomatic patients were identified. The experiences of HCWs confronted with suspected or confirmed SARS cases revealed an often inadequate and incorrect use of PPE.[5,6] A fundamental flaw in the preventive process seemed to involve failure to recognize quickly the key signs, symptoms, or risks that might have led to the early implementation of protective equipment. Although there is little research concerning changing HCW behavior when providing care for patients with respiratory illness, there was some evidence from the SARS outbreak that pointed toward the benefits of training programs and availability of adequate PPE.[7]

The workplace practices identified as problematic during the SARS epidemic mirror those identified by Jagger et al at the International Healthcare Worker Safety Center of the University of Virginia. Jagger et al's work has focused on injuries and exposures involving blood and body fluid exposures among HCWs. In 2001, as part of the EPINet Surveillance Program,[8] a total of 463 blood-body-fluid exposures were reported from 49 participating health care facilities. Of these exposures, over 13% occurred in the ED. Less than 10% of the exposed HCWs reported wearing appropriate eye protection, and fewer than 20% reported wearing some sort of mask or other facial barrier.[9] Clearly, the need still exists for effective training techniques to promote the use of PPE as a way to minimize such workplace exposures.

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Traditional infection prevention and control training for HCWs has involved a review of the Occupational Safety and Health Administration (OSHA) bloodborne pathogens training,[10] as outlined in the current Centers for Disease Control and Prevention (CDC) isolation guidelines,[11] with emphasis on transmission-based precautions. When we conducted an informal telephone interview with infection control professionals (ICPs) from 10 US hospitals chosen at random, results indicated that this type of training involved a classroom setting (80%) and/or written handouts (20%). A pretest and posttest process typically assessed competency. None of the interviewed hospitals reported the consistent inclusion of an observational component in their training or subsequent assessments.

Much of the existing research and education involves exposures to bloodborne pathogens; very little involves respiratory pathogens. The research does, however, enforce the concepts of disease transmission and identifies the lack of consistent protective activities used by health care personnel.[1-4] The risks involved in respiratory pathogen transmission have been included in the concept of ''cough etiquette'' outlined in the draft version of the impending CDC Draft Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings, 2004.[12] It is important to identify innovative methods that will impact practice and result in procedural changes that will better protect the care provider.

Developing new methods that can change the behavior and increase the appropriate use of PPE is a challenge. This pilot study evaluated a novel training approach for HCWs to use PPE when encountering patients who have known or suspected respiratory illnesses. The training approach involved the use of a human patient biosimulator to visually demonstrate respiratory disease transmission. The effectiveness of the visual demonstration was assessed by comparing the PPE-specific knowledge, attitudes, and skills of ED registered nurses (RNs) who received the demonstration to those who only received the standard disease transmission training. The study hypotheses were as follows: (1) The standard disease transmission training will result in an increase in knowledge among RNs, and (2) the additional use of a visual demonstration would result in significant improvement in appropriate PPE use among HCW beyond the improvement produced by the standard training methods.

METHODS

This pilot project involved the use of the patient biosimulator (Medical Education Technologies, Inc. [METI], Sarasota, FL) to demonstrate particle dispersal during a cough. When the biosimulator ''coughed,'' fluorescent powder was dispersed into the air, allowing the study subject to visualize the impact to themselves and the environment. The study subjects were able to see the particles move directly from the patient to the air and contaminate the environment as well as the subject's physical person (Fig 1). The effectiveness of PPE was demonstrated using a black light that showed areas of fluorescent powder contamination and areas in which PPE provided a barrier, thereby preventing contamination.

We used pre-/posttest knowledge assessments and observations of HCW-patient interactions to evaluate the impact of the visual demonstration of respiratory disease transmission on PPE use by HCWs. The study was conducted during the peak of the 2005 influenza season (January to March) to ensure that the HCWs could be observed interacting with the greatest number of patients with respiratory symptoms.

The study was conducted at a university medical center in a large metropolitan city. Training sessions and observations took place in the ED. Initially, 22 RNs were recruited into the study; 2 subjects withdrew from the study following job transfers. An effort was made to recruit an equal number of day shift (7 am to 7 pm) and night shift (7 pm to 7 am) nurses into the study.

The university hospital institutional review board approved the study. Eligible RNs were identified by the ED nurse manager and were informed of the study during scheduled staff meetings and by posted flyers. Eligible RNs were those nurses who were employed by the hospital; therefore, mobile or per diem nurses were excluded. During the staff meetings, the investigators provided a brief overview of the study, answered questions, and determined staff members' willingness and eligibility to participate in the study. The RNs who agreed to participate were provided with a consent form to sign. After the consent form was signed, all subjects were scheduled to attend classroom training. This training focused on mechanisms of disease transmission, standard precautions, and appropriate use of PPE. The 20 subjects were randomly assigned to either the intervention group or the control group. The intervention group received classroom training plus biosimulated visual training, and the control group received classroom training only.

After group assignments were made, a colored sticker was placed on the subjects' identification badges to indicate participation in the study. Observers with experience in the education and training of health care personnel were trained to recognize and evaluate the use of PPE by study participants during real patient interaction. The observers were blinded to the subjects' group assignment. A work schedule was provided to the observers to allow equal opportunity for evaluation

Fig 1. Visual demonstration of respiratory particle dispersal during cough using biosimulation and fluorescent powder.

on both shifts throughout the observation period. The study was designed to continue until a minimum of 10 patient-subject interactions were observed for each study participant or until the ED activity indicated that the presentation of symptomatic patients had declined to a point that observation opportunities were minimal.

Personal handheld computers were used for data entry by the observers. The investigators developed software, and training was provided to the observers. Use of the handheld data collection device allowed the observers to collect and record information in an unobtrusive manner and minimize data entry errors. Written scenarios and monitoring of real-time nurse-patient interactions were observed in an effort to promote interrater reliability between the 2 observers. The 2 observers participated in specific education and evaluation sessions held prior to the study, during the study, and after completion of the study. Sessions were held with both observers together as well as separately. Scenarios were presented to determine the ability of each observer to identify the care setting (eg, triage, assessment) specific types of PPE (eg, mask vs N95 respirator), and symptoms exhibited by the patient (eg, temperature readings, cough, rhinitis). During all reviews, both observers consistently demonstrated 100% accuracy.

Data were collected at 3 points in time: (1) Participants completed a knowledge assessment prior to the classroom training. The pretest phase included an assessment of subject's knowledge of respiratory pathogen transmission as well as standard precautions; (2) once classroom training was completed, the subjects retook the knowledge assessment; and (3) observations began after the posttest had occurred.

Observations of the subjects' use of PPE were made in the weeks immediately following the completion of training. A patient-subject interaction was considered appropriate for study inclusion if the observers noted that the patient exhibited respiratory symptoms (ie, cough and/or fever). If the patient-subject interaction was appropriate, the observers evaluated the subject's behavior with regard to PPE use. The observers also recorded the patient's symptoms, the time and location of the care, and the care that was being provided. Type of care provided was coded as triage, physical assessment, invasive procedure, noninvasive procedure, and resuscitation event. Knowledge related to respiratory pathogen transmission and standard precautions guidelines were measured by a questionnaire developed for this study.

Evaluations of the patient-subject interaction by the 2 trained observers included the date/time of observation, presenting diagnosis, procedure(s) performed during the observation episode, presence of respiratory symptoms, patient cooperation as related to each procedure, and a list of all PPE items used or worn by the observed HCW. The opportunity for the observer to make special comments that may impact the use of PPE (eg, if the patient is masked during the observation episode) was included in the data collection form.

RESULTS

Demographic information was collected on the RN subjects and is shown in Table 1. The 2 groups were found to be similar on most demographic variables. The age range was 23 to 56 years with a mean age of 38 years. The 2 groups were primarily female (95%), with slightly less than half (48%) having a college or graduate degree (bachelor's degree or master's degree in nursing).

Both the intervention group and the control group completed standard classroom training designed to provide text-based information about disease transmission. The preclassroom training knowledge assessment indicated no difference between the intervention and control groups ($t(19) = 1.11$, $P = .28$). The average pretest score was .67 (SD = .12) for the control group and .62 (SD = .09) for the intervention group. The 2 groups also did not differ significantly on the postclassroom training assessment ($t(19) = 1.22$, $P = .24$). The average posttest score for the control group was .81 (SD = .17) and .72 (SD = .18) for the intervention group. Combining the scores of both groups yielded a pretest score of .64 (SD = .11) and a posttest score of .76 (SD = .17). Overall, both groups showed a

Table 1. Demographic characteristics of the nurses in the sample

Characteristics	Intervention group	Control group	*P* value
Sex			ns
Female	100%	90%	
Male	N/A	10%	
Age	38 yr (mean)	37 yr (mean)	ns
Education level			ns
Diploma	9%	10%	
Associate degree	36%	50%	
Bachelor's degree	55%	30%	
Master's degree	N/A	10%	
Employment status			ns
Full-time	91%	90%	
Part-time	9%	10%	
Length of time as RN	13 yr (mean)	7.8 yr (mean)	ns
Length of time worked in emergency care field	8.3 yr (mean)	6.7 yr (mean)	ns
Length of time worked in hospital ED	4.8 yr (mean)	5.3 yr (mean)	ns

significant increase in pretest to posttest knowledge (mean change = .12, SD = .18; t(20) = 3.02, P = .007).

A total of 114 observations were recorded: 56 for the control group and 58 for the intervention group. Of these, 35 involved more than 1 observation on a single patient. In an effort to ensure independent observations, 1 observation was randomly selected from each patient to be included in the final data set. This was done to prevent multiple observations of a single patient for whom PPE was used or not used during each patient interaction. In the final dataset, there were 84 observations, with 42 in each group.

Cough, fever, rhinitis, and/or sneezing were considered conditions in which PPE was required. The intervention group did not differ significantly from the control group on the proportion of patients with symptoms requiring PPE use (86% vs 93%, respectively, [Fisher exact test, P = .16]).

Table 2 shows the breakdown of protective equipment used by study participants stratified by group. Interestingly, RNs in both groups routinely elected to place masks on the patients instead of on themselves. A mask, used on the RN and/or the patient, was considered to be appropriate PPE when the patient condition included fever, cough, sneeze, and/or rhinitis. Self-use of a mask did not differ between the control and intervention groups (Fisher exact test, P = .60). Although use of a mask on the patient occurred more frequently in the intervention group, it was not significant (Fisher exact test, P = .08).

Upon analysis of data, the practice of nurses masking patients was an unexpected finding. It was then decided to aggregate self and patient mask use into a single dichotomous variable: PPE mask use. When

Table 2. Protective equipment used by subjects stratified by group

Group	Mask (surgical or N95)	Goggles	Gown	Gloves	Patient masked	None
Standard training (control)	8	3	1	5	14	19
Standard training + visual demonstration (intervention)	10	2	1	8	22	8

Table 3. Impact of training on use of PPE comparing intervention and control groups

Use of mask	Standard training (control)	Standard training + visual demonstration (intervention)	Total
No	20	11	31
Yes	22	31	53
Total	42	42	84

Fisher's Exact, p = .035

use of PPE (self-use of mask and placement of mask on patient) was dichotomized into ''yes'' or ''no'' and was cross-tabulated with group assignment, analysis comparing use of PPE between control and intervention groups indicated that subjects who received the visual training demonstrated use of PPE more often (74% vs 53%, respectively). Given the exploratory nature of the study and the unidirectional hypothesis that the visual demonstration would improve PPE use, statistical significance for this hypothesis was evaluated as a 1-tailed distribution test (α = .05). A Fisher exact test was performed to determine whether the visual demonstration increased appropriate PPE use relative to the standard training alone. Results are shown in Table 3 and indicate that the standard training plus biosimulation significantly increased the use of PPE for patients with respiratory symptoms (P = .04).

DISCUSSION

The literature that addresses PPE use among HCWs continues to stress the need for education as a means of improving safety practices.[1-7] This study showed, however, that traditional education is not necessarily the sole or even key factor in improving PPE use. Two basic components were addressed in this pilot project. The first involved the increase in knowledge regarding disease transmission using a traditional didactic training process. The second component investigated whether a biosimulated, visual demonstration of particulate transmission would result in increased PPE use.

Traditional classroom training did, indeed, make a significant difference in pre- and posttraining knowledge. The addition of a visual component to training emphasized the personal risk of the individual HCW. Direct observations showed that the subjects trained using this visual approach appropriately used PPE more often than those subjects whose training did not include this visual component: 74% versus 53%, respectively. Therefore, these results suggest that use of the biosimulator and visual training is an important new approach for learning in the health care setting. This type of learning allowed the HCW to see the impact of disease transmission as opposed to simply hearing about it through traditional didactic education. In addition, the components of this visual demonstration built on the principles of adult learning. Teaching occurred within the context of work experience, thereby making the learning relevant to the individual.

Feedback from the subjects in the intervention group reinforced the value of the visual component of training. Several staff commented that they recognized environmental or personal contamination when they could see the blood or other fluids they encounter during emergency procedures but admitted that their use of protective strategies, including PPE, was less than ideal. Every subject trained in the intervention group remarked on the impact they felt the visual demonstration had on their individual practice.

The major limitation of this pilot study was the small size of the sample. Although many results demonstrated significance, the question remains whether or not the results are generalizable. Repeating this study on a larger scale could help answer that question. The logistics involved in unobtrusively observing practice and working around nurses who were not involved in the study made planning and implementation a difficult task. Another issue of concern was our inability to ascertain the influence of the organization on the use of safety practices, including use and selection of PPE. If this study were repeated and involved multiple sites, the culture of safety and its impact could be assessed.

With the availability of inexpensive computer technology in recent years, simulation technology has blossomed, especially in the field of medicine, in which applications range from scientific modeling to clinical performance appraisal in the setting of crisis management. Much of the initial work with human patient biosimulators, or use of a simulation ''dummy,'' has been done by anesthesiologists as part of their road toward medical error reduction. Biosimulators are now used in university medical centers across the country to assist and improve the learning of residents, medical students, nursing students, and employed HCWs. The benefits of simulation technology in medical training include improvements in cardiovascular examination skills, increased precision in surgical technical skills, and acquisition and retention of knowledge compared with traditional modes of teaching (eg, lectures).[13-18] Although there has been significant knowledge and experience gained through simulation in the area of medical education, there has been a lack of research concerning the use of simulation as a method of enhancing performance involving respiratory disease transmission.

Developing an improved model for training HCWs that demonstrates a significant improvement in behavior regarding PPE use has the potential to protect the millions of HCWs that currently practice in health care settings. Reducing the respiratory exposures because of influenza and preventing the repeated scenarios identified during the SARS 2003 global epidemic may also prevent the unnecessary illness/deaths of HCW because of inadequate or inappropriate use of respiratory PPE. Successful demonstration of improvements could change the way HCW education is conducted throughout a variety of environments, not simply the ED. Furthermore, this type of education could be used in other professional disciplines, including physician, therapist, and administrative training.

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The authors have made available to the readers a visual component to this article. Readers may visit the following Web site to see a brief video clip (there is no sound with this clip): http://www.louisville.edu/television/cough.asx

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