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Innovative Bloodborne Pathogen Training for Registered Nurses

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List of Abbreviations:

1. Guidelines: U.S. Public Health Service Guidelines
2. EMS: Emergency Medical Service
3. BBP: Bloodborne Pathogens
4. HIV: Human Immunodeficiency Virus
5. HBV: Hepatitis B
6. HCV: Hepatitis C
7. RN: Registered Nurse
8. UP/SP: Universal Precautions/Standard Precautions
9. PEP: Post Exposure Prophylaxis

Abstract

The purpose of this pre-post intervention assessment proposal was to develop, implement, and evaluate novel computerized simulation training programs for the reduction of infectious disease risk in registered nurses.

Healthcare workers, including nurses, are at risk for a wide range of occupational health hazards, including the risk from infectious diseases such as bloodborne pathogens and tuberculosis. In order to reduce morbidity and mortality associated with occupationally acquired infections, a number of risk management strategies have been developed. While, safety training programs are acknowledged as an important part of an overall risk management strategy, there are however, a number of challenges and barriers to effective health and safety training, especially in the healthcare work setting. These include time constraints, paucity of experienced trainers, limited training facilities available, limited staff resources which make training in large groups difficult if not impossible, and probably most troubling of all, general dissatisfaction with training materials (i.e., boring, repetitious, especially for annual updates). Importantly, there is a general lack of evaluation research on the efficacy of training programs in the health care setting, including those designed to address bloodborne pathogens infection control.

To address this problem, our multidisciplinary team of researchers partnered with two large medical centers and a professional nurses' association in order to develop and evaluate an innovative approach to bloodborne pathogens safety training for nurses. After a review of the literature and consultation with leading experts in adult based continuing education, we decided to develop realistic simulation exercises, which are based on embedded testing theory and shown to be effective in safety training in other occupational settings (e.g., mining). Simulations tell the story of a "real" situation, which the participant can readily identify with. At certain points along the study, decisions have to be made, and this provides an opportunity for participants to can use their decision making skills. Impotently, these types of exercises not only improve knowledge, but help to change or reinforce safety related beliefs. Thus they are powerful tools for developing a strong understanding of why certain safety precautions are necessary. The conceptual model suggests that once participants understand why the precautionary or compliance behaviors are necessary, they will change their intentions of safe work practices, and thus ultimately their safety-related behaviors.

Guided by participatory action research, a simulation team was formed to develop several simulation exercises targeting bloodborne pathogens. After extensive pre and pilot testing, the exercises were then formatted into a computerized interactive web-based version and administered to volunteer registered nurses who were recruited with assistance from our partner collaborators. Participants received one continuing education unit (CEU) for each of three simulations they completed as an incentive for participation. The exercises were linked to the participating hospitals own infection control or bloodborne pathogens home web pages so that participants could readily access information specific to their home institution,. The exercises also provided numerous informational links (e.g., Centers for Disease Control (CDC), Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), and American Nurse Association (ANA) and others so that participants could readily avail themselves of a wealth of information available. The links were also important in terms of helping the participants lean more about the responses to questions that they answered incorrectly, as the exercise were designed so that at certain key points in the story line, the participant was asked a question; forward

movement was precluded until the question was answered correctly. Therefore within the stories, everyone *had to* archive a score of 100%.

To evaluate the program we used three mechanisms: (1) a pre-test of knowledge, intentions to report serious exposures, barriers to reporting, and perceived safety climate, (2) a post-test which included all of the preceding constructs except barriers, and (3) an evaluation of the nurses' satisfaction with simulation exercises and with the computer-based training format.

The results of this study may have important implications for effective health and safety training for nurses.

Significant Findings

Demographics

The sample of 130 registered nurses predominantly female (96%) from hospital including the Johns Hopkins Hospital, New York Presbyterian Hospital, Barnes Jewish as well as other hospitals nation-wide. Fifty-nine percent of participants reported employment related to nursing administration while 28% reported being clinical nurses, and 13% were employed in other positions. Eighty-nine percent of the sample reported being a licensed RN. Respondents were predominantly educated at the Associate Degree or Diploma level (25%), 51% had college Bachelor's Degrees and 17% reported earning Master's Degrees. Most responders had worked as RN's for approximately 20 years.

Knowledge

A new 10-item employee health-specific safety climate scale was developed for this study. The scale has an alpha of .69, mean = 7.7, median = 8.0, mode = 8.0, SD plus/minus 1.3, range = 1-10. While the overall climate was high, low scores were noted on some specific items. For instance, 73.7% of respondents reported that they did not have access to an employee health professional at their organization. And while a high level of training was reported; 91.4% reported that they received annual bloodborne pathogen training, nearly 51% were provided with 3 or more training hours per year, and 32% received 2 hours per year, and a substantial proportion (17%) received 1 hour or less per year.

Pre-Test Post-Test Results: Knowledge

The mean scale score on the pre-test was 7.08 and 7.18 on the post-test out of a possible range of 0-8. There was no significant difference.

Pre-Test Post-Test Results: Intentions

On the pre-test the mean score was 0.93 (possible range of 0-1) and 0.95 on the post-test. There was no significant difference.

Pre-Test Post-Test Results: Safety Climate

On the pre-test the mean score was 0.95 and 0.96 on the post test. There was no significant difference.

Evaluation of the Training Program

The majority of participants gave the program outstanding evaluation scores. The format was highly acceptable and the exercises were enjoyable to complete.

Translation of Findings

These findings indicated that this approach to training did not result in increases in knowledge, perception about safety climate or intentions to report. However it should be noted that most participants were already highly educated and experienced; more then half were administrators with the responsibility for educating their staff. Since, the pre-test scores were already exceptionally high, significant improvements were not feasible. A very important finding however was the acceptability of this format for training and the effectiveness of this type of approach for staff. The nurses overwhelmingly appreciated the viability of the simulation approach. This technique, therefore, could be used as an effective training tool for blood borne pathogen risk management.

Scientific Report

Background: Occupational risk of exposure and infection to bloodborne pathogens

Occupational exposure to blood and body fluids is well documented among health care workers, with annual exposure prevalence rates ranging from less than 10% to as high as 40% depending on the occupational group.[1-3] Risk factors associated with exposure have been identified and these include: urgency of the procedure, the amount of blood loss (>200 mLs), blind procedures (e.g., obstetrical suturing), the duration of the procedure, use of sharps such as needles or scalpels, and the lack of compliance with safe work practices, such as universal precautions.[4] Most exposures that are reported involve percutaneous injuries (e.g., needlesticks or other sharps injury), mucocutanous exposure, (e.g., spray or splashes to the eyes or mouth) or direct contact with non-intact skin.[4] It has been estimated that as many as 1/100 exposures involve HIV contaminated blood.[4]

As of the Centers for Disease Control and Prevention (CDC) reported 57 HCWs with documented HIV seroconversion following occupational exposure and an additional 138 cases of HIV infection in HCWs that most likely resulted from occupational exposure.[5] Reports of HIV infection in non-hospital HCWs, including home healthcare providers, lab technicians, embalmers, and others have been documented.[6] The risk of contracting HIV and other bloodborne pathogen infections by health care workers, given a contaminated needlestick exposure has been estimated at 0.3% to 0.4% for HIV, 10% to 35% for hepatitis B virus (HBV) (in non-vaccinated persons), and 1.2% to 10% for hepatitis C virus (HCV).[7-11] The risk factors commonly associated with HIV infection include percutaneous injuries with hollow-bore needles, deep wounds, devices with visible blood drawn from a vein or artery, and source patients with terminal AIDS.[12-14] Occupational transmission to HIV and HBV has also occurred, albeit rarely, from unusual routes of transmission including contact with bloody saliva, human bites, contact with human remains (e.g., embalming procedures), and stab wounds from contaminated needles.[6,15-16]

Hepatitis B virus infection, while dramatically reduced in HCWs since the introduction of the HBV vaccine, is still reported by approximately 400 HCWs each year.[17-18] And HBV has been occupationally transmitted through blood contact and through contact with saliva and human bites a potential risk.[19] Several studies have shown that HCV may be transmitted both percutaneously as well as through mucutaneous routes. Rarely, HIV and HCV have been transmitted simultaneously through needlestick injuries, with unusually rapid and fatal results.[20]

Risk Management Strategies

The health care community has nearly two decades of experience with managing the risk of bloodborne pathogen exposure in the occupational setting. Early on in the AIDS epidemic, safe work practices were identified and encouraged, first through the

publication of numerous CDC Guidelines, which were then followed by the promulgation of the OSHA Bloodborne Pathogen Standard.[22-25] Not long after, several studies noted widespread lack of compliance with even the most basic elements of the standard, and this was noted for both hospital-based and non-hospital based health care workers.[26-30]

Lack of compliance has been shown by Gershon, *et al.* to be associated with both worker-centered variables (e.g., lack of knowledge, inaccurate perception of risk, maladaptive fear response, negative influence of subjective norms, risk-taking personality profile, and sociodemographic factors, such as male gender and occupation [physician]), as well as organizational variables (e.g., lack of resources, poor safety climate, and inadequate training and educational programs).[31-39] Importantly, exposure has been repeatedly found to be related to a lack of compliance. However, even if adherence to universal precautions and standard precautions were optimal, they are not really designed to protect HCWs from the most serious type of exposures, namely percutaneous injuries. Needles and other sharps devices are simply inherently a risky, and thus more recent risk reduction strategies have appropriately emphasized safer needled devices and other engineering controls. This has resulted in sustained decreases in certain types of injuries, most notably in intravenous catheter-related needlesticks. Jagger and co-workers documented decreases in needlestick injuries related to the introduction of a needleless system ranging from 4% to 88%.[40] needlestick surveillance study we recently conducted noted a 91% decline in needlesticks following the introduction of needleless intravenous systems.[41] However, many other types of injuries and exposures, including wounds associated with hollow-bore needles, have remained a considerable threat. For example, in our recent study, hollow bore injuries still accounted for 68% of all exposures in a mid-sized hospital. Fortunately, new devices designed to safely inject or withdraw blood are rapidly entering the health care field and should have a significant impact on these types of injuries, although cost and availability remain obstacles to their wide-spread use, especially in certain settings, such as the correctional health care setting, where budgets may be severely constrained.

Other risk management strategies have focused on administrative factors, such as involving front-line workers in the management of the bloodborne pathogens program. This has been shown to have an important effect in several ways. First, because this is a highly efficient method for identifying risk reduction measures and second, employee involvement in the safety process leads to more positive perceptions of organizational safety climate, which in turn has been found to lead to higher rates of adoption of safe work practices.[42,45] This has led, in at least one study, to reduced exposure rates; as we noted in our recent total quality management study, bloodborne pathogen team participation was associated with a 30% reduction in exposures.[46] All of these strategies are considered primary prevention strategies, and this approach is clearly the most beneficial and cost-effective since it can prevent exposures from ever occurring. However, when primary prevention fails, secondary prevention strategies can still effectively prevent further adverse outcomes, such as infection. The secondary prevention strategy for bloodborne exposures is to implement effective post-exposure management plans as soon as possible. These are briefly described below.

In order to help lessen the risk of exposure to infectious diseases, a number of risk management strategies have been developed and implemented in the health care setting, including engineering, administrative, and work practice controls. An important administrative control measure is safety training and education, which in some cases, (e.g., the OSHA Bloodborne Pathogen Standard) may be required for compliance with state and federal regulation. While the importance of safety training and educational programs is clear, their effectiveness has been questioned and several barriers identified. For example, the well known resource limitations in the healthcare setting (e.g., limited employee training time, lack of trainers, inadequate training materials, lack of training facilities, etc.) as well as suboptimal employee interest and participation, and

a lack of evaluation and critical assessment methodologies, has tempered enthusiasm for traditional safety training and educational programs. This in turn has led to an increased interest in developing and evaluating new and innovative approaches to occupational health and safety training in the health care setting.

Relatively recent research has identified simulation training, which is based on embedded testing theory, as a promising method to both teach and test safety techniques to employees.[47-49] In simulation exercises, the participant follows a story line that is based upon true events (or realistic scenarios), and asked to make decisions at key points based upon the facts of the story. A valuable aspect of this approach is that the participant receives immediate feedback on the consequences of those decisions. This interactive approach is believed to be more effective than didactic approaches to learning because it tends to make the learning experience more meaningful, memorable and more readily applied to real life situations. This approach is very different from typical safety training for nurses, which tends to rely on videos, self-study packets or in-service lectures by infection control or safety personnel. Simulation exercises can be adapted to a computer format, with the inherent benefits afforded by computer-based training programs (such as cost savings, ease of delivery, consistency, convenience and ease in evaluation). Importantly however, the extent to which computer-based simulation exercises are effective in the health care setting and specifically among nurses remains unknown and needs to be studied.

Because of the inherent logistical problems associated with studying training interventions in the healthcare setting by randomizing participants into two or more treatments and the problems associated with blinding (for example, simulations and videos are intrinsically different from each other), we elected to study the effect of the simulation exercises on preventive health behavior theory constructs (e.g., nurses' beliefs, attitudes, and intentions) by using a multiple measurement approach, with measures taken at baseline and immediately after the intervention. Also, because we want to determine if this approach is effective for nurses working in various work settings, we will compare differences in health behavior determinants over time, stratified by potential risk, and other variables of interest.

Methodlogy: Overview

This two-year, five-phase, intervention study involved the recruitment of 130 registered nurses from collaborating hospitals, including Washington University Medical Center, The Johns Hopkins Medical Institutions, and Columbia University Health Science Center, and others. The nurses were recruited to participate in the following steps:

(1) To complete a baseline pre-test (T_0);
(2) To complete three experimental (simulation) exercises, each targeting bloodborne pathogens from different work situations(e.g., operating room, emergency room, intensive care unit).
(3) To complete an immediate post-test questionnaire (T_1).

Completion of the exercises as well as all of the data collection (T_0, and T_1) will take place on line at the study's website, using an interactive computerized program (Please see Appendix A for . Analysis of data will be directed towards comparisons in risk behavior responses, including behavioral intentions, between the T_0, and T_1 and in determining nurses' satisfaction with both the exercises and the computer format. The relationship between degree of satisfaction and behavioral intentions of safe work practices will also be determined.

There were several innovative aspects of this study. In addition to the use of multi-media interactive simulation exercises for HCWs, we formed a collaborative simulation team comprised of front-line workers and researchers in order to help develop the exercises. Using prepared summaries of exposure data for nurses, as well as risk management data, the teams worked collaboratively using a participatory action framework to prepare the two new intervention exercises. We were guided in these efforts by a study consultant, Dr. Henry Cole, a nationally recognized and respected educational researcher with special expertise in using simulations in safety training. The exercises were formatted by the Columbia Presbyterian Medical Center Network Department. They developed the training modules, as well as the on-line questionnaire.

The overall study plan is outlined in **Figure 1**.

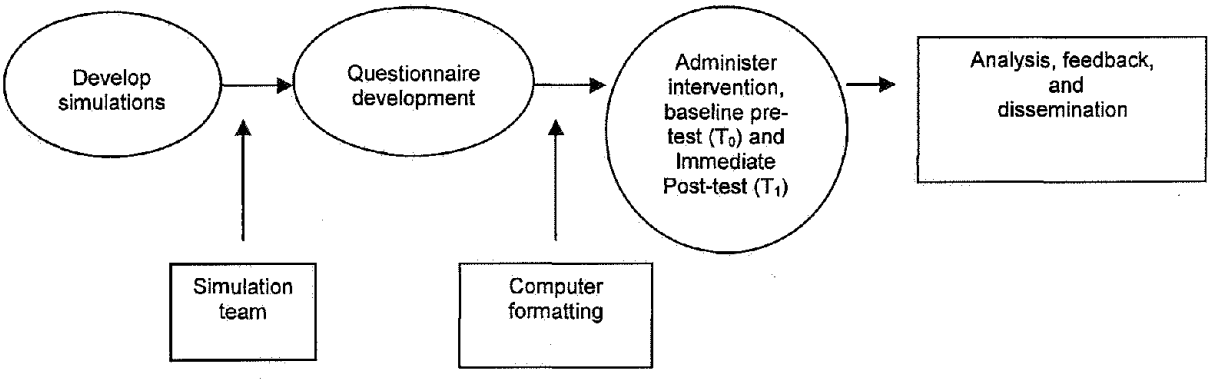


Figure 1. Study Design Overview

The core of the research team (headed by the Principal Investigator, the Co-Investigator and the Project Coordinator), developed an organizational infra-structure for the proposed study, including the preparation of a research manual that included all protocols and documents (e.g., recruitment flyers, intervention exercises, the questionnaire, consent forms, results of pre-testing, etc.) as well as all other study materials relevant to the project. The manual also contained work flow plans, schedules for all procedures, and copies of all communications between hospital site liaisons, the research team and the study consultants. The consultants, in addition to Dr. Henry Cole, a nationally recognized expert in simulation theory and practice and an experienced social science researcher, included Ms. Martha Grimes, a 35 year+ experienced infection control practitioner and researcher. The consultants advised the research core and combined, the two groups comprised the research team.

Study Sites and Study Populations

Registered nurses, both hospital based and non-hospital based, were recruited from three sample frames described below.

Washington University Medical Center

Nurses will be recruited from Barnes Memorial Medical Center, the major hospital affiliate of Washington University Medical Center. It is the largest JCAHO accredited tertiary/care hospital in Missouri. The hospital employs nearly 900 full time physicians, 4500 nurses and other clinical staff and 700 community physicians who are part time faculty members. The hospital currently has 1442 patient beds. It is a non-profit teaching hospital with a wide range of clinical departments, including specialized intensive care units. The Medical Center has both nursing homes and home healthcare affiliates.

Johns Hopkins Hospital

With over 1000 beds and 5,000 nurses, this is one of the nation's leading hospital and medical centers. The liaison for the study site is Dr. Trish Perl, a recognized leader in infection control and the head of the hospital infection control program. Thye have an active training program, which involves a staff of 4, one of whom will serve as the training leader in terms of recruitment for this study

The New York State Nurses Association

The New York State Nurses Association (NYSNA), which draws members from the greater metropolitan New York area (including Manhattan, Long Island, and Nassau County) currently has approximately 33,000 members. They are an affiliate of the American Nurses Association (ANA). About a third of the NYSNA members work in non-hospital settings, including home health care and hospice, nursing homes, correctional facilities, and physicians' or dentists' offices. More than 10,000 NYSNA members hold a bachelor's degree in nursing, and nearly 4000 have a bachelor's in another field. At least 3700 have earned an advanced degree in nursing or another field. Most NYSNA members (about 70%) are aged 40-49. The ANA reports a higher than average number of Hispanic nurses in the New York region, and overall ANA membership in 1996 was 95% female.

Study Design: Study overview

This two-year intervention study was divided into five distinct phases in order to simplify its management. **Phase One** provided ample time to develop the simulation exercises and study questionnaire. The Simulation Team was formed in this phase to help in that process. The research team concurrently developed the study questionnaire and the exercises and the study questionnaire underwent cognitive and pilot testing. In **Phase Two**, we formatted the study exercises and the study questionnaire into computerized versions, which were also extensively piloted. Also in Phase two, the study's web site was finalized and fully operational and the exercises were linked to the study's web site. In **Phase Three**, the simulation exercises were administered online. The questionnaire targeted risk behavior determinants of blood borne pathogen. In **Phase Four**, the follow-up questionnaire was administered, data cleaned, checked for internal validity and reliability, and analyzed. In **Phase Five**, dissemination of results took place. An overview of the study is presented in **Table 1** below.

Table 1. Outline of Study Management Plan

Phase One: Simulation and Questionnaire Development	Phase Two: Computer Technology	Phase Three: Intervention Implementation and Baseline Questionnaire	Phase Four: Follow-up Questionnaires	Phase Five: Dissemination
(months 1-4)	**(months 5-7)**	**(months 8-10)**	**(months 11-19)**	**(months 20-24)**
• Sample frame determination • Prepare Team materials (data, etc.) • Form Simulation Team • Prepare exercises • Cognitive and pre-testing of exercises • Pretest exercises • Prepare questionnaire • Process evaluation	• Computer formatting of exercises • Computer formatting of questionnaire • Pilot testing of computerized versions • Web site finalized • Participant recruitment • Process evaluation	• Administration of exercises • Administration of retrospective pre-test (T_0) • Data cleaning • Data analyses • Process Evaluation	• T_1 administration • Data cleaning • Data analyses • Process evaluation	• Final reports • Preparation of manuscripts and presentations • Process evaluation

Theoretical model and study hypothesis

The rationale for using simulation exercises to modulate safety behavior is supported by two theories, "Embedded Testing Theory", and "Narrative Thinking". Embedded tests involve the learner's performing a specific test (like completing an exercise). The results of the performance can be evaluated in terms of accuracy, time required to completion, completeness, etc. Embedded tests are introduced frequently throughout an exercise and they allow both the learner and the instructor to evaluate performance. They are effective learning tools because they simultaneously teach and test, and importantly they provide immediate corrective feedback to learners.[50-52] Another reason that simulations are believed to be an effective training tool is because they support narrative thinking, as opposed to paradiagmatic thinking. In narrative thinking, events are interpreted by the construction of meaningful patterns, whereas in paradiagmatic thinking, abstract concepts are used to interpret information. Narrative thinking is always contextualized as a story about "*someone doing something*", and comprehension of events takes place even when the information is incomplete. Simulations help to make didatic safety information compelling, memorable and relevant, thus forming the basis for "active knowledge". Dr. Cole has coined the phrase, "*stories to live by*" because they stimulate the participant to "*examine, debate, explore and consider* " the risks they face in their own job.[53] By using the simulation exercises, normally "dry" (i.e., boring) didatic information on risk (e.g., statistics and details on regulations) can still be provided, but in a much more practical and compelling sense. Plus, simulations tend to be highly rated by participants for the following reasons: (1) they recognize and draw upon the extensive knowledge and experience of workers; (2) they respect adults' preference for real-life experiences; (3) they present the skills and knowledge to be learned within problem situations; and (4) they focus on judgment and decision making.

The rationale for using a computer-based approach as a channel for nurses' health and safety training over more traditional methods is because of well- recognized benefits of computerized instruction. For instance, with computer- based training (CBT), training time is kept to a minimum, trainer availability and ability does not vary, and the message can be

consistently delivered. Typically, CBT programs are rated highly in terms of user satisfaction and learning preferences. Also with CBT, documentation of training is easy to keep track of, it eliminates storage of training materials (an important consideration given the length of time required to keep OSHA training records), and CBT programs are easy to schedule and to administer. This is especially important in health care, since units or departments might be adversely affected by decreases in staffing related to training sessions. A library of CBT simulations can easily be developed and downlinked from a centralized web site (e.g., NIOSH's web page).

Finally, the last model to consider is the theoretical model that will be used for evaluating the interventions (**Figure 2**). This is an adaptation of both Ajzens' theory of Planned Behavior and DeJoy's Behavioral Diagnostic Model.[54-56] This adapted model is particularly suitable for studying the impact of a safety intervention since it integrates both worker-centered constructs as well as the impact of organizational determinants (enabling factors on precaution adoption), thus emphasizing the inter-connectedness between the individual and the work environment. This model also illustrates the importance of risk beliefs and attitudes in precaution adoption in the workplace. Worker-centered variables included items related to employees' demographics, such as their work setting (hospital vs. non-hospital), job characteristics, job duties, needle use, patient contact, influence of subjective norm, prior history of exposures, etc. Subjective norm will be measured by items related to perceptions of co-worker attitudes toward safe work practices, patient/patient family attitudes (e.g., towards respirator use) and supervisors attitudes. Factors that influence worker attitudes towards safety in the workplace were measured, such as safety climate. Outcome safety behaviors include intentions to adopt safety practices (e.g., wear respirators when needed, not recap, activate safety devices, report exposures, participate in HBV vaccination, PPD screenings, and post-exposure protocols, etc.). The model that considers these factors is shown below in **Figure 2**.

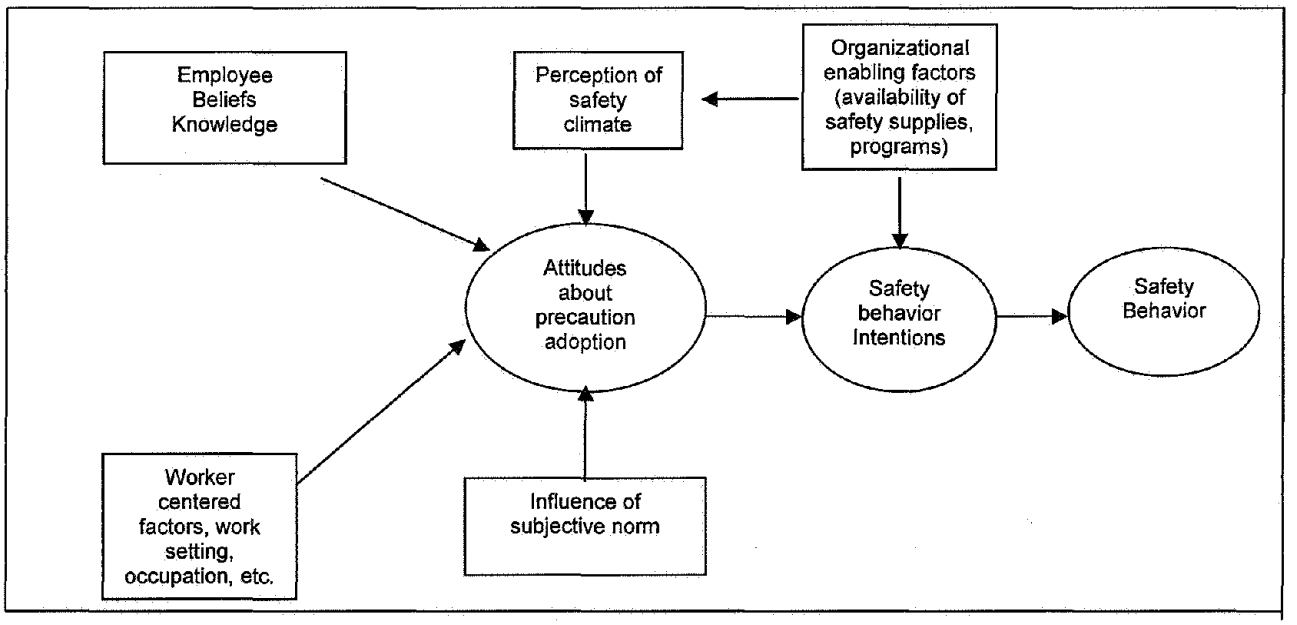


Figure 2. Theoretical Study Model

The intervention targeted these employee beliefs, knowledge, attitudes and perceptions. Because safety climate is such an important variable, the exercises emphasized nurses' ability to be empowered to neutralize a poor safety climate at work (e.g., suggesting options they might have to obtain the safety equipment they may need).

Based on preliminary data from our earlier studies, we hypothesized that the simulation exercises would impact employees; accordingly the study hypothesis was

1) The intervention will be significantly associated with improvements in nurses' beliefs, attitudes and intentions to adhere to safety practices with respect to infectious agents.

Study Phase 1: sample frame determination

In this aspect of Phase One, the Principal Investigator and/or the Project Coordinator contacted site liaisons to determine the sample frame and to gather as much detail as possible on the demographics of each site's sample frame. This allowed us to compare the characteristics of the group with our sample. We also finalized plans for recruitment of study participants for each of the qualitative aspects that took place in Phase One.

Inclusion of women, ethnic and racial groups, and children 18-21 years of age

This application recognized the importance of the inclusion of both genders and as wide a range as possible of various ethnic and racial groups in the study; thus, the sampling strategy was designed to include adequate representation of women and various ethnic/racial groups. Based on information from the site liaisons, we expected that approximately 80%-90% of the nurses in the sample would be female and that at least 50% of the overall sample would belong to an ethnic/racial minority group. There were only a very small percentage of "children" in our sample as HCW populations are, on average, 35-45 years old. Every effort to recruit representative minority (i.e., 18-21 year olds) participation for the qualitative phase of the study was made.

Volunteer recruitment

We recruited a convenience sample of volunteers for four key aspects of the study, 1) simulation team participation, 2) cognitive testing, 3) pilot testing and 4) completion of the questionnaire and simulation exercises. Recruitment for these volunteer activities was conducted as follows: recruitment flyers will be posted at the partner organizations and in employee newsletters. We recruited similarly for pilot testing. All procedures involving study volunteers (e.g., cognitive testing, pre-testing, questionnaire and simulation administration, and Simulation Teams) were reviewed and approved by the Columbia University's Institutional Review Board. This committee maintains the highest possible standards of protection of study volunteers. The number of participants that will be recruited in Phase One is detailed in **Table 2.**

Table 2. Study Population Recruitment – Phase 1 – Phase 3

Study Design	Simulation Teams	Cognitive Testing	Pilot Testing	On-line Questionnaire & Exercises
Questionnaire Development	—	10	25	
Simulation Development	12	10	25	
Totals	12	20	50	100-500

Simulation Team: Development of Simulation Exercises

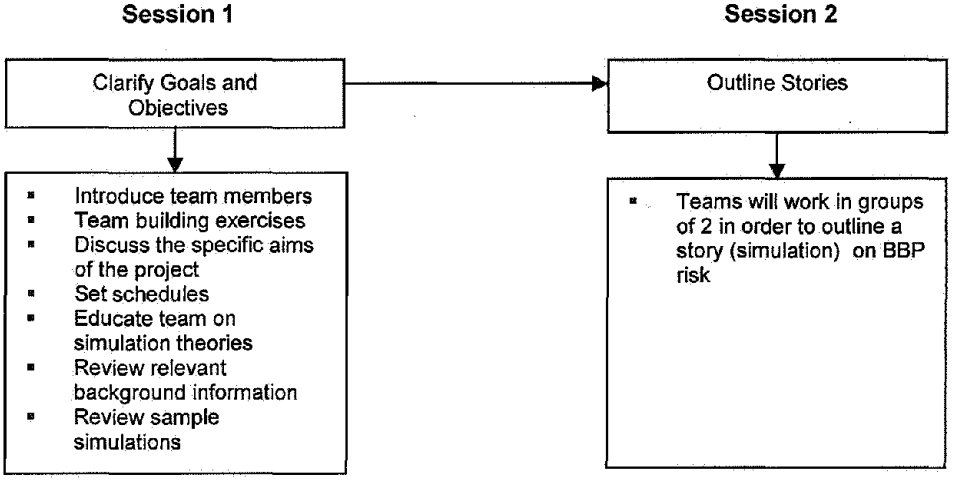
In this component of Phase 1, a simulation team was formed using a Participatory Action Research Framework. Study researchers worked collaboratively with teams of registered nurses, recruited locally. The team's program and work plan was guided by Dr. Gershon, who has experience in team facilitation as well as simulation development. Dr. Hank Cole, a nationally recognized expert in simulation

exercise development, served as the senior consultant and team leader on this aspect of the project (Please see **Appendix A** for simulation team meeting information).

Simulation Team members input on the "stories" helped to ensure their realism, since the exercises were based on the "stories" of the team members or their recollection. The team process built upon the strengths and resources the members bring to the problem. The process promotes co-learning and empowerment and facilitates the reciprocal transfer of knowledge and skills.

The teams worked together in two six hours blocks over the course of two consecutive days. The teams will follow the progression steps listed below:

Figure 3. Simulation Team Process



The research team finalized preliminary drafts of the three stories, ensuring that all key behavioral determinants are targeted and they also prepared the support documentation for the exercises (**specific aim 1**). Each of the exercises underwent both cognitive and pilot testing along with the final draft study questionnaire.

Questionnaire Development

The pre-test questionnaire was developed in order to assess the major study constructs (and demographics) and to meet our specific aims. The questionnaire was based and validated (for the most part) from our earlier studies. The questionnaire was written at a 12thgrade reading level, and took about 20 minutes to complete and was presented in an extremely user-friendly format (Please see **Appendix B** for the pilot testing form). The questionnaire was based on previously well-defined scales and refined through cognitive and pilot testing described below. Most questionnaire items had a four- or five-point Likert scale responses.

Cognitive Testing

This technique is used to evaluate draft survey questionnaires by performing intensive interviews that incorporate use of the "talk aloud" method. For this phase of questionnaire development, ten volunteers were interviewed. These interviews focused on the cognitive processes that participants use when answering the survey questions. Understanding the nature of the response process helped us to redesign and clarify the survey questions. This allows for precise interpretation of the questions and improves the accuracy of responses. Cognitive interviews took approximately two to two-and-a-half hours each and were held at a convenient time for participants in a small, pleasant conference room on the Columbia campus.

Pilot Testing

Pilot testing was needed to validate the questionnaire and to conduct psychometric analyses to check for reliability and validity of the measures. Working drafts of the questionnaires were prepared and pre-tested on a sample of locally recruited nurses as well as nurses from our three partner facilities for us to conduct preliminary psychometric analyses of any new scales that form the core of the questionnaire.

Based upon the literature and our preliminary studies and guided by the theoretical model, the following topics were included in the final instrument. These are described below in.

Questionnaire Constructs

Knowledge: Several questions related to BBP were included, such as routes of transmission.

Exposure history: Nurses were asked to recall past exposures (in the past 12 months including percutaneous and mucocutaneous and airborne exposures), routes of transmission, patient source status (i.e., HIV status), and post-exposure management care, including post-exposure prophylaxis, activity during exposure, device in use during exposure, exposure reporting, and precautions that might have prevented the exposure.

Self reported compliance (or intention to comply) with exposure reporting guidelines: Nurses were asked to self-report their adherence to SP in the previous 12 months as well as their compliance with the reporting of exposures and with vaccine recommendations.

Sociodemographics: This will cover continuous variables, such as age, number of years of work experience, and categorical variables such as gender, race/ethnicity, job category, etc.

Phase 2: computer technology

The research team, in concert with IT specialists prepared each of the simulation exercises as well as the questionnaire, into user friendly, multimedia templates delivered by cross platform CD-ROM and our internet web site. The programming template was developed in Adobe Acrobat.

The exercise programs were self paced, and had conditional branching, that is, the participant was directed through the program in sequences that were determined by their responses. Branching was determined by the quality of their responses (e.g., correct answers). This is referred to as a reactive computer-based training design. The branching allows for remediation training in areas that the participant is weak in. For example, if at a decision point, the RN says eye wear is not needed, and it really is, then they will be directed to a line or two of text (or graphics) that reviews the routes of transmission of blood borne pathogens.

The computer programmer and web worker not only designed and maintained the study's web site, but also set up a chat room, which the study's core research team monitored, so that participants could have a place for discussion of the exercises. The chat room was maintained for the length of the study. The web site was also maintained for the length of the study and the results of the study will be posted as well.

Phase 3: implementation of baseline questionnaire and simulation exercises.

Details of the administration of the questionnaire are described below. Individuals who participated in any other phase of the study were ineligible for participation in the final questionnaire administration phase. Although they were offered the opportunity to complete exercises for CEUs. Nurses who were interested in participating could enroll in the study in one of two ways; 1) they could go directly to the study's web site and enroll, or 2) they could call the study office number and request additional information or hard copies of the exercises and questionnaire (Please see **Appendix C** for study questionnaires and simulation exercises).

Enrollment

Enrollment involved the following steps. Each enrolled nurse was asked to complete three procedures at baseline participation, these are:

- Completion of a brief contact information page
- Read and sign off on an informed consent form
- Complete the exercises and retrospective baseline pre-test
- Each enrolled participant was assigned a unique identifying code number.

CEUs

Once nurses completed the exercises, we were able through NYSNA and arrangement through the Columbia University Continuing Education Program, print CEU certificates from the training website.

Data Management

- **qualitative data**

Cognitive interview data were collected and managed as follows:

- No identifiers were linked to reports.
- Summary reports were made using a standardized format as soon as possible after the event. Original notes and reports were kept under lock and key for the duration of the study. Summary of findings were periodically presented to the research team members.
- All original notes and records will be destroyed at the conclusion of the study.

- **quantitative data**

All pilot and study questionnaires were inspected for legibility and completeness. Questionnaires that had substantial number of questions unanswered were sent back to the RN with a reminder note to fill out all sections. Data from the completed questionnaires formed the study's database. Data were backed up using cds. Data were protected by pass codes. A list of code numbers and mailing addresses for the sample of each occupational group constituted the "master code book." The master codebook was kept under lock and key and only the study Principal Investigator and Project Coordinator had access to this book. Only the study Principal Investigator, Project Coordinator, had access to any unblinded computer files, which were be accessible only by code. Computer data files did not have any personal identifiers. At the conclusion of the study, the master codebook will be destroyed. All stripped computer files will be maintained indefinitely.

Phase 4: analysis of data

After checks for internal reliability and validity of responses and other data editing procedures were completed, we performed an array of descriptive statistics (e.g., frequencies, histograms, and measures of central tendency and dispersion) and graphical techniques to characterize the distribution of variables, starting at the most refined level of measurements. This strategy provided us with familiarity with the data and allowed us to

determine if the data meet assumptions required by the intended statistical testing procedures. Principal components model of factor analysis was run on all scales, using maximum likelihood parameter estimates. All scales underwent correlation procedures. Mean scores for all scales at T_0, and T_1, were calculated (**specific aim 3**). For the change between baseline and the first follow-up or second follow-up, we use paired T-tests for continuous response variables (e.g., perception of risk scale). McNamers' method of matched analysis for dichotomous variable (intends to wear gloves/do not intend to wear gloces). For continuous response variables, the GEE method will be used and for binary response variables, GEE methods will be used to analyze the association of outcomes with interventions using odds ratios, logistic regression methods for dichotomous outcome variables, such as intention to report exposure vs., no intention, and to control for demographic variables, such as age, gender, education, etc., in order to evaluate the effects of other variables of interest, such as availability of safety equipment, etc. The outcome (dependent) variable will be "intentions", knowledge, safety climate (**specific aim 3**). Potential biases may be introduced by differential dropout rates. If the simulation is effective, respondent RNs may not want to revisit the site for T_1 follow-up (i.e., they lose their interest), or it may lead to increased concern among those who have risky behavior, and they may not want to think about it again. This could have made it difficult to measure effect over time. This bias was determined by comparing dropout rates for individuals, clustered by various stages of change. Maturation effects (change over time), was examined through comparisons either 1) stratified by time periods, or 2) estimated using nested linear models that incorporate clusters.

Similar methods were used to study the association between other covariates of interest and continuous outcomes (e.g., satisfaction with training (**specific aim 4**). All analyses were performed by the study statistician, in close collaboration with the research team.

Process Evaluation

It is important to periodically determine how well a program is operating, i.e., to determine how effective it is in terms of meeting the expected project goals in a timely and cost-effective manner. The evaluation component is also important for resolving identified problems or for filling identified needs. This evaluation improves our understanding of how well the project is being conducted and documents the organizational and operational procedures of the project. Process evaluations, which characterize the program, were conducted at the end of each study phase. For example, we evaluated the development of the simulations, the formatting to a computer platform, adequate pre-testing and validity of responses, and the dissemination of reports. We used a modification of the standard process evaluation approach developed by researchers at the Office of Substance Abuse Prevention. We addressed each aspect of the evaluation procedures through audits, observation, and a review of records and data, and made adjustments as needed. Particular attention was focused on the participants' reaction to ensure that we have made all aspects of participation as simple, convenient, and enjoyable as possible. Any risks to participants could therefore be discovered quickly through the evaluation process and immediately managed to avoid untoward adverse effects on study participants. There were no adverse events were reported by participants (Please see **Appendix C** for the evaluation form).

Phase 5: dissemination of data

The study team is committed to providing each participating facility with the study results and CD ROM versions of the simulations. This will be accomplished by preparing a report, including an executive summary, for each of the facilities. Also, we propose to submit a summary of recommendations to national organizations representing the study populations. We also plan to submit abstracts for presentations to their national meetings.

All intramural dissemination to study populations will be handled by the collaborating agencies, and we will assist them in any way possible.

Extramural Dissemination

In order to inform the broadest possible audience with potential interest in this area of study, several approaches are needed. The Principal Investigator and other investigators continue to work closely with our NIOSH colleagues to help publicize our findings as widely as possible. Using a variety of media (e.g., print, video, computer), we intend to make several tangible products available: 1) a synopsis of study results, 2) study questionnaire, constructs and coding information, 3) copies of the simulations and 4) in addition, oral presentations, articles, posters, etc. will be prepared and presented to as wide an audience as possible (e.g., organizational psychologists, nurse researchers, safety specialists, health experts, etc.). Some examples of possible journals for publication include: *American Journal of Infection Control, Journal of Occupational and Environmental Medicine, Infection Control and Hospital Epidemiology, American Journal of Public Health*, and specialty publications, including nursing journals *(Journal of Nursing Research, Journal of Nursing Administration, Nursing Management*). Where indicated, media releases of our findings will be prepared by the Columbia University Department of Public Affairs. Study investigators also expect to present research findings at a variety of conferences intended to reach the target audience (e.g., ANA Conference), etc. We can also access existing nursing links on the web to disseminate our findings.

Study Results

Below please see Table 1 for a summary of the demographic characteristics of the sample.

Table 1. Demographics

Variable	**n=88**	**%**
Gender,		
Female	(n=84)	96%
Employment,		
Administration	(n=52)	59%
Clinical Nurses	(n=25)	
Other	(n=11)	
Licensure,		
RN	(n=79)	90%
Other	(n=9)	10%
Education,		
Less than College	(n=22)	25%
College	(n=45)	51%
Greater than College	(n=16)	17%
Tenure,		
Mean		20 years

On the pre-test there was 33 items, of these 8 were related to knowledge. The knowledge score had 4 response categories, including "*strongly disagree, disagree, agree, strongly agree"* of blood and body fluid exposures. One of the items dealt with barriers to reporting which had 11 different response categories. There were also 10 safety climate

items which formed the safety climate scale. These responses ranged from *"strongly disagree"* to *"strongly agree"*. There was also a section of 4 items that related to exposures that occurred over the last 12 months. There was one final item related to intention to report exposures.

The most common barrier to not reporting was not believing the incident was risky enough to report (6.2%), followed by the thought that the source patient was not a high risk patient (5.4%). Other reasons given for not reporting included *"inconvenience"* (no time to fill out paperwork), "did not want to appear like a hypochondriac", "wanting to forget about the exposure and put it out of my mind", and "fear of getting into trouble with my supervisor."

There were too few exposures to analyze, but at least 10% of the sample reported at least one serious exposure in the past 12 months.

On the post-test, there were a total of 10 items, 8 of which related to knowledge, one related to safety climate and one to intention. All items had a 4 point response scale from *"strongly agree"* to *"strongly disagree."*

Comparison of knowledge between the pre and post test: The mean of the pre-test score was 7.08 and the mean of the post-test knowledge score was 7.18, there was no significant difference using student's t-test.

On the safety climate item, the pre-test mean was 0.95 and the post test mean was 0.96 and there was no significant difference.

On the pre-test intentions item, the mean was 0.93 and the post test had a mean of 0.95 and there was no significant difference.

Please see tables 2, 3 and 4 below for a summary of findings.

Table 2. Pre-test/Post-test Knowledge Scores

	Pre-Test	**Post-Test**	**P**
Mean	7.08	7.18	N.S.

Table 3. Pre-test/Post-test Safety Climate Test Scores

	Pre-Test	**Post-Test**	**P**
Mean	0.95	0.96	N.S.

Table 4. Pre-test/Post-test Intention Test Scores

	Pre-Test	**Post-Test**	**P**
Mean	0.93	0.95	N.S.

Evaluation

The evaluations indicate that the vast majority of participants found the exercises a valuable learning experience and a useful training tool for their staff nurses. The format was acceptable, the exercises were enjoyable to complete, and the availability of CEU's was useful in improving participation rates. Please see table 5 for details on the evaluation results.

Percentage of Participants Who Strongly Agreed with Program Evaluation

Item	n	%
1. This web based training described events and outcomes likely to occur in a healthcare facility.	(n=158)	94.1
2. This web based training identified opportunities to analyze risk of exposure to bloodborne pathogens.	(n=158)	94.1
3. After completing this web based training, I was able to recognize reporting conflicts and the importance of immediate reporting after exposure.	(n=160)	95.2
4. This web based training stressed the importance of prophylaxis to prevent disease.	(n=156)	92.9
5. The content presented was of value to me.	(n=168)	94.1
6. The format was appropriate.	(n=159)	94.6
7. The information was presented effectively.	(n=156)	92.9
8. Overall, I learned new and useful information from this training.	(n=141)	84.1
9. Once I got onto the website, it was easy to understand the directions and work through the simulation(s).	(n=157)	93.4
10. I could access this web based training from home.	(n=126)	75.1
11. I prefer to complete such web based training from home.	(n=82)	48.8
12. I prefer to complete such web based training during work at a computer at my work site.	(n=134)	79.7
13. I like this web based training approach better than face-to-face training.	(n=129)	76.8
14. I like this web based training approach better than the typical printed training materials I receive.	(n=151)	89.9

15. I like this web based training because I can work through the materials as many times as I want to make sure that I understand that material.	(n=158)	94%
16. I learn more from on-the-job training than from web based training programs.	(n=72)	42.9
17. I would recommend this program to other health care workers.	(n=157)	93.4

Participants were also asked to provide any additional comments regarding the training program which we summarized as follows. Respondents thought this was a good way to provide training, they found the simulations very real and that it added a new dimension to training, the respondents appreciated the instant feedback as well as the linkages to the various website to allow them to access additional information. Other respondents said they appreciate being able to complete the exercise at home, and being able to start and stop in their own will. Other respondents thought that the simulations exercises were an entertaining tool although they recommended that we add additional graphics. Several participants stated that although this approach was very useful, it could not replace face-to-face training or hands-on training. Other participants felt that a more advanced version would be needed for more experienced nurses, although it served as a good refresher. Most reported that the system was simple and easy to use.

Discussion

These results indicate that in a highly educated population of nurses with baseline knowledge scores exceptionally high, improvement in knowledge were not obtained after completing the simulation based training program. Similar results were found for safety climate and intention to report, although it should be noted that the barriers to reporting that were provided in the baseline pre-test were not immediately amendable to training but rather were administrative in nature (i.e., no time to report). The results of the training program also indicate that participants found the experience very beneficial, informative, enjoyable and useful in terms of providing annual updates. The participants found the training to be very innovative and a nice departure form the typical annual review. The program will probably show greater significant difference from pre and post-test on less experienced nurses and with a larger sample size. The simulation could also be made more interesting using more advanced web design techniques.

In conclusion, this is a useful approach to mass training on annual bloodborne pathogen risk management. The technique is effective, enjoyable, and logistically feasible in terms of working around the nurses' schedule. These three prototype simulation can therefore be disseminated widely across basic nursing populations. The design and exercises have been submitted to the NIOSH Research to Practice Division where they can be further utilized.

Publications

No publications published or in press at this time, but two papers (one of the exercises and one of the results) are in progress.

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