Using Gaming Simulation to Evaluate Bioterrorism and Emergency Readiness Education

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SYNOPSIS

Objective. We performed an outcome evaluation of the impact of public health preparedness training as a group comparison posttest design to determine the differences in the way individuals who had participated in training performed in a simulated emergency.

Methods. The Experimental Group 1 included students who had graduated from or were currently enrolled in the bioterrorism and emergency readiness (BT/ER) curriculum at the University of Minnesota School of Public Health. The comparison groups included individuals who had access to the Internet and were aware of the 2006 online simulation *Disaster in Franklin County: A Public Health Simulation.* The evaluation process employed surveys and the gaming simulation as sources for primary data.

Results. Participants in the BT/ER curriculum (p=0.0001) and other participants completing at least 45 hours of training in the past year (p=0.0001) demonstrated higher effectiveness scores (accuracy of chosen responses within the simulation) than participants who did not report significant amounts of training.

Conclusions. This evaluation research demonstrated that training is significantly associated with better performance in a simulated emergency using gaming technology.

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One of the most difficult challenges facing public health agencies in their attempt to develop their capacity to respond to public health threats and emergencies is assuring a qualified workforce available to carry out these functions.[1] The Centers for Disease Control and Prevention (CDC), in collaboration with the Columbia University School of Nursing, addressed these concerns in 2002 by developing competencies in bioterrorism and emergency readiness (BT/ER) for public health and health professional workers.[2,3] A national competency development strategy mandated by the 2006 Pandemic and All-Hazards Preparedness Act (PAHPA)[4] is currently being conducted for the development of Public Health Preparedness and Response Core Competencies for Public Health Professionals (hereafter, Core Competencies), which are ultimately to be used to adapt current curricula and develop new curricula, as appropriate, to train the public health workforce. The competency model under development will build upon the existing work in the field.[5]

In 2002, several important initiatives at the federal level were launched to fund educational programs to address competencies. These initiatives brought academicians, practitioners, and governmental partners together to enhance the capabilities of the health professional workforce to meet the challenges of new and emerging threats. One initiative created the CDC-funded network of Centers for Public Health Preparedness (CPHP) that seeks to ensure that frontline workers have the skills and competencies to respond effectively to current and emerging public health threats, including acts of bioterrorism. In a 2003 article, Morse said, "The general purpose of the academic Centers for Public Health Preparedness is to strengthen links between public health practice and academe, for developing and delivering competency-based curricula in public health that address local needs and could also serve as models for national replication."[6]

METHODS

Curriculum design

Funding from the CPHP supported the development of curriculum for the preparation of public health and health-care professionals at the University of Minnesota School of Public Health.[7] The curriculum in BT/ER was based on the Bioterrorism and Emergency Readiness Competencies[8] mapped to the foundational Core Competencies for Public Health Professionals, as identified by the Council on Linkages Between Academia and Public Health Practice.[9] A focus group comprising the directors of the state health alert network office of emergency preparedness and bioterrorism education and training, and local and regional bioterrorism coordinators and community leaders from public health and health-care agencies representing food safety, epidemiology, occupational health, and tribal health, developed content and learning outcomes of the curriculum in 2002.[7] The group identified core content units using a modified Delphi technique, and local public health directors confirmed them in 2003. These content areas included disaster preparedness, crisis/risk communication, incident command management, surveillance, law, impact on community health, and understanding agents.

Focus groups were repeated in 2007 as part of the fifth-year evaluation process to determine changes needed in content and course development and to measure competency. The groups defined competency as a combination of knowledge elements (What do we need to know?), skills (What do we need to be able to do?), and attitudes or attributes (What values and beliefs motivate us and create commitment to action?) that enable professionals to be able to perform their work effectively and efficiently. These three elements, referred to as knowledge, skills, and attitudes or attributes (KSAs), became the building blocks of competency statements.

Competency can only be demonstrated in action; thus, KSAs identified in pertinent literature served as indicators of competency. Competency is best evaluated through observation of performance. However, evaluation of performance during a bioterrorist or emergency event has rarely been practical. An alternative means to observe decision-making skills is through technology—either enhanced or digital methods. Gaming simulation as a technology-enhanced tool for knowledge reinforcement and testing allows for innovation not yet fully realized in public health education.[10]

Bioterrorism and other public health threats have real-world consequences for the public's health. Practice and evaluation of performance in an environment simulated to allow the participant to experiment with decisions without restrictions of time and space and to reflect on the outcomes offers a preferred approach when compared with the stresses and potential outcomes in testing knowledge and skill in a real-world incident such as a bridge collapse. Online simulation provides a performance-based experiential testing environment that allows health professional students and workers to test their ability to put their training into practice through the stages of awareness of an urgent threat, to analysis, and finally to decision-making given the nature and level of threat. Experiential testing of learners better answers the question: Does education make a difference?

Study design

An outcome evaluation of the impact of public health preparedness training was performed as a group comparison posttest design to determine the differences in the way individuals who had participated in training performed in a simulated emergency. Individuals were placed in one of three groups and were the unit of analysis. The process employed surveys and a gaming simulation called *Disaster in Franklin County: A Public Health Simulation*[11] as sources of primary data. The gaming simulation was divided into 13 chapters.

Individuals invited to participate came from a roster of 193 students who graduated from or were currently enrolled in the BT/ER curriculum (these 193 were the target audience for Experimental Group 1). We solicited comparison groups as a convenience sample from open enrollment through standard marketing methods, including:

- E-newsletter notification of availability,
- E-mail to past course participants,
- Flyer distribution at conferences,
- Listing on website, and
- Distribution through national preparedness-related training Web portals and newsletters.

We defined open enrollment for comparison as the universe of individuals who had access to the Internet and were aware of the *Disaster in Franklin County* simulation. The pre-survey was provided online prior to the gaming simulation tasks to capture additional data for the identification of participants. The independent variable under consideration was training in BT/ER. We grouped participants based on pre-survey responses. There were no BT/ER program enrollees without significant participation (<3 semester credits) in the BT/ER curriculum.

1. Experimental Group 1: BT/ER program completers and enrollees with significant participation (≥3 semester credits) in BT/ER curriculum
2. Experimental Group 2: Never enrolled in BT/ER curriculum and reported significant other training (≥3 courses or ≥45 hours)
3. Control Group: Never enrolled in BT/ER curriculum and did not report significant other training (≥3 courses and ≥45 hours)

Dependent variables included (*1*) demonstration of competency measured by efficiency or time taken to complete chapters of the gaming simulation and (*2*) effectiveness or accuracy of chosen responses within the gaming simulation. We examined potential confounders such as age, highest degree earned, and profession for selection bias.

At the time of the study, gaming simulation to evaluate competence in BT/ER was new to the literature.[9] On-site drills and exercises have been used to measure competency as well as real-world event performance. The *Disaster in Franklin County* simulation provided a performance-based experiential testing environment online and available 24/7. This online simulation followed the response of public health workers to a natural disaster that strikes the fictitious community of Franklin County. Simulation players assisted the public health director, environmental health specialist, public health nurse, and other public health workers to apply their BT/ER skills to minimize the disaster's impact on the community. The gaming simulation's interdisciplinary approach promoted flexibility in testing the integration of concepts and the players' decision-making abilities.

We built evaluation functions into the *Disaster in Franklin County* simulation to track each participant's performance. Programming captured parameters such as time on task and responses chosen. These data were automatically gathered via client-side Flash script and Active Server Pages (ASP) server script running on a Windows 2003/IIS 6 server. High performance and a securely managed Microsoft® SQL database server kept all the data gathered. We enabled Hypertext Transfer Protocol to ensure a secured transmission from the client to the database back end.

We measured motivation using self-report on the post-survey and satisfaction with the simulation experience using a six-response scale from "strongly agree" to "strongly disagree." We also used questionnaire survey tools, pretesting them with experts who had both content knowledge and skills in tool development to increase the likelihood that the instrument measured what was intended (content validity). We provided a consent-to-participate form online, blocking continuation of survey or simulation participation if consent was not obtained. This assured compliance with Institutional Review Board guidelines.

We collected demographic profiles, pre- and post-survey data, and outcome data linked to the simulation technology via an online registration system using ASP server technology. It streamlined individual participant activities from registration to simulation access, progress tracking, and, finally, to printing a certificate of completion. Records used an e-mail address as the unique identifier. To protect anonymity, a unique study number was generated for each participant. A member of the team who was not involved in data interpretation maintained the codebook.

The demographic profile included employment location, professional practice area, race/ethnicity, gender, age, and highest degree earned. Those who finished the simulation earned continuing education credit as an incentive for participating in the study and gaming simulation.

Participation in the *Disaster in Franklin County* simulation was used to demonstrate the effectiveness and efficiency of participants for each BT/ER competency.[3] Inclusion criteria for analysis were students who had graduated or were currently enrolled in the University of Minnesota School of Public Health BT/ER curriculum. Individuals who had access to the Internet and were aware of the *Disaster in Franklin County* simulation participated in the evaluation research as comparison group members. Individuals excluded from analysis included known project team members, participants who completed less than 50% of the *Disaster in Franklin County* simulation (service non-completers were defined as those who completed fewer than half of 12 content chapters; summary chapter 13 was not included in analysis), and participants who on post-survey indicated that they were participating in the simulation only to evaluate for others' use.

The desired outcome of training was achievement of competencies in BT/ER (Figure). The simulation was used as the alternative context to a disaster to test participants' abilities to transfer learning (from trainings or BT/ER curriculum) to new situations (gaming simulation). We did not measure competency indicators that included demonstrating use of communication equipment (Competency E), locating the agency's emergency response plan (Competency C), and describing their agency's role (Competency A) because they could not be standardized in the gaming simulation. Participants indicated level of efficiency by the total time needed to complete the chapters mapped to the competency, and level of effectiveness as the percentage of correct answers to questions associated with the competency. All three participant groups reported competency level according to the following:

- *Efficiency:* The gaming simulation measured efficiency as interval data starting at zero for the time participants took to complete each chapter. Thus, efficiency (amount of effort) was measured by the time to completion for each of the 12 chapters in the simulation (excluding summary chapter 13). The timing started when participants clicked on the chapter location and ended when participants clicked on the final "continue" button in each chapter. When participants exited the simulation prior to completion, they were asked the next

Figure. Effectiveness and efficiency measures for evaluating competency-based education in bioterrorism and emergency readiness[a] using the gaming simulation *Disaster in Franklin County*,[b] May 2007 to May 2008, University of Minnesota

A. Describe the public health role in emergency response in a range of emergencies that might arise (not measured).

B. Describe the chain of command in emergency response (efficiency = mean time to complete chapter 3; effectiveness score = mean for the participant group, number correct divided by number of attempts for the six matching roles in chapter 3).

C. Identify and locate the agency emergency response plan (or the pertinent portion of the plan) (not measured).

D. Describe his/her functional role(s) in emergency response and demonstrate his/her role(s) in regular drills (efficiency = mean time to complete chapter 10; effectiveness = percent correct for question 19).

E. Demonstrate correct use of all communication equipment used for emergency communication (phone, fax, radio, etc.) (not measured).

F. Describe communication role(s) in emergency response: within the agency using established communication systems, with the media, with the general public, personal (with family and neighbors) (efficiency = mean time to complete chapters 1 and 12; effectiveness = percent correct for questions 1, 2, 3, 23, 25, and 26).

G. Identify limits to own knowledge, skill, and authority and identify key system resources for referring matters that exceed these limits (efficiency = mean time to complete chapter 11; effectiveness = percent correct for questions 20, 21, and 22).

H. Recognize unusual events that might indicate an emergency and describe appropriate action (efficiency = mean time to complete chapter 5; effectiveness = percent correct for questions 4, 5, and 6).

I. Apply creative problem-solving and flexible thinking to unusual challenges within his/her functional responsibilities and evaluate the effectiveness of all actions taken (efficiency = time to complete chapters 6, 8, and 9; effectiveness = percent correct for questions 7, 9, 11, 12, 13, 15, 16, 17, and 18).

[a]Columbia University School of Nursing, Center for Health Policy. Bioterrorism & emergency readiness: competencies for all public health workers. 2002 [cited 2009 Sep 24]. Available from: URL: https://www.train.org/Competencies/btcomps.pdf

[b]Olson D, Larson S, Scheller A, Johnson L. Disaster in Franklin County: a public health simulation. Minneapolis: University of Minnesota School of Public Health, Center for Public Health Preparedness; 2006. Also available from: URL: http://cpheo.sph.umn.edu/umncphp/franklincounty.html [cited 2009 May 4].

time they entered the simulation if they wanted to "resume from last visit," "restart chapter," or "restart simulation." If they resumed from last visit, the timer resumed as well and calculated the total time from the combination of both sessions. If the participant chose to restart the chapter, the timer would also restart the calculation of time for chapter completion. Of primary interest was the effect of group assignment on the dependent variable—time to completion. We used TimeRank instead of time in minutes to compare groups due to the highly skewed distribution of time. TimeRank was created using all time data points for all groups and then ranked.

- *Effectiveness:* We treated effectiveness as a nominal variable, counting correct vs. incorrect answers for questions within the chapters. Thus, we measured effectiveness (results achieved) by user responses to questions captured at critical points in the simulation. We compared the first response by the participant with a correct response in all but the chapter 3 question. In the chapter 3 question, participants chose players for incident command roles. Participants could continue to choose options until all roles (i.e., planning, operations, logistics, finance, liaison, and public information officer) were correctly filled. All attempts were recorded in the database. An overall score for the question in chapter 3 was calculated as the number of correct matches divided by attempts to match the roles. We were primarily interested in the effect of participant group on the dependent variable—proportion of questions in the simulation answered correctly.
- *Analysis:* Analysis of number of questions answered, not total number of questions asked, adjusted for missing data; thus, the calculations were valid regardless of whether or not participants finished the entire simulation. We were primarily interested in the effect of the participant group (i.e., BT/ER program completers, others with significant training, or others with no significant training) on the dependent variable—effectiveness—as the proportion of correctness by different competency levels.

Analysis

Choice of the study design was influenced by the resources available and by the desire to decrease bias. Instrumentation and testing threats could occur if participants were influenced by previous contact with the evaluation process or tools used in the evaluation. We avoided these effects because no pretest was conducted in this project and there was no previous use of the gaming simulation or surveys.

Nonrandom assignment created the potential for selection bias. BT/ER program completers and enrollees with significant participation (Experimental Group 1) may have differed fundamentally from individuals in Experimental Group 2 (never enrolled in the BT/ER curriculum and reported significant other training) or the Control Group (never enrolled in BT/ER curriculum and did not report significant other training). If the groups were not equivalent, this could confound the outcome. To help control for possible selection bias, we first checked demographic variables to see if participant groups differed. We then adjusted the estimate of the relationship between group membership and performance outcomes using analysis of covariance (ANCOVA) to create adjusted means. We chose the Honestly Significantly Different (HSD) test proposed by Tukey[12] as a test of significance. Tukey's method was based on the studentized range distribution.[13]

In all of the comparisons, we used Chi-square tests to check for associations between two categorical variables, and *t*-tests and analysis of variance and ANCOVA to test for differences in means (alpha: $p<0.05$). We obtained approval to conduct the study in February 2007 from the University of Minnesota Institutional Review Board. From May 2007 to May 2008, the gaming simulation—*Disaster in Franklin County: A Public Health Simulation*—and survey tools were available online at http://cpheo.sph.umn.edu/umncphp/franklincounty.html.

RESULTS

A total of 780 participants signed into the gaming simulation. As shown in Table 1, we excluded 204 participants from analysis, leaving a final sample of 576. A total of 22 participants had completed the BT/ER program (Experimental Group 1), 143 participants had significant levels of other training (Experimental Group 2), and 411 participants had no significant training (Control Group) prior to participation in the *Disaster in Franklin County* simulation (Table 2).

Forty-three states and three unspecified international locations were represented, with the largest percentage of participants (34%) from Minnesota (Experimental Group 1 = 59% from Minnesota, Experimental Group 2 = 27% from Minnesota, and Control Group = 36% from Minnesota). Graduate and undergraduate students and registered nurses comprised 52% of the sample (Table 2). More than half (52%) of participants were employed in academic/

Table 1. Participants (*n*=780) in the gaming simulation *Disaster in Franklin County*[a] for evaluating bioterrorism and emergency readiness education, May 2007 to May 2008, University of Minnesota

Participants	N
Excluded from analysis	
Known project team members	15
Participated only to evaluate for others' use	15
Duplicate records	2
Completed 50% of simulation (≤6 of 12 chapters)	172
Final sample[b]	576
Experimental Group 1	22
Experimental Group 2	143
Control Group	411

[a]Olson D, Larson S, Scheller A, Johnson L. Disaster in Franklin County: a public health simulation. Minneapolis: University of Minnesota School of Public Health, Center for Public Health Preparedness; 2006. Also available from: URL: http://cpheo.sph.umn.edu/umncphp/franklincounty.html [cited 2009 May 4].

[b]Experimental Group 1 included students who had graduated from or were currently enrolled in the bioterrorism and emergency readiness (BT/ER) curriculum at the University of Minnesota School of Public Health. The comparison groups included individuals who had access to the Internet and were aware of the 2006 online simulation *Disaster in Franklin County: A Public Health Simulation*. Experimental Group 2 included those who had never enrolled in the BT/ER curriculum and reported significant other training (≥3 courses or ≥45 hours). The Control Group included those who had never enrolled in the BT/ER curriculum and did not report significant other training (≥3 courses and ≥45 hours).

educational institutions or governmental bodies. Most were white (88%), female (78%), and had a bachelor's degree or less education (75%). More than half (52%) of the participants were younger than 30 years of age, with 20% aged 30–39 years.

Motivation for completing the simulation had been identified as a potential barrier or enhancer to participation.[14] As shown in Table 3, about half of the participants completed the simulation for personal enrichment, 22% wished to earn continuing education credit, and 30%–40% named other reasons.

Satisfaction with the online simulation experience was measured on the post-survey, with most expressing satisfaction. Of the participants who completed the post-survey (n=529), 97% agreed that the simulation would "enhance my ability to perform in my professional role," and 96% agreed that they "found the format of the simulation effective for my learning style." Ninety-eight percent of participants were satisfied with the simulation and 95% of participants agreed they "would recommend the simulation to others."

Of the 576 participants in the gaming simulation, 246 (43%) had participated in training on topics pertinent to BT/ER in the past year. The mean number of hours of training reported for the past year was 11.5 (range: 0–200).

The content topics in which these people (n=246) participated included:

- 87% disaster preparedness,
- 49% crisis/risk communication,
- 74% incident command and management,
- 24% surveillance for unusual events that might indicate an emergency,
- 25% legal considerations in disaster preparedness, response, and recovery,
- 41% impact of disasters on community health, and
- 41% chemical, biological, radiological, nuclear, or explosive agents.

Exercises have been the standard for measuring demonstration of competency beyond real-world events. In Experimental Group 1, 45% applied knowledge through tabletop exercises, 41% through functional exercises, and 27% through full-scale exercises. One-half reported that they had not exercised BT/ER. In Experimental Group 2, 69% applied knowledge through tabletop exercises, 56% through functional exercises, and 29% through BT/ER.

The mean time required to finish chapters 1 through 12 was 37.72 minutes (standard deviation = 50.39). Of primary interest was the effect of the independent variable (Group) on the dependent variable (TimeRank), but because participants were not randomly assigned to the levels of the Group variable, the possibility that the covariates (UserAge, Education, and Student Status) were related to both Group and TimeRank could not be excluded. Therefore, we included the covariates in the model so as to remove their possible confounding effect from the estimation of the effect of Group on TimeRank. Group was found to have a significant effect on TimeRank in this model controlling for the effect of covariates ($p<0.0001$). We conducted Tukey's post-hoc tests (t-tests) to determine among which of the three groups there was a meaningful difference. For at least one of the three groups, TimeRank means differed significantly.

Using Tukey's method, we found significant differences between Experimental Group 1 and Experimental Group 2 (p=0.009), but Experimental Group 1 and the Control Group were not significantly different (p=0.066), nor were Experimental Group 2 and the Control Group (p=0.057). Experimental Group 1 was significantly slower in time to completion than either Experimental Group 2 or the Control Group. Time to

completion in Experimental Group 2 and the Control Group was not significantly different.

We measured demonstration of effectiveness (results achieved) by user responses to questions captured at critical points in the simulation. Effectiveness was presented as the proportion of questions answered correctly (correct answers divided by questions answered) for each participant.

We were primarily interested in the effect of the independent variable group on the dependent variable (ProportionCorrect), but because subjects were not randomly assigned to the levels of the Group variable, the possibility that the covariates (UserAge, Education, and Student Status) were related to both Group and ProportionCorrect could not be excluded. Therefore, we also included the covariates in the model so as to remove their possible confounding effect from the estimation of the effect of Group on ProportionCorrect.

Table 2. Characteristics of participants (*n*=576) in the gaming simulation, *Disaster in Franklin County*,[a] for evaluating bioterrorism and emergency readiness education, May 2007 to May 2008, University of Minnesota

Characteristic	N	*Percent*	*Group 1 (n=22) Percent*	*Group 2 (n=143) Percent*	*Group 3 (n=411) Percent*
Group membership	576	100	4	25	71
Primary professional practice					
Undergraduate student	153	27	0	12	33
Graduate student	32	6	41	1	5
Registered nurse	112	19	9	20	20
Bioterrorism coordinator	24	4	14	10	1
Other	255	44	36	57	40
Primary employment					
Academic/educational institution	144	25	18	15	29
County health department	82	14	18	27	10
Other governmental public health agency	36	6	14	13	3
Other governmental office (non-public health)	40	7	9	17	3
Hospital	89	15	0	10	18
Other health-care setting	53	9	5	4	11
Not employed	75	13	27	4	15
Private business/industry	20	3	9	3	3
All other	37	8	0	7	6
Race/ethnicity					
White	506	88	95	90	87
African American	33	6	5	5	6
American Indian/Alaska Native	4	1	0	1	0
Asian	14	2	0	1	3
Unknown	19	3	0	3	4
Gender					
Female	451	78	77	62	84
Male	125	22	23	38	16
Education					
High school	145	25	0	15	30
Associate degree	81	14	0	10	16
Bachelor's degree	207	36	50	40	34
Master's degree	76	13	14	21	10
Doctoral degree	33	6	32	7	4
Other	34	6	5	8	5
Age (in years)					
<30	299	52	27	30	61
30–39	117	20	14	22	20
40–49	71	12	18	18	10
≥50	89	16	41	29	9

[a]Olson D, Larson S, Scheller A, Johnson L. Disaster in Franklin County: a public health simulation. Minneapolis: University of Minnesota School of Public Health, Center for Public Health Preparedness; 2006. Also available from: URL: http://cpheo.sph.umn.edu/umncphp/franklincounty.html [cited 2009 May 4].

Table 3. Participants' (*n*=576) motivation for completing the gaming simulation, *Disaster in Franklin County,*[a] to evaluate bioterrorism and emergency readiness education, May 2007 to May 2008, University of Minnesota

Motivation	*Number of responses*	*Percent*[b]
Personal enrichment	299	52
Earn continuing education units	125	22
Evaluate ability to respond in times of threat	217	38
Learn more about the field of bioterrorism and emergency readiness	223	39
Enhance job performance	192	33
Other	170	30

[a]Olson D, Larson S, Scheller A, Johnson L. Disaster in Franklin County: a public health simulation. Minneapolis: University of Minnesota School of Public Health, Center for Public Health Preparedness; 2006. Also available from: URL: http://cpheo.sph.umn.edu/umncphp/franklincounty.html [cited 2009 May 4].

[b]Total exceeds 100% because more than one reason could be selected.

Group was found to have a significant effect on ProportionCorrect in this model, which controlled for the effect of covariates. ANCOVA with Tukey's post-hoc adjustment showed that the ProportionCorrect means differed significantly for at least two of the three groups. Experimental Group 1 and Experimental Group 2 were significantly different (p=0.005), Experimental Group 1 and the Control Group were significantly different (p<0.0001), and Experimental Group 2 and the Control Group were significantly different (p<0.0001). The order of the adjusted means was consistent with the evaluation hypothesis that training was associated with better scores.

The simulation was used as the alternative context to a disaster to test the students' ability to transfer learning (from trainings or curriculum) to new situations (simulation). Experimental Group 1 had a significantly greater mean effectiveness for describing chain of command (competency B) than Experimental Group 2 and the Control Group when adjusting for age, education, and profession/student status (p=0.0074 and p<0.0001, respectively). Experimental Group 2 also had a significantly greater mean than the Control Group (p<0.0001). Experimental Group 1 had a significantly greater mean effectiveness for creative problem-solving (Competency I) than the Control Group when adjusting for age, education, and profession/student status (p=0.0135). Group comparisons for effectiveness for Competencies D, F, G, and H showed no significant differences after adjusting for age, education, and student status.

DISCUSSION

This study demonstrated that training is significantly associated with better performance in a simulated emergency using gaming technology. Both the participants in the BT/ER curriculum (Experimental Group 1) and other participants completing at least 45 hours of training in the past year (Experimental Group 2) demonstrated higher effectiveness scores (ProportionCorrect) than participants who did not report significant training (Control Group). These effectiveness scores were adjusted by three covariates (age, highest degree earned, and profession—grouped as student/non-student), alleviating the most probable confounders on performance within groups. We also found a meaningful difference between participants in the BT/ER curriculum (Experimental Group 1) and other participants completing at least 45 hours of training in the past year. Experimental Group 1 subjects participated in a curriculum of study grounded in a recognized set of competencies,[2,3] which may have influenced the level of training.

A significant difference in performance on competencies[8] supported in the content units of the BT/ER curriculum and other trainings taken for continuing education programs was demonstrated in gaming simulation. Performance in describing chain of command in emergency response (Competency B) was significantly greater for both training groups compared with those that did not have at least 45 hours of training. This demonstration of performance in incident command is of particular importance since implementation of the National Incident Management System (NIMS). NIMS provides a "consistent nationwide template to enable federal, state, local, and tribal governments and private-sector and nongovernmental organizations to work together effectively and efficiently to prepare for, prevent, respond to, and recover from domestic incidents, regardless of cause, size, or complexity, including acts of catastrophic terrorism."[15] Knowledge and skill in incident command is foundational to communication and coordination in NIMS and is required training for proficiency. Training was shown to be a significant factor in a participant's ability to perform

during the gaming simulation, thereby reinforcing this national requirement.

Performance in applying creative problem-solving and flexible thinking to unusual challenges within his/her functional responsibilities and evaluate the effectiveness of all actions taken (Competency I) was significantly greater for Experimental Group 1 compared with the Control Group. While this competency was not significantly different for Experimental Group 2, the direction of the least-square means was meaningful with Experimental Group 2, showing a smaller mean than Experimental Group 1 but a greater mean than the Control Group. No training (Control Group) continued to show the lowest scores.

Sixty-six percent (n=380) of all participants reported that they had not participated in exercises or drills. Given the number of student participants (n=185), this number is not surprising; however, there are still almost 200 individuals not having experienced performance-based measurement of competence in response to a threat. Personal and family preparedness is necessary for developing a culture of preparedness. BT/ER exercises traditionally are conducted live with great cost in time and resources. Gaming simulation is a viable method to reinforce knowledge and, thus, increase opportunity to demonstrate performance.

We calculated efficiency scores as time to completion of chapters and reported them as TimeRank. Experimental Group 1 was significantly slower in time to completion than both Experimental Group 2 and the Control Group with adjusted means. This is a surprising outcome, as time on task was assumed to be faster for trained participants as a measure of efficiency. The rankings of time presented an opposite result from what was expected. However, participants were not notified that their time was being recorded. Meaningful interpretation of these data is limited, as participants chose their own pace for completion. Careful consideration of alternatives within the simulation could increase time and at the same time reinforce more effective decision-making. The greater effect scores for trained participants attest to this. Training at a proficient level requires synthesis, organizing, and adapting KSA to use past experience for practice. The BT/ER curriculum participants (Experimental Group 1) are trained at the competent (post-baccalaureate certificate), master's, and executive master's (proficient) levels.

Limitations and unexpected events

This study was subject to several limitations. Self-reports of the number of credits completed in the BT/ER curriculum did not match the actual records of completion reported by participants in Experimental Group 1. This was likely due to recall bias. Thus, coding for inclusion of participants in Experimental Group 1 (those who had completed at least three credits) was accomplished using actual student records. This was completed by staff not involved in the data analysis to assure confidentiality of the remaining data fields.

Efficiency scores were calculated as time to completion of chapters. However, participants were not notified that their time was being recorded. Meaningful interpretation of these data could be limited, as participants chose their own pace for completion.

We measured satisfaction of the simulation experience on post-survey. However, a ceiling effect may have occurred with six response options provided, ranging from "strongly agree" to "strongly disagree." Another limitation was in the conceptual definition of satisfaction that entails a match between expectations and experience.[16]

We did not include the variable race/ethnicity in analysis because almost every subject was Caucasian. Potential confounders (selection bias) were analyzed, with ANCOVA using group as the independent variable along with three covariates (age, highest degree earned, and profession—grouped as student/non-student) that could confound the association between the group variable and the outcome. The resulting adjusted means were used to reduce bias.

CONCLUSIONS

Educational evaluators have recognized that satisfaction and motivation influence performance.[14] Satisfaction with the experience is the traditional, and often only, evaluation conducted in training experiences. In this evaluation, participants reported a high degree of satisfaction (98% satisfied to very satisfied) with the simulation experience. The positive response to the simulation was confirmed when 95% reported they would recommend the simulation to others.

While all training and education programs face challenges that make it difficult to measure outcome with the degree of fidelity needed to produce maximum effectiveness, programs charged with preparing the public health workforce for BT/ER face particular problems. These barriers include limited resources, geographic distribution, and demands on the public health workforce that limit time and access to advanced training. Technology-enhanced tools available asynchronously allow participants and researchers to overcome these barriers.

The data in this study confirm that gaming simulation is seen as enhancing participants' ability to perform in their professional role (96% agreed),

and the format of the simulation is effective for most learning styles (95% agreed). The success of this evaluation of training in BT/ER is due, in part, to use of this online media. The use of a free online gaming simulation eliminates participant resource barriers and allows greater participation. Test/retest can also be conducted as participants move through the simulation multiple times. While only first-time attempts were recorded for this evaluation, the researchers noted several participants reengaging at various points in the simulation. This would not be possible on an individual basis in a real-time exercise or drill or in a real-time emergency.

The simulation was used as the alternative context to a disaster to test the student's ability to transfer learning from previous trainings to the new situations in the game. This evaluation study demonstrated that training is significantly associated with better performance in a simulated emergency using gaming technology.

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