Effects of Simulation on Emergency Vehicle Drivers' Competency in Training

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Abbreviations:
EMS = emergency medical services
EVDTP = Emergency Vehicle Driver Training Program
VFIS = Volunteer Fireman's Insurance Service

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Abstract

Introduction: The number of accidents involving emergency vehicles is a major concern for emergency service providers.

Objectives: This study assessed the effectiveness of adding a driving simulator to a traditional training program.

Methods: The sample consisted of students attending the National Emergency Medical Services Academy in Lafayette, Louisiana. Each participant self-scheduled two days in which he or she would attend the driving portion of the training class. A total of 52 participants were in the control group and 50 participants were in the treatment group. In addition to the classroom training, the treatment group used a driving simulator prior to driving on the competency course.

Results: The treatment group took significantly less time to drive through the competency course on the first run than did the control group. It also acquired significantly fewer penalty points on the first run and required significantly fewer runs to complete the course.

Conclusions: Simulators can be effective training tools for teaching emergency vehicle drivers.

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Introduction

Each year, numerous emergency vehicle drivers are killed or injured when responding to or returning from an incident. On average, 25 firefighters are killed in vehicle collisions in the United States annually,[1] and several hundred are injured (Table 1). There are no reliable sources available for the number of non-fire emergency vehicle drivers killed or injured. Although the literature suggests that human error is the primary reason for emergency vehicle accidents,[1,2] emergency vehicles are operated by drivers who may or may not be trained to operate them in a safe manner. Due to the number of injuries and fatalities, the training program for these professionals is critical.

Although computer simulator-based training for drivers has intuitive appeal, little is known about its effectiveness on the operation of emergency vehicles. Simulators have been deployed to successfully instruct individuals learning to drive other vehicles. For example, high school students use simulators to learn to drive cars,[3] and commercial truck drivers are monitored using a simulator called Sim Val (simulation validation) to re-assess their driving abilities.[4] Vehicle driving simulators also are used to monitor and study driver fatigue and stress.[5]

Increased safety and the reduction of accidents are essential components of training drivers. The combination of an inexperienced driver with an unfamiliar vehicle creates a potentially hazardous situation for on-the-road driver training.[6]

A mid-range simulator was used by a study group of drivers. During the 90 days following the simulator training, the accident rate was monitored for this group. During this time period, this group experienced an 18% reduction in acci-

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	Involving Fire Department Emergency Vehicles		Involving Firefighters' Personal Vehicles	
Year	Accidents	Firefighters Injured	Accidents	Firefighters Injured
1994	13,755	1,035	1,610	285
1995	14,670	950	1,690	190
1996	14,200	910	1,400	240
1997	14,950	1,350	1,300	180
1998	14,650	1,050	1,350	315
1999	15,450	875	1,080	90
2000	15,300	990	1,160	170
2001	14,900	960	1,325	140
2002	15,550	1,040	1,030	210

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Table 1—Fire department vehicle accidents
Source: NFPA's survey of fire departments for US fire experience 1994–2002, 2003

dents.[7] The accident rate of the drivers who were trained conventionally was almost 32%. Another group had 17 accidents reported by those who participated in the simulator training and 154 for those who had not participated in simulator training.[7] This study sought to determine the accident rate following by the use of a mid-range simulator.

Allen, Cook, and Rosenthal (2001) investigated the feasibility of training novice drivers to cope with cognitively complex traffic hazards using low-cost simulator technology.[8] The simulator used was a desktop-configured simulator. The performances of 16 novice drivers and 10 drivers with >10 years of driving experience were studied. The drivers in each of the groups had two experimental sessions, which lasted about 20 minutes. Using the simulator, the study revealed that the total number of accidents decreased with experience (p <0.05). Initially the novice drivers had twice as many accidents in their first session as did the experienced drivers; however, during the second time through the simulation, the accident rate of the novice group dropped to nearly that of the experienced operator's rate. This study demonstrated that a simulator can be used to effectively train novice drivers in complex and critical road/traffic situations and reduce the number of accidents.[8]

Comparisons of the effectiveness of driving simulators using 120 simulator drivers and 192 test track drivers showed no statistical differences between simulator and test track in both total brake reaction time and time to initial steering.[9]

The effectiveness of training using simulators also was investigated by New Jersey Transit, which experienced a high incidence of vehicle accidents in 1994 (42.6 accidents for every million miles driven). After the implementation of a simulator-training program for drivers, there was a reduction in insurance, maintenance, and gas costs with a realized savings of US$375,000 per year. By 1997, the accident rate was reduced by 75% from the initial level.[10]

There are several advantages to adopting the approach of using a simulator in training. The benefits include: (1) reduced training time; (2) automatic logging of individuals' performances; (3) accurately targeted retraining; and (4) lower costs; technology-based training can achieve similar results at lower cost than obtained using conventional methods.[11]

Ross (2002) noted that technology-based training appears to be the most cost-effective in situations when: (1) the course content is relatively stable; (2) the content is largely knowledge-based; (3) there is a long-term training need; (4) trainees are scattered geographically; (5) large numbers of people must be trained in a relatively short period of time on a regular basis; and (6) equipment emulation and special, dangerous, or unusual situations have to be created or facilitated through the use of simulation.[11]

Emergency vehicle operators drive in environments unlike any that previously have been simulated and tested for effectiveness. This study compared a simulator-based learning environment for emergency vehicle drivers with similar training conducted in an environment not using simulators.

Methods

Research Design

The research design for this study was quasi-experimental.[12]

Participants

The participants were EMS students who had not previously driven an emergency vehicle. The study was conducted at an EMS school based in Lafayette, Louisiana. Cluster sampling was used to assign the participants into a control group and a treatment group.[13] Each participant scheduled two days in which he or she would attend the driving portion of the training class. A total sample of 102 participants was selected for this study to provide a power of 0.80, statistical significance was set at $p = 0.05$. A total of 52 participants were in the control group and 50 participants were in the treatment group.

Training Program

The Volunteer Fireman's Insurance Service (VFIS) 1997 Edition of the Emergency Vehicle Driver Training

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	Station	Error	Penalty
No. 1–8	All	Each cone brushed, moved, or overturned	10 points
		Cross any line, each time crossed	3 points
No. 3 and 8	Alley dock and stop exercise	Stop more than 6" but less than 12" from the measured point	3 points
		Stop 12" or more but less than 18" from the measured point	6 points
		Stop 18" or more from or go past the measured point	10 points
No. 6	Parallel park	Park 12" or more from the curb	3 points

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Table 1—Penalty point schedule (" = inches)

Program (EVDTP) was employed. The program cites four critical components to a comprehensive EVDTP:

1. Eight hours of classroom instruction;
2. Eight hours of the competency course completion;
3. Eight hours of street and highway driving; and
4. A combination of knowledge and skill testing.[14]

This study concentrated on the competency portion of the course. Prior to participation in the study, each student attended the same classroom instruction. After the competency course was completed, all students progressed to the street and highway driving component not included in this study.

The EVDTP competency course requires the student to maneuver an emergency vehicle around traffic cones on a parking lot in a limited amount of time. The eight specific maneuvers required to meet the National Fire Protection Association (NFPA) standard on emergency vehicle driver qualifications include: (1) straight-line forward and backward; (2) confined space turn; (3) alley dock backing; (4) serpentine; (5) parallel parking; (6) lane change; (7) diminishing clearance; and (8) stop sign.[15]

Emergency Vehicle Operators Course Competency Test

The VFIS-EVDTP evaluation is completed by the course observer when testing the emergency vehicle driver on the competency course. Each driver must successfully drive through the course at least twice in order to pass the course and receive a certificate. The scores for the driving competency course are based on the completion time. The range of scores generally falls from 3 to 15 minutes, with low scores reflecting better driving skills. Penalty points (for hitting cones, etc.) are added as additional seconds to the score (Table 2).[14] The maximum time is based on the wheelbase of the vehicle being driven. The longer the wheelbase, the more time is allowed for the participant to complete the course. A driver who exceeds the maximum time allowed is required to repeat the driving course until he or she drives through the course under the time allowed in two separate runs. The maximum driving scores on the competency course were validated by VFIS.[14] The transfer driver's first attempt of driving through the course was used for comparison (Table 2).

The researcher was the direct contact for the students during the classroom instruction, administration of the simulation, and the competency course scoring. A maximum of six individuals assisted in the scoring of the participants on the competency course. These individuals were given the parameters for scoring the participants after the didactic portion and before any driving component. The assistant scorekeepers were observed by the researcher to ensure the consistency of scoring and reduce the inter-rater reliability threat.

The Simulator

The computer simulation was designed and developed by Road Safety International. It was designed to allow the participant to maneuver an emergency vehicle through situations they are likely to encounter during a typical response. The simulator incorporates a seat vibration transducer to provide an authentic road feel. In addition, the simulator is equipped with a tilt steering wheel with feedback, a properly weighted accelerator and brake pedals, automatic column shifter, turn signals, ignition key, horn, lights, wipers, and cruise control. The seat is adjustable and includes an integrated seatbelt.

Accurate, physics-based driving simulation provides for realistic vehicle performance and handling. The simulator supports new custom driving scenarios and multimedia training curricula content. A scoring system provides both real-time and post-driving scores.

The design of the simulator emulated the driving competency course (Figure 1). This resulted in a near transfer learning environment for the participant. A "near transfer" is when the participant is placed into an environment very similar to the environment in which he or she will be functioning in the real world.[16] The time the participant took on the simulator was measured by the same scoring process as that used on the competency course. Participants were required to "drive" through the competency course simulation at least twice. The first time, an instructor provided individualized instruction, coaching the student through the process and illustrating the position and maneuvering of the vehicle through the aerial view (the simulator has a feature that can toggle to an aerial view of the unit position

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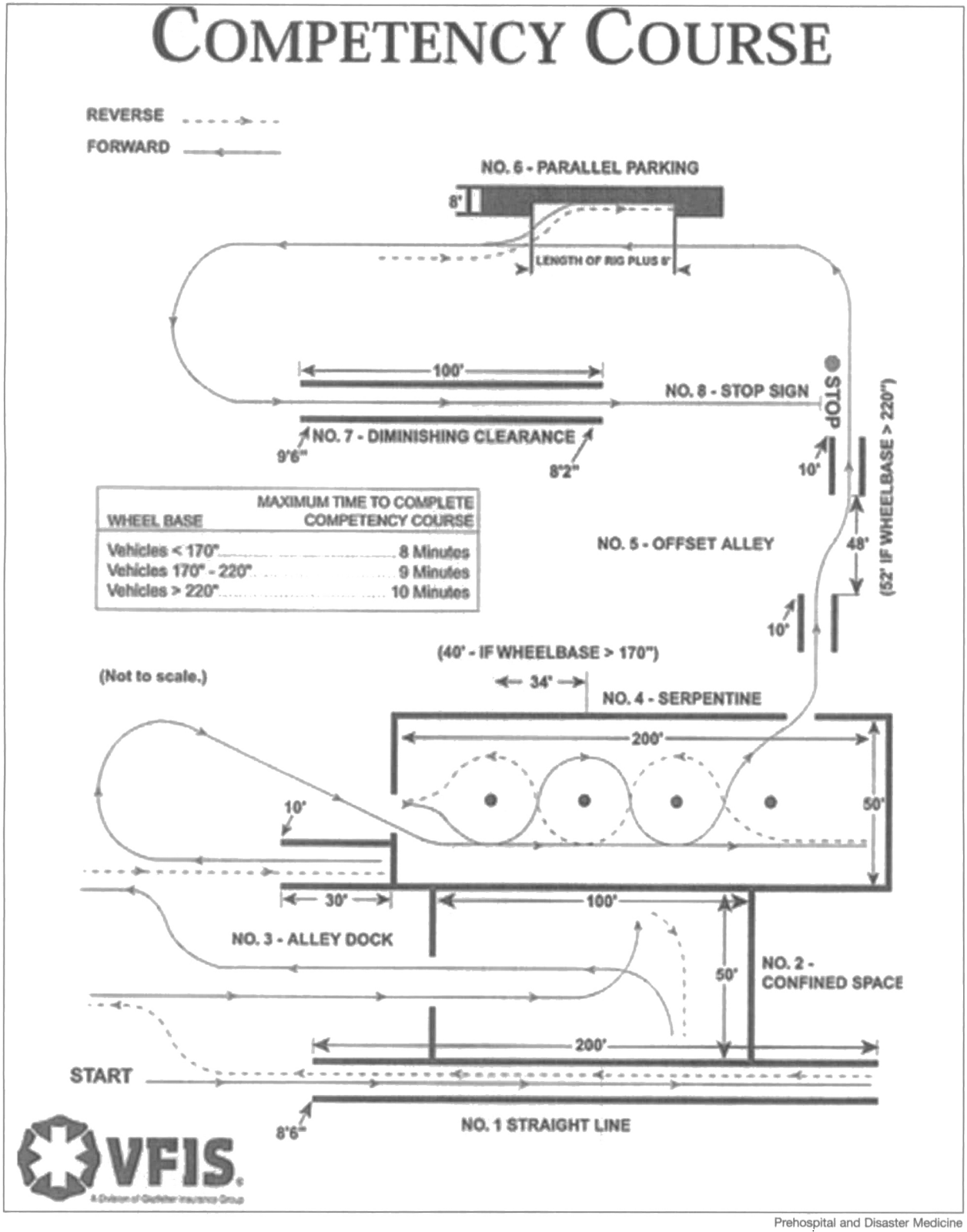


Figure 1—Competency course design
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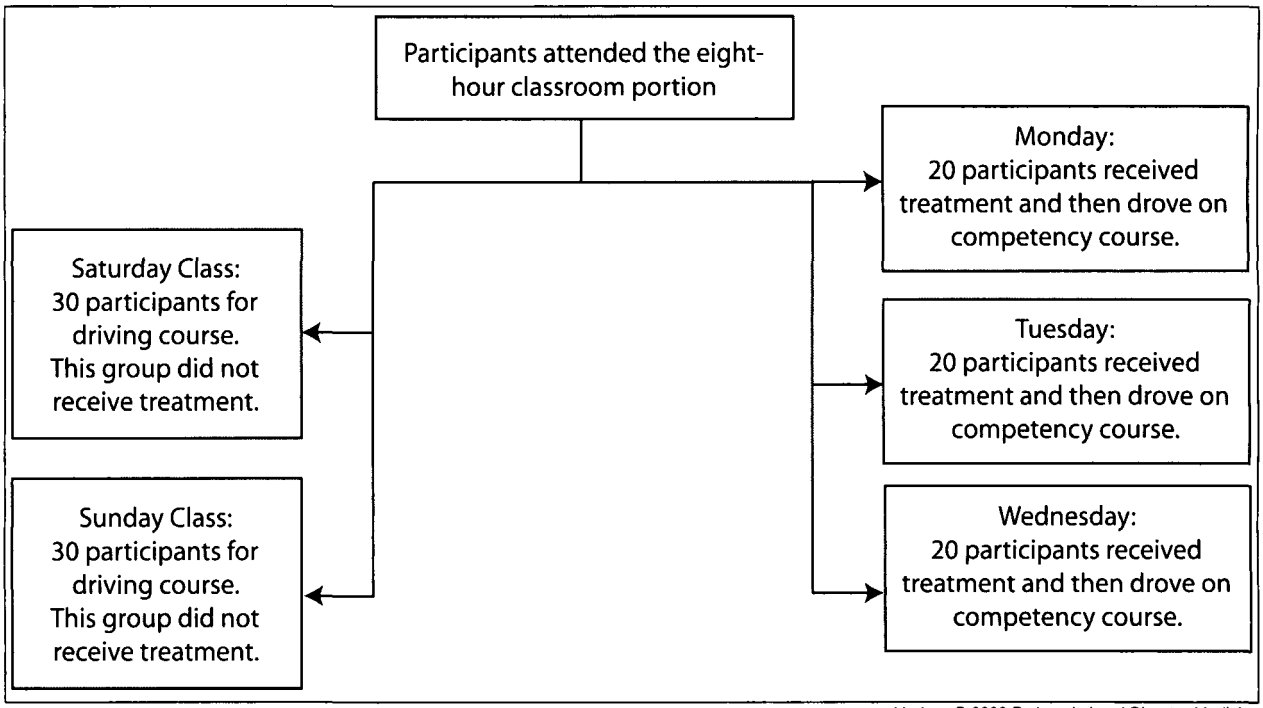


Figure 2—Flow chart of participant progression through program

so the driver can see the unit's position on the course). Because this simulator was new, no prior studies had been conducted using emergency vehicle operators (Figure 1).

Procedures

This study was scheduled over a six-day period. Although the class was taught at the Lafayette site, there also were students at other remote locations who joined the class by interactive satellite television. The class was divided into two groups through a self-scheduling process, without the participant knowing which day the simulator was to be used. All of the participants completed the classroom portion of the course on Thursday.

During the next eight-hour component (which occurred the following week), the treatment group received the simulator training, then completed the competency course component. The control group progressed to the competency course without training in the simulator. The flowchart in Figure 2 illustrates the procedure used for the study.

Ethical Consideration of Study

To ensure ethical compliance and sensitivity in the study, each of the participants was made aware of the study and informed of the study's goals and objectives. Approval was given for this study by the institutional review board of the University of South Florida. Participation was voluntary; all participants signed an informed consent agreement.

Results

Demographics

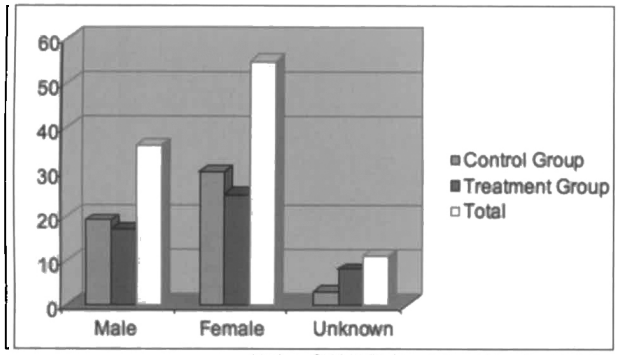
The self-scheduling process resulted in 52 participants in the control group and 50 participants in the treatment group. The participants noted their gender and ethnicity on a survey that was administered prior to training. There were 17 male (34%) and 25 female (50%) participants in the treatment group, and eight participants (16%) did not specify their gender. The control group was comprised of 19 male (37%) and 30 female (58%) participants, and three people (5%) who did not specify their gender (Figure 3). Ethnicity of the treatment group included 38 Caucasians (76%), four African-Americans (8%), and eight unknown (16%). The control group ethnicity was: 36 Caucasians (69%), 10 African-Americans (19%), three Hispanics (6%), one Asian (1%), and three unknown (5%) (Figure 4). Participants' age and overall driving experience were not included. However, there were only two individuals who noted that they had any experience in driving an emergency vehicle and that experience was limited.

First Drive-Through Competency Course

The data collected for each participant included the number of seconds that it took them to drive through the competency course on the first attempt. The mean value for the scores for the control group was 476 ±142 seconds (median = 460 seconds; mode = 384 seconds). The mean value for the scores for the treatment group was 385 ±101 seconds (median = 374 seconds; mode = 409 seconds). To test the effect of the simulator versus non-simulator approach, scores were analyzed using an independent t-test. The t-test was significant, $t = 3.74$, $p = 0.0003$. On average, the simulator group took significantly less time to drive through the competency course on their first attempt (Table 3).

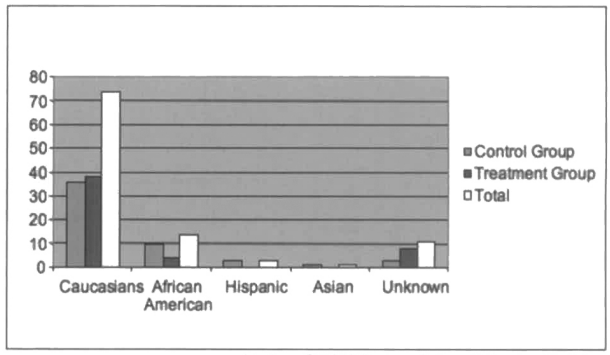
Penalty Points—Penalty points occur when a driver crosses a line, brushes a cone, or commits other infractions. The penalty points were analyzed to see if there were significantly

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Figure 3—Gender of sample



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Figure 4—Ethnicity of sample

	n	Mean (seconds)	Median (seconds)	Mode (seconds)	SD (seconds)	Kurtosis	Skewness
Control Group (non-simulator)	52	476	460	384	142	-0.478	0.382
Treatment Group (simulator)	50	385	374	409	101	3.655	1.427

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Table 3—Competency course time scores on first run through competency course (SD = standard deviation)

	n	Competency Course Points Mean Scores (seconds)	Median (seconds)	Mode (seconds)	SD (seconds)	Kurtosis	Skewness
Control Group (non-simulator)	52	109	103	49	61	0.003	0.555
Treatment Group (simulator)	50	84	82	33	40	0.794	0.175

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Table 4—Competency course points scores on first drive through competency course (SD = standard deviation)

fewer penalty points in one group than in the other. Penalty points are converted to seconds for the purpose of scoring. The mean value for the scores for the control group was 109 ±61 seconds (median = 103 seconds). The mean value for the scores for the treatment group was 84 ±40 seconds (median = 82 seconds). To test the effect of the simulator versus non-simulator approaches, penalty point scores were analyzed using an independent t-test, $t = 2.41$, $p = 0.0178$. The simulator group accumulated significantly fewer penalty points when driving through the competency course (Table 4).

Total Runs for Successful Completion

The total number of attempts it took participants to successfully complete two runs in <480 seconds also was analyzed (the two qualifying runs do not have to be consecutive to pass the course). The value of the mean scores for the control group was 3.1 ±0.88 runs (mode = 3 runs). The mean of the scores for the treatment group was 2.5 ±0.76 runs (mode = 2 runs). In this analysis, the mode appeared to be a better indicator than the mean, $t = 3.88$, $p = 0.0002$. The simulator group took significantly fewer runs to successfully complete the competency course (Table 5).

Discussion

Participants in the treatment group (simulator training) had better scores on their first attempt through the competency course. As a driver of an emergency vehicle, it is important to know the path of travel you are going to take to reach the scene of an emergency. Based on this research, it may be worthwhile to have driving simulators housed at locations where emergency vehicle drivers can practice driving routes throughout their assigned area in order to become familiar with the routes.

The lower penalty points in the treatment group indicates that those drivers handled their vehicle better after practicing with a simulator. If drivers know their vehicles and the characteristics of their vehicle, they will be less apt to incur penalty points. These findings correspond to a study by Mills and Hubal (2001) that tested a group of police cadets on the Profiler system.[18] The cadets used the computer-based simulator, and then drove on a coned competency course. The results showed that the cadets who had higher test scores on the Profiler system had fewer driving errors on the track. Based on these studies, access to a simulator for training purposes may be an effective, cost-saving method for drivers of emergency vehicles.

Furthermore, the treatment group required fewer attempts to master the competency course than did the control group. Similar findings were found by Brock, Jacobs, and Buchter.[7] The success rate of the individuals who used the simulator versus their traditional course to teach bus drivers realized a 95% pass rate. The study did not cite the pass rate of the other drivers. Including simulators in courses for emergency vehicle drivers may help to reduce the total training time (and the impact and cost) required.

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	n	Mean (runs)	Median (runs)	Mode (runs)	SD (seconds)	Kurtosis	Skewness
Control Group (non-simulator)	52	3.08	3	3	0.882	1.371	0.915
Treatment Group (simulator)	50	2.5	2	2	0.763	1.384	1.438

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Table 5—Competency course total number of runs to successfully complete (SD = standard deviation)

Limitations

The study was limited to participants in a specific geographic location and during one period of time. The results could have been different if a different type of simulator was used. The results did not yield data related to memory retention of material; rather, the analysis considered behavioral change. It was anticipated that as a result of the simulation-based training, the participants would recognize they had been in a similar situation during the training and recall how to react appropriately. However, it was not possible to subject the participants to every potential scenario that they may encounter in a real situation.

Another limitation of this study was that the results were evaluated only at Levels I and II of Kirkpatrick's Four Levels of Evaluation. The survey instrument and course evaluation encompassed this level. Level II Learning is an assessment of what the student learned.[17] The post-test, the simulator, and the competency course were the instruments used to measure this level. Additional studies should be conducted to evaluate simulator use at Levels III and IV of Kirkpatrick's Levels of Evaluation.

The findings of this study indicate simulators can be effective training tools for teaching emergency vehicle drivers. Simulators would be beneficial to include in the emergency vehicle driver training program for several reasons. The first benefit is the cost incurred by using the simulator versus the costs of damage to an actual vehicle. When an ambulance is damaged during a training evaluation, there is a cost to repair the damage and a time period for which the ambulance is not available to respond on calls. When a driver "crashes" an ambulance while using the simulator, no actual damage occurs. In addition, if a driver is involved in an ambulance accident, he or she may be injured; whereas, injury is unlikely to occur in a simulator.

In addition to the costs of the emergency vehicle, there are many other costs associated with conducting a competency course training program on a training site. For example, at least two instructors should be on the competency course at all times, along with a safety officer. In contrast, an instructor is not required to be present when the driver is training on a simulator. Additionally, the simulator can be used at any time of any day. To set up the driving course, it takes approximately one and one-half hours to lay out and mark the course. There are 100 cones that must be used, and these orange traffic cones typically become damaged and destroyed over time from the ambulances running them over. There were 15 traffic cones destroyed during this study.

The weather is another factor. The competency course cannot be conducted during inclement weather. The simulator can be used during any type of weather, at any time of the day. The costs of fuel are increasing.[19] Therefore, it may be more economical to have the driver practice on a simulator before they drive an actual vehicle on the course.

Recommendations for Future Research

The direct observation by the researcher and those who scored the competency course raised the possibility that the simulator can be a predictor of the driver's behavior in a real environment. If this could be substantiated, it could help in the recruitment process for individuals to drive emergency vehicles. Further studies must be conducted to validate these observations.

Future studies also should take into account the demographics of the drivers to determine if there are differences between genders. During the study, it was observed that females had more difficulty driving the ambulance on the competency course than did the males. Additional demographic information would be insightful in future research studies to determine if there are any differences when investigating gender, age, physical characteristics (including height), and ethnicity.

Conclusions

The results of this study have illustrated that computer simulations have a positive effect on training emergency vehicle drivers. Future research should examine the effects of using simulator emergency vehicle drivers in real scenarios, such as street driving.

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