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EVALUATING GENDER DIFFERENCES IN TREATMENT OF SIMULATED GUNSHOT WOUNDS USING A FEMALE RETROFIT

Curtis M. Craig
University of Minnesota
Minneapolis, MN

Bradley Drahos
University of Minnesota
Minneapolis, MN

Katelyn R. Schwieters
University of Minnesota
Minneapolis, MN

Nichole L. Morris
University of Minnesota
Minneapolis, MN

Mandi Lye
University of Minnesota
Minneapolis, MN

Timothy M. Kowalewski
University of Minnesota
Minneapolis, MN

Jack E. Norfleet
SFC Paul Ray Smith Simulation and Training Technology Center
Orlando, FL

Mark V. Mazzeo
SFC Paul Ray Smith Simulation and Training Technology Center
Orlando, FL

ABSTRACT

Female soldiers are at greater risk of injury and have higher death rates compared to male soldiers. Female casualties are underrepresented in existing training materials for battlefield medics and the patient simulators are often masculine in appearance. The current study assesses the suitability of a female retrofit for male patient simulators and explores the existence of disparities in treatment between male and female patient simulators among combat medic trainees. Thirty-six participants undergoing training at a U.S. Army Medical Simulation Training Center performed a series of basic procedures on both a male patient simulator and a similar patient simulator with a female retrofit. The chest seal procedure was video-recorded and coded for errors committed by the trainees and analyzed to determine whether the apparent gender and order of the patient simulators affected error likelihood and rate. The results indicated that gender and order did not affect the likelihood of optimal performance, but if trainees treated the female retrofitted patient simulator first, they tended to commit more errors. Therefore, the use of a female retrofit may be useful for providing parity in training for gender; however, the issue of gender disparities remains a pressing issue for medical device design and research.

Keywords: Patient simulators, medical training, combat medicine, gender disparities

NOMENCLATURE

TCCC	Tactical Combat Casualty Care
CLS	Combat Lifesavers
NCD	Needle chest decompression
GSW	Gunshot wound
GRK	Gender Retrofit Kit
MSTC	Medical Simulation Training Center
IFAK	Individual First Aid Kit

1. INTRODUCTION

As of 2016, female soldiers have been allowed to serve in active-duty combat roles in the military, and now represent 16.9% of active-duty service members [1]. Consequently, the increase of female active-duty service members has led to an increase in female casualties on the battlefield. Because women have only recently entered active-duty roles, the research surrounding female patient treatment and care on the battlefield is limited. However, some research indicates that female populations have fewer and less severe battle-related injuries and experience survival rates comparable to their male counterparts [2,3]. Other research indicates that female soldiers are at greater risk for certain types of injuries (e.g., chest, abdomen) and have overall higher death rates than their male counterparts [4,5].

The combat medic training, Tactical Combat Casualty Care (TCCC) is relatively brief (i.e., 16 to 40 hours), and consists of classroom-based instruction and skill-based assessments with patient simulators (i.e., medical manikins). Numerous contextual factors can influence the medical decision-making process, including the visual presentation or characteristics of the patient

(e.g., gender) [6]. Therefore, it is necessary that training protocols adequately prepare combat medics to treat both female and male casualties on the battlefield, especially as medics encounter cases that require treatment to sensitive areas of the body and that anatomically differ. Chest and airway procedures tend to be less common prehospital interventions documented on the battlefield [7,8]. Consequently, the lesser performed interventions are associated with a higher rate of error due to skill degradation from a lack of exposure treating these types of cases [8]. Implementing training for the treatment of sensitive areas of the body may improve the quality of care a patient receives and reduce error, especially for cases that occur on female soldiers.

One issue with the existing training is the lack of female casualty representation in training materials and exercises. Female casualties are underrepresented in existing training materials and the patient simulators are often masculine in appearance and anatomy [9]. Many of the available patient simulator models use the young, fit, white male as the standard, and do not allow for the adjustment of anatomical sex [10]. As such, the absence of representative patients in training materials may contribute to observed gender disparities in patient treatment and care due to an inability to practice treating female casualties. Furthermore, existing female patient simulators are often more costly and lack capabilities to practice treating sensitive procedures (i.e., injuries to the chest).

Given the current bereftness of female patient simulators, and the overall gender disparity in combat medicine training and treatment, the current study (1) assesses the potential suitability of a female retrofit for male patient simulators in order to provide a cost effective training for treating female patients while female simulators remain more expensive than male simulators, and (2) explores whether disparities already exist in treatment between male and female patient simulators among combat medic trainees practicing basic medical procedures on the simulators. The following analysis presents a preliminary account of how effectively trainees treated a male and female-retrofitted patient simulator. Both simulators presented a gunshot wound, which required rapid diagnosis and an application of a chest seal to the wound on the chest and upper back. The study was reviewed by the University of Minnesota IRB (STUDY00013436) and the U.S. Army DEVCOM Soldier Center (UN-210003), both of which determined it was “Not Human Subjects Research” as defined by DHHS and FDA regulations.

2. MATERIALS AND METHODS

2.1 Participant Selection

In total, 36 participants (22.2% female) completed the study. Fifteen participants had the designation of combat lifesavers (CLS), 16 were combat medics, two participants had other designations (e.g., Ophthalmic Tech), and one participant had no medical training. Participants' designated experience ranged from 2 days to 17.5 years. The age range was 18 to 41 years old, with 27 (75.0%) of participants between 18 to 29 years, and 9 (25%) were between 30 to 41 years. For education, 17 (47.2%) had some high school or a high school diploma/GED, 15 (41.6%) had an Associates, Bachelor’s, or graduate degree, and 5 (13.9%) had other degrees.

2.2 Testing Scenario and Setup

To analyze potential performance gaps between patient genders, each participant conducted the following procedures on male and female-retrofitted simulators: massive hemorrhage control via tourniquet application, treatment of gunshot wound (GSW)/penetrating wounds via chest seal application, and pneumothorax (collapsed lung) via needle chest decompression (NCD). Each participant, after being debriefed by project staff and MSTC instructors, would then approach the first simulator, conduct each of the three procedures, then be prompted to move to the second simulator by the MSTC instructor in which they would conduct the same three treatments on the second simulator. Half of the participants performed procedures on the male simulator first, and half of the participants performed procedures on the female-retrofitted simulator first. Following the completion of treatment for both patients, the participants then completed a short survey regarding their simulator interactions and overall experience, received instructor feedback, then completed a post-experience interview.

In total, four SimMan® 3G patient simulators were used to create two separate participant testing lanes. Each lane received two simulators, one of which was not modified to serve as the male patient, which is currently standard use during training, while the other simulator was retrofitted to present as a female patient. Modifications to the female patient simulator included replacing the torso skin with the female Gender Retrofit Kit (GRK) produced by SIMETRI, a wig, and makeup. Uniform clothing between the simulators was nearly identical; however, the female patient was fitted with a nude sports bra underneath the standard undershirt. See Figures 1 and 2.

Figure 1: Research staff testing a procedure on a female patient simulator (leg amputation has been blurred)

Figure 2: Instructor testing treatment procedures on male patient simulator.

While participants carried out three treatments to both patients, which will be analyzed in future studies, the key treatment of interest for analysis for this study is the treatment of gunshot wound (GSW)/penetrating wounds via chest seal application. This procedure is of key interest as it requires the most interaction between the participant and the breasts of the female simulator, which is anticipated to elicit the largest margin of difference in participant performance. Two GSW were placed on both simulators for these scenarios, with the entrance wound on the front of the chest and the exit wound on the upper back/shoulder of the simulator. For both simulators, the GSW on the chest was placed just outside of the mammillary line underneath the fold of the breast. This specific location was selected as it is the most likely to potentially be avoided by participants and will require removal of the female patient's bra to correctly treat. See Figure 3.

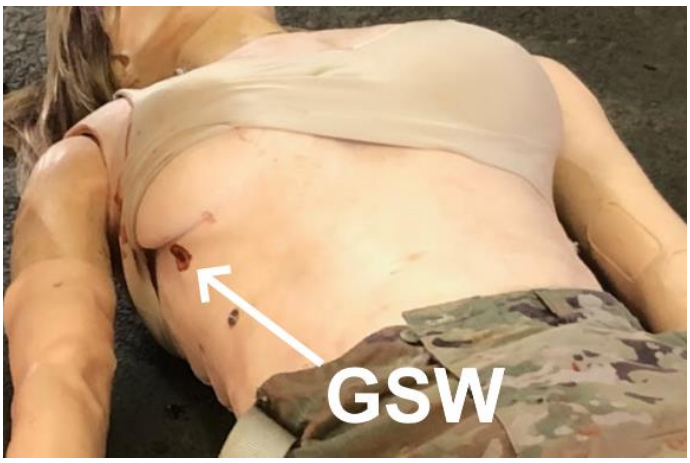

Figure 3: Simulated gunshot entrance wound (GSW) on chest with female retrofit.

Proper chest seal application to treat GSW and penetrating chest wounds has five major steps that must be correctly carried out when treating a patient according to the TCCC handbook [11]. The first step for treating GSW is to completely expose the wound, in this case removing the uniform blouse and undergarments such as the undershirt and bra. Once the patient has been disrobed and the wound has been fully exposed, the combat medic is to then search for any potential exit wounds. Once all wounds have been located, the medic is then to treat the wound. In this scenario, the medic must unpackage the chest seal from the individual first aid kit (IFAK), then firmly apply the chest seal over the wound during the patient's exhale ensuring a complete seal around the entire wound. Once the chest seal is applied, the medic may place the patient on the injured side or sit them upright to monitor the patient for increasing respiratory difficulty or other injuries.

2.3 Data Collection Methodology

In order to monitor participant performance as unobtrusively as possible, all participants were provided a helmet with attached Garmin cameras to wear during the experiment. The use of helmet mounted Garmin VRB XE cameras, designed and implemented by Raytheon BBN, provided research staff the ability to record participant point of view footage that could be reviewed later as needed and ensured no bias due to research staff presence while the participant carried out treatment. This head mounted participant point of view footage was recorded and stored for all 36 participants, which serve as the basis for the following performance analysis.

2.4 Measures

The focus of the analysis of this study is on participant performance and accuracy of chest seal application to the male and female simulators during training. To measure these outcomes, a team of coders reviewed the footage of all participants by coding various stages of the GSW chest seal application treatment process. To measure the chest seal application performance of participants, the chest seal application process was broken down into three codable instances for each GSW that were recorded as either being done correctly (Yes), being done incorrectly (No), or unable to define (Unknown). Three task steps that were of key importance included, exposing the wound, locating the wound, and proper chest seal application to the GSW. Additionally, a final measure of coding was included for each simulator to denote whether the participant went back to correct an error. This correction variable was measured as either Yes, No, or N/A if no errors were made that required correction.

From the measured performance of the participants, it was then possible to generate various key metrics that could be used for statistical analysis to analyze the overall participant performance and whether the patient's gender affects treatment provided. Some of these key statistics generated include overall error rates, error rates for any of the three key GSW treatment steps, and participant correction rates. These rates of error and correction were then analyzed not only as a whole but broken down between treatment of the male simulator and the female-retrofitted simulator separately. An important analysis included whether patient order affected overall performance, hence the use of group A and group B designation for participants.

3. RESULTS AND DISCUSSION

3.1 Inter-rater Reliability

Prior to analyzing the entire dataset, it was necessary to have the two coders analyze a subset of the database separately in order to ensure inter-rater reliability. To ensure inter-rater reliability, both coders reviewed the GSW treatment footage from participants A01, A05, A10, B01, B05, and B10. These participants were chosen such that both participant groups were reviewed, covering a broad range of technical experience and knowledge. The coding process for these participants was identical to the coding process, as discussed previously, that would be used to analyze the entire database of participants.

Across the six participants that were jointly coded by the two coders, there was only one instance of disagreement between the coders of 84 total coded points of interest. This was across 2 (M/F) stimulated patients and 7 coded items per patient. This single disagreement was in regard to whether a participant fully exposed one the wounds on the back shoulder of the male simulator. In this instance the participant did not remove the shirt that the simulator was wearing by moving the undershirt in order to see the back of the simulator. By doing so the participant only briefly exposed the wound which was noticeable through the head mounted Garmin footage. During the coder meeting to discuss the coding process and review the initial batch of data, this was discussed, and the decision was made to classify this as a failure to expose the wound. This is due to the fact that the wound was not exposed enough to fully see nor be properly treated. As a result of this discussion regarding the single disagreement from the initial subset of data coded and additional potential disagreements in coding, inter-rater reliability had now been verified and it was possible to proceed with coding the entire database.

3.2 Analysis of Error Occurrence

Each procedure on each patient simulator was further coded to capture whether an error occurred at all (Y/N). The order of the patient simulator (Male/Female or Female/Male) and the apparent gender of the patient simulator were entered as independent variables on error occurrence. The results of the binary logistic regression indicated no significant relationship between order, gender, and error occurrence, χ^2 (2) = 1.942, p = .379. The gender of the patient simulator did not appear to be associated with the likelihood of an error-free performance, as measured by the aforementioned coding scheme. An exploratory secondary analysis was conducted to see if experience affected error occurrence. Experience of participant in their indicated treatment role was included as an ordinal variable in a similar binary logistic regression along with order and patient simulator gender on error occurrence. The overall model was significant, χ^2 (3) = 19.688, p < .001, with higher experience in their reported role indicating a lower likelihood of those participants committing an error.

3.3 Analysis of Error Count

A follow-up analysis considered error severity or criticality by counting the number of errors in the chest seal procedure, with poorly performed procedures having a higher error count. A within-subjects variable of apparent patient simulator gender and a between-subjects variable of patient simulator order were analyzed with a 2 x 2 mixed ANOVA with error count as the dependent variable. There was no main effect of order, F (1,34) = .864, p = .359, η_p^2 = .025. There was a main effect of the patient simulator gender, F (1,34) = 11.847, p = .002, η_p^2 = .258. Participants committed more errors on the female simulator (M = 1.694, SE = .268) than the male simulator (M = 1.139, SE = .236). Furthermore, there was a significant gender x order interaction, F (1,34) = 9.596, p = .004, η_p^2 = .220. When participants were exposed to the male patient simulator first, the average error count was similar for the male (M = 1.167, SE = .334) and female (M = 1.222, SE = .378) simulators. However, if participants were exposed to the female simulator first, the average error count was higher for the female simulator (M = 2.167, SE = .378) than for the male simulator (M = 1.111, SE = .334). Please refer to Figure 4.

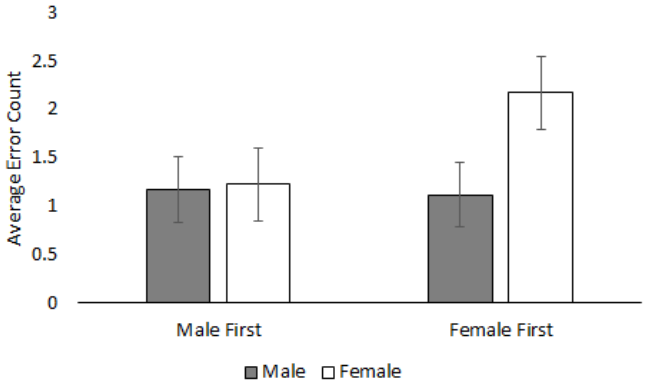

Figure 4. Interaction between patient simulator gender and order of treatment on average error count.

Two exploratory secondary analyses via separate mixed ANOVAs were conducted to account for other factors that may better explain the effect of order and apparent patient gender on average error count. Each separate analysis included a within-subjects variable of apparent patient simulator gender and a between-subjects variable of patient simulator order (2 x 2). The first exploratory analysis included two levels of participant gender as a between-subjects variable (male/female) and found no effect of participant gender (p = .194), while patient gender (p = .019) and the patient gender by order interaction (p = .006) remained significant. The second exploratory analysis included experience of participant in their indicated treatment role was included as an ordinal variable (0 = less than 1 month, 1 = less than or equal to 2 years, 2 = more than 2 years). As expected, experience was significantly predictive of error count (p = .020).

However, patient gender (p = .001) and order by gender (p = .003) remained significant, and there were no observed significant interactions with experience.

3.4 Discussion

Given that (1) female soldiers are at greater risk of worse medical outcomes on the battlefield, (2) medical training given to battlefield medics is primarily focused on treating men, and (3) female trauma patient simulators tend to be less available and more expensive than their male counterparts, the present study and preliminary analysis considers the suitability of using a female retrofit on a male patient simulator for training. Volunteer trainees at the MSTC performed basic procedures on a male and female-retrofitted simulator, and their performance on the chest seal procedure was scored by steps outlined in the TCCC manual. Results indicate that patient simulator gender did not affect a binary measure on whether an error was committed, but if trainees operated on the female simulator first, they tended to commit more errors on the female patient simulator than the male patient simulator, even when controlling for trainee gender and experience. This implies that the female retrofit may be useful as a bridge for training on female patients until female simulators become more widespread. Notably, after performing the procedures, the majority of participants (97.1%) strongly supported the belief that medical training for female patients was important.

Results also suggest that the female retrofit maintains simulation validity, as trainees comparably performed on the retrofit if they first operated on the male patient simulator. However, the observation that more errors were committed if trainees performed first on the female patient simulator highlights the critical need to focus research and design efforts to achieve better gender parity in medical training and devices for female patients.

Some issues remain with the female retrofit as presently designed. First, the retrofit is presently sized for larger male patient simulators and cannot be placed on smaller patient simulators. Second, there are likely issues with the physical fidelity of the simulator. The solution of retrofitting the torso of a large male body with a masculine face may not adequately present the feminine traits that are sufficient to convince some trainees that they are practicing procedures on a female patient. This dissimilarity of feminine traits could have negative implications if treatment practice on this retrofit does not sufficiently transfer to treating female soldiers.

Furthermore, there are some limitations of the present analysis. First, the coding and analysis are preliminary and are intended to illustrate benefits and challenges with performing treatment procedures in this context. Second, the procedure performed and analyzed here was a relatively simple one that can be taught and learned quickly, while more complicated or nuanced procedures may lead to error rates and error types that are more sensitive to gender effects. Third, while 36 participants were present, there may not have been sufficient power to detect gender effects in the binary error metrics.

4. CONCLUSION

Use of a female retrofit may be an effective bridge technology until female patient simulators are more widely distributed. Trainees appeared to effectively treat the apparent female patient with the basic chest seal procedure but had more difficulty if the female simulator was presented first. Gender disparities in training and treatment remain an open area of research for device design and intervention.

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