Research Article

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Pediatric Emergency Care and Medicine: Open Access

2021
Vol.6 No.5:21

A Randomized Controlled Trial Comparing JumpSTART Training for Pediatric Emergency Medicine Physicians Using Online Lecture *vs.* Online Simulation

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Citation: Fisher EH, Jin J, Watson D, Kocken PF, Madhok M (2021) A Randomized Controlled Trial Comparing JumpSTART Training for Pediatric Emergency Medicine Physicians Using Online Lecture *vs.* Online Simulation. Pediatr Emerg Care Med Open Access. Vol.6 No.5:21

Abstract

Introduction: We sought to compare the educational efficacy of training pediatric emergency medical providers in JumpSTART disaster triage using a traditional lecture *vs.* an online simulation tool.

Methods: A group of 42 physicians working in a pediatric emergency department was randomized into two groups. Each group completed a baseline triage of 20 hypothetical patients. One group then watched a Traditional Online Lecture (L) while the other played three scenarios of an Online Simulation (OS). A second triage of 20 patients was sent to assess for improvement. A third triage was sent 3 months later to evaluate retention.

Results: At baseline each group triaged a median of 14/20 patients correctly (IQR 3.5 for the OS group, 2 for the L group). After education the L group triaged 16/20 (IQR 3) patients correctly and the OS group triaged 15/20 (IQR 4) patients correctly. Post-degradation each group triaged 15/20 (IQR 3 OS, IQR 2 L) patients correctly.

Conclusion: No significant difference was noted between the OS and L groups post-degradation period.

Keywords: Disaster; Mass casualty; Triage; Pediatric; JumpSTART

Abbreviations: MCI: Mass Casualty Incident; EMS: Emergency Medical Systems; START: Simple Triage and Rapid Assessment.

Received: March 16, 2021; **Accepted:** September 17, 2021; **Published:** September 24, 2021

Introduction

Mass casualty event planning has become an integral part of hospital preparedness, and pediatric hospitals are no exception [1]. Appropriate triage of patients in a mass casualty incident is important to ensure proper allocation of resources and protect trauma centers from being overwhelmed in surge situations [2]. Depending upon the type and location of the disaster, pediatric patients can represent a large portion of the affected population [3]. In particular, there have been more school shootings each year since 2018 than any year prior [4].

Traditionally, mass casualty triage training has been aimed at prehospital providers, with the assumption that triage will occur in the field. It is reasonable that many prehospital providers report feeling uncomfortable with pediatric physiology, for in most urban and rural areas, pediatrics constitute only approximately 10% of EMS activity [5]. Prehospital providers have reported barriers to appropriate pediatric triage, including emotional obstacles, cognitive and affective error, triage rationale and efficiency, and unfamiliarity with pediatric physiology [6,7]. Children have greater compensatory mechanisms, which can lead to initial under-triage of patients with potentially life-threatening injuries, and cognitive and affective error can lead to under-triage of children who would otherwise be deemed unrecoverable [8,9].

Recent data has demonstrated that in the case of mass casualty events, large portions of the affected populations will self-transport to the closest hospital [2,7]. This was especially notable in the 2016 Pulse Nightclub and 2017 Las Vegas Mandalay Bay shootings [10]. The first patients to arrive often constitute a large proportion of the “walking wounded”, so appropriate triage can protect trauma centers from over-utilizing resources and arrange transport for less critical patients to other hospitals. Pediatric emergency providers must be prepared to perform triage at the door in case of such an event. To date there is no data regarding this group’s ability to accurately perform triage in a mass casualty event, though one study by Kenningham K, et al. [11] showed that both pediatric and emergency medicine experience correlated with higher performance in pediatric MCI triage. Simple Triage and Rapid Treatment (START) is the oldest triage algorithm in the United States (U.S), developed in the 1980s. With its 2002 pediatric modification, JumpSTART (initially created for eight years of age and under), it is the most widely used system for pediatric and adult triage in the United States (U.S) [12,13] **(Figure 1)**.

Training of prehospital providers in this system has demonstrated improvement in triage accuracy before and after intervention [14]. A novel tool for training providers in START/JumpSTART mass casualty incident triage was developed in 2017 by Cicero MX, et al. [15]. 60 Seconds to Survival is a web-based triage simulation that enables providers to collect data on patients such as vital signs and clinical exam, perform life-saving interventions, and assign triage levels, followed by receipt of electronic feedback, with the goal of training providers in a cost-effective, high-fidelity manner. Their initial studies showed that EMS providers improved from a triage accuracy of 89% to 100% in an average of 3 games, using the JumpSTART algorithm. We set out to evaluate how this tool would perform when used to train Pediatric Emergency Medicine physicians in triage, as compared to an online lecture modality.

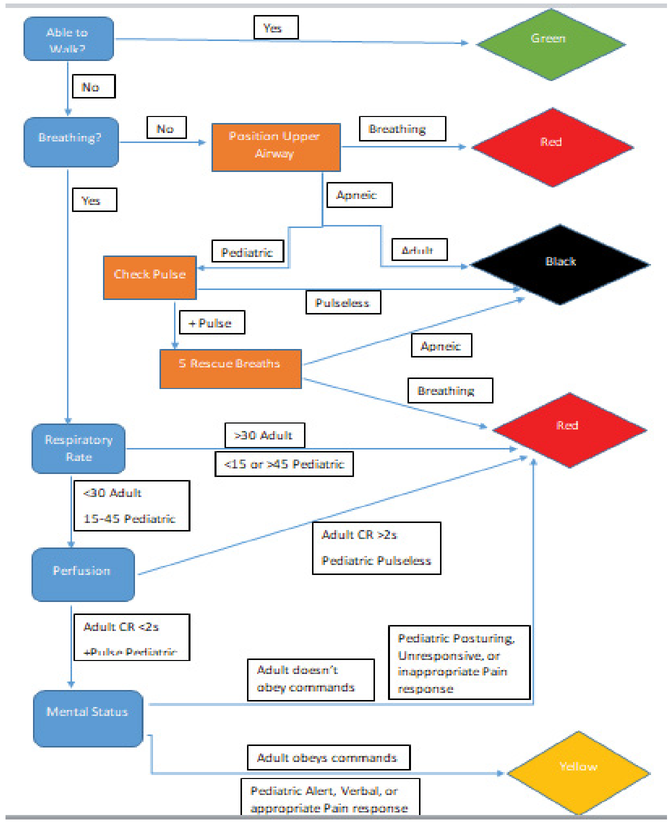

Figure 1 Combined start/Jump start triage algorithm.

Methods

Physicians working in a busy urban Pediatric emergency hospital system were recruited to participate. This hospital system has 2 primary facilities, one of which is a Trauma 1 center, the other of which is Trauma 4. The hospital system employs 44 physicians and 7 fellows, excluding the investigators in this study. The physician group was a mix of board-eligible/board-certified Pediatric Emergency Medicine physicians and general Pediatricians who work exclusively in the Pediatric Emergency Department. For 41 of the physicians an incentive to participate in the study was provided in the form of points toward their physician incentive plan, which is linked to their bonuses. All fellows and 42 of the physicians elected to participate. They were divided into two groups using a random number generator. 24 individuals were randomized to the Online Simulation (OS) group, who played game, 60 Seconds to Survival, and 26 to the Lecture group (L) who watched a pre-recorded lecture explaining JumpSTART triage.

The lecture had been created with the Minnesota Department of Health as a training tool for pediatricians and prehospital providers as part of the state’s disaster preparedness efforts. The video is a total of 11 minutes 41 seconds and covers both triage and decontamination. All participants provided written consent to participate. A demographic survey was collected first using RedCap, gathering data on participants’ age, years of experience in Pediatric Emergency Medicine, board-eligible/board-certified status, whether their primary work location was Trauma 1, Trauma 4, or both, prior exposure to mass casualty training, prior experience with mass casualty events, frequency they played video games, and if they did play video games, what types of games they routinely played.

Three sets of 20 pediatric patients were designed for hypothetical triage: Pre-Intervention Survey (A), Post-Intervention Survey (B), and Post-Degradation Survey (C). Each patient set was evenly divided among the categories Green, Yellow, Red, and Black and ages infant (0-12 months), toddler (1-3 years), school-age (4-8), preteen (9-12) and teenage (13-18). An effort was made to provide various types within each category, as well. For example, JumpSTART Triage has five ways in which a patient is triaged Red: They are apneic initially but breathe after their airway is opened, they are apneic with adequate perfusion but breathe after providing rescue breaths, they are breathing with poor perfusion, they are breathing with a respiratory rate under 15 and over 45, or they have adequate respiratory rate and perfusion but have mental status that is unresponsive or only responsive to pain. One of each type of patient was put into each triage set.

Participants were provided with the following information on each patient: Age, ability to walk, if applicable, respiratory rate, perfusion described as palpability of pulse for the under 8 group, capillary refill for the teenagers, and both pieces of information described for the pre-teens, a description of presenting mental status, and some pertinent information regarding their physical appearance, such as the presence of bleeding or obvious limb deformities. In addition, if the initial respiratory rate was 0, it was indicated whether the patient began breathing after the airway was opened or rescue breaths were given. Survey A was sent to participants via RedCap prior to any educational intervention, to establish a baseline level of triage performance among the groups. Once participants had completed the first triage set they were sent instructions on how to access their education the online video lecture or the game 60 Seconds to Survival. They were asked to complete the education in a 2 week time period.

Participants in the L group were asked to send a screen shot of the video back to the principal investigator as proof that they had completed the exercise. The OS group was asked to register using their participation email and a universal password so that the principal investigator could track the performance and completion. After registering for the game, it provides a brief education to the participant on both the concepts of JumpSTART triage and the basic game play. There is then a sample game prior to any scored games so that the user can get a feel for the instructions.

There are three 10-patient scenarios presented in the game: A school shooting, a house fire, and a tornado. Every participant was asked to play through each scenario once. In each scenario the player must choose actions to evaluate the patient, such as checking pulse or respiratory rate. There are also treatment actions that can be taken, such as opening an airway or placing a tourniquet. When the player feels they have gathered the pertinent information they then assign a triage color and move on to the next patient. Every action that the player makes takes time off the clock. Participants are only given 10 minutes to triage each patient set, and if the timer runs out they may not triage all patients. After the conclusion of each scenario the game provides feedback on whether the player triaged patients correctly or incorrectly and why.

Two weeks after completing Survey A, participants were sent Survey B. There was then a 3 month degradation period in which the material was not reviewed. Survey C was then sent out for completion. The demographic groups were compared using Fisher's exact test. The results of the Pre-Intervention (A), Post-Intervention (B), and Post-Degredation (C) Surveys were analyzed for total correct score, under-triage, and over-triage. Groups were compared using medians and interquartile ranges. We compared the total correct score per triage, in addition to changes in overall over- and under- triage.

Each survey question was also analyzed individually, comparing the percentage correct by each group, to evaluate for any patient type that may be consistently incorrectly triaged by either group. Any question that either group scored <60% on was flagged for review. Finally, subgroup analyses compared total correct score between OS and L groups within each sub-groups over all three surveys (i.e., A, B, and C). Within patient correlations were modelled with exchangeable correlation structure using generalized estimating equations and robust standard errors. Subgroup analysis was performed to determine if there was any difference in within group learning for age greater than or equal to 45, years in practice greater than or equal to 15, any prior triage training, or any regular gaming experience. The cutoff points in age and experience were chosen from the median points in each group from the baseline demographics.

Results

Results of the demographic survey are presented in **Table 1**. The only significant difference between the two groups was that of those who had prior triage training, all of those who had training using tabletop simulation were randomized into the L group. At baseline, each group triaged a median of 14 out of 20 patients correctly. Post-intervention the OS group triaged median 15 patients correctly compared to 16 in the L group. After the degradation period the OS and L groups each triaged median 15 patients correctly. Under- and over-triage were also evaluated. Each group improved on under-triage between Surveys A and B, with the L group making slightly larger gains, but these were not maintained by Survey C. Interestingly, the OS group improved most on Over-Triage between Surveys B and C **(Table 2)**.

Participant triage accuracy was tracked as well. **Figures 2-4** demonstrates the comparison of performance between the two groups on overall accuracy, over-triage, and under-triage for each Survey. Secondary analysis looked at which patients were most likely to be incorrectly triaged by each group. Black patients that were under-triaged to Red in the initial survey were the patients who had perfusion but did not breathe after rescues breaths were provided. There were 2 of these patients in each scenario. In Survey A one of these patients was correctly triaged by 54.2% of the OS group and 44% of the L group, and the other was correctly triaged by 41.7 and 40% of each group, respectively. Post-intervention patients matching that profile were triaged correctly by >70% in each group and that was maintained through Survey C as well.

On Survey A for the Red patients, the patient with high respiratory rate was correctly triaged by 54.2% of the OS group and 60% of the L group for the rest of each under-triaged the patient Yellow. In addition, the patient who breathed with the open airway but had poor perfusion was correctly triaged by 41.8% of the OS participants and 44% of the L group. The rest over-triaged the patient Black. On Survey B, the respiratory rate patient was improved in both groups to correct triage by 70.8% of OS and 64% L, but the patient with good respiratory rate and perfusion but altered mental status was under-triaged, only correctly triaged by 50% of the OS group and 56% of the L group. The patient with poor perfusion but who breathed with an open airway again proved difficult for both groups, with 45.8% of the OS group and 52% of the L group correctly triaging and the rest over-triaged. After the degradation period, all red patients were triaged by each group correctly >60%.

According to the algorithm, yellow patients are those who cannot walk for whatever reason, but have adequate respiratory rate, perfusion, and mental status. On the initial survey a patient who was stable but could not feel their legs was correctly triaged by 54.2% of the OS group and 60% of the L group. That

Table 1 Participant demographics.

Parameters		Total (n=49)	Sim Group (n=24)	Lecture (n=25)	p-value
Age (Mean, SD)	--	45.9,11.3	48,11.2	44,11.2	0.24
Years in Practice (Mean, SD)	--	14.2,10.5	16.1,11.0	12.3,9.9	0.22
Role (N, %)	Attending, PEM Board Certified	40 (81.6)	19 (79.2)	21 (84)	0.46
	Attending, Peds Certified	2 (4.1)	2 (8.3)	0 (0)	
	PEM Fellow	7 (14.3)	3 (12.5)	4 (16)	
Primary Setting (N, %)	Trauma 1	12 (24.5)	7 (29.2)	5 (20)	0.6
	Trauma 4	11 (22.5)	6 (25)	5 (20)	
	Even Split	26 (53.1)	11 (45.8)	16 (60)	
Prior Triage Training	Any	28 (57.1)	13 (54.2)	15 (60)	0.68
	Lecture	24 (85.7)	11 (84.6)	13 (86.7)	1.00
	Table top Sim	5 (17.9)	0 (0)	5 (33.3)	0.04
	Live Sim	20 (71.4)	10 (76.9)	10 (66.7)	0.67
	Jumpstart-Specific	9 (32.1)	3 (23.1)	6 (40)	0.43
Prior Live MCI Experience	--	4 (8.2)	1 (4.2)	3 (12)	--
Personal Gaming	**Frequency**				0.76
	Daily	1 (2.0)	0 (0)	1 (4.0)	
	Weekly	4 (8.2)	1 (4.2)	3 (12.0)	
	Rarely	11 (22.5)	6 (25.0)	5 (20.0)	
	Never	33 (67.4)	17 (70.8)	16 (64.0)	
	Platform (n=16)				
	Console Based	5 (31.3)	2 (28.6)	3 (33.3)	1.00
	Computer Based	3 (18.8)	2 (28.6)	1 (11.1)	0.55
	Mobile Device	9 (56.3)	2 (28.6)	7 (77.8)	0.13
	Social Media Embedded	1 (6.3)	1 (14.3)	0 (0.0)	0.44
	Game Type (n=16)				
	Action	6 (37.5)	2 (28.6)	4 (44.4)	0.63
	Role Playing	1	1 (14.3)	0 (0.0)	0.44
	First Person Shooter	9 (56.3)	2 (28.6)	7 (77.8)	0.13
	Physics Games	1 (6.3)	1 (14.3)	0 (0.0)	0.44
	Strategy	8 (50)	3 (42.9)	5 (55.6)	1.00
	Puzzles	9 (56.3)	3 (42.9)	6 (66.7)	0.61
	Online Multiplayer	2 (12.5)	0 (0.0)	2 (22.2)	0.48

Table 2 Correct, over and under-triage by OS (Online Simulation) and L (Lecture) groups on triage data sets A-C.

Triage	OS median (n=24), IQR	L median (n=25), IQR	Total median (n=49), IQR	p-value
Triage A				
Correct	14,3.5	14,2	14,3	0.82
Under	3,3	2,2	2,3	0.74
Over	2.3.5	2,2	2,3	0.75
Triage B				
Correct	15,4	16,3	16,4	0.73
Under	2,2	1,2	2,2	0.85
Over	3,3	3,3	3,3	0.90
Triage C				
Correct	15,3	15,2	15,3	0.27
Under	2,2	2,2	2,2	0.84
Over	2,1	3,3	2,2	0.44

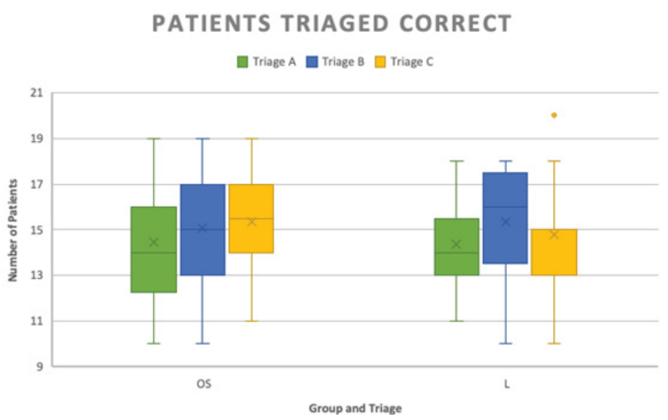

Figure 2 Overall accuracy of triage by participants in each group on Surveys A, B, and C. OS: Online Simulation, L: Lecture.

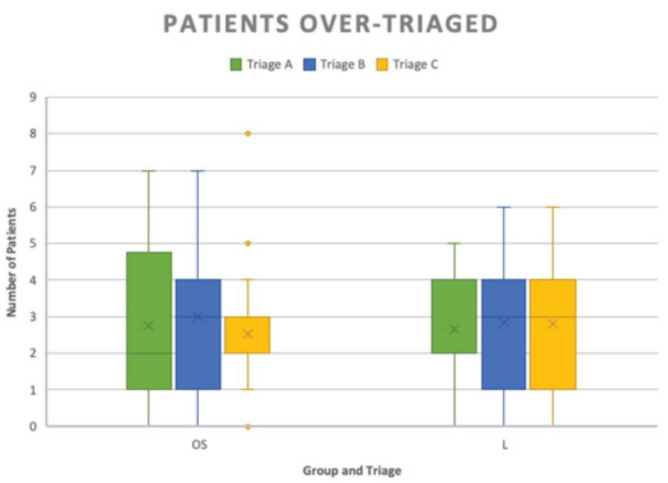

Figure 3 Over-triage by participants in each group on Surveys A, B, and C. OS: Online Simulation, L: Lecture.

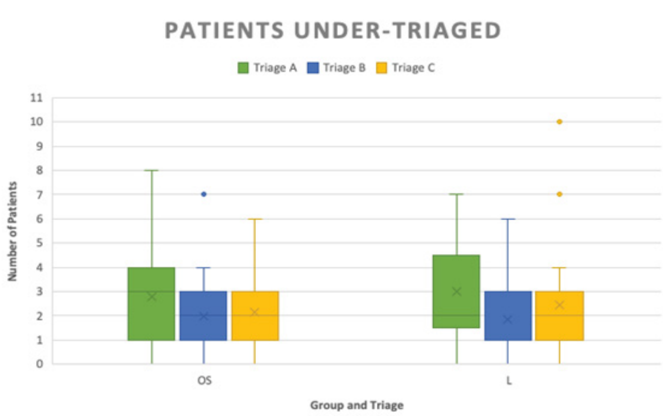

Figure 4 Under-triage by participants in each group on Surveys A, B, and C. OS: Online Simulation, L: Lecture.

patient characteristic improved to >60% for both groups on the subsequent surveys. The patient that was over-triaged by most in Survey B was the one with open lower extremity fracture but controlled bleeding, triaged correctly by 58.3% of OS and 48% of the L group. That presentation had initially been triaged correctly on Survey A by 75% of the OS and 88% of the L group. After degradation that triage improved back to 83.4% of the OS and 84% of the L group. Finally, the patients with no obvious lower extremity injuries who could not walk for other reasons were both under-triaged by both groups on Survey C.

On survey C these patients were a toddler refusing to bear weight and a pre-teen complaining of an ankle injury without deformity. The toddler was correctly triaged by 70.8% of the OS group but only 52% of the L group, being under-triaged to Green by that group. The pre-teen was only correctly triaged 33.3 and 12% of each group, respectively, with most participants under-triaging to Green. Finally, Green patients are considered the Walking Wounded by the JumpSTART algorithm. If a patient is able to physically follow the command “walk to me” they are considered a Green triage level, because the assumption is that if you can follow that command your injuries are not immediately life-threatening. The exception is made for infants, who by definition cannot walk. Infants who have appropriate respiratory rate, perfusion, and appropriate mental status without lower extremity injuries are thus green patients.

It is not the case that these patients do not require any medical treatment, but they may be observed and treated as resources become available. On survey A, one patient with a large facial laceration was over-triaged by most, with only 50% of the OS and 36% of the L group triaging correctly. Laceration patient improved to >60% for both groups on Surveys B and C. On Survey B, an open fracture of the upper extremity was over-triaged, with correct triage by 33.6% of OS and 16% of L participants. Finally on Survey C, a patient with vomiting and abdominal pain was correctly triaged by 58.3% of OS and 44% of L participants, and an infant with a complex arm laceration was triaged correctly by 37.5% and 36%, respectively.

Subgroup analysis demonstrated that the older and more experienced physicians in both groups had slightly lower but not statistically significant baseline knowledge on Triage A and thus showed greater improvement overall post intervention in both OS and L groups. Similarly, those without prior triage training in both groups improved more with each intervention than those who had previously been trained, though again the difference did not reach statistical significance. No significant difference was noted in learning between those with prior gaming experience and those without. To evaluate those subgroups further this study would need much larger numbers to reach sufficient power.

Discussion

As technology advances, education has been moving progressively towards more online formats. The SARS-COV-2 pandemic has led to a vast increase in distance learning for safety reasons, but online educational models have long been increasing in use for economic and accessibility reasons as well. Pediatric Advanced Life Support certification began incorporating online simulation as part of their core curriculum in 2015 [16]. It is important that as our educational modalities shift, we ensure that new modes of education perform as well as those they are replacing.

The median age for each group of participants in this study was over the age of 45 and most reported having no regular gaming experience. While younger physicians have likely encountered more online education and distance learning in their training, in addition to growing up with more personal gaming around them, most of this physician group was trained in an era of in-person instruction only. That combined with an unfamiliarity of common videogame play, as was required to navigate 60 Seconds to Survival, may have proved a barrier to the efficacy of this modality for education. A recent study by Lowe J, et al. [17] using 360 degree virtual reality as a training tool for JumpSTART triage found that participants less than 40 years old outperformed those over the age of 40.

As 60 Seconds to Survival was designed to be a stand-alone educational tool, training in JumpSTART triage was not provided to the OS group other than what was pre-written into the game. It may be that the process of learning the game rules actually interfered with the process of learning Triage. A joint modality of lecture instruction prior to game play, and more hands-on instruction in game play itself may produce better results.

Most of the providers performed fairly well on triage at baseline, so room for improvement was small after either intervention. While no significant difference was seen in prover performance based on experience level, one barrier to following the triage algorithm may be the PEM physician's training. The patients who were initially under-triaged red but the algorithm lists as black were those with apnea despite efforts to restore breathing but adequate perfusion.

In common ED practice these patients are considered salvageable. Similarly, the patients with poor perfusion but who breathed after intervention was consistently over-triaged to black. Perhaps prior physician experience has left the impression that these patients take more resources to save and thus should be considered unsalvageable in a disaster situation. In addition, patients that tended to be over-triaged often had symptoms that may be more concerning to an experienced physician, such as abdominal pain after a blunt force injury, or scalp lacerations that may be indicative of a more significant head injury. There may be a mental block in calling these patients less acute than those who state they cannot walk but have no apparent injuries. To date, none of the Pediatric MCI Triage algorithms have been validated for a hospital setting, so it is difficult to know if following the algorithm exactly would provide better outcomes than physician gestalt in a real MCI. In fact, a criteria outcomes tool applied to a set of pediatric trauma presentations to a large Pediatric trauma center found poor correlation with START, JumpSTART, and Careflight algorithms compared to patient need for admissions and surgeries [18].

Conclusion

While modest gains were demonstrated in each group, the online simulation intervention for teaching JumpSTART appears non-inferior to online lecture education for this group of pediatric emergency physicians. Particularly when accounting for degradation over time, the OS and L groups performed comparably in improvements in overall, over-, and under-triage. Numbers were too small to reach statistical significance between baseline and subsequent performance or between groups. Larger test groups and more vigorous instruction may be required to see statistically significant improvements in triage performance between lecture and simulation groups.

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