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"A short trauma course for physicians in a resource-limited setting: Is low-cost simulation effective?"

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ABSTRACT

Introduction: Morbidity and mortality from intentional and unintentional injury accounts for a high burden of disease in low- and middle-income countries. In addition to prevention measures, interventions that increase healthcare capacity to manage injuries may be an effective way to decrease morbidity and mortality. A trauma curriculum tailored to low-resource settings was implemented in Managua, Nicaragua utilising traditional didactic methods and novel low-cost simulation methods. Knowledge gain in attending and senior residents was subsequently assessed by using pre- and post-written tests, and by scoring pre- and post-simulation scenarios.

Materials and methods: A 5-day trauma course was designed for Nicaraguan attending and senior resident physicians who practice at six hospitals in Managua, Nicaragua. On days 1 and 5, participants underwent pre- and post-training evaluations consisting of a 26-question written exam and 2 simulation cases. The written exam questions and simulations were randomly assigned so that no questions or cases were repeated. The Wilcoxon signed-rank test was used to compare pre- and post-training differences in the written exam, and the percentage of critical actions completed in simulations. Time to critical actions was also analyzed using descriptive statistics.

Results: A total of 33 participants attended the course, including 18 (55%) attending and 15 (45%) resident physicians, with a 97% completion rate. After the course, overall written examination scores improved 26.3% with positive mean increase of 15.4% ($p < 0.001$). Overall, simulation scores based on the number of critical actions completed improved by 91.4% with a positive mean increase of 33.67 ($p < 0.001$). The time to critical action for completion of the primary survey and cervical spine immobilisation was reduced by 55.9% and 46.6% respectively.

Conclusions: A considerable improvement in participants' knowledge of trauma concepts was demonstrated by statistically significant differences in both pre- and post-course written assessments and simulation exercises. The participants showed greatest improvement in trauma simulation scenarios, in which they learned, and subsequently demonstrated, a standardised approach to assessing and managing trauma patients. Low-cost simulation can be a valuable and effective education tool in low- and middle-income countries.

Introduction

Worldwide, intentional and unintentional trauma resulted in 5.1 million (9.6%) deaths in 2010, and low-and middle-income countries account for an estimated 90% of injury-related deaths [1,2]. Available injury surveillance data from Nicaragua is limited; however injury surveillance in one regional hospital reported 15% of Emergency Department (ED) visits were for injuries [3].

Although preventative measures, such as transportation laws, are crucial to decreasing morbidity and mortality from non-accidental trauma, improving trauma care by allocating resources to healthcare capacity building could have immediate effects on

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patient outcomes. The Advanced Trauma Life Support (ATLS) course unifies trauma care among healthcare providers in the United States, and has been shown to improve provider clinical skills, management of multiple trauma patients, organisation, and priority approaches [4]. Modified ATLS courses introduced in low- and middle-income countries have resulted in trauma skill competency in hospital providers, and have demonstrated a decrease in morbidity and mortality in a few countries [5–11].

Medical simulation has been shown to augment traditional didactic curricula and better assess the overall clinical skills of trainees in multiple training scenarios ranging from neonatal to trauma resuscitations [12,13]. Simulation lends itself particularly well to trauma training, as it both emphasises, and provides an opportunity to assess a team-based approach. Procedure labs are another important component of the traditional ATLS course as they allow healthcare providers to practice important skills without risking patient injury. Because simulation and procedure labs usually require expensive resources such as mannequins or models, there is a paucity of data regarding their educational effectiveness for trauma education in the developing world.

The objective of this study was to assess the effectiveness of a short trauma course, which utilises traditional didactic, as well as newer simulation methods, developed specifically for use in low-resource settings.

Materials and methods

Course overview:

A 5-day trauma course was developed based on major concepts in trauma care, injury surveillance data, and the resources available in Nicaragua. To tailor the course to the specific practice environment we assisted the hospital administration in conducting injury surveillance over a 3 month period in preparation for the course, practiced in two of the Managua hospitals, and utilised World Health Organisation guidelines to assess the availability of hospital supplies and procedures in Managua [14]. The didactic and simulation components of the course included 18 lectures, 3 procedure labs, and 4 live simulation cases. Nicaraguan attending and senior resident physicians practicing at six different hospitals in Managua, Nicaragua were selected by La Universidad Nacional Autónoma de Nicaragua – Managua (UNAN), the organisation that houses the equivalent of Continuing Medical Education, to participate in the course. Participants were divided into two groups for written exam purposes and underwent simulations in pairs.

On days 1 and 5, participants underwent pre- and post-training evaluations consisting of two distinct 26-question written exams (tests A and B) and two distinct simulation cases (cases 1 and 2 and cases 3 and 4). On day 1, half of the participants were randomly assigned to Group A, which completed test A and completed simulation cases 1 and 2. The other half, Group B, completed test B and simulation cases 3 and 4. On the last day, the written and simulation cases were reversed for each group. Participants also underwent training on thoracostomy, cricothyrotomy and pericardiocentesis utilising low-cost models, but were not scored on procedural technique.

Fifty-two written questions testing basic trauma knowledge were reviewed for content by board certified attending physicians in emergency medicine, and were randomly assigned to create test A and test B, each with 26-questions. After undergoing the trauma course, participants completed the alternative written test and simulation cases. A final debriefing question and answer session was performed for the written test and simulation components of the course.

Ethics:

Approval from the Ethics Committee of La Universidad Nacional Autónoma de Nicaragua – Managua and the Lifespan (Rhode Island Hospital) Institutional Review Board (IRB) was obtained prior to study implementation. All study participants underwent informed consent on the first day of the trauma course.

Course content

After completing the pre-course evaluation, participants received traditional didactic lectures from either board certified emergency medicine or trauma surgery attending physicians. The 18 lectures covered basic trauma concepts, such as primary and secondary survey, head trauma, spine injuries, and radiology. The cost of the initial course was $74.18 per participant (Appendix E).

Procedure labs:

Participants broke in to groups of 6–7 persons and rotated through three procedure stations: tube thoracostomy, cricothyrotomy, and pericardiocentesis. Procedure labs were designed so that participants could potentially replicate this teaching technique with faculty and residents at their home institutions. The procedures were performed with medical equipment available in local institutions to simulate hospital resources (See Procedure Lab Supplement).

Simulation cases

Simulations were videotaped for educational purposes and were performed utilising Nicaraguan community members, who underwent a brief training as standardised patients. The trained standardised patients along with two Brown University staff members, who served as a nurse and case facilitator (e.g. adjusted patient vital signs and clinical condition based on management by course trainees), participated in the simulation cases. Simulation cases were scored based on (1) a completion checklist scored out of 100 and (2) time elapsed to complete pre-identified actions. These were scored in real-time and verified by reviewing videos of the encounters. The four simulation case patients were a gunshot wound to the abdomen resulting in haemorrhagic shock, blunt trauma in pregnancy, closed head injury requiring airway management, and a tension pneumothorax from a motorcycle crash along with a second victim in traumatic cardiac arrest. Completion checklists were tailored for each simulation case; for example, for the "blunt trauma in a pregnant patient" case, assessing foetal heart tones was a critical action. For a complete list of critical actions, please refer to the supplement. Time to primary survey (airway, breathing, circulation) completion and cervical spine immobilisation were calculated for each simulation team. A debriefing session was held the last day of the course to provide feedback to participants regarding management strengths and pitfalls.

Analysis

Data was entered in to STATA, checked for errors, and used to calculate descriptive characteristics, written and simulation scores. Six of the 52 questions had a difficulty index <0.2, where less than 20% of participants answered the question correctly, and were not considered valid and omitted from the analysis, resulting in Test A with 23 questions and Test B with 23 questions. The Wilcoxon signed-rank test was used to compare pre- and post-training differences in the written exam and the percentage of critical actions completed in simulations. A mean reduction in the time to completion of the pre-training and post-training critical actions was then determined for comparison. Those teams that did not complete the action were excluded from analysis.

Results

Of the 33 participants who completed the course, a majority (61%) were male, about half specialised in emergency medicine (EM) (55%), and about half were attending physicians (55%). Group A had demographics comparable to Group B; for a complete summary of participant demographics see Table 1.

Written test results

Tests A and B had similar means, medians and interquartile ranges. On the initial pre-test, resident and attending physicians performed approximately the same (56% versus 57% correct responses). Table 2 provides detailed results of the pre- and post-written test scores by demographic. Overall, written examination scores improved 26% with a positive mean increase of 15% ($p < 0.001$), with attending physicians having an increase of 13% while residents had an increase of 18%.

Simulation evaluation

Pre-test scores for 16 pairs were calculated; one participant was unable to participate in the simulation portion of the course. The four simulation cases had a pre-course median score of 39 and a post-test median score of 68 (Table 3). Overall, simulation scores based on the number of critical actions completed improved by 75% with a positive mean increase of 29 ($p < 0.001$). Attending and resident-only pairs demonstrated improvement at 66.3% and 77% respectively. Importantly, the completion rate of the primary survey and cervical spine immobilisation improved from 56% to 97% and 81% to 94%, respectively.

Time to complete critical actions in each simulation was available for all pairs for the pre-test portion and was missing for one simulation in post-test analysis. The time to completion of the primary survey and cervical spine immobilisation were reduced by 56% (142–63 s) and 47% in the post-training simulations (117–62 s), respectively (Table 4).

Table 1
Demographics of participants by group.

Demographic:	$n = 33$ (%)	Group A $n = 15$ (%)	Group B $n = 18$ (%)
Sex			
Male	20 (61)	10 (67)	10 (56)
Female	13 (39)	5 (33)	8 (44)
Specialty			
EM	18 (55)	9 (60)	9 (50)
General surgery	10 (30)	3 (20)	7 (39)
Orthopaedics	2 (6)	1 (7)	1 (5.5)
Other	3 (9)	2 (13)	1 (5.5)
Training			
Attending physician[a]	18 (55)	9 (60)	9 (50)
Senior resident[b]	15 (45)	6 (40)	9 (50)

[a] Attending physician: a physician who has completed medical school, mandatory service year, a specialty-specific residency, and passed a specialty-specific exam.
[b] Senior resident: A physician who has completed medical school, mandatory service year, and is at least in his/her second year of residency.

Table 2
Median and IQR of written test scores stratified by specialty and level of training.

	Median (IQR)	
	Pre	Post
Total	58 (50–63)	75 (63–79)
Specialty		
EM	58 (54–65)	75 (67–81)
Gen. surgery	46 (43–58)	69 (59–78)
Ortho	54.5 (50–59)	62.5 (56–69)
Other	54 (52–56)	64.5 (59–70)
Training		
Attending	58 (46–63)	67 (67–83)
Resident	54 (52–63)	75 (60–75)

Table 3
Pre- and post-intervention simulation score median and IQR, and stratified by specialty and training level.

Demographic	n	Median (IQR)	
		Pre	Post
Total	16	39 (30–48)	68 (63–74)
Specialty			
EM	5	40 (30–48)	73 (66–80)
Gen. surgery	3	41 (31–45)	69 (65–73)
Mixed/Other	8	35 (30–48)	63 (57–72)
Training			
Attending	7	44 (31–49)	67 (60–77)
Resident	5	36 (30–46)	68 (63–76)
Mixed	4	35 (29–41)	68 (65–74)

Discussion

We assess knowledge acquisition of Nicaraguan attending physicians and senior residents after participating in a trauma course tailored to a low-resource setting utilising didactics, novel low-cost simulations, and traditional written exam evaluations. Providing the details of this novel trauma course may allow other international or local groups to incorporate relevant aspects in to their trauma training, in particular the simulation component of the course.

Simulation has become nearly universal in EM training programmes in the United States and has been shown to effectively improve case management, procedural technique, mastery learning, and crisis management [13,15,16]. Medical education occurring in a simulation setting provides a controlled and safe environment allowing for real-time feedback [17]. It has also resulted in long-term retention of algorithmic management, like Advanced Cardiac Life Support in trainees [18]. However, simulation education generally occurs in expensive centres with complex mannequins that are cost-prohibitive for low- and middle-income countries. Whereas chest tube simulators can cost up to $3000, our entire course for 33 participants cost $2844.00 (Appendix E). Lectures can be updated as trauma care evolves and diagnostic and treatment tools become available in low-resource settings; the majority of simulation and procedural materials are easily procured in the hospital (i.e. used Normal Saline bags). The estimated cost to purchase consumable supplies and repeat the trauma course for 33 participants is $8.82 (Appendix E). This study demonstrates that it is feasible to introduce simulations that test key concepts in trauma management in a limited-resource setting. In our simulations, the participant pairs demonstrated improvement in absolute number of tasks completed and a decrease in the time to complete critical actions, which is paramount in managing trauma patients, where quick recognition of an acute problem and immediate action can decrease mortality and improve outcomes.

The participants in the first course were carefully selected along with partners at UNAN and included multiple specialties, attending physicians involved with clinical education, and senior

Table 4
Number of simulation pairs completing action, median, IQR and range of time to primary survey, airway, breathing and circulation measured in seconds.

Action	Number of simulation pairs completing action (Total number of Simulations) (n)		Median (IQR)		Range	
	Pre	Post	Pre	Post	Pre	Post
Primary survey	18 (32)	30 (31)	130 (95–172)	65 (30–80)	66–277	14–161
Airway	28 (32)	31 (31)	22 (10–60)	14 (8–38)	1–277	1–76
Breathing	21 (32)	30 (31)	82 (62–129)	45 (15–260)	15–260	10–161
Circulation	28 (32)	31 (31)	29 (21–77)	30 (18–54)	10–273	1–125
C-spine immobilisation	13 (16)	15 (16)	104 (59–131)	57 (38–64)	27–412	11–243

residents. These key stakeholders were strategically chosen as the first participants with the ultimate goal of changing trauma management from the ''top-down'', carefully considering department leadership and educational roles. Therefore, the impact of the course may be underestimated since these highly trained practitioners are likely more knowledgeable in trauma management than junior residents or medical students.

Limitations to this study include a small sample size, non-validated written tests, and a lack of data relating to translation of knowledge to clinical care. We attempted to construct internal validity with the written test by utilising the difficulty index. Additionally, measuring acquired knowledge immediately following the course does not provide information regarding long-term knowledge retention. It would have been useful to perform a 6 or 12 months follow-up with a written test or additional simulations, but this was not possible with available staff. However, repeat implementation of the course in the future will allow for more detailed evaluation of the course in the clinical setting.

This course does align with results of previous trauma courses implemented in low-resource settings [7,8,19]. However, this study was unique in implementing trauma simulations and measuring the time elapsed to critical actions in a low-resource setting. Improvement in both didactic and simulation scores demonstrates acquisition of knowledge through this trauma training course. This course demonstrates that medical simulation, which has been an effective educational tool in high-income countries like the United States, can be implemented in low- and middle-income countries at a low-cost. Simulation should therefore be incorporated more regularly into emergency medicine and trauma curricula in low- and middle-income countries.

Conclusions

Participants demonstrated a considerable improvement in knowledge of trauma concepts demonstrated by statistically significant differences in pre- and post-course written and simulation exercises. Of note, the participants showed greatest improvement in trauma simulation scenarios. Low-cost simulation can be a valuable and effective educational tool in low- and middle-income countries.

Conflict of interest

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.injury.2015.05.021.

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