ORIGINAL RESEARCH

Mass-Casualty Triage Training for International Healthcare Workers in the Asia-Pacific Region Using Manikin-Based Simulations

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WHO = World Health Organization

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Abstract

Introduction: More than half of the world's disasters occur in the Asia-Pacific region. A simulation-based exercise to teach healthcare workers prehospital triage, tagging, and treatment methods was used to link disaster management theory to practice with a student-centered, hands-on educational activity. Various strategies for teaching disaster health education have been advocated, and best-practice disaster education models continue to be sought.

Methods: A manikin-based, primary triage and treatment course was adapted for international healthcare providers in the Asia-Pacific region using symbolic representations of triage categories and physical findings. The pedagogical construct that was used was an interactive, formative assessment in which faculty members mediated learner information gathering and interpretation during four simulation scenarios. After establishing a multi-casualty disaster context, a wireless, audience response system anonymously collected learner responses to four clinical situations: (1) leg wound (hemorrhagic shock/immediate); (2) chest wound (tension pneumothorax/immediate); (3) head wound (traumatic brain injury/expectant); and (4) limb trauma (leg fracture/delayed).

Results: There were 182 healthcare providers from eight Asia-Pacific countries (including the US) that participated in four simulation seminars. The simulation sessions were successfully tailored to groups of learners that varied in size and professional composition. Expectant and delayed triage categories posed the greatest challenge to learners. In one of two groups that were queried, learner self-confidence in applying principles of triage and treatment improved significantly. At the conclusion of the simulation sessions, learners strongly agreed that manikin-based simulation improved their understanding of triage, and should be used to teach principles of primary triage and treatment.

Conclusions: Simulation training represents an opportunity to engage learners regardless of language and cultural barriers. Simulation-based training can be effective in introducing healthcare professionals to principles of primary triage and treatment in an effective and culturally sensitive manner. The characteristics of the course with respect to planned formative assessment and culturally competent scholarship were reviewed.

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Introduction

More than 50% of the world's disasters occur in the Asia-Pacific region. The World Health Organization (WHO) has estimated that more than one-quarter of all injury-related deaths in the world occur in the South East Asia Region. Moreover, the WHO has indicated that regional guidelines and protocols for assisting the development of effective systems of trauma care in the region are lacking. The WHO has stated that a regional priority is the strengthening of emergency care, particularly at the prehospital level.[1]

Various strategies for teaching disaster health education have been advocated, but there is a lack of international consensus regarding who should be

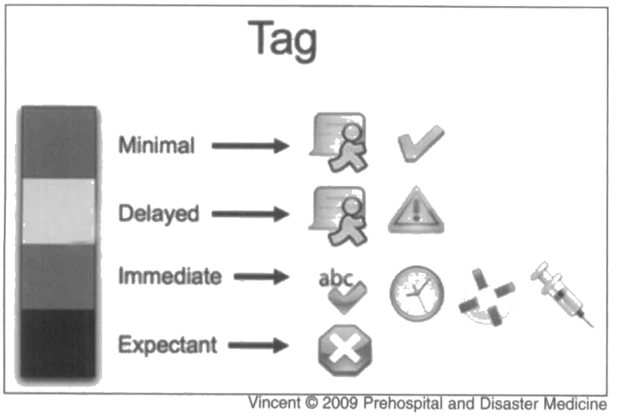

Figure 1—Symbolic representation of a triage tag

educated and trained and what kinds of courses should be provided.[2] Core clinical competencies for healthcare practitioners include the demonstration of proficiency in the use of triage systems in disasters and the application of clinical knowledge and skills in the management of injuries.[3] The use of human patient simulators in health education allows healthcare providers to practice skills without risk to patients/subjects, providing a natural framework for the integration of basic and clinical science.[4] Simulations are ideal for allowing learners to make mistakes safely in lieu of real-life situations, to learn from those mistakes, and to ultimately improve their performance by subsequent avoidance of those mistakes.[5]

Medical simulation using manikins has the potential to advance international medical education in a way that transcends borders. The Education Committee Working Group of the World Association for Disaster and Emergency Medicine (WADEM) has proposed a set of general education principles for disaster health education. These principles include: (1) multi-disciplinary program; (2) vocational focus; (3) case- or scenario-based framework; (4) themed approach; (5) modular approach; (6) supervised practical experience; (7) competency-based approach; and (8) competencies within a conceptual framework.[6] This simulation-based exercise is an example of the use of these principles in practice. Disaster health education commonly takes place in classroom settings. It was hypothesized that the use of manikins to create clinical scenarios found in disaster settings would enhance the engagement of learners despite language barriers.

Methods

Study Design

The University of Hawaii Committee on Human Studies approved the research protocols. All data were collected anonymously using an electronic audience response polling system during the sessions. The triage simulations took place in multiple settings using convenience samples of volunteer participants who were attending a medical conference or course. Orientation instructions, scenarios, and measurement instruments were piloted and refined before the seminars with 28 medical students at the University of Hawaii. All of the sessions were conducted in English. For the sessions in Japan, a translator was available for informal translations during the simulations. A PowerPoint presentation formed the organizing structure of each session. The presentation used international symbols (Wikimedia Crystal Clear icons licensed under Creative Commons[7]) rather than English-language words to amplify the main concepts. An example is in Figure 1.

Settings and Populations

The mass casualty triage training took place in four locations:

1. Graduate School of Medicine in Japan (Osaka City Hospital, Osaka, Japan), attended by a mixture of civilian staff nurses and resident physicians;
2. Medical education center in Japan (Terumo Pranex, Odawara, Japan), attended by a mixture of civilian Japanese nurses, resident physicians, and paramedics;
3. University-based simulation center in Hawaii (Asia-Pacific Nursing Forum, Honolulu, Hawaii), attended by military staff nurses and dentists from Korea, Thailand, the Philippines, Vietnam, and the US; and
4. Military simulation center in Singapore (Asia-Pacific Military Medicine Conference, Singapore), attended by a mixture of civilian and military staff nurses, student doctors, and medics from Singapore, Australia, Japan, Korea, and the US.

Technologies

One to three SimMan® devices (2006, Laerdal Medical, Wappingers Falls, NY) were used for the simulations. These computer-enhanced manikins are able to simulate respirations, variable blood pressures, and central and peripheral pulses. They have embedded speakers capable of transmitting audio files, such as speech, airway, breathing, and heart sounds.

An electronic polling technology, the TurningPoint Audience Response System (2006 Turning Technologies LLC, Youngstown, OH), was used for the debriefing sessions. Learners press wireless keypads to record their responses to questions that have been posed on PowerPoint (Microsoft, Inc., Redmond, WA) slides. Responses are electronically collated, and group results are projected onto a large screen for discussion and feedback (Figure 2).

Scenarios

Four primary triage scenarios were created consisting of two "immediate", one "delayed", and one "expectant" simulated patients. Before each scenario, a mass-casualty context was established by showing a photograph of an actual disaster scene, along with information that there were dozens or scores of casualties. The disaster settings were a bomb blast, a bus accident, a building collapse, and another large explosion. The definitions of the categories were taken from commonly used mass-casualty, primary triage instruments.[8] Immediate (red) indicates critical injury requiring immediate intervention. Expectant (black) indicates deceased or not expected to survive based on available resources given. Delayed (yellow) means less severely injured than immediate. Minimal (green) means ambulatory and not severely injured. The characteristics of the scenarios are detailed in Table 1. The immediate patients consisted of one with hemorrhagic shock and one with a tension pneu-

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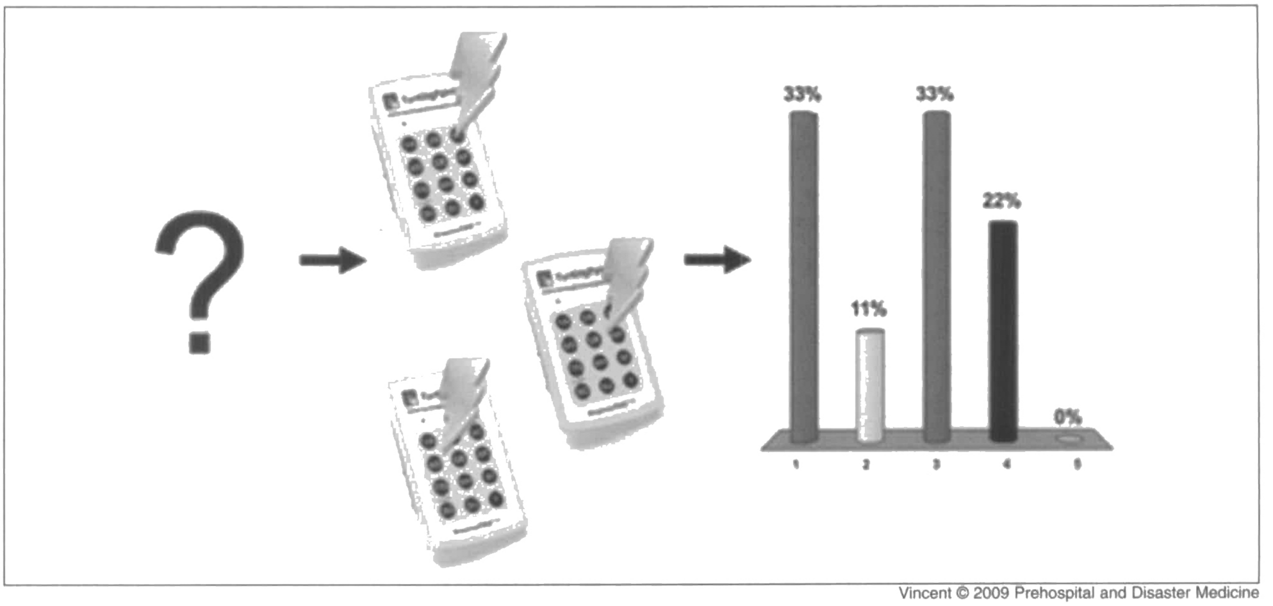

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Figure 2—Audience response system

			Characteristics of Manikin Triage Scenarios			
Triage Criterion	Triage Algorithm	Simulated by Manikin	Traumatic Brain Injury	Hemorrhagic Shock	Tension Pneumothorax	Extremity Trauma
Ability to walk	START, TS, CFT	Inability to Walk	Non-ambulatory	Non-ambulatory	Non-ambulatory	Non-ambulatory
Airway patency	START, TS, CFT	Yes	Yes	Yes	Yes	Yes
Respiratory rate/min	STM, TS	Yes	30	28	24	18
Palpable pulse	START, TS, CFT	Yes	Radial and carotid	Carotid	Carotid	Radial and carotid
Pulse rate/min	STM	Yes	60	150	150	140
Best motor activity	STM	No	Moaning	Moaning	Speaking "I can't breathe"	Speaking "My leg is broken"
Evidence of trauma			Head wound, anisocoria	Leg wound	Chest wound	Leg bent unnaturally
Main problem			Neurologic	Circulation	Breathing	Other (extremity injury)
Intervention			None	Tourniquet	Needle decompression	None
Triage category			Expectant	Immediate	Immediate	Delayed

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Table 1—Characteristics of manikin triage simulations[8]
(CFT = Care Flight Triage; START = Simple Treatment and Rapid Transport; STM = Sacco Triage Method; TS = Triage Sieve)

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Figure 3—Image of traumatic brain injury with anisocoria

mothorax management problem. A delayed casualty was a patient with a leg fracture. An expectant casualty had massive head trauma and anisocoria (Figure 3). No minimal casualties were modeled because the manikins cannot walk.

Initially, learners were oriented to the capabilities of the manikins and to the equipment that was available for the exercise. The equipment consisted of a triage tag, a blood pressure cuff, a stethoscope, a tourniquet, a mock Hem-Con® hemostasis bandage, gauze bandages, a nasopharyngeal tube, and an intravenous (IV) needle. The blood pressure cuff, stethoscope, and gauze bandages were added as distractors (and teaching points), and were not required to make triage or treatment decisions. Learners were given approximately two minutes for each scenario to triage the patient and perform a potentially life-saving intervention, if indicated.

The size and composition of the groups of learners were determined by the local facilitators, based on the length of time allotted for the exercise and the number of course participants.

Debriefing Sessions

The audience response system was used to capture the ideas of learners after each triage scenario. This enabled facilitators to have a clear understanding of whether or not the learners were "getting the point" during the course. It also allowed for the learners to express themselves without having to verbalize their responses. This was particularly useful for groups in which the learners had limited facility with spoken English, and groups in which the learners had different professional backgrounds.

The debriefing discussions focused on whether learners could identify key physical findings and to recognize critical decision points (ambulatory: yes/no; speaking: yes/no; audible or visible respirations: yes/no; radial pulse: yes/no; carotid pulse: yes/no). Four specific patterns of injury, and the application of simple, potentially life-saving interventions also were discussed. The injury patterns were severe extremity trauma with hemorrhagic shock (extremity wound with absent radial pulse, immediate, apply tourniquet); massive head trauma (head wound with anisocoria, expectant, no intervention); and tension pneumothorax (chest wound with shortness of breath, immediate, perform needle decompression). One of the simulated patients required a relatively high level of data integration by the learners. For example, a simulated casualty with a bent leg complaining "my leg is broken" represented a "delayed" casualty with non-critical, extremity trauma (non-ambulatory, speaking patient; radial pulse present).

Educational Groupings

Four models of delivering the material were used (Table 2):

1. *Osaka, Japan*—One small group (4 participants) with one manikin and one facilitator; large group observes; one large group debriefing;
2. *Odawara, Japan*—One small group (4–8 participants) with one manikin and one facilitator, small group debriefing; repeated four times;
3. *Honolulu, USA*—Three small groups (6–8 participants) with three manikins and one facilitator, one large group debriefing; repeated once; and
4. *Singapore*—Three small groups (4–6 participants) with three manikins and three facilitators, one large group debriefing; repeated twice.

Outcome Measures

After each scenario and during the debriefing, learners were asked to identify the main abnormality (one or none), place each casualty into the appropriate triage category, and perform an intervention, if indicated (one or none). The main abnormalities fell into these categories: airway, breathing, circulation, neurologic, and "other" (such as fracture or psychological injury). Intervention options included applying a tourniquet, using a HemCon® bandage, applying a regular bandage, performing a needle decompression, and inserting a nasopharyngeal airway. In some instances, "no intervention" was the appropriate response.

Learner Satisfaction and Self-Efficacy

Two groups of learners (Honolulu and Singapore) were asked to assess their self-confidence in performing mass-casualty triage before and after the triage exercise using 5-point Likert scales. In Honolulu, learners were asked to respond to the statement "I feel confident doing mass casualty triage" (1 = never, 5 = always). In Singapore, learners were asked to respond to the statement "I am confident that I can correctly triage an injured soldier in a mass-casualty situation" (1 = strongly disagree, 5 = strongly agree). All participants were asked to evaluate the sessions at the conclusion of the triage exercise, and to assess the importance of mass-casualty triage training using manikins.

Data Processing

Before and after responses for the self-efficacy questions were compared using a chi-square analysis, and 95% confidence intervals were calculated for group means. Other data are presented as descriptive statistics (SPSS Inc., Chicago, IL).

Results

Demographics

There was a wide spectrum of healthcare providers from eight countries that participated in this study (Tables 3 and 4). The majority of learners were staff nurses, followed by

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	Osaka	Odawara	Honolulu	Singapore
No. of groups per session	1	1	3	3
Hands-on learners per group, n	4	4–8	8–10	4–6
Observer-learners, n	43	0	0	0
Facilitators, n	1	1	1	3
Manikins	1	1	3	3
Debriefings	Large group	Small group	Large group	Large group
Number of sessions	1	4	2	2

Table 2—Characteristics of simulation sessions

	Total, n (%)	Osaka	Odawara	Honolulu	Singapore
Australia	2 (1)	0	0	0	2
Japan	91 (50)	47	40	0	4
Korea	13 (7)	0	0	13	0
Philippines	6 (3)	0	0	6	0
Singapore	32 (18)	0	0	0	32
Thailand	5 (3)	0	0	5	0
US	30 (16)	0	0	30	0
Vietnam	3 (2)	0	0	3	0
Total, n (%)	182 (100)	47 (26)	40 (22)	57 (31)	38 (21)

Table 3—Number and nationality of participants by site

	Total, n (%)	Osaka	Odawara	Honolulu	Singapore
Medical student	9 (5)	9	0	0	0
Staff nurse	111 (61)	18	23	53	17
Resident doctor	11(6)	11	0	0	0
Staff doctor	29 (16)	9	11	0	9
Dentist	4 (2)	0	0	4	0
Student medic	1 (1)	0	0	0	1
Paramedic	17 (9)	0	6	0	11
Total, n (%)	182 (100)	47 (26)	40 (22)	57 (31)	38 (21)

Table 4—Professional roles by site

staff doctors. Resident physicians, dentists, paramedics, and a single student medic attended. The Honolulu sessions, part of a regional nursing forum, were the most homogeneous.

Triage Performance

Group performance for each clinical problem is summarized in Table 5. Traumatic brain injury and tension pneumothorax were the most challenging clinical problems. Hemorrhagic shock was recognized and tagged appropriately by most participants.

The "expectant" triage category for the traumatic brain injury patient was problematic for all groups. Learners quickly identified the head wound, and often failed to check the pupils for anisocoria. Many learners spent valuable time bandaging the head wound. During the debriefing sessions, discussion focused on differences in the approach to the patient with massive head trauma in the setting of a disaster with numerous casualties, compared to the approach to a patient in settings for whom rapid evacuation to an intensive care setting might be possible (such as an urban motor vehicle accident).

Although the extremity trauma was well-recognized by all groups, fewer participants chose "delayed" as the appropriate triage category. The technique of needle decompression was familiar to most participants as an appropriate intervention for tension pneumothorax, however, some pro-

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Clinical Problem		Respondents at each site n (%)			
		Osaka	Odawara	Honolulu	Singapore
Traumatic Brain Injury	Problem	4/47 (9)	4/40 (10)	24/56 (43)	25/33 (76)
	Category	1/48 (2)	2/40 (5)	5/56 (9)	6/35 (17)
Tension Pneumothorax	Problem	24/48 (50)	6/40 (15)	49/55 (89)	38/40 (95)
	Category	24/46 (52)	28/40 (70)	45/58 (78)	31/37 (84)
Hemorrhagic Shock	Problem	42/46 (91)	33/40 (83)	47/56 (84)	33/37 (89)
	Category	38/46 (83)	33/40 (83)	47/55 (86)	28/37 (76)
Extremity Trauma	Problem	34/40 (85)	32/34 (94)	50/55 (91)	Not done
	Category	27/40 (68)	27/40 (68)	44/55 (80)	Not done

Table 5—Number of respondents (%) correctly identifying the main problem and triage category for four simulation scenarios

	Overall	Osaka	Odawara	Honolulu	Singapore
Rate the quality of the course*	4.7 ±0.08	4.0 ±0.57	4.8 ±0.41	4.8 ±0.64	NA
Simulation improved my understanding of mass-casualty triage**	4.6 ±0.09	4.5 ±0.55	4.6 ±0.63	4.7 ±0.82	4.5 ±0.57
Manikins should be part of mass-casualty triage training**	4.7 ±0.10	4.7 ±0.58	4.8 ±0.38	4.6 ±0.98	NA
Learning about mass casualty triage is important**	4.9 ±0.05	4.9 ±0.47	5.0 ±0.22	4.9 ±0.56	NA

Table 6—Course evaluations. Two 5-point Likert scales were used: *(1 = unsatisfactory to 5 = excellent) and **(1 = strongly disagree, 3 = neutral, 5 = strongly agree). Results reported as mean ±SD (not asked = NA).

fessional groups were reluctant to perform the maneuver because of real or perceived injunctions on their scope of practice, even in emergent situations.

Self-Efficacy

Self-confidence levels in their decision-making changed significantly for the Honolulu group (p <0.01), but not for the Singapore group (p = 0.05; Figure 4).

Course Evaluation

The course was well-received at each site, with an average overall rating of 4.7 ± 0.08 on a 5-point Likert scale (1 = unsatisfactory through 5 = excellent). Learners agreed that mass-casualty triage training is important, that the simulations improved their understanding of mass-casualty triage, and that the use of manikins should be a part of mass-casualty triage training (Table 6).

Discussion

A traditional approach to teaching begins with theory taught in a classroom, followed by paper or textbook exercises, and then (sometimes), real-world applications. In contrast, "student-centered" (inductive) teaching shifts the focus of the educational process from the teacher to the learner. Learners start the process by collecting and interpreting data in order to form conclusions; the teacher mediates the learning process through observation, feedback, and supplementary instruction.[9] Cooperative learning describes a student-centered approach in which learners work in teams to solve problems, with the goal of fostering independent thinking and accountability.[10] Thus, this simulation-based disaster training utilized a student-centered approach that emphasized discovery and inquiry by the learners.

The debriefing sessions were structured as a type of formative assessment. Formative assessment occurs when teachers elicit and interpret information from students during the learning activity in order to enhance the learning.[11,12] When the groups of learners responded to teacher queries using the audience response system, they were engaging in formative assessment. Variations in their responses led to interactive discussions regarding the data that were collected (e.g., "was a radial pulse present?"), inferences regarding those data ("what does an absent radial pulse and a palpable carotid pulse imply about the blood pressure?"), and conclusions that were reached ("why is the patient 'immediate' rather than 'delayed'?").

The triage course was created with an international audience in mind. Meleis identified eight criteria for cul-

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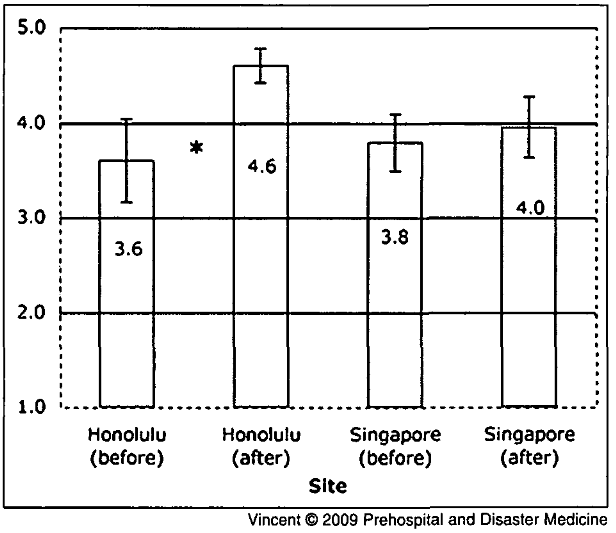

Figure 4—Self-efficacy before and after the course by site based on a 5-point Likert scale. Values are means and vertical bars are 95% confidence intervals. *p <0.01

turally competent scholarship that provide a useful context for assessing elements of this triage course that may have contributed to its success.[13] These criteria consist of:

1. *Contextuality*—Contextuality refers to the avoidance of stereotyping of groups, and the maintenance of sensitivity to the experiences and roles of participants. This course sought to include scenarios that provided a spectrum of difficulty for healthcare providers with varying expertise and scopes of practice.
2. *Relevance*—Relevance describes the importance of serving the interest of the population, and being able to demonstrate significance and meaning for the activity. The settings of the triage scenarios were set to reflect local experiences. For example, in Japan, the disaster setting was an earthquake; in the US, the setting was an explosion; in Singapore, the setting was a building collapse. When the audiences were queried regarding the relevance of the course, all responded that the course was important and relevant.
3. *Communication styles*—Faculty should demonstrate an understanding of communication preferences with respect to data collection and culturally appropriate language. In the triage course, universal symbols and images were used to reduce language barriers, and hands-on interaction with the manikins was emphasized.
4. *Awareness of identity and power differentials*—Instructors should be attuned to differences of identity and power, and permit learners to refuse to participate. Since an anonymous audience polling system was used to collect data from participants, learners were able (and did) refuse to answer at any time during the course.
5. *Disclosure*—This refers to the importance of privacy, and the need to build trust so people feel free to decline to participate. Again, the anonymous polling system maximized personal privacy, while still providing timely feedback to learners.
6. *Reciprocation*—Goals should be achievable for all participating parties. In this course, local facilitators determined the goals for the session, and established the optimal size of the groups based on local educational needs.
7. *Empowerment*—Learners are empowered to participate. Facilitators encouraged hands-on interaction by all participants with the manikins, including the performance of interventions that were outside the traditional scope of practice of some groups (e.g., needle decompression).
8. *Time*—This is adjusted to meet participant goals. Local conference organizers worked closely with visiting faculty to insure that the schedules accommodated the needs of participants.

The use of the audience response polling system worked well to facilitate interaction with groups of learners as well as data collection. These systems have been used in healthcare education to improve learner retention,[14] provide formative assessment,[15,16] improve evaluation,[17] and enhance interactivity.[18] They have proved to be valuable in enhancing trauma performance improvement, probably due to the anonymous nature of the interaction.[19] Audience response systems have been used successfully in other international healthcare educational settings.[20–22]

Providers may have difficulty labeling a patient as "expectant" that may have an injury that is treatable outside of a mass-casualty situation.[23] The context of the simulations was a mass-casualty incident, and the inclusion of an expectant casualty among the scenarios provided a valuable discussion point for learners.

Limitations

No single algorithm or approach to triage was taught in these courses. Instead, the definitions of commonly used triage categories were reviewed for each group of learners, and students were expected to collect and interpret data for the simulated casualties. Appropriate and potentially lifesaving interventions also were discussed in the debriefings, but were not captured for subsequent analysis. The performance of triage algorithms may vary with different injury mechanisms such as blunt trauma or penetrating trauma scenarios.[24] Additionally, there are no commonly used primary triage algorithms that have been well validated.[8]

The use of manikins to teach primary triage and treatment has some limitations. Although manikins can standardize many features of the simulated casualties, some conditions such as capillary refill, a feature of the Triage Sieve algorithm, cannot be simulated. Beyond having a manikin "verbalize" a phrase through a speaker in the device, "best motor response", a feature of the START algorithm,[8] cannot be simulated.

The limitations of triage tagging in mass-casualty incidents have been well described.[25] The tags may be unavailable, they may tear or fall off, and they may become inaccurate as the conditions of patients change. They may vary from country to country. Nevertheless, tagging seemed to provide a valuable visual rubric for learners practicing triage skills, as well as a useful tool for evaluators to assess student performance before providing feedback.

The educational settings were heterogeneous, and the professional roles of the learners also quite variable. Since an audience response system was used to collect the data, not all participants chose to answer all questions. However,

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anonymity may have had an overall positive effect on the willingness of learners to contribute and interact. Because the sessions were designed to promote interactivity, in many instances the learners with greater experience, knowledge, and skills became the teachers. Vigorous exchanges among participants, often in the first language of the learners, appeared to anchor the discussions to local practice and custom; however, this was not formally assessed.

Manikins can be arrayed in groups to simulate multi-casualty events,[26] and this capability was not tested.

Conclusions

Experiential learning using simulation techniques may be an effective way to bridge cultural barriers in disaster health education. Students were uniformly enthusiastic about the hands-on approach to triage training. The audience response system was effective in collecting responses from a spectrum of participants in a variety of settings. The combination of these educational technologies may provide valuable tools to healthcare educators who teach triage and treatment in international settings. Moreover, the use of human patient simulators may provide a tool for the further exploration of the impact of culture on the assessment of patients in mass-casualty situations.

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THE WORLD ASSOCIATION FOR DISASTER AND EMERGENCY MEDICINE

Requests Input and Expressions of Interest in the Development of Regional Chapters

The World Association for Disaster and Emergency Medicine (WADEM) is an international, humanitarian association dedicated to the improvement of disaster and emergency medicine. Its Board of Directors, pursuant to decisions of the Board made at Edinburgh, Scotland, May, 2005, hereby offer the designation of WADEM Chapters to nation-states, nation-state provinces, or individual states, regional organizations and recognized healthcare societies of these entities who share the mission and dedication of WADEM.

Chapters will have an academic, research, and/or operational focus and will participate as a recognized chapter to further develop for the WADEM and the individual chapter membership:

- Education and training
- Interpretation and exchange of information through its network of members and publications
- Development and maintenance of evidence-based standards of emergency and disaster health care and provision of leadership concerning their integration into practice
- Coordination of data collection and provision of direction in the development of standardized disaster assessment and research and evaluation methodologies
- Encourage publications and presentation of evidence-based research findings in scientific publications, national, regional, and international conferences, and congresses
- Will foster and deliberately promote, whenever possible, the recognition of a regional, national, and or profession-specific knowledge base for the general WADEM membership. The WADEM agrees to recognize these advances in publications, conferences, congresses, task forces, and committees.

Interested in developing a Regional Chapter?
Contact Judith Fisher, MD
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