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“SIMBurns”: A high-fidelity simulation program in emergency burn management developed through international collaboration

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ABSTRACT

Acute management of a severely burned patient is an infrequent and stressful situation that requires medical knowledge as well as immediate coordinated action. Many adverse events in health care result from issues related to the application of 'non-technical' skills such as communication, teamwork, leadership and decision making rather than lack of medical knowledge. Training in these skills is known as Crisis Resource Management (CRM) training. In order to create well-prepared burn teams, it is critical to teach CRM principles through high-fidelity simulation (HFS).

While CRM teaches foundational non-technical skills, HFS incorporates lifelike, whole-body, fully-responsive mannequins in order to provide a realistic emergency situation.

The aim of the study is to describe the development of a novel high-fidelity simulation course called “SIMBurns: High Fidelity Simulation Program for Emergency Burn Management” that uses CRM as its foundation and is focused on management of burn injuries. The course was designed by a panel of simulation and burns experts from Meyer Children's Hospital in Italy and Birmingham Children's Hospital in the U.K. Simulation Program experts were certified by Boston Children's Hospital's Simulation Program. In this paper, we describe the course's design, development, structure, and participant's assessment of the course. Since the creation of the SIMBurns course in 2013, 9 courses have been conducted and 101 participants have attended the course. The course was well-received and its “Overall Satisfaction” was rated at 4.8/5. The primary objective in the SIMBurns course— to teach teamwork and CRM skills to medical staff involved in emergency burn care— was also met at 4.8/5. Participants felt that the course developed their ability to interact with other team members, further improved their understanding of how to appropriately use resources, emphasized the importance of role clarity and developed their communication skills. Additional quantitative and qualitative analyses obtained from participants were also reviewed after each course. The SIMBurns course aims to contribute to the education of those in healthcare in order to improve patient safety and to continue advancing the education of our emergency burn care teams.

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1. Introduction

Acute management of a severely burned patient is an infrequent and stressful emergency situation. The proper management of burn patients requires medical knowledge as well as immediate action. The time-sensitive nature of these situations create a stressful environment, which delineates the importance of having a skilled and well-coordinated team. A significant majority of adverse events in health care are often associated with non-technical skills, such as poor leadership, inadequate teamwork, lack of coordination, and ineffective communication [1]. Simulation-training programs are an effective method of education for emergency-medical care teams to reduce adverse-events related to these non-technical skills, thus enhancing patient safety [2-5]. A method of making individuals aware of human errors within medicine can be taught using the principles of Crisis Resource Management (CRM). CRM was first developed by the airline industry after the Federal Aviation Agency concluded in the 1960s that a majority of airline mishaps were due to "pilot error" rather than mechanical malfunction [6]. By applying the same principles of CRM to medical practice [7], individuals within the medical team are able to gain a heightened sense of awareness for the teamwork, communication, and productive use of resources that can lead to decreased adverse patient events. In this way, CRM helps to optimize patient safety and outcome. An effective way to teach CRM principles is through a high-fidelity medical simulation program (HFS) [8]. HFS is a realistic simulation that incorporates lifelike, whole-body, fully-responsive mannequins that provide realistic auditory, visual, and tactile stimuli [9]. These mannequins allow for airway management, breathing assessment, fluid resuscitation, and defibrillation. They create a realistic situation that fulfills the unique training requirements of emergency healthcare providers. HFS has been found to have a positive impact on safety attitudes, changes in organizational performance, and substantial improvements in teamwork. Simulation is not an entirely new concept and has been used by several specialties including anesthesia, emergency medicine, gynecology, otolaryngology, cardiology, and cardiac surgery in order to teach CRM principles and decision-making skills [10-13]. While HFS is an ideal model to prepare healthcare providers for urgent situations, it is unclear to what extent emergency care teams in the field of burn management are utilizing HFS due to lack of published literature on the topic [14-18]. It also may be that HFS, while being a tremendous resource for emergency burn management has not been adopted by many institutions, even though it is an effective resource when it comes to the rare nature of burn injuries. The high failure rate, significant morbidity and mortality, as well as the tremendous psychological impact left on the patient are all factors that place stress on the medical team, thus making them susceptible to failure of teamwork, communication, and leadership [16]. HFS has been shown to effectively target these areas within resuscitation teams in rare and stressful events [10]. For these reasons, HFS is the optimal program

to prepare and unify a multidisciplinary medical team for patients with acute burn injuries [19-21].

1.1. Existing available burn educational programs in Italy

The internationally-standardized programs that currently exist for the acute management of burns include Advanced Burn Life Support (ABLS) and Emergency Management of Severe Burns (EMSB). While ABLS was developed by the American Burn Association (ABA), EMSB was developed by the Australian and New Zealand Burn Association, however countries worldwide have chosen to integrate either course in their emergency medical educational programs [19,21,22]. In 2010, the ABLS course was successfully introduced in Italy [23] as a method of providing technical skills to emergency care teams. Our data has shown that the ABLS course provided a statistically significant improvement in the confidence of participants to comprehensively provide burn care management [23]. However, when asked to provide specific comments on the course, a majority of participants requested for more sessions that included hands-on learning, such as that provided by HFS. In order to provide more practical sessions that realistically mimic emergency burn scenarios, as well as integrate CRM principles into our medical care, we decided to develop high-fidelity simulation (HFS) program specific for acute burn care.

1.2. International collaborations leading to improvement of emergency burn care service

The Emergency Department at Meyer Children's Hospital (MCH) has been using HFS to teach CRM principles since 2010. Meyer Children's Hospital, a leading pediatric medical center in Italy, provides exceptional care to patients from areas across the region.

In 2010 MCH created a simulation program through a partnership with the internationally renowned Pediatric Simulation Program at Boston Children's Hospital, United States (BCH). After the development of this collaboration with BCH, high-fidelity simulation has been used to teach CRM to the medical staff at MCH from a wide variety of departments, such as the Department of Emergency, Intensive Care, Anesthesia, and Pediatric Surgery. The simulation program was further expanded to include acute burn care management, which allowed for the emergency physicians and trauma team to better assess and care for patients with burns.

While the simulation program at MCH was successful, it was limited to only pediatric scenarios and was also not available to staff outside of MCH. In order to expand the scope of the simulation program to include adult cases as well as to make the program more nationally available, we sought the international expertise of a leading, well-known burn team in Birmingham, U.K., who have recognized expertise in burn simulation [24]. Through this collaboration, a new simulation course was developed called "SIMBurns: High Fidelity Simulation Program for Emergency Burn Management."

2. Aim

The aim of this study is to illustrate the development of a high-fidelity patient simulation program in burns that uses Crisis

Resource Management (CRM) as its foundation. We do this by describing the course's model, how it was developed, its structure, leaders and participants, as well as the personal assessment provided by participants at the conclusion of the course.

3. Methods

3.1. Course developers

SIMBurns program was developed through an ongoing collaboration between two medical centers: Birmingham Children's Hospital, a Burns Centre in the U.K. and Meyer Children's Hospital, Trauma and Burns Centre in Florence, Italy. The SIMBurns course was designed by a panel of experts from Meyer Children's Hospital and Birmingham Children's Hospital. The course developers included:

- 1) Burn experts who were fully-trained EMBS and ABLIS course instructors.
- 2) Simulation Program Experts who were certified by Boston Children's Hospital's Simulation Program.
- 3) Educational Consultants who specialize in designing courses for medical staff.

3.2. Educational objectives

3.2.1. Primary objective

To teach CRM skills to medical staff involved in burn emergency care.

3.2.2. Secondary objective

To provide clinical and medical management skills such as treatment of chemical and electrical burns, estimation of burn size, addressing the psychological impact of burn injuries, calculation of fluid requirements, and expanding on the topics that were only briefly introduced in the ABLIS course.

3.3. Faculty

Faculty includes a total of 7 individuals:

- Three trained facilitators:
 - 1) A Course Medical Director, ABLIS medical director, EMSB provider and BCH simulation program certified.
 - 2) A Emergency Medical Physician, Director of Pediatric Simulation at MCH, BCH simulation program certified and ABLIS instructor.
 - 3) A Nurse who is an ABLIS instructor and BCH simulation program certified.
- Two nurses who are ABLIS instructors that conduct parallel sessions.
- A Technician who manages the mannequins and the computer program.
- A Secretary who assists in registration, paperwork, and overseeing time management for the program.

3.4. Participants

Participants are required to have a core knowledge base on how to conduct the primary survey as taught from ABLIS, ATLS (Advanced Trauma Life Support), or ATCN (Advanced Trauma Care for Nurses). This requirement is fulfilled through certification of attendance in one of these courses prior to registration. Once registered in the course, participants receive a review of the primary and secondary survey as well as a summary of the systematic approach of the medical management of burns.

A maximum of 12 participants are selected to participate in the SIMBurns course. Each scenario has a maximum of 6 participants with parallel sessions occurring simultaneously.

3.5. Facilities

The SIMBurns course takes place in a simulation center located in Careggi University Hospital, Florence, Italy.

3.6. Course design

The SIMBurns course is a one-day course. The course structure for this program consisted of 3 components:

- 1) Introduction, lasting 1h 30min.
- 2a) 3 Clinical simulation scenarios, each followed by a debriefing. The time ratio of scenarios to debriefings was organized as 30%-70%, thus giving more time to debrief.
- 2b) 3 Parallel sessions.
- 3) Closing summary with course evaluation, lasting 40min.

3.6.1. Introduction session

In the introduction session, the instructors and participants each introduce themselves, their role in medicine (e.g. physician, nurse, etc), and also take part in icebreakers that helped to construct a friendly, comfortable environment.

Participants are introduced to CRM principles using a PowerPoint slideshow, as well as 2 videos and an educational game. These provide the participants with the foundation for what CRM principles serve as and illustrates to them how to work together as an effective medical team.

After the initial introduction, participants are moved to the 'scenario room' and given 15min to become familiar with the mannequins as well as all available equipment. Participants are then organized into 2 teams (simulation session and parallel session).

3.6.2. Simulation scenarios and debriefing

Each simulation scenario is based on actual patient cases in order to most closely replicate the clinical skills, conditions, stress, and environment that such cases require. There are 3 different scenarios using 2 different mannequins with each scenario lasting 15-20min: 2 scenarios can be performed using an adult mannequin while 1 scenario can be performed using the pediatric mannequin. For the adult scenarios, the Laerdal SimMan mannequin is used (Laerdal Medical Corporation, Wappingers Falls, New York) while Pedihal (Gaumard) is used for the pediatric scenario. All mannequins have makeup by a professional theatre and cinema makeup artist (Filistrucchi, Florence, Italy), which allows for "true"

simulation of burns (Fig. 1). The specific cases covered using the mannequins includes chemical, electrical, and pediatric burns as well as inhalation injury and multi-trauma situations.

Once the scenario is complete, approximately 30-40min is dedicated to debriefing. The debriefings are led by our trained instructors who guides participants through discussions on their perspective of the team's overall performance during the scenario, strengths that the team shares in the simulation, and what they feel could be improved. This method allows for any significant errors to be addressed in order to optimize the team's performance in future simulation and actual patient cases [10].

3.6.3. Parallel session

While 6 out of 12 of our participants are taking part in the simulation session, the remaining 6 participants engage in a Parallel Session. The teaching and interactive sessions that the participants have the opportunity to take part in include:

1. Handover and referral to burn centers.
2. Management of minor burns and emergency escharotomy.
3. Abuse and neglect.

The escharotomy is performed using a low-fidelity mannequin that is dressed in makeup as described from the Greater Sydney Area Helicopter Emergency Medical Service (GSA-HEMS) in their online article "Build Your Own Escharotomy Man!" [25]. They provide the instructions on how to build a training model that participants use to practice performing an escharotomy.

3.6.4. Summary and course evaluation

At the end of the course, instructors summarize their teaching points and take home message. Participants are also given an

opportunity to reflect once more about the simulation, the course, and their experiences as individuals and as a group.

Using the 20-question survey from Table 1, quantitative data are collected from participants such as if the course has met their expectations, is sufficient in duration, has developed their abilities to interact with their colleagues, and apply theory to practice while using CRM skills. Participants are also asked if they feel they were able to practice the skills required in the course, about the realistic nature of the scenarios, the overall course work environment, and if debriefings were non-judgemental and safe spaces to learn. Lastly, participants have the opportunity to document their comments and give the course an overall rating.

All quantitative data are collected using a 1- to 5-point Likert scale where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.

4. Results

4.1. Participants

Since its development in November 2013, the SIMBurns course has been conducted a total of 9 times. There have been 101 participants who have attended the course, including 54 physicians (54%), 44 registered nurses (43%), and 3 medical/nursing students (3%).

From these participants, 59 worked in emergency medical services/emergency department (59%), 21 in a burn center (21%), 15 in an intensive care unit (15%), 4 medical/nursing students, and 2 in a non-hospital medical service. The distribution is shown in Fig. 2. The course was held in Florence, Italy – a city within Tuscany – and was made nationally



Fig. 1 – Mouflage of mannequins.

Table 1 – Course evaluation by participants.

Course evaluation by participants	Average responses (1-5)
The course fully met my expectations.	4.8
The course's duration for the information presented was sufficient.	4.3
Number of participants in the simulation scenario was appropriate	4.9
The course was organized in a way that helped me learn.	4.9
The course developed my ability to interact with other medical team members.	4.8
The course developed my understanding on how to appropriately use available resources.	4.7
The course developed my understanding of the importance of role clarity.	4.7
The course developed my communication skills.	4.8
The course developed my ability to apply medical theory to practice.	5
The course provided the opportunity to practice the skills required in burn management.	4.9
The course work environment was conducive to learning, friendly, non-judgemental, and welcoming.	5
The debriefing was conducted in a non-judgmental manner in a protected environment.	4.9
Parallel sessions	
The “Handover and Referral to Burn Centers” session fully met my expectations.	4.5
The “Management of Minor Burns and Emergency Escharotomy” session fully met my expectations.	4
The “Abuse and Neglect” session fully met my expectations.	4.1
Realistic nature of scenarios	
The simulation is a realistic representation of a an emergency burn and resuscitation case.	4.2
The mannequins used are a realistic representation of true burn patients.	4.9
The simulation closely replicated the environment of a resuscitation/emergency room.	3.6
Overall satisfaction (1-5):	4.8
I would recommend this course to a colleague	5

available. In fact, 56% of participants attended the course from cities outside of the Tuscan region.

4.2. Course evaluation

Of the 101 participants, 100% successfully completed the course, correctly answered 80% of questions on a multiple choice question test focused on burn management as well as CRM principles, and completed the 20-question survey.

In Table 1, the average of the responses given to each statement is listed with the lowest average score being 3.6/ 5 and the highest average score being 5/5. Lastly, Table 2 includes all major overarching comments from our qualitative data collection.

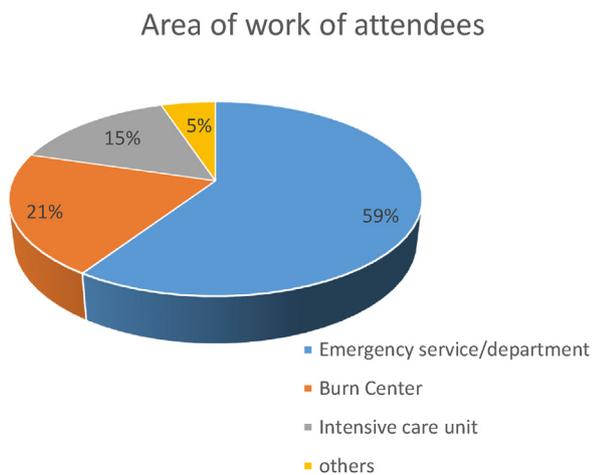


Fig. 2 – Area of work of attendees.

5. Discussion

The principles of CRM teach foundational non-technical skills, such as communication, teamwork, leadership, and decision making. Evidence shows that a large number of adverse events in health care are preventable and result from problems relating to application of ‘non-technical’ skills rather than lack of medical knowledge [1]. For these reasons, it is critical to teach acute care teams the principles of CRM as it helps prevent non-technical errors [13,26,27].

The SIMBurns course is unique in that it incorporates the principles of CRM with HFS. Based on the literature that is currently available, SIMBurns is in fact the first of its kind as a full-day high-fidelity simulation course dedicated for the treatment of acute burns. While participants can arguably read about burn management and CRM principles at their leisure, it is has been repeatedly demonstrated that adults retain more of what they actively ‘say’ and “do” in simulated, emotional experiences than what they passively “read” [28,29].

In this way, SIMBurns develops an education that participants can recall upon in true emergency cases. Based on evaluations submitted by participants, the SIMBurns course was well-received and its “Overall Satisfaction” was rated at 4.8/5.

5.1. Reflection on achievement of educational objectives

As stated in 3.2 “Educational Objectives,” our primary objective in the SIMBurns course is to teach teamwork and CRM skills to medical staff involved in burn emergency care. Based on the course evaluation, this objective was met. Participants felt that the course developed their ability to interact with other medical team members, further improved their

Table 2 – Comments of the program by participants.

Comments by Participants	
Please identify what you consider to be the strengths and/or the most helpful aspects of the course:	<ul style="list-style-type: none"> • The focus on CRM principle. • The debriefings. • The opportunity to practice “teamwork” and “communication skills.” • A non-judgmental debriefing after scenarios allowing us to explore human errors and improving individual performance. • The importance of closing the loop when communicating in emergencies. • Giving a clear role to each team member from the beginning. • Moving past problems on which I previously fixated. • Everyone can contribute (if properly communicate). • I learned that I can speak up even and give my contribution. • Make up and actors felt very real. • Escharotomy session was very useful.
Please identify area(s) where you think the course could be improved:	<ul style="list-style-type: none"> • There is always more room to make scenarios more realistic. • I think doing simulations with my own team would have been really useful. • In situ simulation makes me better immerse into the scenario. • More scenarios are always more helpful. • The Minor Burns Management parallel session could be improved. • More practice on the mannequin before we started with the actual scenario
Other comments:	<ul style="list-style-type: none"> ■ I can't believe simulation training is not mandatory! It should be performed at least once a month! ■ I learned that it is ok to ask (and how to ask) if I don't know what to do. It really helps and it is a great take home message.

understanding of how to appropriately use resources, emphasized the importance of role clarity, and developed their communication skills. Participants rated these objectives being met as a 4.7–4.8/5.

Additionally, the comments left by participants in the questionnaire, as shown in Table 2, reflects the strength of the course's ability to emphasize and teach CRM principles. For instance, participants specifically referenced in their comments the opportunity to practice teamwork, improve their communication skills, and understand how they can contribute as team members with a clear role.

As previously mentioned in Section 3.2, our secondary objective of providing practical and clinical medical management skills such as estimating burn size, calculating fluid requirements, treating chemical and electrical burns, and approaching the psychological impact of burn injuries was also met. Participants rated the course's ability to provide the opportunity to practice these skills required in burn management as 4.9/5, and they also rated the course's ability to apply these medical principles to practice as 5/5.

As part of our secondary objective, we also hoped to expand on the principles and topics that were only briefly introduced in the ABLS courses. This was achieved through the development of the parallel sessions which was created based on the comments left by past ABLS participants and current SIMBurns faculty. The three parallel sessions- ‘Handover and Referral to Burn Centers,’ ‘Management of Minor Burns and Emergency Escharotomy,’ and ‘Abuse and Neglect’ – continued the education that was provided by the ABLS course. While participants were much more enthusiastic about the HFS aspect of SIMBurns, they still felt that each of the parallel sessions met their expectations with a range of rating from 4 to 4.5/5, with the ‘Minor Burns Management’ parallel session ranking the lowest at 4/5 and participants stating that it could be ‘further improved.’

5.2. Reflection on course design

The time frame of the 8h course was felt sufficient by both the faculty as well as the participants, who gave an average score of 4.3/5 for “the course's duration for the information presented was sufficient.” Additionally, the decided number of participants that were included in the course was 12. As reflected by the participants' evaluation, this number of participants for our facilities was deemed appropriate and gave each participant an equal opportunity to be a part of the course.

When the course was first being designed, several elements were taken into consideration in order to create a successful course that facilitates learning for all participants. Course instructors worked with educational consultants to construct the course in a manner that takes into account how adults best learn. There were a considerable number of aspects that were deliberated when creating the course, but some of the major elements included timing and organizational logistics, identifying the participants' target, developing a friendly and non-judgmental environment, setting defined learning objectives while acknowledging participant's expectations, and proper execution of the completed content and schedule. For instance, the introduction session of the SIMBurns simulation program was used to create a positive atmosphere where participants can learn and engage without judgement or criticism. Many of the participants were never previously part of a simulation before, and thus the introduction session was used to gradually acquaint them with the simulation process. This method of design was deemed successful through the participant's evaluations which rated “the course was organized in a way that helped me learn” as 4.9/5. Additionally, a rating of 5/5 was given for “The course work environment was conducive to learning, friendly, non-judgmental, and welcoming,” thus further strengthening the foundation upon which

the course was created. While the introduction of the course was designed to set the tone of the course, the debriefings were created to be the most engaging and essential aspect of SIMBurns. The debriefings provided a medium for discussion and reflection by participants in a protected, non-judgemental environment as confirmed by participants through their evaluation on the questionnaire. While each scenario and debriefing was allotted a time ratio of 30%–70%, as described in Section 3.6 course design, we did find that flexibility on this ratio was important as the amount of time spent on scenarios and time spent on debriefing highly depended on how much time each group used to complete their scenario. If participants completed the scenario quickly, more time was spent debriefing and on CRM principles. On the other hand, if participants took longer to complete the scenario, then debriefings were more focused on reviewing burn management and treatment while continually emphasizing the importance of the CRM principles.

While all scenarios were videotaped for the purpose of further facilitating the learning process, they were never shown to our participants. Facilitators felt that using the videos as ‘evidence’ of inappropriate behaviors or incorrect clinical decisions was not only unnecessary, but could potentially lead to perceptions of judgement and condemnation. Instead, facilitators felt that the ideal way to address incorrect actions or behaviors made during scenarios were by allowing participants to bring them forward independently, thus allowing discussion through verbal recollection. This method required the precise role of the facilitators who had to address and clarify the main clinical issues that occurred during the scenario while still maintaining an environment that promotes learning, encourages participants to openly discuss what they would have done differently, and how they believe they could improve.

For all of these reasons, the SIMBurns course requires “facilitators” rather than “instructors” while facilitators have extensive experience in debriefing techniques in addition to being experts of burn management, instructors do not necessarily have a specific focus on the skills needed to conduct debriefings and serve best when educating participants on how to optimally care for burn patients.

5.3. Reflection on realistic nature of scenarios

The participants felt that each simulation was a realistic representation of a true emergency burn and resuscitation case and also highly rated the mannequins as a realistic and accurate representation of a burn patient. More specifically, participants highly rated the makeup and actors, however, when participants were asked if the simulation environment closely replicated a resuscitation/emergency room, they rated this at 3.6/5. The realistic nature of the simulation room is extremely important. For these reasons, we believe additional resources and development can be utilized to develop our simulation rooms.

5.4. Further development

As previously mentioned, the importance of creating a realistic simulation room is undeniable. In future SIMBurns Courses, we want to further improve our simulation room. One novel

simulation tool that has been developed is a portable, inflatable, self-contained simulation “igloo” called “The Burns Suite (TBS).” TBS closely replicates the emergency room environment, thus providing participants with a powerful realistic learning experience, as reported by Sadideen et al. [24]. For these reasons, a portion of the settings used in TBS will be integrated in future SIMBurns courses.

Secondly, an interesting suggestion made by a participant in the comment section was to organize future SIMBurns simulations to allow teams from the same unit/hospital to work together on simulations. This concept would allow teams to practice with one another using CRM principles and the SIMBurns simulation models, thus allowing for an even more realistic representation of what participants would experience and what they could improve on during management of acute situations. For these reasons, this concept will be considered when designing future SIMBurns Courses.

Based on comments and suggestions from participants, our parallel sessions will continue to be reviewed and improved in order to best optimize the SIMBurns course. However, if SIMBurns were to be utilized as a course in different countries, there may be different needs that must be met in those areas that differ from the needs of our population. For these reasons, the topics for parallel sessions can be tailored to the needs of the institution instead of utilizing the same topics that our institution chose. Additionally, the EMSB program already includes sessions such as escharotomy as well as hand-over and transfer to burn centers– which were two of our parallel sessions– and so they may rather focus on different topics for parallel sessions that are adjusted to the needs of their participants.

Lastly, a common comment that is made by participants who take part of our simulation course is that simulation training should be performed more often and be a more integrated part of our medical education. In an article titled ‘The Future Vision of Simulation in Healthcare’ Gaba [30] predicted that a successful healthcare system will integrate simulation throughout its entire fabric, and that it can become a part of the curriculum implemented by both universities and hospitals. Simulation in healthcare has countless times proven its benefits to our patients, their outcomes, and to the training of healthcare providers. For these reasons, the SIMBurns simulation course hopes to contribute to the education of those in healthcare in order to improve patient safety and to continue advancing how we educate our emergency burn care teams.

6. Conclusion

Crisis Resource Management (CRM) is a powerful method of making individuals aware of human errors and can be taught through High-Fidelity Simulation (HFS). Currently, HFS is one of the most effective means for preparing emergency care teams for infrequent and stressful acute situations, such as in cases of burns. “SIMBurns: High-Fidelity Simulation Program for Emergency Burn Management” is the first full-day course specifically integrating HFS and CRM in burn care management, has been successfully executed multiple times, and well-received by participants. By developing the SIMBurns

simulation course, we strive to improve patient safety and further educate our emergency burn care teams.

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