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Development of an Operative Trauma Course in Uganda—A Report of a Three-Year Experience

Sarah J. Ullrich, MD, MHS,[a,*] *Michael P. DeWane, MD,*[a] *Maija Cheung,*[a] *Matthew Fleming, MD, MPH,*[a] *Martha M. Namugga, MD,*[b] *Whitney Fu, MD,*[a] *Gideon Kurigamba, MBChB,*[b] *Ronald Kabuye, MBChB,*[b] *Jackie Mabweijano, MBChB,*[b] *Moses Galukande, MD, PhD,*[b] *Doruk Ozgediz, MD, MSc,*[c] *and Kevin Y. Pei, MD, MHSEd*[d]

[a] *Department of Surgery, Yale University School of Medicine, New Haven, Connecticut*
[b] *Department of Surgery, Makerere University, Mulago Hospital, Kampala, Uganda*
[c] *Department of Surgery, University of California San Francisco, San Francisco, California*
[d] *Department of Surgery, Houston Methodist Hospital, Houston, Texas*

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ABSTRACT

Background: Trauma is a leading cause of morbidity and mortality in low-income countries. Improved health care systems and training are potential avenues to combat this burden. We detail a collaborative and context-specific operative trauma course taught to post-graduate surgical trainees practicing in a low-resource setting and examine its effect on resident practice.

Method: Three classes of second year surgical residents participated in trainings from 2017 to 2019. The course was developed and taught in conjunction with local faculty. The most recent cohort logged cases before and after the course to assess resources used during initial patient evaluation and operative techniques used if the patient was taken to theater.

Results: Over the study period, 52 residents participated in the course. Eighteen participated in the case log study and logged 117 cases. There was no statistically significant difference in patient demographics or injury severity precourse and postcourse. Postcourse, penetrating injuries were reported less frequently (40 to 21% $P < 0.05$) and road traffic crashes were reported more frequently (39 to 60%, $P < 0.05$). There was no change in the use of bedside interventions or diagnostic imaging, besides head CT. Of patients taken for a laparotomy, there was a nonstatistically significant increase in the use of four-quadrant packing 3.4 to 21.7%) and a decrease in liver repair (20.7 to 4.3%).

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* *Corresponding author*. Department of Surgery Yale School of MedicineYale School of Medicine 330 Cedar Street, FMB 107, New Haven, CT 06520. Tel.: +1 (631) 275-3851; fax: +1 203 785 3820.
E-mail address: sarah.ullrich@yale.edu (S.J. Ullrich).

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Conclusions: The course did not change resource utilization; however, it did influence clinical decision-making and operative techniques used during laparotomy. Additional research is indicated to evaluate sustained changes in practice patterns and clinical outcomes after operative skills training.

Introduction

Injuries and trauma account for 11% of global mortality, more than HIV, Malaria and tuberculosis combined.[1] This burden is disproportionately shifted toward low- and middle-income countries (LMICS) where more than 90% of all global trauma related deaths occur.[2,3] Over a quarter (27%) of global injury-related deaths are due to road traffic injuries, with low-income countries suffering the highest rates at 28.5 deaths per 100,000 in population.[4] As motorization increases, particularly in Africa, this burden is expected to increase.[5]

Several studies have sought to validate interventions and assess the cost effectiveness of aiming to address the disproportionate impact of injuries on LMICs.[6-8] The categories of interventions with proven effectiveness range in scale from those targeting the individual, to changes in built infrastructure and national legislative initiatives.[9,10] In particular, several interventions have focused on training both prehospital and hospital personnel as an avenue for local capacity building.[11-16]

Specialized training aimed at improving the provision of trauma resuscitation and basic surgical care in LMICs has also been undertaken.[15,17] Studies have demonstrated that 21% of the trauma burden in LMICs was "avertable" by the provision of basic surgical care, with sub-Saharan Africa having a large potentially avertable burden, and that the implementation of focused trauma training can have a mortality benefit.[18] Improving the quality of surgical care in Africa is especially important given that the region suffers from a critical shortage of surgical providers, which increases the responsibility and workload of those tasked with providing trauma care.[19]

Kampala, Uganda is burdened by many of the same challenges as Africa at large. The impact of trauma has previously been addressed by training interventions aimed at improving prehospital care and providing instruction on contextually appropriate trauma resuscitation.[16,20-22] However, despite these and other efforts, there may be a gap in training interventions focused specifically on improving the performance of operative interventions performed in the patient with trauma. One potential way of augmenting training is cadaver-based simulation, a technique that has been previously shown to increase trainee confidence and knowledge.[17,23]

This study details our experience in the development of the Mulago Operative Trauma Resuscitation (M-OTR) Course, a collaborative course developed to provide intensive trauma training to postgraduate surgical trainees practicing in a low-resource setting. This report details the surgical needs as expressed by trainees, their thoughts and attitudes toward international training collaborations, and examines the impact this surgical training course has had on resource utilization as well as the operative techniques used by course participants.

Methods

Course development

The M-OTR course was developed in response to a direct request for additional trauma training by local providers at Mulago Hospital in Kampala, Uganda. A board-certified acute care surgeon was recruited to assist in development of a 3-day course in partnership with local surgeons. The resultant curriculum focused on context specific and protocolized resuscitation and operative strategies with a focus on the rapid triage and definitive care of neck, thoracic, abdominal, and pelvic trauma. Because of time constraints, the course specifically did not address the injured extremity or burns. The course received strong support from the Department of Surgery at Mulago Hospital as clinical coverage was provided to allow postgraduate surgical trainees to attend the course.

Course delivery, instructors, and attendees

The course has been hosted three times, taught each time to concurrent classes of second year postgraduate surgical trainees, in the spring of 2017-2019. The course was conducted at Makerere University School of Medicine, whose teaching hospital affiliate is Mulago National Referral Hospital. Mulago is the largest hospital in Uganda, with over 1500 beds. More than 13,000 major surgeries are performed a year, and Mulago hospital is home to a large volume trauma service.[24] The trauma and emergency surgical service is primarily staffed by second year surgical trainees, who are the main medical providers during overnight surgical emergencies and who were the main audience of the course.

Classes were held over 3 days, with mornings devoted to didactic lectures and afternoons devoted to practical sessions and operative anatomy (for Course Agenda see Appendix A). Specific topics covered included team management dynamics, primary and secondary survey, airway management, ultrasound use in trauma, trauma radiology, and penetrating and blunt injuries to the neck, chest, abdomen, and pelvis. A cadaver lab, taught jointly by local and visiting faculty, was held each day sessions devoted to the neck or airway, chest, and abdomen as well as intraoperative team dynamics. The focus of operative didactics was meant to improve the care of higher volume salvageable injuries and thus was primarily focused on laparotomy for blunt and penetrating abdominal trauma. Based on needs, assessment from local faculty and

trainees and the condition of the cadavers, injuries to the neck (vessel, esophageal, and tracheal injuries in penetrating trauma), thorax (tension pneumothorax, aortic cross-clamping, and release of cardiac tamponade), and abdomen (major solid organ injury both penetrating and blunt) were emphasized. Local faculty demonstrates improvisations they use to overcome resource limitations, such as using gowns for abdominal packing in the absence of laparotomy pads. Trainee to cadaver ratio was variable due to changes in cadaver availability but was capped at 6 residents per cadaver. The classroom didactics are largely discussion based where residents present cases they have encountered, and perioperative and intraoperative decision-making is discussed. Joint faculty and trainee conception and delivery of the course has facilitated appropriate contextualization of approaches for operative trauma. Instructional support was provided by consultant trauma surgeons from Mulago hospital. General course and administrative support was provided by two US mid-level surgical residents certified in advanced trauma life support.

Course materials & setting

The course benefitted from a pre-existing education infrastructure developed through a partnership between Makerere Medical School and a locally operating nongovernmental organization. These resources included a lecture space, audiovisual aids including a computer and projector, and support staff. The medical school's anatomy lab space was used for the cadaveric portion of the course. A portable ultrasound from the casualty ward was used for hands on teaching of trauma ultrasound using live models. Additional materials required to support the course were minimal and are shown in Table 1.

Course assessment and test development

Institutional Review Board approval and a waiver of informed consent were obtained from the Makerere University School of Medicine. Before the course, an anonymous pretest was distributed to the trainees. The test covered all aspects of management of the massively injured patient from initial assessment and resuscitation to operative techniques and decision-making. The test was rated in difficulty toward the level of an independent practitioner. Statistical analysis was performed via paired t-test to determine if pooled pretest and posttest performance differed significantly.

For the first two iterations of the course in 2017 and 2018, an anonymous needs assessment survey was also distributed that sought to determine participants' thoughts and attitudes toward trauma education, potential deficits, and the ideal location for further training. Trainees were also asked about other resources for trauma learning, their knowledge of international collaborators, and how they felt international collaborators were integrated. After course completion, an anonymous posttest was administered to assess knowledge retention. A course review was administered after completion of the course. Study authors were blinded to all study questionnaires.

Table 1 – Surgical course supplies.

Surgical instruments
Scalpels
Metzenbaum and heavy scissors
Short and long needle drivers
2-0 and 3-0 silk training suture
Short and long DeBakey forceps
Finochietto rib spreader
Weitlaner retractor
Demonstration endotracheal tube x 2
Demonstration airway bougie x 2
Demonstration tracheostomy tube x 2
Demonstration chest tubes x 2
Gowns and gloves
Skin markers
LED head lamps x 2

Resource utilization study

IRB approval was obtained from the Makerere University School of Medicine. Informed consent was obtained from all residents who participated in this study. In an attempt to evaluate the course further, a resource utilization study was conducted during the third year the course was offered. An electronic, 15-item case log was created (Qualtrics, Provo, UT) and sent to the 2019 cohort of residents 1 month before the start of the course (Appendix B). Participants were instructed to log cases they were asked to consult on in the emergency department 1 month precourse and 1 month postcourse. They were asked to log at least 3 cases per time period. Nonidentifying patient demographics were collected, and trauma severity was calculated using the Kampala Trauma Score, which has been validated for the low-resource setting.[25] Residents were then provided with a low-cost Android tablet loaded with the course materials and the Qualtrics offline software and were asked to log at least three cases each in the month after the course. Responses to fields where the choices were not mutually exclusive were considered to be binary for all calculations. Analysis was carried out using SPSS v24 (Chicago, IL). Univariate analysis using Fisher's exact and χ^2 tests was used where appropriate; $P < 0.05$ was considered to be statistically significant.

Results

Of the 33 residents who completed the course in 2017 and 2018, 28 (85%) completed a baseline survey and needs assessment. All surveyed residents intended to pursue specialty training, with urology, neurosurgery and pediatric surgery being the most popular future career paths. Only 3 (10.7%) stated they planned to specialize in trauma training.

Baseline operative trauma knowledge and subsequent learning were assessed via a pretest and posttest completed by 48 of 52 total course participants. The pooled mean pretest score was 56 + 10% and increased by 23% after course completion in the posttest (79 + 9%, $P < 0.05$). The course itself

was evaluated with a posttest course review in which all participants agreed that the goals or objectives were clear, class time was used effectively, and that the overall course left participants motivated to learn more. All participants felt the course increased their knowledge, and 96% felt they would be able to teach this knowledge to others.

Regarding general surgical care, there was a wide variety of training that participants felt was most needed. A majority (82%) felt that trauma and emergency general surgery training was most needed with a minority instead focusing on high specialty vascular training such as interventional radiology or cardiovascular techniques. When considering their own skill deficits, 79% of participants felt that their trauma operative skills most needed improvement.

When queried as to their general thoughts on training, all agreed that international training was important to their careers, and 96% indicated they were interested in rotating abroad. A majority (71%) were unaware of other trauma training opportunities in Uganda outside of their standard curriculum. Other international courses taught in Uganda noted by participants included an Orthopedic Trauma program, as well as an ongoing partnership between the Royal College of Surgeons of Ireland and College of Surgeons of East, Central, and Southern Africa.[26,27] There was a diversity of opinions regarding how participants perceived cooperation among these international organizations in their region. Three quarters felt there was cooperation, whereas the remainder was neutral or strongly disagreed that international organizations successfully collaborated.

From the 2019 cohort, 18 residents participated in the resource utilization study. The residents logged a total of 117 cases, 58 precourse and 59 postcourse. There was no statistically significant difference in patient demographics or injury severity precourse and postcourse (Table 2). Penetrating injuries were reported more frequently precourse (40 to 21% $P < 0.05$), and road traffic crashes (39 to 60%, $P = 0.05$) were reported more frequently postcourse. Upper extremity injuries were reported more frequently postcourse (8 to 29%, $P < 0.05$), and pelvic injuries were reported more frequently precourse (19 to 7%, $P < 0.05$, Table 3). There was no statistically significant difference in the percent of patients who were taken to the operating theater precourse (71%) and postcourse (54%) or in the types of operations performed. Of patients with abdominal trauma, 78% of patients got a laparotomy precourse and 60% of patients got a laparotomy postcourse, and the proportion of patients admitted to the ICU postcourse increased (3% to 11%). Of patients taken for a laparotomy, there was a nonstatistically significant increase in the use of four-quadrant packing postcourse (3.4 to 21.7%, $P = 0.076$) and a decrease in the use of direct liver repair (20.7 to 4.3%. $P = 0.117$) although this also did not reach statistical significance (Fig. 1). For all patients, there was no difference in immediate patient mortality precourse or postcourse, however, there was a nonstatistically significant increase in the proportion of patients admitted to the ICU postcourse (2% to 12%, $P = 0.099$, Fig. 2).

Discussion

This analysis describes 3 years of teaching the Mulago Operative Trauma Course. This course was well-received and lead to a significant increase in trainee knowledge and a change in practice patterns. The success of this course followed themes associated with successful LMIC course development: 1. a direct ask on the part of learners for the curriculum; 2. a needs assessment aimed at determining what course participants wished to most improve on and learn from the course; 3. a pretest designed to determine learner's baseline knowledge; 4. training that is conducted in collaboration with local experts and designed to utilize local resources; and 5. postcourse evaluation and reflection aimed at course improvement.[28] This novel approach to low-resource setting trauma education, mainly the use of an intensive and context-specific cadaver–based course, may serve as a model that can be expanded and replicated elsewhere.

Our experience and analysis show that increased trauma training is desired by providers in Uganda. Providers in resource-constrained environments are forced to handle more responsibility for patient outcomes with less support, possibly leading to a perceived requirement for improved surgical skills and decision-making. In addition, there is no local trauma specialization in Uganda, so it was essential to develop the operative skill curriculum with the local team. Despite a minority of course participants planning to pursue careers in trauma, a majority felt that increased operative trauma skills were most needed to improve their individual practice. Teaching operative skills through the use of cadaveric modeling has precedent and is proven to be beneficial in improving knowledge retention and short-term skill acquisition.[29,30] Even in high-income countries, high-quality studies examining if cadaveric simulation impacts intraoperative decision-making and techniques are lacking. Our finding that residents tended toward admitting patients to a monitored setting rather than performing a laparotomy, as well was the use of four-quadrant packing in favor of direct liver repair, which are reflective of principles taught in the course, suggest that this intervention had an impact on clinical and intraoperative decision-making.

Although a formal cost analysis of the course has not been undertaken, initial investment in the course was estimated to be $5,000, most of which was borne by high-income country collaborators and spent on surgical instruments for simulation and presentation equipment. Each course costs $1500 USD to conduct—inclusive of all training materials, disposable equipment, fresh cadavers, and meals for participants. Including initial overhead, the course costs an average of $186 per student, compared with the American College of Surgeons Advanced Surgical Skills for Exposure in Trauma course, which costs between $500 and $2000 per student.[31] However, the course exacted a high nonfinancial expense on Mulago Hospital and the attached Department of Surgery as it required great commitment from participants as well as the provision of provider coverage to allow trainees to attend the course. Given the multiple international organizations working in different capacities within Uganda, there is the potential for increased cooperation and resource sharing to decrease the local burden associated with this training work.

Greater collaboration on the part of training institutions could also potentially increase overall course impact while minimizing "workshop fatigue" or excessive time spent away from direct clinical care obligations. To facilitate further

Table 2 – Patient characteristics.

	Pre (n)	%	Post (n)	%	P-value
Age					0.915
Less than 5	2	3.8	4	6.9	
5-14	3	5.8	5	8.6	
15-24	20	38.5	18	31.0	
25-34	15	28.8	16	27.6	
35-44	11	21.2	13	22.4	
45-54	1	1.9	2	3.4	
Greater than 55	0	0.0	0	0.0	
Gender					0.61
Male	45	86.5	48	82.2	
Female	7	13.5	10	17.2	
Mechanism of injury					0.039
Road traffic crash	20	38.5	35	60.3	
Fall	2	3.8	4	6.9	
Blunt force	9	17.3	5	8.6	
Penetrating	21	40.4	12	20.7	
Burn	0	0.0	2	3.4	
Other	0	0.0	0	0.0	
Systolic BP					0.581
Greater than 89 mm Hg	25	49.0	28	50.0	
50-89 mm Hg	24	47.1	25	44.6	
1-49 mm Hg	1	2.0	3	5.4	
Undetectable	1	2.0	0	0.0	
Respiratory rate					0.261
Less than 9 per minute	1	2.0	0	0.0	
10-29 per minute	38	74.5	37	64.9	
Greater than 30 per minute	12	23.5	20	35.1	
Pulse					0.765
Less than 60 BPM	2	3.9	1	1.8	
60-100 BPM	24	47.1	26	26.4	
Greater than 100 BPM	25	49.0	30	29.0	
Neurologic status					0.791
Alert	29	56.9	37	64.9	
Responds to verbal stimuli	7	13.7	6	10.5	
Responds to painful stimuli	12	23.5	10	17.5	
Unresponsive	3	5.9	4	7.0	
Number of serious injuries					0.213
0	3	5.9	5	8.8	
1	31	60.8	25	43.9	
2 or more	17	33.3	27	47.4	

instruction, we hope to integrate the course with additional bedside and possibly intraoperative instruction in the future. Maximizing efficiencies may also lead to enhanced abilities to support trauma registries or other observational studies that would aid in the evaluation of the impact of training programs. Likewise, collaboration between international training institutions and regional training institutions, in particular College of Surgeons of East, Central, and Southern Africa, brings with it the potential to develop "train the trainer" programs to expand the impact of outside training to institutions across the region.

There is a paucity of open source course material specializing in trauma education currently available for context-specific adaptation. Although online resources and paid course materials are easily found, international collaborators who wish to develop curricula aimed at combating the high levels of trauma seen in LMICs often find themselves forced to reinvent the wheel. The M-OTR course was designed to be

Table 3 – Patient injuries and resource utilization.

	Pre (n)	%	Post (n)	%	P-value
Injury location					
Head	15	25.9	24	40.7	0.091
Neck	4	6.9	5	8.5	0.751
Chest	15	25.9	21	35.6	0.258
Abdomen	36	62.1	37	62.7	0.943
Pelvis	11	19.0	4	6.8	0.05
Upper extremity	5	8.6	17	28.8	0.005
Lower extremity	9	15.5	14	23.7	0.268
Intervention					
Intubation	5	8.6	3	5.1	0.453
Cervical immobilization	8	13.8	9	15.3	0.824
Chest X-ray	25	43.1	33	55.9	0.168
Pelvis X-ray	10	17.2	12	20.3	0.671
CT head	6	10.3	19	32.2	0.004
Abdominal US or FAST examination	47	81.0	46	78.0	0.684
Extremity X-ray	10	17.2	15	25.4	0.284
Spine imaging	1	1.7	2	3.4	0.573
Body CT	1	1.7	0	0.0	0.315
Chest tube	4	6.9	7	11.9	0.362
Operation	36	62.1	31	54.4	0.083
Surgical airway	2	3.4	2	33.9	0.986
Thoracotomy	1	1.7	0	0.0	0.311
Laparotomy	29	50.0	23	39.0	0.231
Other	5	8.6	6	10.2	0.547

fully open sourced to facilitate multiple course offerings by local faculty while accounting for the resource limitations. The intent of the M-OTR course will be to open source or distribute material for free adaptation once further course validation has been completed. We are working with the local team to create additional course material, such as instructional videos demonstrating different operative techniques. In addition, we hope to introduce a formal curriculum to teach and evaluate nontechnical skills because effective management of challenging intraoperative dynamics is essential for high-quality surgical care.[32] We feel this should become the standard moving forward in international trauma education.

Previous studies have demonstrated that a trauma education initiative implemented in Rwanda reduced patient mortality, however, did not impact resource utilization.[33] Our study similarly did not demonstrate a change in resource

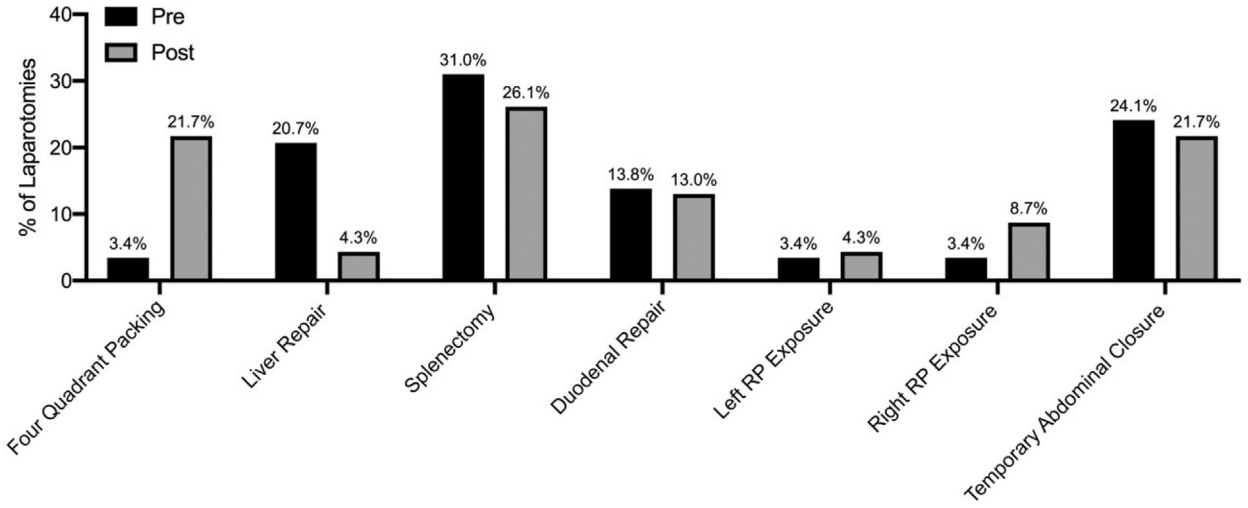

Fig. 1 – Operative techniques used during laparotomy precourse and postcourse.

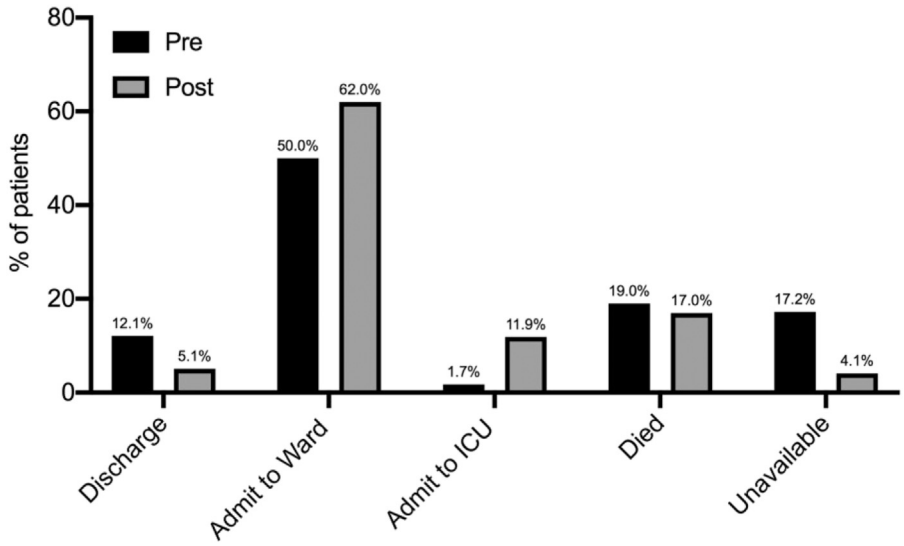

Fig. 2 – Disposition of all patients precourse and postcourse.

utilization postcourse. This is likely a reflection of the complex environment surrounding trauma care in Uganda. As in other similar settings, resource variability, with inconsistently available consumables, equipment, and staff pose unique challenges.[34] In addition, our study did not demonstrate that course participation had an immediate mortality benefit for patients. In this setting, patient outcomes are influenced by a number of external factors, and care is influenced by a number of contextual challenges making mortality a suboptimal indicator of the effectiveness of such interventions.[35] Given these constraints, it can be difficult to interpret if changes in the use of different interventions resulted to better trauma care.

This study has several limitations. We were unable to assess long-term patient outcomes because emergency department, ward, and hospital-wide databases have been difficult to sustain due to staffing and infrastructure changes due to ongoing construction at Mulago Hospital. The data are self-reported by residents and are thus subject to bias. We suspect that the change in from penetrating to blunt trauma cases reflected selection bias on behalf of the trainees but cannot be certain in the absence of a consistently maintained trauma registry. In addition, long-term follow-up with case logs at a more extended time point, such as 6 months was discussed but would not have been possible or accurate because by that time residents are in their third year of training and spend more time covering the surgical subspecialties such as neurosurgery, plastic surgery, orthopedics and urology and are responsible for less emergency cases after their second year of Master of Medicine, necessitating the future development of novel ways to assess the course's impact on resident knowledge and skill in addition to patient outcomes.

Conclusions

The M-OTR course has been well received and effective. International collaborative training via bidirectional course delivery is an important potential method of addressing the high toll that trauma exacts on LMICs. This course has had a positive impact on resident intraoperative and clinical decision-making. Training interventions such as M-OTR are just one component of trauma systems that need to be supported on a large scale to reduce the high toll of trauma in low-resource settings.

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jss.2020.07.024.

Disclosure

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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