Available online at www.sciencedirect.com

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Simulation and education

Resuscitation team training in Rwanda: A mixed method study exploring the combination of the VAST course with Advanced Cardiac Life Support training

Eugene Tuyishime [a,b,c,*], *Adam Mossenson* [d,e,f], *Patricia Livingston* [e], *Alain Irakoze* [a], *Celestin Seneza* [g], *Jackson Kwizera Ndekezi* [h], *Teresa Skelton* [i]

Abstract

Introduction: The influence of non-technical skills training on resuscitation performance in low-resource settings is unknown. This study investigates combining the Vital Anaesthesia Simulation Training Course with Advanced Cardiac Life Support training on resuscitation performance in Rwanda.

Methods: Participants in this mixed method study are members of resuscitation teams in three district hospitals in Rwanda. The intervention was participation in a 2-day Advanced Cardiac Life Support course followed by the 3-day Vital Anaesthesia Simulation Training Course. Quantitative primary endpoints were time to initiation of cardiopulmonary resuscitation, time to epinephrine administration, and time to defibrillation. Qualitative data on workplace implementation were gathered during focus groups held 3-months post-intervention.

Results: Forty-seven participants were recruited. Quantitative data showed a statistically significant decrease in time to cardiopulmonary resuscitation, epinephrine administration, and defibrillation from pre- to post-Advanced Cardiac Life Support, with times of [43.3 (49.7) seconds] versus [16.5 (20) sec], p = <0.001; [137.3 (108.9) sec] versus [51.3 (37.9)], p = <0.001; and [218.5 (105.8) sec] versus [110.8 (87.1) sec], p = <0.001; respectively. These improvements were maintained following the Vital Anaesthesia Simulation Training Course, and at 3-month retention testing. Qualitative analysis highlighted five key themes: ability to initiate cardiopulmonary resuscitation; team coordination for task allocation; empowerment; desire for training and mentorship; and advocacy for system improvement.

Conclusion: A modified 2-day Advanced Cardiac Life Support course improved resuscitation time indicators with retention 3-months later. Combining the Vital Anaesthesia Simulation Training Course and Advanced Cardiac Life Support led to better team coordination, empowerment to act, and advocacy for system improvement. This pairing of courses has promise for improving Advanced Cardiac Life Support skills amongst healthcare workers in low-resource settings.

ClinicalTrials.gov Identifier: NCT05278884.

Keywords: Non-technical skills, Resuscitation skills, Global health, Rwanda, Low-resource settings

Introduction

Cardiac arrest teams and Advanced Cardiac Life Support (ACLS) training have improved outcomes following in-hospital cardiac arrest in high-resource settings.[1–4] Outcomes in low-resource settings are poorer.[5] Unique obstacles exist for effective resuscitation in low-resource settings. Patients routinely present with advanced pathology and disease burden less amenable to resuscitation.[6] Lack of essential medications, scarcity of defibrillators, and workforce shortages further hinder successful resuscitation.[7–9] Therefore, ACLS courses from high-resource settings may need adaptation for use in low-resource settings.

* Corresponding author at: Department of Anesthesia, Critical Care, and Emergency Medicine, University of Rwanda, KG 11 Avenue, Remera, Kigali, Rwanda.

E-mail address: tuyishime36@gmail.com (E. Tuyishime).

https://doi.org/10.1016/j.resplu.2023.100415

Received 1 April 2023; Received in revised form 1 June 2023; Accepted 6 June 2023

In high-resource settings, non-technical skills (NTS) training is associated with improved resuscitation team performance and patient outcomes following in-hospital cardiac arrest.[10–12] The influence of NTS training on resuscitation skills in low-resource settings is unknown but arguably of greater importance for effective team function and safe clinical care in this context.[13] Simulation-based education has been used successfully to teach NTS in both high[14] and low-resource settings.[15–17] In low-resource settings, situational awareness, anticipation, and planning are especially relevant, as prevention of cardiac arrest may offer the only chance of survival.[18] Hence, there is a rationale for exploring the added value of NTS training with ACLS.

The Rwandan Ministry of Health would like ACLS skills for healthcare providers in Rwanda.[19] Capacity to conduct training is limited by few educators, lack of curricula relevant for these settings, competing clinical demands, and scarcity of simulation equipment.[20,21] Study co-investigators (ET, AI, CS, JKN) have experience in conducting ACLS training in Rwanda through the Initiative for Medical Equity and Global Health, a teaching organization providing resuscitation courses for different hospitals across Rwanda.[22] The Initiative for Medical Equity and Global Health has conducted 31 training sessions of 5 courses (Basic Life Support, ACLS, Pediatric Life Support, Vital Anesthesia Simulation Training (VAST), and Safe Anesthesia from Education Obstetrics), reaching 1,060 healthcare providers from 11 district hospitals.[22]

This team has adapted the training curriculum of the National Health Care Providers Solutions (with permission), which is based on the recent American Heart Association ACLS guidelines,[23] to suit low-resource settings. Adaptations include highlighting available resources, modifying course content to extend the duration of Electrocardiogram (EKG) training, and using practical scenarios that reflect common cases seen in Rwandan hospitals (see Table 1). To date, there has been no formal assessment of learning from these courses.

Members of the Initiative for Medical Equity and Global Health (ET, AI, CS, JKN) are also Vital Anaesthesia Simulation Training (VAST) Course facilitators. They sought collaboration with VAST to investigate the impact of combining the VAST Course and ACLS training, with the aim of resuscitation skills development and capacity building for resuscitation teams in Rwanda. VAST is a not-for-profit organization with a mission of advancing perioperative patient safety through supporting the use of simulation-based education in low-resource settings.[24]

The 3-day VAST Course, uses low-cost, immersive simulation to teach NTS and core clinical practices to peri-operative teams with a focus on topics relevant to low-resource settings such as obstetrics, paediatrics, trauma, general surgery, and pre- and postoperative care (see VAST curriculum in Table 1). The core learning objectives are for participants to be able to apply clinical frameworks for systematic practice and to develop skills for effective peri-operative team function. The VAST course is endorsed by the University of Rwanda, the Rwanda Society of Anesthesiologists, and the World Federation Society of Anaesthesiologists.[25] Participants from 18 countries to date have attended VAST Courses. The VAST Course has demonstrated capacity to improve participants' NTS.[26]

The purpose of this study is to evaluate learning following the pairing of a modified ACLS program with the VAST Course in Rwanda.

Methods

This manuscript adheres to both the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and Standards for reporting qualitative research (SRQR) guidelines.[27,28]

Ethical considerations

This study was approved by ethical review boards at the University of Rwanda, College of Medicine and Health Sciences (No 221/CMHS-IRB/2022) and the Hospital for Sick Children, Canada (REB:1000079474). The three selected Rwandan district hospitals granted permission for the training and research. Written informed consent was obtained from all study participants before participation. Participation in the study was not a pre-requisite for training. All training attendees consented to participate in the study.

Study design

The quantitative component of this mixed method study used a pre-designed data collection tool[29] (Appendix 1) to assess performance during simulated resuscitation scenarios at four time points: Pre-A (immediately before the ACLS course); Post-A (immediately after the ACLS course); Post-AV (immediately after the VAST Course,); and Retention (3-months post-training). The study used four cardiac arrest scenarios with ventricular fibrillation due to four different diagnoses (anaphylaxis, asthma attack, post-partum hemorrhage (PPH), and hyperkalemia). At each testing point, all four scenarios were randomly allocated to different participants. Randomization software allocated a different scenario to each participant for each of the four time points; therefore, each participant was exposed to each of the four scenarios during training but in a random order to minimize the possibility of sharing the content of scenarios among fellow participants.

The scenarios were of equivalent complexity and had been previously reviewed for context suitability by three Rwandan anesthesiologists not involved in the study.

The qualitative component used a semi-structured interview guide (Appendix 2) to conduct focus-group interviews 3-months following training to explore participants' experiences with implementation of resuscitation skills in their workplaces.

Study participants

Inclusion criteria were multi-disciplinary healthcare providers (i.e., physicians, nurses, midwives, and non-physician anaesthetists) who are members of resuscitation teams caring for adult patients at one of the three selected hospitals. Non-physician anaesthetists have three or four years of anaesthesia training post-secondary school.

Exclusion criteria were having participated in a VAST Course or resuscitation training course within four months of the study. No study participant had prior VAST training.

Setting

This study was conducted in three district hospitals in Rwanda, all with services in general surgery, gynecology and obstetrics, internal medicine, and pediatrics. These hospitals perform between 1,200 and 2,500 Cesarian deliveries each year.[30] Each hospital has a resuscitation team composed by anesthesiologist or non-physician anaesthetists, medical officers, and nurses. The resuscitation team

Table 1 – Training program for the intervention.

	Day	Core topic (Modified topic in bold)
ACLS	1	Welcome/orientation*
		Introduction to ACLS*
		Systems of care/team dynamics*
		Tachyarrhythmias*
		Bradyarrhythmias*,#
		Cardiac arrest/pulseless electrical activity*,#
		Acute Coronary Syndrome*,#
		Stroke*,#
		Airway Management+
		Post cardiac arrest care*,#
	2	EKG review*
		Cardiac arrest cases/practice#
		Post course cardiac arrest scenario testing
VAST COURSE	3	Welcome*
		Non-technical skills+
		Pre-briefing/simulation demonstration*
		Crisis resource management+
		Pre-operative assessment#
		Pain management*
		Unanticipated difficult intubation+
		Rapid sequence intubation#
		Neonatal resuscitation+
	4	Obstetric anesthesia*
		Obstetric pre-operative assessment#
		C-section under spinal anesthesia#
		General anesthesia for C-section#
		Intra-partum hemorrhage#
		Post-partum hemorrhage#
		Post-operative sepsis#
		Healthcare provider wellbeing*
	5	Pediatric anesthesia*
		Pediatric pre-operative assessment#
		Pediatric post-extubation laryngospasm#
		Trauma primary survey*
		Trauma primary survey – road trauma#
		Trauma re-assessment#
		Action items/commitment to change*

The type of session is indicated by the superscript:
* Group discussion.
+ Practical workshop.
# Simulation scenario.

changes with every shift. Defibrillators should be available in each hospital; however, they are often not maintained or are missing disposable components and staff have insufficient training in their use. There is no Intensive Care Unit capacity in any of the three hospitals.

Intervention

The intervention was pairing 2-day ACLS training with a 3-day VAST Course (Table 1). These paired courses were offered once at each hospital, to multi-disciplinary groups of 15–16 participants/site (47 in total). Refresher training was offered 3-months after the intervention, coinciding with the timing of focus-group interviews (Fig. 1). The focus group interviews were conducted immediately prior to refresher course training. The refresher training discussed essential topics from both ACLS (team dynamics and cardiac arrest) and VAST (non-technical skills, crisis resources management, and commitment to change) courses.

Sample size calculation

Prior studies have shown that, after training, time to initiation of chest compressions can be reduced by up to 23 seconds.[31,32] Using a conservative estimate of a 12 second improvement, a power analysis using the Wilcoxon signed-rank test (matched pairs) revealed that 38 participants were needed to detect a significant difference (Pre-A to Post-AV) with the alpha error of 0.05, power of 80%, and effect size of 0.5. Anticipating a 15% rate of technical difficulties or major protocol deviations we planned to include 44 participants in total.[31–33] Given there has been no prior combination of the VAST Course and ACLS training, it was not possible to conduct a power analysis to detect sample size needed for demonstrating significant improvement Post-A to Post-AV.

Data collection

Quantitative

The study data collection tool was developed based on previous studies that showed high quality resuscitation skills lead to return of spontaneous circulation (ROSC) and improved survival at discharge, one year, and five years.[34] Bircher et al. determined that delays in starting cardiopulmonary resuscitation (CPR), administering epinephrine, and defibrillation all lead to worse outcomes in in-hospital cardiac arrest.[35] Therefore, we selected "time to CPR" as the primary endpoint, with "time to epinephrine administration" and "time to defibrillation" as secondary endpoints. The final tool was obtained by combining the existing tool from Meaney et al.[20] and these 3 endpoints above from Bircher et al.[35]

Prior to data collection, raters were calibrated in the use of the data collection tool by watching three simulated resuscitation videos and rating performance of advanced resuscitation skills. Videos were different from study scenarios and were obtained from resuscitation training in high-resource settings.[36–38] Adequate inter-rater reliability was achieved to 0.9 after rating of three different scenarios over a 4-hour training period.

Before the first scenario, participants were oriented to the simulation workspace and given a briefing on physical and psychological safety. They watched a demonstration scenario to show expected performance during simulation activities. Each scenario required participants to function as team leader in their usual clinical role. Scenarios lasted a maximum of 5 minutes; all involved a witnessed cardiac arrest occurring 30 seconds from scenario onset. The cardiac arrest was evident by a distinct change in the patient's condition (e.g., ventricular fibrillation trace on electrocardiogram). Timing for recording primary and secondary outcomes began at the onset of cardiac arrest. A working defibrillator was used, and the study participant was required to follow defibrillation steps as if using a live defibrillator. For epinephrine delivery, the participant was required to verbalize it and use an empty labelled syringe to simulate delivery of epinephrine. The timer was stopped if all 3 primary time outcomes and the 10 resuscitation actions (team leader identified, scene orderly and quiet, cognitive aid used, CPR started, monitors applied, defibrillator applied safely, pauses in CPR delivery minimized, CPR of subjectively high quality, airway secured efficiently, and re-evaluation done frequently) were completed. Otherwise, the timer was stopped at the end of the scenario at 5 minutes. One rater completed the study data collection tool while a second rater timed par-

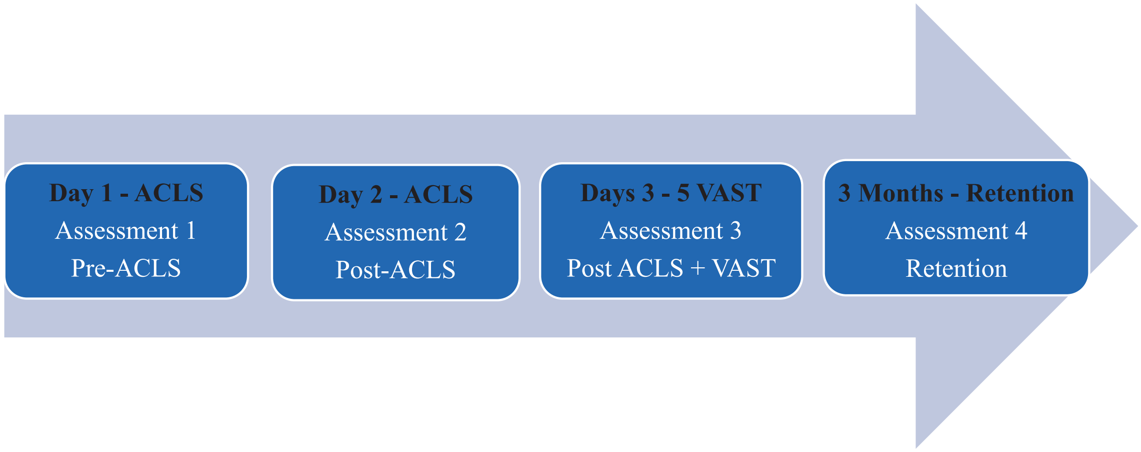

Fig. 1 – ACLS-VAST program timeline Assessment 1: Pre ACLS skills assessment; Assessment 2: Post ACLS skills assessment; Assessment 3: Post ACLS-VAST skills assessment; Assessment 4: Retention skills assessment; and Focus group interviews.

ticipants. If the participant failed to start CPR by 2 minutes after cardiac arrest, a prompt to begin CPR was given by a confederate.

A low-cost part task trainer was used to simulate the patient. Patient monitoring was provided by using SimMon software (https://simmon-app.com) and Bluetooth pairing two iPads (Apple Inc., Cupertino, CA, USA), establishing a remotely controllable patient monitor. A simulation technician played a resuscitation team member supportive role, following a pre-determined script. After completion of scenarios at each study time point, a 15–20-minute debriefing was held for all participants using the VAST debriefing framework, adapted from the Scottish Centre for Simulation and Clinical Human Factors debriefing framework and which blends several conversational techniques.[39,40]

Qualitative

Three months post-course, three focus group interviews (each with 6–8 participants) were conducted by videoconferencing to explore the barriers and enablers to implementing resuscitation skills in the workplace after training (Table 5). We selected participants ensuring representation of all professional profiles (physicians, nurses, midwives, and non-physician anesthetists). The focus groups were audio-recorded with data de-identified during transcription. Participants were free to express themselves in English or Kinyarwanda, with immediate translation to English.

Data analysis

Quantitative

Descriptive statistics are reported as raw percentages, means, and standard deviations. Numerical outcomes (the 3-time variables) were analyzed using linear mixed models with time as a dummy-coded predictor and random intercepts to account for the repeated measures using the lme4 package in R software version 1.1–33.[40]

Categorical outcomes (10 action variables) were analyzed with Bayesian generalized linear mixed models with time as a dummy-coded predictor, assuming a binomial distribution with a logit link, and random intercepts using the bglmer package in R software.[41]

Because there was complete separation in some cases (i.e., 100% success rates for some actions which caused computational problems) we used a Bayesian maximum a posteriori approach with a weak prior on the fixed effects as a correction to ensure model convergence.[42] Omnibus tests were calculated using Wald statistics, and post-hoc tests used the Tukey method to adjust for familywise error rate inflation.

Post-hoc tests were only conducted if the associated omnibus test was statistically significant. Marginal R^2 was used as a standardized effect size measure for all outcomes.[31,32,43]

Qualitative

Thematic analysis followed an inductive approach according to methods described by Braun and Clarke.[44] Two co-investigators (PL, TS) read focus group transcripts to identify frequently used words or phrases and to become familiar with the data. Coding was derived from focus group transcripts based on the research questions. Codes were analysed and grouped into categories that highlighted the underlying themes.

Results

Quantitative results

Forty-seven out of 48 participants completed all 4 study scenarios; 64% had >5 years of clinical experience and 66.1% were nurses and midwives (Table 2). For the primary outcome, time to CPR, there was improvement from a mean (SD) of 43.3 (49.7) sec Pre-A to 16.5 (20) sec Post-A ($p < 0.001$). Similarly, the secondary endpoints (time to epinephrine administration and time to defibrillation) had significant improvements from Pre-A to Post-A (Table 3). Further improvement was not shown Post-A to Post-AV or Post-AV to Retention (Tables 3 and 4). Time to carry out primary and secondary endpoints was maintained at retention testing (Table 3). Raw percentages, Ns and Wald test statistics for secondary outcomes are in Table 4. As with time endpoints, dichotomous outcome resuscitation skills were carried out more often at all three post intervention measures when compared to pre-A. Post-A, Post-AV, and Retention tended not to differ from each other. However, there was one skill “was re-evaluation done frequently” with a statistically significant improvement Post-AV in comparison to Post-A (Table 4).

Qualitative results

Qualitative analysis identified five key themes: ability to initiate CPR; team coordination for task allocation; empowerment; desire for training and mentorship; and advocacy for system improvement. These themes are discussed below with illustrative quotes from focus group transcripts.

Ability to initiate CPR: Participants described improvement in crisis recognition and having the skills to initiate CPR rather than delaying for help to arrive. They found that algorithms and systematic practice, reinforced during simulation, helped to consolidate knowledge. Despite this, participants felt there was a need for more practice with newer skills such as defibrillation.

> "After this course, I had a case. I remember, I was on night shift at the Emergency Department. We had a patient who had a cardiac arrest. I was around and I called the nurses. What I remember is that we did everything we learned, we recognized the arrest on time, and we had EKG in place. The anesthetist was around too, we gave adrenaline and we did CPR. The patient recovered. I remember I informed [anesthesiologist] and we transferred the patient to [hospital]. Actually, for me, it was my first successful resuscitation, yeah. And I found that if you recognize it on time, yeah, you can save the patient, yeah."

Team coordination for task allocation: Prior to the training, participants reported that they often felt alone, unsure how to get help in a crisis. Post-training, they expressed strong appreciation for working in teams. This included descriptions of resuscitations with colleagues who had received the training and comments about the better task allocation, closed loop communication, and task delegation.

> "Before training, if I get a patient in cardiac arrest, I was unable to task someone, do this, do this. But after training, they taught us close loop communication, how to be a good team leader, the medications to use, and how to be careful in everything we are doing. Before there was chaos and lack of organization, but now we are better organized and coordinated."

Table 2 – Participants characteristics, N: 47.

Variable	Number (%)
Sex	
Male	22 (46.8)
Female	25 (53.2)
Experience (years)	
≤5	17 (36)
6–10	22 (47)
11–15	5 (10.6)
>15	3 (6.4)
Speciality	
General practitioner	9 (19.1)
Nurse	22 (47)
Midwife	9 (19.1)
Non-Physician Anesthetist	7 (14.8)
Previous ACLS	
Yes	33 (70.2)
No	14 (29.8)
Previous BLS	
Yes	42 (89.4)
No	5 (10.6)

Empowerment: Participants felt empowered to initiate CPR without waiting for orders, to make changes in the workplace (e.g., implementing cognitive aids, adding adrenaline to the emergency trolley) to take leadership roles during resuscitation, and to use existing resources more effectively. Participants advocated for equipment, medications, and human resources for better resuscitation.

> "If it was before training, I would not have started CPR or given adrenaline especially that there was no doctor's orders."

Desire for training and mentorship: There was a consistent desire to improve outcomes for patients by making training available to all members of the healthcare team and receiving more training and mentorship, both from partners and within hospitals.

> "If we get another chance, we can have more staff to join the training. They need to have those skills. They see changes. If someone in our team is in the department, he trains others and he performs resuscitation differently. Others need this training, that [is] why in our recommendation we requested you to keep this program and go to all departments."

Advocacy for systems improvement: Participants were able to advocate for essential equipment and medications. Advocacy was easier when senior management, such as matrons and quality improvement officers, were involved in the training. These leaders could make changes to improve the provision of equipment and medications, implement cognitive aids and support staffing for resuscitation teams. Despite some positive changes, participants expressed ongoing shortages of materials, medications, and trained staff.

> "Another addition is that we have the administration support, it's very helpful. I remember we had a case in gynecology, the patient arrested on table, we recognized that we need to use the AED which was in the office of Director of Nursing. He brought it but unfortunately, we missed the cable. At least we were together when we learned this course. He recognizes the importance of having the AED in OR rather in the office."
>
> "After this course, now the matron is more aware that we must find medications for the emergency trolley, but before it was a fight."

Discussion

Resuscitation training for healthcare providers in low-resource settings requires a contextually appropriate approach. Learners in low-resource settings have limited access to ACLS training programs.[45] This study demonstrates that a modified 2-day ACLS course can lead to significant improvements in time to CPR, time to epinephrine administration, and time to defibrillation in simulated resuscitation scenarios. These three time-based practices may improve survival after in-hospital cardiac arrest.[35] Following ACLS training, participants improved in nine of ten dichotomous indicators of the 'quality' of resuscitation. Participation in both ACLS and VAST Courses led to greater empowerment to apply resuscitation skills in the workplace, task coordination, and advocacy for systems improvement.

Table 3 – Time to CPR, epinephrine, and defibrillation pre and post training (ACLS and VAST) among healthcare providers in Rwanda.

Actions (N)	Pre-A (Mean, SD)	Post-A (Mean, SD)	Post-AV (Mean, SD)	Retention (Mean, SD)	Wald Statistic, *p*-value, and R^2
Time to CPR (sec)	43.3 (49.7)	16.5 (20)	11.4 (20.8)	9.5 (14.3)	$X^2(3) = 44.49$, $p < .001$, $R^2 = 0.19$
Time to epinephrine (sec)	137.3 (108.9)	51.3 (37.9)	59.6 (70.2)	47.9 (60.5)	$X^2(3) = 51.75$, $p < .001$, $R^2 = 0.20$
Time to defibrillation (sec)	218.5 (105.8)	110.8 (87.1)	69.5 (48.4)	72.8 (83.8)	$X^2(3) = 105.21$, $p < .001$, $R^2 = 0.34$

Table 4 – Resuscitation skills performance during pre and post training (ACLS and VAST) by healthcare providers in Rwanda.

Actions (N)	Pre-A	Post-A	Post-AV	Retention	Wald test, *p*-value and R^2
Was the team leader clearly identified?	45 (96%)	46 (98%)	47 (100%)	46 (98%)	$X^2(3) = 3.05$, $p = .38$, $R^2 = 0.03$
Was the scene orderly and quiet?	38 (81%)	46 (98%)	47 (100%)	43 (91%)	$X^2(3) = 15.74$, $p = .001$, $R^2 = 0.08$
Was a cognitive aid used?	2 (4%)	14 (30%)	22 (47%)	23 (49%)	$X^2(3) = 21.42$, $p < .001$, $R^2 = 0.25$
Was CPR started?	45 (96%)	47 (100%)	47 (100%)	47 (100%)	$X^2(3) = 4.62$, $p = .20$, $R^2 = 0.04$
Were monitors applied?	43 (91%)	45 (96%)	44 (94%)	47 (100%)	$X^2(3) = 3.23$, $p = .35$, $R^2 = 0.19$
Was the defibrillator applied safely?	18 (38%)	43 (91%)	44 (94%)	39 (83%)	$X^2(3) = 33.39$, $p < .001$, $R^2 = 0.30$
Were pauses in CPR delivery minimized?	23 (49%)	39 (83%)	45 (96%)	43 (91%)	$X^2(3) = 27.19$, $p < .001$, $R^2 = 0.26$
Was CPR of subjectively high quality?	19 (40%)	31 (66%)	32 (68%)	30 (64%)	$X^2(3) = 10.24$, $p = .02$, $R^2 = 0.06$
Was an airway secured efficiently?	17 (36%)	30 (64%)	28 (60%)	26 (55%)	$X^2(3) = 8.29$, $p = .04$, $R^2 = 0.05$
Was re-evaluation done frequently?	31 (66%)	39 (83%)	47 (100%)	44 (94%)	$X^2(3) = 17.77$, $p < .001$, $R^2 = 0.25$

Table 5 – Focus Group Interview Guide.

1. How has your practice of resuscitation changed since the training (Prompt for examples)?
2. What difficulties have you encountered with resuscitation team performance in your hospital since the training (Probe for examples)?
3. What supports have you found for resuscitation team performance in your hospital since the training (Probe for examples)?
4. Is there anything else you would like to add about resuscitation team performance in your hospital since the training?

This study found significantly more frequent patient re-evaluation after the VAST Course compared to completing ACLS training only. Findings from focus-group interviews mirror the essential NTS and clinical frameworks taught on the VAST Course. These include improvement in confidence during crisis management, enhanced awareness of team function, and advocacy for patient safety in everyday practice. This is consistent with results from a previous study evaluating the impact of the VAST Course on participants' knowledge, and skill translation.[26]

Non-significant results from this study were of interest. The VAST Course did not lead to a significant stepwise improvement in time-based resuscitation skills. However, the average time measurements in all three post-intervention periods (Post-A, Post-AV and Retention) for time to CPR, time to epinephrine, and time to defibrillation were well within the recommended standards of 60 seconds, 180 seconds, and 180 seconds respectively.[35,46]

Due to resource constraints, the study was not able to provide quantitative assessment of CPR quality (depth of compressions, rate, interruptions). Whilst there was significant improvement in the number of interruptions to chest compressions once CPR was started, the quality of CPR improved post training, but subjectively, still had room for improvement. This may highlight the potential need for additional training, and we recommend further focus on teaching of quality CPR delivery in future ACLS courses.

Contrary to results from a prior study,[47] the use of cognitive aids did not significantly improve after ACLS-VAST training (50%) versus ACLS training only (30%). In part, this may be explained by a lack of contextually appropriate cognitive aids, and their infrequent use in routine practice.[48] This highlights the need for development of clinical resources specifically for use in low-resource settings.

In high-resource settings, resuscitation performance in simulation is improved when combined with NTS training[49]; it is now commonplace to integrate NTS training into ACLS.[49–51] Whilst this study did not demonstrate a significant stepwise improvement in simulated resuscitation performance after the VAST Course, skill improvements made immediately following ACLS were maintained 3-months later. This contrasts to the rapid skill decay commonplace in resuscitation skill training.[52–57] Refresher training is challenging in low-resource settings due to limited funding, lack of trainers, and workforce shortages.[49,50] The possibility that additional training in the VAST Course supports skills retention is an important finding that requires further exploration.

Likewise, in low-resource settings, NTS skills developed during the VAST Course may be valuable in improving response to the deteriorating patient and prevention of in-hospital cardiac arrest, given the potential for poor outcomes after cardiac arrest has occurred.

VAST contributed added value to team dynamics and communication taught in conventional ACLS training as it involves case scenarios commonly seen in low-resource settings and highlights essential NTS. There are opportunities for feedback, self-reflection, and application of learning in future scenarios. The course offers guidance on advocacy for essential medications and equipment. VAST is designed to be relevant for healthcare providers without prior training in NTS; this is essential in low-resource settings where the number of specialists is still low and opportunities for this type of training are limited.

During our literature review and based on our experience, this was the first study to combine ACLS training with a specific NTS course in low-resource settings especially in Sub-Saharan Africa where patients' characteristics, team structure, and availability of specialists, equipment, and drugs are different. Also, the hierarchical culture in most Sub-Saharan Africa and other low- and middle-income countries makes the application of NTS different especially for low-level professionals such as nurses, non-physician anesthetists, and junior doctors. VAST provides an added opportunity to promote graded assertiveness, ability to challenge authority, and a commitment to patient safety.

The ACLS program was adapted to meet the challenges of practicing in low-resource settings. The lack of some ACLS drugs was addressed by using alternative cheaper drugs as first lines of common conditions (e.g., lidocaine and amiodarone for management of tachyarrhythmias); the shortage of acute medicine specialists was addressed by providing specific training (e.g., EKG interpretation) to non-physician anaesthetists and nurses; and scenarios were modified to focus on patient presentations common in low-resource settings (e.g., infections, trauma, and pregnancy complications).

The VAST Course curriculum was designed specifically for low-resource settings with a sustainable model of capacity building of the local educator workforce, not-for-profit delivery, and donation of equipment required for running courses on an ongoing basis. The 5-day course duration allowed for easy planning for educators in comparison to conducting two separate courses (ACLS and VAST) during different periods. Also, the cost of transportation of equipment and educators is decreased with this model.

The results of this study may be relevant for other providers, beyond the anesthesia team, because the ACLS-VAST program was designed for an inter-professional team and this study included other providers such as medical officers, nurses, and midwives.

Limitations

Resuscitation performance assessments were conducted in a simulated environment limiting the transferability to clinical practice. While focus groups gathered participants' ideas on skills translation to the workplace, future investigations should evaluate the impact on workplace performance.

This study examines the combination of ACLS and the VAST Course on resuscitation performance for three-district hospitals in Rwanda; results are not necessarily applicable to other settings.

The study may not have been adequately powered to detect a stepwise improvement in time-based scores across multiple measurements due to the paucity of prior work in this context.

The lack of control group is another limitation of this study. It was not feasible to have a comparison group at all 4 data collection points. This would have required a separate group of practitioners that would have put severe manpower strains on each of the three hospitals and our priority was in ensuring all participants received training.

Conclusion

A modified 2-day Advanced Cardiac Life Support course decreased time to initiation of cardiopulmonary resuscitation, time to epinephrine, and time to defibrillation and it was retained up to 3-months later. Combining the Vital Anaesthesia Simulation Training Course and Advanced Cardiac Life Support led to better team coordination, empowerment to act, and advocacy for system improvement. This pairing of courses has promise for improving Advanced Cardiac Life Support skills amongst healthcare workers in low-resource settings.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 'All co-authors are instructors of the Vital Anesthesia Simulation Training (VAST) course which was part of the intervention for this study'.

Acknowledgments

The authors would like to thank the administration of the three study hospitals for their support to the research team during the whole project and Laurence Mizero, Dr Gaston Nyirigira, Dr. Francoise Nizeyimana, Dr. Claudine Uzamukunda, and Dr. Jean de Dieu Tuyishime for their assistance with all ACLS-VAST courses and refresher courses.

Funding

Australian and New Zealand College of Anaesthetists (ANZCA) Health Equity Projects Fund 2022. Application ID: HEPF202202.

Author contributions

Name: Eugene Tuyishime *MBBS, MMed, MSc.*

Contributions: This author contributed to study design, ethics protocol development/approval, data collection, quantitative data analysis, and manuscript preparation.

Conflicts of interest: Dr Tuyishime is a VAST Course Instructor.

Name: Adam Mossenson MBBS, MPH, FANZCA.

Contributions: This author contributed to study design, ethics protocol development/approval, obtaining funding for the study, data collection, quantitative data analysis, manuscript preparation.

Conflicts of interest: Dr Mossenson is a VAST Course author and VAST Course Instructor.

Name: Patricia Livingston OC, MD, FRCPC, MEd.

Contributions: This author contributed to study design, ethics protocol development/approval, data collection, qualitative data analysis, manuscript preparation and project supervision.

Conflicts of interest: Dr Livingston is a VAST Course author and VAST Course Instructor.

Name: Alain Irakoze, MBBS, MMed.

Contributions: This author contributed to course delivery, data collection, and manuscript preparation.

Conflicts of interest: Dr Irakoze is a VAST Course Instructor.

Name: Celestin Seneza, MBBS, MMed.

Contributions: This author contributed to course delivery and logistics, data collection, and manuscript preparation.

Conflicts of interest: Dr Seneza is a VAST Course Instructor.

Name: Jackson Kwizera Ndekezi, MBBS, MMed.

Contributions: This author contributed to ethics protocol development/approval, course delivery, data collection, and manuscript preparation.

Conflicts of interest: Dr Ndekezi is a VAST Course Instructor.

Name: Teresa Skelton, MD, FRCPC, MPH.

Contributions: This author contributed to study design, ethics protocol development/approval, data collection, quantitative and qualitative data analysis, and manuscript preparation.

Conflicts of interest: Dr Skelton is a VAST Course Instructor.

Appendix A. Supplementary material

Supplementary material to this article can be found online at https://doi.org/10.1016/j.resplu.2023.100415.

Author details

[a]*Department Anesthesia, Critical Care, and Emergency Medicine, University of Rwanda, Rwanda* [b]*Department Anesthesia and Critical Care, University of Botswana, Botswana* [c]*Department of Anesthesia and Perioperative Medicine, Western University, Ontario, Canada* [d]*Department of Anaesthesia, SJOG Public and Private Hospital, Perth, Western Australia* [e]*Department of Anesthesia, Pain Management, and Perioperative Medicine, Dalhousie University, Nova Scotia, Canada* [f]*Curtin University, Perth, Western Australia, Australia* [g]*Kibagabaga District Hospital, Kigali, Rwanda* [h]*Kibogora Level II Teaching Hospital, Western Province, Rwanda* [i]*Department of Anesthesia and Pain Medicine, the Hospital for Sick Children, University of Toronto, Canada*

REFERENCES

1. Morrison LJ, Neumar RW, Zimmerman JL, et al. Strategies for improving survival after in-hospital cardiac arrest in the United States: 2013 consensus recommendations. Circulation 2013:1538–63. https://doi.org/10.1161/CIR.0b013e31828b2770.
2. Maharaj R, Raffaele I, Wendon J. Rapid response systems: a systematic review and meta-analysis. Crit Care 2015:1–15. https://doi.org/10.1186/s13054-015-0973-y.
3. Rocha HAL, de Castro Alcântara AC, Rocha SGMO, Toscano CM. Effectiveness of rapid response teams in reducing intrahospital cardiac arrests and deaths: A systematic review and meta-analysis. Rev Bras Ter Intensiva 2018;30:366–75. https://doi.org/10.5935/0103-507X.20180049.
4. Jabbour M, Osmand MH, Klassea TP. Life support courses: Are they effective? Ann Emerg Med 1996:690–8.
5. Ngunga LM, Yonga G, Wachira B, Ezekowitz JA. Initial rhythm and resuscitation outcomes for patients developing cardiac arrest in Kenyan hospitals. Glob Heart 2018:1–6. https://doi.org/10.1016/j.gheart.2018.07.001.
6. Edwards-Jackson N, North K, Chiume M, et al. Outcomes of in-hospital paediatric cardiac arrest from a tertiary hospital in a low-income African country. Paediatr Int Child Health 2020;40:11–5. https://doi.org/10.1080/20469047.2019.1570443.
7. Lincoln W. Adapting the Advanced Cardiac Life Support for the Experienced Provider (ACLS-EP) course for emergency care education in Rwanda. 2011; 2009: 2–4. doi: 10.4102/phcfm.v3i1.178.
8. Baker T, Lugazia E, Eriksen J, Mwafongo V, Irestedt L, Konrad D. Emergency and critical care services in Tanzania: a survey of ten hospitals. BMC Health Serv Res 2013. https://doi.org/10.1186/1472-6963-13-140.
9. Mellin-olsen J, Gore-booth J. The WFSA global anesthesia workforce survey. Anesth Analg 2017;125:981–90. https://doi.org/10.1213/ANE.0000000000002258.
10. Nallamothu TCG, Molly Harrod JEK, Lehrich JL, et al. How do resuscitation teams at top- performing hospitals for in-hospital cardiac arrest succeed? Circulation 2018:154–63. https://doi.org/10.1161/CIRCULATIONAHA.118.033674.
11. Marsch SCU, Müller C, Marquardt K, Conrad G, Tschan F, Hunziker PR. Human factors affect the quality of cardiopulmonary resuscitation in simulated cardiac arrests. Resuscitation 2004;60:51–6. https://doi.org/10.1016/j.resuscitation.2003.08.004.
12. Oluf P, Kammer M, Lippert A, Østergaard D. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams ☆. 2010;81:695–702. doi: 10.1016/j.resuscitation.2010.01.024.
13. Scott J, Revera Morales D, Mcritchie A, Riviello R, Smink D, Yule S. Non-technical skills and health care provision in low- and middle-income countries: A systematic review. Med Educ 2016;50:441–55. https://doi.org/10.1111/medu.12939.
14. Yee B, Naik VN, Joo HS, et al. Nontechnical skills in anesthesia crisis management with repeated exposure to simulation-based education. 2005; 103. http://pubs.asahq.org/anesthesiology/article-pdf/103/2/241/359087/0000542-200508000-00006.pdf.
15. Skelton T, Nshimyumuremyi I, Mukwesi C, Whynot S, Zolpys L, Livingston P. Low-cost simulation to teach anesthetists' non-technical skills in Rwanda. Anesth Analg 2016;123:474–80. https://doi.org/10.1213/ANE.0000000000001434.
16. Gu Y, Witter T, Livingston P, et al. The effect of simulator fidelity on acquiring non-technical skills: a randomized non-inferiority trial. Can J Anesth 2017;64:1182–93. https://doi.org/10.1007/s12630-017-0973-2.
17. Taché S, Mbembati N, Marshall N, Tendick F, Mkony C, O'Sullivan P. Addressing gaps in surgical skills training by means of low-cost simulation at Muhimbili University in Tanzania. Hum Resour Health 2009:7. https://doi.org/10.1186/1478-4491-7-64.
18. Molyneux EM. Cardiopulmonary resuscitation in poorly resourced settings: better to pre-empt than to wait until it is too late. Paediatr Int Child Health 2020;40:1–6. https://doi.org/10.1080/20469047.2019.1616150.
19. Ministry of Health Rwanda July 2020. Policy/Procedure/Policy code HR2-06. Resuscitative Techniques. Accessed February 2, 2023. https://www.moh.gov.rw/publications/index.php?id=409&tx_kesearch_pi1%5Bsword%5D=resuscitatio&tx_kesearch_pi1%

5Bpage%5D=1&tx_kesearch_pi1%5BresetFilters%5D=0&tx_kesearch_pi1%5BsortByField%5D=&tx_kesearch_pi1%5BsortByDir%5D=.
20. Friedman A, Werner K, Geduld HI, Wallis LA. Advanced life support courses in Africa: Certification, availability and perceptions. Afr J Emerg Med 2020;10. https://doi.org/10.1016/j.afjem.2020.07.013.
21. Norgang K, Muhire AI, Howrath S. Learning the C-A-Bs: Resuscitation training at Rwanda Military Hospital. 2015;2:4314.
22. IMEGH. Initiative for Medical Equity and Global Health. Accessed May 30, 2023. https://imegh.net/on-site-courses/.
23. NHCPS. National Health Care Providers Solutions. Accessed December 10, 2021. https://nhcps.com/course/acls-advanced-cardiac-life-support-certification-course/.
24. Vital Anesthesia Simulation Training (VAST). Vast learning. Accessed February 25, 2023. http://vastlearning.org.
25. Mossenson A, Mukwesi C, Livingston P. The Vital Anaesthesia Simulation Training (VAST) Course: Immersive simulation designed for low-resource settings. 2019. www.wfsahq.org/resources/update-in-anaesthesia.
26. Mossenson AI, Tuyishime E, Rawson D, et al. Promoting anaesthetisia providers ' non-technical skills through the Vital Anaesthesia Simulation Training (VAST) course in a low- resource setting. Br J Anaesth 2019:1–8. https://doi.org/10.1016/j.bja.2019.10.022.
27. Cheng A, Kessler D, Mackinnon R, et al. Reporting guidelines for health care simulation research: extensions to the CONSORT and STROBE statements. Adv Simulat 2016;1:25. https://doi.org/10.1186/s41077-016-0025-y.
28. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: A synthesis of recommendations. Academic Medicine 2014;89:1245–51. https://doi.org/10.1097/ACM.0000000000000388.
29. Oluf P, Kammer M, Lippert A, Østergaard D, Wirenfelt T. Development of a formative assessment tool for measurement of performance in multi-professional resuscitation teams ☆. Resuscitation 2010;81:703–11. https://doi.org/10.1016/j.resuscitation.2010.01.034.
30. Tuyishime AE, Mvukiyehe JP, Cubaka VK, Banguti PR. Post-delivery complications and quality of birth practice in district hospitals in Rwanda: A cross-sectional study. Rwanda Med J 2020;77:9–15.
31. Hunziker S, Bu C, Legeret C, Schumacher C, Semmer NK, Hunziker P. Brief leadership instructions improve cardiopulmonary resuscitation in a high-fidelity simulation: A randomized controlled trial. 2010;38. doi: 10.1097/CCM.0b013e3181cf7383.
32. Hunziker S, Tschan F, Semmer NK, et al. Hands-on time during cardiopulmonary resuscitation is affected by the process of teambuilding: a prospective randomised. 2009;10:1–10. doi: 10.1186/1471-227X-9-3.
33. Dhand NK, Khatkar MS. Statulator: An online statistical calculator. Sample size calculator for comparing two paired means. Accessed February 13, 2022. https://statulator.com/SampleSize/ss2PM.html#.
34. Meaney PA, Bobrow BJ, Mancini ME, et al. Cardiopulmonary resuscitation quality: Improving cardiac resuscitation outcomes. Published online 2013:417–35. doi: 10.1161/CIR.0b013e31829d8654.
35. Bircher NG, Chan PS, XYHAGWTG Investigators. Delays in cardiopulmonary administration all decrease cardiac arrest. Anesthesiology 2019;3:414–22. https://doi.org/10.1097/ALN.0000000000002563.
36. Resuscitation video 1. Accessed February 20, 2022. https://www.youtube.com/watch?v=XW8-t3Dk898.
37. Resuscitation video 2. Accessed February 20, 2022. https://www.youtube.com/watch?v=jQYHQr3ebLo&t=209s.
38. Resuscitation video 3. Accessed February 20, 2022. https://www.youtube.com/watch?v=F0KI6t3sJxo.
39. Oliver N, Shippey B, Edgar S, Maran N, May A. The Scottish centre debrief model. Int J Healthc Simulat 2023. https://doi.org/10.54531/lvxq6860.
40. Sauter R, Held L. Quasi-complete separation in random effects of binary response mixed models. J Stat Comput Simul 2016;86:2781–96. https://doi.org/10.1080/00949655.2015.1129539.
41. Chung Y, Rabe-Hesketh S, Dorie V, Gelman A, Liu J. A nondegenerate penalized likelihood estimator for variance parameters in multilevel models. Psychometrika 2013;78:685–709. https://doi.org/10.1007/s11336-013-9328-2.
42. Bates D, Mächler M, Bolker BM, Walker SC. Fitting linear mixed-effects models using lme4. J Stat Softw 2015;67. https://doi.org/10.18637/jss.v067.i01.
43. Nakagawa S, Johnson PCD, Schielzeth H. The coefficient of determination R2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded. J R Soc Interface 2017;14. https://doi.org/10.1098/rsif.2017.0213.
44. Braun V, Clarke V, Braun V, Clarke V. Using thematic analysis in psychology Using thematic analysis in psychology. J Resuscit 2008;0887.
45. Friedman A, Werner K, Geduld HI, Wallis LA. Advanced life support courses in Africa: Certification, availability and perceptions. Afr J Emerg Med 2020;10:S60–4. https://doi.org/10.1016/j.afjem.2020.07.013.
46. Soar J, Nolan JP, Böttiger BW, et al. European Resuscitation Council Guidelines for Resuscitation 2015. Section 3. Adult advanced life support. Resuscitation 2015;95:100–47. https://doi.org/10.1016/j.resuscitation.2015.07.016.
47. Andersen PO, Andersen HB. Critical incidents related to cardiac arrests reported to the Danish Patient Safety Database ☆. 2010;81:312–16. doi: 10.1016/j.resuscitation.2009.10.018.
48. Tobi KU, Amadasun FE. Cardio-pulmonary resuscitation in the intensive care unit: An experience from a tertiary hospital in Sub-Saharan Africa. Nigerian Med J 2015;56. https://doi.org/10.4103/0300-1652.150694.
49. Dewolf P, Clarebout G, Wauters L. The effect of teaching nontechnical skills in advanced life support: A systematic review. Published online 2021:1–20. doi: 10.1002/aet2.10522.
50. Yeung J, Perkins G, Davies R, et al. Introducing non-technical skills teaching to the Resuscitation Council (UK) Advanced Life Support Course. Resuscitation 2014;85:S71. https://doi.org/10.1016/j.resuscitation.2014.03.178.
51. Briggs A, Raja AS, Joyce MF, et al. The role of nontechnical skills in simulated trauma resuscitation. J Surg Educ 2015;72:732–9. https://doi.org/10.1016/j.jsurg.2015.01.020.
52. Sutton RM, Niles D, Meaney PA, et al. Low-dose, high-frequency CPR training improves skill retention of in-hospital pediatric providers. Pediatrics 2011;128. https://doi.org/10.1542/peds.2010-2105.
53. Anderson R, Sebaldt A, Lin Y, Cheng A. Optimal training frequency for acquisition and retention of high-quality CPR skills: A randomized trial. Resuscitation 2019;135:153–61. https://doi.org/10.1016/j.resuscitation.2018.10.033.
54. Hamilton R. Nurses' knowledge and skill retention following cardiopulmonary resuscitation training: A review of the literature. J Adv Nurs 2005;51:288–97. https://doi.org/10.1111/j.1365-2648.2005.03491.x.
55. Semeraro F, Signore L, Cerchiari EL. Retention of CPR performance in anaesthetists ☆. Published online 2006. doi: 10.1016/j.resuscitation.2005.06.011.
56. Smith KK, Gilcreast D, Pierce K. Evaluation of staff's retention of ACLS and BLS skills. Resuscitation 2008;78:59–65. https://doi.org/10.1016/j.resuscitation.2008.02.007.
57. Lin Y, Cheng A, Grant VJ, Currie GR, Hecker KG. Improving CPR quality with distributed practice and real-time feedback in pediatric healthcare providers – A randomized controlled trial. Resuscitation 2018;130:6–12. https://doi.org/10.1016/j.resuscitation.2018.06.025.

GLOSSARY

ACLS: Advanced Cardiac Life Support
ALS: Advanced Life Support
CPR: Cardio-pulmonary resuscitation
EKG: Electrocardiogram
HOC: Hand on chest
NTS: Non-technical skills
Pre-A: time point immediately before the ACLS course
Post-A: time point immediately after the ACLS course
Post-AV: time point immediately after the VAST Course
Retention: time point 3-months post-training in ACLS and VAST
ROSC: Return of spontaneous circulation
Sec: Seconds
SPSS: Statistical Package for the Social Sciences
VAST: Vital Anaesthesia Simulation Training