BMC Medical Education

RESEARCH

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Prospective multi-centre analysis of rural trauma team development training for medical trainees and traffic law enforcement professionals in Uganda: an interrupted time series study

Herman Lule[1,2,3*], Micheal Mugerwa[2], Robinson Ssebuufu[4], Patrick Kyamanywa[5], Jussi P. Posti[6] and Michael Lowery Wilson[7]

Abstract

Background Research shows that trauma team formation could potentially improve effectiveness of injury care in rural settings. The aim of this study was to determine the feasibility of rural trauma team training amongst medical trainees and traffic law enforcement professionals in Uganda.

Methods Prospective multi-centre interrupted time series analysis of an interventional training based on the 4th edition of rural trauma team development course of the American College of Surgeons. Trauma related multiple choice questions (MCQs), and trauma non-technical skills were assessed pre-and post-training between September 2019-August 2023. Acceptability of the training for promulgation to other rural regions and its relevance to participants' work needs were evaluated on 5- and 3-point Likert scales respectively. The median MCQ scores (IQR) were compared before and after training at 95% CI, regarding $p < 0.05$ as statistically significant. Triangulation with open-ended questions was obtained. Time series regression models were applied to test for autocorrelation in performance using Stata 15.0. Ethical approval was obtained from Uganda National Council for Science and Technology (Ref: SS 5082).

Results A total of 500 participants including: 66 (13.2%) traffic police officers, 30 (6.0%) intern doctors, 140 (28.0%) fifth year and 264 (52.8%) third-year medical students were trained. Among the 434 medical trainees who completed the trauma-based MCQ assessment, the median pre- and post-test scores were 60%, IQR (50–65) and 80%, IQR (70–85) respectively. Overall, the mean difference between pre- and post-test scores was statistically significant ($z = 16.7\%$, P|z|=<0.0001). Most participants strongly agreed to promulgate 389 (77.8%), relevance to their educational 405 (81.0%), and work needs 399 (79.8%). Each of the course components was rated above 76.0% as being very relevant. There was an overall increment in median (IQR) trauma-nontechnical skills team performance scores from 12 (9-14) to 17 (15-20) after the training ($p < 0.001$), with police teams advancing from 9.5 (6.0-12.5) to 19.5 (17.0-21.5) ($p < 0.001$).

*Correspondence:
Herman Lule
lule.herman@gmail.com
Full list of author information is available at the end of the article

Conclusion This study demonstrates that rural trauma team development training had a positive effect on the test scores of course participants. The training is feasible, highly acceptable and regarded as relevant amongst medical trainees and traffic law enforcement professionals who provide first-aid to trauma patients in resource-limited settings. The findings could inform the design of future trauma teams in rural communities.

Trial registration Retrospective registration (UIN: researchregistry9450).

Key highlights

- There is limited human and infrastructural resources for trauma care in Low-and-middle-income countries (LMICs).
- Research shows that trauma education could increase the effectiveness of injury care in remote settings.
- We explore the feasibility of rural trauma team development training through an educational intervention, viewing rural medical trainees and traffic law enforcement professionals as sustainable human resources for health, and discuss policy implications for LMICs.

Keywords Rural trauma, Trauma teams, Team Training, Team Development, Medical Education, Police, Medical students, Rural Health professionals, LMICs, Africa

Introduction

Trauma annually claims 4.5 million lives globally, disproportionately affecting low- and middle-income countries (LMICs) where capacity building for trauma education programs are minimal [1]. LMICs have limited finances, infrastructure, and human resources for health [2, 3]. Moreover, the unmet need for trauma care in rural areas of LMICs has called for task-shifting [4], which without adequate capacity strengthening could negatively impact treatment outcomes. According to the latest 2023 WHO global forum on human resources for health, Africa is the most deficient continent of skilled workforce, partly due to limited training capacity, and the hastened exodus of its qualified health experts to remunerative international recruiters [3]. Task-shifting has been proposed to counteract the "understaffing effects" resulting from brain drain from low-income countries [5, 6] but viewing rural health care trainees and traffic-crash response police as potentially sustainable human resource for injury care has been obscure.

Rationale for rural trauma team development training in Uganda

Studies in high income countries reveal that trauma life support education programs such as the European Trauma Course (ETC) [7], and the Advance Trauma Life Support (ATLS) course influence self-efficacy and behavioural change during clinical practice [8]. In addition, scoping reviews in LMICs show that trauma education programs could result in improved knowledge for injury care, clinicians' self-confidence and skills which when applied could reduce injury related mortality [9, 10]. However, the reviews have mostly utilized short-term single-centre observational studies which have not been contextualized locally to work within an existing cohesive infrastructural framework [9]. Besides, most studies have exclusively limited the educational programs to hospital-based medical providers [11], without involving rural medical trainees and road traffic law enforcement professionals who are the most accessible frontliners following traffic crashes in Uganda [12]. There is currently no formal first-aid training included in the professional curriculum for traffic officers. However, considering their frequent initial encounters with injured individuals in the course of their duties, efforts have been made through feasibility studies to assess their level of knowledge and skill retention in performing these tasks [13]. The present study builds upon this foundation in linking their role to the medical profession.

Uganda is one of the LMICs that lacks both universal health care coverage and formal pre-hospital care systems [3] which complicates injury outcomes [12]. Furthermore, the Ugandan doctor to patient ratio of 1: 25,000 for its 45.8 million population is less than the world average of 49 per 10,000 individuals [3]. As such, Uganda boasts of only 0.7 surgeons for every 100,000 people [14], below the minimum WHO staffing standards for universal access to essential safe surgery [15]. Compelling results from systematic reviews demonstrate that the dearth of trauma care expertise coupled with insufficient competence-based training of frontliners aggravates the mortality resulting from injuries in LMICs [16]. Strengthening capacity for human resource in LMICs is critical for functional trauma systems [17, 18], and is in line with the 2030 agenda for realizing the sustainable development goals on universal health care coverage [19]. The six-year undergraduate medical curriculum in Uganda is structured to ensure that interns and medical students (collectively referred to as medical trainees), gain exposure to elements of ATLS but without formal certification. These

trainees make first contact with trauma patients prior to senior consultancy. In lieu of the country's scarce health workforce, assimilating these cadres into trauma teams through capacity strengthening could catalyze the formation of sustainable rural health trauma systems.

Efforts to integrate an advanced trauma life support course (ATLS) [8] of the American College of Surgeons into the undergraduate medical programme have been fruitless partly due to the lack of its conceptualization to accommodate Uganda's resource constraints and the financial burden of having to take the course abroad due to absence of a local certification centre. Conversely, alternative programs such as the Primary Trauma Course (PTC) [10] and the National Trauma Management Course (NTMC) [20] have demonstrated some degree of success in Africa and Asia, respectively; however, their acceptance within international labor markets remains limited. Recalling that 74% of Ugandans live in rural areas [21], rural trauma team development course (RTTDC) [22] is more suitable for rural health trainees and professionals in lieu of the country's socioeconomic context. The RTTDC course takes advantage of the team concept within the existing infrastructure to maximize clinical efficiency, which is the most critical approach in situations of scarce human resources in rural areas.

Moreover, RTTDC appears to have the potential to help reduce trauma-related mortality [23], but to a greater extent, has been appraised in high-income countries [24]. Besides, the course has been evaluated excluding traffic law enforcement professions who form an integral part of emergency evacuation and pre-hospital transportation of injured patients in rural regions where health professionals are scarce [25]. However, Ugandan studies which have examined the feasibility, application, and results of rural trauma team development training in such settings are scanty [13]. Here we present the results of rural trauma team training amongst rural medical trainees and traffic law enforcement professionals, who in this study are considered the most readily accessible and sustainable human resources for immediate injury care in the Ugandan hard-to-reach rural environment.

Study objectives

The aim of this study was to examine the feasibility of rural trauma team training amongst medical trainees and traffic law enforcement professionals, using the RTTDC model [22]. This study was nested in a clinical trial on the use of allied health and law enforcement trauma registries in Uganda [26] (Pan African Clinical Trial Registry No. PACTR202308851460352). The primary outcome of this study was to determine the level of knowledge retention based on the absolute difference in pre-and post-training mean or median trauma related MCQ scores. The secondary outcome was to determine the absolute difference in pre-and post-training trauma non-technical skills scores as a measure of behavioral change in team performance and to determine the level of acceptability and relevance of this training to the educational and work needs of study participants. The null hypothesis of this study was that there is no difference in pre-and post-training mean or median scores amongst research participants. According to Brown et al. [11], pre-and post-training knowledge assessment is the most used metric to evaluate educational programs.

Methodology

Study design

This was a multi-centre interrupted time-series of interventional training conducted during 27th August 2019-27th August 2023. This manuscript was developed in accordance with the proposed recommendations for reporting of interrupted time-series [27], and in line with guidelines for reporting evidence-based practice educational interventions and teaching (GREET) [28].

Study settings and study population

This study was conducted in three specialized referral teaching hospitals in Uganda, including Kiryandongo, Jinja and Hoima. These facilities serve as internship and residency sites for undergraduate and graduate medical doctors and nurses, and as teaching sites for the Kampala International University Medical School. Given that the regional traffic police headquarters and the hospitals were situated within the same municipalities, we conducted all training sessions in the multimedia surgery exhibition rooms of the respective teaching hospitals due to the availability of sufficient space to facilitate team simulations.

The study subjects were medical trainees and traffic law enforcement professionals. We targeted medical trainees undertaking surgery and traumatology rotations during the study period. A total of 66 traffic police officers were involved in the study, with 22 officers selected from each participating region based on the average number deployed at the three regional police headquarters. These officers were nominated by their superiors, focusing on those regularly assigned to traffic control on highways leading to designated municipalities and teaching hospitals. After obtaining consent, the nominated officers were randomly assigned to medical trainee teams using a blinded lottery method.

On the other hand, we recruited 434 medical trainees. The sample size for medical trainees was determined using a hypergeometric formula based on a total population of 1500 medical trainees which had been recorded at the three study sites during the academic year that

preceded this research. The detailed description of study sites, methodology, sample size estimation, sampling methods, and proportions taken from each site are reported in the study protocol [29].

Inclusion criteria

i. Road traffic officers who were concerned with evacuation of patients who sustain road traffic crashes.
ii. Medical interns (doctors/nurses) who were posted for surgery and traumatology clinical rotations at any of the study sites.
iii. Medical students in clinical years (3-5th), enrolled in Bachelor of Medicine and Bachelor of Surgery (MBChB) who were undertaking the surgical and traumatology clinical rotations at any of the study sites.
iv. Allied health professional trainees in clinical years (3-5th), enrolled in Bachelor of Nursing Sciences (BNS) or Bachelor of Clinical Medicine (BCM) degree programs who were involved in the care of the injured patients or attached to the accident and emergency departments at any of the study sites during the study period.

Exclusion criteria

i. Participants who foresaw could not complete all the course modules due to other competing obligations such as students seating an exam or traffic officer on duty on the day of the training. This was to ensure consistency in the course evaluation. These participants would be offered alterative days (if available).

The specifics to the course materials, scope of the training, course implementation, and study outcomes are summarised below:

Course materials

The standardised face-to-face 4th edition of RTTDC [22] of the American College of Surgeons was adopted, leveraging on its renown team concept. This interventional educational activity was advertised through university hospital administrators and class representatives, so as not to interfere with hospital schedules. Potential participants were screened for eligibility two weeks prior to the training dates, provided with the link to the educational materials, and were registered on a cumulative list based on "first come, first served" by the respective university hospital administrators.

Course attendance and instructors

University hospital administrators used the recruited trainees' unique numbers from their respective attendance databases to randomly assign each block of 15 participants into three teams, each with five members and ensured that each participant was recruited once. The traffic law enforcement participants picked random ballot papers on each first day of the training to be assigned to the already existing medical trainee teams. The chief trainer was a surgeon (HL) who attended the RTTDC instructor course. Since capacity-building was a desired course outcome, the surgeon coached two surgery specialty residents (co-trainers) who were undertaking a traumatology clinical rotation at the study sites, totaling to three instructors. Specialty residents are directly responsible for supervision of intern doctors in Uganda and altogether these two cadres account for 75% of Uganda's health workforce [14].

Course schedule

The training took place exactly two weeks after the arrival of newcomers in the surgery and traumatology clinical rotations. This timing was chosen because third- and fifth-year medical students had completed their introductory lectures on history taking for junior and senior clerkships whereas intern doctors had completed their orientation into the surgery department, by that point. On average 12 [5–23] training courses were conducted per site, following a three-months' time-series cycle, in accordance with the schedule for internship deployment by the Ugandan ministry of health, and commensurate to the duration of clinical rotations in Ugandan medical schools. Further, the effects of the training were assumed to decay after this period since previous studies had demonstrated that post-training scores assessed in this period did not statistically differ from those performed at 12 to 24 months follow-up [30]. The program was initially designed for one day, targeting 30 participants with a trainer: trainee ratio of 1:10. However, this arrangement was later amended when the study was halted by the research and ethics committee shortly after the first two series due to Covid-19 lock downs during March 2020 to March 2021. On resumption of the study in April 2021, the educational activity was converted into a two-days event with trainers: trainee ratio of 1:5 due to Covid-19 local regulations and ethics on public gatherings which restricted the maximum number of participants per event to 20. The other aspects of the training such as data collection methods, variable coding, mode of course delivery and its content were not modified for the remaining ten series of the study period.

The two-days training took a total of eight contact hours in accordance with the committee on trauma of the American College of Surgeons [22], and occurred between 9:00am to 15:00pm with a coffee break of 45 min between sessions on each day of the training. On each opening day of the training, all participants except traffic law enforcement professionals completed pre-training MCQs which were administered individually in "an exam-like" supervised environment during the first 40 min before random team assignment. The training was then delivered in a modular fashion where the first half of modules i.e., (i) introduction to rural trauma systems, primary and secondary survey, (ii) Case scenarios were delivered on the first day, and the remaining half i.e., (iii) trauma communication, (iv) patient safety and process improvement were completed on the following day.

Learning environment and incentives

The physical learning environment for this activity were designated spacious multimedia surgical simulation rooms at the respective teaching hospitals. There were no monetary incentives for participants. However, participation was free with sponsored coffee breaks, and eight continuous professional development (CPD) points were endorsed in the participants' logbooks to maximize attendance.

Course content, learning goals and strategies

The training began with a pre-course questionnaire followed by a brief introduction to rural trauma systems. The teams were assigned specific tasks such as team leader or member to role play a surgeon, surgeon assistant/intern, an anesthesiologist/anesthetic assistant, emergency room nurse, and rescue police (representing paramedics in Uganda's context).

Traffic police officers received training in several critical areas, including the assessment of signs of life, the administration of chest compressions, and safe pre-hospital transportation. Their training encompassed techniques for controlling bleeding through the application of pressure, the implementation of the recovery position, and the immobilization of the head and neck. Additionally, officers were instructed on the proper methods for moving patients with suspected spinal injuries and on effective pre-hospital communication, which includes providing concise handover reports to receiving emergency departments. We identified local resources and limitations and demonstrated trauma resuscitation through lectures and simulated case scenarios using locally feasible: resuscitation equipment, dummies, PowerPoint projections and videos.

For medical trainees, we discussed trauma radiographs in addition to the above, with an emphasis to demonstrate to participants a sequential approach to trauma, i.e., primary survey, timely transfer decisions, secondary survey, and process improvement; leveraging on trauma case scenarios that are commonly admitted at these facilities.

To evaluate the extent to which participants apply their learning in accordance with the Kirkpatrick model (levels 1–3) for training evaluation [31], teams were instructed to manage simulated trauma case scenarios. During these simulations, participants were observed for their ability to conduct primary and secondary surveys, as well as to demonstrate teamwork, leadership, and communication skills in making timely decisions regarding consultation with senior faculty or patient transfer.

Subsequently, participants were assigned the responsibilities of conducting peer reviews, auditing team performance, and identifying areas for improvement to enhance patient safety. Special attention was given to how the team's approaches might differ when addressing the needs of vulnerable trauma populations, such as children, the elderly, and pregnant women, particularly in low-resource environments.

Lastly, teams received expert feedback based on the roles assigned to skilled team members, in accordance with the goals established by the committee on trauma in the fourth edition of the RTTDC [22]. This feedback was also informed by the Trauma Non-Technical Skills Scale (T-NOTECHS) [32], which has been validated for training trauma teams [33], as outlined in the study protocol [29]. In turn, participants provided their feedback through a structured post-course evaluation form after the final session on the second day of training and completed post-course MCQs 90 days after the first day of training.

The overall learning outcomes of the training were designed to ensure that participants possess a competent understanding of the components of their local trauma systems, recognize their resource capacities and knowledge limitations regarding potential barriers to injury care that necessitate transfer, and demonstrate proficiency in the execution of trauma resuscitation. This includes a particular emphasis on basic pre-hospital management, pre-referral treatment, and effective communication between referring and receiving hospitals. These expectations align with the goals established for the RTTDC by the Committee on Trauma of the American College of Surgeons [22].

All participants were instructed to complete a 15-minute course evaluation form following the final session on the last day of the training. Subsequently, medical participants were contacted 90 days after the initial training day to complete individually administered, trauma-based multiple-choice questions (MCQs) in a supervised

environment designed to resemble an examination, with a time limit of 40 min. The pre- and post-training assessment for traffic law enforcement professionals was restricted to the T-NOTECHS, as the technical trauma knowledge-based MCQs were deemed too advanced for lay responders.

Validity and quality control

To minimize inter-operator variations, we ensured high implementation fidelity by strictly adhering to the course content and established protocols. Case scenarios were presented to designated teams in clear, straightforward English, Uganda's official language, during scheduled sessions. The duration of these sessions was consistent across all teams, and attendance tracking was feasible due to the involvement of only three instructors who consistently delivered the training. Participants received materials, including audiovisual aids, in advance to enhance comprehension. Additionally, the key trainer completed a master class in delivering the RTTDC module. Pre- and post-test MCQs underwent pre-testing, resulting in a Cronbach's alpha coefficient of 0.9. These MCQs were subsequently assessed by two independent, blinded offsite surgeons, who achieved a 100% inter-rater agreement. This agreement was validated by the study administrator, who obtained a copy of the marking guide prior to the final data entry. Further details on the training methodology are available in the study protocol [29].

Data collection and statistical analysis

A standardized assessment consisting of 20 MCQs was administered both before and after the course. The desirability of the training and its content was evaluated using a 5-point Likert scale, where 5 indicated "strongly agree," 4 indicated "agree," 3 indicated "neutral," 2 indicated "disagree," and 1 indicated "strongly disagree," across 16 topics. Additionally, the relevance of the quality improvement, case scenarios, and communication course modules to the study subjects was rated on a 3-point Likert scale based on their subjective impressions, with 3 denoting "very relevant," 2 denoting "relevant," and 1 denoting "not relevant." The selected 16 topics and assessment methods had been previously validated [34].

The data were collected in hard copies, entered into the Research Electronic Data Capture (REDCap) hosted by the University of Turku, and later exported to Stata version 15.0 for analysis. The REDCap software was preferred due its presumed secure web-based intuitive interface for validated data capture, offering an additional advantage to retrieve audit trails for tracking data manipulation [35]. Further, the software permits seamless data export and download procedures that are compatible with commonly used statistical packages such as Stata, while allowing for data integration and interoperability with external sources [36].

We tested the data for normalcy using the Shapiro-Francia test and normal histogram curves at 95% CI, regarding $p<0.05$ as statistically significant. The pre-test scores were normally distributed ($z=0.359$, $p=0.36$) whereas the post-test scores were skewed ($z=1.777$, $p=0.04$).

Since the data were skewed, non-parametric tests were used to report the findings. Assuming a null hypothesis of no difference, Friedman non-parametric test was used as a surrogate to one way analysis of variance to estimate the difference between pre- and post-course mean MCQ scores as a measure of knowledge retention.

We conducted the Wilcoxon signed-rank non-parametric test to assess the differences in the impact of training on MCQ scores of various medical trainees. We reported the median scores along with their corresponding interquartile ranges, stratifying the results by pre- and post-COVID cohorts during the exploration analyses. Furthermore, we compared the statistical differences in rank sums concerning median scores, desirability, and relevance of course elements across medical trainees and law enforcement participants using a non-parametric Kruskal-Wallis (H) test.

Additionally, we conducted time-series autoregressive integrated moving average (ARIMA) models and developed graphics to illustrate autocorrelation trends in MCQ performance among study participants over time. Lastly, we employed the Wilcoxon signed-rank and Kruskal-Wallis tests on 100 trained teams to examine differences in overall median scores for the five T-NOTECHS domain items, both before and after training, and across team compositions (police alone, medical trainees, and combined police and medical trainees) for various case scenarios (see Appendix 1). All the analyses were performed using Stata version 15.0. (StataCorp. 2017. *Stata Statistical Software: Release 15.* College Station, TX: StataCorp LLC); at 95% confidence interval, regarding a 2-tailed p-value <0.05 as statistically significant.

Results

By the end of the study period, 500 participants were trained, including 135 (27.0%) females and 365 (73.0%) males. The proportions by gender did not differ significantly across time series ($p=0.071$). There were 66 (13.2%) traffic law enforcement officers and 434 (86.8%) medical trainees (Fig. 1).

The overall median pre-course scores were 60.0%, IQR (50–65) compared to 80.0%, IQR (70–85) post-course (Fig. 2).

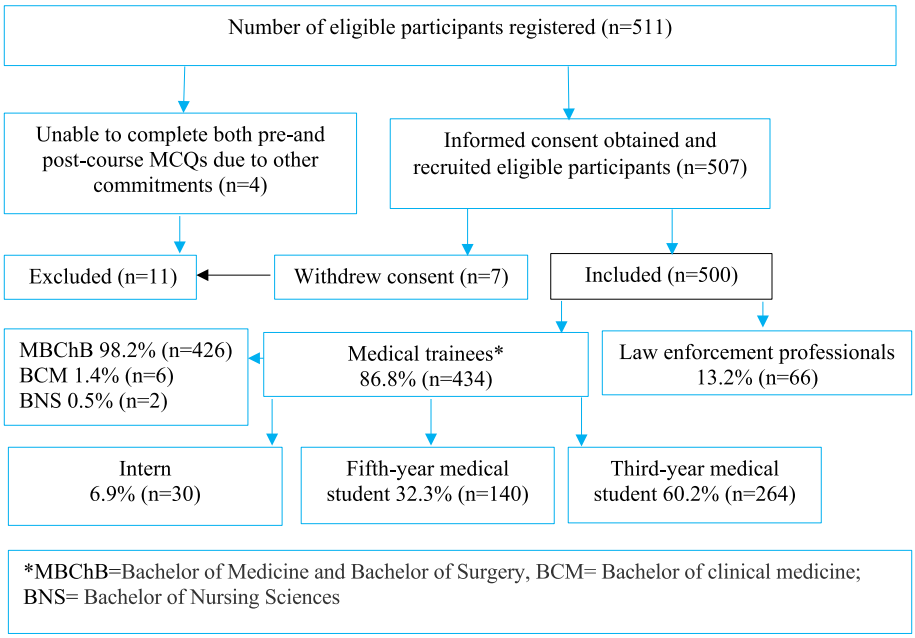

Fig. 1 Flow diagram showing recruitment of study participants

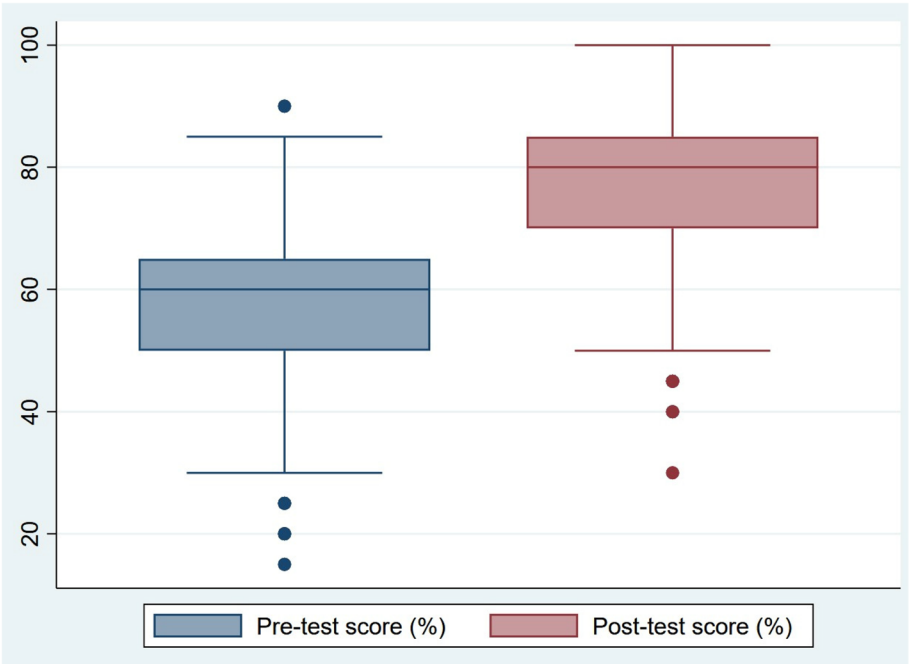

Fig. 2 Box plot showing overall effect of training on MCQ scores of participants

The training led to statistically significant difference in pre-and post-course row mean MCQ scores (Q (3) = 290.51, $P < 0.0001$). Wilcoxon signed rank (matched pairs) showed a difference between pre – and post-course mean MCQ scores of 16.7% which was statistically significant ($p < 0.0001$). There were 82.5% ($n = 359$) comparisons for which the post-course was greater than pre-course, 11.5% ($n = 50$) in which the scores were equal, and 5.8% ($n = 25$) comparisons in which the post-course was less than the pre-course score.

The increase in test scores was highest amongst intern doctors and third year medical students, with a tendency towards bridging the knowledge gap between the third year and fifth year students. Kruskal-Wallis for pre-test scores were (intern vs. third year $p<0.001$, intern vs. fifth year $p=0.353$, fifth year vs. third year $p<0.001$). The Kruskal-Wallis for post-test scores were (intern vs. third year $p<0.001$, intern vs. fifth year $p=0.003$ and fifth year vs. third year $p=0.260$) (Fig. 3).

Of the 20.75% (90) vs. 79.3% (344) medical trainees who were trained before and after COVID-19 pandemic respectively, the median pre-training scores were higher post-COVID-19 [55%, IQR (50–60) vs. 60%, IQR (50–70), $p<0.001$] whereas the post-training scores did not differ significantly before and after COVID-19 pandemic respectively [80%, IQR (70–85) vs. 80% (70–85), $p=0.509$] (Fig. 4).

The majority participants strongly affirmed that this educational activity was excellent for promulgation in Uganda 77.8% ($n=389$) and relevant to their educational 81.0% ($n=405$), and work environment 79.8% ($n=399$). All modules including process improvement for patients' safety, communication, and case scenarios were highly rated above 76.0% as very relevant (Table 1).

The module ranking did not differ significantly across all cadres ($p>0.05$) (Table 2).

Using the auto regressive integrated moving average (ARIMA) model (1, 0,1) with zero differencing, and zero outliers based on the first and last participant, the correlogram lag for post-training scores demonstrated a decay effect with a marginal statistically significant coefficient ($p=0.05$) whereas the coefficient for pre-training scores did not ($p=0.23$) (Appendix 2). The transformed and non-transformed correlograms did not differ in magnitude. Using the non-transformed autocorrelations with ARIMA (p, 1, q) model, 425 computable lags remained after first order differencing and both auto (Fig. 5A and B) and partial (Fig. 6A and B) correlograms demonstrated one predominant lag and a decay effect of ARIMA process.

The results from stratified analyses of the T-NOTECHS domains for five distinct case scenarios assessed with 100 five-member teams comprising medical trainees alone ($N=20$), traffic police alone ($N=20$), or a combination of both ($N=60$) indicated that the overall median (interquartile range) pre-training and post-training T-NOTECHS scores were 12 (9-14) and 17 (15-20), respectively ($p<0.001$). Furthermore, all team compositions exhibited an increase in post-training scores across the various case scenarios (see Fig. 7A and B).

Discussion

This study evaluated the feasibility of rural trauma team training amongst medical trainees and law enforcement first responders in a low-income country. We found that the majority 77.8% (389/500) strongly affirmed that this educational event was excellent for promulgation in other rural parts of Uganda and was regarded as relevant

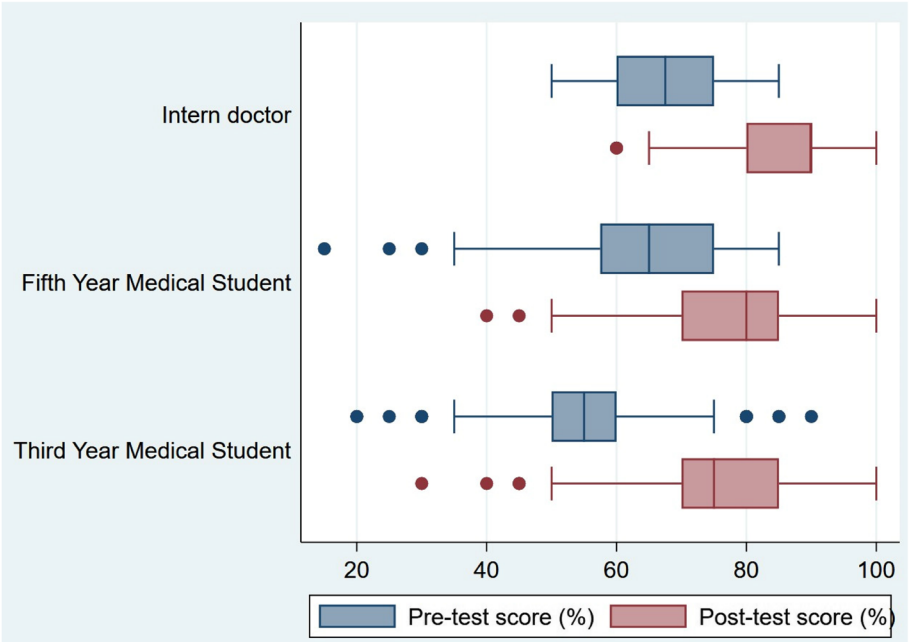

Fig. 3 Box plot showing effect of training on MCQ scores amongst the various cadres

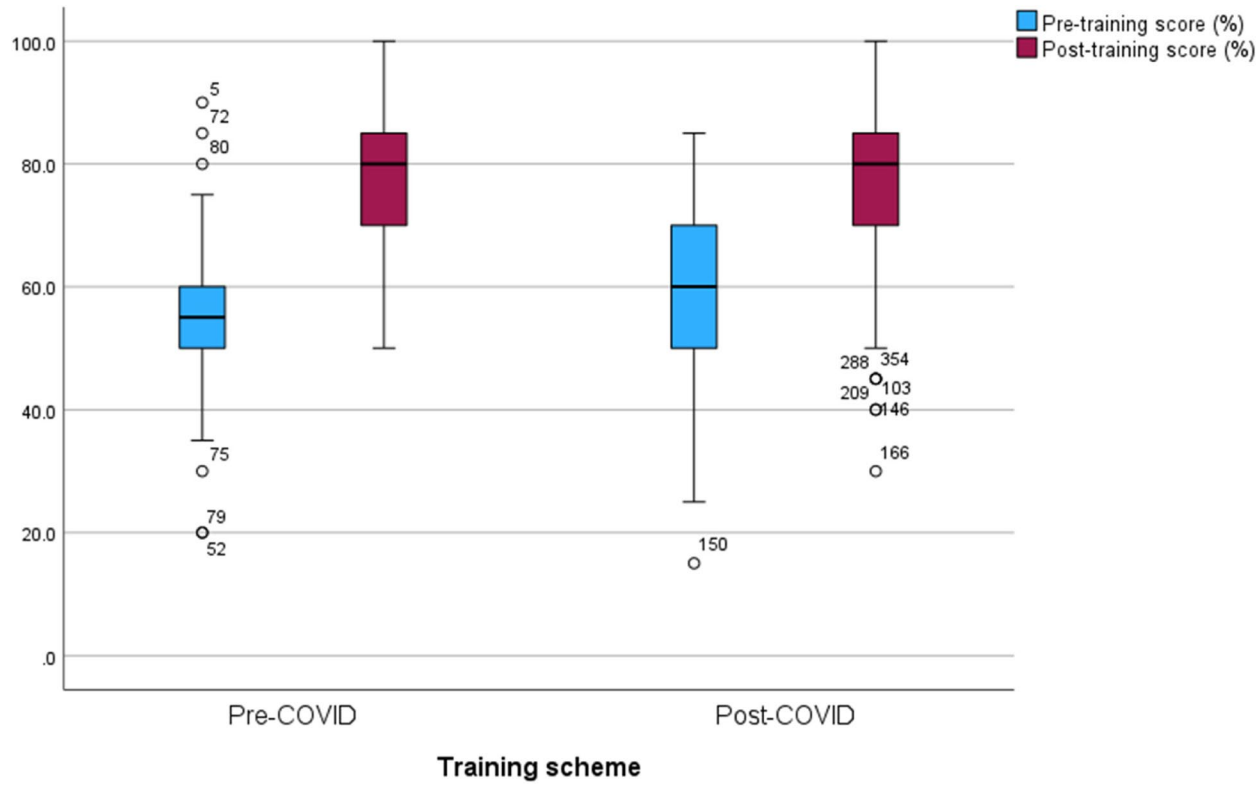

Fig. 4 Comparison of pre- and post-training scores before and after COVID-19

for both their educational 81.0% (405/500), and work needs 79.8% (399/500). There was sufficient evidence that the training had a significant positive effect on the scores of course participants with an overall 16.7% increase in trauma knowledge based MCQs ($p < 0.0001$) and 31.5% (6.3/20) increment in T-NOTECHS ($p < 0.001$). Further, the effect of the training on the knowledge of participants was noticed across all series over the study period with demonstrable decay effect of ARIMA process. Our findings are comparable to those of Ali et al. [34], in which nearly 90% of course participants strongly agreed to its scalability in India, with the mean number of wrong answers decreasing from 13.6 ± 1.4 pre-course to 6.8 ± 0.1 post-training.

Furthermore, although our results from T-NOTECHS may be susceptible to floor and ceiling effects, particularly among law enforcement professionals, they align with studies conducted in the United States. For instance, one conducted at seven critical access rural hospitals in which participants' knowledge of their team roles increased by 16% ($p = 0.02$) post training [37], and another one of nursing staff in which positive perception to the course was reported at 96.3%, and after the training, reasonable improvements were noticed in 68.4% (13/19) of the assessed knowledge items [24].

In terms of policy implications, and to put this research in context; there is compelling evidence from high-income countries to suggest that RTTDC capacitates timely decisions to transfer trauma patients who exceed the capacity of local resources [38] by reducing: emergency department and referral transit times [23], time to definitive injury care [39], lengths of hospital stay [24], and consequently appearing to improve injury outcomes [24]. However, unlike high-income regions such as the United States [37], Europe [40], and those in Asia [41], most LMICs in Africa lack formalized multi-disciplinary physician led pre-hospital and emergency care systems [42]. For instance in the past two decades, evidence shows that the majority (>90%) of trauma patients in rural Uganda are dropped at hospital emergency departments by police trucks or by public means which have no provision for patient beds other than the bare truck-floor as the countrywide ambulance coverage is reported at less than 45% [12]. Moreover, the above means of transportation requires out-of-pocket payment, yet most of the ambulances being used in the country lack equipment and skilled personnel to offer any primary care but rather act as "quick evacuation vehicles". Further, Ningwa et al. [12] recently established that 91% of emergency room staff across all cadres in (101 of 111) evaluated

Table 1 Showing participants' ranking of the educational value of keys aspects of the training

Rating		**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
Topics		n (%)	n (%)	n (%)	n (%)	n (%)
1	Overall, this educational activity was excellent for promulgation	389(77.8)	101 (20.2)	9(1.8)	0(0.0)	1(0.2)
2	Program topics and content met the stated objectives	333(66.6)	155 (31.0)	9(1.8)	2(0.4)	1(0.2)
3	Content was relevant to my educational needs	405(81.0)	84(16.8)	9(1.8)	0(0.0)	2(0.4)
4	Educational format was conducive to learning	312(62.4)	159(31.8)	24(4.8)	4(0.8)	1(0.2)
5	Acquired knowledge will be applied in my practice environment	399(79.8)	84(16.8)	15 (3.0)	1(0.2)	1(0.2)
6	I will seek additional information on this subject	263(52.6)	189(37.8)	45(9.0)	1(0.2)	2(0.4)
7	Program was fair, objective, and unbiased towards any product or program	305(61.0)	154(30.8)	38(7.6)	2(0.4)	1(0.2)
8	Power point slides are professionally written, visually appealing with good references	324(64.8)	142(28.4)	27(5.4)	7(1.4)	0(0.0)
9	The audio-visuals enhance the presentation	337(67.4)	135(27.0)	21(4.2)	6(1.2)	1(0.2)
10	Course format (lecture/ skill station scenarios) stimulates critical thinking	344(68.8)	132(26.2)	21(4.2)	4(0.8)	0(0.0)
11	Content is organized in a concise and logical sequence	325(65.0)	144(28.8)	23(4.6)	8(1.6)	0(0.0)
12	Instructor has knowledge about content	426(85.2)	57(11.4)	16(3.2)	0(0.0)	1(0.2)
13	Instructor presentation style keeps learner's attention	383(76.6)	97(19.4)	17(3.4)	2(0.4)	1(0.2)
14	Instructor uses examples to illustrate major points	414(82.8)	70(14.0)	13(2.6)	3(0.6)	0(0.0)
15	Instructor presents content accurately and confidently	419(83.8)	68(13.6)	12(2.4)	1(0.2)	0(0.0)
16	Instructor answers questions in a supportive manner	415(83.0)	68(13.6)	14(2.8)	3(0.6)	0(0.0)
Ranking the relevance of key course modules						
Score (Rank)		Performance improvement & patient safety module		Communication module		Case scenarios Module
1	Not relevant	8(1.6)		2(0.4)		8(1.6)
2	Relevant	92(18.4)		114(22.8)		111(22.2)
3	Very relevant	400(80.0)		384(76.8)		381(76.2)

hospitals in Uganda lacked any specific training in handling emergencies. These inadequacies for trauma care both prior to hospital arrival and on arrival at emergency departments only imply fewer chances of survival for the injured patients in the hands of unskilled post-crash care providers. Rural trauma team development training could be an ideal skills-bridging course to improve care during transit and on arrival to casualty departments. Moreover the course has been proven to instill confidence amongst injury care givers [37]. Emerging evidence from African contexts indicates that trained response teams, including police personnel, are likely to utilize at least one of the skills acquired during such training [43, 44].

In agreement with findings of Ali et al. [34], all the course elements including trauma communication, case scenarios, process improvement and patient safety scored above 76% as being very relevant across all cadres. This means there should be efforts to incorporate such training within the educational curricula of these participants. The design of the curricula should be formulated in such a way as to include all the modules. Priority support is critical to broaden the size and competency skills-base to sustain existing primary care providers, attract the younger generation to join the industry, and to provide an opportunity for inventing new law enforcement cadres to whom basic but critical skills such as safe emergency

Table 2 Showing comparisons of module rankings amongst the various cadres of course participants

Variable	Observations N=434	Kruskal Wallis (H) Rank sum	X^2	*p*-value
Process improvement for patients' safety			5.089	0.1654
Intern doctor	30	9015		
Fifth year medical student	140	34540		
Third year medical student	264	66536		
Traffic Police Officer	66	15159		
Communication module			3.773	0.287
Intern doctor	30	8259		
Fifth year medical student	140	33230		
Third year medical student	264	65699		
Traffic police officer	66	18062		
Case scenarios			3.587	0.3097
Intern doctor	30	8562		
Fifth year medical student	140	36639		
Third year medical student	264	64017		
Police officer	66	6032		

evacuation could be task-shared. This arguably inclines more accountability to the sectors involved whose primary mandate is not health and retains core skills for societal benefit. Inclusive planning which involves services that would otherwise have no trauma designation has been identified as core to expanding and functionalizing complex rural trauma systems [45]. The alternative would be under-utilization of a capable and needed force to augment trauma care.

An effective strategy to expedite the implementation of such trauma education programs involves international collaborations and the use of virtual technologies. A notable example of this approach was the implementation of community-based emergency first aid responder systems in South Africa [44] and Rwanda [46]. These initiatives, in partnership with local and international stakeholders, significantly enhanced the functionality of their emergency medical services.

Alternatively, novel joint trauma education centers could be established to serve two or more university teaching hospitals, as evidenced by research conducted in the United States [47]. Additionally, telemedicine could be utilized for trauma training and the enhancement of rural trauma systems, as demonstrated in Australia [45]. However, our experience, in conjunction with findings from community-based emergency response systems in South Africa [44] and Rwanda [46] demonstrate that successful implementation of such programs necessitates the resolution of technological limitations, such as electricity and internet disruptions, alongside enhancing secure electronic data systems to track patient outcomes linked to the training. Thus, adequate funding through multidisciplinary collaboration and external partnerships is essential to standardize the training and impact assessment tools, vital for sustainability and improved health outcomes.

Furthermore, successful implementation of such trauma education program necessitates improved trauma coordination to link the training to patient outcomes. The communication module in this study identified significant barriers to effective communication, including inadequate technologies, network failures with emergency toll-free numbers, lack of a common language between law enforcement teams evacuating trauma patients and recipient hospitals, and the absence of designated contact persons among law enforcement professionals for trauma evacuations. These challenges adversely affect the coordination and delivery of emergency trauma care. A recent study in Uganda found that only 50% (26/52) of emergency service providers notified recipient facilities prior to transfer, with the quickest response time recorded at one hour, well above the recommended five minutes [12]. Training for rural trauma teams offers an opportunity to address these challenges, enhancing communication between pre-hospital care providers, non-trauma facilities, and trauma centers by plain language as a critical competency.

Finally, incorporating medical trainees and traffic law enforcement personnel into trauma teams necessitates a thorough understanding of their barriers to injury care. The lack of protected time for continuous professional development contributes to burnout and the subsequent exodus of junior doctors to high-income countries, undermining the accumulation of qualified staff in

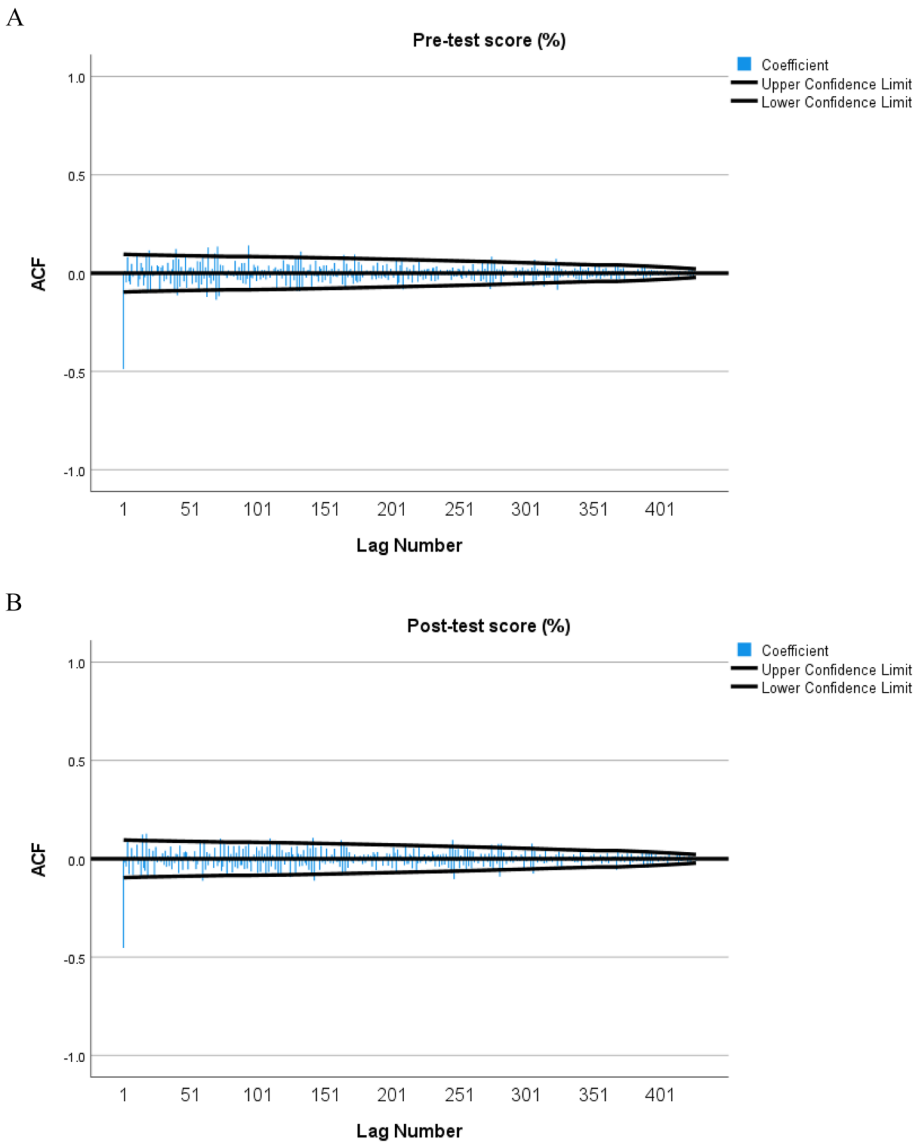

Fig. 5 **A** Auto correlogram with ARIMA (p, 1, q) model pre-training scores. **B** Auto correlogram with ARIMA (p, 1, q) model for post-training scores

LMICs. Conversely, dedicating time to trauma education for medical students is crucial for attracting graduates to trauma care specialties [48].

Study strengths and limitations

This long-term multi-center research adds to the existing works of Jayaraman et al. [13], Ndile et al. [49] and Slingers et al. [44] among others who have examined rural trauma training response amongst medical and lay persons in LMICs, thus our findings truly represent the underutilized potential human resources for health in our setting. However, this research was not exempt from limitations. First, this study used subjective assessment of participants' perceptions towards relevance of the training in addition to purposively recruiting law enforcement participants which could result in selection bias. Secondly, our trauma team training construct simulation with police and medical trainees could potentially differ from the physician-staffed emergency medical services and trauma teams in high income settings [50], thus limiting the generalizability of our findings; although the validity of team concept cuts across all trauma systems. Moreover, due to the perceived lack of prior theoretical exposure to clinical settings, we did not administer the technical trauma knowledge-based MCQ assessment for traffic law enforcement participants. Consequently, aside from the observed changes in T-NOTECHS, we lack

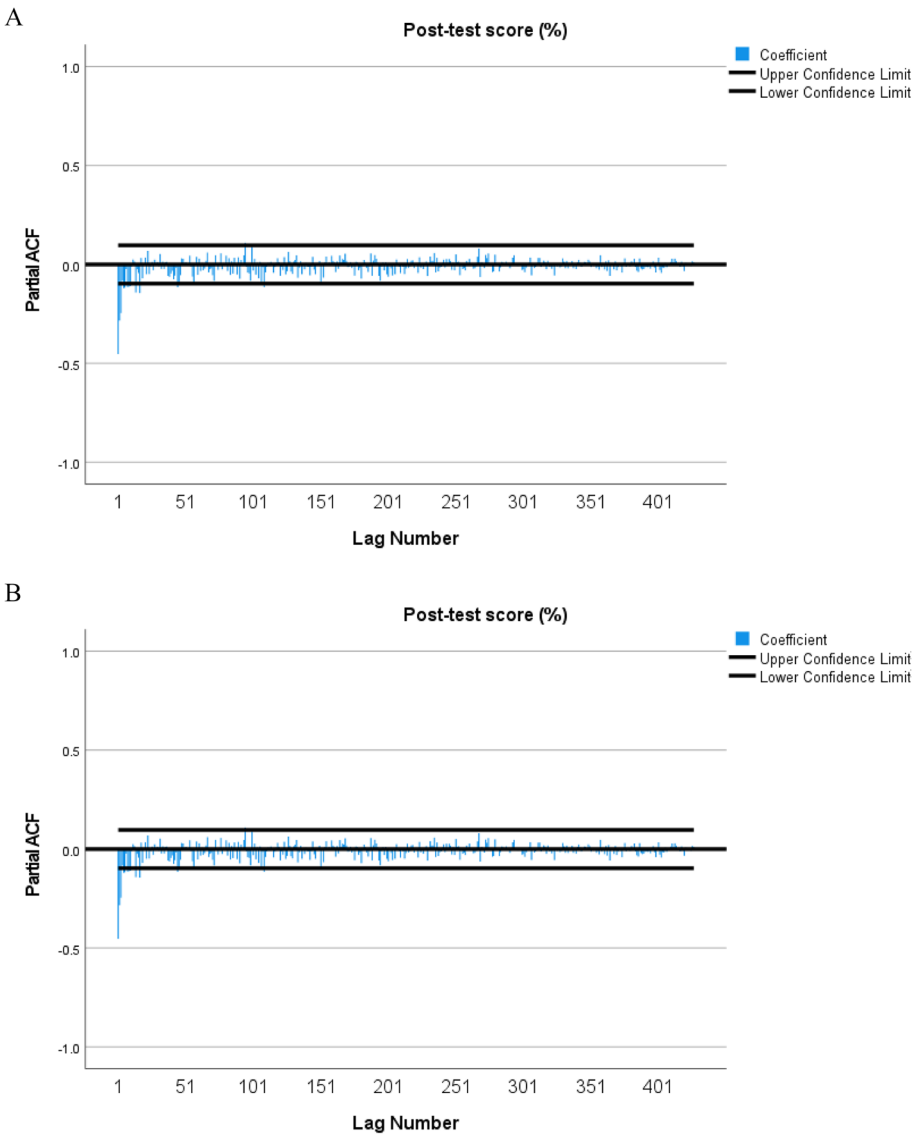

Fig. 6 **A** Partial correlogram with ARIMA (p, 1, q) model for pre-training scores. **B** Partial correlogram with ARIMA (p, 1, q) model for post-training scores

objective measures to report regarding theoretical knowledge gain in this category.

Furthermore, the Friedman test in this study does not assess raw confidence levels post-training but rather the extent of improvement after the training. However, a meaningful effect size is likely in this case since a minimum sample of 30 participants is deemed adequate for research on educational programs [51], and our study had a sample size of 500. Lastly, an individual's knowledge and behavior could change over time without any intervention which in addition to carry-over effects from other clinical knowledge exposure during medical training could account for data variability resulting in higher pre-training scores in the post-COVID cohort, thus having a separate control group with additional data points before and after the intervention could yield more reliable results. However, in the face of financial and human resource constraints, the research and ethics committees did not find merit in assessing 500 controls on a totally new concept as this would strain the already scarce health workforce. Instead, the committees strongly believed that multiple interrupted time series of trainings would minimize this bias in accordance with Wagenaar et al. [52]. Conversely, the absence of a separate control group in this multicenter study minimizes confounding from group differences, although heterogeneity among

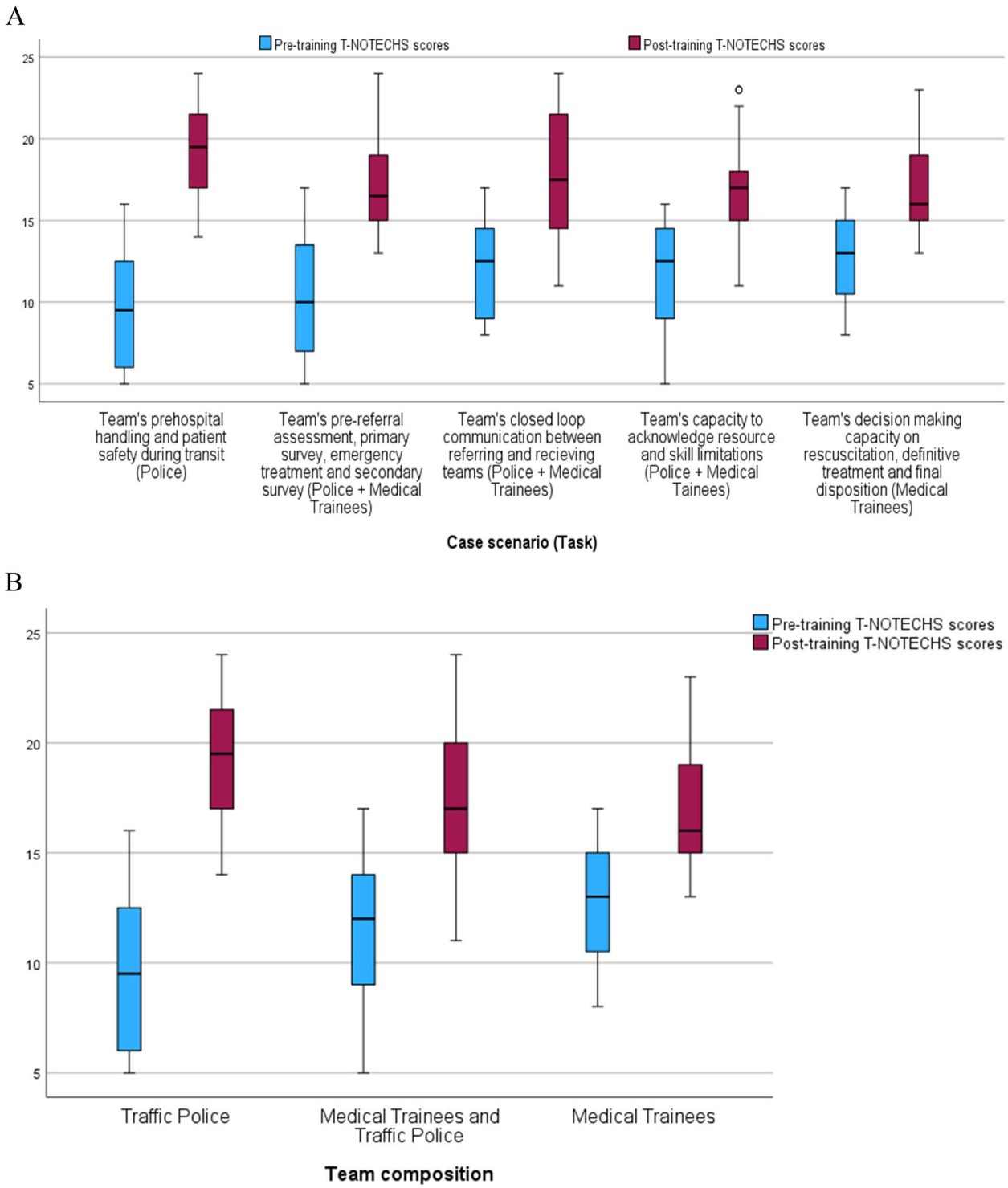

Fig. 7 A Pre-and post-training T-NOTECHS scores for the various case scenarios. **B** Pre-and post-training T-NOTECHS scores for the various team composition

the various study centers cannot be eliminated. Thus, in the context of limited resources, this study supports existing evidence concerning the potential integration of

lay response teams to improve emergency medical services in LMICs [13, 44].

Conclusion

The results of this study demonstrate that locally contextualized rural trauma team training is feasible, highly acceptable and regarded as relevant amongst medical trainees and law enforcement professionals. The subsequent phase of our research will involve examining the practical implications of integrating these groups into actual rural trauma teams, with particular emphasis on connecting the training to patient outcomes and identifying potential barriers [26]. This investigation aims to inform the design of future effective trauma care systems and complete the Kirkpatrick model (level 4) for the evaluation of this training [31].

Abbreviations

ATLS	Advanced Trauma Life Support
ETC	European Trauma Course
LMICs	Low-and Middle-Income Countries
NTMC	National Trauma Management Course
PTC	Primary Trauma Course
RTTDC	Rural Trauma Team Development Course
T-NOTECHS	Trauma Non-Technical Skills Scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-06755-1.

Additional file 1. Microsoft Excel Comma Separated Value File Dataset (Pre- and post-training trauma knowledge based MCQ scores).

Additional file 2. Microsoft Excel Comma Separated Value File Dataset (Pre- and post-training T-NOTECHS).

Additional file 3: Appendix 1. Themed team case scenarios and their pre- and post-training assessment based on Trauma-Non-Technical Skills (T-NOTECHS).

Additional file 4: Appendix 2. ARIMA model (1, 0,1) of pre- and post-training scores for ten data points based on first and end participant.

Acknowledgements

The authors thank Drs: Asiimwe Daniel, Oguttu Benson, Kakeeto Andrew, Kabarokole Annet, and Namutosi Esther who participated in organization of the training sessions and consented for their names to be published. Further, authors thank all the study participants who devoted their time to this educational activity. Lastly, we are grateful to Ms. Mary Nnabagulanyi who provided offsite administration and coordination for this study.

Authors' contributions

HL Principal investigator; HL, MLW Conceptualization; HL Data curation, Investigation, Methodology, Project administration, Resources; HL, MM Formal analysis, Software, Visualization; HL Writing-original draft. RS, PK, JPP, MLW Validation, Writing-review, and editing; JPP, MLW Supervision, Funding acquisition. All authors read and approved the final manuscript for submission.

Funding

HL was supported by Neurocentre, Turku University Hospital, Finland (grant no VTR2023). JPP was supported by the Academy of Finland (grant no 17379) and the Maire Taponen Foundation. The study sponsors did not have any role in the design, collection, analysis, interpretation, writing or decision to submit the study report for publication.

Data availability

The dataset supporting the conclusions of this article is included within the article as additional files 1 and 2. Since the primary country of recruitment which approved the study lacked a publicly available electronic research register, this study was retrospectively registered with research registry (UIN: researchregistry9490).

Declarations

Ethics approval and consent to participate

This study received approval and registration from the research and ethics committees of Mbarara University of Science and Technology (Ref: MUREC 1/7; 05/5–19) and the Uganda National Council for Science and Technology (Ref. No. SS 5082) prior to recruitment. It was conducted in accordance with the US National Institutes of Health guidelines for research involving human subjects, adhering to ethical standards outlined in the Declaration of Helsinki and its subsequent amendments. Written informed consent was obtained from all participants before recruitment. Participation was voluntary, and participants had the right to withdraw from the study at any time.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Surgery, Kiryandongo Regional Referral Hospital, Kigumba, Uganda. [2]Injury Epidemiology and Prevention (IEP) Research Group, Turku Brain Injury Centre, Department of Clinical Neurosciences, Turku University Hospital and University of Turku, Turku, Finland. [3]Center for Health Equity in Surgery and Anesthesia (CHESA), University of California San Francisco (UCSF), San Francisco, USA. [4]Department of Surgery, Mengo Hospital, Kampala, Uganda. [5]Mother Kevin Postgraduate Medical School, Uganda Martyr's University, Nkozi, Uganda. [6]Neurocentre, Department of Neurosurgery and Turku Brain Injury Centre, Turku University Hospital and University of Turku, Turku, Finland. [7]Heidelberg Institute of Global Health (HIGH), University Hospital and University of Heidelberg, Heidelberg, Germany.

Received: 15 September 2023 Accepted: 23 January 2025
Published online: 29 January 2025

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Publisher's Note

Herman Lule Chief of Surgery, Kiryandongo Hospital, Kigumba, Uganda; Doctoral Researcher, Injury Epidemiology and Prevention Research Group, Turku Brain Injury Center, Department of Clinical Neurosciences, Turku University Hospital and University of Turku, Turku, Finland. Perioperative Fellow, Center for Health Equity in Surgery and Anesthesia (CHESA), Institute for Global Health Sciences, University of California, San Francisco, USA.

Micheal Mugerwa Biostatistician and Applied Epidemiologist, Injury Epidemiology and Prevention (IEP) Research Group, Turku Brain Injury Centre, Department of Clinical Neurosciences, Turku University Hospital and University of Turku, Turku, Finland.

Robinson Ssebuufu Associate professor of Surgery; Director of Medical Education, Training and Research, Department of Surgery, Mengo Hospital, Kampala, Uganda; Chair of Ethics and Disciplinary Committee, Uganda Medical and Dental Practitioners' Council.

Patrick Kyamanywa Professor of Surgery; Fellow of High Education Academy, and Vice Chancellor of Mother Kevin Postgraduate Medical School, Uganda Martyr's University, Nkozi, Uganda.

Jussi P. Posti Adjunct Professor of Neurosurgery; Head of Department of Neurosurgery, Brain Injury and Rehabilitation, Turku University Hospital and University of Turku, Turku, Finland; Adjunct Professor of Neurotraumatology, University of Helsinki, Helsinki, Finland.

Michael Lowery Wilson Adjunct Professor and Head of Injury Epidemiology and Prevention, Heidelberg Institute of Global Health (HIGH), University Hospital and University of Heidelberg, Heidelberg, Germany.