Feasibility of rural trauma team development amongst medical trainees and traffic law enforcement professionals in a low-income country: A prospective multi-centre study of interrupted time series of interventional training

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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 the use of rural medical trainees and road traffic law enforcement professionals in the formation of rural trauma teams in Uganda.

Methods

Multi-center interrupted time series of interventional rural health professions education, using the American College of Surgeons' 4th edition of rural trauma team development course model. Trauma related multiple choice questions (MCQs) were administered 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. The overall 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 promulgation 389 (77.8%), relevance to their educational 405 (81.0%), and work needs 399 (79.8%). All the course elements scored above 76.0% as being very relevant.

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)

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 “skeleton staff” effects of brain drain from low-income countries (5), 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) (6), and the Advance Trauma Life Support (ATLS) course influence self-efficacy and behavioural change during clinical practice (7). 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 (8), (9). 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 (8). Besides, most studies have exclusively limited the educational programs to hospital-based medical providers (10), without involving rural medical trainees and road traffic law enforcement professionals who are the most accessible frontliners following rural traffic crashes in Uganda (11).

Uganda is one of the LMICs that lacks both universal health care coverage and formal pre-hospital care systems (3) which complicates injury outcomes (11). Further, the Ugandan doctor to patient ratio of 1: 25,000 for its 45.8 million population is worrisomely lesser than the world average of 49 per 10,000 individuals (3). As such, Uganda boosts of only 0.7 surgeons for every 100,000 people (12), below the minimum WHO staffing standards for universal access to essential safe surgery (13). 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 (14). Strengthening capacity for human resource in LMICs is critical for functional trauma systems (15), (16), and is in line with the 2030 agenda for realizing the sustainable development goals on universal health care coverage (17). The six-year long Ugandan undergraduate medical curriculum is designed such that interns and trainees in clinical rotations make the first contact with patients prior to senior consultancy. In

lieu of the country's skeleton 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) (7) 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. On the other hand, the alternative primary trauma course (PTC) (18) was unsuccessful due to its limited impact on decreasing mortality, and its minimal acceptance for international labor markets (9). Recalling that 74% of Ugandans live in rural areas (19), rural trauma team development course (RTTDC) (20) 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 has demonstrated its potential for trauma-related mortality reduction (21), but to a greater extent, has been appraised in high-income countries (22). 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 (23). However, Ugandan studies which have examined the feasibility, application, and results of rural trauma team development in such settings are scanty. 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 resource 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 development amongst these cadres, using the RTTDC model (20). This study was nested in a progressing clinical trial on the use of allied health and law enforcement trauma registries in Uganda (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 null hypothesis of this study was that there is no difference in pre-and post-interventional training mean or median scores of research participants. According to Brown et al (10), pre-and post-training knowledge assessment is the most used metric to evaluate educational programs. The secondary outcome of this study was to determine the level of acceptability and relevance of this training to the educational and work needs of study participants expressed as percentage.

M**ethodology**

Study design

This was a multi-centre interrupted time-series of interventional training conducted during 28th September 2019-28th August 2023. This manuscript was developed in accordance with the proposed recommendations for reporting of interrupted time-series (24), and in line with guidelines for reporting evidence-based practice educational interventions and teaching (GREET) (25).

Study settings and study population

This study was conducted in three specialized referral and 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.

The study subjects were medical trainees and traffic law enforcement professionals. We targeted medical trainees/interns completing the surgery and traumatology rotations during the study period and police officials who were nominated by their leaders to complete the training by virtue of their roles, targeting police stations on main highways leading to the respective municipalities where the study sites were located. Consequently, the researchers recruited 66 traffic police officers and 434 medical trainees. The sample size 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 (26).

Inclusion criteria

i. Road traffic officers who were concerned with evacuation of patients who sustain road traffic crash.
ii. Medical interns (doctors/nurses) undertaking 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 had completed or were completing the surgical and traumatology clinical rotations at one 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 (20) 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

the 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. Three 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 one the desired effects of the course, 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 interns in Uganda and altogether these two cadres account for 75% of Uganda’s health workforce (12).

Course schedule

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 (27). 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 April 2021. On resumption of the study in March 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 during which restricted the maximum number of participants per event to 20. The other aspects of the training such as data collection methods, 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 (20), and occurred between 9:00am to 15:00pm with a coffee break of 45 minutes 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 minutes 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 and learning strategies.

The training began with a pre-course questionnaire followed by a brief introduction to rural trauma systems, essentials of pre-hospital communication to receiving hospitals and safe transportation of a trauma patient. Further, 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).

First, we identified local resources and limitations and demonstrated trauma resuscitation through lectures and simulated case scenarios using locally feasible: resuscitation equipment, dummies, Radiographs, PowerPoint projections and videos. The emphasis throughout the training were 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.

Subsequently, to assess the degree to which participants apply what they have learnt in accordance with Kirkpatrick model (levels 1–3) for training evaluation (28), teams were asked to manage simulated trauma case situations during which they were observed for skills to perform primary survey and secondary survey, in addition to demonstrating teamwork, leadership, and communication skills in making timely decision to consult senior faculty or transfer.

Consequently, participants were tasked to provide peer review, audit team performance, and suggest areas for improvement to increase patients’ safety with particular attention on how the team's approaches would differ in vulnerable trauma populations such as children, elderly, and pregnant women in a low resource environment.

Lastly, teams were given expert feedback based on the assigned skilled team member roles as per the goals set by committee on trauma in the 4th edition of RTTDC (20), and based on the trauma non-

technical skills scale (T-NOTECHS) (29) which was validated for training trauma teams (30) as detailed in the study protocol (26). In return, participants gave their feedback through a structured post-course evaluation form after the last session of the second day of the training and completed post-course MCQs at 90 days from first day of the training.

Learning goals

The overall learning outcomes of the training were to enable participants to have competent knowledge of components of their local trauma systems, acknowledge their resource capacity and knowledge limitations in terms of potential barriers to injury care that warranty transfer, and to demonstrate competence in execution of trauma resuscitation with particular attention to basic pre-hospital handling, pre-referral treatment, and communication between referring and receiving hospitals. These expectations are in conformity with the goals set forth for RTTDC by the committee on trauma of the American College of surgeons (20). All participants were asked to complete 15-minutes course evaluation form after the last session on the last day of the training. Subsequently, medical participants were followed up at 90 days from the first day of the training to complete individually administered trauma based post-training MCQs in 40 minutes “exam-like” supervised environment.

Validity and quality control

To minimise inter-operator variations, the same three instructors consistently taught the course, and the participants maintained their teams throughout the training. All the instructions and assessments were conducted in English which is the official language in Uganda. The pre- and post-test MCQs were evaluated by two independent blinded offsite surgeons and were validated to have inter-rater agreement of 100% by the study administrator who was provided with a copy of the marking guide prior to the final data entry. Further details on how the training was conducted is available in the study protocol (26).

Data collection and statistical analysis

Standardized 20 items pre- and post-course (MCQs) were administered. Desirability of this training and its content was determined using a 5-point-Likert scale (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree) on 16 topics. The relevance of quality improvement, case scenarios and communication course modules to the study subjects were rated on a 3-point-Likert scale based on their subjective impression (3 = very relevant, 2 = relevant, 1 = not relevant). The selected 16 topics and methods of assessment had been validated earlier (31).

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 (32). 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 (33).

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.

Further, we performed the Wilcoxon signed rank non-parametric test to examine the difference in the effect the training had on MCQ scores of the various cadres and reported the median scores and their corresponding interquartile ranges. We compared the statistical difference in rank sums regarding desirability and relevance of course elements between the various participant categories using a non-parametric Kruskal Wallis (H) test.

Finally, we performed time-series autoregressive integrative moving average (ARIMA) models and developed graphics to report autocorrelation trends in MCQ performance for the study participants over time. 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. 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).

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 ($P|z| = <0.0001$). 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 (Fig. 3).

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).

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)

Rating		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
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)

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

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

Variable	Observations N = 434	Kruskal Wallis (H) Rank sum	χ^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		

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 statistically significant coefficient ($p = 0.05$) whereas the coefficient for pre-training scores did not ($p = 0.23$) (Fig. 4).

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, 5B) and partial (Fig. 6A, 6B) correlograms demonstrated one predominant lag and a decay effect of ARIMA process.

Discussion

This study evaluated the feasibility of rural trauma team development 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 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 ($P < 0.0001$). 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 (31), 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. Further, our results concur with studies based 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 (34), 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 (22).

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 (35) by reducing: emergency department and referral transit times (36), time to definitive injury care (21), lengths of hospital stay (22), and consequently improving injury outcomes. However, unlike high-income regions such as the United States (34), Europe (37), and those in Asia (38), most LMICs in Africa lack formalized multi-disciplinary physician led pre-hospital and emergency care systems (39). For instance in the past two decades, evidence shows that the majority (> 90%) of trauma patients in 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% (11). 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 (11) recently established that 91% of emergency room staff across all cadres in (101 of 111) evaluated 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 (34).

In agreement with findings of Ali et al (31), 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 evacuation could be task-shared. This arguably inclines more accountability to the involved sectors 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 (40). The alternative would be under-utilization of a capable and needed force to augment trauma care.

According to a scoping review by Brown et al (10), the average cost of a primary trauma course (PTC) which was then considered an alternative to ATLS in LMICs was 232$ per participant compared to $820 and $50–100 for ATLS and RTTDC, respectively. To cut such implementation costs for resource constrained health systems, high-income countries that regularly offer similar training such as USA, and Canada could collaborate with African experts to seamlessly provide such programs by leveraging on validated virtual technologies in trauma education (41), (42). Evidence from Canada shows that virtual simulations provide an ideal starting point to identify team errors that can be rectified when a critical mass of trainers and trainees are accumulated (43). Alternatively, novel joint trauma education centers could be used for two or more university teaching hospitals as supported by a cost-effectiveness study from USA (44), and by an integrative literature review that identified the use of telemedicine for trauma training and rural trauma system strengthening in Australia (40).

The communication module in this study revealed barriers to effective communication due to poor technologies, network break down with the emergency toll free numbers, lack of uniformed language between the law enforcement team that evacuates trauma patients and the recipient hospitals and lacking designated focal contact persons from the law enforcement professionals to handle trauma evacuations. These challenges are known to affect the coordination and delivery of emergency services for trauma care. In a recent Ugandan study, it was found that only 50% (26/52) of emergency service providers notified recipient facilities prior transfer, moreover their quickest response time was one hour (11) as opposed to the recommended 5 minutes (45). The rural trauma team development training provides an opportunity to discuss these challenges more effectively, to close the communication loop between pre-hospital care providers, non-trauma facilities, and trauma centers by use of plain language to communicate medicine as a priority competency skill.

To practically incorporate rural medical trainees and traffic law enforcement cadres into trauma teams requires adequate understanding of their barriers to injury care. Research from Sweden shows that medical trainees require adequate support from senior faculty to boost their confidence, ensure safety, and responsibility for their patients (46). Accordingly, their work-based tasks should be designed with essential trauma learning opportunities. Lack of protected time for continuous professional development partly contribute to burnouts and subsequent exodus of junior doctors to high-income countries, crippling the accumulation of qualified staff in LMICs. On the other hand, devoting time for trauma education for medical students is critical in attracting those who graduate to trauma care specialties (47).

Study strengths and limitations

This long-term multi-center research is amongst the few studies that have included rural medical trainees and participants such as police who work outside the hospital environment in the evaluation of the feasibility of rural trauma team development training, thus our findings truly represent the underutilized potential human resource for health in a typical low-income seating. 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 (45), thus limiting the generalizability of our findings; although the validity of team concept cuts across all trauma systems. Due to perceived lack of previous exposure to clinical skill settings, we did not perform the trauma knowledge based MCQ assessment for traffic law enforcement participants, so we do not have objective measures for knowledge gain to report for 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 (48), and our study had a sample size of 500. Lastly, an individual's knowledge and behavior could change over time without any intervention, thus having a separate control group 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, moreover on a totally new concept as this would strain the already skeletonized health workforce. Instead, the committees strongly believed that multiple interrupted time series of trainings would minimize this bias in accordance with Wagenaar et al (49). On the other hand, lack of a separate control group in this multi-center study limited confounding that would result due to between group differences to the minimum despite, although heterogeneity between study centers cannot be completely excluded. Now that we have demonstrated, amidst scarce resources, this uniqueness in team construct with basic proof of concept, we hope to execute the recruitment of these cadres into real-world rural trauma teams in a controlled clinical setting to explore their underutilized potential in contributing to injury care and trauma data registries and to examine if the apparent effects of the training sustainably impact patient outcomes to inform future program replication in other LMICs.

Conclusion

We thus reject the null hypothesis that there is no difference between pre- and post-course scores and conclude with sufficient evidence that the training had a statistically significant positive effect on the MCQ scores of course participants. The results of this study demonstrate that rural trauma team development training is feasible, highly acceptable and regarded as relevant amongst medical trainees and law enforcement professionals. Our next step is to investigate the practicalities of incorporating these cadres into real-world rural trauma teams, with a focus on establishing any barriers that could inform the design of future effective trauma care systems to complete Kirkpatrick model (level 4) for this training evaluation (28).

Abbreviations

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

Declarations

Ethical approval and consent to participate

This study was approved and registered by the research and ethical committees of Mbarara University of Science and Technology (Ref: MUREC 1/7; 05/5-19) and Uganda National Council for Science and Technology (Ref. No. SS 5082) prior recruitment. The study was conducted in accordance with the US National Institute of Health guidelines for research involving human subjects and all methods were performed in accordance with comparable ethical standards as laid down in the Declaration of Helsinki and its later amendments. Written informed consent was obtained from all participants prior recruitment. Participation was free and voluntary, and participants had the right to withdraw from the study at their wish.

Author contribution

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.

Competing interests

All authors report no competing interests to declare. The content of this paper is the sole responsibility of the authors and do not represent any official views of their institutional affiliations. The training simulation for participants in this study was not for any formal academic accreditation or institutional awards, neither does it represent any official views of the American College of Surgeons. The research

and ethics committees approved this educational activity with a maximum of 8 continuous professional development (CPD) credit points claimable at the Uganda Medical and Dental Practitioners Council.

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Availability of data and materials

The dataset supporting the conclusions of this article is included within the article as additional file 1. 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).

Consent for publication

Not applicable

Additional files

Additional file 1: Microsoft Excel Comma Separated Value File Dataset.

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Figures

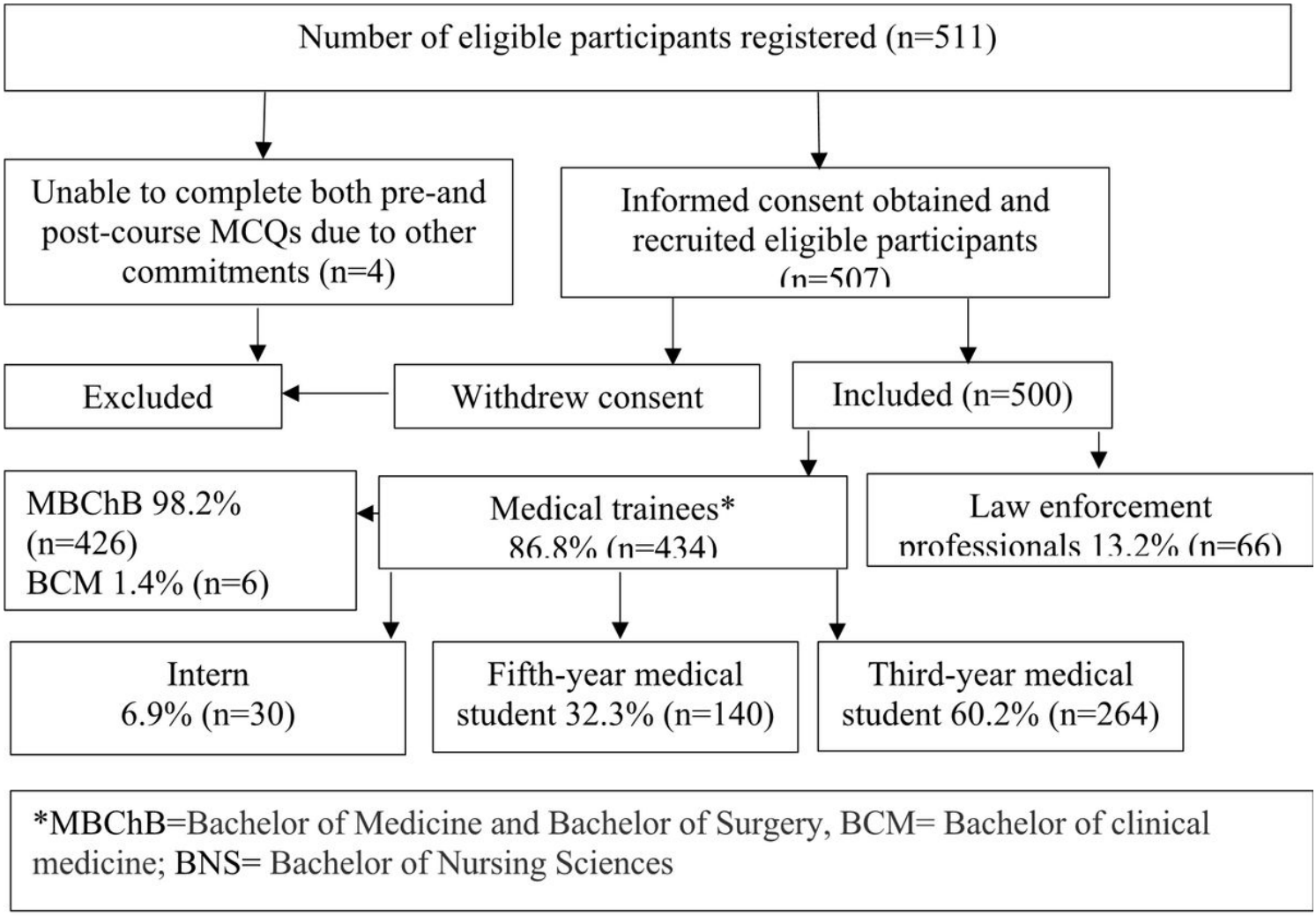

Figure 1

Flow diagram showing recruitment of study participants.

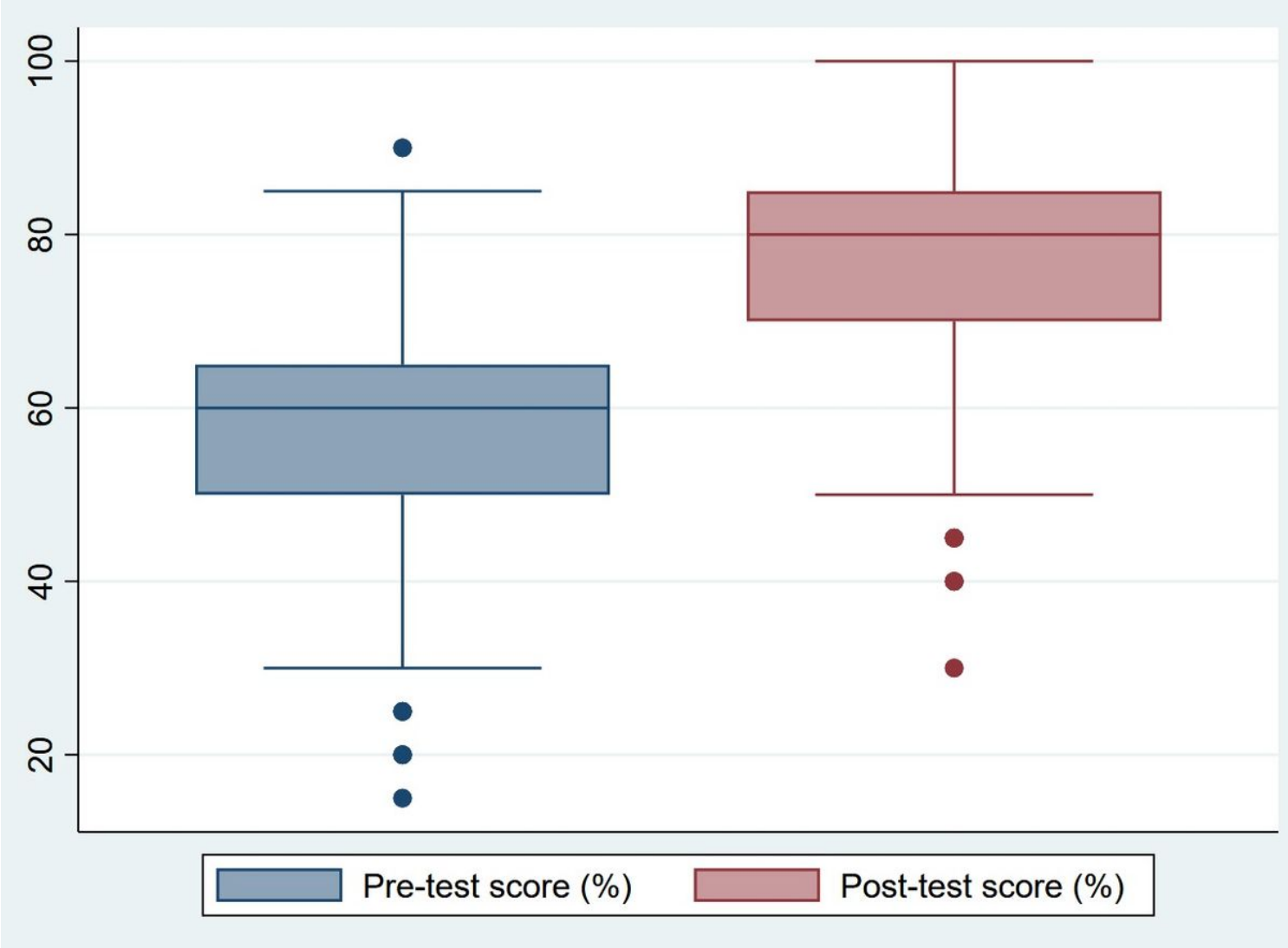

Figure 2

Box plot showing overall effect of training on MCQ scores of participants

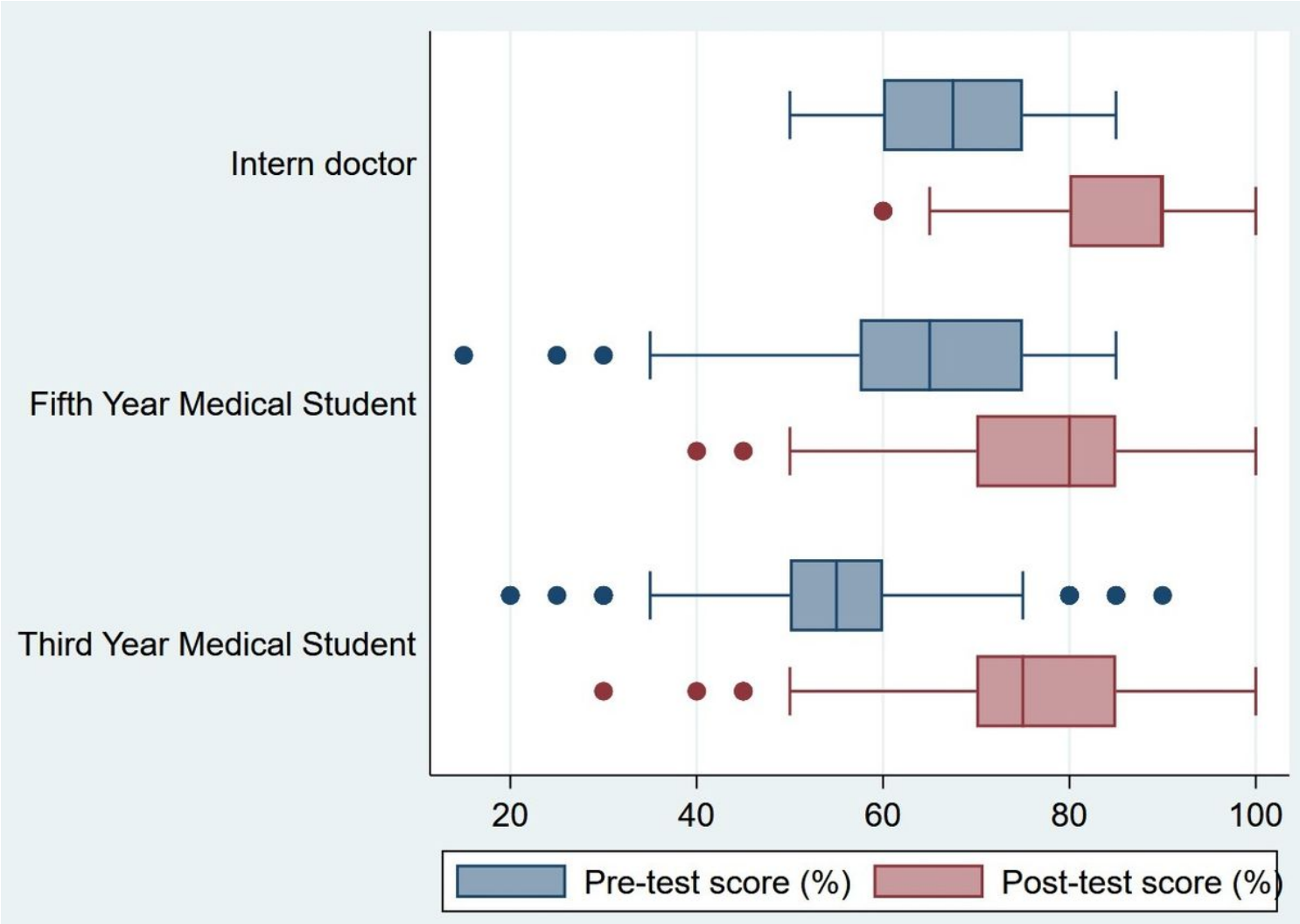

Figure 3

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

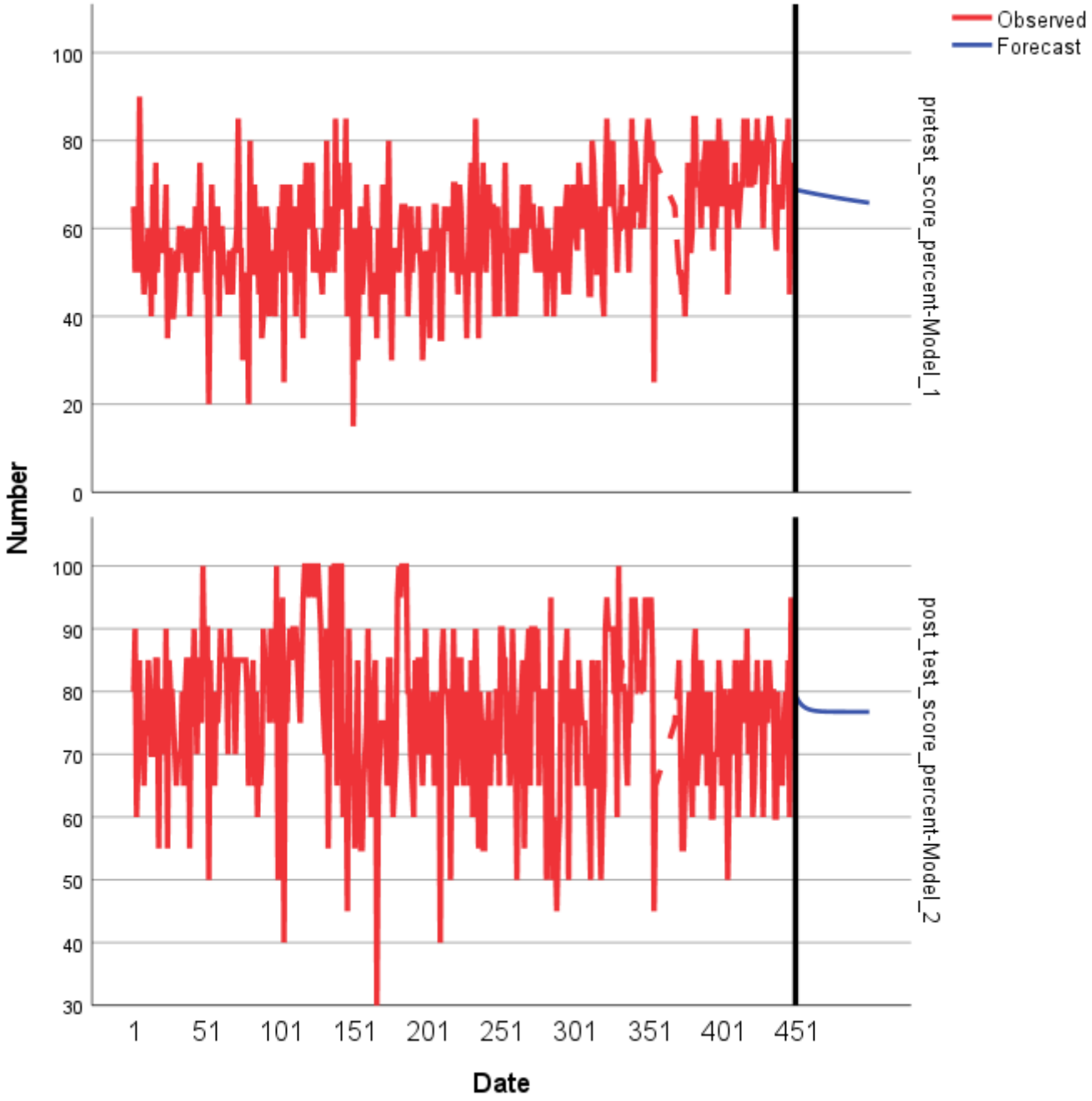

Figure 4

ARIMA model (1, 0,1) of pre- and post-test scores based on first and end participant.

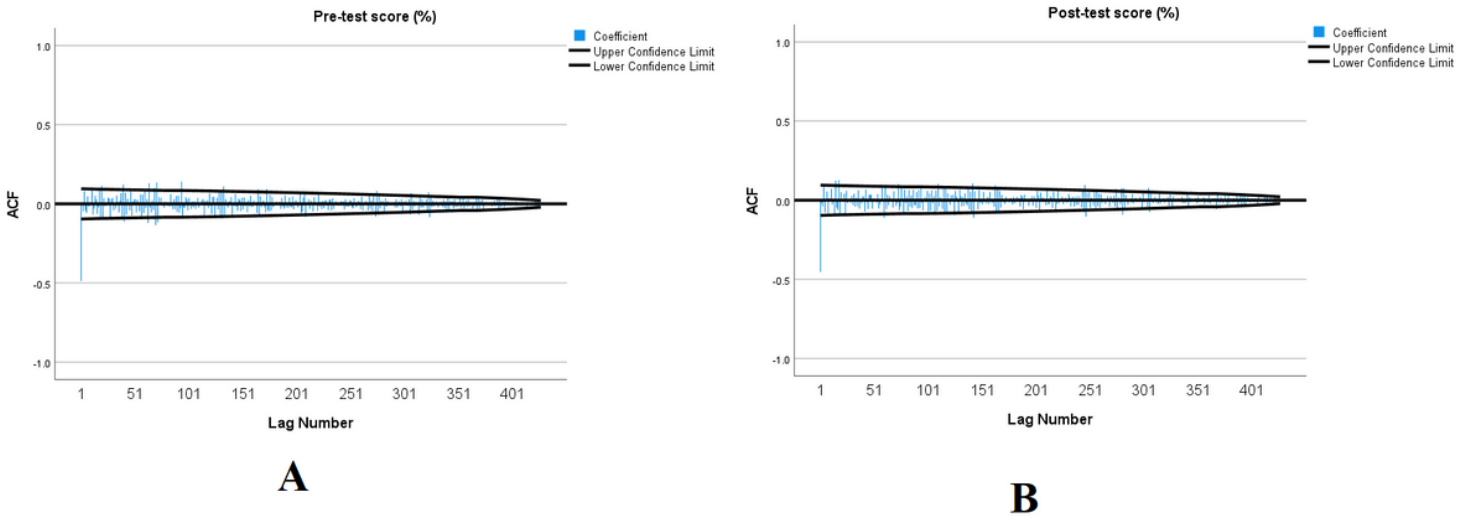

Figure 5

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

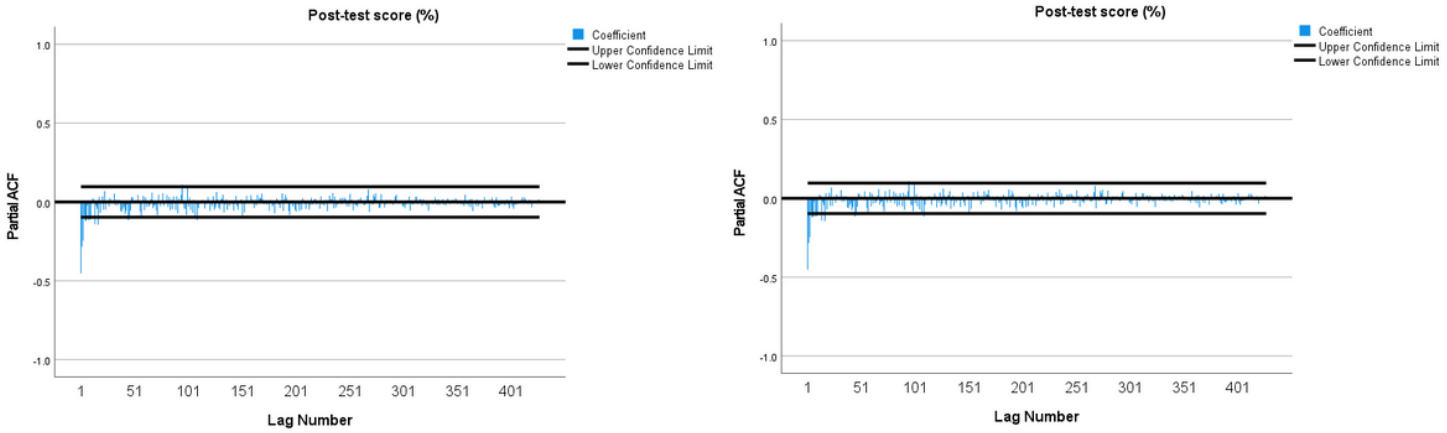

Figure 6

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

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalFile1.csv