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Title: Delivering a sustainable trauma management training programme tailored for low-resource settings in East, Central and Southern African countries using a cascading course model

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DELIVERING A SUSTAINABLE TRAUMA MANAGEMENT TRAINING PROGRAMME
TAILORED FOR LOW-RESOURCE SETTINGS IN EAST, CENTRAL AND SOUTHERN
AFRICAN COUNTRIES USING A CASCADING COURSE MODEL.

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AUTHORS CONTRIBUTION
1. Mr Noel Aaron Peter – Literature Search, Data Collection, Data Analysis, Data Interpretation and Draft of Manuscript
2. Mr Hemant Pandit – Critique of Analysed Data and Revision of Manuscript
3. Miss Grace Le – Data Collection and Revision of Manuscript
4. Dr Mathenge Nduhiu – Critique of Analysed Data and Revision of Manuscript
5. Professor Emmanuel Moro – Critique of Analysed Data and Revision of Manuscript
6. Professor Christopher Lavy – Developing the Concept, Critique of Analysed Data and Revision of Manuscript
DELIVERING A SUSTAINABLE TRAUMA MANAGEMENT TRAINING PROGRAMME TAILORED FOR LOW-RESOURCE SETTINGS IN EAST, CENTRAL AND SOUTHERN AFRICAN COUNTRIES USING A CASCADING COURSE MODEL.

ABSTRACT

BACKGROUND:
Injuries cause five million deaths and 279 Disability Adjusted Life Years (DALYS) each year worldwide. The COSECSA Oxford Orthopaedic Link (COOL) is a multi-country partnership programme that has delivered training in trauma management to nine sub-Saharan countries across a wide-cadre of health-workers using a model of “primary” courses delivered by UK instructors, followed by “cascading” courses led by local faculty. This study examines the impact on knowledge and clinical confidence among health-workers, and compares the performance of “cascading” and “primary” courses delivered in low-resource settings.

METHODS:
Data was collated from 1030 candidates (119 Clinical Officers, 540 Doctors, 260 Nurses and 111 Medical Students) trained over 28 courses (9 “primary” and 19 “cascading” courses) in nine sub-Saharan countries between 2012-2013. Knowledge and clinical confidence of candidates were assessed using pre- and post-course MCQs and confidence matrix rating of clinical scenarios. Changes were measured in relation to co-variants of gender, job roles and primary versus cascading courses. Multivariate regression modelling and cost analysis was performed to examine the impact of primary versus cascading courses on candidates’ performance.
FINDINGS:

There was a significant improvement in knowledge (58% to 77%, p<0.05) and clinical confidence (68% to 90%, p<0.05) post-course. “Non-doctors” demonstrated a greater improvement in knowledge (22%) and confidence (24%) following the course (p<0.05). The degree of improvement of MCQ scores differed significantly, with the cascading courses (21%) outperforming primary courses (15%) (p<0.002). This is further supported by multivariate regression modelling where cascading courses are a strong predictor for improvement in MCQ scores (Coef= 4.83, p<0.05).

INTERPRETATION:

Trauma management training of health-workers plays a pivotal role in tackling the ever-growing trauma burden in Africa. Our study suggests cascading PTC courses may be an effective model in delivering trauma training in low-resource settings, however further studies are required to determine its efficacy in improving clinical competence and retention of knowledge and skills in the long term.

Key-words : Trauma; Injury; Training; Education; Developing Country; Sub-Saharan Africa, Doctors, Nurses
INTRODUCTION

Traumatic injuries are a neglected epidemic in developing countries\textsuperscript{1,2}. More than five million deaths per year are related to injury, and 90\% of this burden is borne by low and middle income countries (LMICs).\textsuperscript{3-5} This burden is expected to grow and current projections estimate that it will overtake HIV/AIDS and TB as a cause of world mortality by 2020\textsuperscript{1,6}.

Although Africa is home to only 2\% of the world’s vehicles, it has one the highest road traffic related mortality rates, reaching unprecedented epidemic proportions at 28 per 100,000 population.\textsuperscript{6-8} This equates to an approximately 14-fold higher risk of dying in a road traffic accident in Africa than in the United Kingdom.\textsuperscript{7} Despite this, many frontline health workers in sub-Saharan African countries manage multiply injured patients with minimal formal training in trauma management, and often work with limited medical resources.\textsuperscript{9-13}

This remains a stark contrast to clinicians in high-income countries (HICs), where trauma management training are commonly founded on principles from the Advanced Trauma Life Support (ATLS)\textsuperscript{®} system. The ATLS\textsuperscript{®} system, produced by the American College of Surgeons\textsuperscript{14}, is a well-established protocol-based system for treating severely injured trauma patients. However, the implementation of this system has not been as widely adopted in sub-Saharan Africa as in Europe and North America.\textsuperscript{15,16} A relative lack of basic medical resources, limited funding and insufficient skilled staff are among the key reasons.\textsuperscript{17} Furthermore, many of the limited resource settings in LMICs are unable to support the specialised resource-dependent and technology-driven protocols advocated by the ATLS system.\textsuperscript{18}

It was with this premise in mind that the Primary Trauma Care (PTC) course was developed in 1997 to address this challenge.\textsuperscript{19} The PTC course aims to train doctors, nurses, paramedics
and other clinical personnel in the management of severely injured patients in low-resource settings. In 2003, the PTC manual was published by the World Health Organisation (WHO) and to date the course has been delivered in over 60 countries, in at least 14 different languages.\textsuperscript{19} Though the course was originally designed for use in low-resource settings in Africa, previous efforts to establish a sustainable programme have met limited success.\textsuperscript{20,21} As a result, trauma training among frontline health workers in sub-Saharan Africa remains sporadic and sparse.\textsuperscript{11,20,22}

In response to this ever-growing need, the College of Surgeons of East, Central and Southern Africa (COSECSA) has collaborated with the University of Oxford in establishing a multi-country partnership programme to improve trauma management training within the region. The COSECSA-Oxford-Orthopaedic Link (COOL)\textsuperscript{23} programme was established in 2012 through the support of the Health Partnership Scheme by the UK Department for International Development (DFID) and the Tropical Health Education Trust (THET). One of the goals of the programme is to address the critical need of training more frontline health workers in trauma management. The project seeks to achieve this by running 45 PTC courses over a three year period (2012-2015), training around 1800 new PTC providers across the ten sub-Saharan countries in the COSECSA region (Burundi, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe).

The framework of the programme, is based on PTC courses being delivered in each of our partner countries applying a “2 : 1 : 2” format. This in simple terms, equates to a standard two day provider training course, followed by a one day instructor’s course and finally ending with a further two day provider training course. The first PTC course (“primary”) in each country is delivered by a team of four UK National Health Service (NHS) instructors. On completion of the first PTC course (“primary”) in the country, subsequent “2 : 1 : 2” PTC (“cascading”) courses are led by a team of local instructors with a UK instructor present to
offer mentorship to the new instructors. This format allows for a quick and effective
dissemination of trauma management training to health-workers, particularly those working
in rural parts of the country, where often the need is greatest.

Although the concept of cascading PTC courses is appealing, its efficacy is not proven.
Ultimately, if cascading courses fail to deliver training to a high standard, then their
introduction in LMICs will be counter-productive and costly in the long-run. We address
the question of how effective the “cascading” training model is in delivering adequate and
appropriate training to health workers in low resource settings.

**METHODOLOGY**

**ETHICS & ROLE OF THE FUNDING SOURCE**

Written informed consent was obtained from all the participants. No identifiable information
was collected. No personal or identifiable data has been reported in the manuscript. Ethics
approval for the study was by the Medical Sciences Inter Divisional Research Ethics
Committee Research Services, University of Oxford. The sponsors of the study had no role in
study design, data collection, data analysis, data interpretation, or writing of the report. The
corresponding author had full access to all the data in the study and had final responsibility
for the decision to submit for publication.

**STUDY SETTING AND PARTICIPANTS.**

All PTC courses instituted by the COOL project adopted the “2 : 1 : 2” model, which was
held over 5 consecutive days. The 2-day provider course outlined the “ABCDE” approach to
trauma management through a mixture of lectures and small group discussions. Practical
skills and “trauma moulages” were run at stations in small groups during the course. The
candidates were assessed on their knowledge of trauma management and clinical confidence
which were administered using a multiple choice questionnaire (30 MCQs) and a confidence
matrix of clinical scenarios (8 scenarios). Consent was obtained from all participants and individual information was anonymised. Candidates who demonstrated strong teaching attributes were invited to attend an instructor’s course the next day. The instructor’s course was centred on the principles of teaching and emphasis was made on giving feedback, teaching a skill, delivering a lecture and facilitating small group discussions. This new faculty of local trainers then ran a further 2-day PTC course, with the UK NHS instructors available to offer support and mentorship. This framework was designed to facilitate delivery of subsequent cascading courses by local faculty to more rural health institutions in each respective country.

Knowledge and clinical confidence scores were collated before and after each course and standardised to percentages for purpose of comparison. Demographic data, MCQ and confidence matrix scores were entered and coded in Excel (Microsoft, Redmond, WA, USA), while further statistical analysis was performed using STATA version 13·0 (StataCorp, College Station, TX, USA). Descriptive and summary statistics were employed with an alpha level set at 0·05. Multivariate regression modelling of MCQ and clinical confidence scores was performed to examine the difference between primary and cascading courses, having adjusted for the confounders of gender, job-roles and country of origin. A cost analysis was calculated, taking into consideration expenditure on venue, operating expenses, flights, accommodation and meals per PTC course. All instructors delivered training during these courses on a voluntary basis.

RESULTS

In the period from December 2012 to December 2013, 1030 new PTC providers were trained across nine countries in the COSECSA region over 28 courses through the COOL programme. 330 of these candidates were trained in nine “primary courses” versus 700 in 19
“cascading courses”. The distribution of health worker roles among the candidates consisted
172 119 non-medically qualified clinical officers, 539 doctors, 261 nurses and 111 other health
173 workers roles (e.g. occupational therapist, physiotherapist, medical students etc). 281 were
174 trained as instructors, which comprised approximately a quarter of the new providers. The
175 overall mean of (primary & cascading combined) pre-course MCQ scores was 58% (SD 19·5,
176 95%CI 57·1-59·5) and the overall mean post-course MCQ score was 77% (SD 16·7, 95%CI
177 75·6 -77·7). Among the different health-worker groups, doctors average significantly higher
178 pre- and post-course scores both in knowledge and clinical confidence. (Doctors PRE-MCQ
179 = 68%, SD 17·3 95%CI 66·1 – 69·0, POST-MCQ = 84%, SD 13·3 95%CI 82·4 – 84·7).
180 However, nurses and clinical officers demonstrated the greater degree of improvement in
181 knowledge and clinical confidence following the course (Nurses = 22%, SD 14.1 95%CI 20·0
182 – 23·6, Clinical Officers = 23%, SD 13·1 95%CI 20·2 – 25·2).
183 Intriguingly, the degree of improvement of MCQ scores differed significantly between
184 primary and cascading courses. Primary courses achieved a mean of 15% improvement (SD
185 11·4, 95%CI 13·2-15·8) compared with the cascading courses mean of 21% improvement
186 (SD 15·3, 95%CI 19·7 – 22·1). The cascading effect is not universally identical across the
187 COSECSA countries, as some countries outperformed others. In particular, cascading courses
188 facilitated in Kenya, Malawi, Mozambique, Rwanda and Tanzania were particularly
189 successful, achieving a mean improvement of MCQ scores >19% (Kenya =24% SD 11·6,
190 Malawi = 20% SD 18·5, Mozambique =22% SD 14·22, Rwanda = 25% SD = 19·3, Tanzania
191 = 24%, SD 16·1). Multivariate regression analysis demonstrates that a predictor to degree of
192 improvement of MCQ scores among candidates includes : attending a cascading course
193 (Coef= 4·83, p<0·05), being a nurse (Coef= 2·67, p=0·05) or clinical officer (Coef=4·93,
194 p=0·002), and attending courses delivered in Kenya (Coef=9·55, p<0·05), Malawi
195 (Coef=6·00, p<0·05), Mozambique (Coef=8·52, p<0·05), Rwanda (Coef=7·22, p=0·001) and
Tanzania (Coef=9.40, p<0.05). Gender had no significant influence over the outcome of improvement in MCQ scores.

The overall mean (primary & cascading combined) pre-course confidence matrix scores were 68% (SD 17.05, 95%CI 67.28 – 69.69) and the overall mean post-course confidence matrix scores were 90% (SD 12.45 95%CI 88.90 – 90.63). Analogously, when sub-analysing confidence scores between the different groups of health-workers, doctors appear more confident prior to the course compared to the rest of their colleagues (73%, SD 15.95, p<0.05). However, this effect is diminished following the course with clinical officers demonstrating equally high levels of clinical confidence in managing trauma scenarios. (Clinical Officers Post= 93%, SD 7.82, Doctors Post= 91% SD 11.26). Once again, clinical officers and nurses demonstrate the largest improvements following the course (Clinical officers =29%, Nurses = 22%).

There was a significant difference in the degree of confidence improvement between primary (19%, SD=13.79, 95%CI 17.53- 21.27) versus cascading courses (23%, SD=17.32, 95%CI 21.48 – 24.53, p<0.05). However, multivariate regression analysis of independent co-variants demonstrated that the only strong predictor towards improvement of clinical confidence in our study was attending courses delivered in the following countries: Kenya, Malawi, Zambia and Zimbabwe. Neither the independent variables of gender, different job roles, nor primary or cascading courses, demonstrated any significant predictive influence on improvement of clinical confidence.

**VALUE FOR MONEY**

From a cost perspective, a 2 : 1 : 2 courses (taking into consideration expenditure on venue, operating expenses, flights, accommodation and meals) demonstrated a significant saving of £2000 in favour of cascading courses compared with primary courses. Assuming 30
candidates are trained during the course of the week, this equates to roughly a saving of £66.86 per candidate attending a cascading course. The main reason the cascading courses are cheaper than primary courses are the lower faculty travel and accommodation expenses for local faculty versus external overseas faculty costs.

**DISCUSSION**

The magnitude of the global trauma burden is staggering. Given the scale of the problem confronted by LMICs, there is a need to ensure that front-line health workers are trained and equipped to deal with life-threatening injuries effectively. Our findings indicate an improvement in knowledge and clinical confidence of trauma management among health-workers across the nine COSECSA countries. Both nurses and clinical officers demonstrate the most significant improvement in these areas. Furthermore, cascading courses delivered by local instructors achieved excellent training outcomes, and represent a cost-effective method in delivering trauma training in LMICs.

Considering that 95% of disaster-related deaths occur in the developing world, it is astounding that less than 1% of all trauma-related publications relate to LMICs. The lack of tangible data and accurate estimates of mortality and morbidity rates in the region have been amongst the challenges of implementing policy-making and public-health initiatives in this area. For this reason, it is unsurprising there is limited evidence in the literature demonstrating whether ATLS® or similar training programs impact the outcomes for trauma victims in LMICs. However, there is evidence that these educational initiatives improve knowledge and clinical confidence among health-workers. Other medical training initiatives suggest that an increase in knowledge and confidence does impact positively on patient outcomes, such as that seen in cardiac resuscitation and obstetric emergency. However, not all models of trauma management training developed in HICs are appropriate for low-
resource settings. Training programmes should be assessed for appropriateness on the basis of effectiveness, affordability, available local resources, and likelihood of sustainability before implementation in LMICs.\textsuperscript{16}

**COST-EFFECTIVENESS**

From an affordability perspective, the cost of a three day ATLS\textsuperscript{®} course is £600 per participant, which is indeed a substantial amount for medical staff in sub-Saharan African countries to afford.\textsuperscript{20} The PTC Foundation has ensured that its material is freely accessible to all, as both the manual and instructor packs are available online at no cost.\textsuperscript{19} However, there is some expenditure incurred in organising these courses, although all candidates as part of the COOL project attended the courses free of charge. The average cost for a primary five day PTC course was £7115, while the average cost for a five day cascading course was £5109. Our cost estimation for a candidate attending a 2 : 1 : 2 primary PTC course was £237, versus the average cost per 2 : 1 : 2 cascading course of £170. We believe, the relative affordability of the PTC programme offers an attractive case for its integration into the wider post-graduate medical curricula in LMICs, with minimal financial support needed from local health ministries. Furthermore, this is a move away from training programmes which are dependent on frequent visits by clinicians from high income countries to deliver training in low-middle income countries, to a model which harnesses and develops local instructors and resources.

**IMPROVING KNOWLEDGE AND CLINICAL CONFIDENCE IN MANAGING THE**

**MULTIPLY INJURED PATIENT**

Knowledge components of trauma training courses are typically assessed through written examinations. Measuring the candidates’ baseline level of knowledge prior to the course, helps to identify areas of weakness and also serves as a measure to evaluate their improvement and effectiveness of the course. The overall mean pre-course MCQ score was
58% and the overall mean post-course MCQ score was 77%. The overall gain of knowledge seen among participants attending the PTC courses overall (primary and cascading courses combined) is a mean of 19%. This compares favourably with the literature that reports increase in knowledge ranging from 8% to 14% in other trauma training courses instituted in LMICs. The overall mean pre-course confidence matrix score was 68% and the overall mean post-course confidence matrix score was 90%. The overall mean gain in clinical confidence among the candidates was 22%. Intriguingly, candidates attending cascading courses appear to have a greater improvement in knowledge (MCQ scores) compared with primary course (21% vs 15%, p<0.05). A similar effect is seen when analysing increase in clinical confidence among candidates in managing a variety of trauma scenarios (Primary 19% vs Cascading 23%, p=0.079). Although clinical confidence scores are “self-perception” scores by each individual candidate, we believe it serves as a gross measure of a candidate’s self-efficacy. Nevertheless, these measures of “confidence” should not be mistaken as a measure of clinical competence, nor is it a measure of clinical performance. Previous studies have demonstrated that confidence levels have poor predictive value in clinical performance. However as per Albert Bandura’s work, we can only assume the greater a candidates self-efficacy/confidence, the greater their likelihood of applying what they have learned in practice. However, it is worth noting this may not translate to an improvement in clinical performance.

**WHY IS THERE A DIFFERENCE BETWEEN PRIMARY AND CASCADING COURSES?**

Some of the key differences between primary and cascading courses are worth noting. As part of the strategy of introducing the PTC programme to a country, the first course tended to be centrally based (i.e. in a major city) and was generally held at a large academic institution. The first course was taught and led by UK NHS instructors with the aim of introducing local senior doctors, academics and educationalists to the concept of the PTC programme and
increasing a sense of local ownership. This was a crucial first step in a transferable cascade of
training other health workers within the country. In general, subsequent cascade courses were
run in more rural settings, and organised and led by local faculty, with a single UK mentor
present for the duration of the course.

Candidates attending the PTC courses within the COOL project were not limited to doctors
only. Where possible, other frontline medical staff involved in the care of severely injured
patients including nurses, clinical officers, physiotherapists and medical students were
included. Clinical officers are mid-level practitioners of medicine in East Africa who are not
medically qualified, but are licensed to perform general medical duties and perform routine
surgical procedures. Often, they are the key clinical workforce in rural health centres and
district general hospitals, and based on our results appear to demonstrate significant benefit
from the training.

Naturally, the primary courses in each country had a much higher distribution of doctors
versus other health workers compared with the cascading courses. This is unsurprising as a
majority of primary courses involved medical staff from teaching hospitals localised in urban
centres. However, it is notable that within the cascading courses there is a much more
diverse inter-professional distribution of health workers among candidates. Nevertheless, it is
interesting that our analysis demonstrates that across all job-roles, health-workers attending
cascading courses demonstrated a greater improvement in knowledge compared to primary
courses (p<0·05).

The reason for this is observation is likely multifactorial, and may be explained by the
different teaching styles of instructors, fluency of the local language, greater appreciation of
cultural differences, and knowledge of effective teaching strategies. It also stands to reason
that local instructors may have a greater advantage in the delivery of the material through
greater understanding of pertinent issues related to their practices. The findings of this study suggest that participants who attended a cascading course received an equal or better quality of training as those who attended a primary course.

However, this observation may also be explained by the difference in pre-course MCQ scores between the primary and cascading courses. The mean of the pre-course MCQ scores for primary courses was 69% versus the mean of cascading courses of 53%. It is plausible, that candidates in the primary courses started at a much higher baseline of knowledge, resulting in a “ceiling effect” to the degree of improvement seen in their scores, explaining the observed differences between the two groups.

The difference seen in the improvement in MCQ and confidence matrix scores among candidates in different countries is also an interesting observation. Tanzania demonstrated an impressive performance in their cascading courses. It may be that this is due in part to a higher distribution of clinical officers and nurses in their cohort of candidates, and the strong and dynamic local leadership seen in these countries. As Burundi joined COSECSA after the COOL programme commenced, PTC courses have yet to be delivered in the country. However, it is hoped that a course will be run in Burundi in the coming year led by newly qualified instructors from neighbouring Rwanda.

**What is the difference between the COOL project and previous efforts?**

The COOL programme sought to learn from lessons from previous efforts to develop sustainable trauma training programmes in sub-Saharan Africa. By collaborating with the COSECSA and PTC Foundation, we have improved partnership with local representatives and succeeded in achieving greater surgical involvement within the programme. For historical reasons, previous efforts to run PTC courses in Africa had little involvement from
local surgeons, who play a pivotal role in trauma management in most African healthcare systems. Engaging with local surgeons has significantly strengthened the leadership of PTC country teams and developed institutional support for further trauma training.

The relative affordability of the PTC programme and the grant provided by the Health Partnership Scheme has provided sufficient funding to allow the running of the initial set of courses. There has been positive engagement with local health ministries and some progress with integrating the programme into postgraduate surgical training in some countries. In Rwanda, Kenya and Uganda, cascading PTC courses have been funded locally by their respective Health Ministries.

Our results suggest that, in contrast to past approaches to training in LMICs the cascading approach adopted in the COOL programme has shown success in building local training capacity and establishing a sustainable model of trauma training. This is a move away from dependency on brief visits from Western-based external trainers, and rather towards establishing a programme empowered and driven by local clinicians.

**LIMITATIONS**

There are several limitations to appreciate in our study. Firstly, the improvement in knowledge and clinical confidence amongst candidates was assessed immediately on completion of the course and does not measure the long-term retention of these principles. We are currently running a follow-up study to monitor variations of knowledge and confidence among candidates in the long-term. Secondly, it was beyond the scope of this study to assess the application of the candidates’ gain in knowledge and clinical confidence translating to an improvement in their day-to-day clinical performance. This is mainly due to the vast distribution of candidates across the nine countries involving more than 150 health institutions. We can only assume a more “knowledgeable” and more “confident” work-force
in trauma management principles will possess the potential to deliver better care to trauma
victims in their respective countries. Further work is required to determine its impact on
clinical performance and competency, and ultimately if it leads to a beneficial outcome for
patients. Thirdly, there was certainly a degree of variation with regards to the mentorship
provided in each cascading course. On the whole for the cascading courses, the UK mentors
encouraged the newly trained local faculty to deliver all the lectures and teach the skill
stations. Their role was primarily to provide dedicated feedback at various points of the
course, particularly during the faculty meeting held at the end of each training day. However,
we were unable to control for the varying degree of mentorship for each course, and
appreciate this may have an influence on the performances of the “new instructors”, as well
as on the candidates in their respective cascading courses.

CONCLUSION

In conclusion, our analysis demonstrates that “cascading PTC courses” may be a suitable
alternative to current trauma training model for health-workers in resource-limited settings. In
view of the strong existing investment of Western-based capacity building training programs
of various specialities that exist across Africa, this training model harnesses the experience
and expertise of UK NHS health-workers to train and empower local African instructors. We
believe it has significantly strengthened the sustainability and capacity of trauma training in
the region. Useful lessons can be learned from this approach to support the development of
global health partnerships and to improve the effectiveness and sustainability of other
medical training programmes.
References


37. Miller PA, Cooper MA, Eva KW. Factors predicting competence as assessed with the written component of the Canadian Physiotherapy Competency Examination. Physiother Theory Pract 2010; 26(1): 12-21.
**FIGURE 1:** PERCENTAGE OF IMPROVEMENT IN MCQ AND CLINICAL CONFIDENCE SCORES BETWEEN DIFFERENT JOB ROLES IN PRIMARY VERSUS CASCADING COURSES

![Bar chart showing percentage of improvement in MCQ and clinical confidence scores between different job roles in primary versus cascading courses.](chart.png)

Legend:
- Change (%) in MCQ scores
- Change(%) in Clinical Confidence
FIGURE 2: PERCENTAGE OF CHANGE IN MCQ SCORES BETWEEN COUNTRIES IN PRIMARY VERSUS CASCADING COURSES
<table>
<thead>
<tr>
<th>Day / Course</th>
<th>Content</th>
<th>Teaching Methods</th>
</tr>
</thead>
</table>
| **Day 1 Provider Course** | Pre-course Assessments  
Primary Survey  
Airway and Breathing  
Circulation and Shock  
Secondary Survey  
Chest Injuries  
Major Haemorrhage | Lectures  
Skill stations  
Workshops  
Small Group Discussions  
Trauma Moulages |
| **Day 2 Provider Course** | Head and Spinal Trauma  
Abdominal and Limb Trauma  
Trauma in Children  
Trauma in Pregnancy  
Burns  
Transport and Transfer  
Disaster Management  
Post-course Assessments | Lectures  
Skill stations  
Workshops  
Small Group Discussions  
Trauma Moulages |
| **Day 1 Instructors Course** | How adults learn?  
Asking Questions  
Feedback  
Giving a lecture / presentation  
Facilitating a discussion group  
Teaching a Skill  
Facilitating a scenario  
Language Issues  
How to run the course? | Lectures  
Discussion groups  
Workshops |
TABLE 2: DEMOGRAPHIC DATA OF CANDIDATES ATTENDING PRIMARY VERSUS CASCADING COURSES

<table>
<thead>
<tr>
<th></th>
<th>Primary Courses</th>
<th>Cascading Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total number of candidates</strong></td>
<td>330</td>
<td>700</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>σ: 238 (72%)</td>
<td>σ: 419 (60%)</td>
</tr>
<tr>
<td>Female</td>
<td>φ: 92 (28%)</td>
<td>φ: 281 (40%)</td>
</tr>
<tr>
<td><strong>Job Titles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical Officers</td>
<td>28 (8%)</td>
<td>91 (13%)</td>
</tr>
<tr>
<td>Doctors</td>
<td>224 (68%)</td>
<td>316 (45%)</td>
</tr>
<tr>
<td>Nurses</td>
<td>40 (12%)</td>
<td>220 (31%)</td>
</tr>
<tr>
<td>Other HW</td>
<td>38 (12%)</td>
<td>73 (10%)</td>
</tr>
<tr>
<td><strong>Number of new instructors</strong></td>
<td>92 (28%)</td>
<td>189 (27%)</td>
</tr>
<tr>
<td></td>
<td>Primary Courses</td>
<td>Cascading Courses</td>
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<tr>
<td><strong>Pre-course MCQ</strong></td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>69%</td>
<td>53%</td>
</tr>
<tr>
<td>SD</td>
<td>18.05</td>
<td>17.91</td>
</tr>
<tr>
<td>Std Error</td>
<td>1.00</td>
<td>0.686</td>
</tr>
<tr>
<td>95% CI</td>
<td>67.36 - 71.30</td>
<td>51.75 – 54.45</td>
</tr>
<tr>
<td><strong>Post-course MCQ</strong></td>
<td></td>
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</tr>
<tr>
<td>Mean</td>
<td>83%</td>
<td>74%</td>
</tr>
<tr>
<td>SD</td>
<td>14.13</td>
<td>16.87</td>
</tr>
<tr>
<td>Std Error</td>
<td>0.801</td>
<td>0.657</td>
</tr>
<tr>
<td>95% CI</td>
<td>81.73 - 84.88</td>
<td>72.22 -74.79</td>
</tr>
<tr>
<td><strong>% Improvement of MCQ</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>15%</td>
<td>21%</td>
</tr>
<tr>
<td>SD</td>
<td>11.39</td>
<td>15.25</td>
</tr>
<tr>
<td>Std Error</td>
<td>0.651</td>
<td>0.599</td>
</tr>
<tr>
<td>95% CI</td>
<td>13.23 - 15.80</td>
<td>19.73 - 22.08</td>
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<td><strong>Pre-course Confidence matrix</strong></td>
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<tr>
<td>Mean</td>
<td>73%</td>
<td>67%</td>
</tr>
<tr>
<td>SD</td>
<td>15.50</td>
<td>17.28</td>
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<tr>
<td>Std Error</td>
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<tr>
<td>95% CI</td>
<td>71.23 - 75.28</td>
<td>65.04 - 67.94</td>
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<tr>
<td><strong>Post-Course Confidence Matrix</strong></td>
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<tr>
<td>Mean</td>
<td>93%</td>
<td>89%</td>
</tr>
<tr>
<td>SD</td>
<td>8.47</td>
<td>13.59</td>
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<td>0.570</td>
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<tr>
<td>95% CI</td>
<td>91.39 - 93.59</td>
<td>87.53- 89.77</td>
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<tr>
<td><strong>% Improvement confidence matrix</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>19%</td>
<td>23%</td>
</tr>
<tr>
<td>SD</td>
<td>13.79</td>
<td>17.32</td>
</tr>
<tr>
<td>Std Error</td>
<td>0.947</td>
<td>0.779</td>
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<tr>
<td>95% CI</td>
<td>17.53 - 21.26</td>
<td>21.47 - 24.53</td>
</tr>
</tbody>
</table>
### TABLE 4: PERCENTAGE OF IMPROVEMENT OF MCQ SCORES BETWEEN HEALTH WORKERS IN PRIMARY AND CASCADING COURSE

<table>
<thead>
<tr>
<th>Job Titles</th>
<th>Primary courses (Mean)</th>
<th>Cascading courses (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Officer</td>
<td>19% (SD 9.71)</td>
<td>24% (SD 13.68)</td>
</tr>
<tr>
<td>Doctor</td>
<td>13% (SD 11.02)</td>
<td>19% (SD 15.54)</td>
</tr>
<tr>
<td>Nurse</td>
<td>18% (SD 11.18)</td>
<td>22% (SD 14.46)</td>
</tr>
<tr>
<td>Other Health workers</td>
<td>16% (SD 12.99)</td>
<td>23% (SD 17.02)</td>
</tr>
</tbody>
</table>

### TABLE 5: COST ANALYSIS BETWEEN PRIMARY AND CASCADING COURSES.

<table>
<thead>
<tr>
<th>Courses</th>
<th>Total cost per course (including flights, accommodation, meals and course venue)</th>
<th>Total Cost Per Participant over a “2 : 1 : 2” PTC course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>£7,115.73</td>
<td>£237.19</td>
</tr>
<tr>
<td>Cascading</td>
<td>£5,109.92</td>
<td>£170.33</td>
</tr>
</tbody>
</table>
Conflict of Interest Statement

Professor Christopher Lavy, Miss Grace Le and Mr Noel Peter all report grants from Health Partnership Scheme (HPS) Multi-Country Health Partnerships for Global Health through the Tropical Health Education Trust (THET) during the course of this study.

Professor Pandit reports grants from Health Partnership Scheme (HPS) Multi-Country Partnership – Partnerships for Global Health through the Tropical Health Education Trust (THET), during the conduct of the study. He also reports grants from UKIERI and personal fees from Biomet outside the submitted work.

Dr Mathenge Nduhiu and Prof Moro declare no conflicts of interest.