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Managing medical emergencies: Sustainable pre-hospital medical education in Rwanda

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ABSTRACT

INTRODUCTION: In Rwanda, non-communicable diseases accounted for 44% of all reported deaths as of 2016. Yet, there is very limited data on pre-hospital management of emergency medical conditions in LMICs. We evaluated the impact of a pre-hospital medical emergencies training course and train-the-trainers program for Service d'Aide Medicale Urgente (SAMU) to address the burden of NCDs.

METHODS: A 100-question baseline assessment was administered to 25 SAMU staff to assess knowledge of basic anatomy, physiology, medicine, obstetrics, pediatrics, trauma, and scene safety. A two-day Emergency Medical Care Course (EMCC) was developed. Two cohorts (one for instructors and another one for staff) from ten district and provincial hospitals. EMCC 1 and a one-day educator course were conducted for the instructor core. They then taught the second cohort of trainees (EMCC 2).

RESULTS: In the baseline assessment of 25 SAMU staff, the median score was 56% overall and 54% in medical. EMCC 1 median scores were 43% vs 86% (pre vs post), $p<0.001$ using matched pair analysis of 18 participants. EMCC 2 median scores were 45% vs 82% (pre vs post), $p<0.001$ using matched pair analysis of 16 participants. A one-way ANOVA mean square analysis showed no statistically significant difference between the two cohorts post-training, with similar post-assessment scores.

DISCUSSION: This study showed that the course improved knowledge for an instructor core and staff from district and provincial hospitals, confirming the effectiveness of a train-the-trainers model, which will allow for sustainability in pre-hospital emergency medical training in Rwanda.

Keywords: Pre-hospital, Non-Communicable Disease, Education, Medical Education, Rwanda

INTRODUCTION

There has been a progressive shift from a focus on communicable diseases to non-communicable diseases (NCDs) worldwide. Every year, 40 million people die as a result of NCDs. In 2017, NCDs were

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responsible for 73.4% of all deaths globally [2]. This is an increase of about 23% from 2007 [2]. In 2015, 15 million people between the ages of 30 and 69 years of age died from NCDs. Over 85% of these deaths occurred in low- and middle-income countries (LMCIs) [3]. In sub-Saharan Africa, the shift to NCDs has been driven by lifestyle changes and an aging population due to substantial decreases in communicable diseases [4].

Worldwide, the two leading causes of NCDs, ischemic heart disease and cerebrovascular disease, contribute to the largest number of NCD deaths [5]. Moreover, the World Health Organization estimates that about three-quarters of cardiovascular disease deaths occurred in LMICs in 2015, with deaths from NCDs increasing by about 27% in the African Region over the next ten years [6]. Data initially presented in the 2012 global burden of disease (GBD) study has been updated to show that 24 million lives are lost each year in LMICs due to emergency medical conditions that can potentially be addressed by pre-hospital and emergency care. This accounts for 932 million years of life lost from communicable and non-communicable diseases [5]. Several factors have been identified as barriers to the delivery of pre-hospital care in LMICs, including lack of skilled personnel and delivery of care by laypersons without formal training [7].

In Rwanda, non-communicable diseases accounted for 44% of all reported deaths as of 2016 [1]. Yet, there is very limited data on pre-hospital management of emergency medical conditions in LMICs. The Ministry of Health of Rwanda created a formal EMS system, Service d'Aide Medicale Urgent (SAMU), using an electronic database to evaluate and optimize pre-hospital care since 2014. Data collected over a two-year period showed that a significant portion of patients cared for by SAMU had NCDs such as stroke, myocardial infarction, hypo and hyperglycemic emergencies, and sepsis (20%) [8]. However, the SAMU staff have not had formal training in identifying or managing such NCD emergencies. Because of this, our collaboration designed and implemented a context-specific, pre-hospital medical emergencies training course for SAMU to address the coming wave of NCDs in this population as a part of a larger train-the-trainers program for SAMU.

METHODS

Study context: Rwanda is a country in Sub-Saharan Africa with a population of about 13 million [1]. There are about 30,000 deaths due to non-communicable diseases annually, with 14% from cardiovascular diseases, 13% from cancers, and 3% from chronic respiratory diseases [1]. A 2016 WHO census of Rwandan adults aged 18 and older found that 20% had high blood pressure, 5% had obesity, 3% had diabetes, and 11% smoked tobacco products [1]. SAMU provides pre-hospital care for those living in and around its capital city of Kigali. They provide care for common complications from NCDs, such as hyperglycemia, hypoglycemia, adult acute respiratory distress, and pediatric acute respiratory distress [8]. SAMU staff are trained bedside nurses and anesthetists; however, they have no established training program for standardized management of pre-hospital emergency medical conditions [8].

Participants: A train-the-trainer model was created, and implemented a two-day training course focused on pre-hospital medical emergencies, Emergency Medical Care Course (EMCC). An instructor core was formed by SAMU staff. This group (EMCC1) was taught by Virginia Commonwealth University (VCU) Health physicians and a member of the VCU Center for Trauma and VCU Center for Trauma and Critical Care Education (CTCCE) and staff from University Teaching Hospital – Kigali Emergency Department. Those who passed the course and completed a one-day educator course became the "instructor core". A second group of emergency staff from ten referral, provincial and district hospitals was selected by the Ministry of Health of Rwanda and taught by the instructor core (EMCC2).

Study design: Through an initial written, 100-question multiple choices, English-language exam was administered to SAMU staff, and their baseline knowledge in multiple areas including basic medical conditions was assessed. The EMCC context-specific curriculum was developed based on identified knowledge gaps within the SAMU program and based on guidelines produced by the International Association for Medical Education (AMEE). The VCU CTCCE developed course materials based on best practices outlined by the WHO as well as other standard emergency

response and emergency nursing resources [9,10]. Questions were reviewed by VCU and the University of Rwanda emergency medicine, surgery, pediatric and medicine faculty. The course started with a traditional 30-minute lecture on "Medical Overview and Patient Assessment," followed by a 20-minute scenario-based team-driven simulation and 10-minute debrief. The rest of the course was broken down into seven broad emergency medical categories: respiratory, cardiovascular, neurological, diabetic, gastrointestinal, infectious disease, and medical shock-related emergencies. Each category followed the same format as the medical overview with a 30-minute traditional lecture, 20-minute simulation and 10-minute debrief. The lectures each consisted of the pathophysiology of the medical condition (e.g., respiratory distress), diagnostic adjuncts (e.g., pulse oximetry), and a case study. Each simulation required the performance of related skills (e.g., reading EKGs). Hands-on individual-skills stations were included in the curriculum.

Table 1: Demographic information for patients with NCDs treated by SAMU

Demographics	**N (%)**
Age in years (Mean+ Standard deviation)	57 (+ 22)
0 – 4	14 (2)
5 – 14	11 (1.5)
15 – 29	74 (9)
30 – 49	168 (21)
50 – 59	128 (16)
60 – 69	148 (18.5)
70+	260 (32)
Gender	**N (%)**
Female	426 (52)
Male	387 (48)

Measurement of proficiency and data analysis: Participation in each two-day EMCC program was assessed through a 50-question multiple-choice timed written assessment administered in English. All assessments were captured confidentially, and each participant was assigned a unique ID for de-identified analysis. Passing score was set at 80%. Instructors had to complete a previously administered educator course, receive a pass score on EMCC 1, and conduct a pre-specified section of EMCC 2 under direct observation of VCU instructor staff to be certified as EMCC Instructors. All participants who passed the course received certificates. All Instructors who met the above criteria received additional Instructor certificates.

A one-way ANOVA mean square analysis was used for comparison of both courses. Matched paired t-tests were used to evaluate assessment scores of each course, with $p<0.05$ considered statistically significant. To validate the multiple-choice assessment, statistical analysis via discrimination index (Di) was conducted. Each assessment item was evaluated for its effectiveness in discriminating between those participants who knew the content and those who did not.

Finally, questions were categorized based on difficulty into knowledge, application, and problem-solving skills-based questions in order of increasing difficulty based on Bloom's taxonomy. Pre and post-course differences for each level were calculated, and a chi-square test of equal proportions was used with an alpha value of 0.05 considered significant.

This study was conducted as part of an ongoing IRB-approved project at VCU (IRB HM20011011_CR1) and the Ministry of Health (CHUK EC/CHUK/443/2017) and as a part of a memorandum of understanding formally established between the Ministry of Health of Rwanda and Virginia Commonwealth University to support emergency systems development in Rwanda.

RESULTS

An exam covering general anatomy, physiology, and pre-hospital-based conditions was administered to SAMU staff. They scored a median of 56% overall and 54% in the medical section (Mean: 51% +/- SD 27%).

A total of 34 participants were divided into two, EMCC 1 and EMCC2. Eighteen SAMU staff made up EMCC1, while 16 hospital staff from throughout Rwanda made up EMCC2. EMCC1 scored 43% on pre-course assessments and increased to 86% on

Table 2: Non-communicable disease emergencies treated by SAMU

Non-Communicable Disease	N (%)
Diabetes Mellitus	444 (53)
Heart Diseases	351 (42)
Hypertension	187 (53)
Hypotension	45 (13)
Chest Pain	30 (4)
Cardiac Decompensation	11 (1)
Palpitations	9 (1)
Shock	7 (0.8)
Arrhythmia	5 (0.6)
Myocardial Infarction	5 (0.6)
Other	78 (9)
Cancer	120 (14)
Prostate	21 (3)
Breast	16 (2)
Liver	15 (2)
Cervical	11 (1)
Gastric	8 (1)
Colon	7 (0.8)
Lung	6 (0.7)
Throat	3 (0.4)
Skin	2 (0.2)
Uterine	1 (0.1)

post-course (Figure 1), while EMCC2 scored 45% and increased to 82% on post-course assessments (Figure 2).

Three students from EMCC1 and five students from EMCC2 failed to meet the minimum passing requirements of 80% in the post-course assessment. They were remediated and passed the post-test.

Using a chi-square test, a question-based analysis was performed comparing EMCC1 and EMCC2 pre-post differences in knowledge-based, application-based, and problem-solving questions. A chi-square test was also used to compare the differences between question types within each cohort, and it found that both groups improved on all three difficulty levels. There were statistically significant differences in all categories in both EMCC 2 and EMCC 1 (Table 1).

A one-way ANOVA mean square analysis was used to compare the pre-course assessment mean scores and post-course assessment mean scores across both groups of trainees. Neither analysis showed a statistically significant difference between the two groups, with the pre-assessment scores showing $F(1) = 0.18$, $p = 0.6718$, and post-

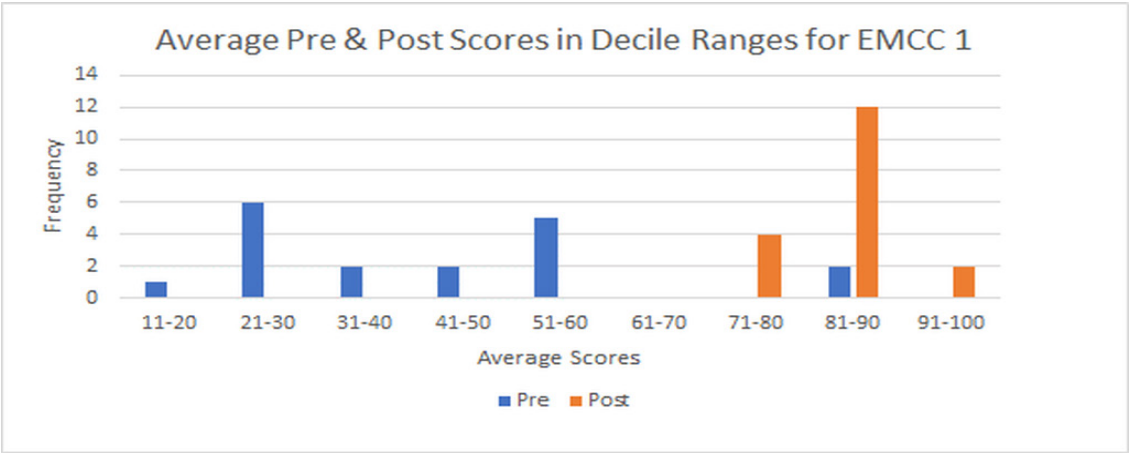

Figure 1: Average pre- and post-scores in decile ranges for EMCC 1

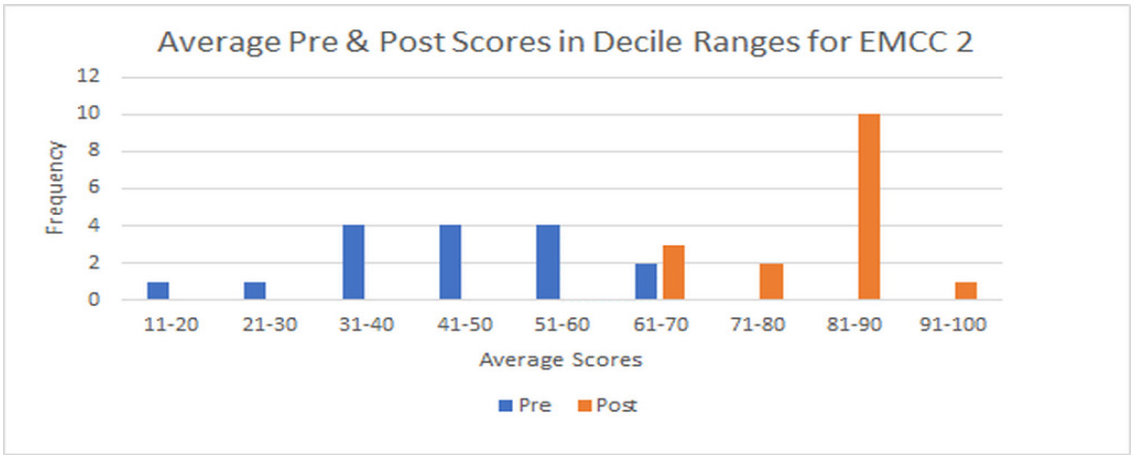

Figure 2: Average pre- and post-scores in decile ranges for EMCC 2

assessment scores showing F(1) = 2.76, p= 0.1045. Similarly, the change between pre and post-mean scores was found to not be significantly different: F(1) = 0.81, p = 0.3751.

Using paired t-tests, EMCC 1 demonstrated an increase from the pre- to post-course assessment by 0.42+0.20 (SD) ($p<0.001$), while EMCC 2 demonstrated an increase by 0.366+0.138 (SD) ($p<0.001$) with 95% confidence (Table 2).

DISCUSSION

Despite a rising number of non-communicable disease emergencies in LMICs, a majority of the world's population does not have access to pre-hospital care, and many LMICs lack an organized EMS system [11]. Investing in emergency medical care in LMICs should be a priority since proper pre-hospital care can address non-communicable diseases among other conditions [12]. There is a paucity of literature on how best to support EMS providers in medical emergencies in LMICs. Several studies have focused on improving pre-hospital trauma care by educating layperson first responders [13,14]. None have specifically addressed the implementation of training for emergencies from the growing burden of non-communicable diseases. NCDs in LMICs are expected to increase by 10 million between 2015 and 2030 to 41.8 million [15]. Not only are NCD rates increasing in LMICs, but they are also more deadly there. People in LMICs with cardiovascular events have a four-fold higher mortality than those in HICs [16]. NCDs such as MI, stroke and sepsis are time-sensitive conditions that are going to increase with the rise of NCDs. There is a need for robust pre-hospital and emergency medical care in LMICs because they are likely to be most vulnerable.

This is one of the first studies in the literature to describe the implementation of a training course specifically for pre-hospital emergency medical conditions within an existing publicly supported EMS system in an LMIC setting.

In this small study, we demonstrated that a short course targeting EMS and emergency staff could result in statistically significant increases in overall knowledge across all levels of difficulty. Both cohorts reached similar post-course assessment scores demonstrating the effectiveness of the train-the-trainer program, and showed improvement in all three levels of question difficulty. This shows participants were only able to understand the information presented in lectures and able to apply the knowledge to new problems. A higher-order level of understanding of the content suggests the knowledge will be more likely to be retained [17]. A question-based analysis showed an improvement in all three levels, knowledge, application, and problem-solving, in both EMCC 1 and EMCC 2. This shows participants were able to understand the information presented in lectures and apply the knowledge to new problems, suggesting the knowledge will be retained. Some of the participants may have remembered questions from the pre-test, but not to the extent that is seen in the overall improvements of scores. Improvements in EMCC 2, demonstrate the effectiveness of the newly trained SAMU instructors under the "train-the-trainer" model. While the data from these initial two groups is promising, additional, more long-term data will be needed to see how this course prepares SAMU staff and other essential personnel for coming waves of NCDs in Rwanda.

Our results are similar to that of other LMICs. In Tanzania, which lacks a formal pre-hospital system, a group created four short courses based on the scope of practice for laypeople. Though their course taught laypeople, unlike our medical professionals, similar to ours, their course portions covered medical emergency topics and had a 90% pass rate. Unlike our course, they developed several courses. The most advanced curriculum was a 6 weeklong course and was the only one to include medical emergencies among the core content. Only a fraction of their lay providers received this education [18]. Similar to our course, in Botswana, a novel two-day course was developed and implemented for Ministry of Health-sponsored pre-hospital providers. Unlike ours, their course focused on many pre-hospital topics, not just medical conditions. Their pre and post-course assessments showed similar improvements to our course in participants' scores with significant changes [19]. Both of these studies included simulation-based training and designated curriculum addressing the index conditions seen in each country's pre-hospital setting, but neither was strictly medically focused.

The application of experiential learning in medical education and adult learning has been shown to be highly effective compared to traditional didactic training because it focuses on developing competencies and practicing skills in specific contexts. Learning outcomes can be refined using Bloom's Taxonomy, focusing on knowledge, comprehension, and application early and later on analysis, synthesis, and evaluation [20]. Our curriculum placed a large emphasis on scenario-based learning and individual-skills practice through Bloom's Taxonomy. Critical reflection has been found to be equally crucial to adult learning, so debrief sessions were included at the end of each simulation. This innovative and interactive educational model has been demonstrated to be effective in trauma training for laypersons. Similar to our study, they focused on short 20-minute didactic sessions followed by 40-minute skills sessions, which led to increased competence in all areas of trauma management [21]. No studies on EMS and experiential learning exist in LMICs beyond trauma training for lay first responders, but these other studies show why this kind of training would be effective for training EMS/EM staff in LMICs. Our results show a 40% increase in assessment scores across both cohorts, demonstrating the effectiveness of our innovative program.

Our study has several limitations. The national language in Rwanda has changed recently, so many residents are only proficient in the language. Language barriers and the complicated medical jargon associated with this content may have overwhelmed the knowledge uptake and test-taking abilities, especially in the second cohort. While this study has demonstrated an improvement in the knowledge base of the pre-hospital staff, we did not seek data on changes in clinical outcomes. There is no current link between the pre-hospital data collection systems and the hospital-based records that would allow for this assessment. While the data from these initial two groups is promising,

additional, more long-term data will be needed to determine retention of knowledge. Furthermore, there was no formal assessment of technical skills learnt during the course, such as reading an EKG. These are areas for further investigation. Data will be needed to see how this course prepares SAMU staff and other essential personnel for rising NCDs in Rwanda.

CONCLUSION

Non-communicable diseases are increasing worldwide, and it is imperative to have EMS systems to substantially reduce the morbidity and mortality related to these time-sensitive diseases. This study effectively implemented a context-appropriate pre-hospital medical training program in Kigali, where almost one-quarter of all patients treated annually by pre-hospital staff present with complications related to NCDs. The course resulted in improved knowledge for the SAMU staff as well as for staff from referral, district, and provincial hospitals. This course confirmed the effectiveness of a train-the-trainers model, which will allow for sustainability in pre-hospital emergency medical training in Rwanda and can be used as a model in other LMICs to foster EMS development.

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