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Emergency Care Education and Triage Implementation improves care outcomes in Rural Liberia

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ABSTRACT

Objective To evaluate key process outcomes before and after two scheduled emergency care and triage trainings.

Design An observational, retrospective cross-sectional review of emergency department handwritten records.

Setting A regional hospital emergency department in Southeastern Liberia from February 1, 2019 to December 31, 2019.

Participants There were 8,222 patient visits recorded that were included in our analysis.

Main outcome measures Primary outcome was a complete set of recorded vital signs at any time during the patient's ED visit. Secondary outcomes examined included documentation of 6 defined process outcomes.

Results Patients in the post-training 1 group had higher odds of having a documented full set of vital signs compared to the baseline group (16% v 3.5%, OR 5.4 (95% CI 4.3 to 6.7)). After triage implementation, patients who were triaged were 16 times more likely to have a full set of vitals compared to those who were not triaged. Similarly, compared to the baseline group, patients in the post-training 1 group had higher odds of having a glucose documented if they presented with altered mental status or a neurologic complaint (37% v 30%, OR 1.7 (CI 1.3 to 2.2)), documented antibiotic administration if they had a presumed bacterial infection (87% v 35%, OR 12.8 (CI 8.8 to 17.1)), documented malaria test if presenting with fever (76% v 61%, OR 2.05 (CI 1.37 to 3.08)) or documented repeat set of vitals if presenting with shock (25% v 6.6%, OR 8.85 (CI 1.67 to 14.06)). There was no significant difference in the above process outcomes between the trainings.

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Conclusion This study showed improvement in most process measures between the baseline and post-training 1 groups, benefits that persisted post-training 2, thus supporting the importance of short-course training interventions to durably improve facility-based care.

Strengths and limitations of this study

- Significant improvements in quality metrics were demonstrated after triage implementation and basic emergency care trainings in a rural hospital where previous emergency care training was limited, supporting the ability of short-course interventions to improve facility-based care.
- This study was conducted at a single site in rural Liberia that had not received any prior emergency care training and the generalizability of our findings is unknown.
- Given retrospective data collection of process metrics from handwritten charts instead of direct observation of tasks there may be missing data from under-reporting or non-recording of tasks.

INTRODUCTION

Emergency care has been increasingly recognized as a fundamental component to strengthening health systems [1,3–6] and an effective means to address multiple Sustainable Development Goals and reduce the overall burden of disease.[1,7] An estimated 54% of annual deaths in low and middle-income countries (LMICs) could be addressed by pre-hospital and hospital-based emergency care.[8] Specifically, injury related mortality disproportionately effects LMICs, and accounts for more than 90% of the total global mortality related to injury.[10] Emergency care

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saves lives across the spectrum of illness, from injuries to acute presentations of chronic disease, and is the first contact with the health system for many. [1-3,9]

Emergency care in Liberia, like many LMICs, is still in its early development. In 2007, emergency care was first included in Liberia's national health plan and basic package of health services.[11,12] There has been some development of emergency education at the national referral hospital in the capital of Monrovia; however, no other consistent or standardized emergency medicine curriculum has been established.[13] The basic package of health services outlines the essentials of emergency care for each service level.[11] Currently, there are no formal indicators measuring care or process outcomes for emergency care nationally.

In 2014, the Ebola outbreak led to the near-collapse of the country's already weakened health system, which was recovering from recent civil war (1989-1996 and 1999-2003).[13–15] In 2015, responding to the Ebola epidemic, the global non-profit organization Partners In Health (PIH), at the invitation of and in partnership with the Liberian government, came to Liberia to support the emergency response and long-term strengthening of the health system. Given clear emergency care needs in Maryland County, a key goal of PIH's became to expand and strengthen emergency services, which included developing the health workforce capacity to provide high-quality emergency care with the support of emergency care trainings and triage implementation. The objective of this observational study was to evaluate key process outcomes before and after triage implementation and emergency care trainings to assess its impact on quality of care and identify areas for future improvement.

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METHODS

Study Design

An observational, retrospective cross-sectional study of patients presenting to a regional hospital ED in Southeastern Liberia.

Study Setting

The observational study was carried out at JJD, the only county referral hospital in rural, Southeastern Liberia. It is a government-run hospital supported by PIH and provides services free of charge. JJD serves a primary catchment area of 187,000 people in Maryland county and receives additional referrals from neighboring counties. At the time of the training, JJD's 8-bed ED was primarily staffed by nurses and physician assistants (PAs). At the time of the trainings there was no trained emergency medicine physician at the hospital. Specialists in the four core clinical departments of pediatrics, internal medicine, surgery and obstetrics and gynecology provide clinical support to the ED in their respective clinical areas as needed. Prior to 2019, no ED staff had specific emergency care course training. In addition to nurses and PAs, nursing students and aides worked within the ED; after triage was implemented in May 2019, nursing aides primarily staffed ED triage.

Emergency Care Trainings

In late April and early May 2019, a series of pre-scheduled trainings were conducted to improve emergency care at JJD. First, staff were trained on the WHO-ICRC-MSF integrated interagency triage tool (IIATT) through didactics followed by real-time supervision and mentorship on the implementation of triage.[16] Triage is an essential component of emergency care; it evaluates a

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patient's acuity and prioritizes evaluation and treatment based on the severity of the patient's condition.[6] The IIATT assigns patients to a 3-tier acuity system, based on specified symptoms, physical signs, and high risk vital signs.[16]

Following the IIATT training, 12 staff received 2 weeks of training on the WHO Basic Emergency Care (BEC) course, followed by the complementary PIH Fundamentals of Emergency Care training. The WHO BEC course was composed of didactic, small group sessions and skills session, designed to train staff to identify and manage acute illnesses and injuries with limited resources. [17,18] The supplemental PIH course included additional topics (eg. approach to abdominal pain and fever), and skills such as basic EKG and ultrasound. The didactic courses were followed by two weeks of clinical mentorship by a visiting faculty emergency physician. Afterwards, ongoing occasional clinical mentorship was supported by non-EM faculty who worked at JJD.

In mid-October 2019, 16 JJD staff participated in a three-day refresher training. Five participants had not completed the initial training, so received a pre-course one-day intensive training on key concepts covered previously. An emergency PA provided ongoing clinical mentorship 4 days a week for the subsequent 3 months.

Study Population

The study was conducted from February 1, 2019 to December 31, 2019. During this period, all patients presenting to the JJD ED for whom a visit was either documented in the ED ledger or a handwritten chart were included in the study.

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Data Collection

Trained data collectors extracted information from handwritten ED records into a pre-developed data extraction tool. Prior to May 2019, all initial visit documentation occurred exclusively in the ED ledger, including demographics, reason for the visit, vital signs, lab testing, key results, diagnosis, and disposition. After May 2019, documentation included three sources: the ED ledger, an ED triage form, and a ED provider documentation form adapted from the WHO Emergency Unit forms.[19] These forms were introduced in May 2019 and used by staff performing the initial evaluation and resuscitation. The ED ledger was a bound book with handwritten content, described above. The ED triage form documented triage acuity based on presenting symptoms and vital signs based on the interagency integrated triage tool. The ED provider documentation form included sections for vital signs, chief complaint, primary survey, history of presenting illness, review of systems, past medical history, assessment, and plan. Data collectors reviewed all these source and recorded demographics, initial vital signs, select clinical process measures and outcome variables, and final patient disposition.

Variables and Outcomes

We classified visits from February 1, 2019 to April 30, 2019 as "pre-training", visits from May 29, 2019 to October 13, 2019 as "post-training 1", and October 21, 2019 to December 31, 2019 as "post-training 2." Visits from May 1, 2019 to May 28, 2019 and October 14, 2019 to October 20, 2019 were considered to be in "intermediate" time periods (e.g., time periods during the trainings themselves) and excluded from comparative analyses (as seen in figure 1). Data with missing date and age variables were also excluded from the analysis.

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Due to differences in documentation standards prior to the ED trainings, we focused our analyses on variables and process metrics that were reliably and routinely captured in the JJD ED register. The study team reviewed process metrics recommended by the African Federation of Emergency Medicine, as well as a review of quality metrics used in LMIC EDs.[20,21] From these lists, study outcomes were chosen based on local context, hospital and government priorities, and pre-existing documentation patterns that determined what baseline data was available. The primary study outcome was a complete set of recorded vital signs at any time during the patient's ED visit and was chosen given the importance of vital signs to triage and emergency care. [22,23]

Secondary outcomes examined included documentation of: blood glucose for patients presenting with altered mental status or a neurologic complaint; antibiotic administration or prescription in patients with a presumed bacterial infection; malaria diagnostic testing in patients with temperature $\geq$ 38^{o}C; oxygen administration for hypoxia; repeat vital signs for shock; and intravenous fluids for shock (hypoxia and shock were defined by age, Table 1). A PA interpreted the final diagnoses to determine if the visit was due to a presumed bacterial infection. In the absence of microbiology capability to perform cultures and accounting for local context and practice patterns, all diagnoses of pneumonia, urinary tract infections, meningitis, cellulitis, and sepsis were presumed to have been bacterial. Tuberculosis (TB) was excluded from the list of bacterial infections, as TB patients are referred to TB clinic to initiate treatment and therefore not reliably documented as part of ED care. A patient was coded as a neurologic complaint if the clinical documentation included altered mental status, weakness, dizziness, or seizures.

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Table 1. Variable Definitions

Hypoxia	
Age ≤ 5 years	SpO2 ≤ 94%
Age > 5 years	SpO2 ≤ 92%
Fever	temperature ≥38°C
Shock Vitals	
Age 0 to < 1 years*	HR > 160bpm
Age ≥1 to < 3 years*	HR > 160bpm
Age ≥ 3 to < 5 years*	HR > 140bpm
Age ≥ 5 to < 13 years	HR of ≥ 130bpm or a systolic blood pressure < 70mmHg
Age ≥ 13 years	HR of ≥ 130bpm or a systolic blood pressure < 80mmHg

*Note: Blood pressure was not included as a criterion in the younger age groups as it is not reliably recorded.

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Data Analysis

Data was transcribed into Excel, then imported into and analyzed with Stata (Version 15). [24] Simple descriptive statistics were used to describe the patient demographics and Chi-Square analyses were used to test for significance using a nominal threshold of 0.05. Odds ratios and 95% confidence intervals were calculated for pre-determined process measurements as described above.

Ethical Approval

The study was approved by the Partners Healthcare IRB 2019P001944 as well as the University of Liberia-Pacific Institute for Research and Evaluation IRB 17-06-048 as part of the clinical and training protocol that Partners In Health Liberia submits annually for review.

Funding

This work was funded by the Ansara Family Foundation; funders did not have any role in study design or the analysis or publication of results. There is not an award or grant number available.

Patient and Public Involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

RESULTS

There were 8,774 patient visits recorded in the JJD ED from February 1, 2019 to December 31, 2019 and included in our analysis: 2,732 in the pre-training time period, 3,194 in the 'post-training 1' time period, 2,296 in the 'post-training 2' time period, and 552 in the 'indeterminate' time periods, which were excluded from the analysis (Table 2).

Table 2. Demographic description of gender and age at J.J. Dossen Hospital^

Age [Years]	Male n (%)	Female n (%)	Gender Missing n (%)	Total n (%)
0 - <5	1,102 (52.9)	954 (45.8)	29 (1.4)	2,085 (25.4)
5 - <18	858 (47.6)	917 (50.9)	26 (1.4)	1,801 (21.9)
18+	2,015 (47.6)	2,183 (51.6)	36 (0.9)	4,234 (51.5)
Age Missing	40 (39.2)	56 (54.9)	6 (5.9)	102 (1.2)
Total	4,015 (48.6)	4,110 (54.9)	97 (1.2)	8,222

^Includes all patients from pre-training, post-training 1, and post-training 2 time periods.

In the baseline time period, only 3.5% of patients had a complete set of vital signs documented (Table 3). In both post-training 1 and post-training 2 time periods, patients had higher odds of having a documented full set of vital signs (16% OR 5.4 (95% CI 4.3-6.7)). Adults were statistically more likely than children to have a documented full set of vitals (OR 1.43 (95% CI 1.26-1.62), and were also more likely to have heart rate, oxygen saturation, respiratory rate and

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blood pressure documented (Table 4). Triage, implemented as part of Training 1, significantly influenced the likelihood of having a full set of vital signs recorded: patients who were triaged were 16 times more likely to have a full set of vitals compared to those in the same time periods who were not triaged (60% v 8.6%, OR 15.9 (95% CI 13.37-18.91)). There was no difference in vital signs obtained by gender.

All process outcomes measured showed significant quality improvements in the post-training groups compared to the baseline group, except the percent of patients with shock documented to receive IV fluids (Table 5). After the initial training, patients had higher odds of having a glucose documented for altered mental status or neurologic complaints (37% v 30%, OR 1.7 (95% CI 1.3-2.2)). Patients also had higher odds of having antibiotics documented for presumed bacterial infections (87% v 35%, OR 12.8 (95% CI 8.8-17.1)) and documented malaria diagnostic testing for fever (76% v 61%, OR 2.05 (1.37-3.08)) in the post-training 1 time periods. Additionally, patients presenting with shock were more likely to have a repeat set of vital signs documented (25% v 6.6%, OR 8.85 (1.67-14.06)). Although there was no statistically significant difference between pre-training and post-training 1 in patients presenting with hypoxia documented to receive oxygen, there was a statistical difference between post-training 2 and pre-training time periods (35.7% v 11.1%, OR 4.44 (1.15 to 17.25)). There were no significant differences between the post-training 1 and post-training 2 groups on any metrics. Metrics did not vary significantly by age group.

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Table 3. Documented vital signs measurement by training group

	Pre-training (n=2,732)	Post-training 1 (n=3,194)		Post-training 2 (n=2,296)		
	n (%)	n (%)	Odds ratio* (95% CI) compared to pre-training	n (%)	Odds ratio* (95% CI) compared to pre-training	Odds ratio^ (95%CI) compared to post-training 1
Heart rate	925 (33.9)	1,763 (55.2)	2.41 (2.17 to 2.67)	1,183 (51.5)	2.08 (1.85 to 2.33)	0.86 (0.77 to 0.96)
Respiratory rate	132 (4.8)	647 (20.3)	5.00 (4.12 to 6.08)	449 (19.6)	4.79 (3.91 to 5.87)	0.96 (0.84 to 1.10)
Oxygen saturation	656 (24.0)	1,511 (47.3)	2.84 (2.54 to 3.18)	960 (41.8)	2.27 (2.02 to 2.57)	0.80 (0.72 to 0.89)
Blood pressure	888 (32.5)	1,580 (49.5)	2.03 (1.83 to 2.26)	942 (41.0)	1.44 (1.29 to 1.62)	0.71 (0.64 to 0.79)
Temperature	1,721 (63.0)	2,201 (68.9)	1.30 (1.17 to 1.45)	1,752 (76.3)	1.89 (1.67 to 2.14)	1.45 (1.28 to 1.64)
AVPU**	0	458 (14.3)	n/a	274 (11.9)	n/a	0.81 (0.69 to 0.95)
Weight	190 (7.0)	715 (22.4)	3.86 (3.26 to 4.57)	456 (19.9)	3.32 (2.77 to 3.97)	0.86 (0.75 to 0.98)
Full set of vitals***	95 (3.5)	516 (16.2)	5.35 (4.27 to 6.70)	372 (16.2)	5.37 (4.25 to 6.77)	1.01 (0.87 to 1.16)

*Odds ratios calculated with pretraining group as baseline odds.
^Odds ratios calculated for post-training group 2 with post-training 1 group as baseline odds.
** AVPU assesses level of consciousness as either **A**lert, responds to **V**erbal stimuli, responds to **P**ain, **U**nresponsive. It is a system to assess the level of consciousness in a patient.
***A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature

Table 4 Documented vital signs measurement by age-group after initial training&

	Age 0 - <5 (n=1,401)	Age 5 - <18 (n=1,214)		Age 18+ (n=2,801)		
	n (%)	n (%)	Odds ratio* (95% CI) compared to age-group 0 - <5	n (%)	Odds ratio*(95% CI) compared to age-group 0 - <5	Odds ratio^ (95% CI) compared to combined age-group 0 - <18
Heart rate	517 (36.9)	526 (43.3)	1.31 (1.12 to 1.53)	1,849 (66)	3.32 (2.91 to 3.8)	2.93 (2.62 to 3.27)
Respiratory rate	245 (17.5)	211 (17.4)	0.99 (0.81 to 1.22)	621 (22.2)	1.34 (1.14 to 1.58)	1.35 (1.18 to 1.54)
Oxygen saturation	466 (33.3)	432 (35.6)	1.11 (0.94 to 1.30)	1,527 (54.5)	2.4 (2.1 to 2.75)	2.29 (2.05 to 2.56)
Blood pressure	167 (11.9)	399 (32.9)	3.62 (3 to 4.42)	1,904 (68)	15.68 (13.1 to 18.78)	7.68 (6.8 to 8.68)
Temperature	1,107 (79)	898 (74)	0.75 (0.63 to 0.90)	1,898 (67.8)	0.56 (0.48 to 0.65)	0.64 (0.57 to 0.72)
AVPU**	149 (10.6)	142 (11.7)	1.11 (0.87 to 1.42)	418 (14.9)	1.47 (1.21 to 1.8)	1.4 (1.19 to 1.64)
Weight	528 (37.7)	304 (25)	0.55 (0.47 to 0.65)	324 (11.6)	0.22 (0.18 to 0.25)	0.28 (0.24 to 0.32)
Full set of vitals***	216 (15.4)	134 (11)	0.58 (0.54 to 0.86)	520 (18.6)	1.25 (1.05 to 1.49)	1.48 (1.27 to 1.71)

&This includes all patients after post-training 1 and post-training2, (excluding those in the pre-training, intermediate time period and those patients missing an age)
*Odds ratios calculated with age-group 0-5 as baseline odds.
^Odds ratios calculated for combined age-group 18+ with combined age groups 0 - <5 and 5 - <18 as baseline odds.
** AVPU- **A**lert, **V**erbal, **P**ain, **U**nresponsive. It is a system to assess the level of consciousness in a patient.
***A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature.

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Table 5. Documented process outcomes by training group

	Pre-training	Post-training 1		Post-training 2		
	n of total (%)	n of total (%)	Odds ratio* (95% CI) compared to pre-training	n of total (%)	Odds ratio* (95% CI) compared to pre-training	Odds ratio^ (95%CI) compared to post-training 1
Glucose test documented, among those with a neurologic chief complaint	145 of 560 (25.9)	254 of 672 (37.1)	1.74 (1.36 to 2.22)	169 of 469 (35.2)	1.61 (1.23 to 2.11)	0.93 (0.73 to 1.18)
Antibiotics documented, among those with a final diagnosis of presumed bacterial infection	154 of 441 (34.8)	415 of 478 (86.5)	12.28 (8.83 to 17.07)	335 of 388 (85.7)	11.78 (8.30 to 16.71)	0.96 (0.65 to 1.42)
Malaria test recorded, among those with a documented fever	139 of 229 (60.7)	168 of 221 (76.0)	2.05 (1.37 to 3.08)	179 of 242 (74.0)	1.84 (1.24 to 2.72)	0.91 (0.59 to 1.38)
Oxygen delivery recorded, among those with documented hypoxia	3 of 27 (11.1)	20 of 71 (28.2)	3.14 (0.85 to 11.59)	15 of 42 (35.7)	4.44 (1.15 to 17.25)	1.42 (0.63 to 3.20)
Repeat set of vital signs recorded, among those with initial shock vital signs**	4 of 61 (6.6)	49 of 193 (25.4)	8.85 (1.67 to 14.06)	34 of 135 (25.2)	4.80 (1.62 to 14.21)	0.99 (0.60 to 1.64)
IVF documented, among those with initial shock vital signs**	16 of 45 (35.6)	41 of 192 (21.4)	0.76 (0.39 to 1.49)	23 of 135 (17.0)	0.58 (0.28 to 1.19)	0.76 (0.43 to 1.33)

*Odds ratios calculated with pretraining group as baseline odds
^Odds ratios calculated for post-training 2 group with post-training group 1 as baseline odds.
** Shock identified by appropriate vital signs according to age.
IVF = Intravenous fluids

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DISCUSSION

The study evaluated key quality process metrics before and after emergency care trainings at a rural Liberian hospital. Almost all metrics improved after clinical training compared to baseline, though additional gains were not seen with a second clinical training. Notably, patients who were triaged in the post-training time periods showed significant gains in having full sets of vital signs documented compared to patients in the same time period who were not triaged. Our study

supports clinical trainings and triage training and implementation as an important step in improving care quality.

Training 1 resulted in a significant increase in the proportion of vital signs performed at JJD ED. Before Training 1, few patients had full sets of vital signs documented. Vital signs are an essential part of a patient's clinical evaluation, can detect serious illness, and help monitor for clinical deterioration.[23,25] Post-training, the odds of having a full set of vitals increased five-fold. Notably, patients who were triaged were nearly 16 times as likely to have a full set of vitals than those who were not, suggesting that small interventions can improve emergency care.

Despite these gains, few patients overall had a full set of vitals documented post-trainings (16.2%). The reasons for this warrant further exploration and there are several likely contributing factors. Due to the limited human resources, triage was inconsistently implemented. Without triage and with limited overall staffing, vitals were performed by the providers themselves as they evaluated patients. Due to the volume of patients and human resource constraints, anecdotal reports suggest providers often only obtained partial or forwent vitals due to time pressure; in addition, providers were observed to not consistently record vitals they obtained, particularly when the ED was very busy. Staffing workload was likely exacerbated by patients boarding within the ED. In the JJD ED, patients can stay for days if there is no space in the medical or surgical wards or if the patient is deemed too critical for the wards. The hospital does not have an ICU and the ED is the only clinical area where patients receive continuous visual observation from providers. Additionally, equipment constraints likely impacted efficiency, as VS machines are limited, and with intermittent electricity, automated machines were not always functional.

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Similarly, limited availability of specific age-appropriate vital sign equipment may have led to variability amongst age groups.

Large gains were seen in documented antibiotic administration among patients with presumed bacterial infections and in patients with shock receiving repeat vital signs. Patients presenting to the ED with a presumed bacterial infection were over 12 times more likely to have antibiotics documented after the initial emergency care training, and patients presenting to the ED in shock were nearly nine times more likely to have repeat vital signs documented. These significant gains have the potential to reduce morbidity and mortality from sepsis, a significant contribution to the burden of disease in LMICs.[26,27] These findings support that the expansion of limited emergency care trainings have the potential to improve the quality of emergency care provided by front-line providers and nurses.

The similarity of outcomes in the post-training 1 and 2 time periods may also be impacted by limitations of human resources and equipment. Staff turnover in the ED is relatively high. Attrition meant that 31% of the participants in training 2 were receiving initial training rather than re-training, possibly limiting impact. Also, the presence of ED-trained supervisors was intermittent, limiting the exposure of the staff to daily supervision and mentorship to help fortify the training. In addition, several of the process metrics depended on the availability of supplies or equipment. Our findings likely reflect a need for comprehensive health system strengthening, of which training is only one component. Increases in overall health financing are also needed to expand the availability of staff and materials to improve patient care. Additionally, further evaluation is needed to identify the best ways for ongoing continuing medical education and staff

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support. Aside from these explanations, the similarity of outcomes in post-training 1 and post-training 2 time periods could reflect that the additional training was necessary to ensure continued higher quality care and to keep metrics stable. If training 2 did not take place, it is possible the outcomes could have been worse, especially without daily supervision or mentorship.

LIMITATIONS

This study's results must be considered within the context of its design. One notable limitation is our method of measuring process metrics was documentation by the ED care provider and not direct observation of whether the care was provided. Particularly in an understaffed environment with many competing clinical demands and without administrative processes to hold providers accountable for their documentation, documentation may lag behind actual performance of tasks. There is also the risk of bias where providers document inaccurately, however, we suspect that under-reporting was likely the larger contributor. In the local care context, care processes such as placing oxygen on the patient or giving IV fluids do not require an order and thus might not be documented in the patient chart.

Given data systems at the hospital, we relied on retrospective data entry from hand-written patient records. It is possible additional interventions or vital sign measurements were performed but not documented. There may be unknown missing patient data, due to mixed methods of chart documentation. There was potential for missing data in the month of June, which had less data points when compared to the remaining months. Second, although this study suggests the interventions are associated with increases in quality metrics, causality cannot be established. In

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addition, we cannot rule out confounding between metrics and/or unmeasured variables, for example if increased rates of full sets of vital signs measured contributed to a higher likelihood of receiving repeat vitals. Future studies should address this. Third, the study looked at interventions as binary variables, but did not assess if the details of the intervention were appropriate to an individual patient. Finally, this study was conducted at a single site in rural Liberia that had not received any prior emergency care training and the generalizability of our findings is unknown.

CONCLUSION

This study demonstrated an improvement in most process metrics after the implementation of triage and emergency care training in rural Liberia, supporting the ability of short-course interventions to improve facility-based care. This complements other evaluations of BEC trainings, which demonstrated increased emergency care knowledge and confidence.[17,18] However, additional gains were not seen with a re-training several months later. Further exploration is needed to determine and intervene on other factors that influence quality metrics as well as the best methods for ongoing continue medical education and staff support.

SUPPLEMENTARY MATERIALS

Supplementary Data: This web only file has been produced by the BMJ Publishing Group from an electronic file supplied by the author(s) and has not been edited for content.

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FOOTNOTES

Contributors: KT, ID, AP, VK, RHM, RC, SAR contributed to study design. KT, ID, AP, NL, VK, RHM, MH, AB, RC, SAR implemented the emergency care trainings. KT, ID, DD, TD, SM contributed to data collection. KT, ID, JG, PS, SAR contributed to data analysis. All authors contributed to interpretation of study results. KT and ID drafted the initial version of the manuscript. All authors contributed to the revision of the manuscript and have approved the final manuscript version. KT and ID were equal contributors. KT is responsible for this paper and content as a guarantor.

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Figure 1 Training Timeline 2019

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REFERENCES

1. Jamison DT, Gelband H, Horton S, et al. Disease Control Priorities: Improving Health and Reducing Poverty. Vol 9. 3rd ed. The World Bank; 2017.

2. Calvello EJB, Broccoli M, Risko N, et al. Emergency care and health systems: consensus-based recommendations and future research priorities. *Acad Emerg Med*. 2013;20(12):1278-1288. DOI: 10.1111/acem.12266

3. Anderson PD, Suter RE, Mulligan T, et al. World health assembly resolution 60.22 and its importance as a health care policy tool for improving emergency care access and availability globally. *Ann Emerg Med*. 2012;60(1):35-44. DOI: 10.1016/j.annemergmed.2011.10.018. DOI: 10.1016/j.annemergmed.2011.10.018

4. Emergency care systems for universal health coverage: ensuring timely care for the acutely ill and injured. Seventy-Second World Health Assembly. May 28, 2019. Accessed November 5, 2020. https://www.who.int/publications/i/item/emergency-care-systems-for-universal-health-coverage-ensuring-timely-care-for-the-acutely-ill-and-injured

5. Razzak JA, Kellermann AL. Emergency medical care in developing countries: is it worthwhile?. *Bull World Health Organ.* 2002;80(11):900-905.

6. Anderson P. The globalization of emergency medicine and its importance for public health. *Bull World Health Organ*. 2006;84(10):835-838. DOI: 10.2471/blt.05.028548

7. Risko N, Chandra A, Burkholder TW, et al. Advancing research on the economic value of emergency care. *BMJ Glob Health*. 2019;4(6). DOI:10.1136/

For peer review only

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8. Thind A, Hsia R, Mabweijano J, et al. Essential Surgery: Disease Control Priorities. Vol 1. 3rd ed. The International Bank for Reconstruction and Development / The World Bank; 2015. Accessed November 9, 2020. http://www.ncbi.nlm.nih.gov/books/NBK333513/

9. Razzak J, Usmani MF, Bhutta ZA. Global, regional and national burden of emergency medical diseases using specific emergency disease indicators: analysis of the 2015 global burden of disease study. *BMJ Glob Health*. 2019;4(2). DOI:10.1136/bmjgh-2018-000733

10. Gosselin R, Spiegel DA, Coughlin R, et al. Injuries: the neglected burden in developing countries. *Bull World Health Organ*. 2009;87(4):246-246. DOI: 10.2471/BLT.08.052290

11. *Basic Package for Health and Social Welfare Services for Liberia.* Ministry of Health and Social Welfare Republic of Liberia. June 2008;42. Accessed November 5, 2020. http://liberiamohsw.org/Policies%20&%20Plans/Basic%20Package%20for%20Health%20&%20Social%20Welfare%20for%20Liberia.pdf

12. Kruk ME, Rockers PC, Williams EH, et al. Availability of essential health services in post-conflict Liberia. *Bull World Health Organ*. 2010;88(7):527-534. DOI: 10.2471/BLT.09.071068

13. Hexom B, Calvello EJB, Babcock CA, et al. A model for emergency medicine education in post-conflict Liberia. *Afr J Emerg Med*. 2012;2(4):143-150. DOI:10.1016/j.afjem.2012.08.006

For peer review only

14. McQuilkin PA, Udhayashankar K, Niescierenko M, et al. Health-care access during the Ebola virus epidemic in Liberia. *Am J Trop Med Hyg*. 2017;97(3):931-936. DOI: 10.4269/ajtmh.16-0702

15. Downie R. The Road to Recovery: Rebuilding Liberia's Health System. Center for Strategic and International Studies: August 2012;24. Accessed November 5, 2020. https://csis-website-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/120822_Downie_RoadtoRecovery_web.pdf

16. Mitchell R, McKup JJ, Bue O, et al. Implementation of a novel three-tier triage tool in Papua New Guinea: a model for resource-limited emergency departments. *Lancet Reg Health - West Pac*. 2020;5:100051. DOI: 10.1016/j.lanwpc.2020.100051

17. Olufadeji A, Usoro A, Akubueze CE, et al. Results from the implementation of the World Health Organization basic emergency care course in Lagos, Nigeria. *Afr J Emerg Med*. 2021;11(2):231-236. DOI: 10.1016/j.afjem.2021.02.004

18. Kivlehan SM, Dixon J, Kalanzi J, et al. Strengthening emergency care knowledge and skills in Uganda and Tanzania with the WHO-ICRC basic emergency care course. *Emerg Med J*. 2021;38(8):636-642. DOI: 10.1136/emermed-2020-209718

19. WHO Standardized Clinical Form. World Health Organization. January 14, 2020. Accessed April 1, 2022. https://www.who.int/publications/i/item/who-standardized-clinical-form

20. Broccoli MC, Moresky R, Dixon J, et al. Defining quality indicators for emergency care delivery: findings of an expert consensus process by emergency care practitioners in Africa. *BMJ Glob Health*. 2018;3(1):e000479. DOI: 10.1136/bmjgh-2017-000479

For peer review only

21. Aaronson EL, Marsh RH, Guha M, et al. Emergency department quality and safety indicators in resource-limited settings: an environmental survey. *Int J Emerg Med*. 2015;8(1):39. DOI 10.1186/s12245-015-0088-x

22. Cooper RJ, Schriger DL, Flaherty HL, et al. Effect of vital signs on triage decisions. *Ann Emerg Med*. 2002;39(3):223-232. DOI: 10.1067/mem.2002.121524

23. DeVita MA, Hillman K, Bellomo R, et al. Textbook of Rapid Response Systems: Concept and Implementation. Springer International Publishing; 2017.

24. *StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC.*

25. Brekke IJ, Puntervoll LH, Pedersen PB, et al. The value of vital sign trends in predicting and monitoring clinical deterioration: A systematic review. *PLoS ONE*. 2019;14(1). DOI: 10.1371/journal.pone.0210875

26. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. *The Lancet*. 2020;396(10258):1204-1222. DOI: 10.1016/S0140-6736(20)30925-9

27. Stephen AH, Montoya RL, Aluisio AR. Sepsis and Septic Shock in Low- and Middle-Income Countries. *Surg Infect*. 2020;21(7):571-578. DOI: 10.1089/sur.2020.047

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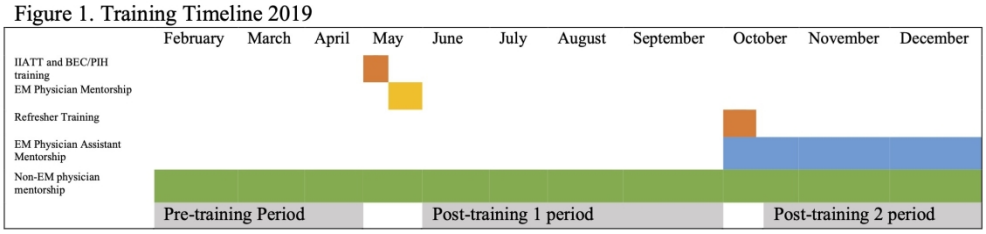

Figure 1 Training Timeline 2019

791x192mm (72 x 72 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	16-17
Study size	10	Explain how the study size was arrived at	10
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	10
Outcome data	15*	Report numbers of outcome events or summary measures	10-11

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-11
		(*b*) Report category boundaries when continuous variables were categorized	10-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Evaluation of Emergency Care Education and Triage Implementation: an observational study at a hospital in rural Liberia

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ABSTRACT

Introduction

In Liberia, emergency care is still in its early development. In 2019, two emergency care and triage education sessions were done at J. J. Dossen Hospital in Southeastern Liberia. The observational study objectives evaluated key process outcomes before and after the educational interventions.

Methods

Emergency Department paper records from February 1, 2019 to December 31, 2019 were retrospectively reviewed. Simple descriptive statistics were used to describe patient demographics and Chi-Square analyses were used to test for significance. Odds ratios were calculated for key pre-determined process measures.

Results

There were 8,222 patient visits recorded that were included in our analysis. Patients in the post-intervention 1 group had higher odds of having a documented full set of vital signs compared to the baseline group (16% v 3.5%, OR 5.4 (95% CI 4.3 to 6.7)). After triage implementation, patients who were triaged were 16 times more likely to have a full set of vitals compared to those who were not triaged. Similarly, compared to the baseline group, patients in the post-intervention 1 group had higher odds of having a glucose documented if they presented with altered mental status or a neurologic complaint (37% v 30%, OR 1.7 (CI 1.3 to 2.2)), documented antibiotic administration if they had a presumed bacterial infection (87% v 35%, OR 12.8 (CI 8.8 to 17.1)),

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documented malaria test if presenting with fever (76% v 61%, OR 2.05 (CI 1.37 to 3.08)) or documented repeat set of vitals if presenting with shock (25% v 6.6%, OR 8.85 (CI 1.67 to 14.06)). There was no significant difference in the above process outcomes between the education interventions.

Conclusion

This study showed improvement in most process measures between the baseline and post-intervention 1 groups, benefits that persisted post-intervention 2, thus supporting the importance of short-course education interventions to durably improve facility-based care.

Strengths and Limitations of this study

- **This study contributes to limited research on educational interventions in LMICs -- where emergency care is in its infancy – by evaluating changes in care processes as a result of educational interventions.**
- **This study evaluated both pediatric and adult populations which fully represents the patient population presenting to the emergency department.**
- **This is an observational cross-sectional study, so causality cannot be established.**
- **This is a single center study and generalizability of results is unknown.**
- **The study design retrospectively reviewed documents and did not include direct observations which may not fully represent actual practice.**

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INTRODUCTION

Emergency care has been increasingly recognized as a fundamental component to strengthening health systems [1-5] and an effective means to address multiple Sustainable Development Goals and reduce the overall burden of disease.[1,6] An estimated 54% of annual deaths in low and middle-income countries (LMICs) could be addressed by pre-hospital and hospital-based emergency care.[7] More specifically, injury related mortality disproportionately effects LMICs, and accounts for more than 90% of the total global mortality related to injury.[8] Timely emergency care saves lives across the spectrum of illness from injuries to acute presentations of chronic disease and is the first contact with the health system for many individuals. [1-2,9-10]

Emergency care in Liberia, like many LMICs, is still in its early development. In 2007, emergency care was first included in Liberia's national health plan and basic package of health services.[11,12] There has been some development of emergency education at the national referral hospital in the capital of Monrovia; however, no other consistent or standardized emergency medicine curriculum has been established.[13] The basic package of health services outlines the essentials of emergency care for each level of service.[11] Currently, there are no formal indicators measuring care or process outcomes for emergency care nationally.

In 2014, the Ebola outbreak led to the near-collapse of the country's already weakened health system, which was recovering from recent civil war (1989-1996 and 1999-2003).[13–15] In 2015, responding to the Ebola epidemic, the global non-profit organization Partners In Health (PIH), at the invitation of and in partnership with the Liberian government, came to Liberia to support the emergency response and long-term strengthening of the health system. Given clear emergency

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care needs in Maryland County, a key goal of PIH's became to expand and strengthen emergency services, which included developing the health workforce capacity to provide high-quality emergency care with the support of emergency care education sessions and triage implementation. The objective of this observational study was to evaluate key process outcomes before and after triage implementation and emergency care education interventions to assess its impact on quality of care and identify areas for future improvement.

METHODS

Study Design

An observational, retrospective cross-sectional study of patients presenting to a regional hospital ED in Southeastern Liberia.

Study Setting

The observational study was carried out at JJD, the only county referral hospital in rural, Southeastern Liberia. It is a government-run hospital supported by PIH and provides services free of charge. JJD serves a primary catchment area of 187,000 people in Maryland county, and receives additional referrals from neighboring counties.[16] At the time of the education interventions, JJD's 8-bed ED was primarily staffed by nurses and physician's assistant. There was no trained emergency medicine physician at the hospital. Specialists in the four core clinical departments of pediatrics, internal medicine, surgery and obstetrics and gynecology provide back-up clinical support to the ED in their respective clinical areas as needed. Prior to 2019, none of the ED staff had specific emergency care education courses. In addition to nurses and

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PAs, nursing aides and nursing students worked within the ED; after triage was implemented in May 2019, nursing aides primarily staffed ED triage.

Education Interventions

A series of education interventions were undertaken with ED staff, that included both nurses and physician assistants, to train them on the implementation of the Integrated Interagency Trial Tool (IIATT) and completion of the WHO Basic Emergency Care course. For the first intervention, a series of education sessions were conducted to improve emergency care at JJD in late April and early May 2019. First, staff were trained on the WHO-ICRC-MSF integrated interagency triage tool through didactics followed by real-time supervision and mentorship on the implementation of triage.[17-19] Triage is an essential component of emergency care; it evaluates a patient's acuity and prioritizes evaluation and treatment based on the severity of the patient's condition.[6] The IIATT assigns patients to a 3-tier acuity system, based on specified symptoms, physical signs, and high risk vital signs.[17-19]

Following the IIATT training, 12 staff received 2 weeks of education on the WHO Basic Emergency Care (BEC) course, followed by the complementary PIH Fundamentals of Emergency Care training. The WHO BEC course was composed of didactic, small group sessions and skills session, designed to train staff to identify and manage acute illnesses and injuries with limited resources. [20,21] The supplemental PIH course included additional topics (eg. approach to conditions such as abdominal pain and fevers), and skills such as basic EKG and ultrasound. The didactic courses were followed by two weeks of clinical mentorship by a visiting

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faculty emergency physician. Afterwards, ongoing occasional clinical mentorship was supported by non-EM faculty who worked at JJD.

In mid-October 2019, 16 JJD staff participated in a three-day refresher education session. Five participants had not completed the initial education intervention, so received a pre-course one-day intensive training on key concepts covered previously. An emergency physician assistant provided ongoing clinical mentorship 4 days a week for the subsequent 3 months.

Study Population

The study was conducted from February 1, 2019 to December 31, 2019. During this period, all patients presenting to the JJD ED for whom a visit was either documented in the ED ledger or a separate paper chart were included in the study.

Data Collection

Trained data collectors extracted information from the paper ED records into a pre-developed data extraction tool. Prior to May 2019, all initial visit documentation occurred exclusively in the ED ledger, including demographics, reason for the visit, vital signs, lab testing, key results, diagnosis, and disposition. After May 2019, documentation included three sources: the ED ledger, an ED triage form, and a ED provider documentation form adapted from the WHO Emergency Unit forms.[22] These forms were introduced in May 2019 and used by staff performing the initial evaluation and resuscitation. The ED ledger was a bound book with paper records, described above. The ED triage form documented triage acuity based on presenting symptoms and vital signs based on the interagency integrated triage tool. The ED provider

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documentation form included sections for vital signs, chief complaint, primary survey, history of presenting illness, review of systems, past medical history, assessment, and plan. Data collectors reviewed all these source and recorded demographics, initial vital signs, select clinical process measures and outcome variables.

Variables and Outcomes

We classified visits from February 1, 2019 to April 30, 2019 as "pre-intervention", visits from May 29, 2019 to October 13, 2019 as "post-intervention 1", and October 21, 2019 to December 31, 2019 as "post-intervention 2." Visits from May 1, 2019 to May 28, 2019 and October 14, 2019 to October 20, 2019 were considered to be in "intermediate" time periods (e.g., time periods during the education sessions themselves) and excluded from comparative analyses (as seen in figure 1). Data with missing date and age variables were also excluded from the analysis.

Due to differences in documentation standards prior to the ED education session, we focused our analyses on variables and process metrics that were reliably and routinely captured in the JJD ED register. The study team reviewed process metrics recommended by the African Federation of Emergency Medicine, as well as a review of quality metrics used in LMIC EDs.[23,24] From these lists, study outcomes were chosen based on local context, hospital and government priorities, and pre-existing documentation patterns that determined what baseline data was available. Outcomes focused primarily on the effectiveness domain of quality of care.[25]The primary study outcome was a complete set of recorded vital signs at any time during the patient's ED visit and was chosen given the importance of vital signs to triage and emergency care. [26,27] A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure

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and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature. Blood pressure was not reliably recorded in this younger age group so was not included.

Secondary outcomes examined included documentation of: blood glucose for patients presenting with altered mental status or a neurologic complaint; antibiotic administration or prescription in patients with a presumed bacterial infection; malaria diagnostic testing in patients with temperature $\geq$ 38^{o}C; oxygen administration for hypoxia; repeat vital signs for shock; and intravenous fluids for shock (hypoxia and shock were defined by age, Table 1). A physician assistant interpreted the final diagnoses to determine if the visit was due to a presumed bacterial infection. In the absence of microbiology capability to perform cultures and accounting for local context and practice patterns, all diagnoses of pneumonia, urinary tract infections, meningitis, cellulitis, and sepsis were presumed to have been bacterial. Tuberculosis (TB) was excluded from the list of bacterial infections, as TB patients are referred to TB clinic to initiate treatment and therefore not reliably documented as part of ED care. A patient was coded as a neurologic complaint if the clinical documentation included altered mental status, weakness, dizziness, or seizures.

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Table 1. Variable Definitions	
Hypoxia	
Age ≤ 5 years	SpO2 ≤ 94%
Age > 5 years	SpO2 ≤ 92%
Fever	temperature ≥38℃
Shock Vitals	
Age 0 to < 1 years*	HR > 160bpm
Age ≥1 to < 3 years*	HR > 160bpm
Age ≥ 3 to < 5 years*	HR > 140bpm
Age ≥ 5 to < 13 years	HR of ≥ 130bpm or a systolic blood pressure < 70mmHg
Age ≥ 13 years	HR of ≥ 130bpm or a systolic blood pressure < 80mmHg
*Note: Blood pressure was not included as a criterion in the younger age groups as it is not reliably recorded.	

Data Analysis

Data was transcribed into Excel, then imported into and analyzed with Stata (Version 15). [28] Simple descriptive statistics were used to describe the patient demographics and Chi-Square analyses were used to test for significance using a nominal threshold of 0.05. Odds ratios and 95% confidence intervals were calculated for pre-determined process measurements as described above.

Patient and Public Involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

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RESULTS

There were 8,774 patient visits recorded in the JJD ED from February 1, 2019 to December 31, 2019 and included in our analysis: 2,732 in the pre-intervention time period, 3,194 in the 'post-intervention 1' time period, 2,296 in the 'post-intervention 2' time period, and 552 in the 'indeterminate' time periods, which were excluded from the analysis (Table 2).

Table 2. Demographic description of gender and age at J.J. Dossen Hospital^

Age [Years]	Male n (%)	Female n (%)	Gender Missing n (%)	Total n (%)
0 - <5	1,102 (52.9)	954 (45.8)	29 (1.4)	2,085 (25.4)
5 - <18	858 (47.6)	917 (50.9)	26 (1.4)	1,801 (21.9)
18+	2,015 (47.6)	2,183 (51.6)	36 (0.9)	4,234 (51.5)
Age Missing	40 (39.2)	56 (54.9)	6 (5.9)	102 (1.2)
Total	4,015 (48.6)	4,110 (54.9)	97 (1.2)	8,222

^Includes all patients from pre-intervention, post-intervention 1, and post-intervention 2 time periods.

In the baseline time period, only 3.5% of patients had a complete set of vital signs documented (Table 3). In both post-intervention 1 and post-intervention 2 time periods, patients had higher odds of having a documented full set of vital signs (16% OR 5.4 (95% CI 4.3-6.7)). Adults were statistically more likely than children to have a documented full set of vitals (OR 1.43 (95% CI 1.26-1.62) (Table 4). Triage, implemented as part of the first education intervention, significantly influenced the likelihood of having a full set of vital signs recorded: patients who were triaged were 16 times more likely to have a full set of vitals compared to those in the same time periods who were not triaged (60% v 8.6%, OR 15.9 (95% CI 13.37-18.91)). There was no difference in vital signs obtained by gender.

All process outcomes measured showed significant quality improvements in the post-intervention groups compared to the baseline group, except the percent of patients with shock documented to receive IV fluids (Table 5). After the initial education session, patients had higher

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odds of having a glucose documented for altered mental status or neurologic complaints (37% v 30%, OR 1.7 (95% CI 1.3-2.2)). Patients also had higher odds of having antibiotics documented for presumed bacterial infections (87% v 35%, OR 12.8 (95% CI 8.8-17.1)) and documented malaria diagnostic testing for fever (76% v 61%, OR 2.05 (1.37-3.08)) in the post-intervention 1 time periods. Additionally, patients presenting with shock were more likely to have a repeat set of vital signs documented (25% v 6.6%, OR 8.85 (1.67-14.06)). Although there was no statistically significant difference between pre-intervention and post-intervention 1 in patients presenting with hypoxia documented to receive oxygen, there was a statistical difference between post-intervention 2 and pre-intervention time periods (35.7% v 11.1%, OR 4.44 (1.15 to 17.25)). There were no significant differences between the post-intervention 1 and post-intervention 2 groups on any metrics. Metrics did not vary significantly by age group.

Table 3. Documented vital signs measurement by intervention period

	Pre-intervention (n=2,732)	Post-intervention1 (n=3,194)		Post-intervention 2 (n=2,296)		
	n (%)	n (%)	Odds ratio* (95% CI) compared to pre-intervention	n (%)	Odds ratio* (95% CI) compared to pre-intervention	Odds ratio^ (95%CI) compared to post-intervention 1
Heart rate	925 (33.9)	1,763 (55.2)	2.41 (2.17 to 2.67)	1,183 (51.5)	2.08 (1.85 to 2.33)	0.86 (0.77 to 0.96)
Respiratory rate	132 (4.8)	647 (20.3)	5.00 (4.12 to 6.08)	449 (19.6)	4.79 (3.91 to 5.87)	0.96 (0.84 to 1.10)
Oxygen saturation	656 (24.0)	1,511 (47.3)	2.84 (2.54 to 3.18)	960 (41.8)	2.27 (2.02 to 2.57)	0.80 (0.72 to 0.89)
Blood pressure	888 (32.5)	1,580 (49.5)	2.03 (1.83 to 2.26)	942 (41.0)	1.44 (1.29 to 1.62)	0.71 (0.64 to 0.79)
Temperature	1,721 (63.0)	2,201 (68.9)	1.30 (1.17 to 1.45)	1,752 (76.3)	1.89 (1.67 to 2.14)	1.45 (1.28 to 1.64)
AVPU**	0	458 (14.3)	n/a	274 (11.9)	n/a	0.81 (0.69 to 0.95)
Weight	190 (7.0)	715 (22.4)	3.86 (3.26 to 4.57)	456 (19.9)	3.32 (2.77 to 3.97)	0.86 (0.75 to 0.98)
Full set of vitals***	95 (3.5)	516 (16.2)	5.35 (4.27 to 6.70)	372 (16.2)	5.37 (4.25 to 6.77)	1.01 (0.87 to 1.16)

*Odds ratios calculated with pre-intervention group as baseline odds.
^Odds ratios calculated for post-intervention 2 group with post-intervention 1 group as baseline odds.
** AVPU assesses level of consciousness as either **A**lert, responds to **V**erbal stimuli, responds to **P**ain, **U**nresponsive. It is a system to assess the level of consciousness in a patient.
***A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature

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Table 4 Documented vital signs measurement by age-group after initial intervention[&]

	Age 0 - <5 (n=1,401)	Age 5 - <18 (n=1,214)		Age 18+ (n=2,801)		
	n (%)	n (%)	Odds ratio* (95% CI) compared to age-group 0 - <5	n (%)	Odds ratio*(95% CI) compared to age-group 0 - <5	Odds ratio^ (95% CI) compared to combined age-group 0 - <18
Heart rate	517 (36.9)	526 (43.3)	1.31 (1.12 to 1.53)	1,849 (66)	3.32 (2.91 to 3.8)	2.93 (2.62 to 3.27)
Respiratory rate	245 (17.5)	211 (17.4)	0.99 (0.81 to 1.22)	621 (22.2)	1.34 (1.14 to 1.58)	1.35 (1.18 to 1.54)
Oxygen saturation	466 (33.3)	432 (35.6)	1.11 (0.94 to 1.30)	1,527 (54.5)	2.4 (2.1 to 2.75)	2.29 (2.05 to 2.56)
Blood pressure	167 (11.9)	399 (32.9)	3.62 (3 to 4.42)	1,904 (68)	15.68 (13.1 to 18.78)	7.68 (6.8 to 8.68)[%]
Temperature	1,107 (79)	898 (74)	0.75 (0.63 to 0.90)	1,898 (67.8)	0.56 (0.48 to 0.65)	0.64 (0.57 to 0.72)
AVPU**	149 (10.6)	142 (11.7)	1.11 (0.87 to 1.42)	418 (14.9)	1.47 (1.21 to 1.8)	1.4 (1.19 to 1.64)
Weight	528 (37.7)	304 (25)	0.55 (0.47 to 0.65)	324 (11.6)	0.22 (0.18 to 0.25)	0.28 (0.24 to 0.32)
Full set of vitals***	216 (15.4)	134 (11)	0.58 (0.54 to 0.86)	520 (18.6)	1.25 (1.05 to 1.49)	1.48 (1.27 to 1.71)

[&]This includes all patients after post-intervention 1 and post-intervention 2, (excluding those in the pre-intervention, intermediate time period and those patients missing an age)
*Odds ratios calculated with age-group 0-5 as baseline odds.
^Odds ratios calculated for combined age-group 18+ with combined age groups 0 - <5 and 5 - <18 as baseline odds.
[%]Note that blood pressure may be less reliably measured…
** AVPU- **A**lert, **V**erbal, **P**ain, **U**nresponsive. It is a system to assess the level of consciousness in a patient.
***A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature.

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Table 5. Documented process outcomes by intervention period						
	Pre-intervention	Post-intervention 1		Post-intervention 2		
	n of total (%)	n of total (%)	Odds ratio* (95% CI) compared to pre-intervention	n of total (%)	Odds ratio* (95% CI) compared to pre-intervention	Odds ratio^ (95%CI) compared to post-intervention 1
Glucose test documented, among those with a neurologic chief complaint	145 of 560 (25.9)	254 of 672 (37.1)	1.74 (1.36 to 2.22)	169 of 469 (35.2)	1.61 (1.23 to 2.11)	0.93 (0.73 to 1.18)
Antibiotics documented, among those with a final diagnosis of presumed bacterial infection	154 of 441 (34.8)	415 of 478 (86.5)	12.28 (8.83 to 17.07)	335 of 388 (85.7)	11.78 (8.30 to 16.71)	0.96 (0.65 to 1.42)
Malaria test recorded, among those with a documented fever	139 of 229 (60.7)	168 of 221 (76.0)	2.05 (1.37 to 3.08)	179 of 242 (74.0)	1.84 (1.24 to 2.72)	0.91 (0.59 to 1.38)
Oxygen delivery recorded, among those with documented hypoxia	3 of 27 (11.1)	20 of 71 (28.2)	3.14 (0.85 to 11.59)	15 of 42 (35.7)	4.44 (1.15 to 17.25)	1.42 (0.63 to 3.20)
Repeat set of vital signs recorded, among those with initial shock vital signs**	4 of 61 (6.6)	49 of 193 (25.4)	8.85 (1.67 to 14.06)	34 of 135 (25.2)	4.80 (1.62 to 14.21)	0.99 (0.60 to 1.64)
IVF documented, among those with initial shock vital signs**	16 of 45 (35.6)	41 of 192 (21.4)	0.76 (0.39 to 1.49)	23 of 135 (17.0)	0.58 (0.28 to 1.19)	0.76 (0.43 to 1.33)

*Odds ratios calculated with pre-intervention group as baseline odds
^Odds ratios calculated for post-intervention 2 group with post-intervention 1 group as baseline odds.
** Shock identified by appropriate vital signs according to age.
IVF = Intravenous fluids

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DISCUSSION

The study evaluated key quality process metrics before and after emergency care education sessions at a rural Liberian hospital. Almost all metrics improved after the education sessions compared to baseline, though additional gains were not seen with a second clinical training. Notably, patients who were triaged in the post-intervention time periods showed significant gains

in having full sets of vital signs documented compared to patients in the same time period who were not triaged. Our study supports clinical trainings and triage training and implementation as an important step in improving care quality.

Pre-intervention, few patients had full sets of vital signs documented. Vital signs are an essential part of a patient's clinical evaluation, can detect serious illness, and help monitor for clinical deterioration.[27,29] Post-interventions, the odds of having a full set of vitals increased five-fold. Notably, patients who were triaged were nearly 16 times as likely to have a full set of vitals than those who were not, even in the same time period, suggesting that small interventions can be associated with improved emergency care.

Despite these gains, few patients overall had a full set of vitals documented post-interventions (16.2%). There are several likely contributing factors to this. First, due to the limited human resources, triage was inconsistently implemented. Without triage, vitals were performed by the providers themselves as they evaluated patients. Due to the volume of patients, boarding patients within the ED, and human resource constraints, anecdotal reports suggest providers often only obtained partial or forwent vitals due to time pressure. In addition, providers were observed to not consistently record vitals they obtained, particularly when the ED was very busy. Additionally, equipment constraints likely impacted efficiency, as VS machines are limited, and with intermittent electricity, automated machines were not always functional. Similarly, limited availability of specific age-appropriate vital sign equipment may have led to variability amongst age groups.

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Large gains were seen in documented antibiotic administration among patients with presumed bacterial infections and in patients with shock receiving repeat vital signs. Patients presenting to the ED with a presumed bacterial infection were over 12 times more likely to have antibiotics documented after the initial emergency care education session, and patients presenting to the ED in shock were nearly nine times more likely to have repeat vital signs documented. These significant gains have the potential to reduce morbidity and mortality from sepsis, a significant contribution to the burden of disease in LMICs.[30,31] These findings suggest that limited emergency care education sessions are associated with improved quality of emergency care provided by front-line providers and nurses. Future randomized studies should be considered to quantify the impact.

The similarity of outcomes in the post-intervention 1 and post-intervention 2 time periods may also be impacted by limitations of human resources and equipment. Staff turnover in the ED is relatively high. Attrition meant that 31% of the participants in intervention 2 were receiving initial training rather than re-training, possibly limiting impact. Also, the presence of ED-trained supervisors was intermittent, limiting the exposure of the staff to daily supervision and mentorship to help fortify the training. In addition, several of the process metrics depended on the availability of supplies or equipment. Our findings likely reflect a need for comprehensive health system strengthening, of which education sessions are only one component. Increases in overall health financing are also needed to expand the availability of staff and materials to improve patient care. Additionally, further evaluation is needed to identify the best ways for ongoing continuing medical education and staff support. Aside from these explanations, the similarity of outcomes in post-intervention 1 and post-intervention 2 time periods could reflect

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that the additional education session was necessary to ensure continued higher quality care and to keep metrics stable. If the second educational intervention did not take place, it is possible the outcomes could have been worse, especially without daily supervision or mentorship.

LIMITATIONS

This study's results must be considered within the context of its design. One notable limitation is that our method of measuring process metrics was documentation by the ED care provider and not direct observation of whether the care was provided. Particularly in an understaffed environment with many competing clinical demands and without administrative processes to hold providers accountable for their documentation, documentation may lag behind actual performance of tasks. There is also the risk of bias where providers document inaccurately, however, we suspect that under-reporting was likely the larger contributor. In the local care context, care processes such as placing oxygen on the patient or giving IV fluids do not require an order and thus might not be documented in the patient chart.

Given data systems at the hospital, we relied on retrospective data entry from paper records. It is possible additional interventions or vital sign measurements were performed but not documented. There may be unknown missing patient data, due to mixed methods of chart documentation. There was potential for missing data in the month of June, which had less data points when compared to the remaining months. Second, although this study suggests the interventions are associated with increases in quality metrics, causality cannot be established. In addition, we cannot rule out confounding between metrics and/or unmeasured variables, for example if increased rates of full sets of vital signs measured contributed to a higher likelihood

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of receiving repeat vitals. Future studies should address this. Third, the study looked at interventions as binary variables, but did not assess if the details of the intervention were appropriate to an individual patient. Finally, this study was conducted at a single site in rural Liberia that had not received any prior emergency care training and the generalizability of our findings is unknown.

CONCLUSION

This study demonstrated an improvement in most process metrics after the implementation of triage and emergency care training in rural Liberia, supporting the utility of short-course interventions on facility-based care. This complements other evaluations of BEC trainings, which demonstrated increased emergency care knowledge and confidence.[20,21] However, additional gains were not seen with a re-training several months later. Further exploration is needed to determine and intervene on other factors that influence quality metrics as well as the best methods for ongoing continue medical education and staff support.

FOOTNOTES

Data Availability Statement

All data relevant to the study are included in the article or uploaded as supplementary information.

Patient consent for publication

The IRB approved a Waiver of informed consent given the study was a chart review study, so informed consent was not obtained.

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Ethics Approval

The study was approved by the Partners Healthcare IRB 2019P001944 as well as approved under the University of Liberia-Pacific Institute for Research and Evaluation IRB 17-06-048 as part of the clinical and training protocol that Partners In Health Liberia submits annually for review.

Contributors: KT, ID, AP, VK, RHM, PU, RC, SAR contributed to study design. KT, ID, AP, NL, VK, RHM, MH, AB, RC, SAR implemented the emergency care trainings. KT, ID, DD, TD, SM contributed to data collection. KT, ID, JG, PS, SAR contributed to data analysis. All authors contributed to interpretation of study results. KT and ID drafted the initial version of the manuscript. All authors contributed to the revision of the manuscript and have approved the final manuscript version. KT and ID were equal contributors. KT is responsible for this paper and content as a guarantor.

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Competing Interests: None declared.

Figure 1 Education Intervention Timeline 2019: Figure 1 shows the timeline of the study including education session time periods, the time periods pre and post-interventions, as well as time periods where mentorship was provided.

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REFERENCES

1. Jamison DT, Gelband H, Horton S, et al. Disease Control Priorities: Improving Health and Reducing Poverty [Internet]. Vol 9. 3rd ed. The World Bank; 2017[cited 2020 Nov 5]. Available from: http://elibrary.worldbank.org/doi/book/10.1596/978-1-4648-0527-1

2. Anderson PD, Suter RE, Mulligan T, et al. World health assembly resolution 60.22 and its importance as a health care policy tool for improving emergency care access and availability globally. *Ann Emerg Med*. 2012;60(1):35-44. DOI: 10.1016/j.annemergmed.2011.10.018. DOI: 10.1016/j.annemergmed.2011.10.018

3. Emergency care systems for universal health coverage: ensuring timely care for the acutely ill and injured. Seventy-Second World Health Assembly. May 28, 2019 [cited 2020 Nov 5]. Available from: https://www.who.int/publications/i/item/emergency-care-systems-for-universal-health-coverage-ensuring-timely-care-for-the-acutely-ill-and-injured

4. Razzak JA, Kellermann AL. Emergency medical care in developing countries: is it worthwhile?. *Bull World Health Organ.* 2002;80(11):900-905. Available from: https://doi.org/https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2567674/

5. Anderson P. The globalization of emergency medicine and its importance for public health. *Bull World Health Organ*. 2006;84(10):835-838. DOI: 10.2471/blt.05.028548

6. Risko N, Chandra A, Burkholder TW, et al. Advancing research on the economic value of emergency care. *BMJ Glob Health*. 2019;4(6). DOI:10.1136/bmjgh-2019-001768

7. Thind A, Hsia R, Mabweijano J, et al. Essential Surgery: Disease Control Priorities. Vol 1. 3rd ed. The International Bank for Reconstruction and Development / The World Bank;

For peer review only

2015. [cited 2020 Nov 9]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK333513/

8. Gosselin R, Spiegel DA, Coughlin R, et al. Injuries: the neglected burden in developing countries. *Bull World Health Organ*. 2009;87(4):246-246. DOI: 10.2471/BLT.08.052290

9. Calvello EJB, Broccoli M, Risko N, et al. Emergency care and health systems: consensus-based recommendations and future research priorities. *Acad Emerg Med*. 2013;20(12):1278-1288. DOI: 10.1111/acem.12266

10. Razzak J, Usmani MF, Bhutta ZA. Global, regional and national burden of emergency medical diseases using specific emergency disease indicators: analysis of the 2015 global burden of disease study. *BMJ Glob Health*. 2019;4(2). DOI:10.1136/bmjgh-2018-000733

11. *Basic Package for Health and Social Welfare Services for Liberia.* Ministry of Health and Social Welfare Republic of Liberia. June 2008;42. [cited 2020 Nov 5]. Available from: http://liberiamohsw.org/Policies%20&%20Plans/Basic%20Package%20for%20Health%20&%20Social%20Welfare%20for%20Liberia.pdf

12. Kruk ME, Rockers PC, Williams EH, et al. Availability of essential health services in post-conflict Liberia. *Bull World Health Organ*. 2010;88(7):527-534. DOI: 10.2471/BLT.09.071068

13. Hexom B, Calvello EJB, Babcock CA, et al. A model for emergency medicine education in post-conflict Liberia. *Afr J Emerg Med*. 2012;2(4):143-150. DOI:10.1016/j.afjem.2012.08.006

For peer review only

14. McQuilkin PA, Udhayashankar K, Niescierenko M, et al. Health-care access during the Ebola virus epidemic in Liberia. *Am J Trop Med Hyg*. 2017;97(3):931-936. DOI: 10.4269/ajtmh.16-0702

15. Downie R. The Road to Recovery: Rebuilding Liberia's Health System. Center for Strategic and International Studies: August 2012;24. [cited 2020 Nov 5]. Available from: https://csis-website-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/120822_Downie_RoadtoRecovery_web.pdf

16. 2008 National Population and Housing Census: preliminary results. Government of the Republic of Liberia. June 2008;23. [cited 2020 Nov 5]. Available from: https://www.emansion.gov.lr/doc/census_2008provisionalresults.pdf

17. Mitchell R, McKup JJ, Bue O, et al. Implementation of a novel three-tier triage tool in Papua New Guinea: a model for resource-limited emergency departments. *Lancet Reg Health - West Pac*. 2020;5:100051. DOI: 10.1016/j.lanwpc.2020.100051

18. Mitchell R, Bue O, Nou G, et al. Validation of the interagency triage tool in a resource limited, urban emergency department in Papua New Guinea: a pilot study. *Lancet Reg Health-West Pac*. 2021;13:100194. DOI: https://doi.org/10.1016/j.lanwpc.2021.100194

19. World Health Organization. Clinical care for severe acute respiratory infection: toolkit. COVID-19 adaptation [Internet]. Geneva: World Health Organization; 2020 [cited 2020 Dec 27]. 13-15p. Available from: https://apps.who.int/iris/handle/10665/331736

For peer review only

20. Olufadeji A, Usoro A, Akubueze CE, et al. Results from the implementation of the World Health Organization basic emergency care course in Lagos, Nigeria. *Afr J Emerg Med*. 2021;11(2):231-236. DOI: 10.1016/j.afjem.2021.02.004

21. Kivlehan SM, Dixon J, Kalanzi J, et al. Strengthening emergency care knowledge and skills in Uganda and Tanzania with the WHO-ICRC basic emergency care course. *Emerg Med J*. 2021;38(8):636-642. DOI: 10.1136/emermed-2020-209718

22. WHO Standardized Clinical Form. World Health Organization. January 14, 2020 [cited 2022 April 1] Available from:https://www.who.int/publications/i/item/who-standardized-clinical-form

23. Broccoli MC, Moresky R, Dixon J, et al. Defining quality indicators for emergency care delivery: findings of an expert consensus process by emergency care practitioners in Africa. *BMJ Glob Health*. 2018;3(1):e000479. DOI: 10.1136/bmjgh-2017-000479

24. Aaronson EL, Marsh RH, Guha M, et al. Emergency department quality and safety indicators in resource-limited settings: an environmental survey. *Int J Emerg Med*. 2015;8(1):39. DOI 10.1186/s12245-015-0088-x

25. World Health Organization. Quality of care [Internet]. Geneva: World Health Organization;2022 [cited 2022 Dec 27]. Available from: https://www.who.int/health-topics/quality-of-care#tab=tab_1

26. Cooper RJ, Schriger DL, Flaherty HL, et al. Effect of vital signs on triage decisions. *Ann Emerg Med*. 2002;39(3):223-232. DOI: 10.1067/mem.2002.121524

For peer review only

27. DeVita MA, Hillman K, Bellomo R, et al. Textbook of Rapid Response Systems: Concept and Implementation. Springer International Publishing; 2017. [cited 2020 Nov 5]. Available from: http://link.springer.com/10.1007/978-3-319-39391-9

28. *StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC.*

29. Brekke IJ, Puntervoll LH, Pedersen PB, et al. The value of vital sign trends in predicting and monitoring clinical deterioration: A systematic review. *PLoS ONE*. 2019;14(1). DOI: 10.1371/journal.pone.0210875

30. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. *The Lancet*. 2020;396(10258):1204-1222. DOI: 10.1016/S0140-6736(20)30925-9

31. Stephen AH, Montoya RL, Aluisio AR. Sepsis and Septic Shock in Low- and Middle-Income Countries. *Surg Infect*. 2020;21(7):571-578. DOI: 10.1089/sur.2020.047

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Figure 1. Education Intervention Timeline 2019

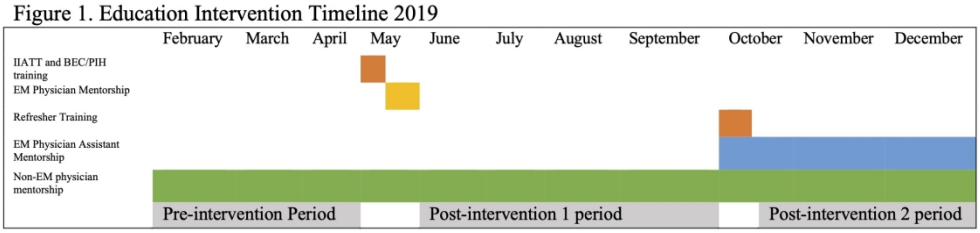

Figure 1 shows the timeline of the study including education session time periods, the time periods pre and post-interventions, as well as time periods where mentorship was provided.

795x192mm (72 x 72 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	16
Study size	10	Explain how the study size was arrived at	6,9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9-11
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	10-11

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-11
		(*b*) Report category boundaries when continuous variables were categorized	10-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Evaluation of Emergency Care Education and Triage Implementation: an observational study at a hospital in rural Liberia

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ABSTRACT

Introduction

In Liberia, emergency care is still in its early development. In 2019, two emergency care and triage education sessions were done at J. J. Dossen Hospital in Southeastern Liberia. The observational study objectives evaluated key process outcomes before and after the educational interventions.

Methods

Emergency Department paper records from February 1, 2019 to December 31, 2019 were retrospectively reviewed. Simple descriptive statistics were used to describe patient demographics and Chi-Square analyses were used to test for significance. Odds ratios were calculated for key pre-determined process measures.

Results

There were 8,222 patient visits recorded that were included in our analysis. Patients in the post-intervention 1 group had higher odds of having a documented full set of vital signs compared to the baseline group (16% v 3.5%, OR 5.4 (95% CI 4.3 to 6.7)). After triage implementation, patients who were triaged were 16 times more likely to have a full set of vitals compared to those who were not triaged. Similarly, compared to the baseline group, patients in the post-intervention 1 group had higher odds of having a glucose documented if they presented with altered mental status or a neurologic complaint (37% v 30%, OR 1.7 (CI 1.3 to 2.2)), documented antibiotic administration if they had a presumed bacterial infection (87% v 35%, OR 12.8 (CI 8.8 to 17.1)),

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documented malaria test if presenting with fever (76% v 61%, OR 2.05 (CI 1.37 to 3.08)) or documented repeat set of vitals if presenting with shock (25% v 6.6%, OR 8.85 (CI 1.67 to 14.06)). There was no significant difference in the above process outcomes between the education interventions.

Conclusion

This study showed improvement in most process measures between the baseline and post-intervention 1 groups, benefits that persisted post-intervention 2, thus supporting the importance of short-course education interventions to durably improve facility-based care.

Strengths and Limitations of this study

- **This study contributes to limited research on educational interventions in LMICs -- where emergency care is in its infancy – by evaluating changes in care processes as a result of educational interventions.**
- **This study evaluated both pediatric and adult populations which fully represents the patient population presenting to the emergency department.**
- **This is an observational cross-sectional study, so causality cannot be established.**
- **This is a single center study and generalizability of results is unknown.**
- **The study design retrospectively reviewed documents and did not include direct observations which may not fully represent actual practice.**

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INTRODUCTION

Emergency care has been increasingly recognized as a fundamental component to strengthening health systems [1-5] and an effective means to address multiple Sustainable Development Goals and reduce the overall burden of disease.[1,6] An estimated 54% of annual deaths in low and middle-income countries (LMICs) could be addressed by pre-hospital and hospital-based emergency care.[7] More specifically, injury related mortality disproportionately effects LMICs, and accounts for more than 90% of the total global mortality related to injury.[8] Timely emergency care saves lives across the spectrum of illness from injuries to acute presentations of chronic disease and is the first contact with the health system for many individuals. [1-2,9-10]

Emergency care in Liberia, like many LMICs, is still in its early development. In 2007, emergency care was first included in Liberia's national health plan and basic package of health services.[11,12] There has been some development of emergency education at the national referral hospital in the capital of Monrovia; however, no other consistent or standardized emergency medicine curriculum has been established.[13] The basic package of health services outlines the essentials of emergency care for each level of service.[11] Currently, there are no formal indicators measuring care or process outcomes for emergency care nationally.

In 2014, the Ebola outbreak led to the near-collapse of the country's already weakened health system, which was recovering from recent civil war (1989-1996 and 1999-2003).[13–15] In 2015, responding to the Ebola epidemic, the global non-profit organization Partners In Health (PIH), at the invitation of and in partnership with the Liberian government, came to Liberia to support the emergency response and long-term strengthening of the health system. Given clear emergency

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care needs in Maryland County, a key goal of PIH's became to expand and strengthen emergency services, which included developing the health workforce capacity to provide high-quality emergency care with the support of emergency care education sessions and triage implementation. The objective of this observational study was to evaluate key process outcomes before and after triage implementation and emergency care education interventions to assess its impact on quality of care and identify areas for future improvement.

METHODS

Study Design

An observational, retrospective cross-sectional study of patients presenting to a regional hospital ED in Southeastern Liberia.

Study Setting

The observational study was carried out at JJD, the only county referral hospital in rural, Southeastern Liberia. It is a government-run hospital supported by PIH and provides services free of charge. JJD serves a primary catchment area of 187,000 people in Maryland county, and receives additional referrals from neighboring counties.[16] At the time of the education interventions, JJD's 8-bed ED was primarily staffed by nurses and physician's assistant. There was no trained emergency medicine physician at the hospital. Specialists in the four core clinical departments of pediatrics, internal medicine, surgery and obstetrics and gynecology provide back-up clinical support to the ED in their respective clinical areas as needed. Prior to 2019, none of the ED staff had specific emergency care education courses. In addition to nurses and

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PAs, nursing aides and nursing students worked within the ED; after triage was implemented in May 2019, nursing aides primarily staffed ED triage.

Education Interventions

A series of education interventions were undertaken with ED staff, that included both nurses and physician assistants, to train them on the implementation of the Integrated Interagency Trial Tool (IIATT) and completion of the WHO Basic Emergency Care course. For the first intervention, a series of education sessions were conducted to improve emergency care at JJD in late April and early May 2019. First, staff were trained on the WHO-ICRC-MSF integrated interagency triage tool through didactics followed by real-time supervision and mentorship on the implementation of triage.[17-19] Triage is an essential component of emergency care; it evaluates a patient's acuity and prioritizes evaluation and treatment based on the severity of the patient's condition.[6] The IIATT assigns patients to a 3-tier acuity system, based on specified symptoms, physical signs, and high risk vital signs.[17-19]

Following the IIATT training, 12 staff received 2 weeks of education on the WHO Basic Emergency Care (BEC) course, followed by the complementary PIH Fundamentals of Emergency Care training. The WHO BEC course was composed of didactic, small group sessions and skills session, designed to train staff to identify and manage acute illnesses and injuries with limited resources. [20,21] The supplemental PIH course included additional topics (eg. approach to conditions such as abdominal pain and fevers), and skills such as basic EKG and ultrasound. The didactic courses were followed by two weeks of clinical mentorship by a visiting

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faculty emergency physician. Afterwards, ongoing occasional clinical mentorship was supported by non-EM faculty who worked at JJD.

In mid-October 2019, 16 JJD staff participated in a three-day refresher education session. Five participants had not completed the initial education intervention, so received a pre-course one-day intensive training on key concepts covered previously. An emergency physician assistant provided ongoing clinical mentorship 4 days a week for the subsequent 3 months.

Study Population

The study was conducted from February 1, 2019 to December 31, 2019. During this period, all patients presenting to the JJD ED for whom a visit was either documented in the ED ledger or a separate paper chart were included in the study.

Data Collection

Trained data collectors extracted information from the paper ED records into a pre-developed data extraction tool. Prior to May 2019, all initial visit documentation occurred exclusively in the ED ledger, including demographics, reason for the visit, vital signs, lab testing, key results, diagnosis, and disposition. After May 2019, documentation included three sources: the ED ledger, an ED triage form, and a ED provider documentation form adapted from the WHO Emergency Unit forms.[22] These forms were introduced in May 2019 and used by staff performing the initial evaluation and resuscitation. The ED ledger was a bound book with paper records, described above. The ED triage form documented triage acuity based on presenting symptoms and vital signs based on the interagency integrated triage tool. The ED provider

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documentation form included sections for vital signs, chief complaint, primary survey, history of presenting illness, review of systems, past medical history, assessment, and plan. Data collectors reviewed all these source and recorded demographics, initial vital signs, select clinical process measures and outcome variables.

Variables and Outcomes

We classified visits from February 1, 2019 to April 30, 2019 as "pre-intervention", visits from May 29, 2019 to October 13, 2019 as "post-intervention 1", and October 21, 2019 to December 31, 2019 as "post-intervention 2." Visits from May 1, 2019 to May 28, 2019 and October 14, 2019 to October 20, 2019 were considered to be in "intermediate" time periods (e.g., time periods during the education sessions themselves) and excluded from comparative analyses (as seen in figure 1). Data with missing date and age variables were also excluded from the analysis.

Due to differences in documentation standards prior to the ED education session, we focused our analyses on variables and process metrics that were reliably and routinely captured in the JJD ED register. The study team reviewed process metrics recommended by the African Federation of Emergency Medicine, as well as a review of quality metrics used in LMIC EDs.[23,24] From these lists, study outcomes were chosen based on local context, hospital and government priorities, and pre-existing documentation patterns that determined what baseline data was available. Outcomes focused primarily on the effectiveness domain of quality of care.[25]The primary study outcome was a complete set of recorded vital signs at any time during the patient's ED visit and was chosen given the importance of vital signs to triage and emergency care. [26,27] A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure

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and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature. Blood pressure was not reliably recorded in this younger age group so was not included.

Secondary outcomes examined included documentation of: blood glucose for patients presenting with altered mental status or a neurologic complaint; antibiotic administration or prescription in patients with a presumed bacterial infection; malaria diagnostic testing in patients with temperature $\geq$ 38^{o}C; oxygen administration for hypoxia; repeat vital signs for shock; and intravenous fluids for shock (hypoxia and shock were defined by age, Table 1). A physician assistant interpreted the final diagnoses to determine if the visit was due to a presumed bacterial infection. In the absence of microbiology capability to perform cultures and accounting for local context and practice patterns, all diagnoses of pneumonia, urinary tract infections, meningitis, cellulitis, and sepsis were presumed to have been bacterial. Tuberculosis (TB) was excluded from the list of bacterial infections, as TB patients are referred to TB clinic to initiate treatment and therefore not reliably documented as part of ED care. A patient was coded as a neurologic complaint if the clinical documentation included altered mental status, weakness, dizziness, or seizures.

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Table 1. Variable Definitions	
Hypoxia	
Age ≤ 5 years	SpO2 ≤ 94%
Age > 5 years	SpO2 ≤ 92%
Fever	temperature ≥38℃
Shock Vitals	
Age 0 to < 1 years*	HR > 160bpm
Age ≥1 to < 3 years*	HR > 160bpm
Age ≥ 3 to < 5 years*	HR > 140bpm
Age ≥ 5 to < 13 years	HR of ≥ 130bpm or a systolic blood pressure < 70mmHg
Age ≥ 13 years	HR of ≥ 130bpm or a systolic blood pressure < 80mmHg
*Note: Blood pressure was not included as a criterion in the younger age groups as it is not reliably recorded.	

Data Analysis

Data was transcribed into Excel, then imported into and analyzed with Stata (Version 15). [28] Simple descriptive statistics were used to describe the patient demographics and Chi-Square analyses were used to test for significance using a nominal threshold of 0.05. Odds ratios and 95% confidence intervals were calculated for pre-determined process measurements as described above.

Patient and Public Involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

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RESULTS

There were 8,774 patient visits recorded in the JJD ED from February 1, 2019 to December 31, 2019 and included in our analysis: 2,732 in the pre-intervention time period, 3,194 in the 'post-intervention 1' time period, 2,296 in the 'post-intervention 2' time period, and 552 in the 'indeterminate' time periods, which were excluded from the analysis (Table 2).

Table 2. Demographic description of gender and age at J.J. Dossen Hospital^

Age [Years]	Male n (%)	Female n (%)	Gender Missing n (%)	Total n (%)
0 - <5	1,102 (52.9)	954 (45.8)	29 (1.4)	2,085 (25.4)
5 - <18	858 (47.6)	917 (50.9)	26 (1.4)	1,801 (21.9)
18+	2,015 (47.6)	2,183 (51.6)	36 (0.9)	4,234 (51.5)
Age Missing	40 (39.2)	56 (54.9)	6 (5.9)	102 (1.2)
Total	4,015 (48.6)	4,110 (54.9)	97 (1.2)	8,222

^Includes all patients from pre-intervention, post-intervention 1, and post-intervention 2 time periods.

In the baseline time period, only 3.5% of patients had a complete set of vital signs documented (Table 3). In both post-intervention 1 and post-intervention 2 time periods, patients had higher odds of having a documented full set of vital signs (16% OR 5.4 (95% CI 4.3-6.7)). Adults were statistically more likely than children to have a documented full set of vitals (OR 1.43 (95% CI 1.26-1.62) (Table 4). Triage, implemented as part of the first education intervention, significantly influenced the likelihood of having a full set of vital signs recorded: patients who were triaged were 16 times more likely to have a full set of vitals compared to those in the same time periods who were not triaged (60% v 8.6%, OR 15.9 (95% CI 13.37-18.91)). There was no difference in vital signs obtained by gender.

All process outcomes measured showed significant quality improvements in the post-intervention groups compared to the baseline group, except the percent of patients with shock documented to receive IV fluids (Table 5). After the initial education session, patients had higher

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odds of having a glucose documented for altered mental status or neurologic complaints (37% v 30%, OR 1.7 (95% CI 1.3-2.2)). Patients also had higher odds of having antibiotics documented for presumed bacterial infections (87% v 35%, OR 12.8 (95% CI 8.8-17.1)) and documented malaria diagnostic testing for fever (76% v 61%, OR 2.05 (1.37-3.08)) in the post-intervention 1 time periods. Additionally, patients presenting with shock were more likely to have a repeat set of vital signs documented (25% v 6.6%, OR 8.85 (1.67-14.06)). Although there was no statistically significant difference between pre-intervention and post-intervention 1 in patients presenting with hypoxia documented to receive oxygen, there was a statistical difference between post-intervention 2 and pre-intervention time periods (35.7% v 11.1%, OR 4.44 (1.15 to 17.25)). There were no significant differences between the post-intervention 1 and post-intervention 2 groups on any metrics. Metrics did not vary significantly by age group.

Table 3. Documented vital signs measurement by intervention period

	Pre-intervention (n=2,732)	Post-intervention1 (n=3,194)		Post-intervention 2 (n=2,296)		
	n (%)	n (%)	Odds ratio* (95% CI) compared to pre-intervention	n (%)	Odds ratio* (95% CI) compared to pre-intervention	Odds ratio^ (95%CI) compared to post-intervention 1
Heart rate	925 (33.9)	1,763 (55.2)	2.41 (2.17 to 2.67)	1,183 (51.5)	2.08 (1.85 to 2.33)	0.86 (0.77 to 0.96)
Respiratory rate	132 (4.8)	647 (20.3)	5.00 (4.12 to 6.08)	449 (19.6)	4.79 (3.91 to 5.87)	0.96 (0.84 to 1.10)
Oxygen saturation	656 (24.0)	1,511 (47.3)	2.84 (2.54 to 3.18)	960 (41.8)	2.27 (2.02 to 2.57)	0.80 (0.72 to 0.89)
Blood pressure	888 (32.5)	1,580 (49.5)	2.03 (1.83 to 2.26)	942 (41.0)	1.44 (1.29 to 1.62)	0.71 (0.64 to 0.79)
Temperature	1,721 (63.0)	2,201 (68.9)	1.30 (1.17 to 1.45)	1,752 (76.3)	1.89 (1.67 to 2.14)	1.45 (1.28 to 1.64)
AVPU**	0	458 (14.3)	n/a	274 (11.9)	n/a	0.81 (0.69 to 0.95)
Weight	190 (7.0)	715 (22.4)	3.86 (3.26 to 4.57)	456 (19.9)	3.32 (2.77 to 3.97)	0.86 (0.75 to 0.98)
Full set of vitals***	95 (3.5)	516 (16.2)	5.35 (4.27 to 6.70)	372 (16.2)	5.37 (4.25 to 6.77)	1.01 (0.87 to 1.16)

*Odds ratios calculated with pre-intervention group as baseline odds.
^Odds ratios calculated for post-intervention 2 group with post-intervention 1 group as baseline odds.
** AVPU assesses level of consciousness as either **A**lert, responds to **V**erbal stimuli, responds to **P**ain, **U**nresponsive. It is a system to assess the level of consciousness in a patient.
***A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature

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Table 4 Documented vital signs measurement by age-group after initial intervention[&]

	Age 0 - <5 (n=1,401)	Age 5 - <18 (n=1,214)		Age 18+ (n=2,801)		
	n (%)	n (%)	Odds ratio* (95% CI) compared to age-group 0 - <5	n (%)	Odds ratio*(95% CI) compared to age-group 0 - <5	Odds ratio^ (95% CI) compared to combined age-group 0 - <18
Heart rate	517 (36.9)	526 (43.3)	1.31 (1.12 to 1.53)	1,849 (66)	3.32 (2.91 to 3.8)	2.93 (2.62 to 3.27)
Respiratory rate	245 (17.5)	211 (17.4)	0.99 (0.81 to 1.22)	621 (22.2)	1.34 (1.14 to 1.58)	1.35 (1.18 to 1.54)
Oxygen saturation	466 (33.3)	432 (35.6)	1.11 (0.94 to 1.30)	1,527 (54.5)	2.4 (2.1 to 2.75)	2.29 (2.05 to 2.56)
Blood pressure	167 (11.9)	399 (32.9)	3.62 (3 to 4.42)	1,904 (68)	15.68 (13.1 to 18.78)	7.68 (6.8 to 8.68)[%]
Temperature	1,107 (79)	898 (74)	0.75 (0.63 to 0.90)	1,898 (67.8)	0.56 (0.48 to 0.65)	0.64 (0.57 to 0.72)
AVPU**	149 (10.6)	142 (11.7)	1.11 (0.87 to 1.42)	418 (14.9)	1.47 (1.21 to 1.8)	1.4 (1.19 to 1.64)
Weight	528 (37.7)	304 (25)	0.55 (0.47 to 0.65)	324 (11.6)	0.22 (0.18 to 0.25)	0.28 (0.24 to 0.32)
Full set of vitals***	216 (15.4)	134 (11)	0.58 (0.54 to 0.86)	520 (18.6)	1.25 (1.05 to 1.49)	1.48 (1.27 to 1.71)

[&]This includes all patients after post-intervention 1 and post-intervention 2, (excluding those in the pre-intervention, intermediate time period and those patients missing an age)
*Odds ratios calculated with age-group 0-5 as baseline odds.
^Odds ratios calculated for combined age-group 18+ with combined age groups 0 - <5 and 5 - <18 as baseline odds.
[%]Note that blood pressure may be less reliably measured…
** AVPU- **A**lert, **V**erbal, **P**ain, **U**nresponsive. It is a system to assess the level of consciousness in a patient.
***A full set of vitals for patients age 5 and over includes heart rate, respiratory rate, oxygen saturation, blood pressure and temperature. A full set of vitals for patients under age 5 includes heart rate, respiratory rate, oxygen saturation and temperature.

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Table 5. Documented process outcomes by intervention period						
	Pre-intervention	Post-intervention 1		Post-intervention 2		
	n of total (%)	n of total (%)	Odds ratio* (95% CI) compared to pre-intervention	n of total (%)	Odds ratio* (95% CI) compared to pre-intervention	Odds ratio^ (95%CI) compared to post-intervention 1
Glucose test documented, among those with a neurologic chief complaint	145 of 560 (25.9)	254 of 672 (37.1)	1.74 (1.36 to 2.22)	169 of 469 (35.2)	1.61 (1.23 to 2.11)	0.93 (0.73 to 1.18)
Antibiotics documented, among those with a final diagnosis of presumed bacterial infection	154 of 441 (34.8)	415 of 478 (86.5)	12.28 (8.83 to 17.07)	335 of 388 (85.7)	11.78 (8.30 to 16.71)	0.96 (0.65 to 1.42)
Malaria test recorded, among those with a documented fever	139 of 229 (60.7)	168 of 221 (76.0)	2.05 (1.37 to 3.08)	179 of 242 (74.0)	1.84 (1.24 to 2.72)	0.91 (0.59 to 1.38)
Oxygen delivery recorded, among those with documented hypoxia	3 of 27 (11.1)	20 of 71 (28.2)	3.14 (0.85 to 11.59)	15 of 42 (35.7)	4.44 (1.15 to 17.25)	1.42 (0.63 to 3.20)
Repeat set of vital signs recorded, among those with initial shock vital signs**	4 of 61 (6.6)	49 of 193 (25.4)	8.85 (1.67 to 14.06)	34 of 135 (25.2)	4.80 (1.62 to 14.21)	0.99 (0.60 to 1.64)
IVF documented, among those with initial shock vital signs**	16 of 45 (35.6)	41 of 192 (21.4)	0.76 (0.39 to 1.49)	23 of 135 (17.0)	0.58 (0.28 to 1.19)	0.76 (0.43 to 1.33)

*Odds ratios calculated with pre-intervention group as baseline odds
^Odds ratios calculated for post-intervention 2 group with post-intervention 1 group as baseline odds.
** Shock identified by appropriate vital signs according to age.
IVF = Intravenous fluids

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DISCUSSION

The study evaluated key quality process metrics before and after emergency care education sessions at a rural Liberian hospital. Almost all metrics improved after the education sessions compared to baseline, though additional gains were not seen with a second clinical training. Notably, patients who were triaged in the post-intervention time periods showed significant gains

in having full sets of vital signs documented compared to patients in the same time period who were not triaged. Our study supports clinical trainings and triage training and implementation as an important step in improving care quality.

Pre-intervention, few patients had full sets of vital signs documented. Vital signs are an essential part of a patient's clinical evaluation, can detect serious illness, and help monitor for clinical deterioration.[27,29] Post-interventions, the odds of having a full set of vitals increased five-fold. Notably, patients who were triaged were nearly 16 times as likely to have a full set of vitals than those who were not, even in the same time period, suggesting that small interventions can be associated with improved emergency care.

Despite these gains, few patients overall had a full set of vitals documented post-interventions (16.2%). There are several likely contributing factors to this. First, due to the limited human resources, triage was inconsistently implemented. Without triage, vitals were performed by the providers themselves as they evaluated patients. Due to the volume of patients, boarding patients within the ED, and human resource constraints, anecdotal reports suggest providers often only obtained partial or forwent vitals due to time pressure. In addition, providers were observed to not consistently record vitals they obtained, particularly when the ED was very busy. Additionally, equipment constraints likely impacted efficiency, as VS machines are limited, and with intermittent electricity, automated machines were not always functional. Similarly, limited availability of specific age-appropriate vital sign equipment may have led to variability amongst age groups.

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Large gains were seen in documented antibiotic administration among patients with presumed bacterial infections and in patients with shock receiving repeat vital signs. Patients presenting to the ED with a presumed bacterial infection were over 12 times more likely to have antibiotics documented after the initial emergency care education session, and patients presenting to the ED in shock were nearly nine times more likely to have repeat vital signs documented. These significant gains have the potential to reduce morbidity and mortality from sepsis, a significant contribution to the burden of disease in LMICs.[30,31] These findings suggest that limited emergency care education sessions are associated with improved quality of emergency care provided by front-line providers and nurses. There is also a possibility that any improvement in outcomes is unrelated to the education sessions and due to other factors not evaluated. For example, overall improvement in documentation over time could have impacted results as vital signs and/or recording of interventions could have been performed more often than what was previously captured. Additionally, as noted above, any increased or decreased accessibility to equipment or supplies could have unclear contributions to the results. Future randomized studies should be considered to quantify the impact.

The similarity of outcomes in the post-intervention 1 and post-intervention 2 time periods may also be impacted by limitations of human resources and equipment. Staff turnover in the ED is relatively high. Attrition meant that 31% of the participants in intervention 2 were receiving initial training rather than re-training, possibly limiting impact. Also, the presence of ED-trained supervisors was intermittent, limiting the exposure of the staff to daily supervision and mentorship to help fortify the training. In addition, several of the process metrics depended on the availability of supplies or equipment. Our findings likely reflect a need for comprehensive

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health system strengthening, of which education sessions are only one component. Increases in overall health financing are also needed to expand the availability of staff and materials to improve patient care. Additionally, further evaluation is needed to identify the best ways for ongoing continuing medical education and staff support. Aside from these explanations, the similarity of outcomes in post-intervention 1 and post-intervention 2 time periods could reflect that the additional education session was necessary to ensure continued higher quality care and to keep metrics stable. If the second educational intervention did not take place, it is possible the outcomes could have been worse, especially without daily supervision or mentorship.

LIMITATIONS

This study's results must be considered within the context of its design. One notable limitation is that our method of measuring process metrics was documentation by the ED care provider and not direct observation of whether the care was provided. Particularly in an understaffed environment with many competing clinical demands and without administrative processes to hold providers accountable for their documentation, documentation may lag behind actual performance of tasks. There is also the risk of bias where providers document inaccurately, however, we suspect that under-reporting was likely the larger contributor. In the local care context, care processes such as placing oxygen on the patient or giving IV fluids do not require an order and thus might not be documented in the patient chart.

Given data systems at the hospital, we relied on retrospective data entry from paper records. It is possible additional interventions or vital sign measurements were performed but not documented. There may be unknown missing patient data, due to mixed methods of chart

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documentation. There was potential for missing data in the month of June, which had less data points when compared to the remaining months. Second, although this study suggests the interventions are associated with increases in quality metrics, causality cannot be established. In addition, we cannot rule out confounding between metrics and/or unmeasured variables, for example if increased rates of full sets of vital signs measured contributed to a higher likelihood of receiving repeat vitals. Future studies should address this. Third, the study looked at interventions as binary variables, but did not assess if the details of the intervention were appropriate to an individual patient. Finally, this study was conducted at a single site in rural Liberia that had not received any prior emergency care training and the generalizability of our findings is unknown.

CONCLUSION

This study demonstrated an improvement in most process metrics after the implementation of triage and emergency care training in rural Liberia, supporting the utility of short-course interventions on facility-based care. This complements other evaluations of BEC trainings, which demonstrated increased emergency care knowledge and confidence.[20,21] However, additional gains were not seen with a re-training several months later. Further exploration is needed to determine and intervene on other factors that influence quality metrics as well as the best methods for ongoing continue medical education and staff support.

FOOTNOTES

Data Availability Statement

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All data relevant to the study are included in the article or uploaded as supplementary information.

Patient consent for publication

The IRB approved a Waiver of informed consent given the study was a chart review study, so informed consent was not obtained.

Ethics Approval

The study was approved by the Partners Healthcare IRB 2019P001944 as well as approved under the University of Liberia-Pacific Institute for Research and Evaluation IRB 17-06-048 as part of the clinical and training protocol that Partners In Health Liberia submits annually for review.

Contributors: KT, ID, AP, VK, RHM, PU, RC, SAR contributed to study design. KT, ID, AP, NL, VK, RHM, MH, AB, RC, SAR implemented the emergency care trainings. KT, ID, DD, TD, SM contributed to data collection. KT, ID, JG, PS, SAR contributed to data analysis. All authors contributed to interpretation of study results. KT and ID drafted the initial version of the manuscript. All authors contributed to the revision of the manuscript and have approved the final manuscript version. KT and ID were equal contributors. KT is responsible for this paper and content as a guarantor.

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Competing Interests: None declared.

Figure 1 Education Intervention Timeline 2019: Figure 1 shows the timeline of the study including education session time periods, the time periods pre and post-interventions, as well as time periods where mentorship was provided.

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REFERENCES

1. Jamison DT, Gelband H, Horton S, et al. Disease Control Priorities: Improving Health and Reducing Poverty [Internet]. Vol 9. 3rd ed. The World Bank; 2017[cited 2020 Nov 5]. Available from: http://elibrary.worldbank.org/doi/book/10.1596/978-1-4648-0527-1

2. Anderson PD, Suter RE, Mulligan T, et al. World health assembly resolution 60.22 and its importance as a health care policy tool for improving emergency care access and availability globally. *Ann Emerg Med*. 2012;60(1):35-44. DOI: 10.1016/j.annemergmed.2011.10.018. DOI: 10.1016/j.annemergmed.2011.10.018

3. Emergency care systems for universal health coverage: ensuring timely care for the acutely ill and injured. Seventy-Second World Health Assembly. May 28, 2019 [cited 2020 Nov 5]. Available from: https://www.who.int/publications/i/item/emergency-care-systems-for-universal-health-coverage-ensuring-timely-care-for-the-acutely-ill-and-injured

4. Razzak JA, Kellermann AL. Emergency medical care in developing countries: is it worthwhile?. *Bull World Health Organ.* 2002;80(11):900-905. Available from: https://doi.org/https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2567674/

5. Anderson P. The globalization of emergency medicine and its importance for public health. *Bull World Health Organ*. 2006;84(10):835-838. DOI: 10.2471/blt.05.028548

6. Risko N, Chandra A, Burkholder TW, et al. Advancing research on the economic value of emergency care. *BMJ Glob Health*. 2019;4(6). DOI:10.1136/bmjgh-2019-001768

7. Thind A, Hsia R, Mabweijano J, et al. Essential Surgery: Disease Control Priorities. Vol 1. 3rd ed. The International Bank for Reconstruction and Development / The World Bank;

For peer review only

2015. [cited 2020 Nov 9]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK333513/

8. Gosselin R, Spiegel DA, Coughlin R, et al. Injuries: the neglected burden in developing countries. *Bull World Health Organ*. 2009;87(4):246-246. DOI: 10.2471/BLT.08.052290

9. Calvello EJB, Broccoli M, Risko N, et al. Emergency care and health systems: consensus-based recommendations and future research priorities. *Acad Emerg Med*. 2013;20(12):1278-1288. DOI: 10.1111/acem.12266

10. Razzak J, Usmani MF, Bhutta ZA. Global, regional and national burden of emergency medical diseases using specific emergency disease indicators: analysis of the 2015 global burden of disease study. *BMJ Glob Health*. 2019;4(2). DOI:10.1136/bmjgh-2018-000733

11. *Basic Package for Health and Social Welfare Services for Liberia.* Ministry of Health and Social Welfare Republic of Liberia. June 2008;42. [cited 2020 Nov 5]. Available from: http://liberiamohsw.org/Policies%20&%20Plans/Basic%20Package%20for%20Health%20&%20Social%20Welfare%20for%20Liberia.pdf

12. Kruk ME, Rockers PC, Williams EH, et al. Availability of essential health services in post-conflict Liberia. *Bull World Health Organ*. 2010;88(7):527-534. DOI: 10.2471/BLT.09.071068

13. Hexom B, Calvello EJB, Babcock CA, et al. A model for emergency medicine education in post-conflict Liberia. *Afr J Emerg Med*. 2012;2(4):143-150. DOI:10.1016/j.afjem.2012.08.006

For peer review only

14. McQuilkin PA, Udhayashankar K, Niescierenko M, et al. Health-care access during the Ebola virus epidemic in Liberia. *Am J Trop Med Hyg*. 2017;97(3):931-936. DOI: 10.4269/ajtmh.16-0702

15. Downie R. The Road to Recovery: Rebuilding Liberia's Health System. Center for Strategic and International Studies: August 2012;24. [cited 2020 Nov 5]. Available from: https://csis-website-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/120822_Downie_RoadtoRecovery_web.pdf

16. 2008 National Population and Housing Census: preliminary results. Government of the Republic of Liberia. June 2008;23. [cited 2020 Nov 5]. Available from: https://www.emansion.gov.lr/doc/census_2008provisionalresults.pdf

17. Mitchell R, McKup JJ, Bue O, et al. Implementation of a novel three-tier triage tool in Papua New Guinea: a model for resource-limited emergency departments. *Lancet Reg Health - West Pac*. 2020;5:100051. DOI: 10.1016/j.lanwpc.2020.100051

18. Mitchell R, Bue O, Nou G, et al. Validation of the interagency triage tool in a resource limited, urban emergency department in Papua New Guinea: a pilot study. *Lancet Reg Health-West Pac*. 2021;13:100194. DOI: https://doi.org/10.1016/j.lanwpc.2021.100194

19. World Health Organization. Clinical care for severe acute respiratory infection: toolkit. COVID-19 adaptation [Internet]. Geneva: World Health Organization; 2020 [cited 2020 Dec 27]. 13-15p. Available from: https://apps.who.int/iris/handle/10665/331736

For peer review only

20. Olufadeji A, Usoro A, Akubueze CE, et al. Results from the implementation of the World Health Organization basic emergency care course in Lagos, Nigeria. *Afr J Emerg Med*. 2021;11(2):231-236. DOI: 10.1016/j.afjem.2021.02.004

21. Kivlehan SM, Dixon J, Kalanzi J, et al. Strengthening emergency care knowledge and skills in Uganda and Tanzania with the WHO-ICRC basic emergency care course. *Emerg Med J*. 2021;38(8):636-642. DOI: 10.1136/emermed-2020-209718

22. WHO Standardized Clinical Form. World Health Organization. January 14, 2020 [cited 2022 April 1] Available from:https://www.who.int/publications/i/item/who-standardized-clinical-form

23. Broccoli MC, Moresky R, Dixon J, et al. Defining quality indicators for emergency care delivery: findings of an expert consensus process by emergency care practitioners in Africa. *BMJ Glob Health*. 2018;3(1):e000479. DOI: 10.1136/bmjgh-2017-000479

24. Aaronson EL, Marsh RH, Guha M, et al. Emergency department quality and safety indicators in resource-limited settings: an environmental survey. *Int J Emerg Med*. 2015;8(1):39. DOI 10.1186/s12245-015-0088-x

25. World Health Organization. Quality of care [Internet]. Geneva: World Health Organization;2022 [cited 2022 Dec 27]. Available from: https://www.who.int/health-topics/quality-of-care#tab=tab_1

26. Cooper RJ, Schriger DL, Flaherty HL, et al. Effect of vital signs on triage decisions. *Ann Emerg Med*. 2002;39(3):223-232. DOI: 10.1067/mem.2002.121524

For peer review only

27. DeVita MA, Hillman K, Bellomo R, et al. Textbook of Rapid Response Systems: Concept and Implementation. Springer International Publishing; 2017. [cited 2020 Nov 5]. Available from: http://link.springer.com/10.1007/978-3-319-39391-9

28. *StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC.*

29. Brekke IJ, Puntervoll LH, Pedersen PB, et al. The value of vital sign trends in predicting and monitoring clinical deterioration: A systematic review. *PLoS ONE*. 2019;14(1). DOI: 10.1371/journal.pone.0210875

30. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. *The Lancet*. 2020;396(10258):1204-1222. DOI: 10.1016/S0140-6736(20)30925-9

31. Stephen AH, Montoya RL, Aluisio AR. Sepsis and Septic Shock in Low- and Middle-Income Countries. *Surg Infect*. 2020;21(7):571-578. DOI: 10.1089/sur.2020.047

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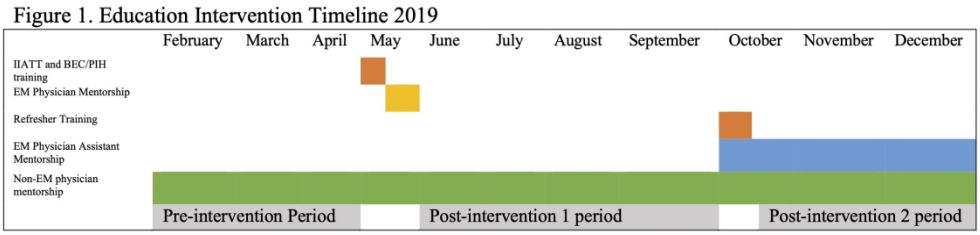

Figure 1 shows the timeline of the study including education session time periods, the time periods pre and post-interventions, as well as time periods where mentorship was provided.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	16
Study size	10	Explain how the study size was arrived at	6,9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9-11
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	10-11

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-11
		(*b*) Report category boundaries when continuous variables were categorized	10-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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