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ORIGINAL RESEARCH

Effect of a Triage-Based Screening Protocol on Diagnosis and Treatment of Acute Coronary Syndrome in a Tanzanian Emergency Department: A Prospective Pre-Post Study

Julian T. Hertz, MD, MScGH; Francis M. Sakita, MD; Godfrey L. Kweka, CO; Gerald S. Bloomfield, MD, MPH; John A. Bartlett, MD; Tumsifu G. Tarimo, BS; Gloria Temu, MD; Janet P. Bettger, ScD; Nathan M. Thielman, MD, MPH

BACKGROUND: Evidence suggests that acute coronary syndrome (ACS) is underdiagnosed in sub-Saharan Africa. Triage-based interventions have improved ACS diagnosis and management in high-income settings but have not been evaluated in sub-Saharan African emergency departments (EDs). Our objective was to estimate the effect of a triage-based screening protocol on ACS diagnosis and care in a Tanzanian ED.

METHODS AND RESULTS: All adults presenting to a Tanzanian ED with chest pain or shortness of breath were prospectively enrolled. Treatments and clinician-documented diagnoses were observed and recorded. In the preintervention phase (August 2018 through January 2019), ACS testing and treatment were dictated by physician discretion, as per usual care. A triage-based protocol was then introduced, and in the postintervention phase (January 2019 through October 2019), research assistants performed ECG and point-of-care troponin I testing on all patients with chest pain or shortness of breath upon ED arrival. Pre-post analyses compared ACS care between phases. Of 1020 total participants (339 preintervention phase, 681 postintervention phase), mean (SD) age was 58.9 (19.4) years. Six (1.8%) preintervention participants were diagnosed with ACS, versus 83 (12.2%) postintervention participants (odds ratio [OR], 7.51; 95% CI, 3.52–19.7; $P<0.001$). Among all participants, 3 (0.9%) preintervention participants received aspirin, compared with 50 (7.3%) postintervention participants (OR, 8.45; 95% CI, 3.07–36.13; $P<0.001$).

CONCLUSIONS: Introduction of a triage-based ACS screening protocol in a Tanzanian ED was associated with significant increases in ACS diagnoses and aspirin administration. Additional research is needed to determine the effect of ED-based interventions on ACS care and clinical end points in sub-Saharan Africa.

Key Words: acute coronary syndrome ■ emergency department ■ screening ■ sub-Saharan Africa ■ Tanzania

Acute coronary syndrome (ACS) is a leading cause of death globally and a life-threatening condition requiring emergency treatment.[1] In sub-Saharan Africa (SSA), the recent growth in ACS risk factors has resulted in a presumed rise in ACS incidence.[2] In Tanzania, for example, ACS is currently estimated to be the fourth-leading cause of death.[3] Despite the presumed rise of ACS burden in SSA, ACS remains a rare clinical diagnosis in the region; multiple hospital-based studies have found that, although diagnoses of other cardiovascular conditions like stroke are rapidly increasing, clinicians rarely identify cases of ACS.[4–8]

Correspondence to: Julian T. Hertz, MD, MScGH, Division of Emergency Medicine, Duke University School of Medicine, 2301 Erwin Rd, Durham, NC 27710. E-mail: julian.hertz@duke.edu

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CLINICAL PERSPECTIVE

What Is New?

- Following the introduction of a triage-based protocol in which patients presenting to a Tanzanian emergency department with chest pain or shortness of breath automatically underwent screening with ECG and troponin testing, significant increases in acute coronary syndrome diagnosis and aspirin administration were observed.

What Are the Clinical Implications?

- Triage-based screening protocols in emergency departments in sub-Saharan Africa may improve diagnosis and care of acute coronary syndrome.

Nonstandard Abbreviations and Acronyms

ACS	acute coronary syndrome
BMI	body mass index
ED	emergency department
KCMC	Kilimanjaro Christian Medical Centre
OR	odds ratio
SSA	sub-Saharan Africa

There are likely many reasons ACS is infrequently diagnosed in SSA. Prior studies have suggested that ACS underdiagnosis in SSA may be driven in large part by physician behaviors.[9–11] Studies of emergency department (ED) physicians in Tanzania, for example, found that they did not routinely pursue ACS diagnostic workups—even among high-risk patients with classic ACS symptoms.[9,10] Failure to initiate ACS testing has been explored in recent qualitative studies. These studies, conducted among Tanzanian and Kenyan clinicians, found that a principal barrier to ACS diagnosis in SSA was failure to consider the diagnosis.[11,12]

Outside of SSA, numerous ED-based interventions have improved the accuracy and speed of ACS diagnosis.[13–20] On the basis of evidence that broad and rapid ACS screening improves outcomes,[18,21] international guidelines recommend that all adults presenting to an ED with chest pain undergo ECG testing within 10 minutes.[20,22] In SSA, however, many patients presenting to the ED with chest pain never receive an ECG during their visit.[9] Triage-based ED protocols in high-income settings generally involve routine ACS screening before physician contact.[13–19] These protocols have been shown to streamline ACS diagnosis and reduce cases of missed ACS.[13–16,18,21] In SSA, however, the utility of such protocols remains unexplored.

Given evidence that ACS underdiagnosis is common in SSA and that failure to consider the diagnosis is a principal barrier to ACS care, interventions in EDs in SSA are needed to improve ACS diagnosis and care. In this prospective pre-post study, we assessed the effect of a triage-based ACS screening protocol on rates of ACS diagnosis and treatment. Our hypothesis was that a triage-based screening protocol implemented in an ED in northern Tanzania would increase the ACS diagnosis and evidence-based treatment with aspirin.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Setting

This study was conducted in the ED at Kilimanjaro Christian Medical Centre (KCMC), a tertiary care center in northern Tanzania. In 2014, the community prevalence of hypertension and diabetes mellitus among adults in northern Tanzania was 28% and 6%, respectively.[23,24] A retrospective chart review conducted in the KCMC ED in 2018 found that 0.3% of adult admissions were for ACS when ACS testing and treatment was directed by physician discretion.[8] The KCMC ED is staffed by a mix of physicians, residents, interns, clinical officers, and nurses. The KCMC ED is equipped with an ECG machine and has access to laboratory-based troponin I testing.

Participant Selection

This study was nested within a larger study of ACS at KCMC, with methods reported elsewhere.[9,25,26] Briefly, all adults presenting to the KCMC ED between August 20, 2018, and October 12, 2019, were screened by trained research assistants. Patients presenting with chest pain or shortness of breath as a primary or secondary complaint were eligible for inclusion. Exclusion criteria were (1) inability to provide informed consent, (2) self-reported fever, and (3) chest pain secondary to trauma.

Study Procedures

A standardized questionnaire eliciting symptoms and medical history was administered to each enrolled patient in the ED immediately after consent. History of hypertension, diabetes mellitus, hyperlipidemia,

heart failure, chronic kidney disease, HIV infection, tobacco use, and alcohol use were defined by patient self-report. Personal history of cardiovascular disease was defined as self-reported history of heart attack or stroke. Each participant's height, weight, and blood pressure were measured and recorded. Participants were observed throughout the course of their ED care: All diagnostic testing and treatments were observed and recorded. Clinician-documented ED diagnoses were copied directly from the medical record. An ACS diagnosis was defined as any case where the ED clinician documented a diagnosis of ACS, myocardial infarction, or unstable angina. ED treatment with aspirin or clopidogrel was determined both by direct observation and by review of the electronic medical record. Inpatient care was not observed by research staff.

Preintervention Phase

The preintervention phase was conducted from August 20, 2018, through January 4, 2019. In the preintervention phase of the study, ACS testing and care was performed according to usual care—only when the ED clinician decided to order it. When ordered by the ED clinician, ECGs were obtained via the Phillips PageWriter TC70 Cardiograph ECG machine (Phillips Medical Systems, Andover, MA) located in the ED, and cardiac biomarkers were obtained using the laboratory-based troponin I assay. ECG and laboratory-based troponin testing were available in the ED during the entire preintervention phase, and the costs for these tests were borne by the patients or their health insurance plans—as per usual care. ECG interpretation was performed by the ED clinician. Aspirin was administered by ED nurses only when the ED clinician ordered it. Diagnoses and treatments were observed and recorded for all enrolled patients. In the preintervention phase, research staff documented whether ECGs or troponin assays were obtained, but the results of such testing were not collected. General education regarding ACS diagnosis and treatment was provided to ED staff before the preimplementation phase of the study, but no additional ACS training was provided during the course of the study. This ACS education, which was provided to both ED physicians and nurses, included training on ECG interpretation.

Intervention

A triage-based ACS screening protocol was implemented in January 2019. Trained research assistants performed routine ECG and troponin testing on all enrolled patients with chest pain or shortness of breath upon presentation to ED triage. ECG was performed using the tablet-based PADECG (Edan Instruments, Shenzhen, China), and point-of-care troponin I assay was performed using the Abbott i-Stat instrument (Abott iSTAT cTnI assay, Abbott Point of Care, Princeton, NJ). Troponin testing was performed at time of enrollment unless a patient reported that his or her symptoms had lasted <6 hours, in which case troponin testing was performed 6 hours after symptom onset.[27,28] Protocol start-up occurred over 2 days (January 7–8, 2019).

Postintervention Phase

The postintervention phase was conducted from January 9, 2019, through October 12, 2019. Research staff immediately shared the results of ECG and troponin testing with the ED clinician. As in the preintervention phase, ECG interpretation was performed by the treating ED physician, and aspirin was administered by ED nurses only when ordered by the ED clinician. ED treatments and clinician-documented diagnoses were observed and recorded in the same manner as in the preintervention phase. Table 1 summarizes the differences between preintervention and postintervention ACS screening and care.

Statistical Analysis

All analyses were performed using the R Suite (version 3.6.1). Continuous variables are presented as means (SDs), and univariate associations between continuous and categorical variables were assessed via Welch's t test. Categorical variables are presented as proportions, and univariate associations between categorical variables were assessed via Pearson's chi-square test. Body mass index (BMI) was calculated by dividing the measured weight (in kilograms) by the square of the measured height (in meters). Mean arterial pressure was calculated by adding the measured systolic blood pressure to twice the measured diastolic blood pressure and dividing by 3. Five-year risk of a cardiovascular event was calculated using the Harvard National Health and Nutrition Examination Survey risk score[29,30]; the National Health and Nutrition Examination Survey risk score is an internationally validated model using age, sex, BMI, blood pressure, smoking history, and history of diabetes mellitus to calculate individual risk of cardiovascular event.[30] The primary study outcome was the proportion of patients with a physician-documented diagnosis of ACS before and after the implementation of the study intervention, using Pearson's chi-square to compare proportions in the pre- and postintervention phases with a 2-sided α of 0.05. Fisher's exact test was used when expected cell values were <10. Odds ratios (ORs) were calculated directly from contingency tables. Secondary outcomes were the proportion of patients treated with aspirin and clopidogrel based on prevailing ACS treatment guidelines. In order to account for potential confounders, multivariate analysis was used to

Table 1. Comparison of Preintervention Usual Care and Postintervention Triage-Based ACS Screening Protocol in a Northern Tanzanian Emergency Department, 2018 to 2019

	Preintervention Usual Care	Postintervention Triage-Based Screening Protocol
Decision to obtain ECG or cardiac biomarker	At clinician's discretion	Automatically obtained for all patients reporting chest pain or shortness of breath
Timing of ECG or cardiac biomarker testing	After physician evaluation	Immediately on patient arrival in the emergency department for all eligible patients
Person performing ECG and troponin testing	Clinical staff (bedside nurse and laboratory technician)	Trained research assistant
Determination of ACS diagnosis	At clinician's discretion, as documented in medical record	At clinician's discretion, as documented in medical record
Decision to treat with aspirin or clopidogrel	At clinician's discretion	At clinician's discretion

ACS indicates acute coronary syndrome.

assess the association between the use of the triage-based screening protocol and the probability of ACS diagnosis. First, univariate analyses were used to assess the relationship between various patient characteristics and the probability of ACS diagnosis for all participants. Second, a multivariate logistic regression model was developed using ACS diagnosis as the outcome variable and use of the triage-based screening protocol as the explanatory variable. Any participant characteristic with evidence of univariate association with ACS diagnosis (P<0.10) was included in the model; participant age and sex were also forced into the model.

Ethical Approval

This study received ethical approval from the Tanzanian National Institute of Medical Research, the institutional review board at KCMC, and the institutional review board at Duke Health. All participants provided written informed consent before enrollment.

RESULTS

A total of 1020 patients were enrolled during this study, including 339 patients in the preintervention phase and 680 patients in the postintervention phase. Of all participants, the mean (SD) age was 58.9 (19.4) years and 559 (54.8%) were women. Table 2 compares the characteristics of patients in the pre- and postintervention phases. Patients in the postintervention phase had a lower mean BMI (24.9 kg/m^2 versus 25.9 kg/m^2; P=0.018) and were more likely to report a history of diabetes mellitus (22.2% versus 13.0%; OR, 1.90; 95% CI: 1.33–2.77, P<0.001) than patients in the preintervention phase. There were otherwise no differences between patients in the pre- and postintervention phases with regards to age, sex, mean arterial blood pressure, tobacco use, alcohol use, self-reported history of hypertension, self-reported history of chronic kidney disease, self-reported history of HIV infection, personal history of cardiovascular disease, or overall 5-year risk of cardiovascular event.

Table 3 compares the management of ED patients with chest pain or shortness of breath before and after the intervention. With respect to the primary outcome, 6 (1.8%) patients with chest pain or shortness of breath were diagnosed with ACS in the preintervention phase, whereas 83 (12.2%) patients with chest pain or shortness of breath were diagnosed with ACS in the postintervention phase (OR, 7.51; 95% CI, 3.52–19.7; P<0.001). Among all patients with chest pain or shortness of breath, participants in the postintervention phase were also more likely to be treated with aspirin (0.9% versus 7.3%; OR, 8.45; 95% CI, 3.07–36.13; P<0.001) and clopidogrel (0.6% versus 2.3%; OR, 3.80; 95% CI, 1.06–26.18; P=0.044). Among participants with a physician-documented diagnosis of ACS, there was no difference in the proportion of patients receiving aspirin in the 2 phases: Two of the 6 preintervention ACS cases (33.3%) were treated with aspirin compared with 28 of the 83 postintervention ACS cases (33.7%; OR, 0.99; 95% CI, 0.17–8.36; P=0.984). Patients with ACS were more numerous and tended to be older with more comorbidities in the postintervention phase, although significance testing is limited by the small number of patients diagnosed with ACS in the preintervention phase (Table S1). The Figure summarizes ACS diagnosis and aspirin administration before and after the intervention.

The only participant characteristic that demonstrated potential univariate association with probability of ACS diagnosis was BMI (Table S2). In the multivariate model including participant age, sex, and BMI, the association between use of the triage-based ACS screening protocol and probability of ACS diagnosis remained statistically significant (OR, 7.71; 95% CI, 3.61–20.0; P<0.001).

DISCUSSION

To our knowledge, this is the first study evaluating a triage-based intervention to improve ACS diagnosis and

Table 2. Characteristics of Adult Emergency Department Patients Presenting With Chest Pain or Shortness of Breath, Northern Tanzania, 2018 to 2019 (N=1020)

Patient Characteristic	Preintervention Patients (N=339), n (%)	Postintervention Patients (N=681), n (%)	OR (95% CI)	*P* Value*
Sex, female	195 (57.5	364 (53.5)	0.85 (0.65–1.10)	0.218
Age, y, mean (SD)	57.3 (18.7)	59.6 (19.7)	…	0.074
History of tobacco use	109 (32.2)	211 (31.0)	0.95 (0.72–1.26)	0.704
History of alcohol use	234 (69.0)	471 (69.2)	1.01 (0.76–1.33)	0.965
History of hypertension	203 (59.9)	415 (60.9)	1.05 (0.80–1.36)	0.745
History of diabetes mellitus	44 (13.0)	151 (22.2)	1.90 (1.33–2.77)	<0.001†
History of chronic kidney disease	21 (6.2)	56 (8.2)	1.35 (0.81–2.32)	0.248
History of HIV infection	6 (1.8)	16 (2.3)	1.31 (0.53–3.75)	0.548
Personal history of cardiovascular disease	18 (5.3)	42 (6.2)	1.17 (0.67–2.11)	0.583
>10% 5-y risk of cardiovascular event	222 (65.5)	467 (68.6)	1.15 (0.87–1.52)	0.321
BMI in kg/m^2, mean (SD)	25.9 (7.1)	24.9 (5.6)	…	0.018†
Mean arterial pressure in mm Hg, mean (SD)	102.8 (19.7)	103.3 (23.6)	…	0.721

BMI indicates body mass index.
*Associations for categorical variables were assessed via Pearson's chi-square and associations for continuous variables were assessed via Welch's t test.
†*P*<0.05.

treatment in SSA. We found that a protocol for routine ACS testing in triage without depending on a physician to order such testing resulted in substantial increases in the proportion of patients diagnosed with ACS and treated with evidence-based therapy such as aspirin and clopidogrel. Our study suggests that developing protocols for routine ACS testing in EDs across SSA could improve case detection, reduce the number of missed ACS cases, increase the provision of guideline-based care, and improve ACS outcomes.

The large discrepancy between the rate of ACS diagnoses in the pre- versus postintervention phases indicates that many ACS cases were likely missed because of failure to test in usual care. This finding lends credence to speculation that undertesting is leading to underdetection of ACS in Tanzania and across SSA.[31] Indeed, the 6-fold increase in proportion of ACS diagnoses we observed with routine testing suggests that efforts to increase ACS testing across SSA would likely result in large increases in identified ACS cases. The reasons for undertesting for ACS in SSA are likely myriad: Recent qualitative studies among providers in SSA identified multiple contributors to ACS underdiagnosis, including physician failure to consider the diagnosis, physician discomfort with interpreting ECGs, and delayed patient care seeking.[11,12] Although we tested a triage-based testing protocol that primarily addressed physician failure to consider the diagnosis, other interventions may also improve ACS detection in EDs in SSA, including provider education, nurse-driven interventions, physician reminders, and audit/feedback mechanisms.[32]

In addition to increasing ACS diagnoses, the screening intervention evaluated in this study also had downstream effects on ACS treatment. Interestingly, the proportion of patients with ACS receiving aspirin did not change between the pre- and

Table 3. Emergency Department Management of Adults Presenting With Chest Pain or Shortness of Breath, Northern Tanzania, 2018 to 2019 (N=1020)

	Preintervention Patients With Chest Pain or Shortness of Breath (N=339), n (%)	Postintervention Patients With Chest Pain or Shortness of Breath (N=681), n (%)	OR (95% CI)	*P* Value
ECG obtained	170 (50.1)	681 (100)		NA
Cardiac biomarkers obtained	9 (2.7)	681 (100)		NA
Diagnosed with ACS	6 (1.8)	83 (12.2)	7.51 (3.52–19.7)	<0.001*
Treated with aspirin	3	50 (7.3)	8.45 (3.07–36.13)	<0.001*
Treated with clopidogrel	2	16 (2.3)	3.80 (1.06–26.18)	0.044*
Treated with both aspirin and clopidogrel	1	14 (2.1)	6.26 (1.25–152.2)	0.027*

ACS indicates acute coronary syndrome; and ED, emergency department.
**P*<0.05.

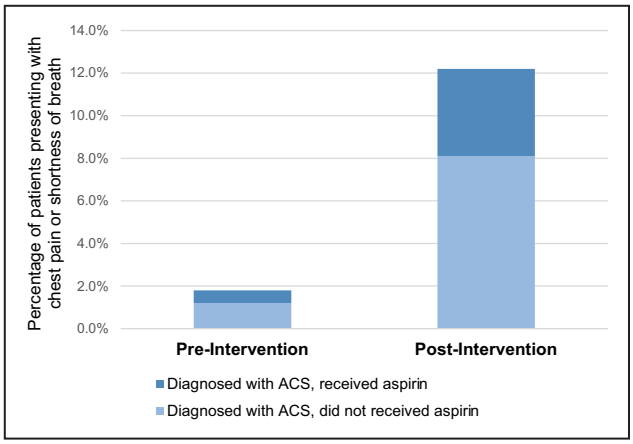

Figure 1. Proportion of adults diagnosed with ACS and treated with aspirin before and after introduction of a triage-based screening protocol in a Tanzanian emergency department (2018–2019).
ACS indicates acute coronary syndrome.

postintervention phases; nonetheless, the absolute number of patients receiving aspirin did increase substantially because of an increase in ACS diagnoses. After adoption of the intervention, aspirin administration among all patients with chest pain or shortness of breath increased more than 8-fold. Aspirin is an inexpensive, widely available treatment known to reduce ACS-associated morbidity and mortality, and is a class 1 indication for patients with suspected ACS.[33] Given its low cost and substantial benefit, administering aspirin to patients with ACS is promoted by the World Health Organization as a "best buy" for treating noncommunicable disease.[34] Despite this, a recent systematic review identified no studies of interventions to improve uptake of aspirin treatment for myocardial infarction in low-income settings.[35] Our findings suggest that in settings in SSA where underdiagnosis of myocardial infarction may be common, interventions aimed at improving myocardial infarction case detection hold potential to improve the uptake of lifesaving treatment. However, it should be noted that even in the postintervention period, approximately two-thirds of patients with physician-documented diagnoses of ACS were not treated with aspirin. This finding suggests that, apart from failure to pursue ACS testing, there are other barriers to evidence-based ACS care in northern Tanzania that warrant intervention. Recent qualitative studies in SSA identified other barriers to ACS care, including inadequate clinician training, absence of treatment protocols, and limited medication supplies.[11,12] Additional study is needed to evaluate interventions to address these and other barriers to uptake of evidence-based therapies for ACS.

This study had several limitations. As with any pre-post analysis, the results of this study may have been affected by unmeasured time-related confounders. Specifically, if there were background changes in standard ED care practices affecting ACS diagnosis and treatment, this may have resulted in an overestimation of the effect of the triage-based screening intervention. Second, this study did not evaluate cost-effectiveness considerations that would help to inform future feasibility and scale-up. The point-of-care troponin assays and ECGs were performed free of charge during this study, and research staff were externally funded. Thus, additional implementation research is needed with key stakeholders to determine the feasibility of standardizing ACS screening in resource-limited EDs. Third, increasing ACS testing may have resulted in overdiagnosis of ACS, as several other conditions can also result in abnormal troponin or ECG findings, such as left ventricular hypertrophy or massive pulmonary embolism.[36] As cardiac catheterization is not available locally, absolute confirmation of coronary artery disease was not possible in this study. Thus, the accuracy of clinician-documented cases of ACS diagnoses and the degree of ACS overdiagnosis in this study is unknown. Therefore, given local resource limitations preventing objective confirmation of atherothrombosis, it is unknown if the triage-based screening intervention increased appropriate ACS diagnosis and treatment. Fourth, different ECG and troponin assays were used in the pre- and postintervention phases; thus, our results may have been affected by different sensitivities and specificities of these tests. Finally, not all patients with ACS present with chest pain or shortness of breath; thus, ACS patients with atypical presentations were likely excluded from this study.

CONCLUSIONS

In conclusion, in an ED in northern Tanzania, a triage-based screening protocol involving routinized ECG and troponin testing was associated with large and significant increases in ACS diagnosis and evidence-based treatment. Additional research is needed across SSA to develop interventions to improve ACS care and to determine impacts on clinical outcomes.

ARTICLE INFORMATION

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Affiliations

From the Department of Surgery, Duke University School of Medicine (J.T.H.) Duke Global Health Institute, Durham, NC (J.T.H., G.S.B., J.A.B., J.P.B., N.M.T.); Department of Emergency Medicine, Kilimanjaro Christian Medical Centre (F.M.S.); Kilimanjaro Christian Medical University College (F.M.S., J.A.B., G.T.); Kilimanjaro Christian Research Institute, Moshi, Tanzania (G.L.K., T.G.T.); Department of Medicine, Duke University School of Medicine, Durham, NC (G.S.B., J.A.B., N.M.T.); Department of Medicine, Kilimanjaro Christian Medical Centre, Moshi, Tanzania (G.T.); and Department of

Orthopaedic Surgery, Duke University School of Medicine, Durham, NC (J.P.B.).

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Supplementary Materials

Tables S1–S2

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SUPPLEMENTAL MATERIAL

Table S1. Characteristics of emergency department patients diagnosed with ACS, northern Tanzania, 2018-2019 (N=89).

Patient characteristic	Pre-intervention patients (N=6), n (%)	Post-intervention patients (N=83), n (%)
Male sex	3	38 (45.8%)
Age in years, mean (sd)	39.5 (15.0)	58.0 (19.8)
History of tobacco use	1	28 (33.7%)
History of alcohol use	3	52 (62.7%)
History of hypertension	0	51 (61.4%)
History of diabetes	0	15 (18.1%)
History of chronic kidney disease	0	5 (6.0%)
History of HIV infection	0	3
>10% five-year risk of cardiovascular event	1	83 (65.1%)
BMI in kg/m^2, mean (sd)	23.5 (3.4)	24.4 (4.6)
Mean arterial pressure inmmHg, mean (sd)	98.1 (6.5)	105.1 (25.8)

Table S2. Association between participant characteristics and diagnosis of acute coronary syndrome in a northern Tanzanian emergency department, 2018-2019 (N=1020).

Patient characteristic	Patients diagnosed with ACS (N=89), n (%)	Patients not diagnosed with ACS (N=931), n (%)	OR (95% CI)	$p^{\dagger}$
Male sex	41 (46.1%)	420 (45.1%)	1.04 (0.67-1.61)	0.863
Age in years, mean (sd)	56.8 (20.0)	59.0 (19.4)	--	0.310
History of tobacco use	29 (32.6%)	291 (31.3%)	1.07 (0.66-1.68)	0.797
History of alcohol use	55 (61.8%)	650 (69.8%)	0.70 (0.45-1.11)	0.118
History of hypertension	51 (57.3%)	567 (60.9%)	0.86 (0.56-1.35)	0.507
History of diabetes	15 (16.9%)	180 (19.3%)	0.85 (0.46-1.48)	0.569
History of	5 (5.6%)	72 (7.7%)	0.73 (0.25-	0.470

chronic kidney disease			1.70)	
History of HIV infection	3	19 (2.0%)	1.74 (0.39-5.30)	0.431
Personal history of CVD	8 (9.0%)	52 (5.6%)	1.69 (0.72-3.51)	0.192
>10% five-year risk of cardiovascular event	55 (61.8%)	634 (68.1%)	0.76 (0.48-1.20)	0.225
BMI in kg/m^2, mean (sd)	24.3 (4.6)	25.3 (6.2)	--	0.061*

* $p < 0.10$; variable included in multivariate model

† Associations for categorical variables were assessed via Pearson's chi-square and associations for continuous variables were assessed via Welch's t-test