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Atrial fibrillation and mortality in outpatients with heart failure in Tanzania: a prospective cohort study

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ABSTRACT

Objective In recent years, the prevalence and mortality of heart failure (HF) and other associated cardiovascular diseases have doubled in sub-Saharan Africa (SSA). Studies in high-income countries indicate that HF with concurrent atrial fibrillation (AF) is linked to increased mortality. Our objective was to determine the incidence and clinical outcomes of AF among patients with HF in SSA.

Design A prospective cohort study using data collected between October 2018 and May 2020.

Setting Outpatient clinic at a tertiary hospital in Mwanza, Tanzania.

Participants 303 adult participants (aged ≥18 years) with HF as defined by the European Society of Cardiology guidelines (2016) and 100 adults with HF as defined by clinical criteria alone were enrolled into the study. Patients with comorbid medical condition that had prognosis of <3 months (ie, advance solid tumours, advance haematological malignancies) were excluded.

Methods Participants were screened for AF, and their medical history, physical examinations and sociodemographic information were obtained. Multivariable logistic regression models were used to examine factors associated with AF incidence. Cox regression models were used to analyse 3-month mortality and its associated risk factors.

Results We enrolled 403 participants with HF (mean age 60±19 years, 234 (58%) female). The AF prevalence was 17%. In multivariable models, factors associated with AF were low income, alcohol consumption and longer duration of HF. At the end of the 3-month follow-up, 120 out of 403 (30%) participants died, including 44% (31/70) of those with AF. Higher heart rate on ECG, more severe New York Heart Association HF class, rural residence and anaemia were significantly correlated with mortality.

Conclusion AF is common, underdiagnosed and is associated with significant mortality among outpatients with HF in Tanzania (HR 1.749, 95% CI 1.162 to 2.633, p=0.007). Our findings additionally identify tachycardia (>110 bpm, HR 1.879, 95% CI 1.508 to 2.340, p<0.001) as an easily measurable, high-impact physical examination finding for adverse outcomes in patients with HF.

Strengths and limitations of this study

- ► This study is one of the few to examine the prevalence and mortality of atrial fibrillation (AF) among outpatients with heart failure (HF) in sub-Saharan Africa.
- ► This study focuses on readily accessible physical examination measures, demographics, socioeconomic and lifestyle attributes. They are inexpensive to acquire and are well adapted for risk stratification in resource-limited settings.
- ► As a cohort study, no causal relationships can be established between the risk factors and mortality. Questionnaire data on social and personal history are contingent on patient report accuracy. Given the limitations in medical equipment, concurrent coronary artery disease, the order in which AF and HF developed, and whether HF was due to non-ischaemic or ischaemic causes were not established.
- ► All participants were recruited from a single healthcare facility, which may qualify the generalisability of the findings.

INTRODUCTION

As global life expectancy increases, the incidence of heart failure (HF) has risen substantially.[1] Approximately 26 million people live with HF worldwide,[2] with low-income and middle-income countries bearing the greatest burden.[1 3] From 1990 to 2013, cardiovascular disease-related deaths in Africa increased twofold, and accounted for roughly 38% of all non-communicable disease mortalities.[1 4] Within sub-Saharan Africa (SSA), previous studies have indicated an 'epidemiological transition,' whereby chronic, non-communicable diseases are gradually overtaking infectious diseases in prevalence.[1 3] In particular, HF constitutes roughly 9.4%–42.5% of all hospital admissions and 25.6%–30.0% of the cardiology clinic visits at institutions across Africa.[5] HF has a higher 1-year post-hospital discharge mortality than all other diagnoses.[6] In addition to patient-level burden, HF poses significant economic strain secondary to recurrent hospitalisations, lost productivity and pharmacological costs.[5 7]

Atrial fibrillation (AF) incidence is also escalating rapidly among new cardiovascular diagnoses.[8] Between 1990 and 2010, the annual deaths caused by AF grew by 2-fold and 1.9-fold in men and women, respectively.[9] While AF and HF are known to share common cardiometabolic risk factors, growing evidence suggests that the presence of one may precipitate the severity of the other. Compared with sinus-rhythm, comorbid AF is associated with higher all-cause mortality and hospitalisation rates in patients with HF.[10] Furthermore, AF-related atrial remodelling, altered ventricular haemodynamics and arrhythmia-induced myopathy are linked to further HF progression.[11]

Despite the synergistic comorbidity of AF and HF, little is known about the prevalence of AF among outpatients with HF within SSA, or its impact on clinical outcomes. Therefore, we conducted a prospective cohort study to elucidate the prevalence, correlates and mortality associated with this patient population in Tanzania.

METHODS

Overview

This clinic-based prospective cohort study involved 403 patients who were enrolled in a registry of HF. This registry was created as part of a more extensive hospital quality improvement programme for patients with HF. Data collection and follow-up spanned from October 2018 to May 2020.

Setting and participants

The study was conducted at the outpatient clinic of Bugando Medical Center (BMC), a zonal hospital for the Lake Victoria Zone in northwest Tanzania. BMC serves a population of over 14 million with a 950-bed capacity. In each month, BMC provides care for approximately 400 patients with HF, with an average of 100 patients seen weekly. BMC is similar to other facilities that provide care for HF in Tanzania and Uganda.[12 13]

All patients attending the outpatient clinic with a diagnosis of HF were screened between October and December of 2019. Patients ≥18 years of age and seeking HF care were recruited serially until the target sample size was attained (n≥331). Patients with comorbid medical conditions with a prognosis of <3 months (ie, advanced malignancy) were excluded from the study. Of the 403 enrolled patients, 303 had the diagnosis of HF objectively confirmed according to the European Society of Cardiology (ESC) 2016 guidelines,[14] where 133 had heart failure with reduced ejection fraction (HFrEF) and 170 had heart failure with preserved ejection fraction (HFpEF). For the remaining 100 patients, the diagnosis of HF was made according to the Framingham criteria, and in the absence of another primary diagnosis responsible for volume overload.[15]

Study procedures

Consented participants were interviewed using a standard questionnaire that collected clinical and demographic information such as age, sex, residence, duration of HF and New York Heart Association (NYHA) functional classification. Participants were also evaluated for palpitations, shortness of breath, syncope or presyncope, exercise intolerance, chest pain and fatigue. Physical examination was performed on every participant. Blood pressure measurements were taken from the right arm using an automated blood pressure monitor after subjects had rested for at least 5 min. Pulse rate was determined, and noted for irregularity, regularity and amplitude, then compared with the heart rate for pulse deficit.

Height was measured using a rigid ruler attached to a wall and rounded to the nearest 0.5 cm. Weight was measured without shoes, with patients wearing light clothing and recorded to the nearest 500 g using the DETECTO scale. Body mass index (BMI) was calculated using the Quetelet equation[16] and categorised using the WHO Classification Scale, with underweight BMI classified as <18.5 kg/m^2, normal BMI as 18.5–24.9 kg/m^2, overweight BMI as 25–29.9 kg/m^2 and obese BMI as ≥30 kg/m^2. Additionally, electronic medical records were reviewed to extract blood haemoglobin and serum creatinine values.

Study participants were then subjected to a resting 12-lead electrocardiography. The heart rate on ECG was recorded for all subjects. Tracings with irregular QRS complexes and absent discrete P waves were categorised as AF, in accordance with the ESC 2016 criteria.[17] All diagnoses of atrial fibrillation were confirmed by a staff cardiologist. Patients with AF had their results communicated to the attending physician and were treated according to protocol.

Follow-up and outcome determination

At least three contact phone numbers were obtained at the time of enrolment, including one from the patient and two from friends and relatives. All participants were followed for a period of 3 months, with none lost to follow-up. The research team interviewed the participants during their regularly scheduled visits on a monthly basis. Phone calls were made to those not presenting to clinic. During these interviews, information about their recent medical updates or hospitalisations was collected. If the participant could not be reached, the designated alternate contact was called to determine the patient's vital status. Mortality was ascertained via phone call to each individual family. The families confirmed the death was cardiac in origin or related to their cardiac diagnosis (HF/cardioembolic stroke/cardiorenal syndrome). Additionally, for those who died during hospitalisation, care was taken to confirm with the family member that the original admission was due to cardiac aetiologies.

Statistical analysis

By the difference in proportions calculation, a minimum sample size of 331 patients was needed to provide at least 80% power to detect the difference in mortality rates between patients with AF and those without (two-sided test with a 5% level of significance).[18] Our pretest estimation

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Table 1 Social, demographic and medical history of enrolled patients

Patient data (n=403)	Subclass	Number (n=403)
Sex	Female	234 (58.1%)
Age	Mean (SD)	60.2 (18.8)
Education	Informal	109 (27.1%)
	Primary	214 (53.1%)
	Secondary or higher	80 (19.9%)
Reside	Urban	169 (41.9%)
	Rural	234 (58.1%)
Health insurance	Yes	202 (50.1%)
Income level	Low	154 (38.2%)
	Medium/high	249 (61.8%)
BMI categories	Underweight	26 (6.5%)
	Normal	191 (47.4%)
	Overweight	120 (29.8%)
	Obese/severely obese	66 (16.4%)
History of hypertension	Yes	323 (80.2%)
Duration of heart failure (years), median (IQR)		4 (3–9)
Family history of heart failure	Yes	180 (44.7%)
NYHA function class	II	83 (20.6%)
	III	317 (78.7%)
	IV	3 (0.7%)
Diabetes mellitus	Yes	97 (24.1%)
HIV	Positive	21 (5.2%)
Atrial fibrillation	Present (ECG confirmed AF)	70 (17.4%)
Alcohol (average units of alcohol/day)	Yes	189 (46.9%)
	Median (IQR)	0 (0–10)
	Range	0–60
Cigarette smoking	Yes	77 (19.1%)
Echo LV EF (%)	<40	133 (33.0%)
	>=40	170 (42.2%)
	Unknown	100 (24.8%)
Haemoglobin	Normal (>12 g/dL)	175 (43.4%)
	Mild anaemia (100–119 g/L)	188 (46.7%)
	Moderate/severe anaemia (<=99 g/L)	38 (9.9%)
Rheumatic heart disease	Positive history and AF	6 (1.5%)
	Positive history and no AF	18 (4.5%)
	Negative history and AF	64 (15.8%)
	Negative history and no AF	315 (78.2%)
Creatinine level, median (IQR)		94 (77–169)
Systolic blood pressure, median (IQR)		122 (106–142)
Diastolic blood pressure, median (IQR)		70 (66–82)
Pulse rhythm	Regular	300 (74.4%)
	Irregular (diagnosed by clinical exam)	103 (25.6%)
Heart rate (bpm), median (IQR)		79 (71–91)
Pulse deficit (bpm), median (IQR)		6 (3–11)
ECG heart rate (bpm), median (IQR)		79 (67–94)
ECG rhythm	Regular	304 (75.4%)
	Irregular	99 (24.6%)
Goal-directed therapy	Beta-Blocker	254 (63.0%)
	ACE-inhibitor	188 (46.7%)
	Diuretic	300 (74.4%)
	Nitrates	39 (9.6%)
	Digitalis	58 (14.4%)
	ARB	156 (38.7%)
	Calcium channel blocker	48
	Vasodilator	35

AF, atrial fibrillation; ARB, aiotensin receptor blocker; BMI, body mass index; LV EF, left ventricular ejection fraction.

of AF prevalence was 16%.[19 20] For the secondary analyses, this sample size was expected to provide at least 10 observations (ie, number of patients with AF or death events) per predictor in the final models to allow good estimates.[21 22] Stata V.16.1 was the statistical analysis software used in this study. Unknowns were recorded as null prior to analysis. For tabulation purposes, we reported count for discrete variables, and mean/SD or median/IQR for continuous variables. Logistic regression was used to determine which baseline features were most strongly correlated with AF, and Cox proportional hazard analysis was used to evaluate their associations with mortality. The primary outcome of interest was death within 3 months of the index visit. A p value <0.05 was considered statistically significant.

Patient and public involvement statement

No patients involved in the design of this study.

RESULTS

Baseline characteristics

Baseline characteristics of the patients are described in table 1. The cohort included 234 females (58.1%) and 169 males (41.9%), with a mean age of 60±19 years. Nearly one-half (186, 46.2%) were overweight or obese (≥25 kg/m^2). Among the participants, 202 (50.1%) had health insurance. One hundred and fifty-four (154, 38.2%) self-identified as low income (less than 500 000 TZS/month). Two hundred and thirty-four participants lived in rural settings (234, 58.1%) and 169 (41.9%) lived in urban environments. One hundred and nine participants (109, 27.1%) did not receive formal education, 214 (53.1%) completed primary school and 80 (19.9%) obtained secondary or higher degrees. The median HF duration in this cohort was 4 years (IQR 3–9), and 180 (44.7%) noted a family history of HF. The majority, 320 (79.4%), were

Table 2 Univariate logistic regression for sociodemographic, clinical history and anthropomorphic correlates associated with atrial fibrillation

Screening characteristics	Subclass	AF (%)	No AF (%)	OR (95% CI)	P value
Sex	Male	31 (18.3)	138 (81.7)	1.000	
	Female	39 (16.7)	195 (83.3)	0.890 (0.530 to 1.497)	0.661
Age	Mean±SD	66.4±19.0	58.8±18.5	1.025 (1.009 to 1.041)	**0.002**
Education	Informal	27 (24.8)	82 (75.2)	1.000	
	Formal	43 (14.6)	251 (85.4)	0.520 (0.303 to 0.895)	**0.018**
Income	Low	34 (22.1)	120 (77.9)	1.000	
	Medium/high	36 (14.5)	213 (85.5)	0.597 (0.355 to 1.003)	**0.051**
Residence	Urban	26 (15.4)	143 (84.6)	1.000	
	Rural	44 (18.8)	190 (81.2)	1.274 (0.749 to 2.166)	0.372
Health insurance	Yes	31 (15.4)	171 (84.7)	1.000	
	No	39 (19.4)	162 (80.6)	0.753 (0.448 to 1.264)	0.283
BMI (kg/m^2)	Underweight	4 (15.4)	22 (84.6)	1.000	
	Normal	43 (22.5)	148 (77.5)	1.598 (0.522 to 4.889)	0.411
	Overweight	15 (12.5)	105 (87.5)	0.786 (0.238 to 2.595)	0.692
	Obese	8 (12.1)	58 (87.9)	0.759 (0.207 to 2.774)	0.676
Duration of heart failure (years), median (IQR)		6.5 (3–13)	4 (2–7)	1.076 (1.034 to 1.076)	**<0.001**
NYHA function class	I/II	9 (10.8)	74 (89.2)	1.000	
	III/IV	61 (19.1)	259 (80.9)	1.937 (0.918 to 4.083)	**0.083**
Diabetes mellitus	No	55 (18.0)	251 (82.0)	1.000	
	Yes	15 (15.5)	82 (84.5)	0.835 (0.448 to 1.556)	0.57
Alcohol	No	26 (12.2)	188 (87.8)	1.000	
	Yes	44 (23.3)	145 (76.7)	2.194 (1.290 to 3.732)	**0.004**
Cigarette smoking	No	53 (16.3)	273 (83.7)	1.000	
	Yes	17 (22.1)	60 (77.9)	1.459 (0.790 to 2.696)	0.227

AF, atrial fibrillation; BMI, body mass index; NYHA, New York Heart Association.

diagnosed with advanced HF (III/IV NYHA class). The most predominant comorbidity was hypertension, with 323 cases (80.2%). Ninety-seven (97, 24.1%) had concurrent diabetes mellitus. Nearly half of the participants (189, 46.9%) reported a social history positive for alcohol consumption, and 77 (19.1%) had a smoking history.

Prevalence of AF

Of the 403 study participants with heart failure, 70 (17.4%) participants had AF detected on screening ECG. Of these, 29 out of 70 (41.4%) had previously been diagnosed with AF and 41 out of 70 (58.6%) were new diagnoses. Twenty-five per cent (6/24) of participants with a history Rheumatic Heart Disease (RHD) had atrial fibrillation (table 1).

Sociodemographic correlates of AF

In a univariable logistic regression model (table 2), advanced age, low income, informal education, alcohol consumption and longer HF duration were significantly associated with AF. In the multivariable model (table 3), lower income (high income adjusted OR (aOR) 0.5, 95% CI 0.3 to 0.9), duration of HF (aOR 1.05, 95% CI 1.0 to 1.1) and alcohol consumption (aOR 2.1, 95% CI 1.2 to 3.8) were associated with AF.

Clinical and physical exam correlates of AF

By univariate logistic regression (table 4), irregular pulse rhythm, higher baseline heart rate and greater

Table 3 Multivariate logistic regression of demographic factors associated with atrial fibrillation

Variable	aOR (95% CI)	P value
Age	1.006 (0.987 to 1.025)	0.564
Education (formal)	0.659 (0.354 to 1.223)	0.186
Income (med/high)	0.531 (0.306 to 0.920)	**0.024**
Duration of heart failure (years)	1.049 (1.000 to 1.100)	**0.050**
NYHA (III/IV)	1.347 (0.612 to 2.962)	0.459
Alcohol consumption	2.083 (1.150 to 3.771)	**0.015**

aOR, adjusted OR; NYHA, New York Heart Association.

Table 4 Univariate logistic regression for physical exam correlates of atrial fibrillation

Screening characteristics	Subclass	AF (%)	No AF (%)	OR (95% CI)	P value
Systolic blood pressure, median (IQR)		117 (97–134)	124 (107–145)	0.985 (0.974 to 0.996)	**0.009**
Diastolic blood pressure, median (IQR)		69 (64–82)	70 (67–82)	0.996 (0.977 to 1.016)	0.699
Pulse rhythm	Regular	7 (2.3)	293 (97.7)	1.000	
	Irregular	63 (61.2)	40 (38.8)	**65.925** (28.237 to 153.915)	**<0.001**
Heart rate (bpm), median (IQR)		85 (74–102)	78(70–89)	1.026 (1.013 to 1.040)	**<0.001**
Pulse deficit (bpm), median (IQR)		11 (10–13)	5 (3–8)	1.328 (1.233 to 1.431)	**<0.001**

AF, atrial fibrillation.

pulse deficit were linked to AF prevalence. Conversely, higher systolic blood pressure at baseline was associated with a decreased risk of having AF. With respect to physical examination findings, in the multivariate analysis (table 5), irregular pulse rhythm (OR 38.0, 95% CI 15.3 to 94.4) and pulse deficit (OR 1.1, 95% CI 1.0 to 1.2) are strongly suggestive of AF presence.

Three-month mortality

At the end of the 3-month follow-up, 120 (29.8%) participants died, including 44.3% and 26.7% of those with and without AF, respectively. Among the clinical variables (table 6), the factor most significantly associated with 3-month mortality was higher heart rate on ECG (HR 1.88, 95% CI 1.508 to 2.340). Other noteworthy risk factors for death include AF (HR 1.75, 95% CI 1.162 to 2.633), worse heart function (III/IV) on the NYHA scale (HR 1.64, 95% CI 0.981 to 2.738), rural residence (HR 1.47, 95% CI 1.006 to 2.150) and anaemia (HR 1.33, 95% CI 1.012 to 1.738). Conversely, higher education, higher ejection fraction (≥40%) and baseline systolic blood pressure within the normal range were associated with decreased HR. By multivariate analysis (table 7), increased ECG heart rate remained significantly associated with mortality. Collinearity was noted between AF and other measures of HF, and the singular inclusion of AF displayed statistically significant mortality hazards when other diluting factors were omitted (table 8). On stratified analysis, death rate increased significantly with each increment in ECG heart rate, with a 3-month mortality of 21.5% for those with HR below 90 bpm, 38.6% for those between 90 and 110 bpm and 64.4% for patients with >110 bpm at baseline (figures 1 and 2). Additional analyses comparing the AF prevalence and 3-month mortality data for participants with echocardiograph confirmed HF (according to the ESC criteria) against those participants diagnosed based on clinical criteria alone was conducted. In the HFrEF cohort, death rate at 3 months was similar for those with AF and those without. For both HFpEF and clinical criteria diagnosis, there was a marked increase in the 3-month mortality in those with AF (table 9).

Table 5 Multivariate logistic regression for screening factors associated with atrial fibrillation

Variable	OR (95% CI)	P value
SBP	0.987 (0.967 to 1.007)	0.186
DBP	1.019 (0.988 to 1.051)	0.240
Pulse rhythm (irregular)	38.001 (15.292 to 94.436)	**<0.001**
Heart rate	1.003 (0.984 to 1.022)	0.778
Pulse deficit	1.110 (1.018 to 1.211)	**0.018**

DBP, diastolic blood pressure; SBP, systolic blood pressure.

DISCUSSION

In this study, we sought to elucidate the prevalence and correlations of AF, as well as the significant 3-month mortality risk factors for patients with HF in Tanzania. AF was common among our cohort: nearly one out of six (17.4%) ambulatory adults had AF that was evident on a screening ECG. This high prevalence is similar to other reports from East Africa[19] and is likely a result of poor post-diagnosis linkage to care.[23] Of note, patients were more likely to be symptomatic if they were alcohol consumers, more elderly, or had longer HF duration. These are common risk factors for disruptions in cardiac electrophysiology, and in particular, heavy drinking is linked to sudden-onset supraventricular arrhythmias.[24] Unlike age and HF duration, decreasing alcohol consumption is a lifestyle adjustment that patients can readily make to reduce their risk of developing AF. In addition, we found that socioeconomic factors associated with poverty, such as less education and lower monthly income, were correlated with AF. Previous studies[19 25] cited these attributes as major barriers to outpatient care access, and potential contributors to poorer outcomes.

At the end of the 3-month follow-up, almost half of the patients with AF died (44.3%). Participants with HF and concurrent AF experienced a 75% higher risk of dying in the first 3 months after enrolment compared with those with HF alone. This finding aligns with data from the Framingham Heart Study, which indicated a 1.5-fold to 1.9-fold increased mortality risk for patients with AF, further highlighting the need for early detection and treatment.[26] Anaemia, a common condition in lower-income countries, was significantly linked to mortality in

Table 6 Univariate Cox hazard model with death as outcome

Patient data (n=403)	Subclass	No death (%)	Death (%)	HR (95% CI)	P>|z|
Sex	Female	157 (67.1)	77 (32.9)	1.304 (0.898 to 1.894)	0.163
	Male	126 (74.6)	43 (25.4)		
Age				1.000	0.998
Residence	Urban	129 (76.3)	40 (23.7)	1.471 (1.006 to 2.150)	**0.046**
	Rural	154 (65.8)	80 (34.2)		
Education	Informal	68 (62.4)	41 (37.6)	0.689 (0.472 to 1.004)	**0.053**
	Formal	215 (73.1)	79 (26.9)		
Income level	Low	103 (66.9)	51 (33.1)	0.827 (0.576 to 1.188)	0.303
	Medium/high	180 (72.3)	69 (27.7)		
Health insurance	Yes	147 (72.8)	55 (27.2)	1.183 (0.826 to 1.694)	0.359
	No	136 (67.7)	65 (32.3)		
BMI categories	Underweight/normal	148 (68.2)	69 (31.8)	0.876 (0.610 to 1.258)	0.474
	Overweight/obese	135 (72.6)	51 (27.4)		
Hypertension	Yes	227 (70.3)	96 (29.7)	0.982 (0.628 to 1.536)	0.936
	No	56 (70.0)	24 (30.0)		
HF duration (years)				1.282 (0.767 to 2.141)	0.343
NYHA	I/II	66 (79.5)	17 (20.5)	1.639 (0.981 to 2.738)	**0.059**
	III/IV	217 (67.8)	103 (32.2)		
Diabetes	Yes	70 (72.2)	27 (27.8)	0.903 (0.588 to 1.386)	0.641
	No	213 (69.6)	93 (30.4)		
AF	Absent	244 (73.3)	89 (26.7)	1.749 (1.162 to 2.633)	**0.007**
	Present	39 (55.7)	31 (44.3)		
Alcohol	Yes	132 (69.8)	57 (30.2)	1.051 (0.735 to 1.504)	0.785
	No	151 (70.6)	63 (29.4)		
Smoking	Yes	53 (71.6)	21 (28.4)	0.964 (0.602 to 1.544)	0.879
	No	230 (69.9)	99 (30.1)		
Echo LV EF (%)	<40	86 (64.7)	47 (35.3)	0.736 (0.488 to 1.111)	0.144
	>=40	126 (74.1)	44 (25.9)		
	Unknown	71 (71)	29 (29)		
Hb	Normal (>12 g/dL)	131 (74.9)	44 (25.1)	1.326 (1.012 to 1.738)	**0.041**
	Mild (10–11.9 g/dL)	129 (68.6)	59 (31.4)		
	Moderate/severe anaemia (<=9.9 g/dL)	23 (57.5)	17 (42.5)		
Creatinine level				0.996 (0.990 to 1.002)	0.200
SBP				0.992 (0.985 to 1.000)	**0.051**
DBP				0.991 (0.977 to 1.005)	0.195
ECG heart rate				1.017 (1.012 to 1.023)	**<0.001**
ECG HR category (bpm)	<90	216 (78.6)	59 (21.5)	1.879 (1.508 to 2.340)	**<0.001**
	90–110	51 (61.5)	32 (38.6)		
	>110	16 (35.6)	29 (64.4)		

AF, atrial fibrillation; BMI, body mass index; DBP, diastolic blood pressure; Hb, haemoglobin; HF, heart failure; LV EF, left ventricular ejection fraction; NYHA, New York Heart Association; SBP, systolic blood pressure.

our study participants, a finding corroborated by other reports from Tanzania.[19] Lower systolic blood pressure was also associated with reduced survival, which was possibly a consequence of severely diminished left ventricular function.[27] Finally, rural residence emerged as one of the significant predictors of mortality for outpatients with

Table 7 Multivariate Cox HR

Patient data	HR (95% CI)	P value
Residence	1.288 (0.821 to 2.021)	0.271
Education	0.841 (0.535 to 1.322)	0.453
Income level	0.964 (0.631 to 1.471)	0.863
NYHA function class	1.275 (0.701 to 2.318)	0.426
AF	1.030 (0.629 to 1.687)	0.907
Echo LV EF (%)	0.910 (0.578 to 1.431)	0.682
ECG heart rate	1.015 (1.009 to 1.021)	**<0.001**
Haemoglobin	1.062 (0.760 to 1.485)	0.723
SBP	0.996 (0.987 to 1.005)	0.377

AF, atrial fibrillation; LV EF, left ventricular ejection fraction; SBP, systolic blood pressure.

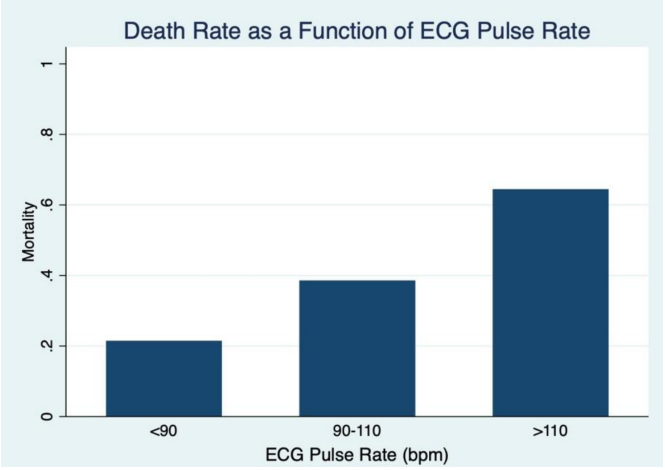

Figure 1 3-Month mortality per categorical heart rate.

HF. In developing regions, wealthier populations often congregate in urban areas, leading to significant disparities in healthcare access and physician shortages in rural communities.[28] These barriers contribute to delayed diagnosis of existing conditions as well as severely limited treatment options, thus further exacerbating the disease burden.

In both univariate and multivariate models of mortality, elevated heart rate on ECG was the strongest independent predictor of death within 3 months.[29–31] Above the bounds of normal resting heart rate (>110 bpm), an increase of 20 beats/min was associated with >65% increased risk of death; a finding that remained significant even after adjusting for the presence of AF and other possible confounders. Furthermore, nearly 40% of people with ECG heart rates between 90 and 110 (ie, controlled by current guidelines) are dead at the end of the 3-month study period. It is likely that higher heart rate signals HF exacerbation. Our data identify a heart rate of >125 beats/min as extraordinarily high risk; therefore, this cut-off could help risk-stratify patients to appropriate care (ie, admission vs outpatient).

AF is specifically associated with higher mortality in the participants with confirmed HF with preserved ejection fraction as well as those with HF diagnosed based on clinical criteria alone. In fact, participants with AF in these two groups had higher mortality than those participants with confirmed HF with reduced ejection fraction. One possible explanation may be that those with worsened HF necessitate more physician visits. The greater contact with the healthcare system allows for more regular screenings, and any incidental findings to be noted and addressed in a timelier manner. Despite the growing global burden of AF, electrocardiograms are not routinely conducted in many HF clinics in low-income communities.[9] Barriers to AF screening include the relative paucity of medical devices such as electrocardiograms, supplies such as ECG paper, and available specialty physicians per capita.[12 13 21] Encouragingly, our data imply that physical examination findings such as irregularly irregular pulse rate and pulse deficit are highly sensitive to detect patients with AF. Both measures can be ascertained with only palpation and a stethoscope and remain useful in clinical environments where ECG machines are not available.

There are limitations to this study. All participants were recruited from a single healthcare facility. Therefore, patients with HF included in this study may have different risk profiles than patients in other geographic locations

Table 8 Multivariate Cox HR (without collinear measures of heart failure)

Patient data	HR (95% CI)	P value
Residence	1.343 (0.912 to 1.979)	0.136
Education	0.813 (0.551 to 1.200)	0.297
Income level	0.931 (0.645 to 1.345)	0.704
AF	1.541 (1.012 to 2.345)	**0.044**
Haemoglobin	1.217 (0.925 to 1.602)	0.161
SBP	0.995 (0.987 to 1.003)	0.23

AF, atrial fibrillation; SBP, systolic blood pressure.

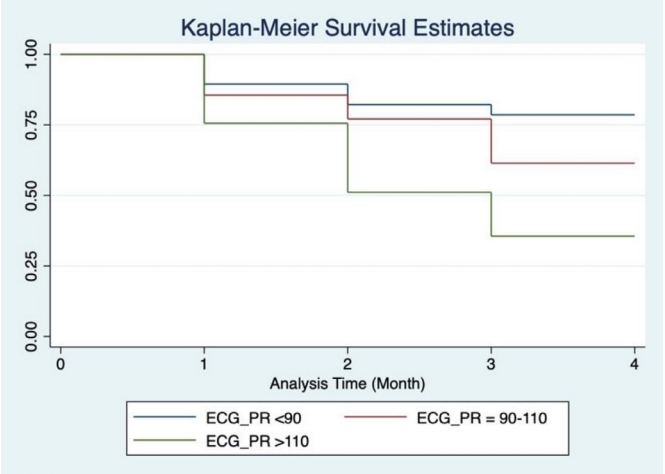

Figure 2 Kaplan-Meier curve for 3-month survival of adults with heart failure.

Table 9 Stratified analysis of HFpEF, HFrEF, clinical criteria diagnosis and AF

Heart failure condition	AF/history of AF	N	3-Month mortality (% of subgroup N)
HFrEF—Echo diagnosis	Yes	35	12 (34.3%)
	No	98	35 (35.7%)
HFpEF—Echo diagnosis	Yes	27	13 (48.1%)
	No	143	29 (20.3%)
Clinical criteria alone	Yes	8	7 (87.5%)
	No	92	18 (19.6%)

AF, atrial fibrillation; HFpEF, heart failure with preserved ejection fraction ; HFrEF, heart failure with reduced ejection fraction.

and clinics. However, our study facility follows identical standards of care and the same protocols as other East African heart failure clinics, which promotes the generalisability of the results. Some aspects of the questionnaire, such as social history, rely on patient self-report, which may suffer from recall bias. Another study limitation is that we did not assess for rate-control medication adherence. This information could have helped differentiate deaths due to AF alone from those caused by poor drug adherence. While none of the subjects had a history of coronary artery disease, the diagnosis cannot be objectively ruled out from the existing clinical data. Additionally, because the focus of this study is the presence of AF and HF, the order in which the two conditions developed, and whether HF was due to non-ischaemic or ischaemic causes were not recorded.

CONCLUSIONS

Our data highlight the compounding morbidity and mortality of AF and HF in low-income and middle-income countries. AF is common, underdiagnosed and is associated with high mortality. In resource-limited settings, the presence of irregular heart rate and pulse deficit, along with affirmative responses to alcohol consumption and chronic HF, should push AF forward on the differential. Heightened resting heart rate should alert physicians to possible HF-related mortality. Common predictors that emerged for both AF and death are associated with systemic impediments to healthcare access and disparities in fiscal and human resource distribution. Thus, in order to effectively alleviate cardiovascular disease burden in Tanzania and other medically underserved regions, in general, there needs to be wider availability of preventative care and targeted screening of AF, particularly among vulnerable populations in rural communities. Our findings also provide a reminder to clinicians in low-income countries that physical examination still matters, and that HF patients with high heart rate deserve more careful clinical scrutiny.

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Patient consent for publication Consent obtained directly from patient(s)

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