

# A Simplified Echocardiographic Strategy for Heart Failure Diagnosis and Management Within an Integrated Noncommunicable Disease Clinic at District Hospital Level for Sub-Saharan Africa

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- Objectives** This study sought to describe a decentralized strategy for heart failure diagnosis and management and report the clinical epidemiology at district hospitals in rural Rwanda.
- Background** Heart failure contributes significantly to noncommunicable disease burden in sub-Saharan Africa. Specialized care is provided primarily at referral hospitals by physicians, limiting patients' access. Simplifying clinical strategies can facilitate decentralization of quality care to the district hospital level and improve care delivery.
- Methods** Heart failure services were established within integrated advanced noncommunicable disease clinics in 2 rural district hospitals in Rwanda. Nurses, supervised by physicians, were trained to use simplified diagnostic and treatment algorithms including echocardiography with diagnoses confirmed by a cardiologist. Data on 192 heart failure patients treated between November 2006 and March 2011 were reviewed from an electronic medical record.
- Results** In our study population, the median age was 35 years, 70% were women, 63% were subsistence farmers, and 6% smoked tobacco. At entry, 47% had New York Heart Association class III or IV functional status. Of children age <18 years (n = 54), rheumatic heart disease (48%), congenital heart disease (39%), and dilated cardiomyopathy (9%) were the leading diagnoses. Among adults (n = 138), dilated cardiomyopathy (54%), rheumatic heart disease (25%), and hypertensive heart disease (8%) were most common. During follow-up, 62% were retained in care, whereas 9% died and 29% were lost to follow-up.
- Conclusions** In rural Rwanda, the causes of heart failure are almost exclusively nonischemic even though patients often present with advanced symptoms. Training nurses, supervised by physicians, in simplified protocols and basic echocardiography is 1 approach to integrated, decentralized care for this vulnerable population. (J Am Coll Cardiol HF 2013;1:230–6) © 2013 by the American College of Cardiology Foundation

Heart failure is common throughout sub-Saharan Africa. The contemporary Heart of Soweto study (involving 1,593 patients) confirmed this, showing 44% of patients with newly

diagnosed cardiovascular disease (CVD) had heart failure, whereas only 10% had coronary artery disease (1). Reviewing data from selected urban echocardiographic centers reveals the

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common etiologies include nonischemic cardiomyopathies, rheumatic heart disease (RHD), congenital heart disease (CHD), hypertensive heart disease (HTN HD), and endomyocardial fibrosis; ischemic heart disease remains relatively uncommon (2-6). Additionally, there may be significant variation within the continent as endomyocardial fibrosis, in particular, appears to be more predominant in pockets of East and Central Africa (4,7,8). The socioeconomic impact of this disease is high as heart failure strikes individuals in sub-Saharan Africa at a much younger age profile than in the United States and Europe (3).

Heart failure management requires trained healthcare workers who are able to accurately determine its structural or functional etiology. For decades, cardiologists and other specialized physicians trained in echocardiography have made diagnosis available at referral centers in capital cities throughout sub-Saharan Africa (4). However, available healthcare human resources are limited (9) and heterogeneous physician distribution exacerbates the mismatch between supply and demand: 80% of physicians live in urban areas, whereas 80% of the population is rural (10). Specialists are rare, resulting in long waits, expensive fees, and high transport costs, severely limiting timely access to definitive management. Despite exciting new initiatives to expand the number and quality of health professionals in sub-Saharan Africa, tasks distribution among existing providers will need to be optimized (11).

A public health system strategy employing portable echocardiography and simplified algorithms for diagnosis and initial management of heart failure has been developed in several rural districts in Rwanda since 2006. Heart failure treatment is accomplished in integrated noncommunicable disease (NCD) clinics that allow sharing of staff and resources in managing a group of chronic conditions endemic in rural sub-Saharan Africa. Community health workers (CHW) improve adherence through directly observed therapy, a strategy long-used to ensure adherence and to provide social support for patients with chronic conditions including tuberculosis and human immunodeficiency virus (HIV) (12). Although there are several reports on the chronic management of other NCD (including uncomplicated hypertension, asthma, and epilepsy) (13,14), there are no published examples of decentralized approaches for heart failure. Here we describe our diagnostic approach, treatment pathways, and preliminary experience from district-level clinics.

## Methods

### Integrated district-level outpatient heart failure program.

Since 2006, Partners In Health, a Boston-based organization dedicated to health and social justice, has supported the Rwandan Ministry of Health's efforts to decentralize services for NCD including heart failure (15). Integrated nurse-run and physician-supervised NCD clinics were established at 2 rural public sector district hospitals (Kirehe and Southern Kayonza districts: approximate population in 2009 of 350,000). Teams include 2 nurses, a clinical data officer, and

a clerk, who are periodically supervised by generalist physicians (who have not completed specialty residency training). Further mentoring is provided monthly by an adult endocrinologist and a pediatric cardiologist (who occasionally consulted on adults), visiting from the national teaching hospital in the capital. In addition to heart failure, conditions treated in these decentralized district NCD clinics include hypertension, diabetes, renal failure, chronic respiratory disease, thrombotic disorders, and some malignancies.

**Protocol development.** Our review of the literature and clinical experience suggests heart failure in rural sub-Saharan Africa encompasses a handful of diagnostic categories with distinct treatment pathways (Table 1) (2,4-6). These 5 categories are: dilated cardiomyopathies (including peripartum cardiomyopathy); mitral stenosis; other RHD and CHD (excluding mitral stenosis); HTN HD; and isolated right-sided heart failure (including constrictive pericardial disease). We developed diagnostic protocols incorporating simple physical exam and echocardiographic findings to assign patients into 1 of these 5 broad diagnostic categories (Fig. 1). This simplified echocardiographic approach uses only the parasternal long-axis and subcostal views for preliminary diagnosis. Nurses were trained to perform and interpret these limited studies to identify 4 main features by visual qualitative inspection: depressed left ventricular systolic function (ejection fraction  $\leq 40\%$ ); mitral stenosis; large pericardial effusion; and inferior vena cava diameter (16). SonoSite MicroMaxx (SonoSite, Inc., Bothell, Washington) portable ultrasound machines with 5-1 MHz and 8-4 MHz probes for adult and pediatric studies, respectively, were used. Diagnostic physical exam findings included only blood pressure and presence of a loud murmur.

Treatment protocols for each category preferentially used medications on the existing national formulary (including amlodipine, atenolol, captopril, digoxin, furosemide, hydrochlorothiazide, nifedipine, and spironolactone) when available. Additional advantageous generic medications (based on cost, scientific evidence, dosing frequency, and need for electrolyte monitoring) were added through external procurement including a heart failure beta-blocker (carvedilol), a once-a-day angiotensin converting enzyme inhibitor (lisinopril), hydralazine, isosorbide dinitrate, and warfarin.

Total estimated annual direct program costs including medications (US\$40), laboratory consumables, equipment depreciation, staff time, patient transportation, and hospitalization are \$315 per patient (Table 2). A national

### Abbreviations and Acronyms

<b>CHD</b> = congenital heart disease
<b>CHW</b> = community health worker(s)
<b>CVD</b> = cardiovascular disease
<b>HIV</b> = human immunodeficiency virus
<b>HTN HD</b> = hypertensive heart disease
<b>NCD</b> = noncommunicable disease(s)
<b>NYHA</b> = New York Heart Association
<b>RHD</b> = rheumatic heart disease

**Table 1** Important Heart Failure Diagnostic Categories and Therapeutic Plans in Rural Rwanda

Heart Failure Category	Diagnostic Criteria	General Therapeutic Plan
Cardiomyopathy	Moderately to severely depressed left ventricular function (LVEF $\leq$ 40%)	Fluid management Beta-blocker ACE inhibitor (or hydralazine and isosorbide)
Hypertensive heart disease (adults $\geq$ 18 yrs)	Severe hypertension ( $\geq$ 180/110 mm Hg) Shortness of breath Normal to mildly depressed left ventricular function (LVEF $\geq$ 40%)	Fluid management Blood pressure control
Mitral stenosis (rare before age 25 yrs)	Mitral valve that does not open well with typical elbow deformity Normal to mildly depressed left ventricular function (LVEF $\geq$ 40%)	Fluid management Heart rate control Stroke prevention Penicillin prophylaxis Referral for cardiac surgery evaluation
Other valvular disease (including rheumatic and congenital disease)	Normal to mildly depressed left ventricular function (LVEF $\geq$ 40%) No mitral stenosis Blood pressure $\leq$ 180/110 mm Hg (adult age $\geq$ 18 yrs) Dramatic heart murmur or cyanosis (in a child or young adult)	Fluid management Penicillin prophylaxis Referral for cardiac surgery evaluation
Isolated right heart failure	LVEF $\geq$ 40% No mitral stenosis Blood pressure $\leq$ 180/110 mm Hg (adult age $\geq$ 18 yrs) No heart murmur Large right ventricle or dilated IVC on echocardiography	Fluid management Screening for active tuberculosis

ACE = angiotensin converting enzyme; IVC = inferior vena cava; LVEF = left ventricular ejection fraction.

government-subsidized health insurance program (in which 91% of the population is enrolled) provides services and medications after modest copayments to individual patients (17). Further subsidy from Partners In Health allowed patients to receive care without out-of-pocket expense and a transportation allowance. For reference, per capita gross domestic product in Rwanda in 2011 (in current U.S. dollars) was \$595; though this value is likely lower in rural communities (18).

Treatment protocols start with the recognition of decompensated disease, appropriate triage, and assessment of fluid status. Nurse clinicians then either rule out heart failure as a cause of symptoms or initiate 1 of 5 evidence-based treatment pathways based on their preliminary physical exam and echocardiographic findings (Table 1). All patients are treated with diuretics for symptom relief. Medications to reduce afterload are administered for cardiomyopathy and nonmitral stenosis RHD. Those with mitral stenosis are treated additionally to control the heart rate and prevent strokes. Patients with valvular or CHD are given prophylaxis for rheumatic fever with penicillin and referred for full echocardiography and surgical evaluation. Complete protocol algorithms are available online (15).

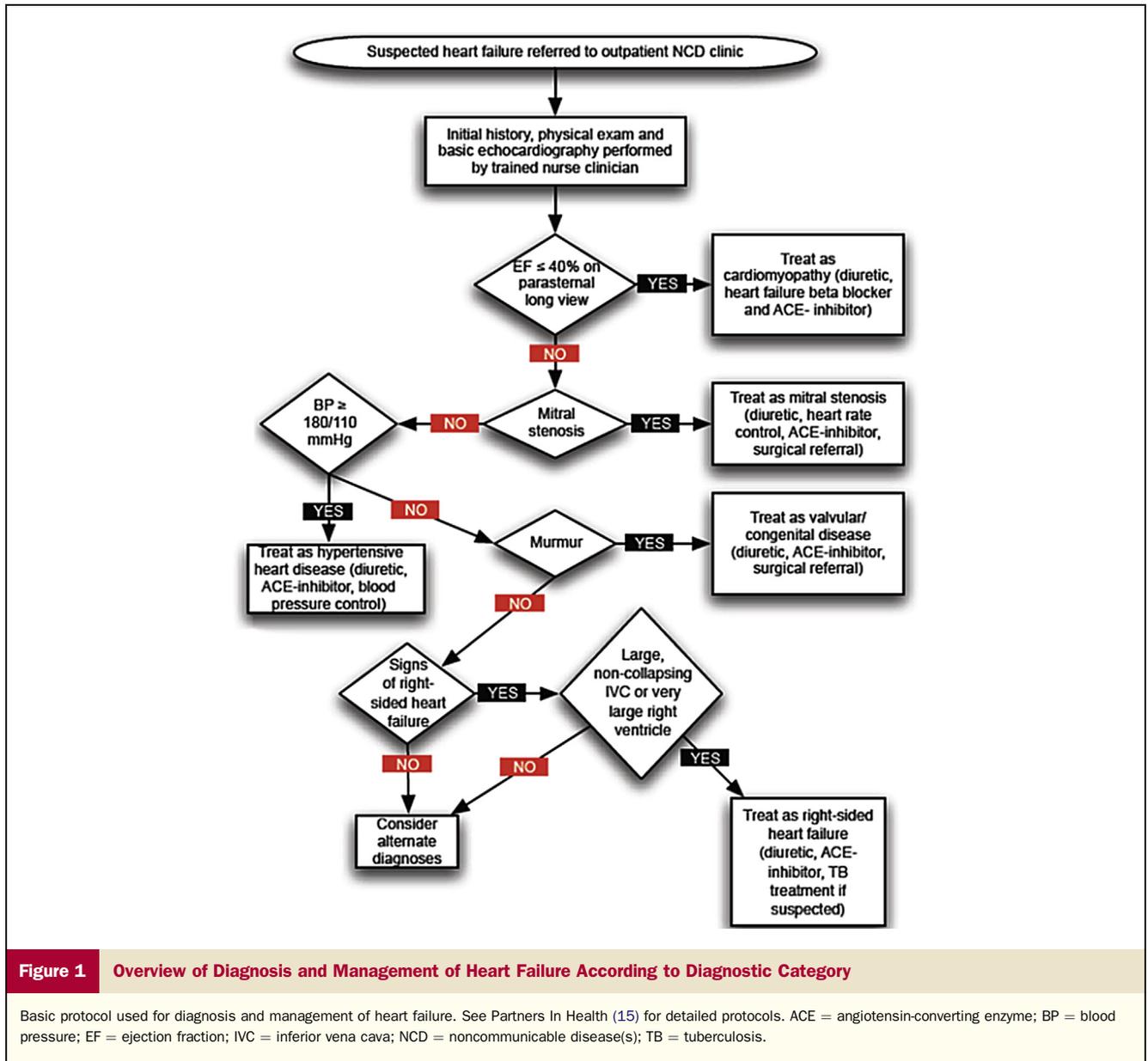
Limited, locally available diagnostic tests are incorporated into the protocols as necessary, including basic laboratory tests (blood count, electrolytes, and HIV serology) and plain film radiography (if there is concern for active pulmonary infections). Advanced renal disease is generally locally defined as serum creatinine  $\geq$ 200  $\mu$ mol/l ( $\geq$ 2.3 mg/dl), approximately corresponding to an estimated glomerular filtration rate of  $\leq$ 30 ml/min in an adult of average weight (50 kg). Advanced tests (such as thyroid-stimulating hormone, cholesterol, B-type natriuretic peptide, and cardiac troponins) are not available. Electrocardiography for

patients with irregular rhythm focuses on arrhythmia identification, particularly atrial fibrillation.

**Specialized nurse training.** Initial 2-month training for NCD was conducted by internal medicine physicians and cardiologists through didactic and problem-based-learning discussions in small groups. Sixteen days were devoted specifically to heart failure and echocardiography. Daily supervised clinic sessions were employed for practical experience including hands-on instruction in basic echo-cardiography.

**Patient recruitment.** Patients are referred from outpatient acute care clinics or after discharge from district hospitals based on the referring provider's clinical suspicion. Patients are evaluated for symptoms (shortness of breath, orthopnea, paroxysmal nocturnal dyspnea, and extremity swelling) and physical exam signs (tachycardia, pulmonary rales, loud heart murmurs, extremity edema) of heart failure. Symptom severity is assessed using the New York Heart Association (NYHA) classification. Patients are enrolled in the heart failure program if their findings cannot be attributed to an alternative etiology.

**Service provision.** The NCD clinic devotes 1 day each week to patients with heart failure, evaluating approximately 20 patients per day. Patients enrolled in the heart failure program undergo basic echocardiography to assign a preliminary diagnosis and initiate appropriate treatment. Patients with a nurse-assigned preliminary diagnosis are evaluated within 6 months by a cardiologist during an outreach visit. After an independent history, physical exam, and formal echocardiogram, a confirmed diagnosis is assigned by the cardiologist. Patients with hypertension, preserved systolic function, and left ventricular hypertrophy on echocardiogram were considered to have confirmed HTN HD. Those with possible surgical disease (valvular,



congenital, or isolated right-sided heart failure symptoms found to have constrictive pericarditis) are prioritized for cardiology referral. Patients are followed every 6 weeks by nurses who provide protocol-directed care. This follow-up interval balances the demand of patient volume with the limited supply of trained nurses. Complex patients are referred to district hospital physicians or a referral center cardiologist. A CHW is assigned to provide daily directly observed therapy ensuring medication adherence and social support. Patients are also referred to a social worker for possible assistance with transportation, housing, and food.

**Monitoring and evaluation.** Clinical data are recorded in paper charts and subsequently transcribed into an open-source electronic medical record system (OpenMRS, OpenMRS LLC, Indianapolis, Indiana) by dedicated data

entry personnel (19). Aggregate clinical data are periodically reviewed to inform ongoing quality improvement. Patients who are not seen in clinic within 6 months are considered “lost to follow-up” and outreach attempts are made with the assistance of CHW. Clinic staff are notified of patient deaths through the CHW.

**Data extraction.** We extracted baseline data on patients enrolled in Southern Kayonza and Kirehe districts between November 2006 and March 2011. Data include demographics, diagnosis (confirmed by cardiologist), creatinine (for adults), and NYHA functional class. Dates of most recent follow-up were used to determine the length of time in care. Pediatric patients are defined as those <18 years of age. Patients without a cardiologist-confirmed diagnosis or who were evaluated as “normal” were excluded from this analysis. Use of routinely collected clinical data for research

**Table 2** Annual Cost Model for an Average Patient With Cardiomyopathy

Program Costs	Annual Cost per Patient
Typical regimen: furosemide 40 mg 2×/day, lisinopril 20 mg 1×/day, carvedilol 25 mg 2×/day	\$40
Laboratory testing and imaging (including point-of-care chemistries and echocardiography)	\$59
Transport subsidy (\$3 per visit, 12 visits)	\$36
Community health worker (\$30 per month divided among 5 patients)	\$72
Advanced NCD clinician salary (\$10,000 per yr)	\$33
Marginal cost of hospitalization (5 days per yr at \$15 per day)	\$75
<b>Total cost</b>	<b>\$315</b>

NCD = noncommunicable disease(s).

was approved by the Rwanda National Ethics Committee and the Institutional Review Board of Brigham and Women’s Hospital, Boston. Descriptive statistics were generated using Stata 11 (StataCorp LP, College Station, Texas).

### Results

Over 5 years, NCD clinics in 2 rural districts enrolled 192 patients with a confirmed cardiologist diagnosis (out of 237 patients with suspected heart failure). On average, patients had been receiving care for 19 months (range <1 to 47 months). Table 3 displays available demographic data for these patients. Seventy percent of patients were women. Median age was 35 years with 28% in the pediatric age range. Sixty-two percent of adults were rural farmers; 86% lived in dirt floor housing (as opposed to cement); and 13% had inadequate roofing (tarp or thatch as opposed to metal). Forty percent of patients sought traditional medical care prior to coming to the clinic. Only 6% of patients reported tobacco use. Average adult weight was 53 kg.

Table 4 shows the clinical characteristics of this cohort. Nonischemic dilated cardiomyopathy (54%), RHD (25%), and HTN-HD (8%) were the leading diagnoses among adults. Of pediatric patients, 48% had RHD and 39% had CHD. Some patients were formally diagnosed with “other” causes of heart failure, including several patients with cor pulmonale, infective endocarditis, or myxomatous valve disease, and 1 patient with an atrial myxoma. None of the patients had a left ventricular contraction pattern consistent with ischemic heart disease—no significant echocardiographic regional wall motion abnormalities were observed.

Of those with NYHA class documented at enrollment, 44% (n = 80) presented to the outpatient clinic with decompensated disease (NYHA class III or IV symptoms). Of patients with RHD, 46% and 62% of adult and pediatric patients, respectively, presented with decompensated heart failure. Three of the 11 adult patients with HTN-HD had advanced renal disease.

**Table 3** Demographic Characteristics of Patients With Confirmed Heart Failure Diagnosis (n = 192 Unless Otherwise Specified)

Female	134 (70)
Weight at intake of adults, kg	52 (34–84)
Age at enrollment, yrs	35 (0–91)
Pediatric patients, age <18 yrs	54 (28)
Marital status of adults with documented marital status, n = 114	
Married	64 (56)
Never married	19 (17)
Widowed	24 (21)
Divorced	4 (4)
Partner in prison	3 (3)
Farmer, adults, n = 138	85 (62)
Living in house with dirt floor, n = 136	117 (86)
Living in house with inadequate roofing (tarp or thatch), n = 146	19 (13)
Current tobacco use of adults, n = 138	8 (6)
Treated by a traditional healer, n = 145	59 (41)

Values are n (%) or median (range). Characteristics are reported for patients with available data. Adult = age ≥18 years.

Mortality and loss to follow-up were analyzed among patients with confirmed diagnoses (n = 192). Eighteen patients (9%) had documented deaths. Of those who died, 4 were pediatric patients whereas 14 were adults. Eight had dilated cardiomyopathy, 4 had CHD, and 3 had RHD. During data extraction, 5 patients did not have the date of the last visit recorded and were considered lost to follow-up. Median time in care, of patients who were alive and had complete date recording (n = 169), was 13 months for children and 20 months for adults. Fifty-five patients (29%) were lost to follow-up whereas 119 (62%) of all enrolled patients were retained in care and alive by the end of the review period.

### Discussion

This heart failure series from district hospitals and clinics in rural Rwanda demonstrates a disease distribution similar to those previously reported from referral centers throughout sub-Saharan Africa (2–6). Few patients had risk factors for ischemic heart disease and no patient had regional wall motion abnormalities consistent with previous myocardial infarction. Patients tended to be young women working as farmers. Though body mass index could not be calculated due to unavailable height data, this is estimated at 21.4 kg/m<sup>2</sup>, assuming a historical mean adult female height of 156 cm (20), suggesting that obesity is infrequent among women. Physical activity was assumed to be high because subsistence farming was the major source of income.

Patients presented at advanced stages to this ambulatory clinic. With long-term follow-up by nurses, observed mortality (9%) in this mixed cohort—referred after hospitalization and from acute care clinics—was similar to a recently published series (18% at 180 days after heart

**Table 4** Distribution of Disease and Baseline Status Among Heart Failure Clinic Patients

	DCMP	RHD	CHD	HTN HD	PERIC	EMF	Other*	Total
Full cohort†	79 (41)	61 (32)	28 (15)	11 (6)	2 (1)	2 (1)	9 (5)	192 (100)
Female	57 (72)	45 (74)	16 (57)	9 (82)	1 (50)	1 (50)	3 (33)	132 (69)
NYHA class III–IV	28 (35)	45 (74)	5 (18)	6 (55)	2 (100)	1 (5)	4 (44)	91 (47)
Adult, ≥18 yrs†	74 (54)	35 (25)	7 (5)	11 (8)	2 (1.4)	1 (0.7)	8 (6)	138 (100)
Female	54 (73)	27 (77)	5 (71)	9 (82)	1 (50)	0	3 (38)	99 (72)
NYHA class III–IV	28 (38)	29 (83)	2 (29)	6 (55)	2 (100)	1 (100)	4 (50)	72 (52)
Creatinine ≥2.3 mg/dl	7 (9)	0	0	3 (27)	—	—	0	10 (7)
Children, age <18 yrs†	5 (9)	26 (48)	21 (39)	0	0	1 (2)	1 (2)	54 (100)
Female	3 (60)	18 (69)	11 (52)	0	0	1 (100)	0	33 (61)
NYHA class III–IV	0	16 (62)	3 (14)	0	0	0	0	19 (35)

Values are n (%). Dashes indicate that data were unavailable. \*Cor pulmonale (4), non-rheumatic valvular disease (2), atrial myxoma (1), ascending aortic aneurysm (1), infective endocarditis (1), no patients with ischemic cardiomyopathy were observed. †Proportion of patients per the total number of patients in the age category (full cohort, adult or children). All other percentages are reported per the number of patients in the diagnostic category within the age category.

CHD = congenital heart disease; DCMP = dilated cardiomyopathy; EMF = endomyocardial fibrosis; HTN HD = hypertensive heart disease; NYHA = New York Heart Association; PERIC = pericardial disease; RHD = rheumatic heart disease.

failure hospitalization) (3). For this economically and socially vulnerable population with many barriers to accessing care, decentralization of services is essential.

We believe this strategy can successfully decentralize the initial diagnosis and medical management of heart failure to district-level providers for three reasons. First, assessing complex regional wall motion abnormalities is not needed as ischemic heart disease and the prevalence of traditional atherosclerotic risk factors are rare, particularly among this group of young individuals. Second, grouping the prevalent causes of heart failure into larger categories defined by 1 or 2 simple physical exam or echocardiographic findings allows for ease of diagnosis without the need for advanced echocardiographic techniques at the district level. Third, diseases within these categories share common medical treatment pathways and/or need for surgical evaluation. Detailed echocardiographic assessments, performed upon referral to a cardiologist, remain essential during cardiac surgery evaluation.

Comparing outcomes (mortality and hospitalization) to other health districts without similar programs is limited given the lack of national reporting on patients with heart failure and the high degree of referrals from neighboring districts to these NCD clinics. The observed retention in this program (62%) is comparable to that of a large systematic review of antiretroviral treatment cohorts throughout sub-Saharan Africa (70% at 24 months) (21). Improved CHW networks can lead to robust advancements in retention rates (as high as 92% for chronic HIV care) (22).

Several strengths of this program have been highlighted. This simplified, protocol-based model has been expanded from 1 pilot site to 3 districts, with plans for national-level scale-up in the near future. Optimizing tasks between physicians to nurses in part addresses the imbalance between the vast current clinical need and relatively sparse healthcare workforce in Rwanda. Medications for heart failure are generic and program costs are comparable to treating HIV throughout sub-Saharan Africa, though overall budgetary impacts will be smaller given the lower prevalence of heart failure. CHW are essential in rural areas. Universal health

insurance systems to lower out-of-pocket costs for patients are essential for chronic, life-long conditions and must be implemented by supportive governments and policy makers.

Since the 1950s, the epidemiology of CVD throughout sub-Saharan Africa has remained unchanged with heart failure being the dominant cause (23). The current global dialogue advocating for increased awareness toward CVD in low- and middle-income countries focuses on combating traditional atherosclerotic risk factors—hypertension, high cholesterol, obesity, and tobacco smoking (24). Whereas forward-thinking policies are needed to address the predicted increase in CVD morbidity and mortality given overall continental trends in urbanization and adoption of westernized lifestyles, efforts in rural Africa should also be devoted to today's endemic diseases. Optimizing simple tasks between physicians and nurses using standardized protocols is one method to achieve these goals.

**Study limitations.** High clinic volume leads to incomplete clinical and research data recording. Dedicated data entry officers may complement service delivery allowing for continued monitoring, evaluation, and improvement. More frequent cardiologist outreach would enhance diagnosis confirmation. Additionally, our reported mortality is likely underestimated as patients labeled “lost to follow-up” may have died.

In regions where resources (provider availability and finances) are limited, identifying patients with definite heart failure was emphasized. These simplified diagnostic criteria enhance specificity while limiting sensitivity. Thus, there are heart failure patients who remain unidentified using these protocols (i.e., false negatives). Future analyses are planned to evaluate the diagnostic characteristics of this algorithm.

## Conclusions

Simplified approaches to the diagnosis and management of heart failure in resource-limited settings have long been recognized. Training nurses and generalist physicians at the district level is one strategy to improve health systems with

limited specialists, avoiding delays in care and needless suffering. It facilitates the initiation of appropriate medical therapy and expedited referral of patients with possible surgical disease. The system depends on the essential elements of any successful chronic care strategy: diagnostic algorithms; stable drug supply; standardized treatment protocols; adherence support; record keeping and reporting; and political commitment (23,25).

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