Current Heart Failure Reports (2025) 22:29
https://doi.org/10.1007/s11897-025-00712-1

REVIEW

Geographic Variations, Peculiarities, and Management of Heart Failure in Sub-Saharan Africa

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Received: 3 March 2025 / Accepted: 19 August 2025 / Published online: 24 October 2025

Abstract

Purpose of Review Heart failure is a complex cardiovascular syndrome with diverse etiologies. It is prevalent and has a substantial adverse global health impact. This review focuses on the peculiarities of HF in sub-Saharan Africa.

Findings Heart failure poses a significant challenge in sub-Saharan Africa, primarily affecting young adults aged 36.5 to 61.5 years. Patients often present with advanced symptoms, exacerbated by socioeconomic factors and other complications. Key risk factors include hypertension, diabetes, chronic kidney disease, and chronic obstructive pulmonary disease, with new challenges arising from obesity, air pollution, and infectious diseases, further complicating treatment approaches. Diagnostic capabilities in sub-Saharan Africa remain limited. Non-adherence to prescribed medications ranges between 23.7% and 74.7%, worsening disease progression and leading to increased rehospitalizations and mortality rates. Moreover, the high costs of guideline-recommended medications, including sodium-glucose cotransporter-2 inhibitors and angiotensin receptor-neprilysin inhibitors, restrict their availability. Additionally, advanced device therapies like implantable cardioverter-defibrillators and cardiac resynchronization therapy are often inaccessible due to their high costs, the scarcity of invasive cardiac laboratories, and a limited number of trained healthcare professionals.

Summary Heart failure poses a significant challenge in sub-Saharan Africa, especially among younger adults. Late clinical presentations, compounded by socioeconomic barriers, underscore the urgent need for improved healthcare access and education. Addressing key risk factors, enhancing diagnostics, and ensuring treatment adherence are vital for better management. Additionally, the high costs of advanced medications highlight the necessity for more affordable healthcare solutions to alleviate the burden of heart failure in the region.

Keywords Heart failure · Cardiac failure · Epidemiology · Risk factors · Geography · Africa

Abbreviations

ACEI	Angiotensin Converting Enzyme Inhibitor
ACS	Acute Coronary Syndrome
AF	Atrial Fibrillation
AUROC	Area Under the Receiver Operating Curve
BNP	B-type Natriuretic Peptide
CAD	Coronary Artery Disease
CI	Confidence Interval
CKD	Chronic Kidney Disease
CMP	Cardiomyopathy
COPD	Chronic Obstructive Pulmonary Disease
CRT	Cardiac Resynchronization Therapy
CVD	Cardiovascular Disease
CVDs	Cardiovascular Diseases
DM	Diabetes Mellitus
ECG	Electrocardiogram
eGFR	Estimated Glomerular Filtration Rate
GBD	Global Burden of Disease
GDMT	Guideline Directed Medical Therapy
HF	Heart Failure
HFpEF	Heart failure with preserved Ejection Fraction

Extended author information available on the last page of the article

HFrEF	Heart failure with reduced Ejection Fraction
HIV	Human Immunodeficiency Virus
HRQoL	Health-Related Quality of Life
ICD	Implantable Cardioverter Defribrillator
ID	Iron Deficiency
LIPRA	Lipid Registry of Africa
ML	Machine Learning
MNA	Medication Non-Adherence
MRA	Minerocorticoid Receptor Antagonist'
NCD	Non-communicable Diseases
NT	N-Terminal
NTDs	Neglected Tropical Diseases
NYHA	New York Heart Association
PAPUCO	Pan African Pulmonary Hypertension Cohort
QoL	Quality of Life
RHD	Rheumatic Heart Disease
SGLT2	Sodium-glucose cotransporter-2
SNP	Single Nucleotide Polymorphism
SSA	Sub-Saharan Africa
THESUS-HF	The Sub-Saharan Africa Survey of Heart Failure
TTE	Transthoracic Echocardiography
TTR-CA	Transthyretin Cardiac Amyloidosis
UI	Uncertainty Interval

Introduction

Heart failure (HF) is currently a global health problem with an estimated prevalence of more than 64 million persons affected globally [1–3]. It is associated with frequent hospital admissions and readmissions, impaired quality of life (QoL), high morbidity and mortality and high health-related and economic costs [1–3]. The prognosis for HF is now understood to be worse than that of most cancers, with a 5-year survival rate after diagnosis of less than 50%.[4, 5]

Contemporary guidelines classify HF into three categories: HF with reduced ejection fraction (HFrEF), HF with mildly reduced ejection fraction (HFmrEF), and HF with preserved ejection fraction (HFpEF). [6, 7] There is a global geographic disparity in the distribution of these classes, and this is compounded by the dearth of data (especially community data) on the prevalence and incidence of HF in SSA. This review aims to evaluate the current epidemiology, risk factors, etiologies, and emerging approaches to the diagnosis, treatment, management, outcomes, health-related quality of life (QoL), and prevention of HF and associated conditions in the region. We have used real-world data from recent clinical registries and observational studies conducted in the region.

We searched for real world data from recent clinical registries and observational studies in the region published between 2012 and 2023. The following databases were searched: PubMed, Embase, Web of Science, African index medicus, African Journals Online (AJOL) and Google Scholar. A total of 26 articles were extracted and analysed as shown in Table 1, and this was described under the following heading; country; year of publication; author name, number of participants, mean age, proportion of female participants, as well as cardiovascular risk factors and comorbidities.

Epidemiology

Prevalence and Incidence

Population-based estimates of HF are very limited in SSA with one study in a rural community in the north-central region of Nigeria reporting a prevalence of 0.95% [35]. On the other hand, hospital-based studies reported a prevalence of 9.4–42.5% of all medical admissions [23, 36–39] and 25.6–30% of cardiac-related admissions. [40–42]

Currently, there is no data on the incidence of HF in SSA. However, the ongoing THESUS-II study aims to fill this gap. According to data from the Global Burden of Disease (GBD) Study, the global age-standardized prevalence of HF per 100,000 population was 765.9(UI 626–936) in 1990, which decreased to 711.9 (UI 591.2 −858.3) in 2019 [2]. In SSA, the age-standardized rates (ASRs) of HF prevalence per 100,000 population in 1990 were 499.3(UI 368.4–658.7) in Central Africa, 761.6(UI 601.1–958.1) in Eastern Africa, 740.2(UI 580.9–932.4) in Southern Africa, and 593.1(UI 467.7–746.6) in Western Africa, respectively. The rate only fell in Central Africa in 2019 to 482.0(UI 356.3–639.3), while it increased in the other sub-regions: Eastern Africa – 812.6(UI 640.9–1019.9), Southern Africa- 662.4 (UI 517.9–831.6), and Western Africa (Fig. 1).

Clinical Features

Heart failure is a disease affecting young and middle-aged adults in SSA, occurring between the third and fifth decades of life. The mean ages ranged from 36.5 to 61.5 years, with varying gender disparities across studies [43]. This contrasts with reports from high-income countries, where HF predominantly affects the elderly, manifesting in the seventh and eighth decades of life. Patients with acute HF in SSA often present late, exhibiting severe symptoms and worse NYHA functional class [44].

Table 1 Some sociodemographic characteristics, risk factors and co-morbidities in contemporary heart failure studies in SSA. (2012–2023)

Country	Year	Author	No	Mean Age (years)	Female(%)	HTN(%)	DM (%)	CKD(%)	COPD(%)	AF (%)	Ane-mia(%)
Angola	2023	Morais et al. [8]	257	49.9	55.6	36.6	5.4	N/A	N/A	7.78	N/A
Botswana	2017	Mwita et al. [9]	193	54.2	46.1	54.9	15.5	15.0	N/A	9.8	N/A
Burkina faso	2019	Bamouni et al. [10]	123	52.7	55.3	37.4	6.5	N/A	N/A	13.1	N/A
Burkinafaso	2020	Mandi et al. [11]	298	58.6	49.7	56.38	4.4	N/A	N/A	29.53	N/A
Cameroon	2019	Nkoke et al. [12]	86	59.4	55.5	53.4	14.0	5.8	N/A	2.3	N/A
Cameroon	2021	Lemogoum et al. [13]	142	58	41.5	59.2	16.2	18.3	N/A	25.4	48.6
Cameroon	2017	Boombhi et al. [14]	148	61.5	57.2	54.79	17.1	N/A	N/A	N/A	N/A
Congo	2018	Didier malamba –lez et al. [15]	231	56	53	N/A	N/A	N/A	N/A	N/A	N/A
Ethiopia	2016	Abebe et al. [16]	311	53.6	69.8	31.2	1.29	N/A	N/A	25.41	37.94
Ethiopia	2022	Tekle et al. [17]	263	51.1	58.2	27.0	N/A	N/A	N/A	N/A	23.6
Ghana	2023	Agyekum et al. [18]	140	51.3	56.4	46.4	15.7	N/A	N/A	N/A	N/A
Lesotho	2022	Ndongala et al. [19]	126	66.0	56	61	20	N/A	N/A	N/A	N/A
Ghana	2017	Bonsu et al. [20]	1488	60.3	54.4	61.2	22.8	17.6	2.20	20.7	9.90
Multi-country	2012	Damasceno et al. [21]	52.3	51.1	55.5	11.4	7.7	N/A	N/A	15.2	N/A
Nigeria	2013	Ojji et al. [22]	475	N/A	54.9	48.6	N/A	N/A	N/A	N/A	14.6
Nigeria	2014	Ogah et al. [23]	452	56.6	45.1	64.3	10.0	N/A	3.5	N/A	N/A
Nigeria	2016	Ogbemudia [24]	102	74.8*	52	84.3	31.4	N/A	N/A	14.7	1.0
Rwanda	2018	Eberly et al. [25, 26]	451	42	68	N/A	N/A	N/A	N/A	N/A	N/A
Somalia	2022	Yusuf et al. [27]	155	65.9	58.7	65.8	26.4	N/A	N/A	N/A	N/A
South Africa	2018	Szymanski et al. [28]	119	49.9	58.0	48.7	21.8	N/A	N/A	5.0	N/A
Tanzania	2021	Prattipatti et al. [29]	267	55	52.1	62.9	15.0	10.5	N/A	N/A	N/A
Tanzania	2020	Sadiq et al. [30]	136	62.8	63.2	64.0	27.9	N/A	N/A	23.5	19.1
Tanzania	2014	Makubi et al. [31]	427	N/A	N/A	17.0	12.0	N/A	N/A	16	N/A
Tanzania	2017	Kingery et al. [32]	107	50.8	61.7	43.0	8.3	10.4	N/A	N/A	N?A
Uganda	2018	Abeya et al. [33]	215	53	66.0	55.4	8.8	N/A	N/A	N/A	N/A
Uganda	2014	Okello et al. [34]	274	52**	69.7	35.8	7.3	8.0	N/A	N/A	N/A

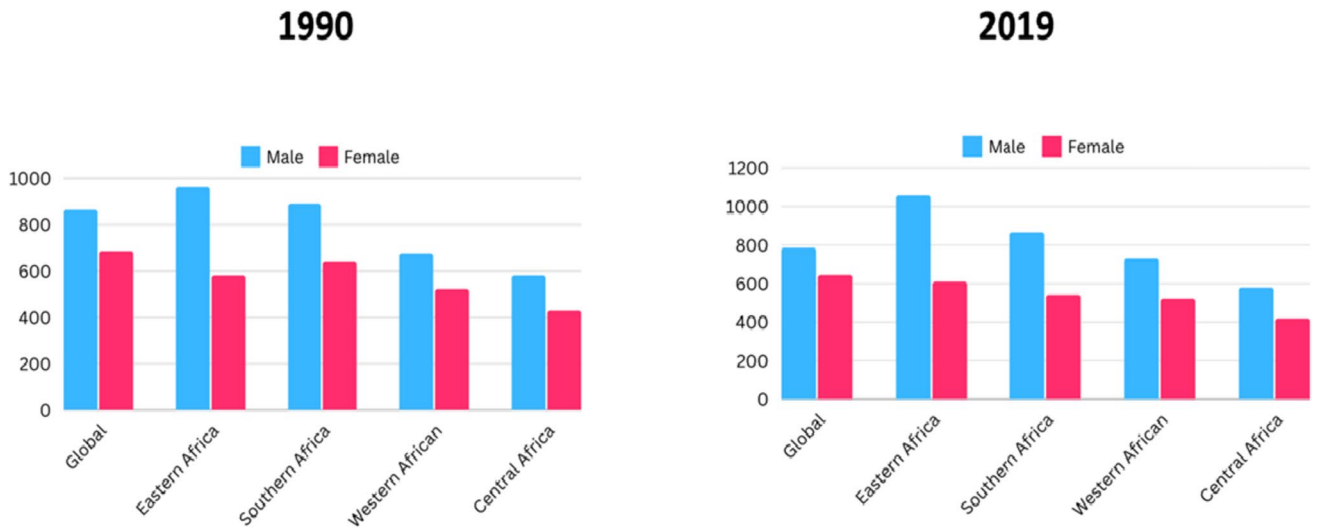

Fig. 1 The age-standardized rate of prevalence per 100,000 population for heart failure in 1990 and 2019 globally and in sub-Saharan Africa by sex

Cardiovascular Risk Factors and Co-Morbidities

Hypertension

Hypertension is the most prevalent and etiological risk factor reported in most series of HF studies in SSA [43]. The Non-Communicable Disease (NCD) Risk Factor Collaboration reported diagnosis, treatment, and control rates of 48%, 29%, and 13% for women and 34%, 22%, and 9% for men, respectively [45]. Hypertension leads to endothelial dysfunction, diastolic dysfunction, left ventricular hypertrophy, and systolic dysfunction. It is also a risk factor for atherosclerosis and coronary artery disease. In the INTER-CHF study[44], hypertensive heart disease accounted for 35% of HF cases and 45.4% in the Sub-Saharan Africa Survey of Heart Failure (THESUS–HF) survey [21].

Diabetes Mellitus

Individuals with diabetes mellitus (DM) have more than twice the risk of developing HF compared to non-diabetics. Hyperglycaemia is associated with the accumulation of advanced glycation end-products and heightened oxidative stress, which leads to myocardial dysfunction. Furthermore, insulin resistance and resulting hyperinsulinemia contribute to myocardial remodeling and fibrosis.

Diabetes mellitus was reported in 11.4% of patients in the THESUS-HF survey, [21] whereas the prevalence was higher at 28.7% in the SSA sub-analysis of the INTER-CHF study [44]. The differences may be due to the prevalence of diabetes in the dominant population in the two registries (Nigeria in THESUS-HF and Sudan in INTER-CHF). A study in Botswana found that about 27.9% of patients admitted with HF also had diabetes. Specifically, 15.5% had a known diagnosis of diabetes, while 12.4% were found to have undiagnosed diabetes mellitus. This significant number of undiagnosed cases can worsen the severity of HF and negatively impact treatment outcomes, highlighting the issue of undetected diabetes in this patient population.

Chronic Kidney Disease

Chronic kidney disease (CKD) and HF also share common risk factors and pathophysiology, which lead to the progression and worsening of the other. In the THESUS-HF survey, 30.6% of acute HF patients had an estimated glomerular filtration rate (eGFR) of $\leq$60 ml/min/1.73m^2. A similarly high prevalence of renal dysfunction was observed in Botswana, where 31.1% of patients with acute HF experienced renal dysfunction, frequently associated with hypertension and diabetes Worsening renal function has been documented in up to 9.8% of patients with HF upon follow-up and this was an independent predictor of readmission or death over 60 days [46].

Chronic Obstructive Pulmonary Disease

In a recent systematic review, COPD prevalence estimates in SSA populations vary widely between studies and settings (from as low as 1.7% in rural Uganda to as high as 24.8% in urban South Africa, with an average of 8% [47]. Chronic obstructive pulmonary disease often co-exists with HF because they share key pathophysiologic mechanisms (chronic systemic inflammation), clinical symptoms, and signs. The frequency of COPD in HF patients in SSA is likely to be underdiagnosed because of a lack of diagnostic tools in most health facilities.

Atrial Fibrillation

The relationship between atrial fibrillation (AF) and HF is bidirectional, where HF leads to the development of AF, and conversely, AF contributes to the worsening of HF. [48]. Patients with AF have a three-fold increased risk of incident HF [49]. The frequency of AF in HF in Africa is about 17.3–18.3%, which is lower than the rate in high-income countries [50]. In the THESUS-HF survey, patients with AF were older, more likely women, and had significantly lower systolic and diastolic blood pressure and higher heart rate. About 44% of AF patients in the survey had valvular heart disease. The presence of AF was not associated with all-cause mortality, but having valvular AF predicted death in six months [51].

Overweight and Obesity

There is a growing trend of increasing body mass index (BMI) and obesity in Africa. Notably, between 1984 and 2014, the age-standardized mean BMI rose from 21.0 kg/m^2 to 23.0 kg/m^2 in adult men, while in women, it increased from 21.9 kg/m^2 to 24.9 kg/m^2. [52] The mean BMI was over 24.9 kg/m.^{2} in the two contemporary SSA registries. [21, 44]

Obesity is an independent risk factor for HF, and in the obese population, HFpEF tends to be more common due to metabolic and hemodynamic alterations that promote diastolic dysfunction. The risk of HF increases by 5% to 7% for every unit increase in body mass index.

Tobacco Use and Smoking

Tobacco use and smoking are well-recognized risk factors for CVDs [53, 54]. The burden of tobacco-related morbidity

and mortality is highest in low and middle-income countries where 80% of the global 1.3 billion tobacco users live [55]. It is predicted that Africa will have the highest increase in smoking prevalence of 39% in 2030 if there are no effective preventive measures [56–58]. About 9.8% (17.3% men and 2.5% women) of HF patients in SSA have a history of cigarette smoking [21].

Air Pollution

Air pollution is a major environmental risk factor for human health worldwide and a risk factor for CVD [59] and is associated with 6.7 million premature death worldwide each year. About 89% of these premature deaths occurred in low- and middle-income countries [60–63]. In SSA, air pollution occurs from the widespread use of biomass for cooking and heating and the open burning of agricultural waste [64]. The continent faces challenges such as rapid urbanization and increasing motorization, with estimates of transport-related emissions accounting for 40% of air pollution sources. The region lacks data on the health effects of air pollution, which hampers the development of targeted public health interventions. In a small study in Nigeria, household air pollution was associated with adverse pregnancy (fetal) outcomes [65].

A different study conducted in Kenya identified a link between increased levels of household air pollution and both right- and left-sided cardiac dysfunction, as measured by echocardiography. The pathobiological mechanisms underlying pollution and CVD are complex, including inflammation, oxidative stress, vascular endothelial dysfunction, and thrombosis. [66–68]

Amyloidosis

Transthyretin cardiac amyloidosis (TTR-CA) is now increasingly recognized as an essential cause of HF [69, 70]. The most common hereditary type (hTTR), is associated with a single gene mutation (V142I) and has the highest allele frequency in West Africa. The pathobiological mechanism is linked to the deposition of monomers of transthyretin in the cardiac extracellular space, which results in restrictive cardiomyopathy, congestive HF, atrial fibrillation, and death [71, 72].

There is limited data on the clinical impact of hTTR-CA in West African and most SSA populations. Amyloidosis is likely severely underdiagnosed in West Africa and among the African diaspora due to limited access to diagnostic testing, which is impacted by financial constraints and technological challenges in these low- and middle-income countries. Additionally, there is a lack of awareness and health literacy regarding the disease, insufficient regional registries, deficits in human resources, inadequate infrastructure for testing and treatment, financial barriers, economic inaccessibility, and a lack of social safety nets. The available information on the impact of (hTTR) on HF is based on findings from the United States [73] and the United Kingdom [74].

There is, therefore, a need for strategies to build infrastructure and local capacity for an effective response. This should include healthcare financing mechanisms, especially for at-risk populations, and training health workers in diagnosing and managing the disease. Additionally, collaborations between African institutions and centers of excellence in high-income countries are essential to improve clinical care and research on this disease, particularly in West Africa [75].

Genetics

It has been shown that SSA populations are the most genetically diverse on the earth [76]. About 29.8 million single nucleotide polymorphisms (SNPs) were found in the native African whole genome sequences [76]. In Europe-Africa locus-specific differentiation studies, variants were identified within genes sub-serving osmoregulatory function, such as ATP1A1 and AQP2 [76]. Deregulation of AQP2 has been linked to primary hypertension [77], while loss-of-function mutations are associated with secondary hypertension [78]. Additionally, evidence suggests that the high prevalence, variability, and salt sensitivity of hypertension in SSA are partly due to local adaptation to ambient temperature [76, 79]. Hypertension remains the dominant risk factor for HF in SSA [21, 44]. Several genetic polymorphisms have been reported in Africans [80, 81].

Anemia

Anemia and iron deficiency (ID) are common in HF and associated with unfavourable outcomes [82, 83]. Data on the burden of anemia and ID in SSA is very scarce, unlike in high-income countries. In high-income countries, it varies from 10–49% (average 34%) compared to 8% in the general population [84, 85]. The prevalence of ID was reported as 67% in Tanzania[86] and 60% in Nigeria [82]. The high prevalence of anemia in SSA may be related to the burden of infections and infestations, hemoglobinopathies, nutritional deficiencies, and genetics [87, 88].

Table 1 shows the sociodemographic characteristics, risk factors, and co-morbidities in contemporary HF studies in SSA.

Infections, Infestations and Neglected Tropical Diseases

Infections, infestations, and neglected tropical diseases (NTDs) are still prevalent in many developing countries, particularly in tropical climates. It is estimated that about 1.6 billion people worldwide are affected, with these diseases being endemic in 149 countries. Sub-saharan African countries are the worst hit [89]. These infections, infestations, and NTDs are increasingly recognized as contributing to the growing burden of cardiovascular diseases (CVDs) in SSA[90, 91], especially in children and women[89] These infections and infestations include viral infections (such as Chikungunya, Dengue, Zika, and HIV), protozoal infections (like Cysticercosis, Echinococcosis, and Schistosomiasis), and bacterial infections (including Streptococcus and Tuberculosis).

Supplementary Table 1 is a summary of infections associated with heart diseases in SSA.

Etiology of Heart failure

Hypertensive Heart Disease

Hypertensive heart disease is the foundation of heart disease and HF in SSA [21, 44]. The region has the highest prevalence of high blood pressure worldwide[92] This is complicated by low awareness, treatment, and control rates. In a systematic review, hypertensive heart disease emerged as the most common cause of HF in SSA with a pooled prevalence of 39.2% (95% CI = 32.6–45.9%) [43]. The west coast of Africa has the highest burden; 48.4% (95% CI = 40.3–56.4%). Contemporary HF studies show that hypertension is the most common cause in most parts of SSA [21, 44]. Figure 2 shows the etiologic risk factors for contemporary HF studies in SSA.

Cardiomyopathies

Cardiomyopathies (CMPs) are the second most common cause of HF in the region and are responsible for 21.4% (95% CI = 16.0–27.2%) [43]. The highest burden is in the southern region of SSA; 40.2% (95% CI = 17.2–65.7%). Idiopathic dilated, peripartum, HIV-associated, and hypertrophic cardiomyopathies are the most common forms of CMPs in SSA [43]. In a recently published registry of 665 CMPs in South Africa, dilated CMP was responsible for 478 (72%) [93, 94]. Others were arrhythmogenic (78/11.7%), hypertrophic (70/10.5%), and restrictive CMP (39/5.8%) [93, 94]. Dilated and restrictive CMP occur at a younger age and more frequently in persons of African origin and women. The sex distribution and age of onset of hypertrophic CMP and arrhythmogenic CMP were similar to North American and European cohorts [93]. Finally, the causes of CMPs were found to be diverse; idiopathic/non-familial (36%), familial (27%), and secondary etiologies (37%) [93].

Rheumatic Heart Disease/Infective Endocarditis

In a recent systematic review and meta-analysis of 22 population-based studies on rheumatic heart disease (RHD) in Africa conducted between 2015 and 2023, the pooled prevalence of RHD was documented as 18.41/1000 (95% Cl: 14.08- 22.79.)[95] The prevalence of definite cases was 8.91/1000 (95% Cl: 6.50–11.33/1000) and borderline cases 10.69/1000 (95% Cl: 7.74–13.65/1000). The prevalence is almost similar in males and females, and the predominant lesion is mitral regurgitation (75%)[95]. The pooled prevalence of RHD as an etiology for HF in the region is 13.8% (95% CI = 10.0–18.0%) [43]. The highest prevalence is on the east coast of SSA (22.2% (95% CI = 10.4–36.7%) [43]. A recent study in Ethiopia suggests that it is the most common cause of adult HF [16] (Fig. 2).

Patients with HF due to rheumatic heart disease in SSA are younger, more often females, have higher rates of atrial fibrillation, are less likely to be hypertensive or diabetic, and have lower blood pressures and higher pulse rates. They also have higher LV ejection fraction and HFpEF. They have worse short-term outcomes compared to other etiologies in SSA [96]. Rheumatic heart disease is the most common risk factor for infective endocarditis in SSA with a pooled prevalence of 52.0% (95% CI: 42.4–61.5).

Coronary Artery Disease

Coronary artery disease (CAD) is still a less common cause of HF in SSA compared to other parts of the world [21]. The pooled prevalence of CAD in HF studies in SSA is 7.2% (95% CI-4.1–11.0%) [43]. The highest rates are reported from the eastern coast of SSA, especially in the Horn of Africa (Sudan, Djibouti) [43]. (Fig. 2) The diagnosis and management of CAD in SSA are often hindered by limited experience and a lack of diagnostic tools and biomarkers [97]. The prevalence is projected to increase in the future with rising rates of CVD risk factors and the availability of diagnostic facilities [98]. In addition, the ongoing Lipid Registry of Africa (LIPRA) will improve our understanding of CAD in the regions, especially premature cases [99]. The all-cause in-hospital mortality from acute coronary syndrome (ACS) in Africa is high (about 22%; 95%CI:17–27%). It is lower in cardiac centers compared to referral hospitals. The incidence of in-hospital HF, cardiogenic shock, and arrhythmia are about 42%, 17%, and 20% respectively [100].

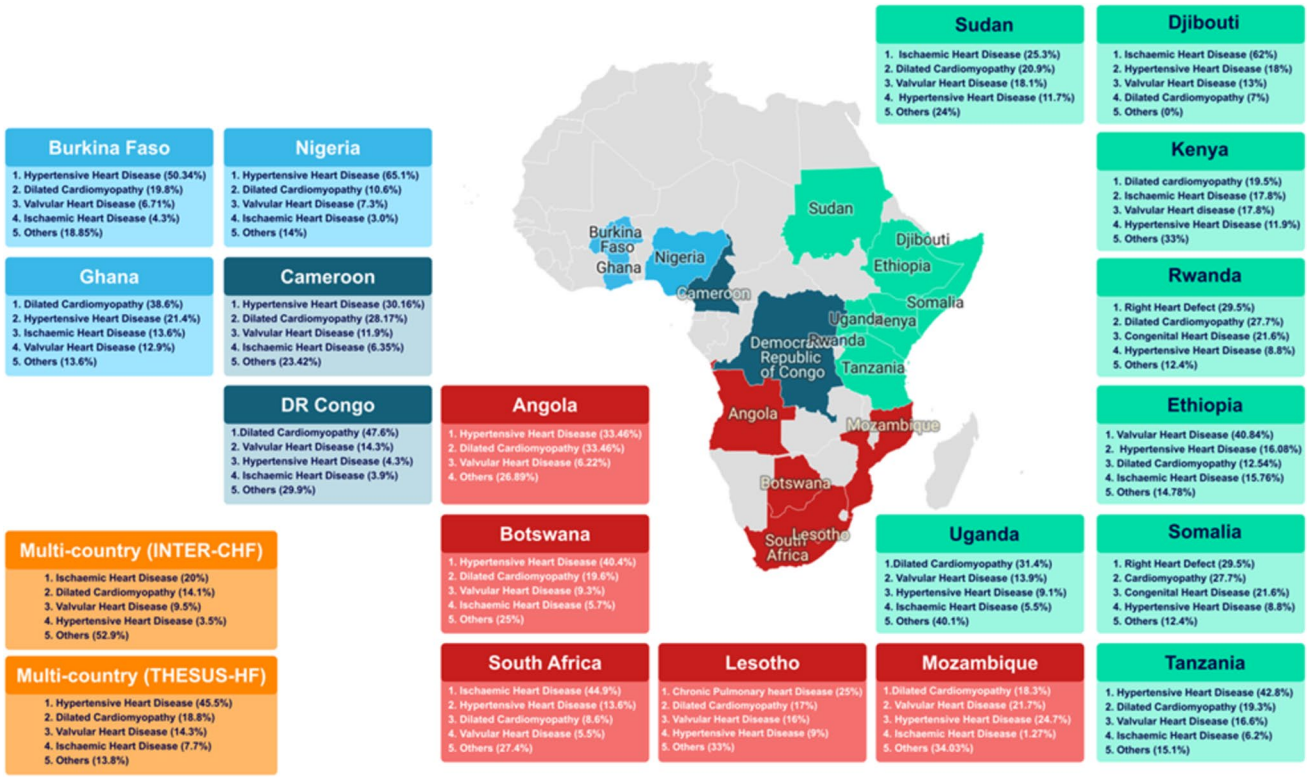

Fig. 2 The etiologic risk factors for contemporary HF studies in SSA

Pericardial Diseases

The prevalence of pericardial diseases in SSA differs according to the population of interest. It occurs in 1.1% of those with cardiac complaints, in 3.3–6.8% of persons with HF, and 46.5% of HIV-infected individuals [101]. Tuberculosis is the most common cause in both HIV-infected and HIV-negative patients [101]. The most common form is effusive tuberculous pericarditis (79.5%), 15.1% have the effusive constrictive type, and 13% have myopericarditis. About 20% may present in cardiac tamponade [101]. Diagnosis of tuberculous pericarditis in SSA is often challenging because of the limited diagnostic tools. The outcome is poor, with mortality rates in the range of 18–25% [101].

Right Heart Disease and Pulmonary Hypertension

There is no population-based incidence or prevalence data on SSA. There is also the problem of lack of facilities for definite diagnosis. The pan African pulmonary hypertension cohort (PAPUCO) study reported left heart disease to be responsible for 68.9%, primary pulmonary hypertension 15.8%, lung disease 12.0%, chronic thromboembolic disease 1.9%, and unclear/multifactorial cause 15.8%. [102] In a systematic review of pulmonary hypertension in Africa, it was shown to be present in 9.8% of persons with cardiac complaints, 10.6% in HIV-infected persons, and 12.9% in rheumatic heart disease. [103] The prognosis of pulmonary hypertension is poorer in those with associated HIV infection [103].

Diagnosis, Classification, and Phenotypes of Heart Failure in SSA

The diagnosis of HF in SSA is mostly based on clinical symptoms and signs, supplemented by chest X-rays, ECG, and echocardiography [21–23, 31]. More recent studies and regional clinical registries have used the European Society of Cardiology guidelines for diagnosing and classifying HF [21–23, 31]. Studies have shown that BNP and NT-proBNP levels correlate with HF severity, response to treatment, and prognosis [104–107]. In the Bi Treatment With Hydralazine/Nitrates Versus Placebo in Africans Admitted With Acute Heart Failure (B-AHEF) trial, baseline NT-proBNP and galectin-3 predicted HF admission and mortality at six months [105]. Elevated BNP levels (>525 pg/ml) were linked to worse survival post-discharge.[87]NT-proBNP is also a prognostic marker in peripartum cardiomyopathy[107], while soluble ST_2 predicts LV dysfunction in hypertension and HIV [108–111]. Phenotypically, HFrEF is more common in acute HF, while HFpEF is frequently

seen in outpatient chronic HF cohorts. Figure 3 illustrates the distribution of different phenotypes of HF in SSA and Table 2 is a comparison of the clinical profile of HF in SSA and other parts of the world.

Management

Pharmacological Treatment

Heart failure (HF) management in SSA relies on diuretics for symptom relief, while essential evidence-based therapies such as beta-blockers, angiotensin converting enzyme inhibitors (ACE-I), angiotensin receptor blockers (ARBs), angiotensin receptor-neprilysin inhibitors (ARNI), sodium-glucose cotransporter-2 (SGLT2) inhibitors, and mineralocorticoid receptor antagonists (MRAs) are proven to improve survival, particularly in HFrEF [112]. However, most landmark HF trials have excluded native African participants[113], raising concerns about treatment efficacy in this population, considering the region's unique health profiles and socioeconomic factors [114]. African HF patients often present distinct characteristics influenced by genetics, comorbidities, and healthcare access. Expanding clinical trial participation and HF registries can help develop region-specific treatment strategies [115]. Medication availability remains challenging, with limited access to evidence-based therapies due to high costs and shortages [115]. Promoting the use of generic medications and educating healthcare professionals are crucial for improving HF management in SSA [116].

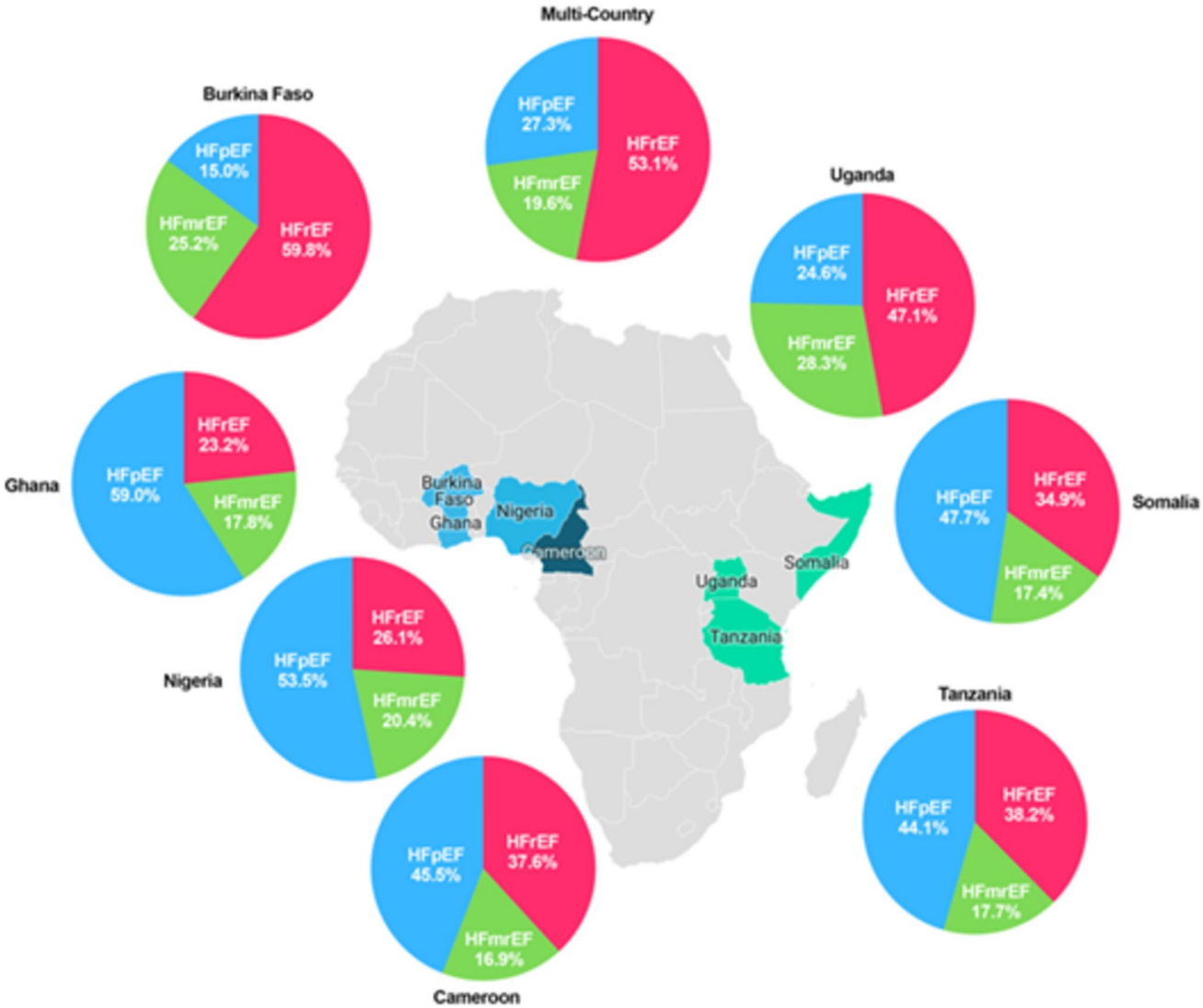

Fig. 3 The distribution of different phenotypes of HF in SSA

Table 2 Comparison of the clinical profile of HF in SSA and other parts of the world (Source INTERCHF Study)

	Overall	Africa ($n=1294$)	India ($n=858$)	South East Asia ($n=811$)	Middle East ($n=1000$)	China ($n=991$)	South America ($n=869$)
Demographic variables							
Mean Age (years)	59	53	56	57	56	66	67
Male sex (%)	61	52	62	59	72	57	61
Clinical variables							
Mean body mass index (kg/m^2)	26	26	23	26	30	24	29
Mean systolic BP (mmHg)	125	124	125	128	126	126	123
Mean diastolic BP (mmHg)	76	79	77	76	72	77	75
History of DM (%)	29	17	26	41	57	19	21
History of CKD (%)	8	4	3	13	12	6	11
Current tobacco use (%)	6	4	7	6	7	8	4
History of COPD (%)	6	2	16	4	4	8	10
Reduced LV ejection fraction(<40%) (%)	50	54	53	39	73	27	53
Valve disease (%)	46	57	42	40	50	41	48
NYHA functional class III or IV (%)	40	56	50	16	37	56	32
Admission for HF in the previous year (%)	27	36	14	35	22	34	28
Recruited as hospital inpatient (%)	34	48	45	23	31	35	26
Common cause of HF							
Ischaemic heart disease (%)	39	20	46	56	50	45	25
Hypertensive heart disease (%)	17	35	14	15	10	14	21
Idiopathic DCM (%)	12	14	11	3	18	15	15
Valvular heart disease (%)	11	11	12	12	8	11	13
GDMT*							
Beta blocker (%)	67	48	57	66	85	60	73
ACE inhibitor (%)	49	59	51	46	62	34	40
ARBs (%)	24	19	17	27	20	29	36
ACEi/ARBs (%)	74	78	68	73	82	64	76
Aldosterone inhibitor (%)	48	59	47	27	46	56	55

**GDMT* guideline directed medical therapy

Use of Device Therapies

Device therapies such as implantable cardioverter defibrillators (ICDs) and cardiac resynchronization therapy (CRT) are emerging options for treating HF in SSA, offering potential survival benefits [117]. However, their implementation in SSA is hindered by high costs, limited availability in many centers, and a shortage of trained specialists [116]. Addressing these challenges necessitates investment in healthcare infrastructure and specialist training [116].

Medication Non-Adherence

Medication non-adherence (MNA) is a serious issue in managing chronic diseases like HF, affecting up to 25%—50% of patients globally [118], and contributing to rehospitalizations, higher costs, and mortality [119, 120]. In Africa, MNA prevalence ranges from 23.7% to 74.7% [121–124], reaching 69.3%–71.4% in Nigeria [123, 124]. Identified predictors of MNA include advanced age, comorbidities, heavy pill burden, and psychological, economic, and health-system-related factors. Although the burden of MNA in HF patients is high, timely interventions such as behaviour modifications, medication reminders, health education, and mHealth can improve adherence and outcomes [125–129].

Task Shifting in Heart Failure Management

In SSA, where there is a critical shortage of physicians, the burden of HF continues to rise. Decentralizing HF care through task-shifting to allied health professionals offers a promising solution. This approach trains mid-level providers to undertake diagnostic and treatment tasks, resulting in reduced rehospitalizations, improved guideline-directed medical therapy (GDMT), enhanced patient satisfaction, and lower mortality rates. This approach could help address gaps in HF care access and contribute to the long-term goal of improving outcomes in HF patients. [130–132] In Rwanda, trained nurses demonstrated effectiveness in optimizing GDMT, which

is comparable to high-income countries[132] and in Uganda, non-expert healthcare workers improved diagnostic accuracy of transthoracic echocardiography (TTE) for HF after training, despite only 3% of hospitals having adequate imaging equipment [133].

While task shifting can help address the healthcare gap, challenges include establishing training structures, ongoing mentorship, and competency testing to ensure high-quality care. Supervision of mid-level providers' clinical practice and competency testing is essential to guarantee high-quality patient care [131, 133].

Outcomes and Prognosis of Heart Failure in Sub-Saharan Africa

Length of Hospital Stay and Intra-hospital Mortality

In the THESUS-HF survey, the mean length of hospital stay (LOS) was 9.2 days, with slight differences between genders (9.4 days for men and 9.1 days for women) [21]. The LOS is longer for endemic conditions (e.g., cardiomyopathies, valvular heart diseases, pericardial diseases) at 9.8 days compared to emerging conditions (hypertensive heart disease and coronary artery disease), which averaged 8.7 days [21]. This duration exceeds that of Western Europe[134] and North America[135], likely due to severity of disease. The LOS in SSA is similar to data from Brazil [136] and Japan [137].

The intrahospital mortality rate stands at 4.2% (4.9% in men and 3.5% in women), higher in patients with endemic diseases (5.9%) compared to those with emerging diseases (2.8%) [21].

Short and Medium-Term Outcomes

Rehospitalization and Mortality

In the THESUS-HF survey, the 60-day rehospitalization rate was 9.1% (9.7% in men, 8.5% in women, 9.4% in endemic diseases, and 9.0% in emerging diseases) [21]. Key predictors include a history of malignancy, severe lung disease, heart rate, systolic blood pressure, signs of pulmonary congestion, renal function, and left ventricular ejection fraction [138].

The 180-day mortality rate was 17.8% in the THESUS HF survey (18.3% in men, 17.4% in women, 20.5% in endemic conditions, and 15.5% in emerging conditions) [21], Predictors include malignancy, severe lung disease, smoking history, heart rate, systolic blood pressure, signs of lung congestion, renal dysfunction, anemia, and HIV infection [138].

Long Term Outcomes

One-Year Outcomes

Data from INTER-CHF reveal that 24.3% of HF patients in SSA experience rehospitalization within 12 months, with variation across countries [44]. Approximately 26.4% of HF patients die within one year, with mortality highest in Sudan (42.7%) and lowest in South Africa (11.8%) [44]. The composite outcome of rehospitalization or death at 12 months is around 39%: lowest in Mozambique and highest in Sudan (59.7%) [44]. Factors associated with mortality include increasing age, male sex, lower systolic blood pressure, presence of kidney disease, prior history of admission for HF, and presence of valve disease. Supplemental Fig. 1 shows the 1-year outcomes of HF in countries that participated in the INTER-CHF study.Comparison of one-year mortality with other regions suggests that SSA has the highest age-adjusted mortality rate (33.6% vs India (23.3%), southeast Asia (15.0%), China (7.3%), South America (9.1%), and Middle East (9.4%) [139] (Supplemental Fig. 2).

Five-Year Outcomes

In a nurse-led HF program in Rwanda, a 5-year mortality rate of 38.6% and a composite event rate of 57.4% were observed, with the highest mortality in cardiomyopathy cases and the highest composite outcome in isolated right HF. [25, 140] A retrospective study in Ghana reported survival rates of 90.3%, 64.7%, and 38.4% at one, two, and five years, respectively. [20] The 5-year all-cause mortality for HFrEF, HFmrEF, and HFpEF was 34.5%, 33.6%, and 30.1% respectively. Predictors of mortality varied by HF phenotype, including age and atrial fibrillation in HFrEF, NYHA functional class, beta-blocker use and cigarette smoking in HFmrEF, and factors like kidney disease, diabetes, and anemia in HFpEF [20].

High Morbidity and Mortality of Heart Failure in Sub-Saharan Africa: Possible Explanations

Sub-Saharan Africa reports the highest HF mortality worldwide, with a case fatality rate of 34% and an annual mortality rate ranging from 29 to 58%, as highlighted by the INTER-CHF study [139]. Heart failure mortality in SSA disproportionately affects the economically productive age group [138].

Contributing factors include genetic mutations, and environmental influences, particularly coexisting infections like HIV/AIDS and tuberculosis. Specific cardiomyopathies,

such as peripartum cardiomyopathy and endomyocardial fibrosis (EMF), significantly impact outcomes [9, 141–143], though EMF prevalence has declined over the years. Comorbidities like iron deficiency anemia, CKD, sarcopenia, chronic obstructive pulmonary disease, hyponatremia, and protein-losing enteropathy further exacerbate HF mortality. [15, 143–145] Access to healthcare, high treatment costs, lack of insurance, low literacy, and late presentations are common challenges in the region. Seasonal mortality variations have also been noted, with increased HF deaths during the hot, wet months in Nigeria. [15, 146, 147] Table 3 summaries the factors responsible for poor outcomes of HF in SSA.

Health-related Quality of Life

Poor Health-Related Quality of Life (HRQoL) in HF is linked with an increased risk of hospitalizations and serves as a strong independent predictor of mortality across all NYHA classes [185]. The HRQoL scores in Africa are notably lower compared to Western Europe, the Middle East,

Table 3 Factors associated with poor heart failure prognosis in SSA

Demographic characteristics[	Increasing age[20] Male sex[148, 149]
Clinical symptoms and signs	Resting tachycardia[138, 150] Low blood pressure[138, 150] Presence of crepitations/Rales/Crackles[20, 138, 150] Presence of mitral and tricuspid regurgitation[20, 144, 150, 151]
Laboratory profile	Hyponatremia[33, 152, 153] Renal dysfunction[15, 20, 32, 33, 154] Hypoalbuminemia[151] NT-ProBNP[15, 155] Hematocrit level [155, 156]
Geographic factors	Seasonal climatic variations, e.g. the hot wet season[146, 147, 157, 158] Tropical rainforest[159, 160] Sahel/Savanah region[161]
Social factors	Low education/illiteracy[144] Poverty[15, 144] Adherence/compliance[15, 15, 28, 118, 121, 124, 124] Transportation/poor physical access[144, 147, 162]
Healthcare system factors	Length of hospital stay[155, 163] Readmission rates[24, 144] Mortality rate[15, 23, 28, 138, 139, 163] Guideline-directed medical therapy[16, 21, 44, 115] Diagnostic facilities[116] Human resources for health
CVD risk factors/comorbidities	Hypertension[20, 21, 44, 164] Diabetes mellitus[21, 165] Chronic obstructive pulmonary disease[33, 102, 142, 164, 166] Alcoholism[15] Anemia[86, 155]−102,103 Iron deficiency anemia[82, 86] Depression/cognitive dysfunction[167–169] Cardiac cachexia[144, 151, 170] Atrial fibrillation[171] Thyroid dysfunction[172, 173] Renal dysfunction[46, 155]
12 lead ECG parameters	QRS duration[174, 175] QT dispersion[176] Left bundle branch block[174, 175]
Echocardiographic parameters	Low left ventricular ejection fraction[33] Diastolic dysfunction[33] Left ventricular remodeling and reversal[138, 177] Right ventricular dysfunction[151, 178–182] Tricuspid regurgitation[151] Pulmonary hypertension[102, 166]
Genetics/Genomics	ADRB1,ADR2AC-,GRK,TTR,Mt haplotypes-MMP-2,-e-NOS Corin[80, 183, 184]

and Asia, even among younger patients.[186],.[175]Several SSA hospital-based studies using heart failure-specific QoL instruments[187, 188] report a high prevalence of poor HRQoL ranging from 25 to 54%. Identifying predictors of poor HRQoL can inform interventions aimed at improving outcomes [189]. While some research suggests increasing age correlates with lower HRQoL scores, [168, 190, 191] there is consensus that gender does not significantly influence HRQoL outcomes in African patients, [168, 190, 191] contrasting with findings in developed countries where women tend to report worse HRQoL [168, 190, 191].

Co-morbidities such as atrial fibrillation [191], diabetes mellitus[168], and depression[168, 190] can adversely affect HRQoL. Other contributing factors to poor HRQoL include lack of social support[168, 191] financial challenges[191] increased number of HF hospitalizations[192], increased severity of left ventricular dysfunction[191] and a higher NYHA classification [189, 190]. In Ethiopia, HRQoL was impacted by significant physical limitations, emotional distress, social challenges, and disruptions in sexuality. [186] Therefore, policies and interventions addressing these issues and improving the HRQoL of HF patients in SSA are crucial [167].

Lived Experiences in Heart Failure Management in SSA

The experience of individuals with HF is profound and characterized by debilitating symptoms and psychosocial challenges. In SSA, diagnosis and management of HF remain difficult in remote, low-resource settings, where specialized care is primarily available in urban centers, with many patients presenting late [25]. A lack of knowledge about HF among these patients often results in poor self-care and delayed medical visits, negatively affecting outcomes.

Lived experiences from a Cardiac Care Centre in Uganda highlight several challenges, including overdependence on the clinic for almost all HF care and management information despite a high patient volume. Patients also face the inconvenience of attending clinics due to the financial burden of both direct and indirect treatment costs. Moreover, inconsistent home self-care is prevalent, driven by inadequate understanding and insufficient funds. Additionally, low technological literacy restricts the implementation of digital health solutions [193, 194].

A study in central Kenya identified unmet information needs, financial burdens, psychosocial challenges, spiritual concerns, and debilitating physical symptoms among patients with advanced HF. These findings highlight the urgent need for HF awareness programs, support groups, and improved access to health insurance [167, 195]. The challenges of HF in SSA are therefore complex and multifaceted.

Cost of Heart Failure in SSA

Heart failure imposes significant economic burdens on individuals and healthcare systems, encompassing direct medical costs and indirect costs associated with lost productivity [196]. Available data on HF financing in Africa originates from hospitalized patients, with reported costs often under $100 per patient per day[197] or less than $200 per patient per admission. [197, 198] However, a Nigerian study indicated that annual treatment costs for outpatients and inpatients averaged $2,128, with 49.1%% attributed to indirect expenses like transportation [162]. Hospitalized patients, particularly those with severe symptoms or comorbidities, incur higher costs [162].

The projected burden of HF on healthcare expenditures worldwide is a cause for concern, with a 127% increase by 2030. [199] Attempts to decrease this financial drain should be a major global public health priority. Despite lower overall costs in Africa, many patients struggle to afford HF management, leading to increased morbidity, economic loss and mortality, [6] especially as out-of-pocket payments remain high. In SSA, health insurance coverage is limited, often reaching only about 5% of the population, and individuals in the informal sector face significant barriers to accessing care. [200, 201] This situation exacerbates the risk of catastrophic health expenditures, further entrenching poverty and health disparities [201, 202].

Role of Artificial Intelligence and Machine Learning in Heart Failure Care in SSA

Machine learning (ML), a sub-field of artificial intelligence (AI), plays a significant role in HF management by enhancing risk stratification, early diagnosis, decompensation detection, disease classification, optimizing therapies, and selecting candidates for intracardiac devices and clinical trials [203]. While ML has significant potential to improve HF care and research,[193–195] most outcome prediction models are derived from high-income countries, limiting their generalizability to Africans due to population-specific biases. The use of ML in HF management is almost non-existent, though initial studies from South Africa and Rwanda show promising results [204,

205]. In Johannesburg, six supervised ML algorithms were trained to predict all-cause mortality, with the Support Vector Machine (SVM) model achieving the best performance (AUROC of 0.77, accuracy rates of 91% and 86%, during training and testing, respectively). This model excelled due to its capacity to handle complex, non-linear data and identified key predictors for mortality, including the use of specific medications and clinical signs [203, 206]. While the Random Forest (RF) algorithm achieved a higher AUROC, it showed signs of overfitting, affecting its performance.

In Rwanda, a multi-center study indicated that the RF algorithm had the highest performance for predicting HF rehospitalization (AUC of 94%), followed by the SVM model at 88%. Key predictors for HF rehospitalization included residential district, dyspnea, blood pressure levels, arrhythmia, alcohol use, gender, admission duration, and age in order of importance [205]. An unsupervised ML model using the agglomerative clustering algorithm was employed at a tertiary institution in South Africa to categorize HF patients into uremic, hypotensive, and congestive clusters. This approach utilized various clinical parameters for risk stratification rather than relying solely on imaging modalities [203].

Challenges persist due to the lack of comprehensive HF data in SSA, as effective ML models necessitate large, high-quality datasets. To address the rising burden of HF in the region, enhancing electronic data collection and fostering collaboration among policymakers, healthcare providers, and researchers are essential for improving care standards and health outcomes.

Gaps and Future Directions

Gaps lie in three key areas; there is a dearth of human resources for health, access to HF care, and limited research productivity.

The physician and other health professional to population ratio is abysmally low. Currently, human resources of health are scarce for the health of all cadres and in most parts of SSA. Although there has been an increase in the number of medical schools in the region, productivity is hampered by a shortage of medical teachers, poor remuneration, and a high rate of brain "drain".

Access to cardiac care (both physical and financial access) is very poor. The reasons for this include poor healthcare funding and limited access to healthcare. About 50% of SSA countries have out-of-pocket expenditures of above 40%. [207, 208] There is also limited access to evidence-based HF medications and limited access to advanced cardiovascular procedures and investigations. In addition, low education and illiteracy in the region affect health-seeking behaviors and health-related choices [209]. This may be contributory to the late presentation of HF in SSA. Most SSA countries also lack effective policies and political will in the area of implementation of evidence-based, integrated, and cost-effective cardiovascular care programs.

Finally, research capacity and productivity are low in the region. There is currently no population-based and robust data on the burden of HF in the region. The lack of systematic surveillance information hampers disease burden estimates (rather than information developed from models) which affects disease monitoring as well as evaluation of existing intervention programs.

The key priorities for HF care will therefore, lie in the identification and implementation of evidence-based prevention strategies, increase in access to cardiac care, increase and improvement in training of health workers, and increase in useful research outputs.

Conclusion

Heart failure (HF) in SSA presents unique challenges. It primarily affects younger adults aged between 36 and 61 years, unlike in high-income countries, where older adults are mostly affected. Clinical presentations are often late, with severe symptoms exacerbated by socioeconomic barriers and other complications. The six-month mortality rate is as high as 18%.

Hypertension is the leading risk factor for HF in SSA. Others include diabetes mellitus, CKD, and chronic obstructive pulmonary disease, alongside infections and neglected tropical diseases that complicate management and increase morbidity and mortality. Environmental factors, such as air pollution from biomass fuels and the increasing prevalence of transthyretin cardiac amyloidosis, further complicate the HF landscape in SSA.

There is a shortage of healthcare professionals and invasive cardiac laboratories. Diagnostic tools, such as echocardiography and cardiac biomarkers, are also not readily available. Access to guideline-directed medications and advanced therapies is similarly limited in the region. Catastrophic out-of-pocket healthcare costs and high medication non-adherence rates further hinder effective treatment and contribute to worse outcomes.

To improve HF outcomes in SSA, there is a need for enhanced healthcare financing and infrastructure, better access to medications, and increased research and clinical trials.

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  The investigator reported average HRQL differed between regions of the world (lowest in Africa [mean± SE, 39.5±0.3], highest in Western Europe [62.5±0.4]). HRQL is a strong and independent predictor of all-cause mortality and heart failure related admissions in all the regions irrespective of severity and phenotype.

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The authors demonstrated that task-shifting in heart failure management is possible in SSA.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11897-025-00712-1.

Authors' Contributions OSO, KS, and MOO conceived the topic; OSO, FO, BE, OA, CO, DO, CEA searched the literature and gathered all the data; OSO, BE, OO designed the figures; OSO, FO, CU, and OO made the tables; OSO, DO, AA, JM, DO,CEA, JM, MS, AD, and KS participated in draft and review phases of the manuscript. All authors reviewed the manuscript.

Data Availability No datasets were generated or analyzed during the current study.

Declarations

Informed Consent and Funding This article does not contain any studies with human or animal subjects performed by any of the authors. No grant from any funding agency in the public, commercial, or not-for-profit sectors was received for this research.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Competing interests The authors declare no competing interests.

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