

SPATIAL DISTRIBUTION AND RISK FACTOR PROFILING OF HEART FAILURE ACROSS RWANDA'S HEALTHCARE LANDSCAPE

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ABSTRACT

Purpose: This research paper aims to investigate heart failure (HF) epidemiology in Rwanda, with special emphasis on distribution and mapping, clinical characteristics and risk factors of HF, and its New York Heart Association (NYHA) classification in Rwandan society.

Design/Methodology Approach: The study design is retrospective, and secondary data were abstracted from 4,085 available HF files of patients hospitalised in seven hospitals in Rwanda from 2008 to 2019. This study applied a combination of descriptive, spatial, and inferential statistical methods to analyse the distribution and patterns of HF across Rwanda

Research Limitation: The study was limited to existing data on the classification of heart failure cases recorded in Rwanda from 2008 to 2019, using the New York Heart Association (NYHA) classification.

Findings: The findings revealed an unequal distribution of HF patients across all 30 administrative districts of Rwanda, as 71.8 percent of HF patients resided in only 10 districts. The results further showed that the significant symptoms of HF in Rwanda were dyspnea, edema, persistent cough, and abdominal swelling. Furthermore, dilated cardiomyopathy, valvular heart disease, hypertension, and congenital heart defects were found to be the common risk factors for HF in Rwanda.

Practical Implication: This research can contribute to the development of clinical practice guidelines for heart failure (HF) in Rwanda, ensuring standardised and evidence-based care for HF patients.

Social Implication: Promoting awareness about heart failure (HF), facilitating access to strengthened health facilities in all districts of Rwanda, and diagnosing, treating, and controlling the risk factors of HF at earlier stages may significantly reduce the impact of HF on sufferers, their families, and health systems in Rwanda.

Originality and value: The geographic mapping of HF prevalence identifies hotspots, facilitating targeted interventions and resource allocation to the areas of greatest need.

Keywords: *Clinical characteristics. heart failure. mapping. risk. Rwanda*



INTRODUCTION

While significant progress in prevention and treatment has been made, the global burden of heart failure (HF) continues to rise, particularly in low- and middle-income countries (LMICs). The number of individuals living with heart failure (HF) has nearly doubled in recent decades, rising from 33.5 million in 1990 to 64.3 million in 2017 (Bragazzi et al., 2021a). An estimate of around 60 to 70 percent of the global HF population is concentrated in LMICs (Wei et al., 2023). This alarming increase shows no signs of slowing, and the burden of heart failure (HF) varies significantly across geographical regions and socio-demographic groups. Projections between 2025 and 2050 suggest a dramatic 90% increase in cardiovascular disease prevalence, encompassing HF, alongside a 73.4% rise in crude mortality (Chong et al., 2024). This is expected to result in a devastating 35.6 million cardiovascular deaths by 2050, compared to 20.5 million in 2025.

In addition to this unacceptable loss of life, HF also imposes substantial direct and indirect costs on healthcare systems and to society in general through unpaid healthcare costs, high morbidity, and poor productivity due to repeated costly and prolonged hospitalisation (Rizinde, Ngaruye, & Cahill, 2024; Cook, Cole, Asaria, Jabbour, & Francis, 2014). Each year worldwide, HF imposes an economic burden estimated to be more than 100 billion US dollars, of which more than 60 billion are attributed to direct cost and more than 40 billion to indirect cost (Lesyuk, Kriza, & Kolominsky-Rabas, 2018). Although more than 75 percent of global deaths due to cardiovascular diseases take place in low and middle-income countries (World Health Organization, 2021), most of the information available in the existing published literature about HF epidemiology and control is from high-income countries like the United States of America (USA), some European countries, Australia and others (Cook, et al., 2014).

It is known that 1 to 2 percent of the adult population in developed countries lives with HF (McMurray et al., 2012). In 2016 the USA alone accounted for 9.4 percent of all deaths attributable to cardiovascular diseases caused by HF (American Heart Association, 2020). This rate has been on rise since it was 13.4 percent in 2018 (Virani, Alonso, Benjamin, Bittencourt Callaway, Carson, 2020), and a further worrisome increase is expected to reach 46 percent by 2030 (Savarese & Lund, 2017).

Heart Failure epidemiology and management present a different scenario for both developed and low-income countries (Kingue, Dzudie, Menanga, Akono, Ouankou, & Muna, 2005). Unlike the situation prevailing in high-income countries where HF is known to be a common medical condition for the elderly, HF also affects young and middle-aged adults in Sub-Saharan Africa (Okechukwu, Ogah, Adewole, Adebisi, Karen & Sliwa, 2019).

Like in many countries of Sub-Saharan Africa, the burden of HF is also a significant health issue in Rwanda, and it arises from a continuous increase in heart diseases and associated risk



factors. These non-communicable diseases appear to be the most important causes of death in Rwanda (Rwanda Ministry of Health, 2015). Sufficient evidence from the World Health Organization confirms that non-communicable diseases account for 44% of all deaths in Rwanda, of which cardiovascular diseases account for 14% (WHO, 2018). In addition, data from the Rwanda Health Management Information System show that cardiovascular diseases in Rwanda were the third most common cause of death in 2012 (Rwanda Ministry of Health, 2015).

Using the data gathered from only three rural district hospitals over 10 years, Eberly and colleagues (Peirlinck et al., 2019) conducted a research in order to understand the etiology of HF in Rwanda. However, the study's results could not provide a comprehensive picture of HF epidemiology for the entire country, which would inform policy planning and interventions. Therefore, further investigation is needed to achieve the same result. This paper aims to investigate the epidemiology of heart failure (HF) in Rwanda, focusing on its distribution and geographical mapping, the clinical characteristics and risk factors associated with the condition, and the New York Heart Association (NYHA) functional classification of HF patients within the Rwandan population. The study utilised data collected from all hospitals in Rwanda that were equipped to treat heart failure (HF).

LITERATURE REVIEW

Heart failure (HF) is increasingly recognised as a significant public health challenge, with mounting evidence indicating a growing incidence among younger age groups. While it was once primarily associated with the elderly, recent trends over the last two decades point to a marked rise in HF cases among younger individual (Parizad, Batta, Hatwal, Taban-Sadeghi, & Mohan, 2025). Epidemiological studies estimate that over 64 million people worldwide are living with HF, with significant increases observed since 1990 (Ran et al., 2025). While substantial research has been conducted in high-income regions such as Europe and North America, there remains a notable gap in data from low- and middle-income countries (LMICs), which account for approximately 80% of the global cardiovascular disease (CVD) burden (Groenewegen, Rutten, Mosterd, & Hoes, 2020).

In terms of risk factors, the literature identifies several interlinked determinants that contribute to the onset and progression of heart failure (HF). These include demographic factors (such as population and ageing), behavioural risk factors (such as tobacco use, physical inactivity, and unhealthy diets), environmental exposures (particularly poor air quality), and physiological indicators (including hypertension and hyperlipidaemia) (Pratley, Guan, Moro, & do Lago, 2024) Socioeconomic factors such as low income, limited access to education, and poverty further exacerbate these risks. Urbanisation and genetic predispositions are also significant contributors (Sadeghi, Haghdoost, Bahrampour, & Dehghani, 2017).



Despite the global burden of HF, there is an uneven distribution in both the prevalence and mortality associated with the condition. Research by Cherla et al. (2024) and Lababidi et al. (2023) indicated that, while some developed countries have seen a plateau or even a reversal in HF-related mortality due to improved interventions and preventive measures, LMICs are experiencing increasing trends in both prevalence and fatality (Emmons-Bell, Johnson, & Roth, 2022). These trends are closely tied to socioeconomic disparities, changing age demographics, and constrained health system capacities. Males generally exhibit higher HF mortality rates than females, and variations exist not only between countries but also within regions (Baptista & Queiroz, 2022)

Spatial analysis and mapping techniques have become vital in understanding HF distribution patterns. Through geospatial technologies and models such as those applied using ArcGIS, researchers have identified clusters of HF prevalence in specific geographic locations (Baptista & Queiroz, 2022). These spatial insights are critical for guiding resource allocation and tailoring public health responses. Spatial autocorrelation measures, such as Moran's I, have been employed to assess whether HF cases are randomly dispersed or geographically clustered, with studies confirming spatial disparities across multiple settings.

The classification of HF severity is commonly guided by the New York Heart Association (NYHA) functional classification, which ranges from Class I (no symptoms and no limitation in ordinary physical activity) to Class IV (severe limitations and symptoms even at rest) (Rohde et al., 2023). Despite its widespread use, the NYHA classification is criticised for its subjective nature and inter-observer variability. Recent research has explored the integration of objective metrics, including machine learning tools, to enhance consistency in patient classification (Blacher et al., 2021). In developing countries, additional factors such as high prevalence of rheumatic heart disease, late diagnosis, and poor adherence to treatment regimens compound the challenges of HF management. Self-care and follow-up practices remain inadequate in many such settings due to cultural, economic, and infrastructural barriers (Ran et al., 2025). Acosta et al. (2022) also demonstrate that in developed countries such as the United States, the slowing of life expectancy gains is partly attributed to increased heart failure (HF) mortality, which is influenced by rising obesity and diabetes prevalence. Comparatively, in higher-income Asian countries, a higher per capita income is associated with lower CVD mortality rates, although this effect becomes weaker at higher income thresholds.

Collectively, these studies underscore the importance of context-specific strategies in managing and studying heart failure (HF). While advances in data science and spatial analytics can enhance the ability to map and understand health factors (HF), addressing global disparities necessitates focused investment in healthcare infrastructure, education, and culturally appropriate interventions, particularly in low- and middle-income countries (LMICs), such as Rwanda.



METHODS AND MATERIALS

Study design

We conducted a retrospective study using existing medical records. The research included all patients with HF who were treated and hospitalised in the following seven hospitals from January 1st, 2008, to December 31st, 2019: University Teaching Hospital of Butare (CHUB), University Teaching Hospital of Kigali (CHUK), Rwanda Military Hospital (RMH), King Faisal Hospital (KFH), Rwinkwavu hospital, Kirehe, and Butaro hospitals.

Study sample and sampling methods

This study employed a census sampling technique whereby all 4,085 patients hospitalised with confirmed heart failure (HF) from 2008 and 2019 were included. Data were retrospectively abstracted from medical records at four major urban referral hospitals in Rwanda. University Teaching Hospital of Butare (CHUB), the King Faisal Hospital (KFH), the Rwanda Military Hospital (RMH), and the University Teaching Hospital of Kigali (CHUK). Recognising that these are all urban referral hospitals, data from all patients with confirmed heart failure (HF) admitted to three rural district hospitals (Rwinkwavu, Kirehe, and Butaro) were also included in the analysis. These rural hospital data, provided by the Department of Non-Communicable Diseases at Partners in Health Rwanda, were shared upon request specifically for this research.

To ensure consistency, accuracy, and, consequently, the quality of the collected data, the University of Rwanda made every effort to hire and train seven medical practitioners, four professional nurses, and three statisticians to collect the required data over 30 days. The University of Rwanda paid these enumerators under the sponsorship of the National Council for Science and Technology of Rwanda, which funded this research.

Variables

Variables denoting demographic characteristics, laboratory tests, physical examination, signs of life at presentation, and previous medical and family history were recorded. These include age, sex, district of residence, marital status, occupation, resting heart rate, blood pressure, history of hypertension, and smoking history. In addition, heart ultrasound, HF risk factors, number of hospitalisation days, respiratory rate as soon as the patient is admitted, family history of cardiovascular diseases, chest pain location, slope, chest pain type, cholesterol status, blood sugar, the result of electrocardiographic at rest, experienced maximum heart rate, resting blood pressure and the reason for discharge.

Statistical methods

To ensure the quality and efficiency of the study, the collected data were cleaned before statistical analysis. This study applied a combination of descriptive, spatial, and inferential



statistical methods to analyse the distribution and patterns of HF across Rwanda. Descriptive statistics, including frequencies and percentages, were used to summarise categorical variables, such as sex, hospital location (urban vs. rural), and comorbid conditions, including hypertension and diabetes. A simple time trend analysis was conducted to assess the annual average and overall trend of HF admissions in Rwanda from 2008 to 2019. Geospatial mapping techniques, supported by ArcGIS software, were used to visualise the spatial distribution of HF cases across Rwandan districts. To determine whether the spatial distribution of cases was random or clustered, Moran's I statistic was calculated. Furthermore, to assess the relationship between the number of HF admissions and the total length of hospital stay, a chi-square test was performed supported by probability values. Data were processed using Stata, ArcGIS, and Microsoft Excel, enabling robust statistical and spatial analyses.

FINDINGS AND DISCUSSION

Demographic information

A total of 4,085 cases of HF patients were identified in all 7 hospitals of interest. Among them 30.3 percent were from CHUB, 22.5 percent from CHUK, 12.9 percent from Butaro Hospital, 10.5 percent from Kirehe Hospital, 8.8 percent from Rwinkwavu Hospital, 7.2 percent from Rwanda Military Hospital, and 4.6 percent from King Faisal Hospital. The female patients comprise of 61.4 percent against 38.6 percent of males, and 34.8 percent of HF patients were under 30 years old. Patient under 18 years old who were hospitalized for HF diagnosis amounted to 884 (21.6 percent) against 3,201 (78.4 percent) of patients aged 18 years and above.

The province with the majority of diagnosed HF cases was the Southern Province (31.9 percent), followed by the Eastern Province (27.1 percent), Kigali City (19.2 percent), the Northern Province (15.8 percent), and the Western Province (6.0 percent). As depicted in Figure 1, the first 10 districts with a relatively high number of diagnosed HF cases constituted 71.8 percent of all cases diagnosed in the whole country.

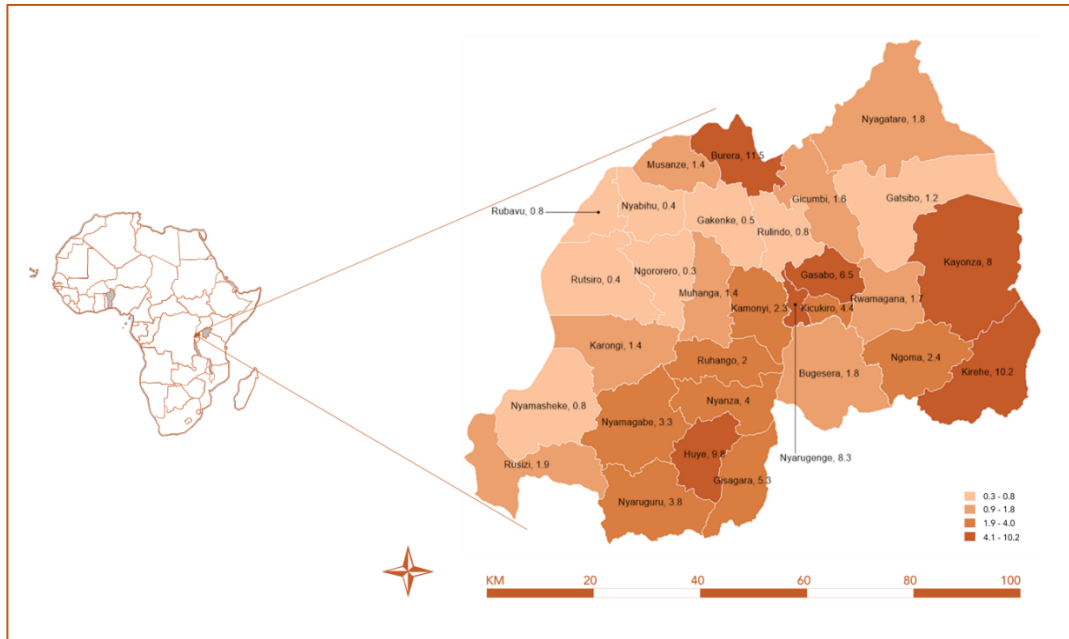


Figure 1: Distribution (%) of cases of heart failure by district

These districts are Burera (11.5 percent), Kirehe (10.2 percent), Huye (9.8 percent), Nyarugenge (8.3 percent), Kayonza (8.0 percent), Gasabo (6.5 percent), Gisagara (5.3 percent), Kicukiro (4.4 percent), Nyanza (4.0 percent), and Nyaruguru (3.8 percent).

Although most HF cases were found in the Southern and Eastern Provinces, the distribution shows spatial randomness justifying the absence of spatial autocorrelation (Moran's I statistic = -0.33, p-value = 0.45). A negative Moran's I statistic (-0.33) implies the dispersion of the distribution of diagnosed HF cases across provinces and Kigali City, a counter case for the distribution across districts, which shows the spatial clustering (with a positive Moran's I statistic of 0.06, p-value = 0.022). Knowing that HF is a non-communicable disease, the spatial autocorrelation (spatial clustering) across districts is subject to the unavailability of (or limited access to) health facilities for testing and/or diagnosing HF.

Figure 2 shows that more than half (55.26 percent) of HF patients are farmers/cultivators.

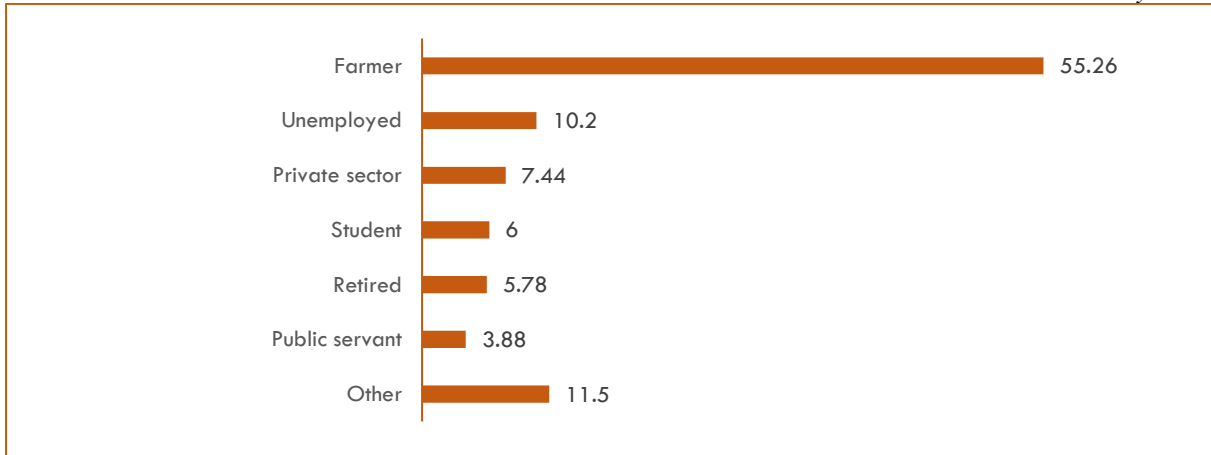


Figure 2: Distribution (%) by occupation of patients diagnosed with HF

The study revealed that 55.26 percent of HF patients in Rwanda are farmers. This finding is consistent with the fact that over 70 per cent of the employed population in Rwanda works in agriculture, and 51.3 per cent of those not in the labour force are subsistence farmers. The patients diagnosed with HF working in Rwanda’s private sector comprise 7.4 percent, public servants 3.9 percent, retirees 5.8 percent, unemployed HF patients 10.2 percent, HF patients who are students 6.0 percent, while the remaining 11.5 percent of HF patients consist of population other types of occupation, a considerable proportion being foreigners. Table 3 shows the trend of hospitalised patients from 2008 to 2019.

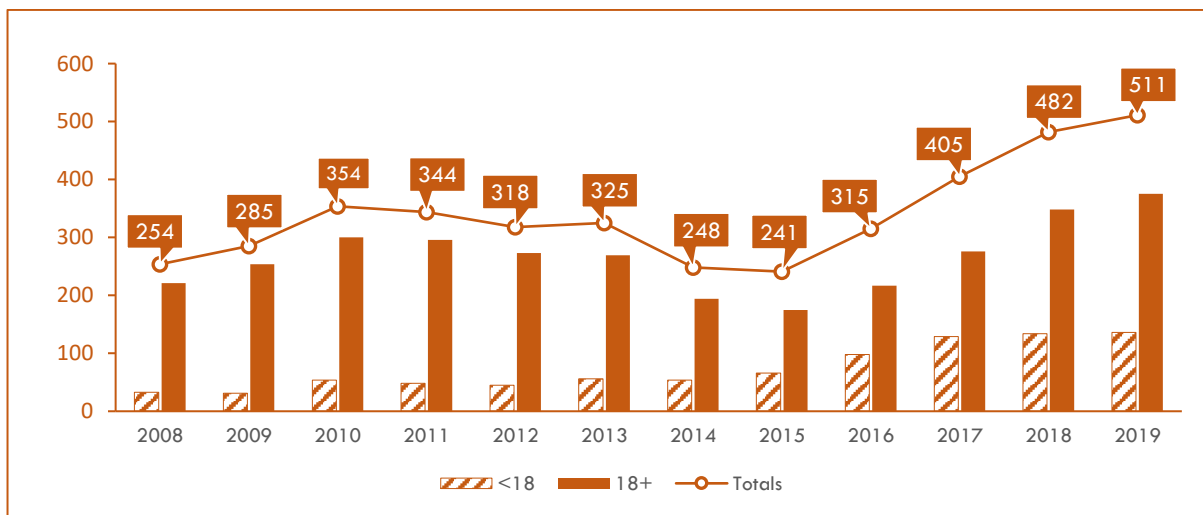


Figure 3: Trend in the number of HF patients from 2008 to 2019



The number of hospitalised HF patients showed a general increase from 254 cases in 2008 to 511 cases in 2019, with an average increase of 23.3 percent of HF cases per year. Table 1 shows the prevalence of different symptoms of HF among both young people under 18 years old and adults.

Table 1: Symptoms shown by patients diagnosed with HF

Symptoms	<18	18+	Totals
Shortness of breath (dyspnea), n (%)	638 (75.4)	1,457 (59.5)	2,095 (63.6)
Fatigue and weakness, n (%)	187 (22.1)	406 (16.6)	593(18)
Lower limb swelling (edema), n (%)	263 (31.1)	909 (37.1)	1,172 (35.6)
Rapid or irregular heartbeat, n (%)	70 (8.3)	212 (8.7)	282 (8.6)
Reduced ability to exercise, n (%)	9 (1.1)	31 (1.3)	40 (1.2)
Persistent cough with white or pink blood-tinged phlegm, n (%)	332 (39.2)	575 (23.5)	907 (27.5)
Increased need to urinate at night, n (%)	1 (0.1)	3 (0.1)	4 (0.1)
Abdominal swelling (ascites), n (%)	165 (19.5)	639 (26.1)	804 (24.4)
Very rapid weight gain from fluid retention, n (%)	3 (0.4)	4 (0.2)	7 (0.2)
Sudden, severe shortness of breath and coughing up pink foamy mucus, n (%)	60 (7.1)	49 (2)	109 (3.3)
Chest pain if HF is caused by heart attack, n (%)	107 (12.6)	466 (19)	573 (17.4)
Others, n (%)	255 (30.1)	566 (23.1)	821 (24.9)

As shown by Table1 the most prevailing symptoms of HF are shortness of breath (presented by 63.6 percent), lower limb swelling or edema (presented by 35.6 percent), and persistent cough with white or pink blood-tinged phlegm (presented by 27.5 percent). In addition, abdominal swelling or ascites (presented by 24.4 percent), fatigue and weakness (presented by 18.0 percent), and chest pain especially (presented by 17.4 percent) in adults were also significant symptoms of HF. The prevalence of shortness of breath is higher among young



patients under 18 years old (75.4 percent) than those aged 18 years and above (59.5 percent). The prevalence of fatigue/weakness and persistent cough with white or pink blood-tinged phlegm as symptoms of HF is higher among young people under 18 years old compared to adults. Both lower limbs and abdominal swelling are more likely to be present among adults compared to young patients under 18 years old.

Moreover, this study examined the classification of heart failures based on the cases recorded in Rwanda from 2008 to 2019 using the NYHA classification, the most commonly used HF classification system. For NYHA class I, patients can perform ordinary activities without having undue fatigue, dyspnea or palpitations. For class II, HF patients have a slight limitation of physical activity, and ordinary activity may cause fatigue, palpitation, dyspnea, or angina pectoris. Patients in NYHA class II usually show mild congestive heart failure symptoms. The NYHA class III is marked by limited physical activity, while NYHA class IV is characterised by the inability to carry out any physical activity efficiently. Moderate congestive HF symptoms are present among NYHA class III patients, while class IV patients experience severe Congestive HF symptoms. The findings further revealed that almost half of hospitalised HF patients in Rwanda fall in class III and IV (35.6 percent and 13.3 percent in class III and IV respectively). Only 7.8 percent are in class I, 43.3 percent are in class II, 40 percent of young people under 18 years old and 43 percent of adults are in this class. In addition, the proportions of HF patients in class III were 26.1 percent and 36.5 percent of young people under 18 years old and adults respectively. However, Table 2 shows that more than a half (61.8 percent) of HF cases were irreversible, 37.0 percent were fixed, and the remaining 1.2 percent were normal.

Table 2: Classification of HF defect type [n(%)]

Defect type	<18	18+	Totals
Normal	4 (0.5)	38 (1.4)	42 (1.2)
Fixed	468 (58)	834 (30.7)	1,302 (37)
Irreversible	335 (41.5)	1,842 (67.9)	2,177 (61.8)

While more than a half of HF cases for young people under 18 years old were fixed (58.0 percent), 67.9 percent of HF cases for adults were irreversible.

At the same time, Table 3 shows that the heart ultrasound test showed that 30.5 percent of patients with HF had valvular heart diseases, while 29.0 percent had dilated cardiomyopathy, which are some of the core risk factors of heart failure.



Table 3: Heart ultrasound results

Heart ultrasound	<18	18+	Totals
Left ventricular hypertrophy, n (%)	50 (5.7)	187 (5.8)	237 (5.8)
Valvular heart diseases, n (%)	384 (43.4)	860 (26.9)	1,244 (30.5)
Dilated cardiomyopathy, n (%)	174 (19.7)	1,010 (31.6)	1,184 (29)
Infective endocarditis, n (%)	44 (5)	27 (0.8)	71 (1.7)
Clot in heart chamber, n (%)	6 (0.7)	36 (1.1)	42 (1)
Left ventricular ejection fraction, n (%)	123 (13.9)	560 (17.5)	683 (16.7)
Normal, n (%)	10 (1.1)	46 (1.4)	56 (1.4)

Dilated cardiomyopathy is less likely to be present in young people under 18 years old than in adults. The ultrasound results confirmed that 19.7 percent of HF patients aged under 18 had dilated cardiomyopathy, which is relatively low compared to that of adults (31.6 percent).

Unlike dilated cardiomyopathy, which is more present in adults than in young people, valvular heart diseases and infective endocarditis were confirmed to be more prevalent in young people under 18 years old than in adults. The valvular heart diseases confirmed by the ultrasound test comprised 43.4 percent among young people under 18 years old against 26.9 percent among adults, and 5.0 percent against 0.8 percent for infective endocarditis. The heart ultrasound results showed that 5.8 percent had left ventricular hypertrophy, slightly lower in young people under 18 years old (5.7percent) than in adults (5.8percent). Similarly, Table 4 lists several risk factors that contribute to heart failure in Rwanda. The main risk factors for heart failure in Rwanda were revealed to be cardiomyopathy, valvular heart diseases, hypertension, congenital heart defects, and diabetes.

Table 4: Prevalence of risk factors for heart failure [n (%)]

Risk factor for HF	<18	18+	Totals
Hypertension	69 (7.8)	770 (24.1)	839 (20.5)
Cardiomyopathy	219 (24.8)	1,422 (44.5)	1,641 (40.2)
Myocarditis	23 (2.6)	32 (1)	55 (1.3)
Valvular heart diseases	466 (52.7)	1,009 (31.5)	1,475 (36.1)
Congenital heart defects	286 (32.4)	47 (1.5)	333 (8.2)
Coronary artery disease	5 (0.6)	8 (0.3)	13 (0.3)
Heart attack	-	1 (0)	1 (0)
Diabetes	-	165 (5.2)	165 (4)



Risk factor for HF	<18	18+	Totals
Faulty heart valves	-	2 (0.1)	2 (0)
Others	159 (18)	470 (14.7)	629 (15.4)

Among all HF patients that were diagnosed, 40.2 percent were found to have dilated cardiomyopathy, 36.1 percent had valvular heart diseases, 20.5 percent suffered from hypertension, 8.2 percent had congenital heart defects, and 4.0 percent were sick with diabetes as risk factors for heart failure. Both myocarditis and coronary artery diseases had low prevalence with 1.3 percent and 0.3 percent, respectively, while diabetes and heart attack were more likely not to happen.

Furthermore, this study compared adults and young people under 18 years old. The results revealed that the risk factors for heart failure in Rwandan young people were different from those in adults. The prevalence of congenital heart defects among children were significantly high, being at about 22 times the prevalence among adults. More specifically, it was 32.4 percent for young people and 1.5 percent for adults. The prevalence of valvular heart diseases was 52.7 percent among young people against 31.5 percent among adults. On the other hand, the prevalence of hypertension and cardiomyopathy was higher among adults than among young people under 18 years old. Hypertension was 24.1 percent among adults, about three times the prevalence among young people (7.8 percent). The prevalence of dilated cardiomyopathy as a risk factor of HF was also higher among adults (44.5 percent) than among young people (24.8 percent). The fact that congenital heart defects and valvular heart diseases can be fixed while hypertension and dilated cardiomyopathy cannot be fixed serves to explain why 58.0 percent of HF cases among young people are fixed while 61.8 percent of HF cases among adults are irreversible. Besides the risk factors for heart failure, there are several risk factors for decompensated heart failure (DHF).

The results in Table 5 show that infection is the leading factor for decompensated heart failure with a prevalence of 45 percent, being higher among young people under 18 years old (72.3 percent) than among adults (35.7 percent).

Table 5: Risk factors for decompensated heart failure [n (%)]

Risk factor for DHF	<18	18+	Totals
Poor compliance on drugs	46 (6.5)	210 (10.2)	256 (9.3)
Infections	510 (72.2)	734 (35.7)	1,244 (45)
Cardiac arrhythmia	52 (7.4)	220 (10.7)	272 (9.8)
Anemia	113 (16)	167 (8.1)	280 (10.1)
Others	122 (17.3)	803 (39)	925 (33.5)



Other risk factors for DHF include anemia (with a prevalence of 10.1 percent), cardiac arrhythmia (9.8 percent), poor drug compliance (9.3 percent), and others. The prevalence of poor drug compliance and cardiac arrhythmia was higher in adults than in young people under 18 years old.

The findings in Table 6 revealed that, on average, 55.9 percent of HF patients had abnormal heart sounds (murmur), 21.1 percent had abnormal lungs sounds (lung crackles), while only 15.6 percent had normal heart and lung sounds.

Table 6: Auscultation [n (%)]

Auscultation	<18	18+	Totals
Murmur	651 (73.6)	1,630 (51)	2,281 (55.9)
Normal	59 (6.7)	576 (18)	635 (15.6)
Crackles	210 (23.8)	650 (20.3)	860 (21.1)

Young people under 18 years old were more likely to have abnormal heart sound (73.6 percent) than adults(51.0 percent). Although auscultation can be used to detect and diagnose abnormal heart function, an electrocardiogram (ECG/EKG) is used to confirm the diagnosis of heart failure (HF).

This study assessed the ECG results recorded for HF patients. Only 4.5 percent of HF patients had normal electrocardiographic results, 9.2 percent had ST wave abnormality (T wave inversions and/or ST elevation or depression), 6.6 percent had ECG showing probable or definite left ventricular hypertrophy by Estes’ criteria). In comparison, 25.9 percent showed other abnormal ECG results.

Considering the ECG slope, as shown in Table 7, 64.2 percent of HF patients had an ECG diagram with a flat slope, 22.4 percent had an upward slope, and the remaining 13.4 percent had a downward slope.

Table 7: Distribution of ECG slope [n (%)]

Slope	<18	18+	Totals
Upward	43 (44.8)	225 (20.4)	268 (22.4)
Flat	40 (41.7)	729 (66.2)	769 (64.2)
Downward	13 (13.5)	148 (13.4)	161 (13.4)

This study again, disclosed that 45.3 percent of adult patients (aged 18 years and above) took alcohol, 53.4 percent of them being female and the remaining 46.6 percent being male. Among



the patients aged 18 years and above who drank, 46.0 percent of them had dilated cardiomyopathy, while 27.5 percent had hypertension as risk factors for heart failure.

Among other variables, this study also examined the fasting blood sugar of HF patients. Given the fact that diabetes is one of the significant risk factors for HF, it is important to examine the level of blood sugar. Fasting blood sugar is the sugar level present in your blood when you have not eaten for 8 hours before the test. Previous research confirmed that the increased fasting blood sugar has an associated risk for HF (Leong et al., 2023). The level of blood sugar (glucose) for a normal person on fast ranges between 80 and 100, between 170 and 200 after eating, and between 120 and 140 after 2-3 hours following the meal. This study showed that 87.9 percent of HF patients with diabetes as a risk factor for HF had abnormal fasting blood sugar levels.

Currently, there is no cure for HF, though there are some treatments that can help people with HF live longer. This study examined the relationship between admission count and total hospitalisation time and found no statistically significant relationship between total hospitalisation days and number of admissions (chi square= 403, $p>0.05$). The average hospitalisation days for the first admission was 15.6 days, 15.8 days for the second admission, 16.6 days for the third admission, 18.0 days for the fourth admission, and 14.1 days for patients admitted more than four times, giving the general average of 15.7 hospitalisation days for each HF patient.

This study also examined the resting heart rate of HF patients and found that 55.9 percent had unhealthy resting heart rates. According to the Mayo Clinic (2009), heart failure is a chronic disease that requires long-term management. This study revealed that only 12 percent of HF patients in Rwanda had chronic disease(s) in their families. Those diseases include heart disease, hypertension, stroke, asthma, diabetes, kidney disease, and cancer. In addition, as for any hospitalised patients, they could be discharged from the hospital if they improved, were transferred elsewhere, died, or defaulted. Most of HF patients were discharged home after improvement (74.9 percent), although they sometimes required a follow-up plan. 16.8 percent died in hospitals, 3.4 percent were transferred to other hospitals, and the remaining 4.8 percent were defaulters.

Table 8 shows that the statistics for the main reason for discharge from hospitals slightly differ across different age categories.



Table 8: The reason for discharge [n (%)]

Reason for discharge	<18	18+	Totals
Defaulted	33 (3.7)	164 (5.2)	197 (4.8)
Improved	675 (76.5)	2,370 (74.5)	3,045 (74.9)
Died	132 (15)	549 (17.3)	681 (16.8)
Transferred	42 (4.8)	98 (3.1)	140 (3.4)

While 76.5 percent of young people under 18 years old were discharged after improvement, it was 74.5 percent for adults. One of the significant threats to the hospitalisation and treatment of HF is the high cost, which includes medical fees payable to the hospital and travel expenses from home to the treatment centres. An HF patient spends an average of Frw 2,707 on transport costs, and this amount can increase to Frw 16,000 to reach hospitals and receive treatment. Since 38.2 percent of the Rwandan population lives under the poverty line, with 19.2 percent extremely poor (Angraal et al., 2020), some patients are likely to become victims of high costs associated with the treatment of HF.

As discussed earlier, the distribution of HF cases shows spatial clustering across the districts. Surprisingly, Table 9 shows that 86.3 percent of HF patients diagnosed and treated at Butaro Hospital located in Burera district were residents of the same Burera district, 10.3 percent resided in other districts in the same province, and only the remaining 3.4 percent lived in other provinces and Kigali City.

Table 9: Distribution (%) of HF patients with treatment hospital and district of residence

District	District/Provincial Hospitals			Referral Hospitals		
	<18	18+	Totals	<18	18+	Totals
Gasabo	0	0.3	0.2	4.1	11.3	9.5
Kicukiro	0.6	0.1	0.2	2.6	7.8	6.5
Nyarugenge	0	0.1	0.1	4	15.1	12.2
Gisagara	0	0	0	10.3	7.1	7.9
Huye	0.6	0	0.1	18.3	13.2	14.5
Kamonyi	0	0	0	3.3	3.4	3.4
Muhanga	0	0	0	3.7	1.5	2.1
Nyamagabe	0	0	0	8.3	3.8	4.9
Nyanza	0	0.1	0.1	7.2	5.5	6
Nyaruguru	0	0	0	8.9	4.5	5.6
Ruhango	0	0.2	0.2	3	2.9	2.9



District	District/Provincial Hospitals			Referral Hospitals		
	<18	18+	Totals	<18	18+	Totals
Karongi	0	0.1	0.1	2	2	2
Ngororero	0	0.3	0.2	0.1	0.5	0.4
Nyabihu	0	0.4	0.4	0.7	0.2	0.4
Nyamasheke	0	0	0	2.6	0.7	1.2
Rubavu	0	0.4	0.4	1	0.9	1
Rusizi	0	0	0	2.6	2.8	2.8
Rutsiro	0	0	0	1.6	0.3	0.6
Burera	30.1	35.2	34.6	0.7	0.3	0.4
Gakenke	0	0.2	0.2	1.3	0.5	0.7
Gicumbi	0.6	0.5	0.5	2.3	2	2.1
Musanze	4	3.3	3.3	0.7	0.3	0.4
Rulindo	0.6	0.2	0.2	0.7	1.2	1.1
Bugesera	0	0.1	0.1	2.3	2.7	2.6
Gatsibo	0	0.5	0.5	2	1.5	1.6
Kayonza	27.3	21.1	21.9	0.9	1.4	1.2
Kirehe	25.6	29.9	29.3	0.7	1.1	1
Ngoma	9.7	5.2	5.8	0.9	0.7	0.7
Nyagatare	0.6	1.3	1.2	1.7	2.2	2.1
Rwamagana	0.6	0.6	0.6	1.6	2.5	2.2

Concerning Kirehe hospital, 85.4 percent of its HF patients were residents of Kirehe district, 12.5 percent of Ngoma district, and only 2.1 percent resided in the remaining districts of Rwanda. About 80.1 percent of HF patients treated at Rwinkwavu Hospital resided in Kayonza district, where this hospital is situated. A similar pattern was observed in the remaining hospitals, where a high percentage of treated HF patients came from the same district where the hospitals are located or from neighbouring districts.

For the case of King Faisal Hospital (located in Gasabo district, Kigali City) 76.3 percent of HF patients diagnosed resided in Kigali City (37.6 percent from Gasabo district, 26.5 percent from Nyarugenge district, and 12.2 percent from Kicukiro district). The same goes for the University Teaching Hospital (CHUB) located in Huye district, Southern Province, where 82.7 per cent of HF patients hospitalised were from Huye and neighbouring districts (Huye: 31.1 per cent, Gisagara: 17.3 per cent, Nyaruguru: 12.4 per cent, Nyanza: 11.4 per cent, and Nyamagabe: 10.4 per cent). About 61.9percent of HF patients hospitalised at the University



Teaching Hospital of Kigali (CHUK) (located in Nyarugenge district, Kigali City) they lived in Nyarugenge or neighboring districts (Nyarugenge: 26.3 percent, Gasabo: 13.3 percent, Kicukiro: 7.9 percent, Kamonyi: 8.0 percent, Bugesera: 3.7 percent, and Rulindo: 2.8 percent). As for Rwanda Military Hospital (RMH) located in Kicukiro District - Kigali City, 59.2 percent of HF patients treated at RMH reside in Kicukiro and its neighbouring Districts (Kicukiro: 25.4 percent), Gasabo: 18.0 percent, Nyarugenge: 4.0 percent, Bugesera: 7.7 percent, and Rwamagana: 4.0 percent).

Despite its global emergence as a pandemic and its wide epidemiological variation among countries and regions, most studies about HF focus on East Asia, Western Europe, and North America, frequently ignoring the circumstances outside of these regions (Bragazzi et al., 2021b). Our findings were intended to fill in this knowledge gap. Therefore, based on the results from this study, it is clear that the absolute number and HF prevalence are still on the rise in Rwanda, similar to some other developing countries (Chiang et al., 2023). This research did not consider the initial contact of HF patients with the hospital staff (OPD), but only hospitalised HF patients. It may be argued that there could be more cases of HF in Rwanda than reported in this study. In addition, this study revealed that in some districts of Rwanda (like Ngororero, Nyabihu, Rutsiro and Gakenke), there were surprisingly significantly fewer HF cases than in other districts. This observed significant geographic variation in the levels and trends of heart failure in Rwanda is common in some other countries (Bragazzi et al., 2021b). For the case of Rwanda, it may be associated with a scarcity of healthcare systems in the affected districts, a lack of or very few heart failure professionals available in these districts, a skewed budget allocated to heart failure diagnosis and treatment, or a relatively high cost of heart failure treatment, among other factors. This is in line with the research conducted in 2022 by Klassen et al. (2022).

In addition, we observed that almost 50 percent of hospitalised HF patients in Rwanda fell in NYHA class III and IV. This conforms with similar studies that found that a significant fraction of heart failure cases in non-western countries are caused by heart failure with preserved ejection fraction (Pfeffer, Shah, & Borlaug, 2019). This finding suggests the need for earlier diagnosis and treatment to help Rwandans with heart failure (HF) live more active lives for a longer period. On the other hand, it is essential to note that only 7.8 percent of hospitalised HF patients fell in NYHA class I. This could be an indication that, in the early stages of the disease, either HF patients were unaware of their disease and therefore did not consult medical doctors, or, it was difficult for some medical professionals in Rwanda to detect HF in its early stages. In addition, the findings showed that more than half (61.8 percent) of HF cases in Rwanda were irreversible, 37.0 percent could be fixed, and the remaining 1.2 percent were normal. These proportions reflect the same trend in a similar setting (Wang & Zhao, 2021). The findings also indicated that more than half of HF cases in young people under 18 could be fixed (58.0 percent), while 67.9 percent of HF cases in adults were irreversible. In light of these findings,



many of the risk factors of HF in both young and adult populations need to be controlled or eliminated to prevent HF in Rwanda.

CONCLUSION AND RECOMMENDATION

The dynamic nature of Heart Failure (HF) epidemiology in Rwanda is a point of concern. Retrospective data from seven Rwandan hospitals have shown that it is necessary to develop an HF prevention and control policy, as HF constitutes a significant burden on healthcare systems in Rwanda. As per the findings of this research, more than 70 percent of the cases of HF are present in only 10 districts of Rwanda. It seems unrealistic for 20 districts to be free from HF cases or have relatively few cases of HF. This calls for the government of Rwanda to expand and strengthen its healthcare systems to prevent and control heart failure (HF) in areas of the country where cases of HF are not currently reported. In addition, almost 50 percent of HF patients who were hospitalised in Rwanda were in NYHA class III and IV, and only 7.8 percent were in class I. This highlights the need to raise awareness of the importance of self-care for Rwandan people. They need to understand the importance of maintaining their physical and emotional stability, adopting a balanced and healthy diet, monitoring their weight, and scheduling regular check-ups, even when there are no noticeable signs or symptoms. Besides, more than 60 percent of HF patients who were hospitalised in Rwanda were subsistence farmers or unemployed people, these are socio-economically vulnerable people. There is a need to educate this category of the population on how to prevent HF and how to help an HF patient, which will promote the above-mentioned self-care behaviour. An annual increase of 23 percent of HF patients who were hospitalised in Rwanda is an alarming figure. It is therefore necessary to develop an intelligent model that can accurately predict HF in Rwanda, enabling better diagnosis, treatment, and control of the disease in its early stages.

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Ethics Approval and Consent to Participate

Both the Rwandan National Health Committee and the College of Medicine and Health Science Institutional Review Board Committee approved this study with the reference numbers NHRC/2019/PROT/009, dated 23 February 2019, and 137/CMHS IRB/2019, dated 28 March 2019, respectively. In addition, the Ministry of Health in Rwanda has officially authorised the execution of this research by the Rwandan Health Sector Research Policy.



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