Primary causes and direct medical cost of heart failure among adults admitted with acute decompensated heart failure in a public tertiary hospital, Kenya

Authors: Victor M. Wauye*[1], Chrispine O. Oduor[1], Felix A. Barasa[2], G. Titus Ngeno[3]

Affiliations
[1]Department of Internal Medicine, Moi University, Eldoret, Kenya
[2]Department of Cardiology, Moi Teaching and Referral Hospital, Eldoret, Kenya
[3]Division of Cardiology, Department of Medicine, Duke University, Durham, USA

***Corresponding author:**

Dr. Victor Mwaka Wauye,
P. O. Box 85 – 50405,
Butula, Kenya,
Tel: +254 729-771-653
Email: vmwauye@gmail.com

Abstract

Heart failure (HF) is a major contributor of cardiovascular morbidity and mortality globally. Despite its adverse impact on health outcomes in low- and middle-income countries such as Kenya, data on the direct medical cost of HF hospitalization is limited.

This was a prospective study conducted at Moi Teaching and Referral Hospital. Patients with HF were identified by sequential medical chart abstraction. Primary causes were extracted from echocardiogram reports and adjudicated by a cardiologist. Direct medical cost of hospitalization was derived using activity-based costing, micro-costing method, and payers' system perspective. Drivers of overall cost were explored using linear regression models.

142 participants were consecutively recruited from September to November 2022. 51.4% were females, and the overall mean age was 54 (SD 20). The leading primary cause was cor pulmonale (CP), 28.9%; then dilated cardiomyopathy (DCM), 26.1%; rheumatic heart disease (RHD), 19.7%; hypertensive heart disease (HHD), 16.9%; ischaemic heart disease (IHD), 6.3%; and pericardial disease (PD), 2.1%. Overall direct cost of HF hospitalization was Kshs. 11,470.94 (SD 8,289.57) per patient per day, with the mean length of hospital stay of 10.1 (SD 7.1). RHD incurred the highest costs, Kshs. 15,299.08 (SD 13,196.89) per patient per day, then IHD, Kshs. 12,966.47 (SD 6656.49), and DCM, Kshs.12,268.08 (SD 7,816.12). Cost of medications was the leading driver, $\beta = 0.56$ (0.55 – 0.56), followed by inpatient fees, $\beta = 0.27$ (0.27 – 0.28) and laboratory investigations, $\beta = 0.19$ (0.18 – 0.19).

Cor pulmonale, CM, RHD and HHD were the major causes of HF. The overall direct medical cost of hospitalization was extremely expensive compared with the average monthly household income per capita in Kenya. Widespread insurance cover is therefore recommended to cushion families against such catastrophic health expenditures beside public health measures aimed at addressing primary causes of HF.

Keywords: Primary causes, heart failure, direct medical cost, hospitalization, Moi Teaching and Referral Hospital

1 Introduction

Cardiovascular diseases (CVDs) are the most common cause of global morbidity and mortality, accounting for more than 17.9 million deaths annually in the recent years. More than 75% of these deaths occur in the middle and low income countries (1). Heart failure (HF), is one of the most common primary CVD diagnosis among hospitalized medical patients in Sub-Saharan Africa (SSA), Kenya included (2,3). The main causes of HF in SSA have been traditionally described as hypertensive heart disease (HHD), dilated cardiomyopathy (DCM) and rheumatic heart disease (RHD) and less commonly, other causes of HF such as ischemic and congenital cardiomyopathies (4,5).

Treatment of HF confers significant financial burden both to the healthcare system as well the affected families, being largely driven by direct medical costs of hospitalization (6,7). Direct medical costs accounted for about 60% of the total costs in a review by Cook et al. (6). There is however limited data published on the cost of treatment of HF in Africa. Ogah et al. reported a total cost of USD 2,128 per patient per year in Nigeria, using a broader societal costing approach (8).

To the best of our knowledge, there is no published study on medical cost of hospitalization of HF in Kenya despite the efforts towards the achievement of universal health coverage. According to the 2023 Kenya Demographic Health Survey, healthcare expenditure in Kenya is mainly paid for out of pocket, with only 26.5% of the Kenyans having any form of health insurance (9). Of these, only 24% are covered by the government sponsored national health insurance fund (NHIF), while the rest are covered by private insurance. At tertiary government health facilities, about 35% of the hospitalized patients have NHIF cover (10). Furthermore, it is notable that about 83% of workforce in Kenya is comprised of informal sector (11). A study assessing the uptake of NHIF among informal workers in Western Kenya showed that only

12% had health insurance coverage, with the majority experiencing catastrophic health expenditure (12), thus implying that patients with HF would be at a high risk of financial catastrophe.

In our study, we sought to further develop the understanding of the cost of HF treatment in a low-middle-income economy, by describing the primary causes of HF at Moi Teaching and Referral Hospital (MTRH), Kenya, and determining the direct medical cost of hospitalization among patients hospitalized with acute decompensated HF (ADHF).

2 Methodology

2.1 Study design and population

This was a prospective study conducted at the Moi Teaching and Referral Hospital (MTRH), Kenya, over a period of three months from 01 September to 30 November 2022. MTRH is a national referral hospital located in Western Kenya, with a catchment area of about 24 million people. It has two wings: public and private wing, with the former being where the general public seek treatment. All those who were hospitalized to the public wing medical wards and cardiac care unit (CCU) with the diagnosis of ADHF based on the Modified Framingham clinical criteria for HF and were aged 18 years and above were included in the study. Those who were less than 18 years old, readmitted during the study period and discharged to or from the MTRH private wing were excluded from the study.

2.2 Case definition for the primary causes of HF

Comprehensive clinical data including clinical symptoms and signs, past medical history, and results of laboratory as well as imaging investigations were gathered and collated with the two-dimensional doppler echocardiography (ECHO) and 12-lead electrocardiography (ECG)

findings. Both electrocardiograms and echocardiograms were performed by well-trained ECHO/ECG technicians at MTRH ECG/ECHO centre, according to the American Society of Cardiology guidelines (13). The findings were summarized by the principal investigator, and further confirmed by the consultant cardiologist. The most likely primary cause of HF was then established using a predetermined case definition criteria (Table 1), which was guided by the European Society of Cardiology guidelines (14). A similar criteria was previously applied in the Heart of Soweto study in South Africa (2,15), and the Sub-Saharan Africa Survey of Heart Failure which recruited participants from 9 African countries, Kenya included (4). The criteria was however tweaked to fit our set up with limited diagnostic resources.

Cause of HF	**Case Definition**
Hypertensive Heart Disease	Documented history or new diagnosis of HTN plus ECHO report of LVH or ECG features of LVH: LAD or Positive Cornell Voltage ECG criteria for LVH (Sum of R wave in aVL and S wave in V3 > to 2.8mV in males and 2.0mV in females) or Sokolow-Lyon criteria: sum of S in V1 or V2 and R in V5 or V6 >35mm.
Rheumatic Heart Disease	Pathological MR with at least 2 of: AMVL thickening, chordal thickening, restricted leaflet motion or excessive leaflet tip motion during systole or MS mean gradient ≥4mmHg or Pathological AR with at least 2 of: AV focal thickening, coaptation defect, restricted leaflet motion or prolapse.
Ischemic Heart Disease	Regional wall abnormality plus/minus pathological Q waves defined as any Q waves >0.02s in V2-V3 or QS complex in V2-V3, or Q waves ≥0.03s and ≥1mm deep or QS complex in other leads in at least 2 contiguous leads.
Dilated Cardiomyopathy	Dilated ventricular chambers with reduced LVEF or dilated ventricular chambers with ECG features of LVH in the absence of HHD and IHD.
Cor Pulmonale	ECHO: Pulmonary HTN of >35mmHg (in the absence of valvular heart disease as RHD and LVEF ≤40%), TAPSE <1.7cm, right ventricular enlargement, and dilated non-collapsing IVC, and/or ECG: Right Axis Deviation, R/S amplitude ratio>1 in V1, R/S amplitude ratio<1 in V6, $S_1Q_3T_3$, or Right Bundle Branch Block and/or Documented chronic lung disease.
Pericardial Disease	Pericardial echo free fluid plus/minus any features of cardiac tamponade and indices of cardiac contusion in the absence of any identifiable causes above.

Table 1:Case definition for the primary causes of heart failure

Abbreviations: AR, Aortic valve; AMVL, anterior mitral valve leaflet; AV, aortic valve; ECG, electrocardiogram; ECHO, echocardiogram; HHD, hypertensive heart disease; HTN, hypertension; IHD, ischaemic heart disease; IVC, inferior vena cava; LAD, left axis deviation; LVEF, left ventricular ejection fraction; LVH, left ventricular hypertrophy; MR, mitral regurgitation; TAPSE, transannular plane systolic excursion.

2.3 Direct medical costing approaches

Costing was done using payers' perspective(16), with a prevalence and prospective methods (17). Detailed data regarding direct medical costs were obtained from the MTRH finance department in printed forms. The data included a breakdown of all the costs that each patient incurred during hospitalization, from the date of admission to the point of discharge (the date on which the attending physician decided that the patient be discharged, or the patient died). Micro-costing technique was used to detail the cost components, which included costs related to inpatient charges (nutrition, admission, physiotherapy, bed and nursing charges), medications, laboratory investigations, imaging, oxygen therapy, and other utilities (consumables such as syringes, gauzes, needles, nasal prongs among others) (18,19). Further, direct costs included both out of pocket (OOP) and national health insurance (NHIF) payments. Notably, being a public health facility with human resource remuneration largely covered by the government, charges related to remuneration were not included. Moreover, indirect costs such as transport and productivity losses were not included.

2.4 Data collection

Data were collected using interviewer administered questionnaires, and included information on socio-demographic characteristics, past medical history, New York Heart Association assessment (NYHA), vital signs such as blood pressure and heart rate, ancillary laboratory investigations such as haemoglobin, electrolytes, urea and creatinine, lipid profile, thyroid function tests, liver function tests and international normalizing ratio, chest Xray, select ECG and ECHO findings. Comorbidities were physician-diagnosed and documented in the files, largely based on the patients' past medical history and laboratory investigations.

2.5 Statistical analysis

Data were analysed using RStudio statistical software version R.4.2.2. Continuous variables were reported using mean and median with respective standard deviations (SD) and interquartile range (IQR). Primary causes of HF were reported using proportions and percentages, with respective 95% confidence intervals (CI). Costs were reported using mean (SD) as cost (in Kenya shillings) per patient per day; calculated by dividing the total cost during hospitalization by the mean length of hospital stay (LOS) by the total number of participants, N, and compared between the CCU and the general ward. Linear regression model with standardized β-coefficients was used to determine how each cost component drove the overall cost. Due to inability to delineate direct medical cost of comorbidities, the mean costs were all-inclusive. However, the effect of each comorbidity on the overall cost was explored using generalized linear regression model with gamma distribution and log-link function. Regressions involved both bivariate and multivariate analyses. Comparisons of mean costs between general ward and CCU was done using Mann-Whitney and Kruskal-Wallis non-parametric tests of association. Further, sub-analysis of the overall costs was done by NYHA, grade of ejection fraction, and in-hospital outcome (discharged alive or dead). Costs were further converted to American dollars (USD) per the Central Bank of Kenya foreign exchange rates during the study period, for which 1USD = Kshs 122.6129(20).

2.6 Ethics statement

A formal written and signed informed consent was obtained from the participants before enrolment into the study. The informed consent described the details of the study, detailing both the benefits and potential harms. Participants' data were decoded anonymously for confidentiality. Further, the study was approved by the Moi University Institutional Research Ethics Committee (approval number 003738 and reference number IREC/2020/187).

3. Results

A total of 142 participants were included in the study, after 178 cases were screened for eligibility (Fig 1). The mean age was 54 (SD 17) years, with the median age of 60 (IQR 37.3, 70). 51.4% were females. Further, 73.9% had unskilled labour, and only 52.8% had NHIF cover. The mean length of hospital stay was 10.1 (SD 7.1) days. Table 2 shows further socio-demographic, laboratory, comorbidities, medications and ECG/ECHO findings.

[Fig 1 Recruitment schema of the participants]

Baseline characteristics		(n, %)
Gender	Male	69 (48.59)
	Female	73 (51.41)
Age (years) (mean (SD) | Median (IQR)[1]		54.0 (20.0) | 60 (37.3, 70)
Marital Status	Married	92 (64.8)
	Single	25 (17.6)
	Divorced/Separated	7 (4.93)
	Widowed	18 (12.7)
Level of Education	Primary	85 (59.9)
	Secondary	36 (25.4)
	Tertiary	21 (14.8)
Occupation	Unskilled	105 (73.9)
	Students	11 (7.7)
	Skilled	15 (10.6)
	Professional	8 (5.6)
	Retired	3 (2.1)
Mode of Payment	NHIF	75 (52.8)
	OOP	67 (47.2)
LOS (mean (SD)| median (IQR))[1]		10.1 (7.1) | 8 (5, 12.8)
Ward	General ward	73 (51.4)
	CCU	69 (48.6)
Discharge Status	Alive	115 (81.0)
	Dead	27 (19.0)
HF History	De novo HF	68 (47.9)
	ADCHF	74 (52.11)
Comorbidities	HIV	8 (5.6)
	HTN	45 (31.7)
	DM	17 (12.0)
	Anaemia	37 (26.1)
	Chronic Lung Disease	31 (21.8)
	Liver Disease	47 (33.1)
	Renal Insufficiency	97 (68.3)
	Thyroid Dysfunction	26 (18.3)
	Dyslipidaemia	87 (61.3)
	Cancers	6 (4.2)
NYHA Stage	II	2 (1.4)
	III	87 (61.2)
	IV	53 (37.3)
ECG/ECHO summary	HR (bpm)[1]	105 (29) | 102 (85, 121)
	Sinus	110 (77.5)
	Atrial fibrillation	32 (22.5)
	Reduced	70 (49.3)
	Mildly reduced	18 (12.7)
	Preserved	54 (38.0)
	RVSP[1]	60 (20) | 56 (45, 75)
	TAPSE[1]	1.5 (0.5) | 1.3 (1, 1.9)
Medications	Diuretics	131 (92.3)
	MRAs	83 (58.5)
	ACEIs/ARBs	74 (52.1)
	SGLT2 Inhibitors	35 (24.7)
	Vasopressors	32 (22.5)
	B-Blockers	30 (21.1)
	Digoxin	29 (20.4)
	Amiodarone	27 (19.0)
	CCBs	19 (13.4)

Table 2: Baseline characteristics of the participants

[1]Mean (SD) |Median (IQR). **Abbreviations**: ACEIs, angiotensin converting enzyme inhibitors; ADCHF, acute decompensation of chronic heart failure; ARBs, angiotensin receptor blockers; CCB, calcium channel blockers; CCU, Cardiac care unit; DM, diabetes mellitus; HIV, human immunodeficiency virus; HR, Heart rate; MRAs, mineralocorticoids; NHIF, National health insurance fund; OOP, Out of pocket payment; RVSP, right ventricular systolic pressure; SGLT2, sodium glucose transporter-2; TAPSE, Transannular plane systolic excursion.

3.1 Primary causes of HF

The most common primary cause of HF was cor pulmonale (CP), accounting for 28.9% (95% CI 21.1% – 37.9%) of the cases, followed by dilated cardiomyopathy (CM), 26.1% (95% CI 18.3% - 35.0%), rheumatic heart disease (RHD), 19.7% (95% CI 12% - 28.7%) and hypertensive heart disease (HHD), 16.9% (9.2% - 25.9%) (Table 3).

Primary Cause of Heart Failure	**n (%)**	**95% CI**
Cor Pulmonale	41 (28.9)	21.1 – 37.9
Dilated cardiomyopathy	37 (26.1)	18.3 – 35.0
Rheumatic Heart Disease	28 (19.7)	12.0 – 28.7
Hypertensive Heart Disease	24 (16.9)	9.2 – 25.9
Ischaemic Heart Disease	9 (6.3)	0 – 15.3
Pericardial Disease	3 (2.1)	0 – 11.1
Total, N	142	

Table 3: Primary causes of heart failure

3.2 Direct medical cost of HF hospitalization

The mean direct medical cost of HF hospitalization was Kshs. 11,470.94 (SD 8,289.57) per patient per day, with the cost in the CCU being as twice as the cost in the general ward (table 4). Of the cost components, cost of medications was the leading driver of the overall cost, with standardized β-coefficient of 0.56 (95% CI 0.55 – 0.56), followed by the cost of inpatient fees and laboratory investigations respectively (Fig 2). Stratified by the primary cause of HF, RHD incurred the highest mean direct medical cost, Kshs. 15,299.08 (SD 13,196.89) per patient per day (Fig 3). Overall, direct medical cost of HF hospitalization was increasingly higher among those with NYHA stages III and IV, HFrEF and HFmrEF, comorbid renal and liver diseases, and those who died during hospitalization (S Table 1, S Table 2, S Table 3 and S Table 4, and S Fig 1).

Item Line	Amount (Kshs) (Mean, SD)			
	Overall	**General ward**	**CCU**	**P-value**
Inpatient Fees	18091.72 (20861.32)	7919.78 (4856.96)	28853.34 (25471.93)	<0.0001
Lab Investigations	22733.39 (14135.5)	20953.01 (11167.76)	24619.99 (16590.92)	0.5124
Imaging	5139.44 (4928.71)	6434.25 (5814.52)	3769.57 (3296.85)	0.0004
Medications	36694.92 (42403.40)	18833.61 (19719.78)	55591.67 (51105.17)	<0.0001
Oxygen	10044.44 (9743.60)	7960.53 (6530.91)	12373.53 (12076.73)	0.167
Other Utilities	11427.48 (12925.69)	7505.31 (4583.15)	15577.02 (17035.38)	0.0011
Cost/patient (Kshs)	**99065.65 (76339.71)**	**65775.94 (36922.10)**	**134285.20 (90510.95)**	<0.0001
Total cost/patient (USD)	**807.44 (622.21)**	**536.11 (300.94)**	**1094.50 (737.71)**	
LOS (days)	**10.1 (7.1)**	**10.0 (6.6)**	**10.3 (7.7)**	
Cost/patient/day (Kshs)	**11470.94 (8289.57)**	**7687.57 (3783.92)**	**15473.63 (9782.79)**	
Cost/patient/day (USD)	**93.49 (67.56)**	**62.66 (30.84)**	**126.12 (79.74)**	

Table 4: Direct medical cost of heart failure hospitalization

[Fig 2. Drivers of the overall direct medical cost of HF hospitalization]

[Fig 3. Stratified direct medical costs by the primary cause of HF]

4. **Discussion**

This study found that CP was the most common primary cause of HF among patients hospitalized with ADHF in MTRH, accounting for 28.9%. Other leading causes of HF were HHD, DCM and RHD, consistent with several previously published studies in Sub-Saharan Africa (SSA) (4,15,21–23). Our findings highlight the importance of CP, as well as the role of chronic lung diseases (CLDs), alongside other drivers of HF morbidity in SSA (24–26). Notably, 46.3% of those who had CP in this study had chronic obstructive lung disease, 24.4% had indeterminate pulmonary hypertension, 17.1% had post-tuberculosis lung fibrosis and bronchiectasis, 7.3% had lung masses and 4.9% had pulmonary embolism. Although we did not collect data on indoor air pollution, it is possible that indoor air pollution contributed to the high prevalence of chronic lung diseases hence CP. Recent studies conducted in Western Kenya reported significantly high levels of indoor air pollution due to biomass fuel use (27,28), and this was strongly associated with different cardiac abnormalities, differentially affecting women and those with low socioeconomic status (29,30). It is notable that more women than

men had HF in this study; 51.4% vs 48.6%, had CP; 56.1% vs 43.9%, and 73.9% overall had unskilled labour, reflecting low socio-economic status.

This study found that the mean direct medical cost of HF hospitalization at MTRH was Kshs. 11,470.94 (SD 8,289.57) {USD 93.49 (67.56)} per patient per day. Kwok et al., in the US reported a cost of USD 11,845 (SD 22,710)(31), while Zaour et al., in Canada reported USD 10,123 per patient per hospitalization (32). Other studies from observational cohorts in SSA have estimated the of societal cost impact of HF hospitalization to be USD 2,128 per patient per year (8). Comparatively, these costs are much higher than what we found, highlighting the importance of healthcare service delivery context in cost modelling. It is possible that higher healthcare resource utilization in the developed countries, alongside different costs of health system inputs, variable health insurance coverage, and heterogeneity in the study designs resulted in the differences observed (33–36). In addition, our cost estimates represent costs in a government-subsidized health care system wherein, indirect costs as well as the human resource costs are not charged directly to patients.

The 2022 Economic Survey by the Kenya National Bureau of Statistics showed that the gross national income per capita in 2021 was Kshs. 20,122.23 (USD 164.01) per month(37). We were not able to get data on the average monthly income of the participants in this study, but it is notable that 83.5% of the participants did not complete high school, and 73.9% were unskilled labourers. Therefore, our finding of Kshs 11,470.94 (USD 93.49) indirect costs per patient per day would be extremely high against the Kenyan gross national income per capita, posing a high risk of financial catastrophe to the affected family members and public healthcare system. Although higher proportion of patients (52.8%) had national health insurance cover compared to the national average (26.5%), the higher coverage rate likely represents increased awareness of the importance of insurance cover and utilization among patients with chronic disease seeking tertiary facility care. This notwithstanding, there remains a need to intensify

advocacy for and implementation of widespread national health insurance coverage among patients with HF towards the achievement of universal health coverage (UHC) and sustainable development goal (SDG) 3.8)(38,39). Further, there is need to intensify primary management and prevention strategies among patients with HF to reduce chances of hospitalization hence the high direct medical costs of hospitalization.

To the best of our knowledge, this was the first study in the region to stratify direct medical cost of HF hospitalization by aetiology. This study found that treatment of HF caused by RHD was the most expensive, costing Kshs 15,299.08 per patient per day. Sub-analysis showed that of the patients with RHD, 67.9% were admitted in the cardiac intensive care unit (CCU). RHD associated HF accounted for 27.5% of the total CCU admissions. Further, 28.6% of those admitted with RHD associated HF died, accounting for 29.6% of all those who died (S Table 5). Notably, direct medical cost of those who died was twice the cost of those who were discharged alive. Finally, RHD accounted for 37.8% of all the patients with atrial fibrillation in this study. It is possible that additional treatment modalities such as cardioversion and anticoagulation among patients with RHD and atrial fibrillation (40) increased the cost of treatment. It is further arguable that most patients with RHD were critically ill at presentation, were admitted to the CCU for intensive care, and a significant number died, driving the cost upwards. Further studies are needed to characterize costs attributable to RHD, as well as community-based prevention measures noting that RHD is a preventable disease.

The cost of medications was the leading driver of the overall cost as has been evidenced in prior literature (41,42). The overall cost also expectedly increased with advanced NYHA (S Table 1), EF (S Table 2), comorbidities particularly (S Table S, and S Fig 1), and discharge status; overall cost of those who died was as twice as that of those who were discharged alive (S Table 3). Additionally, overall treatment cost among those who were hospitalised in CCU was twice as high as treatment cost in the general wards (Table 4). This would be because of

increased resource utilisation following intensive care for critically ill patients with advanced stages of HF (43–49).

This study however had the following limitations. First, participants were recruited from a public healthcare facility, hence the findings regarding cost may not be applicable to private healthcare facilities. Second, the utility of the findings on cost in designing healthcare budgets should be taken with caution because this study was conducted over a short period of time, and it may be difficult to predict how the cost may change over a longer time horizon. However, the costs reported per patient per day are intuitive and reflects daily consumption of healthcare resources during hospitalization with ADHF. Finally, payer's perspective used for costing in this study could be narrow and may not reflect the total cost of HF treatment during hospitalization.

5. Conclusion

In conclusion, cor pulmonale was the most common primary cause of HF, followed by CM, RHD and HHD. The mean direct medical cost of hospitalization was Kshs. 11,470.94 per patient per day. Weighted against Kenyan monthly gross national income per capita, this was extremely expensive. Stratified by primary cause of HF, RHD incurred the highest direct medical costs. Therefore, policies and community-oriented interventions should be put in place for early recognition and treatment of CP, among other primary causes of HF in view of the ongoing epidemiological transition in SSA since these causes are completely preventable. Further studies are also recommended exploring causal relationship between wider causes of HF in SSA, particularly with the current public health challenges of global concern such as climate change and air pollution. Additionally, widespread and improved health insurance coverage should be implemented to protect the affected families and the healthcare system from catastrophic spending resulting from high direct medical cost of HF hospitalization amid

the efforts towards the achievement of universal health coverage in Kenya. Finally, more extensive cost of illness studies such as societal perspective are recommended, detailing lost productivity among patients hospitalized with HF.

Acknowledgements

The authors thank all the staff and study participants for their co-operation during the study.

References

1. World Health Organization. Cardiovascular diseases (CVDs) [Internet]. Cardiovascular Diseases (CVDS). 2017. https://www.who.int/news-room/fact-sheets/detail/cardio-vascular-diseases-(cvds)

2. Sliwa K, Wilkinson D, Hansen C, Ntyintyane L, Tibazarwa K, Becker A, et al. Spectrum of heart disease and risk factors in a black urban population in South Africa (the Heart of Soweto Study): a cohort study. Lancet. 2008;371(9616):915–22.

3. Kimani K, Namukwaya E, Grant L, Murray SA. What is known about heart failure in sub-Saharan Africa: A scoping review of the English literature. Vol. 7, BMJ Supportive and Palliative Care. BMJ Publishing Group; 2017. p. 122–7.

4. Damasceno A, Mayosi BM, Sani M, Ogah OS, Mondo C, Ojji D, et al. The Causes, Treatment, and Outcome of Acute Heart Failure in 1006 Africans From 9 Countries. Arch Intern Med. 2012 Oct 8;172(18):1386.

5. Bloomfield GS, Barasa FA, Doll JA, Velazquez EJ. Heart Failure in Sub-Saharan Africa. Curr Cardiol Rev. 2013 May 17;9(2):157–73.

6. Cook C, Cole G, Asaria P, Jabbour R, Francis DP. The annual global economic burden of heart failure. Int J Cardiol. 2013 Feb 15;171(3):1–9.

7. Stevens B, Pezzullo L, Verdian L, Tomlinson J, George A, Bacal F. The economic burden of heart conditions in Brazil. Arq Bras Cardiol. 2018;111(1):29–36.

8. Ogah OS, Stewart S, Onwujekwe OE, Falase AO, Adebayo SO, Olunuga T, et al. Economic burden of heart failure: Investigating outpatient and inpatient costs in Abeokuta, Southwest Nigeria. PLoS One. 2014 Nov 21;9(11):1–17.

9. KNBS and ICF. Kenya Demographic and Health Survey 2022.Key Indicators Report.. Nairobi, Kenya, and Rockville, Maryland, USA; 2023. https://dhsprogram.com/-pubs/pdf/PR143/PR143.pdf

10. Binanay CA, Akwanalo CO, Aruasa W, Barasa FA, Corey GR, Crowe S, et al. Building Sustainable Capacity for Cardiovascular Care at a Public Hospital in Western Kenya. J Am Coll Cardiol. 2015;66(22):2550–60.

11. Chuma J, Okungu V. Viewing the Kenyan health system through an equity lens: Implications for universal coverage. Int J Equity Health. 2011 May 26;10(1):1–14.

12. Maritim B, Koon AD, Kimaina A, Lagat C, Riungu E, Laktabai J, et al. "It is like an umbrella covering you, yet it does not protect you from the rain": a mixed methods study of insurance affordability, coverage, and financial protection in rural western Kenya. Int J Equity Health. 2023 Dec 1;22(1):1–13.

13. Rudski LG, Lai WW, Afilalo J, Hua L, Handschumacher MD, Chandrasekaran K, et al. Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography: Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. J Am Soc Echocardiogr. 2010 Jul 1;23(7):685–713.

14. McDonagh TA, Metra M, Adamo M, Gardner RS, Baumbach A, Böhm M, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J. 2021;42(36):3599–726.

15. Stewart S, Wilkinson D, Hansen C, Vaghela V, Mvungi R, McMurray J, et al. Predominance of Heart Failure in the Heart of Soweto Study Cohort. Circulation. 2008 Dec 2;118(23):2360–7.

16. Choi H-J, Lee E-W. Methodology of Estimating Socioeconomic Burden of Disease Using National Health Insurance (NHI) Data. In: Reddy S, Tavares AI, editors. Rijeka: IntechOpen; 2019. p. Ch. 8.

17. Costa N, Derumeaux H, Rapp T, Garnault V, Ferlicoq L, Gillette S, et al. Methodological considerations in cost of illness studies on Alzheimer disease. Health Econ Rev. 2012 Sep 11;2(1):1–12.

18. Turner HC, Archer RA, Downey LE, Isaranuwatchai W, Chalkidou K, Jit M, et al. An Introduction to the Main Types of Economic Evaluations Used for Informing Priority Setting and Resource Allocation in Healthcare: Key Features, Uses, and Limitations. Front Public Heal. 2021 Aug 25;9:722927.

19. Jo C. Cost-of-illness studies: concepts, scopes, and methods. Clin Mol Hepatol. 2014;20(4):327–37.

20. Central Bank of Kenya. Foreign Exchange Rates | CBK. 2022. https://www.central-bank.go.ke/rates/forex-exchange-rates/

21. Karaye KM, Dokainish H, ElSayed A, Mondo C, Damasceno A, Sliwa K, et al. Clinical Profiles and Outcomes of Heart Failure in Five African Countries: Results from INTER-CHF Study. Glob Heart. 2021 Jul 30;16(1):50.

22. Eberly LA, Rusingiza E, Park PH, Ngoga G, Dusabeyezu S, Mutabazi F, et al. Understanding the Etiology of Heart Failure Among the Rural Poor in Sub-Saharan Africa: A 10-Year Experience From District Hospitals in Rwanda. J Card Fail. 2018;24(12):849–53.

23. Makubi A, Hage C, Sartipy U, Lwakatare J, Janabi M, Kisenge P, et al. Heart failure in Tanzania and Sweden: Comparative characterization and prognosis in the Tanzania Heart Failure (TaHeF) study and the Swedish Heart Failure Registry (SwedeHF). Int J Cardiol. 2016 Oct 10;220:750.

24. Onyango EM, Onyango BM. The Rise of Noncommunicable Diseases in Kenya: An Examination of the Time Trends and Contribution of the Changes in Diet and Physical Inactivity. J Epidemiol Glob Health. 2018;8(1–2):1.

25. Xie M, Liu X, Cao X, Guo M, Li X. Trends in prevalence and incidence of chronic respiratory diseases from 1990 to 2017. Respir Res. 2020 Feb 11;21(1):1–13.

26. Binegdie AB, Meme H, El Sony A, Haile T, Osman R, Miheso B, et al. Chronic respiratory disease in adult outpatients in three African countries: a cross-sectional study. Int J Tuberc Lung Dis. 2022 Jan 1;26(1):18.

27. Dida GO, Lutta PO, Abuom PO, Mestrovic T, Anyona DN. Factors predisposing women and children to indoor air pollution in rural villages, Western Kenya. Arch Public Heal. 2022 Dec 1;80(1):1–13.

412 28. Musyoka D, Muindi K. A Descriptive Assessment of Household Air Pollution in Rural
413 Kitchens in Kenya. Atmos 2022, Vol 13, Page 2115. 2022 Dec 16;13(12):2115.

414 29. Lagat DK, Delong AK, Wellenius GA, Carter EJ, Bloomfield GS, Velazquez EJ, et al.
415 Factors associated with isolated right heart failure in women a pilot study from western
416 kenya. Glob Heart. 2014;9(2):249–54.

417 30. Agarwal A, Kirwa K, Eliot MN, Alenezi F, Menya D, Mitter SS, et al. Household air
418 pollution is associated with altered cardiac function among women in Kenya. Am J
419 Respir Crit Care Med. 2018 Apr 1;197(7):958–61.

420 31. Kwok CS, Abramov D, Parwani P, Ghosh RK, Kittleson M, Ahmad FZ, et al. Cost of
421 inpatient heart failure care and 30-day readmissions in the United States. Int J Cardiol.
422 2021;329:115–22.

423 32. Zaour N, Barbeau M, Liu N, Borrelli R, Fischer A. The cost of hospitalization and length
424 of stay for chronic heart failure cases in Canada. Can J Cardiol. 2015 Oct 1;31(10):S273.

425 33. Garcia-Escribano M, Mogues T, Juarros P. Patterns and Drivers of Health Spending
426 Efficiency. IMF Work Pap. 2022;2022(048):1.

427 34. Urbich M, Globe G, Pantiri K, Heisen M, Bennison C, Wirtz HS, et al. A Systematic
428 Review of Medical Costs Associated with Heart Failure in the USA (2014–2020).
429 PharmacoEconomics 2020 3811. 2020 Aug 19;38(11):1219–36.

430 35. Osenenko KM, Kuti E, Deighton AM, Pimple P, Szabo SM. Burden of hospitalization
431 for heart failure in the United States: a systematic literature review. J Manag Care Spec
432 Pharm. 2022;28(2):157–67.

433 36. Tarricone R. Cost-of-illness analysis. What room in health economics? Health Policy
434 (New York). 2006;77(1):51–63.

435 37. Kenya National Bureau of Statistics. Economic Survey 2022. 2022.

436 38. WHO. Targets of Sustainable Development Goal 3. 2023. https://www.who.int/europe/-
437 about-us/our-work/sustainable-development-goals/targets-of-sustainable-development-
438 goal-3

439 39. WHO. Universal health coverage (UHC). 2022. https://www.who.int/news-room/fact-
440 sheets/detail/universal-health-coverage-(uhc)

441 40. Katritsis DG, Gersh BJ, John Camm A. Anticoagulation in Atrial Fibrillation – Current
442 Concepts. Arrhythmia Electrophysiol Rev. 2015 Sep 1;4(2):100.

443 41. Wang S, Petzold M, Cao J, Zhang Y, Wang W. Direct Medical Costs of Hospitalizations
444 for Cardiovascular Diseases in Shanghai, China. Med (United States). 2015;94(20):1–8.

445 42. Ong SC, Low JZ, Yew WY, Yen CH, Abdul Kader MASK, Liew HB, et al. Cost analysis
446 of chronic heart failure management in Malaysia: A multi-centred retrospective study.
447 Front Cardiovasc Med. 2022 Nov 2;9.

448 43. Alghamdi A, Algarni E, Balkhi B, Altowaijri A, Alhossan A. Healthcare Expenditures
449 Associated with Heart Failure in Saudi Arabia: A Cost of Illness Study. Healthcare. 2021
450 Aug 1;9(8).

451 44. Delgado JF, Oliva J, Llano M, Pascual-Figal D, Grillo JJ, Comín-Colet J, et al. Health
452 care and nonhealth care costs in the treatment of patients with symptomatic chronic heart
453 failure in Spain. Rev Esp Cardiol (Engl Ed). 2014 Aug;67(8):643–50.

454 45. Givertz MM, Yang M, Hess GP, Zhao B, Rai A, Butler J. Resource utilization and costs
455 among patients with heart failure with reduced ejection fraction following a worsening
456 heart failure event. ESC Hear Fail. 2021 Jun 1;8(3):1915–23.

457 46. Stafylas P, Farmakis D, Kourlaba G, Giamouzis G, Tsarouhas K, Maniadakis N, et al.
458 The heart failure pandemic: The clinical and economic burden in Greece. Int J Cardiol.
459 2017 Jan 15;227:923–9.

460 47. Rihova B, Paremca J, Jarkovsky J, Miklik R, Sulcova A, Littnerova S, et al. Cardiology
461 department hospitalization costs in patients with acute heart failure vary according to
462 the etiology of the acute heart failure: Data from the AHEAD Core registry 2005–2009.
463 Cor Vasa. 2013 Feb 1;55(1):e7–14.

464 48. Chamberlain AM, Sauver JLS, Gerber Y, Manemann SM, Boyd CM, Dunlay SM, et al.
465 Multimorbidity in heart failure: A community perspective. Am J Med [Internet].
466 2015;128(1):38–45.

467 49. Mehrotra S, Sharma TM, Bahl A. Impact of Comorbidities in Heart Failure – Prevalence,
468 Effect on Functional Status, and Outcome in Indian Population: A Single-Center
469 Experience. J Clin Prev Cardiol. 2019;(8):166–72.

470

Supporting information

S Table 1. Direct medical cost by NYHA

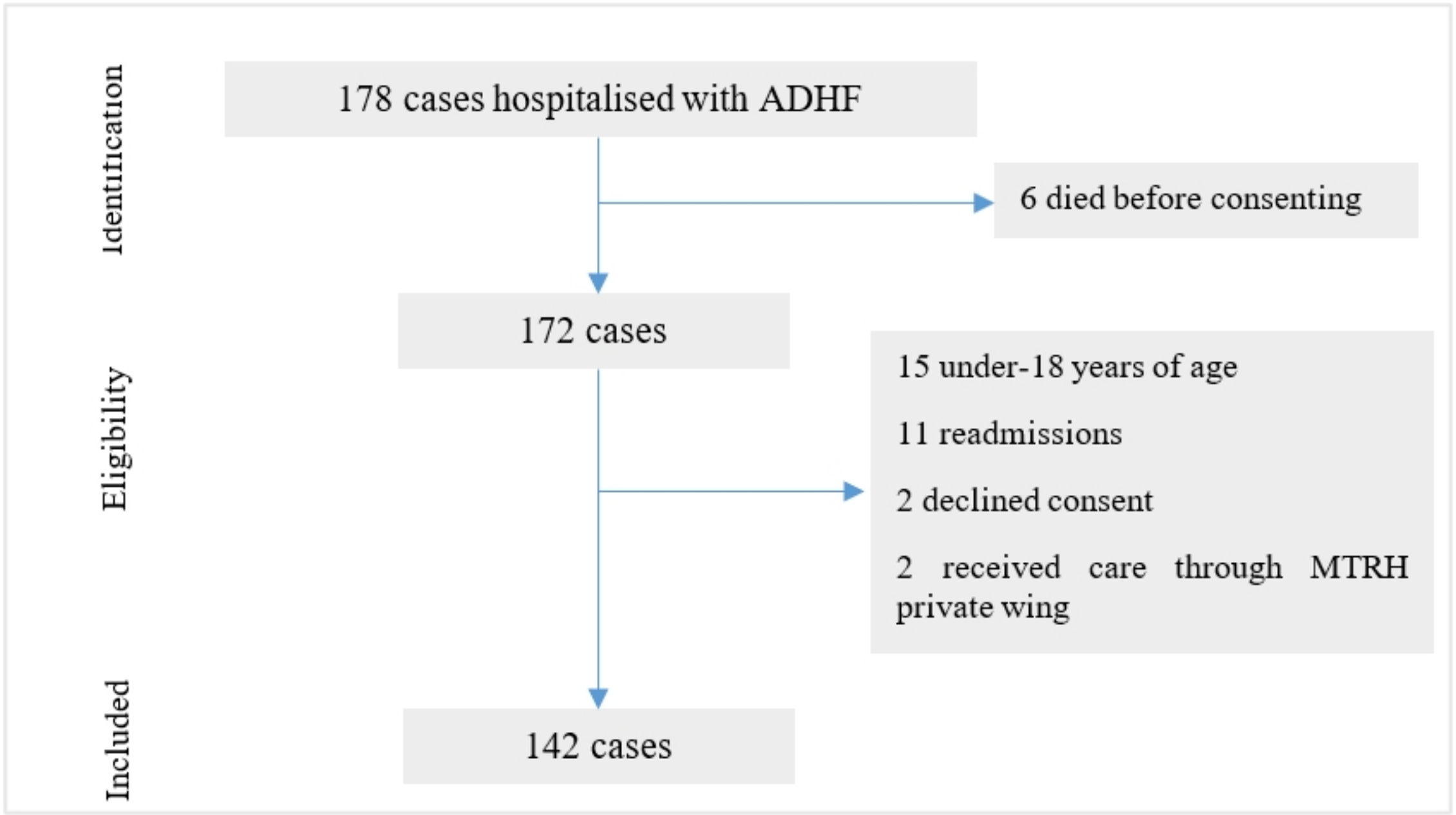
S Table 2. Direct medical cost by EF

S Table 3. Direct medical costs by outcome status

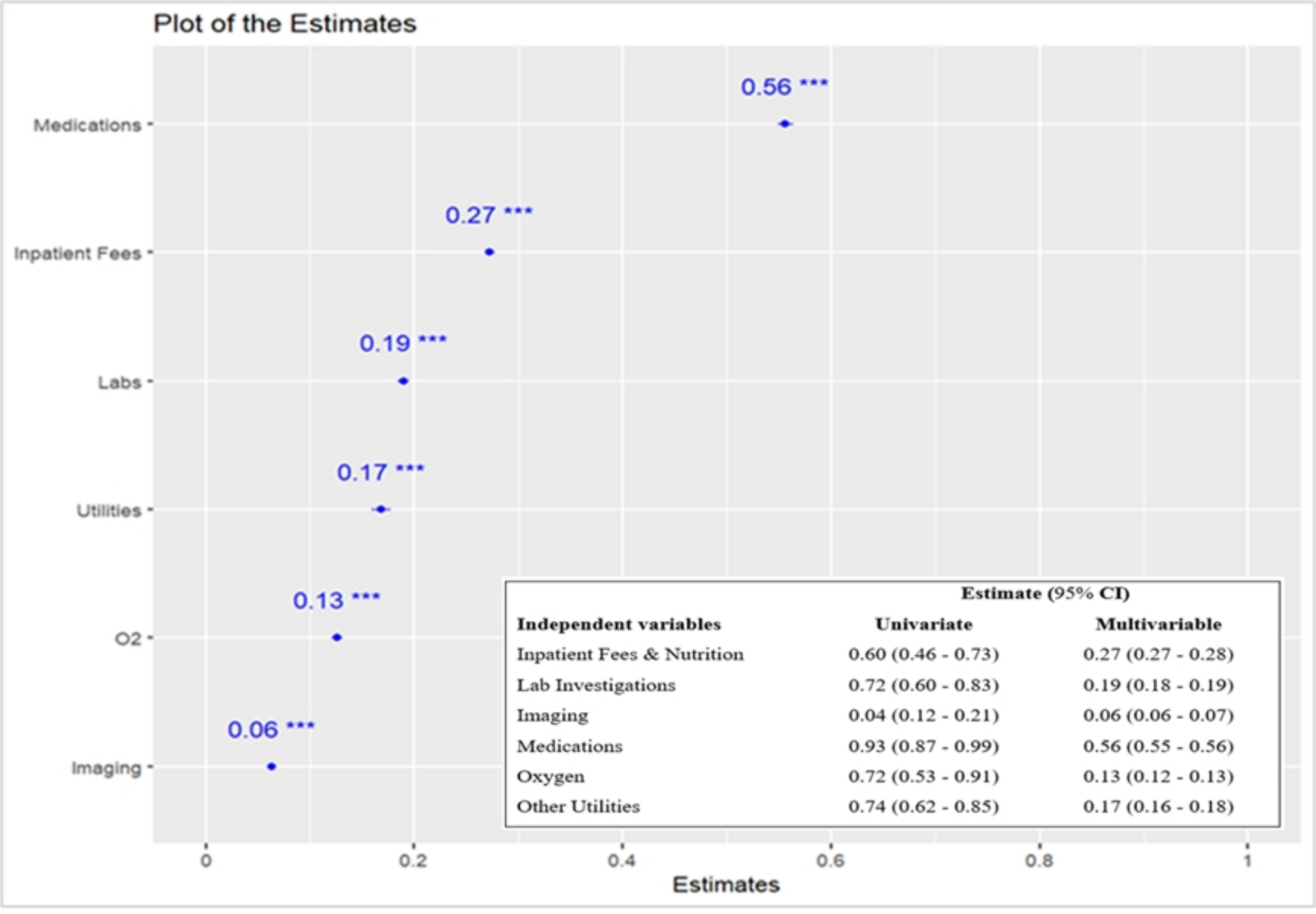
S Table 4. Effect of comorbidities on the overall cost

S Table 5. Baseline Characteristics per primary cause of HF

S Fig 1. Coefficient plot of the effect of the comorbidities on the overall cost

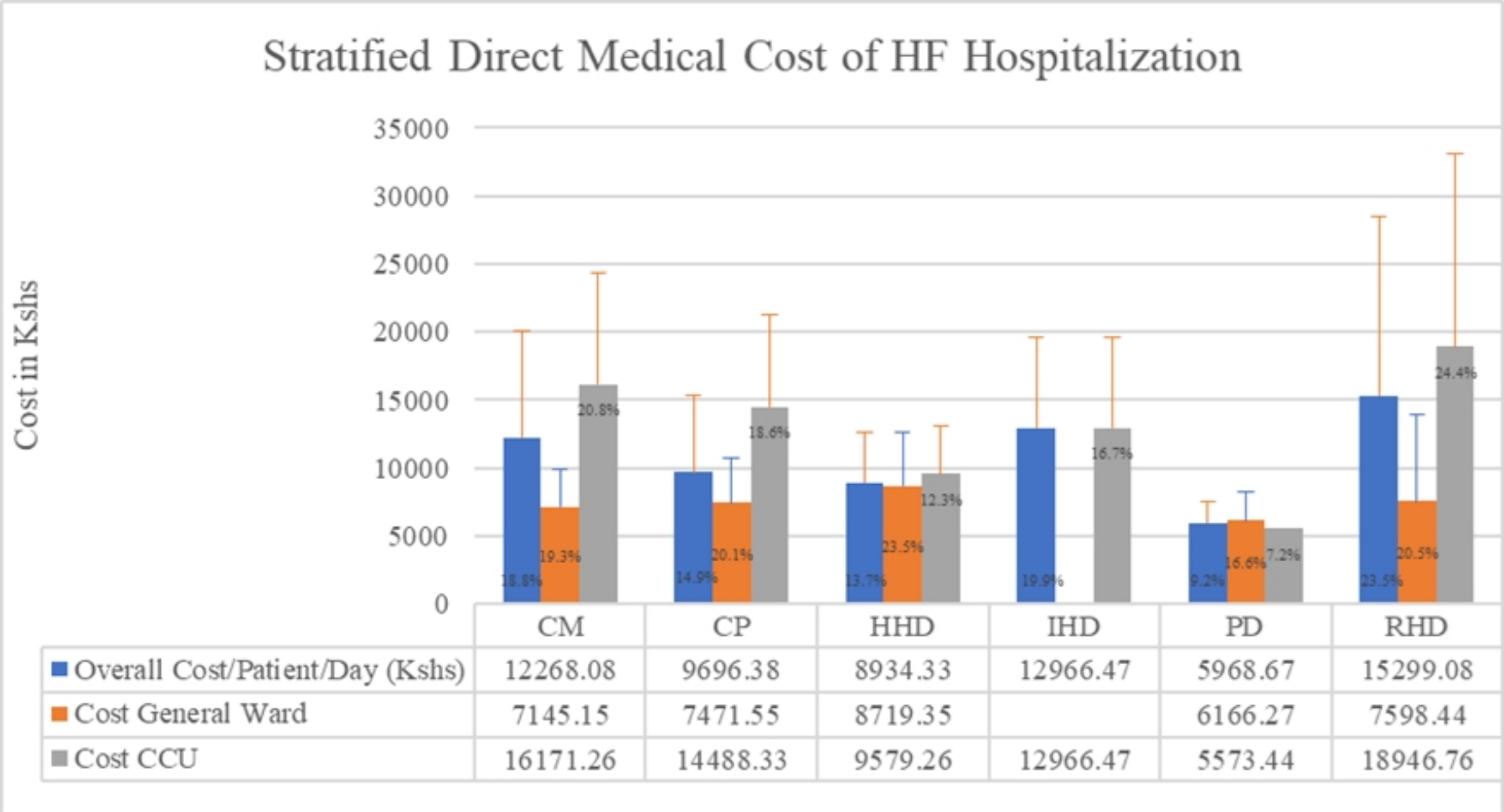

Identification
178 cases hospitalised with ADHF
6 died before consenting
Eligibility
172 cases
15 under-18 years of age
11 readmissions
2 declined consent
2 received care through MTRH private wing
Included
142 cases

Figure



Independent variables	Estimate (95% CI) Univariate	Multivariable
Inpatient Fees & Nutrition	0.60 (0.46 - 0.73)	0.27 (0.27 - 0.28)
Lab Investigations	0.72 (0.60 - 0.83)	0.19 (0.18 - 0.19)
Imaging	0.04 (0.12 - 0.21)	0.06 (0.06 - 0.07)
Medications	0.93 (0.87 - 0.99)	0.56 (0.55 - 0.56)
Oxygen	0.72 (0.53 - 0.91)	0.13 (0.12 - 0.13)
Other Utilities	0.74 (0.62 - 0.85)	0.17 (0.16 - 0.18)

Figure



	CM	CP	HHD	IHD	PD	RHD
Overall Cost/Patient/Day (Kshs)	12268.08	9696.38	8934.33	12966.47	5968.67	15299.08
Cost General Ward	7145.15	7471.55	8719.35		6166.27	7598.44
Cost CCU	16171.26	14488.33	9579.26	12966.47	5573.44	18946.76

Figure