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Clinical Characteristics, Comorbidity Profile, and Medication Use Among Patients with Heart Failure: A Cross-Sectional Study

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Abstract

Background: Heart failure (HF) is associated with substantial morbidity and frequently occurs alongside multiple comorbidities, contributing to complex medication use. This study aimed to describe the clinical characteristics, comorbidities, laboratory findings, and medication use among patients with HF in Saudi Arabia, focusing on sex differences. **Methods:** A retrospective cross-sectional study was conducted among adults with heart failure at King Abdul-Aziz Medical City, Saudi Arabia. Data from electronic medical records (2016–2018) were analyzed for demographic, clinical, laboratory, comorbidity, and medication characteristics. Differences between male and female patients were assessed using appropriate statistical tests, with odds ratios and 95% confidence intervals calculated for selected variables. Statistical significance was set at $p < 0.05$. **Results:** Among 1363 patients, 669 (49.1%) were male and 694 (50.9%) female. Females had higher BMI (34.64 ± 7.99 vs. 28.99 ± 6.91 kg/m^2, $p < 0.001$), hypertension (50.7% vs. 41.4%; $p < 0.001$), diabetes (47.4% vs. 40.7%; $p = 0.012$), and atrial fibrillation (29.7% vs. 20.0%; $p < 0.001$). Males had higher smoking prevalence (60.4% vs. 3.3%; $p < 0.001$), ischaemic heart disease (43.6% vs. 27.1%; OR 2.08, 95% CI 1.66–2.61; $p < 0.001$), creatinine ($p < 0.001$), and BNP ($p = 0.004$). Beta-blocker and ACE inhibitor use was higher among males, whereas ARB use was higher among females (all $p < 0.05$). **Conclusions:** In this study, patients with heart failure had a high burden of cardiovascular and cardiometabolic comorbidities, with notable sex-related differences in clinical characteristics, comorbidities, laboratory measures, and medication use. These findings provide real-world evidence on HF profiles and medication use in a Saudi tertiary-care setting and highlight the need for multicenter studies to characterize these patterns across diverse populations.

Keywords: heart failure; comorbidities; medication use; sex differences; clinical characteristics; real-world evidence; Saudi Arabia

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1. Introduction

Cardiovascular diseases (CVDs), including heart failure (HF), coronary artery disease, hypertensive heart disease, and stroke, remain the leading cause of death and a major con-

tributor to morbidity worldwide. These conditions share several common cardiometabolic and behavioral risk factors, including hypertension, diabetes mellitus, dyslipidemia, obesity, smoking, and physical inactivity, which are associated with cardiovascular disease development and progression [1,2].

HF is a complex clinical syndrome associated with structural or functional abnormalities of the heart and impaired cardiac performance [3,4]. Common clinical manifestations include dyspnea, fatigue, and reduced exercise tolerance, while physical examination may reveal peripheral edema, pulmonary crackles, elevated jugular venous pressure, and hepatomegaly [5,6]. The clinical characteristics and underlying causes of HF vary across populations, with ischemic heart disease, hypertension, and cardiomyopathies among the commonly reported underlying conditions [7].

HF affects an estimated 64 million people worldwide, reflecting population aging, improved survival after acute cardiovascular events, and the high prevalence of cardiometabolic risk factors [8]. Although HF incidence has stabilized in some high-income countries, its overall burden continues to increase in many settings [9]. HF prevalence rises markedly with age, from approximately 1–2% in the general population to more than 8% among individuals aged over 75 years [10,11].

Patients with HF frequently have multiple comorbidities, which increase clinical complexity and influence treatment selection, and their burden varies considerably across populations [12–14]. Medication use is a central component of HF management, and patients commonly receive multiple cardiovascular drug classes according to their clinical characteristics.

In Saudi Arabia, the high prevalence of diabetes mellitus and obesity makes CVD a major public health challenge, highlighting the importance of locally generated evidence [15,16]. Previous Saudi studies, including the HEARTS registry and hospital-based investigations, have described the clinical characteristics, comorbidity profiles, and sex-related differences among patients with HF [17–21]. However, these studies were based on data collected between 2002 and 2011, predominantly included male patients, or focused on specific subgroups, such as patients with acute decompensated HF or subsequent stroke [17,20–22]. More recent data from broader hospital-based populations, particularly those examining sex-related differences across a wide range of laboratory parameters and individual medication classes, remain limited. The present study addresses this gap by analyzing data from 1363 patients with HF treated at King Abdul-Aziz Medical City during 2016–2018, identified hospital-wide from electronic medical records and including an equal representation of men and women. Accordingly, this study aimed to describe the clinical characteristics, comorbidity profile, laboratory findings, and medication use among patients with HF, with a specific focus on differences between men and women.

2. Methods

2.1. Study Design and Setting

A retrospective cross-sectional study was conducted at King Abdul-Aziz Medical City, a tertiary care hospital in Saudi Arabia. Patient data were retrospectively retrieved from the hospital's electronic medical records for the period from 2016 to 2018.

2.2. Study Population and Patient Identification

The study population comprised adult patients with heart failure (HF) identified from the electronic medical records at King Abdul-Aziz Medical City. Patients were identified primarily using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code 428.x, supplemented by relevant diagnostic terms and search criteria available within the electronic medical record system. Inclusion criteria were:

(1) age ≥18 years; and (2) a documented diagnosis of HF identified using ICD-9-CM code 428.x and/or relevant diagnostic terms in the electronic medical record.

Exclusion criteria were: (1) records in which HF could not be confirmed following review of the available medical records; (2) duplicate entries for the same patient, with one valid record retained for each eligible patient; and (3) patients with incomplete required clinical or laboratory data. Eligible patients meeting the inclusion criteria and none of the exclusion criteria were included in the final study population.

2.3. Data Collection and Study Variables

Demographic, clinical, laboratory, echocardiographic, comorbidity, and medication-related information was retrospectively obtained from electronic medical records. Demographic variables included age, sex, and ethnicity. Clinical variables comprised heart rate, systolic and diastolic blood pressure, and body mass index (BMI).

Laboratory variables included white blood cell count, troponin I, sodium, potassium, low-density lipoprotein (LDL), glycated hemoglobin (HbA1c), creatinine, total cholesterol, B-type natriuretic peptide (BNP), hemoglobin, and calcium. Echocardiographic data included ejection fraction (EF).

Medication use was assessed based on documented medication records and included beta-blockers, angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), diuretics, statins, calcium channel blockers (CCBs), digoxin, and isosorbide dinitrate.

The recorded comorbidities included ischemic heart disease, hypertension, diabetes mellitus, chronic renal disease, asthma, Alzheimer's disease, anemia, depression, atrial fibrillation, dyslipidemia, osteoporosis, benign prostatic hyperplasia, cancer, cataracts, and hip fractures. For descriptive purposes, BNP values of ≥100 pg/mL were categorized as elevated, creatinine concentrations of >110 μmol/L as raised, and BMI values of ≥30 kg/m^2 as indicative of obesity. Hypertension, diabetes mellitus, chronic kidney disease, and atrial fibrillation were classified based on documented diagnoses in the medical records.

2.4. Statistical Analysis

Data analysis was conducted using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables were reported as means with standard deviations (SDs), whereas categorical variables were summarized using frequencies and percentages. Differences between male and female patients were evaluated using independent-samples Student's *t*-test when the assumption of equal variances was met and Welch's *t*-test when this assumption was not met. For categorical variables, Pearson's chi-square (χ^2) test was applied, with Fisher's exact test used when the expected frequency in a cell was less than 5. For selected categorical comorbidity and medication variables, odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to quantify the association between sex and the respective variables. Associations between selected clinical and laboratory variables were assessed using Pearson correlation coefficients (r); smoking status was coded as a binary variable for correlation analysis. All statistical tests were two-sided, and a p-value < 0.05 was considered statistically significant. To place the findings in context, the characteristics of the present cohort were descriptively compared with those reported in published regional and international HF registries, without formal statistical testing.

2.5. Ethical Considerations

The study protocol was reviewed and approved by the hospital Research Ethics Board (RFN: RC/18/407/R). As the study involved a retrospective review of existing medical records and did not require direct participant contact, the requirement for informed consent

was waived by the Research Ethics Board. All data were analyzed in accordance with the requirements of the approving institutional ethics committee.

3. Results

A total of 1363 patients with heart failure were included, comprising 669 (49.1%) males and 694 (50.9%) females. The mean age was 69.14 ± 12.16 years, with no significant difference between males and females ($p = 0.591$). Females had significantly higher systolic blood pressure (137.78 ± 27.09 vs. 134.53 ± 25.67 mmHg, $p = 0.023$) and BMI (34.64 ± 7.99 vs. 28.99 ± 6.91 kg/m^2, $p < 0.001$), whereas males had higher diastolic blood pressure (71.18 ± 15.73 vs. 68.90 ± 14.52 mmHg, $p = 0.006$). Heart rate did not differ significantly between males and females ($p = 0.377$). Smoking was reported in 427 (31.3%) patients, including 404 (60.4%) males and 23 (3.3%) females, with a significant difference between the groups ($p < 0.001$). The mean left ventricular ejection fraction was 39.89 ± 10.81%, with no significant difference between males and females (39.42 ± 11.24% vs. 40.34 ± 10.36%, $p = 0.117$) (Table 1).

Table 1. Baseline Demographic, Clinical, and Echocardiographic Characteristics of Patients with Heart Failure.

Variable	Overall (n = 1363)	Male (n = 669)	Female (n = 694)	*p*-Value
Age (years)	69.14 ± 12.16	69.32 ± 12.54	68.97 ± 11.80	0.591
Systolic blood pressure (mmHg)	136.18 ± 26.44	134.53 ± 25.67	137.78 ± 27.09	0.023
Diastolic blood pressure (mmHg)	70.02 ± 15.16	71.18 ± 15.73	68.90 ± 14.52	0.006
Heart rate (beats/min)	85.47 ± 19.50	85.00 ± 19.41	85.93 ± 19.58	0.377
Body mass index (kg/m^2)	31.87 ± 7.99	28.99 ± 6.91	34.64 ± 7.99	<0.001
Smoking, n (%)	427	404 (60.39%)	23 (3.31%)	<0.001
Ejection Fraction (%)	39.89 ± 10.81	39.42 ± 11.24	40.34 ± 10.36	0.117

Student's *t*-test.

The comorbidity profile of the study population is presented in Table 2. Ischaemic heart disease, hypertension, and diabetes mellitus were among the most frequently reported comorbidities. The prevalence of ischaemic heart disease was higher among males than females (43.6% vs. 27.1%; OR, 2.08; 95% CI, 1.66–2.61; $p < 0.001$). In contrast, hypertension (50.7% vs. 41.4%; OR 0.69, 95% CI 0.55–0.85; $p < 0.001$) and diabetes mellitus (47.4% vs. 40.7%; OR 0.76, 95% CI 0.61–0.94; $p = 0.012$) were more frequently reported among females. Asthma was more common among females than males (5.2% vs. 1.9%; OR 0.36, 95% CI 0.19–0.69; $p = 0.001$), as were atrial fibrillation (29.7% vs. 20.0%; OR 0.59, 95% CI 0.46–0.76; $p < 0.001$) and osteoporosis (5.2% vs. 1.5%; OR 0.28, 95% CI 0.14–0.56; $p < 0.001$). Cataracts were documented more frequently among females than males (11.8% vs. 8.4%; OR, 0.68; 95% CI, 0.48–0.98; $p = 0.035$). The distribution of chronic kidney disease was similar between the two groups ($p = 0.925$). No statistically significant sex-based differences were identified for Alzheimer disease ($p = 0.185$), anemia ($p = 0.295$), depression ($p = 0.136$), dyslipidaemia ($p = 0.518$), cancer ($p = 0.626$), or hip fracture ($p = 0.288$) (Table 2).

The laboratory characteristics of the study population are presented in Table 3. The mean WBC count was significantly higher among females than males (8.58 ± 3.60 vs. 8.16 ± 3.33 × 10^9/L, $p = 0.026$). Mean creatinine levels were significantly higher among males than females (147.07 ± 123.11 vs. 114.73 ± 88.59 µmol/L, $p < 0.001$).

Total cholesterol concentrations differed significantly by sex, with females showing a higher mean level than males (3.87 ± 1.07 vs. 3.74 ± 1.14 mmol/L, $p = 0.037$). Mean BNP levels were significantly higher among males than females (232.04 ± 293.42 vs. 186.55 ± 270.17, $p = 0.004$). Similarly, mean hemoglobin levels were higher among males than females (126.73 ± 22.35 vs. 117.07 ± 19.09 g/L, $p < 0.001$), whereas mean calcium

levels were higher among females (2.32 ± 0.16 vs. 2.28 ± 0.12 mmol/L, $p < 0.001$). No statistically significant differences between males and females were observed for troponin I ($p = 0.934$), sodium ($p = 0.883$), potassium ($p = 0.833$), LDL ($p = 0.787$), or HbA1c ($p = 0.176$) (Table 3).

Table 2. Comorbidity Profile of Patients with Heart Failure.

Comorbidity	Male n (%)	Female n (%)	Odds Ratio (95% CI)	*p*-Value
Ischaemic heart disease	292 (43.6)	188 (27.1)	2.08 (1.66–2.61)	<0.001
Hypertension	277 (41.4)	352 (50.7)	0.69 (0.55–0.85)	<0.001
Diabetes mellitus	272 (40.7)	329 (47.4)	0.76 (0.61–0.94)	0.012
Chronic kidney disease	148 (22.1)	155 (22.3)	0.99 (0.77–1.28)	0.925
Asthma	13 (1.9)	36 (5.2)	0.36 (0.19–0.69)	0.001
Alzheimer's disease	15 (2.2)	9 (1.3)	1.75 (0.76–4.02)	0.185
Anemia	69 (10.3)	84 (12.1)	0.84 (0.60–1.17)	0.295
Depression	9 (1.3)	17 (2.5)	0.54 (0.24–1.23)	0.136
Atrial fibrillation	134 (20.0)	206 (29.7)	0.59 (0.46–0.76)	<0.001
Dyslipidaemia	27 (4.0)	33 (4.8)	0.84 (0.50–1.42)	0.518
Osteoporosis	10 (1.5)	36 (5.2)	0.28 (0.14–0.56)	<0.001
Cancer	12 (1.8)	15 (2.2)	0.83 (0.38–1.78)	0.626
Cataract	56 (8.4)	82 (11.8)	0.68 (0.48–0.98)	0.035
Hip fracture	2 (0.3)	6 (0.9)	0.34 (0.07–1.71)	0.288

Comparisons were performed using **Pearson's χ^2 test**. **Fisher's exact test** was used when expected cell counts were <5. Odds ratios (ORs) with **95% confidence intervals (CIs)** were calculated from 2 × 2 contingency tables.

Table 3. Laboratory Characteristics of Patients with Heart Failure.

Laboratory Parameter	n	Overall (Mean ± SD)	Male (Mean ± SD)	Female (Mean ± SD)	*p*-Value
WBC ($\times 10^9$/L)	1358	8.38 ± 3.47	8.16 ± 3.33	8.58 ± 3.60	**0.026**
Troponin I	1245	237.16 ± 1692.96	233.16 ± 1570.80	241.08 ± 1805.85	0.934
Sodium (mmol/L)	1360	135.51 ± 4.31	135.53 ± 4.07	135.50 ± 4.54	0.883
Potassium (mmol/L)	1352	4.56 ± 0.61	4.56 ± 0.63	4.57 ± 0.59	0.833
LDL (mmol/L)	1111	2.24 ± 0.92	2.23 ± 0.96	2.25 ± 0.88	0.787
HbA1c (%)	1195	7.90 ± 2.00	7.98 ± 2.03	7.82 ± 1.97	0.176
Creatinine (µmol/L)	1359	130.65 ± 108.16	147.07 ± 123.11	114.73 ± 88.59	**<0.001**
Total cholesterol (mmol/L)	1123	3.81 ± 1.11	3.74 ± 1.14	3.87 ± 1.07	**0.037**
BNP	1286	209.01 ± 282.70	232.04 ± 293.42	186.55 ± 270.17	**0.004**
Hemoglobin (g/L)	1351	121.84 ± 21.31	126.73 ± 22.35	117.07 ± 19.09	**<0.001**
Calcium (mmol/L)	1335	2.30 ± 0.14	2.28 ± 0.12	2.32 ± 0.16	**<0.001**

Welch's independent-samples *t*-test, which does not assume equal variances.

Medication utilization patterns among patients with heart failure are presented in Table 4. Beta-blockers were used by 73.2% of males and 67.6% of females (OR 1.31, 95% CI 1.04–1.66; $p = 0.022$). ACE inhibitor use was also more frequent among males than females (49.2% vs. 39.2%; OR 1.50, 95% CI 1.21–1.86; $p < 0.001$). In contrast, ARB use was more frequent among females than males (42.5% vs. 29.1%; OR 0.56, 95% CI 0.44–0.70; $p < 0.001$). Calcium channel blocker use was also more frequent among females (49.4% vs. 41.7%; OR 0.73, 95% CI 0.59–0.91; $p = 0.004$). Isosorbide dinitrate use was more frequent among males than females (33.0% vs. 27.0%; OR 1.34, 95% CI 1.06–1.69; $p = 0.014$). No statistically significant differences between males and females were observed for diuretic use (69.8% vs. 68.3%; OR 1.07, 95% CI 0.85–1.35; $p = 0.548$), statin use (75.0% vs. 77.8%; OR 0.86, 95% CI 0.67–1.10; $p = 0.228$), or digoxin use (15.7% vs. 19.6%; OR 0.76, 95% CI 0.58–1.01; $p = 0.059$) (Table 4).

Table 4. Medication Utilization Patterns Among Patients with Heart Failure.

Medication Class	Male (n = 669)	Female (n = 694)	Odds Ratio (95% CI)	*p*-Value
Beta-blockers	490 (73.2%)	469 (67.6%)	1.31 (1.04–1.66)	0.022
ACE inhibitors	329 (49.2%)	272 (39.2%)	1.50 (1.21–1.86)	<0.001
ARBs	195 (29.1%)	295 (42.5%)	0.56 (0.44–0.70)	<0.001
Diuretics	467 (69.8%)	474 (68.3%)	1.07 (0.85–1.35)	0.548
Statins	502 (75.0%)	540 (77.8%)	0.86 (0.67–1.10)	0.228
Calcium channel blockers	279 (41.7%)	343 (49.4%)	0.73 (0.59–0.91)	0.004
Digoxin	105 (15.7%)	136 (19.6%)	0.76 (0.58–1.01)	0.059
Isosorbide dinitrate	221 (33.0%)	187 (27.0%)	1.34 (1.06–1.69)	0.014

Sex differences were assessed using Pearson's χ^2 test. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated from 2 × 2 contingency tables.

The Pearson correlation matrix for selected clinical and laboratory variables is presented in Table 5. Age showed a weak negative correlation with smoking ($r = -0.281$). BMI was weakly negatively correlated with BNP ($r = -0.232$) and smoking ($r = -0.186$). SBP showed a weak positive correlation with DBP ($r = 0.321$) and weak correlations with creatinine ($r = 0.116$) and smoking ($r = 0.118$). DBP showed weak correlations with age ($r = -0.132$), SBP ($r = 0.321$), and smoking ($r = 0.072$). Heart rate showed weak correlations with age ($r = -0.080$), BNP ($r = 0.041$), and smoking ($r = 0.089$). BNP showed a positive correlation with creatinine ($r = 0.297$) and a weak positive correlation with smoking ($r = 0.162$). Creatinine showed a weak positive correlation with smoking ($r = 0.194$). HbA1c demonstrated weak correlations with the other variables, with correlation coefficients ranging from −0.108 to 0.084 (Table 5). Overall, the observed correlations were predominantly weak in magnitude.

Table 5. Pearson Correlation Matrix of Selected Clinical and Laboratory Variables Among Patients with Heart Failure.

Variable	Age	BMI	SBP	DBP	HR	BNP	Creatinine	HbA1c	Smoking
Age	1.000	−0.086	0.003	−0.132	−0.080	−0.045	0.004	−0.108	−0.281
BMI	−0.086	1.000	0.105	−0.031	0.002	−0.232	−0.109	0.061	−0.186
SBP	0.003	0.105	1.000	0.321	0.032	0.010	0.116	0.052	0.118
DBP	−0.132	−0.031	0.321	1.000	0.026	0.022	−0.026	0.048	0.072
HR	−0.080	0.002	0.032	0.026	1.000	0.041	0.014	−0.012	0.089
BNP	−0.045	−0.232	0.010	0.022	0.041	1.000	0.297	−0.019	0.162
Creatinine	0.004	−0.109	0.116	−0.026	0.014	0.297	1.000	−0.058	0.194
HbA1c	−0.108	0.061	0.052	0.048	−0.012	−0.019	−0.058	1.000	0.084
Smoking	−0.281	−0.186	0.118	0.072	0.089	0.162	0.194	0.084	1.000

The distribution of categorized clinical and laboratory variables by sex is presented in Table 6. Obesity was more frequently observed among females than males (72.0% vs. 38.7%, $p < 0.001$). In contrast, elevated BNP (≥100 pg/mL) and elevated creatinine (>110 µmol/L) were more frequently observed among males than females (52.9% vs. 43.4% and 47.5% vs. 31.8%, respectively; both $p < 0.001$) (Table 6).

A comparison of the present cohort with major regional and international heart failure registries is presented in Table 7. Compared with the regional registries, patients in the present study were older (mean age 69.1 years) and included a higher proportion of women (50.9%). The prevalence of atrial fibrillation (24.9%) was higher than in the Saudi and Gulf registries, and obesity (55.7%) was more prevalent than in the Jordan registry, whereas hypertension (46.1%) and diabetes mellitus (44.1%) were less prevalent than in the Saudi, Gulf, and Jordan registries (Table 7).

Table 6. Clinical and Laboratory Characteristics by Sex in Patients with Heart Failure.

Variable	Male (n = 669)	Female (n = 694)	*p*-Value
Obesity (BMI ≥ 30 kg/m²)	259 (38.7%)	500 (72.0%)	<0.001
Elevated BNP (≥100 pg/mL)	354 (52.9%)	301 (43.4%)	<0.001
Elevated creatinine (>110 µmol/L)	318 (47.5%)	221 (31.8%)	<0.001

Pearson's χ^2 test.

Table 7. Comparison of the Present Cohort with Regional and International Heart Failure Registries.

Characteristic	Present Study	HEARTS Acute, Saudi Arabia [19]	HEARTS Chronic, Saudi Arabia [18]	Gulf CARE, Gulf Countries [23]	Egyptian Cohort, Acute/Chronic [24]	Jordan HF Registry [25]	ADHERE, USA [26]	ESC-HF-LT, Europe § [27]
Patients, n	1363	2610	685	5005	1475/670	2151	105,388	5039 §
Age, years	69.1	61.4 ‡	55.7	59	61/57 ‡	66	72.4	69.4
Female, %	50.9	34	29.9	37	30.4/35.8	42.0	52	37.4
Diabetes mellitus, %	44.1	64.1	52.7	50	45.4/31.8	69.2	44	39.0
Hypertension, %	46.1	70.6	66	61	43.5/40.8	80.7	73	65.6
Obesity, %	55.7	—	—	—	—	36.5	—	—
Atrial fibrillation, %	24.9	15.7	11.8	14	24.3/24.8	31.4	31	44.0
Chronic kidney disease, %	22.2	29.6	22	15	17.6/13.4	—	—	25.3
Ischaemic heart disease *, %	35.2	55.7	38.8	53	68.1/41.0	—	57	53.8
Beta-blockers †, %	70.4	79	90	71	65.8/67.0	67.4	—	72.6

* Ischaemic heart disease or coronary artery disease as a comorbidity in the present study, ADHERE, and ESC-HF-LT; ischaemic aetiology of heart failure in the other registries. † Documented use in the present study; use at admission in HEARTS acute and Egyptian cohorts; before heart failure clinic admission in HEARTS chronic cohort; home medication in the Jordan registry; and at discharge in Gulf CARE and ESC-HF-LT. ‡ Median age. § Patients hospitalized with acute heart failure; other ESC-HF-LT values refer to the 4449 hospitalized patients who completed 1-year follow-up. Chronic kidney disease corresponds to renal dysfunction in ESC-HF-LT. Values not reported in the primary publications were taken from the summary by Sulaiman et al. [23]. — = not reported. Abbreviations: ADHERE, Acute Decompensated Heart Failure National Registry; ESC-HF-LT, European Society of Cardiology Heart Failure Long-Term Registry (hospitalized patients); Gulf CARE, Gulf Acute Heart Failure Registry; HEARTS, Heart Function Assessment Registry Trial in Saudi Arabia; HF, heart failure.

4. Discussion

The present retrospective study describes the demographic, clinical, comorbidity, laboratory, and medication-use characteristics of 1363 patients with heart failure. The principal finding was substantial sex-related heterogeneity across clinical characteristics, comorbidity profiles, laboratory measures, and medication-use patterns.

To place our findings in context, the profile of the present cohort was compared with major regional and international HF registries. Several distinctive features emerged. First, patients in the present study were older (mean 69.1 years) than those in regional registries, including HEARTS acute (median 61.4 years) and chronic (55.7 years) cohorts, Gulf CARE (59 years), the Egyptian cohort (median 57–61 years), and the Jordan registry (66 years) [18,19,23,25,28]. Their age was similar to that of European patients in ESC-HF-LT (69.4 years) and closer to the ADHERE registry (72.4 years) [26,27]. Second, women constituted half of the present cohort (50.9%), compared with approximately 30–42% in Arab registries, in which women have been consistently under-represented [18,19,22–25]. This provides a valuable opportunity to examine sex-related differences in a Middle Eastern HF population.

Third, the comorbidity profile differed from that of earlier regional registries. Atrial fibrillation was more prevalent (24.9%) than in the Saudi and Gulf registries (11.8–15.7%) [18,19,23],

although lower than in the Jordan, ADHERE, and ESC-HF-LT registries (31.0–44.0%) [25–27]. In contrast, hypertension (46.1%) and diabetes mellitus (44.1%) were less prevalent than in HEARTS, Gulf CARE, and the Jordan registry [18,19,23,25], whereas obesity was more common (55.7% vs. 36.5% in the Jordan registry) [25]. The prevalence of chronic kidney disease (22.2%) was comparable with HEARTS chronic (22%) [18]. Ischaemic heart disease (35.2%) was less frequent than reported in most registries (38.8–68.1%), although definitions differed between studies [18,19,23,24,26,27]. Fourth, beta-blocker use (70.4%) was comparable with Gulf CARE and the Egyptian, Jordan, and ESC-HF-LT registries (65.8–72.6%) but lower than in the HEARTS registries (79–90%) [18,19,23–25,27].

These differences may reflect the older age, higher proportion of women, and hospital-wide case identification of the present cohort, compared with registries that predominantly enrolled younger, male, cardiology-referred patients, as well as differences in study periods and definitions. Together, these findings suggest that the HF population in routine tertiary care in Saudi Arabia may differ from that described in earlier registries, highlighting the value of contemporary, sex-specific real-world data.

Beyond these registries, the mean age of the present cohort (69.14 ± 12.16 years) was also higher than the mean age of 63 ± 13.75 years reported in a Saudi cohort of patients with acute decompensated heart failure [17], but was comparable with the mean age of approximately 70 years reported in the EuroHeart Failure Survey II (EHFS II) [29]. Similarly, previous studies from Saudi Arabia reported younger mean ages of 55.6 years among patients from Riyadh and Buraidah and approximately 63 years in a retrospective cohort from the Eastern region [30,31]. These differences may reflect variation in study settings, patient populations, and healthcare utilization. Females had slightly higher systolic blood pressure and BMI, whereas males had higher diastolic blood pressure; heart rate did not differ significantly between the sexes.

A substantial burden of cardiometabolic and cardiovascular comorbidities was observed, particularly obesity, hypertension, diabetes mellitus, ischemic heart disease, and atrial fibrillation. Ischemic heart disease was more frequently reported among males than females (43.6% vs. 27.1%; OR, 2.08; 95% CI, 1.66–2.61; $p < 0.001$).

Diabetes mellitus was present in 44.1% of the present cohort and was more frequently reported among females than males (47.4% vs. 40.7%; $p = 0.012$). Although lower than in most regional registries, this prevalence was higher than the 35% in acute HF and 29% in chronic HF reported in the ESC-HF Pilot Survey [32]. Thus, the diabetes prevalence in the present cohort was within the range reported across regional and international HF populations.

Obesity was present in 55.7% of the present cohort and was substantially more frequently observed among females than males (72.0% vs. 38.7%, $p < 0.001$). This prevalence was higher than that reported in the Jordan registry [25] and the 46.9% reported in the Egyptian registry [24]. Hypertension was present in 46.1% of patients and was more frequently reported among females (50.7% vs. 41.4%, $p < 0.001$), although the overall prevalence was lower than in most regional registries. Taken together, the higher prevalence of obesity, hypertension, and diabetes among females suggests a prominent cardiometabolic component of the female HF profile in this cohort. This pattern is broadly consistent with the published literature describing sex-related differences in heart failure risk factors, comorbidities, and clinical presentation, although the magnitude and distribution of these differences vary by population and heart failure phenotype [33].

Smoking was reported in 31.3% of patients, with a marked sex difference (60.4% in men vs. 3.3% in women, $p < 0.001$). This prevalence was lower than the 41% reported in the 2019 Jordan STEPS survey [34], while the substantially higher prevalence among men was consistent with previous regional studies [35,36]. Differences in smoking prevalence across

populations may reflect variation in demographic characteristics, smoking definitions, study settings, and data-collection methods. Atrial fibrillation was present in 24.9% of patients and was more frequently reported among women than men (29.7% vs. 20.0%; OR, 0.59; 95% CI, 0.46–0.76; $p < 0.001$). This prevalence was within the range reported by regional and international HF registries [24,26,28,32]. The higher prevalence of AF among women in the present cohort differs from the sex distribution reported in some previous HF populations and may reflect differences in patient demographics, HF phenotypes, comorbidity profiles, and clinical settings. Chronic kidney disease was present in approximately 22% of patients, with no significant difference between males and females ($p = 0.925$). Less common conditions, including asthma, osteoporosis, cataract, anemia, depression, dyslipidaemia, cancer, and hip fracture, were also documented, although their lower frequencies suggest that they accounted for a smaller proportion of the overall comorbidity burden.

Laboratory parameters demonstrated significant sex-related differences in WBC count, creatinine, total cholesterol, BNP, hemoglobin, and calcium. Men had higher mean creatinine (147.07 vs. 114.73 µmol/L), BNP (232.04 vs. 186.55 pg/mL), and hemoglobin (126.73 vs. 117.07 g/L), whereas women had slightly higher WBC count, total cholesterol, and calcium levels. Consistent with findings from the Colombian Heart Failure Registry, men had higher creatinine and hemoglobin levels than women [37]. No significant sex-related differences were observed for troponin I, sodium, potassium, LDL, or HbA1c. Although several laboratory parameters showed statistically significant sex-related differences, the absolute differences for some measures, particularly WBC count, total cholesterol, and calcium, were relatively small and should therefore be interpreted in terms of both statistical and potential clinical relevance. The higher BNP and creatinine levels among males, together with the higher prevalence of elevated BNP and creatinine, are consistent with sex-related differences in the laboratory and clinical profiles of this HF population.

Correlations among the selected clinical and laboratory variables were generally weak. The strongest relationships were observed between SBP and DBP ($r = 0.321$) and between creatinine and BNP ($r = 0.297$), while the remaining correlations were of weak magnitude. These findings indicate limited linear relationships among the evaluated variables and should be interpreted as descriptive patterns given the cross-sectional design.

The clinical phenotype findings further illustrate the observed sex-related heterogeneity. Women had higher frequencies of obesity, hypertension, diabetes, and atrial fibrillation, whereas men had higher smoking prevalence, ischemic heart disease, creatinine, and BNP levels. The markedly higher prevalence of obesity among women is consistent with recent evidence describing an obesity-related heart failure phenotype characterized by a substantial cardiometabolic comorbidity burden [38]. Similar sex-related differences in clinical and laboratory characteristics have been reported in heart failure registry data [18,37]. These findings should be interpreted as descriptive differences rather than evidence that sex itself determines the underlying clinical phenotype.

Medication utilization was characterized by frequent documented use of statins (76.4%), beta-blockers (70.4%), and diuretics (69.0%). Beta-blockers, ACE inhibitors, and isosorbide dinitrate were more frequently documented among males, whereas ARBs and calcium channel blockers were more frequently documented among females. No significant sex differences were observed for diuretics, statins, or digoxin. Previous observational registries have reported variation in real-world heart failure treatment patterns and medication utilization across different healthcare settings [39,40]. The observed sex-related differences in medication use should be interpreted in the context of the differing comorbidity profiles. The higher prevalence of hypertension among women may be relevant when considering their greater documented use of ARBs and calcium channel blockers, while the higher prevalence of ischemic heart disease among men may provide context for their more frequent use

of beta-blockers, ACE inhibitors, and isosorbide dinitrate [33]. However, these are potential clinical explanations rather than demonstrated associations, because the indications for individual prescriptions were not available. Heart failure pharmacotherapy should be individualized according to left ventricular ejection fraction, clinical status, comorbidities, and treatment indications and contraindications [12].

Although medication-use patterns differed between men and women, the available data were insufficient to determine whether these differences reflected appropriate individualized prescribing or differences in guideline concordance. Medication indications, contraindications, treatment duration, adherence, and heart failure phenotype were not comprehensively assessed. Therefore, the findings should be interpreted as descriptive differences in documented medication use rather than evidence that treatment was more or less appropriate in either sex. Future studies incorporating detailed heart failure phenotypes and prescription-level information are warranted to evaluate the appropriateness of pharmacotherapy and concordance with guideline-directed treatment. The present findings provide additional real-world data on sex-related differences in medication-use patterns among patients with heart failure in Saudi Arabia.

4.1. Limitations

This retrospective study has several limitations. First, reliance on routinely recorded clinical data may have resulted in incomplete or inconsistently documented variables. Second, the observational design limits assessment of temporal relationships and causal inference. Third, residual confounding from unmeasured clinical and socioeconomic factors cannot be excluded. Fourth, medication data reflected documented use and did not capture adherence, treatment duration, treatment indications, or subsequent changes in therapy. Furthermore, aldosterone antagonists were not analyzed as a separate medication category, limiting the detailed assessment of this class of heart failure pharmacotherapy. Fifth, although ejection fraction (EF) data were available, other measures of heart failure phenotype and severity, such as New York Heart Association (NYHA) functional class and additional echocardiographic parameters, were not consistently documented. This limited the characterization of heart failure beyond EF and may have affected the interpretation of comorbidity and medication-use patterns. Sixth, the study used retrospective data collected between 2016 and 2018. Consequently, the observed patient characteristics and medication utilization patterns may not fully reflect contemporary HF management practices. Future studies using more recent data are needed to determine whether these patterns remain consistent over time. Finally, as the study was conducted within a specific healthcare setting in Saudi Arabia, the findings may not be fully generalizable to other populations or healthcare systems. Nevertheless, the large sample size of 1363 patients provides substantial real-world data on the clinical characteristics, comorbidity burden, and treatment patterns of patients with HF.

4.2. Clinical Implications and Recommendations

The findings underscore the substantial cardiometabolic and cardiovascular burden among patients with HF and highlight the importance of comprehensive assessment of obesity, hypertension, diabetes mellitus, ischemic heart disease, and atrial fibrillation in routine HF care. The observed sex-related differences in comorbidities, laboratory profiles, smoking, and medication utilization support consideration of individual patient characteristics during clinical assessment and therapeutic review. Several practical recommendations follow from these findings. First, cardiometabolic comorbidities should be systematically assessed and managed, with particular attention to obesity, hypertension, and diabetes mellitus among women, as well as ischemic heart disease among men. Atrial fibrillation

should also be assessed and managed according to clinical indications. Second, structured smoking cessation support should be incorporated into HF care, particularly for men, given the higher smoking prevalence observed in this group. Third, renal function and electrolytes should be monitored as clinically indicated, particularly when initiating or adjusting relevant therapies; natriuretic peptide measurements may support clinical assessment when appropriate. Fourth, routine documentation of left ventricular ejection fraction, HF phenotype, and medication indications should be strengthened to support individualized treatment decisions and future audits of guideline-directed medical therapy (GDMT) [12]. Fifth, pharmacist-supported medication review within multidisciplinary HF teams may help identify medication-related problems and support treatment optimization according to each patient's clinical profile. Finally, multicenter prospective studies in Saudi Arabia incorporating HF phenotype, contemporary therapies, and clinical outcomes are needed to evaluate treatment patterns and identify opportunities to improve HF care. These real-world data provide clinically relevant descriptive insights that may inform patient-centered HF assessment, therapeutic review, and healthcare planning in Saudi Arabia. As this study was descriptive, the recommendations represent potential practice considerations rather than interventions evaluated by the present study.

5. Conclusions

This retrospective study describes the clinical characteristics, comorbidity profile, and medication use among 1363 patients with heart failure in a tertiary care hospital in Saudi Arabia. Compared with previous regional heart failure registries, the present cohort was older, included a substantially higher proportion of women, and had a higher prevalence of atrial fibrillation than the Saudi and Gulf registries, but a lower prevalence of hypertension and diabetes mellitus. A substantial burden of cardiometabolic and cardiovascular comorbidities was observed, with notable sex-related differences: women more frequently had obesity, hypertension, diabetes mellitus, and atrial fibrillation, whereas men more frequently had ischemic heart disease, smoking, and higher creatinine and BNP levels. Medication use also differed between men and women; however, because heart failure phenotype and treatment indications were not consistently available, these differences should be interpreted as descriptive rather than as evidence of differences in treatment appropriateness. These findings highlight the importance of sex-aware assessment and management of cardiometabolic comorbidities, routine smoking cessation support, regular monitoring of renal function and natriuretic peptides, and improved documentation of heart failure phenotype and treatment indications in enabling the evaluation of guideline-directed therapy.

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