







# Disparities in the characteristics and outcomes of patients hospitalized with acute decompensated heart failure admitted to internal medicine and cardiology departments: a single-centre, retrospective cohort study

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## Abstract

**Aims** Efforts are constantly made to decrease the rates of readmission after acute decompensated heart failure (ADHF). ADHF admissions to internal medicine departments (IMD) were previously associated with higher risk for readmission compared with those admitted to cardiology departments (CD). It is unknown if the earlier still applies after recent advancement in care over the last decade. This contemporary cohort compares characteristics and outcomes of ADHF patients admitted to IMD with those admitted to CD.

**Methods and results** The data for this single-centre, retrospective study utilized a cohort of 8332 ADHF patients admitted between 2007 and 2017. We compared patients' baseline characteristics and clinical and laboratory indices of patients admitted to CD and IMD with the outcome defined as 30 day readmission rate. In comparison with those admitted to CD, patients admitted to IMD (89.5% of patients) were older (79 [70–86] vs. 69 [60–78] years;  $P < 0.001$ ) and had a higher incidence of co-morbidities and a higher ejection fraction. Readmission rates at 30 days were significantly lower in patients admitted to CD (15.9% vs. 19.6%;  $P = 0.01$ ). Conflicting results of three statistical models failed to associate between the admitting department and 30 day readmission (odds ratio for 30 day readmission in CD: forced and backward stepwise logistic regression 0.8, 95% confidence interval 0.65–0.97,  $P = 0.02$ ; stabilized inverse probability weights model odds ratio 1.0, confidence interval 0.75–1.37,  $P = 0.96$ ).

**Conclusions** This contemporary analysis of ADHF patient cohort demonstrates significant differences in the characteristics and outcomes of patients admitted to IMD and CD. Thus, focusing strategies for readmission prevention in patients admitted to IMD may be beneficial.

**Keywords** Heart failure; Internal medicine; Cardiology; Quality of care; 30 day readmission; Mortality

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## Introduction

Heart failure (HF) is a major cause of morbidity and mortality and accounts for high healthcare-related costs with a

trajectory for increase in prevalence during the next decade.<sup>1</sup> Despite advances in care, readmission rates after acute decompensated HF (ADHF) remain high and are associated with poor outcomes.<sup>2</sup>

The management of patients with ADHF is not solely under the care of cardiologists but also handled by non-cardiologists, which in the hospital context are mainly internists. Patients with ADHF who are admitted to internal medicine departments (IMD) are reported to be older, with multiple co-morbidities, and are at high risk for readmission.<sup>3,4</sup> In contrast, although patients admitted to cardiology departments (CD) tend to be younger men, with a high prevalence of coronary artery disease and reduced systolic function, their readmission rate is lower compared with those admitted to IMD.<sup>5,6</sup> Most of the data for these disparities were collected in the 1990s and early 2000s. Given the advances made in the field of HF and the actions taken for decreasing the rate of readmission, we aim to explore if disparities in characteristics and outcomes of ADHF patient exist between patients admitted to IMD and those admitted to CD. We hypothesize that these disparities exist and that the admitting department is independently associated with 30 day readmission.

## Methods

### Study design: setting and population

This single-centre, observational retrospective cohort study utilized data of all adult patients admitted to Shamir Medical Center (Assaf Harofeh Medical Center) with ADHF between 1 January 2007 and 31 December 2017. Shamir Medical Center is the fourth largest government-owned hospital in the centre of Israel, serving a population of over 1 million with 880 inpatient beds. Eligible patients were those older than 18 years, admitted to either the IMD or CD, and who were clinically diagnosed with ADHF upon admission (ICD-9 codes: 428.xx, 429.xx, and 514) and were discharged with the relevant diagnosis codes as their primary or secondary diagnosis. These data were adjudicated to exclude cases in which an ICD code was used, but the free text added to it ruled out the relevant diagnosis. Patients who were transferred between departments during admission, those admitted outside the IMD or CD, and those who were transferred to a different hospital were further excluded for they represent a population different from the one intended to be included in the study. This study was approved by the local institutional review board at Shamir Medical Center and conforms to the principles outlined in the Declaration of Helsinki.<sup>7</sup> Patient consent was waived because of the retrospective nature of the data and analysis. The pre-specified measured outcome was 30 day readmission rate defined as inpatient admission within 30 days of discharge.

Demographic (age and sex), clinical (e.g. admitting department, medical history, chronic medical therapy, length of stay, and medical therapy at discharge), laboratory (serum white blood cell count, haemoglobin, creatinine, and

sodium), and follow-up data for readmission during 30 days after discharge were extracted from the hospital's electronic medical record. Data extraction was performed by the hospital's information technology group according to pre-specified criteria defined by the leading authors (S. L. M. and S. M.). Cardiology Picture Archiving and Communication System (cPACS) was used to extract the ejection fraction of patients who underwent echocardiography in our centre within a 6 month time frame before or after the index admission. Visual assessment methods were used to determine ejection fraction.

A secondary dataset was created to consolidate the chronic and post-discharge prescribed medications. The generic and trade names of all relevant drugs were taken from Israel's Ministry of Health Drug Registry, and each name was associated with a drug class, that is, beta-blockers and angiotensin-converting enzyme inhibitor (ACEi). This list was used as a source for quarrying the patients' data and to indicate if patients were prescribed with a specific drug class.

### Statistical analysis

This study compared two patient populations: those admitted to IMD vs. those admitted to either the intermediate cardiac care unit or intensive coronary care unit (collectively referred to as the CD). Normality was evaluated by one-sample Kolmogorov–Smirnov test. Continuous variables are expressed as median and inter-quartile range. Categorical variables are expressed as percentages. The Mann–Whitney *U* test was used to compare continuous variables, and the  $\chi^2$  test was used to compare categorical values. Full data were available for most of the variables. Missing data for ejection fraction and five continuous variables are reported as limitations in the discussion section, and none of these variables were included in the multivariable models. All statistical tests were two tailed. *P*-value <0.05 was considered significant. SPSS software was used for statistical analysis (IBM SPSS Statistics for Windows, Version 25, IBM Corp., Armonk, NY, USA, 2017).

Three statistical models were used to explore whether admitting department was independently associated with an increased risk for 30 day readmission. First, a multivariable logistic regression model was used to explore variables independently associated with 30 day readmission. Initially, all the baseline characteristics and chronic medical therapy were entered into the regression model. Then a backward method was applied (Wald test used as a criterion for removal). Because the admitting department was the focus of this study, it was forced into the regression model in the initial step. Only variables that were associated with the outcome with a significant level of *P* < 0.1 were kept, while the others were removed. In the second logistic regression model, clinically relevant indices reported to be associated with an increased

risk for 30 day readmission were forced into the model. The indices included age, sex, hospitalization days, renal failure, diabetes mellitus, hypertension, anaemia, obesity, atrial fibrillation, chronic obstructive pulmonary disease, ischaemic heart disease, and admitting department.

To further control the difference in baseline characteristics between the groups, a propensity score was calculated as the probability to be admitted to CD. Logistic regression was used to calculate the propensity score using clinically relevant indices associated with high probability to be admitted to a CD (sex, age, anaemia, hypertension, diabetes mellitus, chronic obstructive pulmonary disease, obesity, smoking, ischaemic heart disease, renal failure, peripheral vascular disease, atrial fibrillation, and chronic statin use). The propensity score was used for calculation of the inverse weight probability of admission to the CD. Stabilized weights were calculated, and univariable weighted logistic regression model with robust standard errors was performed.

## Results

### Research population

A total of 8332 patients admitted for ADHF were included in the analysis. *Figure 1* depicts the flow chart of the study. The median age was 78 [69–85] years, and male sex was prevalent in 4208 (50.5%) of included patients. ADHF was the primary discharge diagnosis in 3572 (42.9%) of the patients. Most patients (89.5%,  $n = 7457$ ) were admitted to the IMD, while the rest were admitted to the CD.

### Baseline characteristics

The baseline demographics and clinical characteristics of patients admitted to the IMD and CD are presented in *Tables 1* and *2*. Compared with patients admitted to CD, those admitted to IMD were older, were less frequently male, and were more likely to have ADHF as their primary diagnosis at discharge. Co-morbidities such as diabetes mellitus, hypertension, and obesity were more prevalent in patients admitted to IMD. In contrast, patients admitted to the CD were more likely to be smokers with prior history of myocardial infarction. Patients admitted to IMD were more likely to be chronically prescribed with oral anticoagulants, while patients admitted to CD were more likely to be prescribed with beta-blockers, anti-platelets, and statins prior to admission. Patients admitted to IMD had lower serum haemoglobin values compared with those admitted to CD.

### In-hospital procedures and prescriptions at discharge

The total number of patients that underwent echocardiographic evaluation within 180 days of admission was 2574 (30.9%). Echocardiography was obtained in higher prevalence in patients admitted to CD as opposed to those admitted to IMD (82.7% vs. 17.3%;  $P < 0.001$ ). More than half of the patients admitted to IMD had normal left ventricular (LV) function (51.6% vs. 9.1%;  $P < 0.001$ ). Conversely, severe LV dysfunction was more prominent in patients admitted to CD (19.8% vs. 10.5%;  $P < 0.001$ ).

Procedures during hospitalization were performed more frequently in patients admitted to CD and, among others, included diagnostic coronary angiography, percutaneous coronary interventions, and cardiac resynchronization therapy/defibrillator insertion.

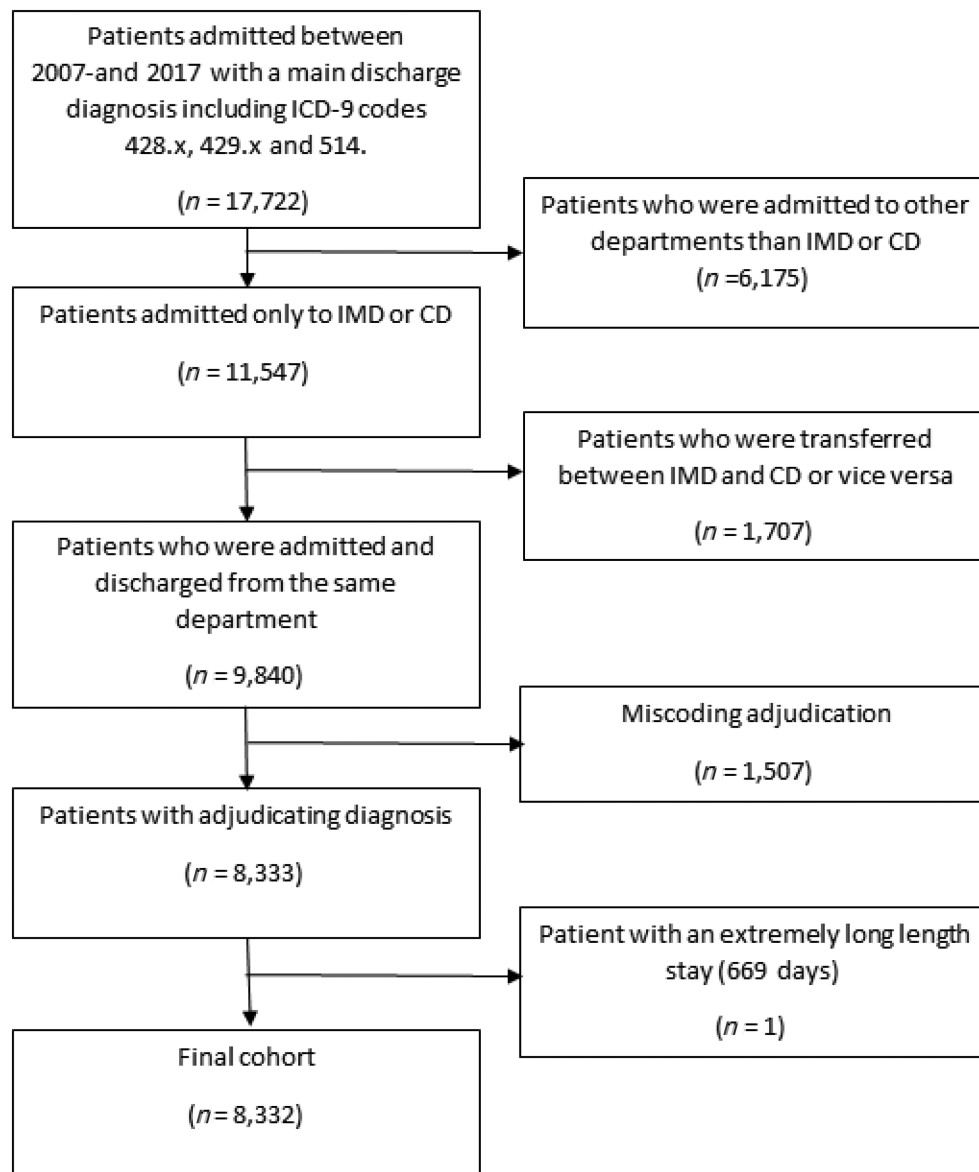
Compared with medication prescribed chronically, the rate of use of all relevant medications associated with heart failure increased at discharge, but significant disparities were recorded between the prescription rates of these drugs, with lower rates recorded in patients admitted to IMD compared with those admitted to CD. In contrast, diuretic prescription at discharge was more frequent in patients admitted to IMD.

### Clinical outcomes

Length of hospital stay was longer for patients admitted to IMD (8.3 [3–10] vs. 6.2 [3–8] days;  $P < 0.001$ ), and readmission rates at 30 days were significantly higher in patients admitted to IMD (19.6% vs. 15.9%;  $P = 0.01$ ).

To explore whether differences in readmission rate occurred over time, the cohort of patients was re-stratified by admission time for 'early' (patients admitted between 2007 and 2011) and 'late' (those admitted between 2012 and 2017). The readmission rates did not differ between the early and late periods (19.6% vs. 18.8%;  $P = 0.37$ ). Although more patients were readmitted to CD in the late period than in the early period (9.1% vs. 12.1%;  $P < 0.001$ ), the readmission rates in each group did not differ between the two time periods (CD early vs. late—15.6% vs. 16.1%,  $P = 0.85$ ; IMD early vs. late—20.0% vs. 19.2%,  $P = 0.39$ ). The backward method multivariable logistic regression analysis for indices associated with 30 day readmission (*Table 3*) indicates that admission to CD was independently associated with a lower risk for this outcome [odds ratio (OR) 0.8, 95% confidence interval (CI) 0.65–0.97;  $P = 0.02$ ]. This was also established in the forced logistic regression model (OR 0.8, 95% CI 0.65–0.96;  $P = 0.02$ ). On the other hand, in the inverse probability stabilized weighted model, admitting department was not associated with an increased risk for 30 day readmission (OR 1.0, 95% CI 0.75–1.37;  $P = 0.96$ ).

**Figure 1** Study flow diagram. CD, cardiology departments; ICD-9, International Classification of Diseases 9th Edition; IMD, internal medicine departments.



## Discussion

The results of this study including contemporary data of over 8000 patients admitted for ADHF demonstrate that (i) most patients with ADHF are admitted to IMD, (ii) interdisciplinary disparities exist in the ADHF populations admitted to each department and in the care given at discharge, and (iii) an independent association between the admitting department and 30 day readmission was not established.

Heart failure is a major health concern, associated with high morbidity and mortality and with a projection for 46% increase in prevalence between 2012 and 2030.<sup>1</sup> Disparities in the population, therapy, and outcomes of patients with

ADHF cared for by physicians from different disciplines were all previously reported and are summarized in Supporting Information, *Table S1*. In accordance with the present study, most patients admitted for ADHF are not admitted to CD. Although the span of reported proportion of patients admitted to CD is large, ranging from 5% to 60%,<sup>5,8</sup> most of the studies addressing this issue reported that ~20% patients are admitted to CD while the rest are admitted to general or geriatric wards.<sup>3,4,9–12</sup> Beyond difference in proportions, it seems that different populations of patients are admitted to each service. Patients cared for by cardiologists are reported to be younger and with higher prevalence of coronary artery disease and decreased LV function, while the opposite

**Table 1** Baseline demographic, pharmacological, clinical, and laboratory indices of patients admitted with acute decompensated heart failure to internal medicine and cardiology departments

Index	Internal medicine (n = 7547)	Cardiology (n = 785)	P-value
Male sex	3622 (49%)	586 (67%)	<0.001
Age (median years [IQR])	79 [70–86]	69 [60–78]	<0.001
Heart failure as primary diagnosis	3333 (45%)	239 (27%)	<0.001
Medical history			
Myocardial infarction	61 (0.80%)	13 (1.50%)	0.046
Ischaemic heart disease	3024 (41%)	326 (37%)	0.060
Valvular disease	1039 (14%)	129 (15%)	0.514
Anaemia	1771 (24%)	104 (12%)	<0.001
Renal failure	2532 (34%)	210 (24%)	<0.001
Atrial fibrillation	2407 (32%)	163 (19%)	<0.001
Hypertension	1307 (17%)	114 (13%)	<0.001
Diabetes mellitus	3750 (50%)	405 (46%)	0.025
COPD	1234 (16%)	71 (8%)	<0.001
PVD	543 (7%)	59 (7%)	0.560
Obesity	1611 (22%)	144 (16%)	<0.001
Smoking	1080 (14%)	247 (28%)	<0.001
Chronic medical therapy			
Alpha-blockers	825 (11%)	68 (8%)	0.003
Beta-blockers	2637 (35%)	381 (43%)	<0.001
Calcium channel blockers	1940 (26%)	179 (20%)	<0.001
ACEi	1388 (19%)	180 (21%)	0.161
ARB	814 (11%)	111 (13%)	0.115
Aldactone	188 (2%)	17 (2%)	0.296
Other heart failure medications	2 (<0.1%)	1 (0.10%)	0.283
Anti-arrhythmic	498 (7%)	68 (8%)	0.224
Anti-platelets	3104 (42%)	452 (52%)	<0.001
Oral anticoagulant	1081 (14%)	98 (11%)	0.008
Statin	2860 (38%)	420 (48%)	<0.001
Other hyperlipidaemic	143 (2%)	21 (2%)	0.331
Digoxin	351 (5%)	79 (5%)	0.658
Diuretics	3705 (55%)	878 (55%)	0.932
Combination pills	97 (1%)	17 (1%)	0.243
Laboratory indices			
Haemoglobin (g/dL ± SD)	11.6 [10.3–13.0]	12.7 [11.3–14.1]	<0.001
WBC (K/μL [IQR])	10.5 [7.1–12.1]	11.25 [7.8–13.7]	<0.001
Urea (mg/dL [IQR])	64.54 [36.90–77.90]	52.48 [34.52–62.60]	<0.001
Sodium (mmol/L [IQR])	137.36 [135–141]	137.57 [135–140]	0.91
Creatinine (mg/dL [IQR])	1.47 [0.85–1.57]	1.29 [0.86–1.42]	0.074
Echocardiography			
Normal LV function	1099 (51.60%)	110 (24.70%)	<0.001
Mild LV dysfunction	312 (15%)	72 (16%)	<0.001
Moderate LV dysfunction	495 (23%)	157 (39%)	<0.001
Severe LV dysfunction	223 (10%)	88 (20%)	<0.001
Total LV dysfunction	445 (17%)	2129 (83%)	<0.001

ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; COPD, chronic obstructive pulmonary disease; IQR, inter-quartile range; LV, left ventricular; PVD, peripheral vascular disease; SD, standard deviation; WBC, white blood cell.

is seen in most patients admitted to IMD.<sup>3,4,13–15</sup> The present analysis demonstrates similar trends with patients admitted to IMD being a decade older than those admitted to CD (79 vs. 69 years;  $P < 0.001$ ) with multiple co-morbidities and higher prevalence of preserved LV function. It seems that while the ADHF population admitted to CD is homogenous in its characteristics, the IMD ADHF population represents a more diverse population of patients with aetiologies other than primary cardiac disease leading to HF. These consistent differences in the population of ADHF patients admitted to each service call for exploration of the triage process of these patients. Although we lack the data to establish the process

determining the triage for each patient, by observing the differences in baseline characteristics, it seems reasonable to hypothesize that while young patients with cardiac events as their presenting symptom (i.e. ischaemic events or arrhythmias complicated by heart failure) are admitted to CD, older patients with heart failure secondary to non-cardiac aetiology (e.g. infections, anaemia, and other aetiologies) are admitted to IMD. This is supported by triage practice guidelines advocating, for example, admission of patients with myocardial ischaemia or infarction, those with planned cardiac intervention, and those with lack of response to diuretics to CD.<sup>16,17</sup>

**Table 2** In-hospital procedures and discharge prescriptions of patients admitted with acute decompensated heart failure to internal medicine and cardiology departments

Index	Internal medicine	Cardiology	P-value
Procedures performed during hospitalization			
Cardiac stress test	8 (0.10%)	10 (1.10%)	<0.001
Nuclear stress test	1 (<0.1%)	0 (0%)	>0.999
Diagnostic coronary angiography	100 (1%)	102 (12%)	<0.001
Urgent PCI	32 (0.40%)	85 (10%)	<0.001
Therapeutic PCI	52 (0.70%)	84 (10%)	<0.001
CABG	62 (0.80%)	115 (13%)	<0.001
Permanent pacemaker implantation	66 (0.90%)	36 (4%)	<0.001
CRTD	11 (0.10%)	10 (1%)	<0.001
Dialysis	106 (1%)	9 (1%)	0.346
Discharge drugs			
Alpha-blockers	1140 (15%)	57 (6%)	<0.001
Beta-blockers	3997 (54%)	503 (57%)	0.029
Calcium channel blockers	2494 (33%)	153 (17%)	<0.001
ACEi	1976 (26%)	357 (41%)	<0.001
ARB	1070 (14%)	112 (13%)	0.214
Aldactone	207 (3%)	13 (1%)	0.024
Other HF	2 (0%)	0 (0%)	>0.999
Anti-arrhythmic	651 (9%)	123 (14)	<0.001
Anti-platelets	4316 (56%)	562 (64%)	<0.001
Oral anticoagulation	1992 (27%)	162 (18%)	<0.001
Statin	4038 (54%)	562 (64%)	<0.001
Other hyperlipidaemic	178 (2%)	14 (1.7%)	0.142
Digoxin	337 (4%)	34 (4%)	0.390
Diuretics	5702 (76%)	458 (52%)	<0.001
Combination pills	228 (3%)	13 (1%)	0.009

ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; CABG, coronary artery bypass graft; CRTD, cardiac resynchronization therapy/defibrillator; other HF, other heart failure medications; PCI, percutaneous coronary intervention.

**Table 3** Multivariable logistic regression analyses for indices independently associated with 30 day readmission

Index	Backward stepwise logistic regression model			Forced logistic regression model		
	Odds ratio	95% confidence interval	P-value	Odds ratio	95% confidence interval	P-value
Admitting department —cardiology	0.79	0.65–0.97	0.023	0.79	0.65–0.96	0.023
Sex				0.94	0.83–1.05	0.274
Age (years)	0.99	0.99–1.00	0.062	0.99	0.99–1.00	0.047
Diabetes mellitus	1.11	0.99–1.25	0.061	1.12	0.99–1.25	0.060
Hypertension				1.01	0.94–1.27	0.210
Ischaemic heart disease	1.16	1.04–1.30	0.009	1.15	1.02–1.28	0.017
Chronic obstructive pulmonary disease	1.14	0.99–1.33	0.074	1.17	1.00–1.35	0.045
Atrial fibrillation	1.28	1.14–1.44	<0.01	1.31	1.17–1.48	<0.01
Smoking	1.28	1.01–1.49	0.002	1.26	1.08–1.47	<0.01
Renal failure	1.20	1.07–1.36	0.003	1.17	1.04–1.32	0.010
Anaemia	1.37	1.20–1.56	<0.01	1.39	1.27–1.58	<0.01
Valvular disease	1.23	1.05–1.44	0.008			
Alpha-blockers at admission	0.83	0.69–0.99	0.046			
Other heart failure medications at admission	8.26	0.72–93.9	0.089			
Hospitalization days				0.52	0.99–1.00	0.525
Obesity				0.91	0.78–1.05	0.182

Interdisciplinary disparities in the care of ADHF patients have been reported since the 1990s. Different populations of patients were admitted to each service with patients admitted to IMD being less likely to undergo echocardiography or other cardiac-related testing such as coronary

angiography.<sup>18,19</sup> On the other hand, cardiologists were more likely to prescribe patients with guideline-directed medical therapy (GDMT), mainly ACEi and beta-blockers, and these differences were translated into differences in outcomes.<sup>18</sup>

Multiple evidence exists regarding the aetiologies for these interdisciplinary discrepancies. It is well established that cardiologists are more likely to adhere to GDMT, and this may be a plausible aetiology for improved outcomes.<sup>20,21</sup> Although Saxon *et al.* demonstrated that non-cardiologists are less aware of guidelines when addressing the care for HF patients with preserved left ventricular function,<sup>21</sup> it is also possible that the lower incidence of GDMT used at IMD is the result of the different population cared for by generalists and internists, namely, the elderly. Indeed, as demonstrated by the present and other studies, IMD care for patients who are in their 70s and 80s. These patients tend to have a lower heart rate, higher incidence of conduction abnormalities, and decreased renal function all of which may hamper the ability to prescribe GDMT.<sup>22</sup> Another plausible explanation for the disparities in medication prescription may be related to the motivation of physicians to avoid polypharmacy. As reported by Carroll *et al.* polypharmacy is a major health concern especially in the age group of patients admitted to IMD—a fact that may influence the decision to prescribe additional medications to this population.<sup>23</sup> Further, the elderly population is under-represented in HF clinical trials, and the applicability of guidelines based on these trials is thus equivocal for this population. It should also be noted that at present, the merits of ACEi, beta-blockers, and other GDMT are validated mainly for patients with reduced LV function, while this is not established for patients with preserved LV function.<sup>24</sup> Thus, the fact that patients admitted to IMD (which more frequently had preserved LV function) were less frequently prescribed with these drugs may coincide with this lack of evidence for these therapies and not lack of adherence to GDMT.

Beyond GDMT, cardiologists were more likely to refer the patients to echocardiography and other procedures (i.e. coronary angiography).<sup>3,14</sup> It seems reasonable that specifically for ADHF patients, echocardiography has a pivotal role in the management of patients. Echocardiography can classify patients to those with preserved LV function vs. those with decreased LV function and detect unrecognized valvular diseases or regional wall motion abnormalities that warrant further work-up. Moreover, the underutilization of echocardiography is associated with poor outcome but also with lower propensity for prescribing ACEi.<sup>25</sup>

Readmission is an important outcome metric in the care for patients with HF, and efforts are constantly made aiming for decreasing its incidence. Although some of the registries demonstrate improvement during the last decade, the reported 30 day readmission rates are still high, ranging between 15.2% and 28%.<sup>2,5,9,11,26</sup> This was the main driver for penalizing hospitals in the USA for ADHF readmissions under the Affordable Care Act, and indeed, a lower incidence of readmission was noted, but the association between the reported decrease in readmission rates and outcome remains controversial.<sup>27</sup> Our results complement those reported by

most contemporary studies demonstrating a 30 day readmission rate of 19.2%. The fact that these rates did not decrease despite major efforts invested strengthens the need for further evaluation of obstacles for improving this outcome.

Following prior reports, the present analysis demonstrated significant differences in 30 day readmission rates between CD and IMD (19.6% vs. 15.9%;  $P = 0.01$ ).<sup>5,13</sup> On the other hand, conflicting results from three statistical models failed to establish the hypothesis that the admitting department is independently associated with 30 day readmission. While both a forced logistic regression model (clinically oriented model) and a backward stepwise logistic regression model (statistically oriented model) demonstrated that CD was independently associated with the main outcome, an inverse probability weighted model demonstrated the opposite. This highlights the significant differences in the populations included, which limits the ability of multivariable statistical models to adequately control for possible confounders. This is also relevant when interpreting other results of the multivariable models. One example is the fact that in the present study, age was not established as an independent variable associated with readmission while this association was reported in previous literature.<sup>28</sup> That being said, other studies with a similar population were also unable to exhibit age association.<sup>29</sup> Hence, it seems plausible that in some patient populations, like the one presented in this study, the impact of co-morbidities on readmission may be more significant than age and other demographic variables. We thus opted to focus our discussion on the baseline characteristic of these two groups while the impact of these disparities on outcomes is yet to be established.

The ample evidence demonstrating the disparities between the characteristics, care, and outcomes of patients admitted to IMD vs. CD raises the obvious question: how can ADHF care be improved in the IMD? Attempts for decreasing the readmission rates focus primarily on predictors associated with this outcome. These include demographic, social, and clinical variables.<sup>26</sup> When addressing the disparities between CD and IMD, Foody *et al.* demonstrated no survival benefit for ADHF patients admitted to IMD that underwent cardiology consultation, which suggests that a single clinical encounter is not sufficient and perhaps multidisciplinary care is the key.<sup>10</sup> As demonstrated by Ahmed *et al.* and Indridason *et al.*, collaborative care by cardiologists, internists, and physicians from other disciplines was associated with an increase in the use of GDMT, echocardiography, and improved outcomes including mortality.<sup>30,31</sup> Healthcare providers and policymakers for IMD should also focus on patient education, pre-discharge programmes, and, most importantly, communicating with the primary care physician or homecare staff because all of these interventions have a positive impact on the outcome of ADHF patients especially in the elderly population admitted to IMD.<sup>32,33</sup>

Several limitations to this analysis should be acknowledged. First, this was a retrospective study with its inherent limitations. Our meticulous adjudication process focused on including patients discharged with ADHF as one of their diagnoses and who were hospitalized in the same department throughout the entire stay. We could not collect, analyse, and group all the primary discharge diagnoses because of the large number of diagnoses recorded over the course of a decade.

Second, full data were available for most of the variables included in the study. The relevant interpretation of missing echocardiographic data was included in this section. Other indices with missing data include serum haemoglobin ( $n = 1000$ ), white blood cell count ( $n = 1000$ ), serum urea ( $n = 1051$ ), serum creatinine ( $n = 1051$ ), and serum sodium ( $n = 1085$ ). None of these variables were included in multivariable models.

Finally, readmission was based on hospital records. Although it is plausible that patients who reside near our centre would prefer to be readmitted to the same centre, it is possible that some readmissions to other centres are not accounted for. Because the recorded readmission rate in this study is similar to prior reports, we assume that this is a fair representation of the true incidence.

In conclusion, this study's findings suggest that most patients presented with ADHF to a large medical centre are admitted to IMD, while only a minority are admitted to CD. These patients represent an older and sicker ADHF

population. The independent association between the admitting department and 30 day readmission was not established in this study. Further efforts should focus on improving care for ADHF patients in the IMD by increasing the involvement of multidisciplinary teams aiming for care improvement during hospitalization and after discharge.

## Conflict of interest

None declared.

## Funding

None.

## Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Table S1.** Main studies addressing interdisciplinary discrepancies in the care for heart-failure patients.

## References

- Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Delling FN, Djousse L, Elkind MSV, Ferguson JF, Fornage M, Khan SS, Kissela BM, Knutson KL, Kwan TW, Lackland DT, Lewis TT, Lichtman JH, Longenecker CT, Loop MS, Lutsey PL, Martin SS, Matsushita K, Moran AE, Mussolino ME, Perak AM, Rosamond WD, Roth GA, Sampson UKA, Satou GM, Schroeder EB, Shah SH, Shay CM, Spartano NL, Stokes A, Tirschwell DL, VanWagner LB, Tsao CW, American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2020 update: a report from the American Heart Association. *Circulation* 2020; **141**: e139–e596.
- Ross JS, Chen J, Lin Z, Bueno H, Curtis JP, Keenan PS, Normand SL, Schreiner G, Spertus JA, Vidan MT, Wang Y, Wang Y, Krumholz HM. Recent national trends in readmission rates after heart failure hospitalization. *Circ Heart Fail* 2010; **3**: 97–103.
- Bellotti P, Badano LP, Acquarone N, Griffo R, Lo Pinto G, Maggioni AP, Mattiauda C, Menardo G, Mombelloni P, Investigators O. Specialty-related differences in the epidemiology, clinical profile, management and outcome of patients hospitalized for heart failure. The OSCUR study. *Eur Heart J* 2001; **22**: 596–604.
- Grigioni F, Carinci V, Favero L, Bacchi Reggiani L, Magnani G, Potena L, Barbieri A, Magelli C, Branzi A, Magnani B. Hospitalization for congestive heart failure: is it still a cardiology business? *Eur J Heart Fail* 2002; **4**: 99–104.
- Salata BM, Sterling MR, Beecy AN, Ullal AV, Jones EC, Horn EM, Goyal P. Discharge processes and 30-day readmission rates of patients hospitalized for heart failure on general medicine and cardiology services. *Am J Cardiol* 2018; **121**: 1076–1080.
- Uthamalingam S, Kandala J, Selvaraj V, Martin W, Daley M, Patvardhan E, Capodilupo R, Moore S, Januzzi JL Jr. Outcomes of patients with acute decompensated heart failure managed by cardiologists versus noncardiologists. *Am J Cardiol* 2015; **115**: 466–471.
- Rickham PP. Human experimentation. Code of ethics of the World Medical Association. Declaration of Helsinki. *Br Med J* 1964; **2**: 177.
- Lee DS, Stukel TA, Austin PC, Alter DA, Schull MJ, You JJ, Chong A, Henry D, Tu JV. Improved outcomes with early collaborative care of ambulatory heart failure patients discharged from the emergency department. *Circulation* 2010; **122**: 1806–1814.
- Avaldi VM, Lenzi J, Urbinati S, Molinazzi D, Descovich C, Campagna A, Taglioni M, Fioritti A, Fantini MP. Effect of cardiologist care on 6-month outcomes in patients discharged with heart failure: results from an observational study based on administrative data. *BMJ Open* 2017; **7**: e018243.
- Foody JM, Rathore SS, Wang Y, Herrin J, Masoudi FA, Havranek EP, Krumholz



- HM. Physician specialty and mortality among elderly patients hospitalized with heart failure. *Am J Med* 2005; **118**: 1120–1125.
11. Selim AM, Mazurek JA, Iqbal M, Wang D, Negassa A, Zolty R. Mortality and re-admission rates in patients hospitalized for acute decompensated heart failure: a comparison between cardiology and general-medicine service outcomes in an underserved population. *Clin Cardiol* 2015; **38**: 131–138.
  12. Philbin EF, Jenkins PL. Differences between patients with heart failure treated by cardiologists, internists, family physicians, and other physicians: analysis of a large, statewide database. *Am Heart J* 2000; **139**: 491–496.
  13. Reis SE, Holubkov R, Edmundowicz D, McNamara DM, Zell KA, Detre KM, Feldman AM. Treatment of patients admitted to the hospital with congestive heart failure: specialty-related disparities in practice patterns and outcomes. *J Am Coll Cardiol* 1997; **30**: 733–738.
  14. Auerbach AD, Hamel MB, Davis RB, Connors AF Jr, Regueiro C, Desbiens N, Goldman L, Califf RM, Dawson NV, Wenger N, Vidaillet H, Phillips RS, SUPPORT Investigators. Resource use and survival of patients hospitalized with congestive heart failure: differences in care by specialty of the attending physician. *Ann Intern Med* 2000; **132**: 191–200.
  15. Lowe J, Candlish P, Henry D, Wlodarczyk J, Fletcher P. Specialist or generalist care? A study of the impact of a selective admitting policy for patients with cardiac failure. *International J Qual Health Care* 2000; **12**: 339–345.
  16. Weingarten SR, Riedinger MS, Shinbane J, Siegel R, Conner L, Prechtel K, Ellrodt AG. Triage practice guideline for patients hospitalized with congestive heart failure: improving the effectiveness of the coronary care unit. *Am J Med* 1993; **94**: 483–490.
  17. Peacock WF, Braunwald E, Abraham W, Albert N, Burnett J, Christenson R, Collins S, Diercks D, Fonarow G, Hollander J, Kellerman A, Gheorghiadu M, Kirk D, Levy P, Maisel A, Massie BM, O'Connor C, Pang P, Shah M, Sopko G, Stevenson L, Storrow A, Teerlink J. National Heart, Lung, and Blood Institute working group on emergency department management of acute heart failure: research challenges and opportunities. *J Am Coll Cardiol* 2010; **56**: 343–351.
  18. Edep ME, Shah NB, Tateo IM, Massie BM. Differences between primary care physicians and cardiologists in management of congestive heart failure: relation to practice guidelines. *J Am Coll Cardiol* 1997; **30**: 518–526.
  19. Di Lenarda A, Scherillo M, Maggioni AP, Acquarone N, Ambrosio GB, Annichiarico M, Bellis P, Bellotti P, De Maria R, Lavecchia R, Lucci D, Mathieu G, Opasich C, Porcu M, Tavazzi L, Cafiero M, TEMISTOCLE Investigators. Current presentation and management of heart failure in cardiology and internal medicine hospital units: a tale of two worlds—the TEMISTOCLE study. *Am Heart J* 2003; **146**: E12.
  20. Boom NK, Lee DS, Tu JV. Comparison of processes of care and clinical outcomes for patients newly hospitalized for heart failure attended by different physician specialists. *Am Heart J* 2012; **163**: 252–259.
  21. Saxon DT, Kennel PJ, Guyer HM, Goyal P, Hummel SL, Konerman MC. Specialty-based variability in diagnosing and managing heart failure with preserved ejection fraction. *Mayo Clin Proc* 2020; **95**: 669–675.
  22. Mirza M, Strunets A, Shen WK, Jahangir A. Mechanisms of arrhythmias and conduction disorders in older adults. *Clin Geriatr Med* 2012; **28**: 555–573.
  23. Carroll C, Hassanin A. Polypharmacy in the elderly—when good drugs lead to bad outcomes: a teachable moment. *JAMA Intern Med* 2017; **177**: 871.
  24. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ, Falk V, Gonzalez-Juanatey JR, Harjola VP, Jankowska EA, Jessup M, Linde C, Nihoyannopoulos P, Parissis JT, Pieske B, Riley JP, Rosano GM, Ruilope LM, Ruschitzka F, Rutten FH, van der Meer P, Authors/Task Force Members. 2016 ESC guidelines for the diagnosis and treatment of acute and chronic heart failure: the Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *Eur J Heart Fail* 2016; **18**: 891–975.
  25. Senni M, Rodeheffer RJ, Tribouilloy CM, Evans JM, Jacobsen SJ, Bailey KR, Redfield MM. Use of echocardiography in the management of congestive heart failure in the community. *J Am Coll Cardiol* 1999; **33**: 164–170.
  26. Allen LA, Smoyer Tomic KE, Smith DM, Wilson KL, Agodoa I. Rates and predictors of 30-day readmission among commercially insured and Medicaid-enrolled patients hospitalized with systolic heart failure. *Circ Heart Fail* 2012; **5**: 672–679.
  27. Gupta A, Allen LA, Bhatt DL, Cox M, DeVore AD, Heidenreich PA, Hernandez AF, Peterson ED, Matsouka RA, Yancy CW, Fonarow GC. Association of the hospital readmissions reduction program implementation with readmission and mortality outcomes in heart failure. *JAMA Cardiol* 2018; **3**: 44–53.
  28. Chamberlain RS, Sond J, Mahendraraj K, Lau CS, Siracuse BL. Determining 30-day readmission risk for heart failure patients: the Readmission After Heart Failure scale. *Int J Gen Med* 2018; **11**: 127–141.
  29. Krumholz HM, Parent EM, Tu N, Vaccarino V, Wang Y, Radford MJ, Hennen J. Readmission after hospitalization for congestive heart failure among Medicare beneficiaries. *Arch Intern Med* 1997; **157**: 99–104.
  30. Ahmed A, Allman RM, Kiefe CI, Person SD, Shaneyfelt TM, Sims RV, Howard G, DeLong JF. Association of consultation between generalists and cardiologists with quality and outcomes of heart failure care. *Am Heart J* 2003; **145**: 1086–1093.
  31. Indridason OS, Coffman CJ, Oddone EZ. Is specialty care associated with improved survival of patients with congestive heart failure? *Am Heart J* 2003; **145**: 300–309.
  32. Gwadrý-Sridhar FH, Flintoft V, Lee DS, Lee H, Guyatt GH. A systematic review and meta-analysis of studies comparing readmission rates and mortality rates in patients with heart failure. *Arch Intern Med* 2004; **164**: 2315–2320.
  33. Bradley EH, Curry L, Horwitz LI, Sipsma H, Wang Y, Walsh MN, Goldmann D, White N, Pina IL, Krumholz HM. Hospital strategies associated with 30-day readmission rates for patients with heart failure. *Circ Cardiovasc Qual Outcomes* 2013; **6**: 444–450.