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Research Paper

Evaluating the quality of care for heart failure hospitalizations in inflammatory arthritis – A population-based cohort study☆

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ABSTRACT

Background: Individuals with inflammatory arthritis (IA) face an elevated risk of heart failure (HF). However, whether the quality of HF care in IA patients differs from other high-risk groups, such as those with diabetes mellitus (DM), remains unclear.

Methods: This population-based cohort study in Ontario, Canada, included patients who experienced their first HF hospitalization and survived to discharge. Patients were categorized into four groups: IA alone, DM alone, IA + DM, and a general population comparator. We assessed quality care measures within 30 days of hospitalization (echocardiogram, electrocardiogram, chest x-ray) and physician follow-up within 7 days. Guideline-directed medical therapy (GDMT) adherence was evaluated within 90 days and classified as perfect, moderate, or poor. Logistic regression was used to determine whether IA was independently associated with lower HF care quality.

Results: Among 101,645 eligible hospitalizations, 1987 had IA + DM, 3849 had IA alone, 33,553 had DM alone, and 62,256 were general comparators. While all groups showed high adherence to testing, IA patients (with or without DM) had significantly lower GDMT use compared to DM patients ($p < 0.001$). IA was independently linked to lower odds of moderate or perfect GDMT adherence.

Conclusion: Although adherence to HF testing quality measures was high, IA patients were less likely to receive GDMT than those with DM. Further research is needed to understand the reasons for lower GDMT use in IA and its impact on HF outcomes such as re-hospitalization and mortality.

1. Introduction

Heart failure (HF) is a global epidemic, associated with significant health care costs and a high rate of mortality [1]. There continues to be an urgent need for attention to HF prevention and management. One strategy involves quantifying and reporting the quality of HF care through achievement of recognized benchmarks in hospitals. This approach aims to identify actionable gaps or disparities at the patient or system-level to improve HF outcomes [2,3].

The integration of quality measures for HF hospitalizations is recommended for all patients. However, these have been particularly emphasized in patients with diabetes mellitus (DM) because they are at higher risk of all cause cardiovascular disease (CVD) and HF development and face a poorer prognosis. Adhering to quality measures in this population is challenging because of the need to provide consistent treatment for the simultaneous presence of both HF and DM and the

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inherent issues with resource availability and healthcare system complexities [4]. As such, comprehensive approaches to enhance the quality of HF care have been proposed. For example, initiatives to improve education, adherence, and foster engagement among patients and healthcare providers regarding the significance of adopting guideline-recommended care in diabetes have been implemented and evaluated [4–7].

Similar to DM, inflammatory arthritis (IA), is a group of chronic, systemic diseases that substantially increases the risk of CVD. Patients with IA have approximately double the risk of HF as compared to individuals without IA, and this risk persists even after adjustment for traditional cardiovascular risk factors or ischemic heart disease [8–10]. Individuals with IA and HF also have higher all-cause mortality [11]. The connection between IA and HF originates primarily from systemic inflammation, which has the potential to accelerate atherosclerotic disease, provoke arrhythmias, and cause direct myocardial damage [12]. Drawing from this pathophysiological mechanism, it has been proposed that IA be classified a risk-equivalent condition for HF akin to DM [13,14]. Despite the natural comparison, the same focus has not been paid to IA as it has in DM, and studies evaluating the impact of HF quality standards in the IA population have not been conducted.

Our objective was to address this knowledge gap and characterize the quality of care for IA patients experiencing their first HF hospitalization, comparing their care with that of patients with DM (a high risk HF condition where there has been more focus on application of HF care) and the general population. We evaluated key HF measures and identified demographic and disease-related factors associated with adherence to measures within these groups. We hypothesized that IA patients would have lower rates of conformity with HF measures compared patients with DM, thus representing a group requiring optimized provision of HF management.

2. Methods

2.1. Study design and data sources

We conducted a retrospective, population-based cohort study using data from the CANHEART initiative, which is aimed at improving the quality of ambulatory care and cardiovascular health of Canadians [15]. This population-based cohort is comprised of 9.8 million adults 20 years and older living in Ontario, Canada. It was created using multiple individual-level datasets that are linked using unique encoded identifiers and held securely in coded form at ICES (www.ices.on.ca, Supplementary fig. 1). Use of these databases was authorized under section 45 of Ontario's Personal Health Information Protection Act and did not require review by a Research Ethics Board. Full details on CANHEART have been previously described [15].

2.2. Study population

We included adults aged 40–105 years who had an incident HF hospitalization as the primary diagnosis occurring January 1, 2011 to December 31, 2019, and who were eligible for the province's health insurance plan for the five years prior to cohort start date. The date of HF admission was the index date and was identified using International Classification of Diseases, Tenth Revision, Canada code of I50, and has been validated for hospitalized patients [16]. All patients with missing age or sex, invalid date of birth, invalid health insurance number or non-Ontario residences were excluded. Individuals with any history of HF hospitalization before entry into CANHEART were excluded. We did not include HF diagnosed outside of hospital due to inconsistent coding in the outpatient setting and to focus on processes of care following acute hospitalization.

Within the cohort, we stratified hospitalized HF patients into 4 mutually exclusive exposure groups comprised of patients with either: (1) DM alone (no IA), (2) IA + DM, (3) IA alone (no DM), and (4) population controls without IA or DM. IA included rheumatoid arthritis, ankylosing spondylitis and psoriatic arthritis, and these diagnoses were ascertained by validated case definitions and algorithms used to identify IA diagnoses established before the cohort start date [17,18]. Patients with other systemic autoimmune rheumatic diseases were excluded. Individuals with DM were determined from the Ontario Diabetes Database (ODD) and included those with and without IA conditions as defined above [19]. Population controls were Ontario residents without IA or DM who were hospitalized for HF.

2.3. Outcomes

We followed the framework of published quality standards for HF care by Health Quality Ontario and focused on testing and medication process measures [20]. We ascertained the percentage of subjects in each of the exposure groups who were discharged alive, and achieved the recommended measures within 30 days following index HF hospitalization as individual and composite measures. Testing measures included proportion of patients who: (1) received an echocardiogram, (2) received an electrocardiogram, (3) received a chest radiograph, and (4) were seen by any physician (primary care, or internist, or cardiologist) within 7 days of discharge. For those over the age of 65 years in whom medication information was universally available in the province, we examined the proportion who were dispensed guideline-directed medical therapy (GDMT, medication measures) within 90 days of hospital discharge including: (5) beta-blockers, (6) renin-angiotensin-aldosterone-system inhibitor [RAAS inhibitor, i.e., angiotensin converting enzyme inhibitor (ACEI), angiotensin receptor blocker (ARB), or angiotensin receptor neprilysin inhibitor (ARNI)], or (7) mineralocorticoid receptor antagonist (MRA).

We further categorized adherence as perfect (achieving all testing and/or medication measures), perfect (achieving 100 %), moderate (achieving ≥50–99 %), poor (1–49 %) or no adherence (achieving none of the testing or medication measures).

2.4. Statistical analysis

Baseline characteristics of the exposure groups was compared via one-way ANOVA for continuous and chi-square testing for categorical measures. Sociodemographic variables included age, sex, rurality of residence (defined using the Rurality Index of Ontario), neighbourhood socioeconomic status (income quintiles, derived from census data and postal codes), and ethnicity classified as Chinese, South Asian, or other [21]. We ascertained comorbid conditions: hypertension, atrial fibrillation, valvular heart disease, ischemic heart disease, and history of coronary revascularization (percutaneous coronary intervention or coronary artery bypass graft), stroke, diabetes, cancer, dementia, chronic obstructive pulmonary disease, asthma, chronic renal disease, or inflammatory bowel disease as published previously [22,23]. We evaluated the number of health care visits in the year preceding index date, admission for HF to an academic teaching hospital or site capable of revascularization and total number of unique medications for those over the age of 65 years. We compared the proportion achieving the testing and medication measures by chi-square testing with significance level set to $p < 0.05$. We also conducted sensitivity analyses changing the thresholds for moderated adherence (achieving ≥26–99 %) and poor adherence (1–25 %).

We then performed separate, unadjusted, age/sex-adjusted, and fully adjusted (for covariates including comorbidities, and health-care utilization) multinomial logistic regression models to calculate odds ratios (OR) and their 95 % confidence interval (CI) to determine if IA diagnosis was independently associated with moderate/perfect adherence for the composite measures.

3. Results

Among a sample of 9,402,681 patients in the CANHEART cohort, 101,645 had a first HF hospitalization during our accrual period and met study inclusion criteria. Overall, there were 5836 (5.7 %) IA patients. The majority of IA patients did not have DM ($N = 3849$ or 67 % of total IA) and 1987 (34 % of total IA) had DM. Thirty three percent of the total cohort (33,553) had DM and 62,256 (61.2 %) were general comparators. Mean age at the time of HF hospitalization was significantly higher in the IA alone group (79 years) versus the DM group (76 years) group, but not the general population controls (79 years, Table 1). Among the groups with HF, the proportion of females was higher in the IA alone group (61 %) compared to either the IA + DM (53 %), DM (46 %) or general population group (50 %) (Table 1). The median (IQR) length of stay in hospital was 6 [3–10] days for all groups. The most common antecedent HF etiology across all groups was atrial fibrillation (51 %), ischemic heart disease (33 %), and valvular heart disease (18 %), and many of these cardiovascular comorbidities were significantly higher in the DM and IA+ DM groups compared to the IA alone group (Table 1). For those over the age of 65 with prescription information available, the total number of unique medications was highest in both IA groups as was the use of NSAID/COXIBs and corticosteroids (Table 1).

All groups had high achievement of the process measures including electrocardiogram and chest x-ray testing (Table 2). Among patients discharged alive, receiving an echocardiogram within the first 30 days was moderate (range 67–69 %) and seeing any physician within 7 days post discharge had the lowest adherence in 39 % across the groups (Table 2). There were no statistical differences in the proportions achieving perfect, moderate, poor or no adherence for these measures between the DM vs IA groups or (Table 2) or IA vs. general population comparators (supplementary Table). The results remained consistent regardless of variations in the definitions of adherence thresholds.

For those >65 years of age and discharged alive, patients with IA were less likely to receive GDMT (Table 2). IA patients had significantly fewer dispensations for beta-blockers, RAAS inhibitors and MRA compared to those with DM alone. Lower dispensation rates were especially pronounced in IA patients without DM (Fig. 1). Additionally, IA patients with or without DM were more likely to meet criteria for poor or non-adherence to GDMT compared to those with DM. A similar trend was seen for poor or no adherence comparing IA to the general population controls (supplementary Table).

Since testing measures were not significantly different between groups, we did not construct multivariable models to identify baseline characteristics associated with these process measures. However, we did examine which factors influenced the observed differences in prescription of GDMT among groups. In analyses controlling for demographic, healthcare utilization and comorbidities, older age, and some chronic conditions were associated with lower odds of medication adherence (chronic lung or kidney disease, stroke, dementia, cancer) but a diagnosis of DM was not independently associated with lower odds of GDMT adherence (Table 3). However, a diagnosis of IA was significantly associated with lower odds of moderate/perfect adherence to medications, and this was most pronounced in the IA alone group (OR 0.68, 95 % CI 0.61–0.75) but was significant in the IA + DM group as well (OR 0.78, 95 % CI 0.68–0.94). The findings were not significantly affected by different definitions of adherence thresholds.

4. Discussion

To our knowledge, this is the first study exploring HF quality measures in patients with inflammatory arthritis and an incident HF hospitalization. We found a high rate of conformity to HF testing measures but overall low achievement of post-discharge evaluation within 7 days. Our key finding was a significantly lower dispensation of GDMT among patients with IA. There appeared to be a dose-response relationship, with adherence to GDMT being highest in patients with DM, lower in those with both IA+ DM, and lowest in patients with IA alone. This suggests that the presence of DM may be prompting more consistent adherence to HF recommended care. While the reasons behind this gap remain unclear, it presents an opportunity to find solutions and determine if these differences may be contributing to the higher than average risk of HF-related death still observed in contemporary IA cohorts [24].

Our findings can be compared to other studies assessing HF quality measures. However, as none have specifically examined the IA population, some extrapolation is necessary. A study by Warner et al. found lower than desired rates of discharge appointments at 7 days (56 %) and low use of all GDMT, with prescribing rates decreasing over time [25]. In contrast to the present study, the analysis by Warner was among the Veterans Affairs Hospital System, which is comprised almost exclusively older male patients. They found RAAS inhibitor use was particularly low relative to the population eligible (12 %) but similar to other Canadian estimates and may reflect some inertia in prescribing agents that may cause adverse effects in older adults [26]. Like our study, Mukhopadhyay et al. also found low rates of RAAS inhibitors or MRA, but a strong predictor of increased GDMT prescribing was private insurance or Medicaid coverage [27]. In our setting of universal health care and easily accessible medications for adults over the age of 65, we would conceivably expect higher rates since financial barriers are ales of a limitation. We also did not observe any association of improved adherence based on health care setting such as admission to an academic hospital or one capable of performing percutaneous coronary interventions (supp Table 1). This contrasts the work of Gupta et al. which found all HF quality core measures were significantly better (albeit still lower than expected) among hospitals providing tertiary or specialized cardiology care [2]. We did not investigate site-level variances, as Gupta et al. did across hospitals in China. However, our multivariable analysis did reveal a negative association between rurality and HF performance, which will be the focus of a forthcoming study.

Upon reviewing the collective body of research showing suboptimal GDMT use and disparities in post-discharge HF care, our study raises some unique concerns. We observed diminished rates of GDMT use in IA, mirroring general population trends, despite consistent evidence indicating markedly elevated HF mortality risk in IA patients [14,24]. Why then, are evidenced-based therapies proven to reduce HF death disproportionately underutilized in IA? Several plausible explanations emerge. First, apprehensions regarding potential pharmacological interactions between GDMT and systemic immunosuppressive regimens used to treat IA may deter comprehensive HF therapy adoption [12]. Second, patients with IA may exhibit distinct comorbidities, contraindications, or treatment preferences that differentially influence HF discharge medication selection. However, although DM management entails intricate medication protocols, similar effects on prescribing patterns were not observed, suggesting underlying distinctions. A third explanation may relate to age and sex. Patients with IA in our study were older and more likely to be women. Several studies have shown small, but consistent trends, of patient-level quality measures being disproportionately lower for women and older patients, possibly related to underlying biases or systemic issues within the healthcare system [2,28]. We also noted that patients with IA alone had lower rates of prior revascularization procedures and hypertension, both of which were linked to higher odds of GDMT adherence. This could suggest that IA patients without these prior indications are prescribed less medication, as they may not demonstrate the same necessity for specific treatments as those with additional risk factors. Nevertheless, it is imperative to underscore that clinical guidelines are intended to apply uniformly to the “right person, at the right time”, irrespective of their comorbid diagnoses, unless contraindications dictate otherwise.

A major strength of our study was the comprehensiveness of data within a universal health care program and the use of validated disease specific cohorts and outcomes that minimized misclassification. It is also the first study to contextualize HF care in IA compared to the general population and DM. However, we acknowledge some limitations.

Table 1
Characteristics of the study population at the time of the index HF hospitalization.

	DM Alone	IA + DM	IA Alone	General Comparators (No DM or IA)	IA + DM versus DM Alone		IA Alone versus DM Alone	
					Standardized Difference	*P*-value	Standardized Difference	P-value
Study sample, n	33,553	1987	3849	62,256				
Age in years, mean (SD)	76.4 (11.1)	76.8 (10.4)	79.2 (11.6)	78.8 (13.1)	0.001	0.81	0.30	<0.0001
Female sex	15,309 (46 %)	1046 (53 %)	2330 (61 %)	31,329 (50 %)	0.14	<0.001	0.30	<0.0001
Rurality Index for Ontario, mean (SD)	11.6 (17.9)	10.7 (17.2)	12.0 (18.5)	12.3 (18.4)	0.05	0.03	0.02	0.17
Ethnicity					0.04	0.04	0.12	<0.0001
South Asian	1041 (3 %)	49 (3 %)	50 (1 %)	955 (2 %)	0.05		0.08	
Chinese	623 (2 %)	25 (1 %)	36 (1 %)	1154 (2 %)	0.06		0.15	
All Others	31,889 (95 %)	1913 (96 %)	3763 (98 %)	60,147 (96 %)				
Neighbourhood income quintile								
1	8949 (27 %)	520 (26 %)	888 (23 %)	15,067 (25 %)	0.01	0.57	0.08	<0.0001
2	7770 (23 %)	474 (24 %)	833 (22 %)	12,033 (19 %)	0.01		0.02	
3	6420 (19 %)	391 (20 %)	761 (20 %)	10,279 (16 %)	0.03		0.07	
4	5569 (17 %)	334 (17 %)	719 (18 %)	261 (0.5 %)	0.02		0.01	
5	4700 (14 %)	256 (13 %)	630 (16 %)					
Unknown	145 (0.4 %)	12 (0.6 %)	18 (0.5 %)					
Chronic obstructive pulmonary disease	13,321 (40 %)	971 (49 %)	1819 (47 %)	24,975 (40 %)	0.19	<0.0001	0.15	<0.0001
Asthma	6590 (20 %)	482 (24 %)	841 (22 %)	11,458 (18 %)	0.11	<0.0001	0.06	0.001
Inflammatory bowel disease	108 (0.3 %)	13 (0.7 %)	29 (0.8 %)	261 (0.4 %)	0.05	0.02	0.06	<0.0001
Chronic kidney disease	12,606 (38 %)	784 (40 %)	1109 (29 %)	14,667 (24 %)	0.04	0.09	0.19	<0.0001
Dementia	4189 (13 %)	277 (14 %)	572 (15 %)	9042 (15 %)	0.04	0.06	0.07	<0.0001
Cancer	7183 (21 %)	434 (22 %)	976 (25 %)	14,692 (24 %)	0.01	0.65	0.09	<0.0001
Hypertension	32,175 (96 %)	1928 (97 %)	3407 (89 %)	53,868 (87 %)	0.06	0.01	0.28	<0.0001
Atrial Fibrillation	14,898 (44 %)	948 (48 %)	2104 (55 %)	34,224 (55 %)	0.07		0.21	<0.0001
Valvular Disease	5002 (15 %)	340 (17 %)	766 (20 %)	11,958 (19 %)	0.06	0.001	0.13	<0.0001
Ischemic heart disease	13,647 (41 %)	803 (40 %)	1141 (30 %)	18,307 (29 %)	0.01	0.82	0.23	<0.0001
Hospitalization for myocardial infarction	10,528 (31 %)	605 (30 %)	926 (24 %)	14,533 (23 %)	0.02	0.39	0.16	<0.0001
Percutaneous coronary intervention	5681 (17 %)	345 (17 %)	466 (12 %)	7286 (12 %)	0.01	0.62	0.14	<0.0001
Coronary artery bypass graft	5859 (18 %)	343 (17 %)	371 (10 %)	6007 (9.6 %)	0.01	0.82	0.23	<0.0001
Stroke	3477 (10 %)	195 (10 %)	328 (9 %)	5326 (9 %)	0.02	0.43	0.06	<0.0001
Emergency department visits in prior 12 months, mean (SD)	2.52 (2.74)	2.63 (2.91)	2.53 (2.29)	2.44 (3.61)	0.04	0.18	0.01	0.78
Hospitalizations in preceding 12 months, mean (SD)	1.70 (1.14)	1.84 (1.22)	1.73 (1.15)	1.61 (1.04)	0.12	<0.0001	0.03	0.28
Admission to teaching hospital	7867 (23 %)	513 (26 %)	998 (26 %)	15,550 (25 %)	0.06	0.02	0.06	0.001
Admission to hospital capable of percutaneous coronary intervention	12,016 (36 %)	732 (37 %)	1377 (36 %)	22,429 (36 %)	0.02	0.35	0.001	0.96
Total number of unique drug identification products, mean (SD)[a]	1.95 (1.27)	2.41 (1.52)	2.21 (1.59)	1.65 (1.29)	0.33	<0.0001	0.18	<0.0001
NSAID or COXIB dispensing[a]	1271(5 %)	112 (7 %)	250 (8 %)	2499 (5 %)	0.09	<0.0001	0.12	<0.0001
Corticosteroid dispensing[a]	5506 (21 %)	540 (35 %)	1099 (35 %)	9925 (21 %)	0.31	<0.0001	0.32	<0.0001

DM, diabetes; IA, inflammatory arthritis; NSAID, nonsteroidal anti-inflammatory drugs; COXIB, cyclooxygenase-2 inhibitors.
[a] Among patients >65 years of age.

Table 2
Proportion achieving HF process measures after hospitalization among DM patients, and IA patients with and without DM who were discharged alive.

Process measure	DM Alone	IA + DM	IA alone	P-value	Standardized difference between DM vs. IA + DM	Standardized difference between DM vs. IA alone
Testing or Provider Measure 0–30 days after index HF hospitalization	*N* = 31,245	*N* = 1862	*N* = 3550			
Echocardiogram	69 %	68 %	67 %	0.61	0.004	0.02
Electrocardiogram	91 %	91 %	91 %	0.69	0.003	0.21
Chest x-ray	94 %	93 %	93 %	0.01	0.04	0.02
Health care provider visit within 7 days of discharge	39 %	38 %	38 %	0.67	0.02	0.01
Perfect adherence	24 %	24 %	24 %	0.59	0.02	0.01
Moderate adherence	49 %	49 %	49 %		0.01	0.01
Poor adherence	26 %	27 %	27 %		0.04	0.02
No adherence	0.7 %	0.5 %	0.5 %		0.02	0.02
Medication Measure within 90 days of index HF discharge	***N* = 25,721**	***N* = 1550**	***N* = 3127**	**P-value**	**Standardized difference between DM vs. IA + DM**	**Standardized difference between DM vs. IA Alone**
Receipt of beta-blocker	71 %	68 %	63 %	<0.0001	0.06	0.15
Receipt of RAAS inhibitor	61 %	59 %	53 %	<0.0001	0.06	0.17
Receipt of mineralocorticoid receptor antagonist	21 %	20 %	20 %	0.001	0.01	0.02
Perfect adherence	12 %	10 %	11 %	<0.0001	0.06	0.03
Moderate adherence	41 %	40 %	34 %		0.17	0.14
Poor adherence	34 %	36 %	36 %		0.04	0.04
No adherence	13 %	14 %	19 %		0.03	0.16

Perfect adherence (achieving all of testing and/or medication measures).
Moderate adherence (achieving ≥50–99 % of testing and/or medication measures).
Poor adherence (achieving 1–49 % of testing and/or medication measures).
No adherence (achieving none of the testing or medication measures).
RAAS inhibitor [renin-angiotensin-aldosterone-system inhibitor, i.e. angiotensin converting enzyme inhibitor (ACEI), angiotensin receptor blocker (ARB), angiotensin receptor neprilysin inhibitor (ARNI)].

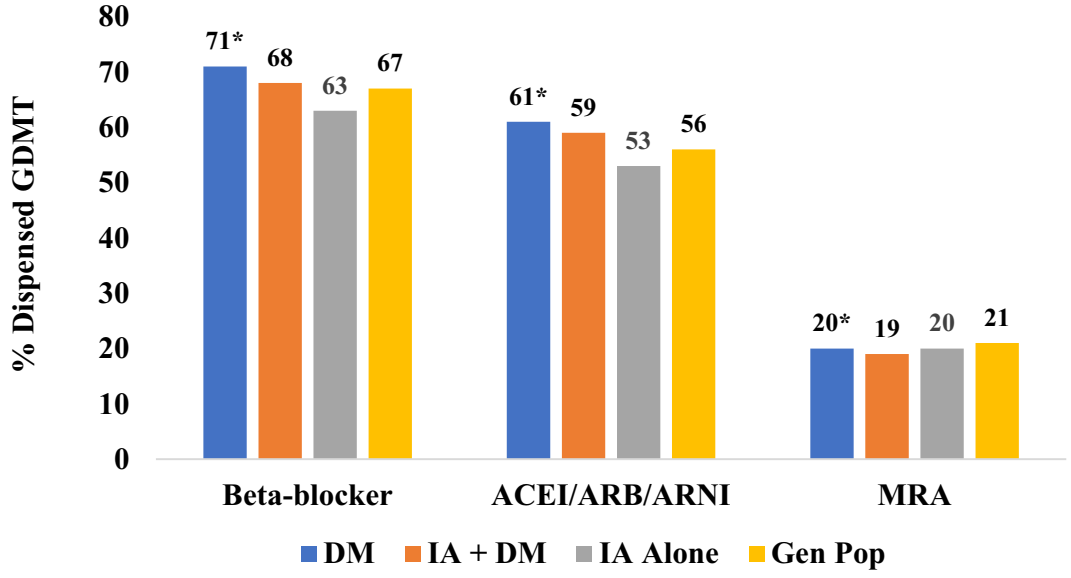

Fig. 1. Dispensing of guideline-recommended therapies (GDMT) within 90 days post HF hospitalization among patients discharged alive with diabetes mellitus (DM), inflammatory arthritis with DM (IA+ DM), inflammatory arthritis alone (IA) or general population comparators (Gen Pop). ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor neprilysin inhibitor; MRA, Mineralocorticoid receptor antagonist. *Denotes *p*-value <0.001 comparing DM group to IA.

Inherent to administrative health data, we lacked certain clinical variables to inform the applicability of the quality measures, specifically left ventricular ejection fraction and blood pressure. This restricted our ability to differentiate HFpEF versus HFrEF, for which the level of evidence for GDMT medication vary. Further, not all dimensions of HF quality of care were measured in this study. We did not evaluate laboratory testing after initiation of medications, achievement of target dosing for therapeutics, or newer evidence-based therapies such as sodium-glucose cotransporter-2 inhibitors that have become standard of care for HF since 2020 [29]. We also did not explore other important quality metrics such as costs of care, procedures (e.g., implantable devices for qualifying candidates) or if services like cardiac rehabilitation post-discharge differed between groups. Finally, our results may not be generalizable to other countries where health care systems or population characteristics may differ.

In summary, we found certain quality measures are adhered to in a high proportion of patients with IA following HF hospitalization. However, patient or system-level reasons for lower GDMT prescribing in

Table 3
Multivariable model examining associations with perfect or moderate medication adherence versus no adherence among patients >65 years with diabetes (DM), inflammatory arthritis with diabetes (IA + DM) or inflammatory arthritis alone (IA) compared to the general population. Presented as odds ratios with 95 % confidence intervals.

Variable	Unadjusted	Sex/age adjusted	Fully adjusted
DM Cohort	1.36 (1.30–1.43)	1.17 (1.12–1.23)	0.98 (0.93, 1.03)
IA + DM	1.20 (1.03–1.39)	1.01 (0.86–1.17)	0.78 (0.68–0.94)
IA alone	0.81 (0.73–0.89)	0.77 (0.69–0.85)	0.67 (0.61–0.76)
Age at index date (per year)			0.95 (0.95, 0.96)
Male sex			0.97 (0.92, 1.01)
Rural residence			0.89 (0.83, 0.95)
Income quintile (highest vs lowest (ref))			0.99 (0.93, 1.07)
Admission to hospital capable of PCI			1.05 (0.99, 1.10)
Admission to an academic teaching hospital			0.96 (0.90, 1.01)
Hospitalization for acute myocardial infarction			1.26 (1.19, 1.34)
Hospitalization for PCI or CABG			1.19 (1.11, 1.26)
COPD/Asthma			0.83 (0.79, 0.87)
Hypertension			1.37 (1.27, 1.49)
Stroke			0.96 (0.89, 1.03)
Chronic kidney disease			0.56 (0.53, 0.59)
Cancer			0.84 (0.80, 0.88)
Dementia			0.81 (0.77, 0.86)
Inflammatory bowel disease			0.96 (0.67, 1.37)
At least 1 outpatient visit within past year			0.92 (0.79, 1.08)
At least 1 ED visit within past year			0.99 (0.95, 1.06)
At least 1 hospitalization within past year			0.77 (0.73, 0.81)
Corticosteroid use			0.27 (0.26, 0.29)
NSAID/COXIB use			0.41 (0.37, 0.45)
Total number of unique medications			2.54 (2.48, 2.61), $p < 0.001$

Abbreviations: CABG, coronary artery bypass graft; COPD, chronic obstructive pulmonary disease; COXIB, cyclooxygenase-2 inhibitors; ED, emergency department; NSAID, non-steroidal anti-inflammatory drug; PCI, percutaneous coronary intervention. Results for poor vs non-adherent are not shown.

patients with IA compared to patients with DM will require further evaluation. This is particularly concerning because these treatment gaps may only widen as HF treatments continue to expand. Based on our findings, ongoing monitoring of care processes and validation of these results across diverse IA cohorts and other high-risk HF populations is needed. A crucial next step will be to determine if these differences in quality of care implementation are associated with an increased risk of adverse outcomes such as repeat HF hospitalizations and HF mortality. It will also be important to assess whether newer classes of HF medications, indicated regardless of ejection fraction and with potential anti-inflammatory effects, like SGLT2 inhibitors, will modify this association.

CRediT authorship contribution statement

Bindee Kuriya: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Lihi Eder:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sahil Koppikar:** Writing – review & editing, Methodology, Investigation, Formal analysis, Conceptualization. **Jessica Widdifield:** Writing – review & editing, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anna Chu:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Jiming Fang:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis, Data curation. **Irene Jeong:** Writing – review & editing, Validation, Methodology, Formal analysis, Data curation. **Douglas Lee:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Jacob Udell:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Bindee Kuriya reports financial support and statistical analysis were provided by This study received funding from the Canadian Initiative for Outcomes in Rheumatology Care (CIORA) grant from the Canadian Rheumatology Association. Bindee Kuriya reports a relationship with AbbVie Inc. that includes: consulting or advisory. Bindee Kuriya reports a relationship with Pfizer Canada Inc. that includes: consulting or advisory. Jacob Udell reports a relationship with Amgen, AstraZeneca, Boehringer-Ingelheim, Janssen, Merck, Novartis and Sanofi that includes: consulting or advisory. Jacob Udell reports a relationship with AstraZeneca, Bayer, Novartis and Sanofi that includes: funding grants. Lihi Eder reports a relationship with Abbvie, UCB, Pfizer, Janssen, Novartis, Eli Lilly, Sandoz, Fresenius Kabi. that includes: funding grants. Sahil Koppikar reports a relationship with Abbvie, Celltrion, Eli Lilly, Fresenius Kabi, JAMP, Janssen, Novartis, Sandoz, and UCB that includes: consulting or advisory. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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We thank IQVIA Solutions Canada Inc. for use of their Drug Information File. This manuscript also identified cohorts of people with South Asian and Chinese origins based on their surnames as a proxy variable, rather than based on self-reported ethnicity. The lists of surnames that were used have been validated and show very high specificity (>99.5 %) but low sensitivity (50 % for South Asians and 80 % for Chinese) (BMC Medical Research Methodology, 10:42, 2010, https://doi.org/10.1186/1471-2288-10-42). For example, the lists deliberately exclude certain surnames which, while common in the South Asian or Chinese population, are not unique to that population. Hence, only subsets of these ethnic communities are identified, and results may not be generalizable to the entire community. The remaining population is labeled as the "general population" and includes both people with European origins and those from all racial/ethnic groups not identified by surnames.

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Appendix A. Supplementary data

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