Quality of care delivery in patients with acute heart failure: insights from the international REPORT-HF registry

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Summary

Background Heart Failure (HF) quality of care (QoC) is associated with clinical outcomes. Therefore, we investigated differences in HF QoC across worldwide regions (with differing national income) and the association of quality indicators with outcomes.

Methods We examined the quality of care (QoC) in acute heart failure (HF) patients across different regions using quality indicators (QIs) from the European Society of Cardiology (ESC) and the American Heart Association (AHA) to evaluate QoC. The analysis included 17,632 patients enrolled from 358 medical centres in 44 countries between 23 July 2014 and 24 March 2017, all part of the prospective REPORT-HF cohort study. We investigated how QoC varied by region and its relationship with mortality rates at 30 days and 1 year after hospital discharge. For each QI, percentage attainment of QI among eligible patients was calculated and compared across regions.

Findings Among 17,632 patients (median age: 67 years; 61% women) followed up for a median of two years, we assessed 16 QIs. QIs that were least often achieved included measurement of natriuretic peptides, performance of echocardiography, treatment with guideline medical therapy, and a scheduled follow-up consultation after discharge. QI achievement was significantly lower in lower-than higher-income countries. Higher (≥50% vs. <50%) achievement of cumulative QIs was associated with lower 30-day (hazard ratio [HR] 0.58, 95% Confidence Interval [CI] 0.40–0.83; p < 0.001), and 1-year mortality (HR 0.58, 95% CI 0.50–0.68; p < 0.001).

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Interpretation QoC is lower in lower-than higher-income countries and lower QoC is associated with worse outcomes. Improving QoC by addressing structural barriers and quality improvement programs may improve the outcomes of patients with HF.

Funding Novartis.

Keywords: Quality of care; Quality improvement; Quality indicators; Heart failure; Mortality; Implementation

Research in context

Evidence before this study

We searched PubMed for studies in English from 1 January 1995 until 31 December 2023 on the association of quality of care in heart failure and its association with outcomes across worldwide regions. We initially used the following search terms: "quality of care", "quality indicators", "heart failure", "outcomes", or "mortality", and "implementation", which yielded 54 studies, few of which were based on a single country or region. Extending the search to include "worldwide", "global", or "international" did not identify any global cohort study which investigated the association of heart failure quality indicators with mortality across worldwide regions.

Added value of this study

Our study adds to previous literature limited to a single country or region by providing data on the geographical variation in the quality of care and its association with mortality in heart failure across 44 countries from six continents, confirming that achievement of quality indicators is consistently associated with better outcomes. Many of the AHA/ACC/ESC quality indicators were associated with heart failure outcomes, regardless of the country's income level. This study suggests that these quality indicators could be a suitable tool to assess and measure the quality of care in HF worldwide. The findings can inform the quest for a global strategy to reduce the heterogeneity in HF care quality.

Implications of all the available evidence

The study findings underscore the critical importance of a coordinated approach with accurate diagnosis, holistic assessment, treatment optimization with guideline-recommended medical therapy of patients with heart failure, and scheduled consultations post-discharge for better long-term outcomes. These results are consistent with the conceptual framework for the management of patients with heart failure. Programs or interventions to facilitate the implementation of AHA/ACC/ESC quality indicators can improve patients' outcomes with heart failure. Nevertheless, ideal quality indicators must be customised based on differing healthcare systems and available resources in different regions.

Introduction

Despite advances in medical therapy, long-term trends in post-discharge 1-year mortality among patients hospitalised with heart failure (HF) remain poor.[1] Quality of care (QoC) in hospitals is central to improving HF outcomes.[2] Therefore, the American Heart Association (AHA)/American College of Cardiology (ACC) and the European Society of Cardiology (ESC) recommend adherence to various quality indicators to improve HF-QoC.[2,3]

Reports from Europe, the United States, and China suggest that QoC varies substantially within and between countries.[4–7] Furthermore, patients with HF from lower and middle-income countries (LMICs) have higher post-discharge mortality rates than those from high-income countries.[8,9] Differences in QoC might explain this disparity.[10] However, regional variation in HF-QoC has only been estimated in single, predominantly higher-income countries.[4–6] A better understanding of the quality of care in HF around the world can serve as a benchmark for quality-of-care monitoring and to support local quality improvement, guide international efforts, and identify national best practices.[2,11]

The REPORT-HF (international REgistry to assess medical Practice and lOngitudinal obseRvation for Treatment of Heart Failure) is a global, prospective registry uniquely designed to investigate regional differences in QoC in patients hospitalised for acute HF.[12,13] Therefore, we investigated global differences in HF-QoC in 44 countries with differing national income. The association between quality indicators (QI) and outcomes was also investigated.

Methods

This study is reported per the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.

Study design, study population and setting

The study design of the REPORT-HF registry has been previously published.[12–16] In brief, The REPORT-HF is a

global, prospective, and observational cohort study designed to characterise global differences in clinical presentations, and quality of care in patients hospitalised for AHF. Patients with a primary diagnosis of acute HF (AHF-as diagnosed by the clinician investigator) were prospectively enrolled in 358 centres from 44 countries on six continents between July 2014 and March 2017. The inclusion and exclusion criteria have been previously described.[12–14,16] In REPORT-HF, all patients were admitted with a primary diagnosis of AHF and excluded if enrolled in a concomitant clinical trial.

Ethics approvals were obtained from each participating centre's local institutional review committee, and all participating subjects provided written informed consent. This study conforms to the ethical guidelines in the Declaration of Helsinki.

Data collection and definitions using uniform case report forms at all sites, investigators recorded data on demographics, clinical signs and symptoms on physical examination, New York Heart Association (NYHA) functional status, clinical chemistry, medical history, prior interventions, and medication history at admission and/or discharge. Comorbidities were defined based on medical history; anaemia was defined based on sex-specific haemoglobin levels according to the World Health Organization (WHO) criteria.[17] HF with reduced ejection fraction (HFrEF) was defined as left ventricular ejection fraction (LVEF) < 40%, HF with mildly reduced ejection fraction (HFmrEF) as LVEF 40–49% and HF with preserved ejection fraction (HFpEF) as LVEF ≥ 50%.

Quality of care indicators

This study used the ESC (2022) quality indicators for HF[3] and the 2020 American College of Cardiology/AHA performance measures[2] to assess HF-QoC in each centre. Available data in the REPORT-HF registry were mapped to QoC indicators primarily in patient assessment (and tests) and treatment with guideline-recommended medications as in the ESC and ACC/AHA frameworks. A total of 13 quality indicators (QI) were included as individual factors and components of a composite score for attainment. Three additional quality indicators [for medications: evidence-based β-blockers, angiotensin-converting enzyme inhibitors (ACEi)/angiotensin receptor blocker (ARB)/angiotensin receptor/neprilysin inhibitor (ARNI), mineralocorticoid receptor antagonists (MRA)] were included only for the patients with HFrEF. The denominator (of all eligible patients with records) and the numerator (as fulfilment of QI) among these patients were calculated for each QI. The composite opportunity-based QI score was then calculated as the number of times each QI was attained (numerator) out of the number of care processes the patients were eligible for (denominator). Health-related quality of life was not collected in all REPORT-HF countries and structural indicators in domain 1 of the ESC framework were not recorded. Findings were reported for the total cohort and stratified by tertiles of percentage attainment of QIs by centres and national income.

Outcomes

The primary outcomes of this study were 30-day all-cause mortality and 1-year all-cause mortality from discharge. Mortality was prospectively captured during follow-up from death records and phone follow-up visits, as previously described.[14] Patients were considered lost to follow-up if no vital status could be obtained.

Statistical analyses

Countries were stratified into subgroups based on the national income categorised by the World Bank classification into '*Lower-middle-income countries'(Lower)*, '*upper-middle income*' (*Middle*) and '*high-income' countries (High)*.[12,16] Centres were categorised into tertiles according to the average composite QI scores attained by the patients. Standard descriptive statistics, including, as appropriate, mean ± standard deviation (SD) and median plus 25th–75th percentiles or numbers and percentages, were used to describe patient demographics and characteristics, clinical signs and symptoms, medical history/comorbidities, biochemistry, medications, and device therapy. The distribution of all continuous variables was visually inspected at the start of the analysis. We tested differences between groups using the one-way analysis of variance, the Kruskal–Wallis test, or the χ^2 test, where appropriate. Analyses of 30-day and 1-year all-cause mortality were done using a mixed-effects parametric survival model, incorporating a random effect for the centres to account for potential clustering at the site level. Patients who were lost to follow-up or had missing data in the variables used in adjustment were excluded from survival analysis. Models were adjusted for age, sex, region, income class, HF diagnosis, peripheral oedema, NYHA, systolic blood pressure, diabetes mellitus, chronic kidney disease, anaemia, atrial fibrillation, coronary artery disease, and valvular heart disease. Additionally, interactions of the composite QI score with regional income level were further explored. We also performed several sensitivity analyses by including (i) country in the hierarchical model, (ii) ethnicity in place of geographical region, (iii) a modified Charlson Comorbidity index and (iv) smoking and alcohol in the multivariable models for 1 year mortality. We confirmed the Cox proportional hazards assumption using log–log plots and the Schoenfeld residuals test. All analyses were two-tailed, and $p < 0.05$ was considered statistically significant. Analyses were performed in Stata v16 (StataCorp).

Role of the funding source

The funder of the REPORT-HF registry had no role in the study design, data collection, data analysis, data interpretation, or report writing.

Results

Baseline characteristics

In total, REPORT-HF included 18,553 patients admitted for AHF. We excluded 451 patients who died during the index admission and 470 who were lost to follow-up post-discharge. Patients excluded tended to be younger, have new onset HF, and have lower prevalence of diabetes and CAD. The rest of the baseline characteristics are mostly similar.

Based on available data, we could estimate 11 ESC HFA 2022 and 7 ACC/AHA QIs. In total, 28.3% of centres were categorised in the '*Low*' (34.5–<65.0% attainment of QIs), 37.3% in the '*Medium*' (65.0–<74.0% attainment), and 34.4% (≥74% QI attainment) in the '*High*' tertile.

Table 1 shows the baseline characteristics stratified according to tertiles of QI achievement on the centre level. The median age of the remaining 17,632 patients was 67 (interquartile range [IQR] 57–77) years, and 61% were women. Patients enrolled in centres with higher attainment of QIs were older, more often men or had HFrEF, had more comorbidities, had worse NYHA class, and had higher use of HF medications at discharge. Fig. 1 and Table 2 show that cumulative QI attainment was worse in lower-than higher-income countries.

Variation in quality of care across centres and low/middle/high-income countries

Table 3 shows the attainment of QIs stratified according to centres with low, medium, and high cumulative attainment of QIs. Table 3 shows that attainment of QIs for patient assessment was high across centres, except for overall low referral rates to cardiac rehabilitation, NT-proBNP measurement, scheduled follow-up consultations within six months after discharge, NYHA class assessment, and performance of transthoracic echocardiography/transesophogeal echocardiography (TTE/TEE) during hospitalisation.

As for the medications at discharge, the proportions of patients with HFrEF in the overall cohort prescribed a β-blocker, ACEi/ARB/ARNi, MRA and a loop diuretic were 76.2%, 70.9%, 59.7%, and 85.5%, respectively. The difference in proportions across centres was most marked for treatment with a β-blocker.

Table 4 shows that QI attainment for patient assessment and medications was lower in lower-than higher-income countries. Differences across country income levels were especially marked for NT-proBNP measurement, performance of TTE/TEE during hospitalisation, scheduled follow-up appointment planning, HF medication use and ICD/CRT-D use.

Association of attainment of quality indicators and all-cause mortality at 30 days and 1-year post-discharge

The 1-year and 30-day all-cause mortality (uncorrected) were 20% and 3%, respectively. Fig. 2 shows that patient level ≥50% attainment of composite QI was independently associated with 1-year post-discharge mortality (adjusted HR: 0.58, 95% CI 0.50–0.68, p < 0.001). In a sensitivity analysis of the composite QI as a continuous percentage, per percentage point increase was associated with 4% lower hazard of 1 year mortality (HR 0.96, 95% CI 0.96–0.97; p < 0.001). We further separated the QIs into domains for "Patient assessment" and "Treatment" in relation to mortality. In the patients with HFrEF, ≥50% achievement of cumulative QIs in the patient assessment domain was associated with lower 1-year mortality (age-adjusted HR 0.72, 95% CI 0.59–0.89; p = 0.002) but attenuated with multivariable adjustment (HR 0.85, 95% CI 0.63–1.13; p = 0.26). Triple GDMT was associated with lower 1-year mortality (adjusted HR 0.71, 95% CI 0.63–0.80; p < 0.001). In a separate sensitivity analysis including country in the hierarchical model (with centre being nested in country), ≥50% achievement of cumulative QIs was associated with lower 1-year mortality (HR 0.58, 95% CI 0.50–0.68; p < 0.001). Several sensitivity analyses were also performed by including (i) ethnicity in place of geographical region, (ii) a modified Charlson Comorbidity index and (iii) smoking and alcohol in the multivariable models for 1 year mortality. All results were similar as before. Supplementary Table S1 shows that results were consistent for 30-day all-cause mortality (adjusted hazard ratio [HR]: 0.58, 95% CI 0.40–0.83). We also found a significant interaction between patient-level ≥50% attainment of composite QI and national income level (age-adjusted $P_{interaction}$ <0.001), where the association of ≥50% attainment of composite QI with lower 1-year mortality was more pronounced in higher than lower-income regions (Supplementary Table S2).

Among the individual QIs, TTE/TEE during hospitalisation, prescription of ACEi/ARB/ARNI at discharge, and a scheduled consultation with a GP or cardiologist post-discharge were associated with 30-day (Supplementary Table S1) and 1-year (Fig. 2) post-discharge mortality. Having an ECG done and being prescribed a β-blocker were associated with 1-year but not 30-day post-discharge mortality (Fig. 2 and Supplementary Table S1). The higher hazard ratios observed for patients referred for cardiac rehabilitation, chest X-ray and those who had acute IV treatment within 6 h (of admission) could reflect sicker patients (Fig. 2).

Discussion

In this global cohort with patients hospitalised for acute HF from 44 countries, we found (1) significant variation in HF-QoC, and (2) better QoC was associated with improved outcomes. Many of the AHA/ACC/ESC QIs were associated with outcomes in HF, regardless of country income level. This study suggests that these QIs, as benchmarks for QoC monitoring for HF, could be a suitable tool to assess and measure the QoC in HF

Characteristic	Total cohort	Low-Tertile 1 (34.5–<65.0%)	Medium-Tertile 2 (65.0–<74.0%)	High-Tertile 3 (≥74.0%)	p-value
N	17,632	4985	6574	6073	
Demographics and characteristics					
Age, years	67 (57, 77)	66 (56, 75)	67 (57, 76)	69 (59, 78)	<0.001
Women, n (%)	10,822 (61%)	3156 (63%)	3897 (59%)	3769 (62%)	<0.001
Ethnicity, n (%)					<0.001
White	9213 (52%)	2259 (45%)	3365 (51%)	3589 (59%)	
Black	834 (5%)	52 (1%)	416 (6%)	366 (6%)	
Asian	5469 (31%)	1862 (37%)	1985 (30%)	1622 (27%)	
Native American	340 (2%)	219 (4%)	115 (2%)	6 (<1%)	
Others	1776 (11%)	593 (12%)	693 (10%)	490 (8%)	
Private medical insurance, n (%)	2160 (12%)	667 (13%)	771 (12%)	722 (12%)	<0.001
Regional income class, n (%)					<0.001
Lower middle	2934 (16.6%)	1676 (33.6%)	828 (12.6%)	430 (7.1%)	
Upper middle	7354 (41.7%)	1744 (35.0%)	3365 (51.2%)	2245 (37.0%)	
Higher	7344 (41.7%)	1565 (31.4%)	2381 (36.2%)	3398 (55.9%)	
NYHA class at discharge, n (%)					<0.001
Class I/II	7564 (68%)	1695 (64%)	2912 (66%)	2957 (73%)	
Class III/IV	3526 (32%)	958 (36%)	1471 (34%)	1097 (27%)	
Heart rate, bpm	86 (73, 102)	88 (75, 103)	86 (73, 100)	85 (72, 101)	<0.001
Systolic blood pressure, mmHg	130 (111, 150)	130 (110, 150)	130 (114, 150)	130 (110, 150)	<0.001
Diastolic blood pressure, mmHg	80 (70, 90)	80 (70, 90)	80 (70, 90)	79 (68, 90)	0.006
BMI, kg/m^2	26.3 (22.9, 31.2)	26.7 (23.4, 31.6)	26.3 (22.7, 31.2)	26.3 (22.9, 30.9)	0.091
Current smoker, n (%)	2420 (15%)	607 (13%)	943 (15%)	870 (15%)	0.012
New onset HF, n (%)	7523 (43%)	2508 (50%)	2556 (39%)	2459 (40%)	<0.001
Heart failure duration, years	2.6 (0.7, 6.3)	2.6 (0.7, 6.1)	2.5 (0.6, 5.9)	2.8 (0.7, 7.1)	0.001
LVEF group, n (%)					<0.001
LVEF <40%	8448 (48%)	2291 (46%)	3148 (48%)	3009 (50%)	
LVEF 40–49%	2746 (16%)	720 (14%)	1003 (15%)	1023 (17%)	
LVEF ≥50%	4951 (28%)	1115 (22%)	1932 (29%)	1904 (31%)	
Unknown	1487 (8%)	859 (17%)	491 (7%)	137 (2%)	
Aetiology, n (%)					<0.001
Ischaemic	5891 (33%)	1650 (33%)	2062 (31%)	2179 (36%)	
Hypertension	2749 (16%)	891 (18%)	1132 (17%)	726 (12%)	
Others	6096 (35%)	1450 (29%)	2317 (35%)	2329 (38%)	
Unknown	2896 (16%)	994 (20%)	1063 (16%)	839 (14%)	
Signs and symptoms, n (%)					
Dyspnea at rest	12,938 (83%)	3645 (83%)	4736 (84%)	4557 (82%)	<0.001
Orthopnea	11,062 (78%)	3140 (80%)	3879 (76%)	4043 (77%)	<0.001
Peripheral oedema	10,812 (69%)	2920 (70%)	3968 (67%)	3924 (69%)	0.003
Pulmonary rales	9769 (67%)	2413 (66%)	3698 (67%)	3658 (68%)	0.066
Medical history, n (%)					
Hypertension	11,256 (64%)	2922 (59%)	4221 (64%)	4113 (68%)	<0.001
Atrial fibrillation/flutter	1134 (6%)	222 (4%)	484 (7%)	428 (7%)	<0.001
COPD/Asthma	2528 (14%)	626 (13%)	929 (14%)	973 (16%)	<0.001
Anaemia	8235 (47%)	2140 (43%)	3018 (46%)	3077 (51%)	<0.001
Valvular heart disease	3451 (20%)	613 (12%)	1317 (20%)	1521 (25%)	<0.001
Diabetes	6760 (38%)	1887 (38%)	2523 (38%)	2350 (39%)	0.67
Chronic kidney disease	3561 (20%)	683 (14%)	1399 (21%)	1479 (24%)	<0.001
Prior MI/PCI/CABG	8525 (48%)	2449 (49%)	3149 (48%)	2927 (48%)	0.35
Prior stroke	1227 (7%)	286 (6%)	438 (7%)	503 (8%)	<0.001
Peripheral arterial disease	838 (5%)	193 (4%)	253 (4%)	392 (6%)	<0.001

(Table 1 continues on next page)

Characteristic	Total cohort	Low-Tertile 1 (34.5–<65.0%)	Medium-Tertile 2 (65.0–<74.0%)	High-Tertile 3 (≥74.0%)	p-value
(Continued from previous page)					
Clinical chemistry, median (IQR)					
NT-proBNP (ng/L)	4347 (2052, 9000)	4784 (2257, 11,206)	4554 (2127, 8960)	4155 (2009, 9000)	0.041
Haemoglobin (g/L)	12 (10, 14)	12 (11, 14)	12 (11, 14)	12 (10, 14)	0.054
eGFR (ml/min/1.73 m^2)	54 (37, 73)	47 (32, 65)	50 (33, 71)	49 (32, 68)	<0.001
Medications at discharge, n (%)					
ACEI/ARB/ARNI	11,680 (66%)	3175 (64%)	4310 (66%)	4195 (69%)	<0.001
Beta-blocker	12,723 (72%)	3238 (65%)	4561 (70%)	4639 (77%)	<0.001
MRA	8624 (49%)	2273 (46%)	3334 (51%)	3017 (50%)	<0.001
Loop diuretic	14,378 (82%)	4030 (81%)	5323 (81%)	5025 (83%)	0.028
Statin	9778 (56%)	2765 (56%)	3568 (54%)	3445 (57%)	0.025
Nitrate	3331 (19%)	1053 (21%)	1181 (18%)	1097 (18%)	<0.001
Device therapy, n (%)					
ICD/CRT-D	1191 (7%)	205 (4%)	465 (7%)	521 (9%)	<0.001
Outcomes, n (%)					
30 days all-cause mortality	547 (3%)	164 (3%)	198 (3%)	185 (3%)	0.66
1-year all-cause mortality	3461 (20%)	1070 (21%)	1318 (20%)	1073 (18%)	<0.001
1-year CV mortality	2076 (12%)	600 (12%)	847 (13%)	629 (10%)	<0.001

Table 1: **Baseline characteristics for total cohort and stratified by tertiles of percentage attainment of QIs by centres.**

worldwide. The findings provide the data which can inform the quest for a global strategy to reduce the heterogeneity in the QoC for HF, using HF quality improvement programs. Despite its proven usefulness, these QIs are not used enough for quality improvement.

Greater disparities in QI attainment were observed in centres from lower-than high-income countries across domains. Geographical variation in QoC had similarly been reported in the China PEACE (Patient-centered Evaluative Assessment of Cardiac Events),[5] SWEDE-HF,[4] and the US[6] studies, specifically about the association of similar QIs with outcomes. Those studies were done in a single country. The EuroHeart Failure survey programme[18] was a comprehensive survey of the QoC across 24 countries in Europe; our results extend previous findings to 44 countries, confirming that QI achievement is consistently associated with better outcomes.

Areas for quality improvement identified included measurement of NT-proBNP, NYHA class assessment, performance of echocardiography, guideline-directed medical therapy, scheduled follow-up consultation following discharge, referrals for cardiac rehabilitation, and ICD/CRT-D use; all of which reinforce the importance of national routines in medical care of HF. Notably, scheduled follow-up consultation was

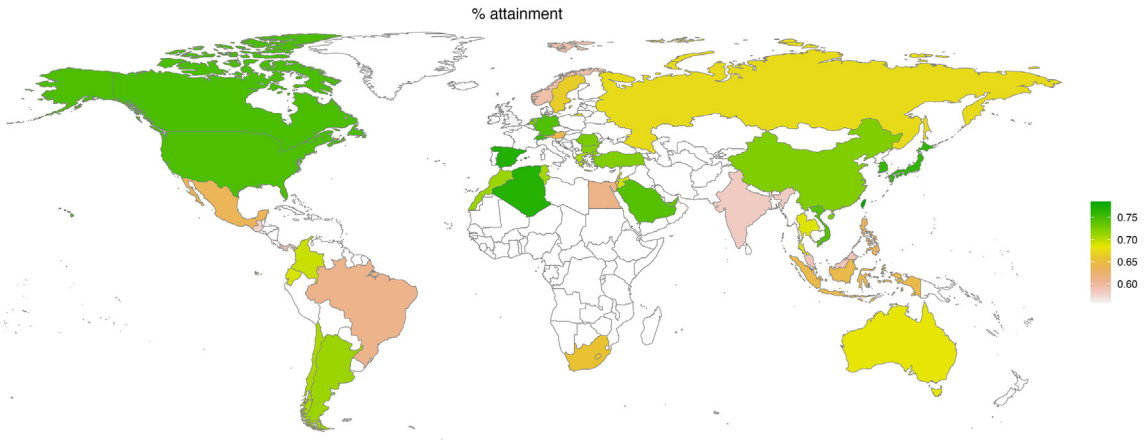

Fig. 1: World map showing the percent attainment of quality indicators across centres in seven regions. Fig. 1 shows the percentage attainment of quality indicators across centres in seven geographical regions; it may overestimate (or underestimate) the quality of care at country level due to bias in selection of centres and patients enrolled.

Characteristic	Total cohort	Missing data	Low income	Middle income	High income	p-value
N	17,632		2934	7354	7344	
Demographics and characteristics						
Age, years	67 (57, 77)	0%	61 (52, 70)	67 (57, 76)	71 (60, 80)	<0.001
Female sex, n (%)	10,822 (61%)	0%	1893 (65%)	4372 (59%)	4557 (62%)	<0.001
Ethnicity, n (%)		0%				<0.001
White	9213 (52%)		334 (11%)	3716 (51%)	5163 (70%)	
Black	834 (5%)		2 (<1%)	117 (2%)	715 (10%)	
Asian	5469 (31%)		2421 (83%)	2059 (28%)	989 (13%)	
Native American	340 (2%)		0 (0%)	262 (4%)	78 (1%)	
Others	1776 (11%)		177 (6%)	1200 (16%)	399 (6%)	
Private medical insurance, n (%)	2160 (12%)	5%	454 (15%)	817 (11%)	889 (12%)	<0.001
NYHA class at discharge, n (%)		37%				<0.001
Class I/II	7564 (68%)		1516 (83%)	3814 (62%)	2234 (71%)	
Class III/IV	3526 (32%)		314 (17%)	2312 (38%)	900 (29%)	
Heart rate, bpm	86 (73, 102)	9%	92 (80, 108)	84 (72, 100)	86 (72, 102)	<0.001
Systolic blood pressure, mmHg	130 (111, 150)	8%	130 (110, 150)	130 (110, 150)	133 (115, 153)	<0.001
Diastolic blood pressure, mmHg	80 (70, 90)	9%	80 (70, 90)	80 (70, 90)	78 (67, 90)	0.001
BMI, kg/m^2	26.3 (22.9, 31.2)	66%	23.9 (21.5, 26.4)	25.7 (22.5, 29.5)	27.0 (23.3, 32.4)	<0.001
Current smoker, n (%)	2420 (15%)	6%	398 (15%)	977 (14%)	1045 (15%)	0.11
New onset HF, n (%)	7523 (43%)	0%	1993 (68%)	2811 (38%)	2719 (37%)	<0.001
Heart failure duration, years	2.6 (0.7, 6.3)	10%	1.3 (0.3, 4.0)	2.8 (0.7, 6.2)	2.8 (0.7, 7.0)	<0.001
LVEF group, n (%)		0%				<0.001
LVEF <40%	8448 (48%)		1430 (49%)	3274 (45%)	3744 (51%)	
LVEF 40–49%	2746 (16%)		491 (17%)	1212 (16%)	1043 (14%)	
LVEF ≥50%	4951 (28%)		598 (20%)	2359 (32%)	1994 (27%)	
Unknown	1487 (8%)		415 (14%)	509 (7%)	563 (8%)	
Aetiology, n (%)		0%				<0.001
Ischaemic	5891 (33%)		1121 (38%)	2701 (37%)	2069 (28%)	
Hypertension	2749 (16%)		572 (19%)	1215 (17%)	962 (13%)	
Others	6096 (35%)		897 (31%)	2464 (34%)	2735 (37%)	
Unknown	2896 (16%)		344 (12%)	974 (13%)	1578 (21%)	
Signs and symptoms, n (%)						
Dyspnea at rest	12,938 (83%)	11%	2215 (84%)	5932 (86%)	4791 (79%)	<0.001
Orthopnea	11,062 (78%)	19%	1697 (71%)	5392 (82%)	3973 (75%)	<0.001
Peripheral oedema	10,812 (69%)	11%	1229 (51%)	5060 (72%)	4523 (72%)	<0.001
Pulmonary rales	9769 (67%)	18%	1620 (71%)	4949 (72%)	3200 (60%)	<0.001
Medical history, n (%)						
Hypertension	11,256 (64%)	0.1%	1459 (50%)	4894 (67%)	4903 (67%)	<0.001
Atrial fibrillation/flutter	1134 (6%)	<0.1%	125 (4%)	514 (7%)	495 (7%)	<0.001
COPD/Asthma	2528 (14%)	<0.1%	220 (8%)	1027 (14%)	1281 (17%)	<0.001
Anemia	8235 (47%)	<0.1%	1500 (51%)	2762 (38%)	3973 (54%)	<0.001
Valvular heart disease	3451 (20%)	0.1%	254 (9%)	1534 (21%)	1663 (23%)	<0.001
Diabetes	6760 (38%)	<0.1%	1227 (42%)	2617 (36%)	2916 (40%)	<0.001
Chronic kidney disease	3561 (20%)	<0.1%	316 (11%)	1313 (18%)	1932 (26%)	<0.001
Prior MI/PCI/CABG	8525 (48%)	0.1%	1592 (54%)	3766 (51%)	3167 (43%)	<0.001
Prior stroke	1227 (7%)	0.1%	85 (3%)	515 (7%)	627 (9%)	<0.001
Peripheral arterial disease	838 (5%)	0.1%	16 (1%)	356 (5%)	466 (6%)	<0.001
Clinical chemistry, median (IQR)						
NT-proBNP (ng/L)	4347 (2052, 9000)	70%	4614 (2014, 10,205)	4379 (2055, 9220)	4248 (2071, 8810)	0.48
Haemoglobin (g/L)	12 (10, 14)	33%	12 (10, 13)	12 (11, 14)	12 (10, 14)	<0.001
eGFR (ml/min/1.73 m^2)	54 (37, 73)	46%	54 (36, 73)	56 (39, 76)	53 (36, 71)	<0.001
Medications at discharge, n (%)						
ACEI/ARB/ARNI	11,680 (66%)	0.4%	1771 (61%)	4998 (68%)	4911 (67%)	<0.001
Beta-blocker	12,723 (72%)	0.4%	1449 (50%)	5477 (75%)	5797 (79%)	<0.001

(Table 2 continues on next page)

Characteristic	Total cohort	Missing data	Low income	Middle income	High income	p-value
(Continued from previous page)						
MRA	8624 (49%)	0.4%	1118 (38%)	4074 (56%)	3432 (47%)	<0.001
Loop diuretic	14,378 (82%)	0.4%	2227 (76%)	5726 (78%)	6425 (88%)	<0.001
Statin	9778 (56%)	0.4%	1856 (64%)	3834 (52%)	4088 (56%)	<0.001
Nitrate	3331 (19%)	0.4%	1010 (35%)	1127 (15%)	1194 (16%)	<0.001
Device therapy, n (%)						
ICD/CRT-D	1191 (7%)	0.1%	58 (2%)	252 (3%)	881 (12%)	<0.001
Outcomes, n (%)						
30 days all-cause mortality	547 (3%)	0%	113 (4%)	210 (3%)	224 (3%)	0.03
1-year all-cause mortality	3461 (20%)	0%	619 (21%)	1457 (20%)	1385 (19%)	0.031
1-year CV mortality	2076 (12%)	0%	404 (14%)	974 (13%)	698 (10%)	<0.001
Percentage attainment of QIs		0%				<0.001
Tertile 1	4985 (28.3%)		1676 (57.1%)	1744 (23.7%)	1565 (21.3%)	
Tertile 2	6574 (37.3%)		828 (28.2%)	3365 (45.8%)	2381 (32.4%)	
Tertile 3	6073 (34.4%)		430 (14.7%)	2245 (30.5%)	3398 (46.3%)	

Table 2: **Baseline characteristics for total cohort and stratified by low, middle and high-income countries.**

associated with a low hazard ratio (and tight confidence intervals, in Fig. 2), suggesting that it is a marker of a sub-cohort of patients at specifically low risk of future problems. Of the QI measures, NYHA classification (a fundamental tool for risk stratification of HF despite its limitations) and its routine assessment in HF (with minimal cost) should be promoted. Importantly, only performing investigations to make a diagnosis and to classify the type of HF may not translate into a therapeutic strategy that will improve an individual patient's prognosis. Echocardiography, followed by administration of GDMT and scheduled consultation with a healthcare provider post-discharge would be most relevant for implementation. While echocardiography or ARNI might not be universally available due to limited resources in certain areas, outpatient follow-up and treatment with other GDMT–a beta-blocker, ACEi/ARB and MRA–may be more globally achievable goals in the short-term, being less dependent on the country's wealth. Of note, a lack of compliance with GDMT could be a marker for a sicker or more deprived group of patients. Sicker patients with, for example, low blood pressure or renal impairment are less likely to be treated with HF therapies other than diuretics. Such patients could thus be at risk of a higher mortality. Indeed, an earlier study,[13] reported that patients who were older, more frail, with advanced stage of HF, chronic kidney disease and without medical insurance were less likely to be on triple GDMT (ACEi/ARBs/ARNi, β-blockers, and MRAs) at discharge and 6 months.

Higher opportunity-based ≥50% (vs. <50%) attainment of the composite quality index was associated with about 30%–40% reduction in the adjusted hazards for 30-day and 1-year all-cause mortality among all patients with HF. The composite QI was found to be more reliable than individual QIs, which is consistent with previous findings.[4] While the findings suggest the pursuit of overall quality improvement is advocated, improvement in individual QIs, as building blocks of the composite QI is as important. Nevertheless, ideal QI measures still need revision which may differ according to the health care system and available resources. Regarding quality of care, this is not a one-size-fits-all situation. These findings underscore the critical importance of a coordinated approach with accurate diagnosis, holistic assessment, treatment optimisation with guideline-recommended medical therapy of patients with HF, and scheduled consultations post-discharge for better long-term outcomes. These results are consistent with the conceptual framework for managing patients with HF.[3,19]

Previous studies have reported the association of QI and outcomes among patients with HF.[2,4,5,20–23] Several clinical registries, such as Get-With-The Guidelines for Heart Failure (GWTG-HF),[20] OPTIMIZE-HF,[21] ADHERE,[22] and SWEDE-HF,[4] have elucidated the patterns of care for HF over the long-term, with the former 3 using the AHA/ACC core performance measures. More recently, the nationwide Danish study[23] and the China PEACE study[5] have also extended previous findings. Long-term real-world registry data are useful in identifying gaps in performance or quality measures and hence, areas calling for quality improvement. Although our study examined the use of combined ESC and AHA/ACC quality and performance indicators, our findings were very similar to those reported by investigators of the SWEDE-HF,[4] which used the ESC QIs for benchmarking. In all, findings showed that fulfilment of more QI or process performance measures was associated with better clinical outcomes among patients with HF. Facilitating real-time physicians' access to performance-related quality data benchmarked against standard QIs and other hospitals could augment quality improvement and reduce the wide heterogeneity in the quality of care

Quality indicator (QI)	Patients receiving care/ eligible patients, (%)	Low-Tertile 1 (34.5–<65.0%)	Middle-Tertile 2 (65.0–<74.0%)	High-Tertile 3 (≥74.0%)
N	**17,632**	**4985**	**6574**	**6073**
Patient assessment				
Proportion of patients with HF with documentation of HF phenotype (HFrEF, HFmrEF, HFpEF)[a]	16,145/17,632 (91.6%)	4126/4985 (82.8%)	6083/6574 (92.5%)	5936/6073 (97.7%)
Proportion of patients with HF who had their ECG (rhythm only) documented[a]	14,799/17,632 (83.9%)	3805/4985 (76.3%)	5567/6574 (84.7%)	5427/6073 (89.4%)
Proportion of patients with HF who had their NT-proBNP tested at index hospitalization[a]	5213/17,632 (29.6%)	409/4985 (8.2%)	1436/6574 (21.8%)	3368/6073 (55.5%)
Proportion of patients with HF who had (any of) their blood tests documented[a]	17,132/17,632 (97.2%)	4620/4985 (92.7%)	6471/6574 (98.4%)	6041/6073 (99.5%)
Proportion of patients who had referral for cardiac rehabilitation (at chronic/rehab facility)[a]	201/17,629 (1.1%)	34/4985 (0.7%)	72/6574 (1.1%)	95/6070 (1.6%)
Proportion of patients who had a (scheduled 6 m) follow-up by a GP/ cardiologist after discharge[a]	9677/17,632 (54.9%)	2156/4985 (43.3%)	3658/6574 (55.6%)	3863/6073 (63.6%)
Sign & symptom assessed at admission[b]	17,226/17,632 (97.7%)	4811/4985 (96.5%)	6432/6574 (97.8%)	5983/6073 (98.5%)
NYHA class assessed[b]	10,774/17,632 (61.1%)	2602/4985 (52.2%)	3750/6574 (57.0%)	4422/6073 (72.8%)
TTE/TEE (Yes, undertaken)[b]	12,322/17,632 (70.0%)	2239/4985 (44.9%)	4760/6574 (72.4%)	5323/6073 (87.7%)
Chest X-ray performed during admission[b]	15,110/17,625 (85.7%)	3647/4983 (73.2%)	5811/6570 (88.5%)	5652/6072 (93.1%)
Cardiac biomarkers assessed[b]	10,433/17,632 (59.2%)	1510/4985 (30.3%)	4128/6574 (62.8%)	4795/6073 (79.0%)
Serum eGFR assessed[b]	16,234/17,632 (92.1%)	4237/4985 (85.0%)	6145/6574 (93.5%)	5852/6073 (96.4%)
Acute treatment (within 6 h) for HF during admission[b]	14,115/17,632 (80.1%)	3952/4985 (79.3%)	5268/6574 (80.1%)	4895/6073 (80.6%)
Initial treatment (at discharge)				
Proportion of patients with HFrEF prescribed with evidence-based β-blocker[a]	6421/8424 (76.2%)	1600/2278 (70.2%)	2353/3144 (74.8%)	2468/3002 (82.2%)
Proportion of patients with HFrEF prescribed with ACEi/ARB/ARNI[a]	5975/8424 (70.9%)	1528/2278 (67.1%)	2238/3144 (71.2%)	2209/3002 (73.6%)
Proportion of patients with HFrEF prescribed with an MRA[a]	5025/8424 (59.7%)	1229/2278 (54.0%)	1960/3144 (62.3%)	1836/3002 (61.2%)
Proportion of patients with HF prescribed with a loop diuretic in the presence of fluid retention[c]	9200/10,765 (85.5%)	2473/2895 (85.4%)	3347/3955 (84.6%)	3380/3915 (86.3%)
Therapy optimization				
Proportion of symptomatic patients with HF and NYHA II/III, LVEF≤30% despite HF duration >6 months who had an ICD prior to or during index hospitalization.[c]	338/1304 (25.9%)	33/235 (14.0%)	116/454 (25.6%)	189/615 (30.7%)
Composite QI				
≥50% attainment among **patients with HF** (individual QIs marked[a,b], excluding treatment)	16,380/17,632 (92.9%)	3970/4985 (79.6%)	6364/6574 (96.8%)	6046/6073 (99.6%)
≥50% attainment among **patients with LVEF<40%** (QIs marked[a,b])	8194/8448 (97.0%)	2080/2291 (90.8%)	3108/3148 (98.7%)	3006/3009 (99.9%)
≥50% attainment among **patients with LVEF ≥40%** (QIs marked[a,b], excluding treatment)	7373/7697 (95.8%)	1590/1835 (86.7%)	2863/2935 (97.6%)	2920/2927 (99.8%)

[a]Quality indicators in the ESC and AHA/ACC frameworks. [b]Quality indicators in the AHA/ACC framework. [c]Quality indicators in the ESC framework, but not included in composite QI.

***Table 3*: Performance in accordance to the ESC 2021 QI or ACC/AHA for heart failure for all and stratified by tertiles of percentage attainment of QIs by centres.**

Quality indicator (QI)	Patients receiving care/ eligible patients, (%)	Lower middle income	Upper middle income	High income
N	**17,632**	**2934**	**7354**	**7344**
Patient assessment				
Proportion of patients with HF with documentation of HF phenotype (HFrEF, HFmrEF, HFpEF)[a]	16,145/17,632 (91.6%)	2519/2934 (85.9%)	6845/7354 (93.1%)	6781/7344 (92.3%)
Proportion of patients with HF who had their ECG (rhythm only) documented[a]	14,799/17,632 (83.9%)	2352/2934 (80.2%)	6357/7354 (86.4%)	6090/7344 (82.9%)
Proportion of patients with HF who had their NT-proBNP tested at index hospitalization[a]	5213/17,632 (29.6%)	648/2934 (22.1%)	1622/7354 (22.1%)	2943/7344 (40.1%)
Proportion of patients with HF who had (any of) their blood tests documented[a]	17,132/17,632 (97.2%)	2790/2934 (95.1%)	7091/7354 (96.4%)	7251/7344 (98.7%)
Proportion of patients who had referral for cardiac rehabilitation (at chronic/rehab facility)[a]	201/17,629 (1.1%)	11/2934 (0.4%)	26/7354 (0.4%)	164/7341 (2.2%)
Proportion of patients who had a (scheduled 6 m) follow-up by a GP/cardiologist after discharge[a]	9677/17,632 (54.9%)	1500/2934 (51.1%)	3635/7354 (49.4%)	4542/7344 (61.8%)
Sign & symptom assessed at admission[b]	17,226/17,632 (97.7%)	2849/2934 (97.1%)	7231/7354 (98.3%)	7146/7344 (97.3%)
NYHA class assessed[b]	10,774/17,632 (61.1%)	1637/2934 (55.8%)	5452/7354 (74.1%)	3685/7344 (50.2%)
TTE/TEE (Yes, undertaken)[b]	12,322/17,632 (70.0%)	1199/2934 (40.9%)	5669/7354 (77.1%)	5454/7344 (74.3%)
Chest X-ray performed during admission[b]	15,110/17,625 (85.7%)	2114/2933 (72.1%)	6260/7351 (85.2%)	6736/7341 (91.8%)
Cardiac biomarkers assessed[b]	10,433/17,632 (59.2%)	1418/2934 (48.3%)	3655/7354 (49.7%)	5360/7344 (73.0%)
Serum eGFR assessed[b]	16,234/17,632 (92.1%)	2710/2934 (92.4%)	6637/7354 (90.3%)	6887/7344 (93.8%)
Acute treatment (within 6 h) for HF during admission[b]	14,115/17,632 (80.1%)	2393/2934 (81.6%)	6249/7354 (85.0%)	5473/7344 (74.5%)
Initial treatment (at discharge)				
Proportion of patients with HFrEF prescribed with evidence-based β-blocker[a]	6421/8424 (76.2%)	740/1427 (51.9%)	2549/3260 (78.2%)	3132/3737 (83.8%)
Proportion of patients with HFrEF prescribed with ACEi/ARB/ARNI[a]	5975/8424 (70.9%)	902/1427 (63.2%)	2361/3260 (72.4%)	2712/3737 (72.6%)
Proportion of patients with HFrEF prescribed with an MRA[a]	5025/8424 (59.7%)	642/1427 (45.0%)	2176/3260 (66.7%)	2207/3737 (59.1%)
Proportion of patients with HF prescribed with a loop diuretic in the presence of fluid retention[c]	9200/10,765 (85.5%)	1001/1222 (81.9%)	4109/5031 (81.7%)	4090/4512 (90.6%)
Therapy optimization				
Proportion of symptomatic patients with HF and NYHA II/III, LVEF≤30% despite HF duration >6 months who had an ICD prior to or during index hospitalization[c]	338/1304 (25.9%)	8/84 (9.5%)	93/604 (15.4%)	237/616 (38.5%)
Composite QI				
≥50% attainment among **patients with HF** (individual QIs marked[a,b], excluding treatment)	16,380/17,632 (92.9%)	2482/2934 (84.6%)	6980/7354 (94.9%)	6918/7344 (94.2%)
≥50% attainment among **patients with LVEF<40%** (QIs marked[a,b])	8194/8448 (97.0%)	1298/1430 (90.8%)	3213/3274 (98.1%)	3683/3744 (98.4%)
≥50% attainment among **patients with LVEF ≥40%** (QIs marked[a,b], excluding treatment)	7373/7697 (95.8%)	967/1089 (88.8%)	3461/3571 (96.9%)	2945/3037 (97.0%)

[a]Quality indicators in the ESC and AHA/ACC frameworks. [b]Quality indicators in the AHA/ACC framework. [c]Quality indicators in the ESC framework, but not included in composite QI.

Table 4: **Performance in accordance to the ESC 2021 QI or ACC/AHA for heart failure for all and stratified by national income.**

for HF among hospitals. A global strategy is thus needed to improve and harmonise the quality of HF care.

Interestingly, although higher (≥50%) attainment of composite QI in the total cohort was associated with better 1-year survival, a significant interaction between ≥50% attainment of composite QI and regional income level was found, where the association of ≥50% attainment of composite QI with lower 1-year mortality was more pronounced in HICs (vs. lower- and middle- ICs). We were unable to pinpoint the exact reasons for the difference observed. Wide variations in the epidemiology, diagnostic accuracy and aetiology of HF have been reported in different parts of the world.[9,24–26] For LMICs, other unmeasured factors, i.e. patient (e.g. socio-economic status[27]) and macro factors (e.g. differences in health care systems, access which could impact the delivery of health care services)[27,28] could have contributed to patients' outcomes, apart from the attainment of QIs. The ESC/AHA guidelines for managing HF are derived from evidence in mainly white populations from Europe and North America, with an under-representation of ethnic minorities and developing countries. Certain areas might have limited economic resources and a lack of educated health care personnel, making implementation of guidelines very difficult. Moreover, patients with HF in many countries are often managed by internal medicine specialists or family physicians, who might not adhere to the ESC/AHA guidelines. Furthermore, complementary and alternative medicines are commonly used by different populations and diverse ethnicities worldwide, despite controversial benefits in HF.[29]

Limitations to the study include the following: The clinical practice during enrolment was based on the 2012 international guidelines for HF. Since then, the clinical practice and guidelines in diagnosis and

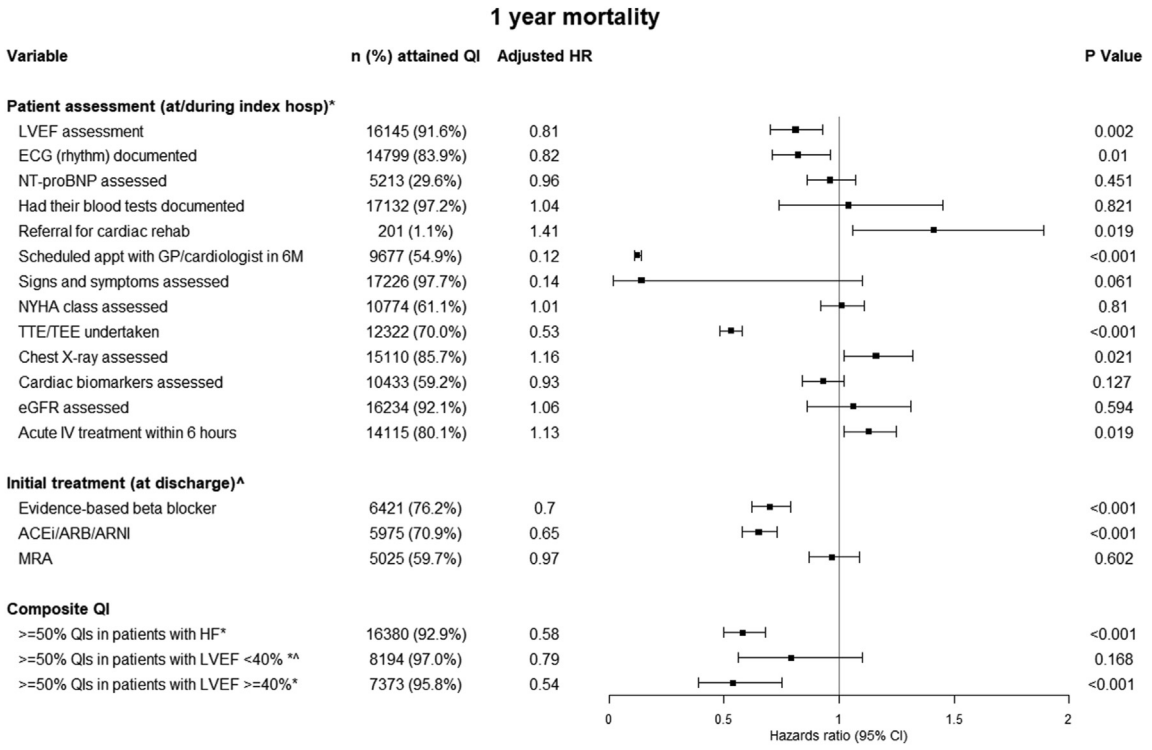

Fig. 2: Association of the ESC/AHA/ACC quality indicators with 1-year all-cause mortality. * *Quality indicators for patient assessment included.* ^ Quality indicators for treatment included. Mixed effects model with random intercepts for centre. Multivariable model adjusted for age, sex, region, income class, HF diagnosis, peripheral oedema, NYHA, SBP, diabetes, CKD, anaemia, AF, CAD, valvular heart disease.

treatment of HF patients have improved. The biases generated through the consent and inclusion process, potentially leading to better documentation of care among participants vs. non-participants, have to be acknowledged. Implementing GDMT during HF hospitalisation is central, however, titration is an issue among vulnerable patients, which has not been investigated in our study post-discharge. Moreover, treatment at discharge was not adjusted for eligibility factors. Separately, patients' health-related quality of life and socio-economic status at the patient level have not been examined. The benefits of cardiac rehabilitation could not be established as our cohort's referral rate was low. Certain QIs need to be interpreted with knowledge of the centre facilities (which is unfortunately lacking in REPORT-HF), such as the provision of a HF clinic or cardiac rehabilitation (CR) programme, which could influence uptitration of GDMT or CR referral. Centre/hospital level analysis could not be performed. The use of ARNI, SGLT-2 inhibitors and IV iron therapy could not be examined. Furthermore, the pitfall of using national income to classify regions must be acknowledged. The World Bank relies on official data published by countries; however, in developing countries, the dearth of reliable and detailed statistical information regarding sectors of an economy limits accurate national accounting. Other outcomes, apart from all-cause mortality, were not examined. Finally, causality cannot be established for observational studies, like the REPORT-HF registry. Regardless, there is robust literature to support the association of the QIs with better outcomes in HF; many of which are realistic and achievable.

The ESC and AHA/ACC quality indicators could be measured in a large proportion of patients with HF in a global cohort, and as a result could be used to benchmark quality of care for HF. Attainment of more quality indicators was associated with better outcomes. Significant variation in quality of care for HF was observed, with centres with lower attainment of QIs, not limited to those from LMICs, having the poorer outcomes. Opportunities for quality improvement for specific centre categories have been identified. The findings underscore the need for a global strategy to reduce the heterogeneity in the QoC for HF using internationally agreed quality or process indicators for quality improvement.

Contributors

THKT, WTT, JT and WO drafted the manuscript. WTT and WO undertook the analyses. JT, THKT, WO, CSPL, WTT refine the methodology. CSPL, KD, CEA, JGFC, UD, SPC provided critical clinical inputs to the study. All authors reviewed the manuscript. Final revision was done by CSPL, JT and THKT. All authors read and approved the final version of the manuscript.

WTT, WO and JT had directly accessed and verified the underlying data in the study.

Data sharing statement

Data can only be shared with the agreement of Novartis, led by the REPORT-HF Steering Committee members. The publications group of the REPORT-HF study meets regularly to discuss manuscript development. Proposals for further analyses may be submitted to the group and will be judged based on their feasibility, originality, and scientific merit. Applicants might be asked to meet the costs of data preparation and statistical analysis and are expected to involve REPORT-HF investigators in manuscript development. Applications should be made to Gerasimos Filippatos (geros@otenet.gr), Sean Collins (sean.collins@vumc.org).

Editor note

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Declaration of interests

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.eclinm.2024.103031.

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