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RESEARCH ARTICLE

Association between heart failure quality of care and mortality: a population-based cohort study using nationwide registries

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Aims To evaluate the quality of heart failure (HF) care using the European Society of Cardiology (ESC) quality indicators (QIs) for HF and to assess whether better quality of care is associated with improved outcomes.

Methods and results We performed a nationwide cohort study using the Swedish HF registry, consisting of patients with any type of HF at their first outpatient visit or hospitalization. Independent participant data for quality of HF care was evaluated against the ESC QIs for HF, and association with mortality estimated using multivariable Cox regression. In total, 43 704 patients from 80 hospitals across Sweden enrolled between 2013–2019 were included, with median follow-up 23.6 months. Of the 16 QIs for HF, 13 could be measured and 5 were inversely associated with all-cause mortality during follow-up. Higher attainment (≥50% vs. <50% attainment) of the composite opportunity-based score (combination of QIs into a single score) for patients with reduced ejection fraction was associated with lower all-cause mortality (adjusted hazard ratio 0.81; 95% confidence interval 0.72–0.91). Attainment of the composite score was less in the outpatient than inpatient setting (adjusted odds ratio 0.85; 95% confidence interval 0.72–0.99). Quality of care varied across hospitals, with assessment of health-related quality of life being the indicator with the widest variation in attainment (interquartile range 61.7%).

Conclusion Quality of HF care may be measured using the ESC HF QIs. In Sweden, attainment of HF care evaluated using the QIs demonstrated between and within hospital variation, and many QIs were inversely associated with mortality.

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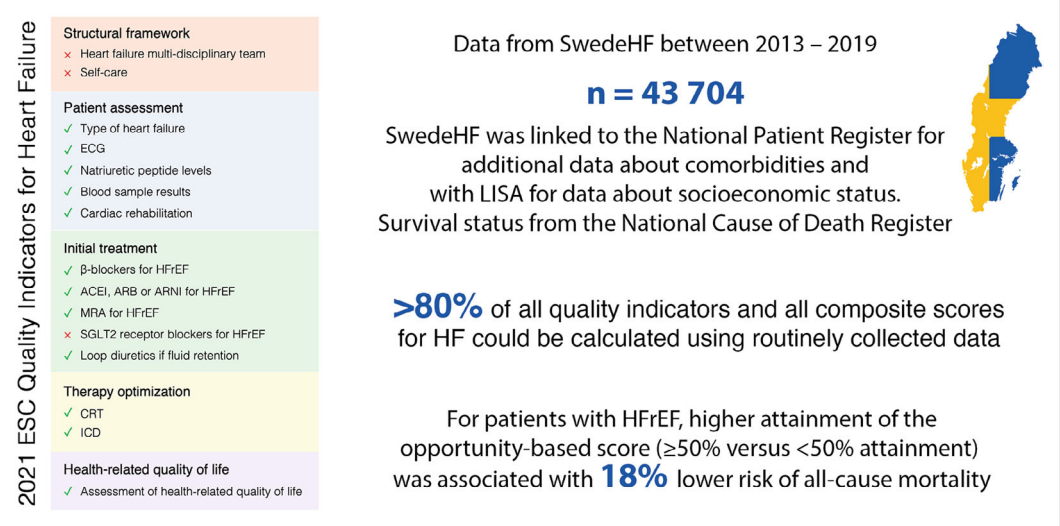
Graphical Abstract



Hospital performance and outcomes according to the 2021 European Society of Cardiology (ESC) quality indicators for heart failure (HF). ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor–neprilysin inhibitor; CRT, cardiac resynchronization therapy; ECG, electrocardiogram; HFrEF, heart failure with reduced ejection fraction; ICD, implantable cardioverter-defibrillator; MRA, mineralocorticoid receptor antagonist; SGLT2, sodium–glucose cotransporter 2.

Keywords Quality indicators • Quality of care • Implementation • Utilization • Treatment • Heart failure • Cardiovascular outcomes • Mortality

Introduction

Whilst established treatments for heart failure (HF) help reduce the burden of the disease, interventions are needed to facilitate the implementation of these treatments.[1] Clinical practice guidelines help healthcare professionals to manage patients according to best available evidence.[2,3] Despite the availability of guidelines and the evidence underlying the recommendations, observational studies have reported a considerable gap and geographic variation between the development and the implementation of evidence-based care, potentially creating a missed opportunity to reduce HF morbidity and mortality.[4,5]

Measuring and evaluating quality of care is an integral part of learning health systems and is an important tool for stakeholders such as patients, the public and health authorities. For this purpose, quality indicators (QIs) have increasingly been used as measurable tools to quantify adherence to guideline recommendations, identify variations in practice, and drive quality improvement.[6] In addition, data from routine clinical registries allow the quantification of HF processes and outcomes of care, particularly when integrated with QIs.[7]

The European Society of Cardiology (ESC) published a suite of QIs for HF that were aligned with and embedded in the 2021 ESC Clinical Practice Guidelines for HF.[2,8] These QIs cover HF care and include 16 QIs (12 main and 4 secondary) across five domains reflecting structural framework, patient assessment, initial treatment, therapy optimization, and assessment of patient health-related quality of life (HRQoL), as well as two composite scores. The composite scores are a combination of several QIs into a single score, and serve to summarize a number of individual QIs into a comprehensive measure of care quality.[9] Whilst these QIs were developed in accordance to the European healthcare system characteristics and using a structured methodology, the attainment of these QIs and their association with mortality have not been evaluated in a real-world setting.

We aimed to evaluate the quality of HF care in Sweden against the ESC QIs for HF using nationwide data, and investigate whether attainment for these QIs was associated with lower mortality rates.

Methods

Study population and data sources

The study population was identified in the Swedish HF registry (SwedeHF). SwedeHF is a nationwide quality registry that enrols patients with HF at outpatient visits or discharge after HF hospitalization in Sweden since May 2000. In SwedeHF, the inclusion criterion was clinician-judged HF until April 2017 and thereafter a diagnosis of HF according to the following International Classification of Diseases, 10th revision (ICD-10) codes: I50.0, I50.1, I50.9, I42.0, I42.6, I42.7, I25.5,

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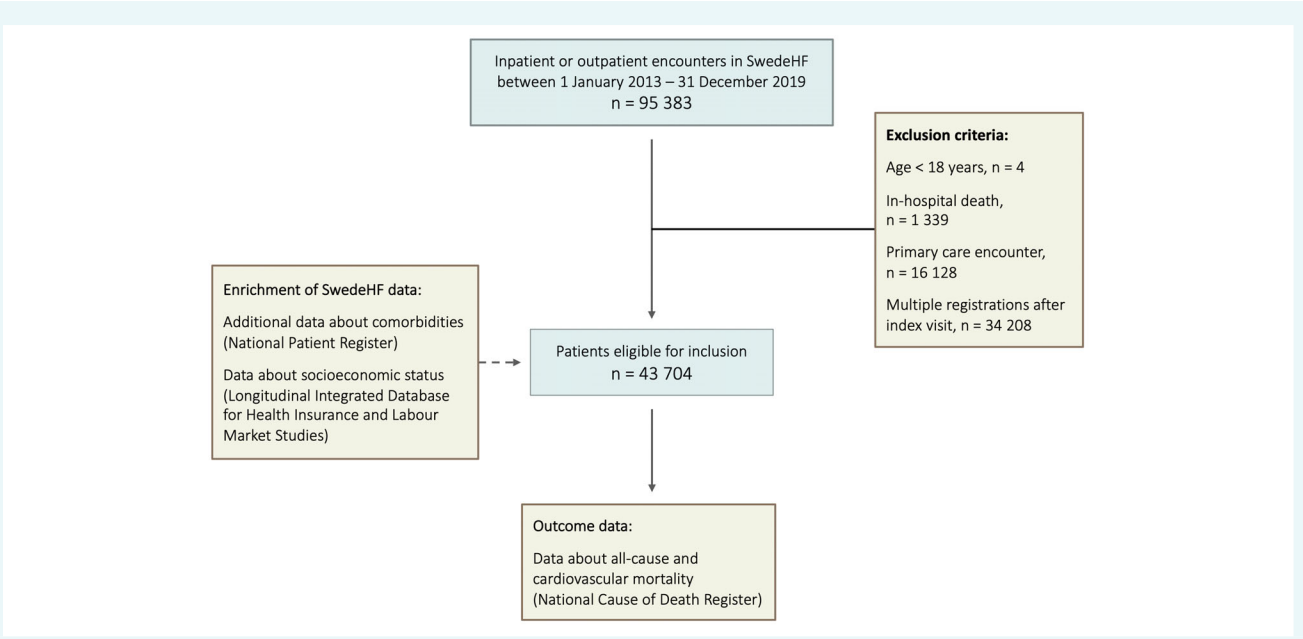

Figure 1 Consort diagram illustrating data sources and inclusion and exclusion of patients.

I11.0, I13.0, and I13.2.[10] In 2019, the coverage of SwedeHF was 30.4% of the prevalent HF population in Sweden, and 84% of all hospitals entered data into the registry.[7] Each SwedeHF entry comprises approximately 80 variables including details about patient demographics, medical history, clinical care and medication. Patients included in SwedeHF are informed about their registration and are given the option to opt out. Details about SwedeHF have been described previously.[10] The cohort for the present study was drawn from consecutive patients with first time in- or outpatient hospital registration in SwedeHF between 1 January 2013 and 31 December 2019. The study included patients from 2013 given this date coincided with an update of the variables within SwedeHF. The exclusion criteria comprised age <18 years and for this study, death during index hospitalization/visit (*Figure 1*).

Using the unique identifier available to all Swedish citizens, SwedeHF was linked to the National Patient Register, the Longitudinal Integrated Database for Health Insurance and Labour Market Studies (LISA) and the National Cause of Death Register in Sweden. The National Patient Register is a mandatory nationwide registry that collects discharge/visit date and diagnoses for all patients admitted to inpatient and outpatient hospital clinics in Sweden based on the ICD-10 system.[11] Data from the National Patient Register was used to enrich baseline data (e.g. comorbidities not available in SwedeHF itself) and the LISA database was utilized to obtain socioeconomic data (online supplementary *Table S1*).[12] The National Cause of Death Register is a mandatory nationwide registry that captures information about date and cause of death (online supplementary *Table S2*).[13] Linkage between all registries was performed by Statistics Sweden and the National Board of Health and Welfare in Sweden and fully pseudonymized data were provided for statistical analysis and reporting. The study was registered and approved by the SwedeHF board and by the Swedish Ethical Review Authority (application number 2019-02698).

Heart failure care

To measure HF care at each hospital centre we used the 2021 ESC QIs for HF.[8] These comprise 12 main and 4 secondary QIs across five domains of care: structural framework (e.g. multidisciplinary care), patient assessment (diagnostic tests), initial treatment (guideline-recommended medications), therapy optimization (cardiac resynchronization therapy [CRT] or implantable cardioverter-defibrillator [ICD] referral) and assessment of patient HRQoL (*Graphical Abstract* and online supplementary *Figure S1*).

We mapped each QI against available data in SwedeHF to assess its attainment (online supplementary *Table S3*). For each measured QI, the applicability (denominator) and fulfilment (numerator) criteria were identified from SwedeHF. QIs relevant to in-hospital care were only calculated for patients hospitalized for HF during their first registration in SwedeHF. We calculated an opportunity-based score by diving the total number of times each care process was accomplished (numerator) by the number of opportunities for eligible patients (denominator). In addition, an all-or-none score was calculated by dividing the number of patients who have received all the component QIs within this composite indicator by the number of patients eligible for all of the individual QIs within the composite (online supplementary *Table S3*).

Outcomes

All outcomes were assessed at the patient level, with all-cause mortality as the primary outcome and cardiovascular mortality as the secondary outcome. Outcome data were obtained from the National Cause of Death Register (online supplementary *Table S2*). Follow-up was available until 31 December 2019.

Statistics

The present study is reported in compliance with Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement (online supplementary *Figure S2*). Patient demographics, comorbidities and medical care was reported using numbers and percentages for categorial data and medians and interquartile ranges

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(IQR) for continuous data. For each QI, the eligibility (denominator) and the fulfilment among eligible patients (numerator) were calculated. For the composite opportunity-based score, findings were reported comparing patients with ≥50% versus <50% attainment of component QIs. To estimate variability between hospital centres, attainment of indicators for all patients were reported using medians and IQR at each hospital centre and illustrated using box plots. Only centres with ≥10 patients were included. Differences in attainment of QIs between type of clinical encounter (inpatient or outpatient) were modelled using logistic regression. In the logistic regression analysis, adjustment was made for baseline characteristics, comorbidities and clinical findings (age, sex, body mass index, highest educational level, family and living status, disposable income, smoking status, hypertension, diabetes mellitus, chronic obstructive pulmonary disease, atrial fibrillation/flutter, prior myocardial infarction, prior percutaneous coronary intervention/coronary artery bypass grafting, prior stroke/transient ischaemic attack, peripheral arterial disease, chronic kidney disease, liver disease, anaemia, cancer [within 3 years], HF duration, index year, New York Heart Association [NYHA] class, mean arterial pressure, heart rate and N-terminal pro-brain natriuretic peptide). Time-to-event for the outcomes for each QI was illustrated using Kaplan–Meier plots. The association between QIs and outcomes was determined using crude and adjusted Cox regression analysis including a frailty term to model the centre effect. Censoring was performed at end of follow-up (31 December 2019, emigration from Sweden or, for cardiovascular mortality, other causes of death). In the Cox regression analysis, adjustment was made for the same variables as in the adjusted logistic regression analysis. Continuous variables were modelled using natural cubic splines with four degrees of freedom and clinical encounter at index was stratified due to non-proportional hazards. Missing information about height was imputed using (i) the first registration with non-missing height within each individual, and (ii) the median height within sex and 5-year age groups. Body mass index was calculated from the imputed height (but not weight). All other missing data were handled using chained multiple imputation (10 imputed datasets generated) including the same variables that were included in the adjusted Cox model together with all-cause mortality as the Nelson–Aalen estimator.[14] The QIs were not imputed. All statistical tests were two-sided with p-value <0.05 considered as statistically significant. Statistical analyses were performed at Karolinska Institutet, Stockholm, Sweden, with the use of R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria). The R code for the data handling and statistical analysis is available online: https://github.com/KIHeartFailure/validation_qi.

Results

Patient characteristics and comorbidities

Between 1 January 2013 and 31 December 2019, 43 704 patients were identified from 80 hospital centres, with a median of 362 (IQR 183–735) patients per centre (*Figure 1*). The median age was 75 (IQR 67–83) years and 16 133 (36.9%) were women. Baseline characteristics, including demographics, medical history, clinical care and medical therapy at discharge are presented in *Table 1*. Hospital variation is presented as the median (IQR) of the proportion (categorical variables) or the median (continuous variables) at each hospital centre. Overall, hospital variation in patients' baseline characteristics was small (*Table 1*).

Quality indicator attainment

Of the 16 QIs for HF, 13 (81.3%) could be calculated based on data available in SwedeHF (*Graphical Abstract*), 8 (61.5%) directly and 5 (38.5%) after slight modifications (online supplementary *Table S3*). All the calculated QIs except two (referral for a cardiac rehabilitation and review after discharge) could be measured during the whole study period.

The structural framework QIs in domain 1 were not calculated given the unavailability of such information in SwedeHF. For domain 2 which included QIs related to patient assessment, all QIs were calculated in SwedeHF, but two required slight modifications (online supplementary *Table S3*). HF type was reported in 91.0% of patients, however, with left ventricular ejection fraction (LVEF) <40% for the definition of HF with reduced ejection fraction (HFrEF) and LVEF ≥40% for the definition of HF with mildly reduced ejection fraction (HFmrEF) or HF with preserved ejection fraction (HFpEF). Attainment of QIs in domain 2 was generally high, however, with the QI related to referral to cardiac rehabilitation showing low attainment at 2.3% and documentation of blood results around the time of HF diagnosis showing moderate attainment at 61.8% (*Table 2*). In domain 3, related to initial drug treatment, calculation of the sodium–glucose cotransporter 2 (SGLT2) inhibitor QI was not possible given that this treatment was only recently indicated, and this variable was recently added to the registry. Of note, the prescription of mineralocorticoid receptor antagonists (MRA) for patients with HFrEF was low (44.4%) relative to the other therapies for HFrEF (*Table 2*). Given the cut-offs of LVEF in SwedeHF, the identification of those with LVEF ≤35% was not feasible in domain 4 capturing information about therapy optimization. Therefore, we used LVEF <30% as an indication for CRT and ICD in those with HF duration ≥6 months and who meet all other eligibility criteria for CRT or ICD. The assessment of HRQoL in domain 5 was recorded in 36.1% of the patients.

Variation in care delivery

The patient-level performance and hospital variability (median [IQR] of the attainment for each QI at every hospital centre) against the 2021 ESC QI for HF are presented in *Table 2* and *Figure 2*. The assessment of HRQoL was the QI with the greatest hospital variation among all QIs (median 33.0%; IQR 13.4–75.1) (*Table 2* and *Figure 2*). The prescription of MRA for eligible patients with HFrEF also showed a degree of variation between healthcare centres in Sweden (median 44.4; IQR 37.0–54.0), with little variation observed for the other QIs (*Table 2* and *Figure 2*). The composite opportunity-based scores showed higher variation between hospitals in patients with LVEF ≥40% compared with those with LVEF <40% (median 86.3%; IQR 72.3–93.5 vs. median 96.6%; IQR 93.6–98.7). Overall, there was lower attainment for the opportunity-based composite scores in patients who were seen in an outpatient setting compared with those who were managed during HF hospitalization (adjusted odds ratio [OR] 0.57; 95% confidence interval [CI] 0.52–0.63 for patients with LVEF ≥40% and adjusted OR 0.85; 95% CI 0.72–0.99 for patients with LVEF <40%) (online supplementary *Table S4*).

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Table 1 Baseline characteristics and hospital variation in characteristics

Characteristic	Total cohort (n = 43 704)	Hospital variation, median (IQR)	Missing data, %
Demographics and characteristics			
Age, years, median (IQR)	75.0 (67.0–83.0)	75.0 (73.0–77.5)	0.0
Female sex, *n* (%)	16 133 (36.9)	35.1 (31.0–40.8)	0.0
BMI (kg/m^2), median (IQR)	26.5 (23.4–30.3)	26.6 (26.3–27.2)	9.6
Current smoker, *n* (%)	3539 (11.3)	10.6 (8.9–13.2)	28.3
Highest educational level,[a] *n* (%)			1.8
Primary and lower secondary education	17 142 (39.9)	39.2 (34.4–45.2)	
Upper secondary education	17 684 (41.2)	42.0 (38.8–46.1)	
University education	8090 (18.9)	16.2 (13.4–21.2)	
Disposable income[b], *n* (%)			0.3
Low	14 370 (33.0)	33.6 (28.1–38.2)	
Medium	14 395 (33.0)	33.8 (31.5–35.6)	
High	14 829 (34.0)	32.2 (27.1–38.0)	
Living alone, *n* (%)	21 112 (48.4)	46.5 (42.7–50.5)	0.3
Parent with children, *n* (%)	36 643 (83.8)	84.4 (82.2–86.3)	0.0
Medical history, *n* (%)			
Hypertension	31 385 (71.8)	72.0 (69.0–77.0)	0.0
Diabetes mellitus	12 052 (27.6)	27.1 (24.8–30.4)	0.0
COPD	5781 (13.2)	12.6 (10.6–14.8)	0.0
Atrial fibrillation/flutter	25 039 (57.3)	57.0 (52.0–61.1)	0.0
Prior MI	15 595 (35.7)	36.3 (32.3–39.4)	0.0
Prior PCI/CABG	13 519 (30.9)	31.9 (27.1–35.4)	0.0
Prior stroke/TIA	7876 (18.0)	17.3 (14.9–20.1)	0.0
Peripheral arterial disease	4968 (11.4)	10.6 (9.1–12.7)	0.0
Chronic kidney disease	6703 (15.3)	14.1 (10.7–17.8)	0.0
Liver disease	1324 (3.0)	2.6 (1.9–3.3)	0.0
Anaemia	14 488 (35.6)	32.4 (26.1–38.4)	6.9
Cancer (within last 3 years)	10 699 (24.5)	23.9 (21.0–26.0)	0.0
Heart failure duration, *n* (%)			4.9
<6 months	23 036 (55.4)	51.3 (44.8–62.6)	
≥6 months	18 532 (44.6)	48.7 (37.4–55.2)	
Clinical encounter at index, *n* (%)			0.0
Inpatient	17 861 (40.9)	13.6 (0.1–64.5)	
Outpatient	25 843 (59.1)	86.4 (35.5–99.9)	
Clinical presentation at index			
NYHA class, *n* (%)			38.6
I	3076 (11.5)	10.1 (6.1–14.4)	
II	13 169 (49.0)	49.3 (43.0–55.8)	
III	9962 (37.1)	36.7 (28.5–45.2)	
IV	643 (2.4)	1.6 (0.8–2.9)	
LVEF, *n* (%)			9.0
LVEF ≥50%	9016 (22.7)	19.2 (10.3–27.2)	
LVEF 40–49%	9139 (23.0)	22.7 (19.0–25.7)	
LVEF 30–39%	11 308 (28.4)	29.4 (24.4–37.1)	
LVEF <30%	10 323 (25.9)	26.3 (20.6–31.7)	
Systolic blood pressure (mmHg), median (IQR)	125.0 (112.0–140.0)	125.0 (122.0–130.0)	1.8
Heart rate (bpm), median (IQR)	72.0 (63.0–84.0)	71.5 (70.0–74.0)	2.5
LBBB morphology, *n* (%)	6643 (17.9)	18.8 (15.4–22.1)	15.3
QRS duration (ms), median (IQR)	104.0 (92.0–134.0)	106.0 (102.4–108.5)	10.9
QRS duration ≥150 ms, *n* (%)	4221 (11.9)	12.1 (10.7–13.7)	10.9
NT-proBNP (ng/L), median (IQR)	2398.0 (1027.0–5304.0)	2193.5 (1636.2–3013.2)	27.4
Haemoglobin (g/L), median (IQR)	132.0 (119.0–145.0)	134.0 (130.0–137.0)	6.9
eGFR (ml/min/1.73 m^2), median (IQR)	68.1 (49.8–86.3)	68.2 (63.8–70.9)	2.1
Sodium (mmol/L), median (IQR)	140.0 (138.0–142.0)	140.0 (140.0–140.5)	6.4
Potassium (mmol/L), median (IQR)	4.2 (3.9–4.5)	4.2 (4.1–4.3)	4.2

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Table 1 (Continued)

Characteristic	Total cohort (n = 43 704)	Hospital variation, median (IQR)	Missing data, %
Transferrin[c] (%), median (IQR)	22.0 (15.0–31.0)	20.0 (15.0–25.5)	89.3
Ferritin[c] (μg/L), median (IQR)	136.0 (64.0–259.0)	141.0 (112.5–160.2)	87.5
Medication at discharge, *n* (%)			
ACEI/ARB/ARNI	36 476 (84.2)	87.8 (82.4–93.9)	0.9
Beta-blockers	38 685 (88.8)	90.3 (87.8–93.2)	0.4
MRA	16 319 (37.7)	38.7 (31.7–49.6)	0.9
Loop diuretics	30 957 (71.2)	70.5 (65.4–75.6)	0.5
Digoxin	4480 (10.3)	10.4 (8.1–12.4)	0.4
Platelet inhibitors	15 281 (35.1)	34.4 (30.8–39.3)	0.5
Oral anticoagulants	21 992 (50.5)	50.9 (46.5–54.5)	0.4
Statins	21 200 (48.7)	51.0 (44.8–56.0)	0.4
Nitrates	4389 (10.1)	10.1 (7.5–12.4)	0.4
Device therapy, *n* (%)			0.5
ICD	1402 (3.2)	2.9 (1.6–4.2)	
CRT-P	583 (1.3)	1.1 (0.4–2.3)	
CRT-D	1104 (2.5)	2.1 (1.2–3.9)	

Categorical variables are presented as *n* (%) and continuous variables as median (interquartile range [IQR]). The hospital variation is presented as the median (IQR) of the proportion (categorical variables) or median (continuous variables) at each hospital centre.

ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor–neprilysin inhibitor; BMI, body mass index; BNP, brain natriuretic peptide; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; CRT-D, cardiac resynchronization therapy-defibrillator; CRT-P, cardiac resynchronization therapy-pacemaker; eGFR, estimated glomerular filtration rate; ICD, implantable cardioverter-defibrillator; LBBB, left bundle branch block; LVEF, left ventricular ejection fraction; MI, myocardial infarction; MRA, mineralocorticoid receptor antagonist; NT-proBNP, NT-proBNP, N-terminal prohormone brain natriuretic peptide; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; TIA, transient ischaemic attack.

[a]Highest educational level according to the Swedish school system where primary and lower secondary education is from year 1–9 and upper secondary education from year 10–12.

[b]Disposable income in tertiles based on calendar year and sex.

[c]Data available starting 1 January 2017.

Association between attainment of quality indicators and all-cause mortality

In total, 13 670 (31.3%) patients died during a median follow-up of 23.6 months (IQR 0.0–83.9 months) (130 events/1000 patient-years). For all QIs and the composite scores, crude time to all-cause mortality was illustrated using Kaplan–Meier survival plots (*Figure 3*). After adjustment for potential confounders, 5 (38.5%) QIs were significantly associated with improved long-term survival (*Figure 4*). The association of the greatest magnitude was for follow-up review after hospitalization for HF (adjusted HR 0.69; 95% CI 0.55–0.87), and prescription of beta-blockers (adjusted HR 0.66; 95% CI 0.53–0.82) and angiotensin-converting enzyme inhibitors (ACEI)/angiotensin receptor blockers (ARB)/angiotensin receptor–neprilysin inhibitors (ARNI) (adjusted HR 0.78; 95% CI 0.72–0.84) (*Figure 4*). For patients with LVEF ≥40%, no association was observed between patients who scored ≥50% versus <50% on the composite opportunity-based score and all-cause mortality (adjusted HR 1.05; 95% CI 0.97–1.14) as opposed to those with LVEF <40% (adjusted HR 0.81; 95% CI 0.72–0.91). Whilst the all-or-none composite score was associated with an improvement in crude mortality among patients with LVEF <40% (HR 0.77; 95% CI 0.71–0.80), this association attenuated after adjustment (adjusted HR 0.99; 95% CI 0.93–1.06).

Association between attainment of quality indicators and cardiovascular mortality

In total, 8000 (18.3%) patients died due to cardiovascular causes (58.5% of all deaths) during a median follow-up of 23.6 months (76 events/1000 patient-years) (online supplementary *Figure S3*). Similar to all-cause mortality, the same five QIs were significantly associated with lower rates of cardiovascular mortality, with the greatest beneficial association observed for follow-up review after hospitalization for HF, documentation of HF clinical type, documentation of electrocardiogram and prescription of beta-blockers and ACEI/ARB/ARNI (online supplementary *Figure S4*). For patients with HFrEF and with ≥50% versus <50% attainment of the composite opportunity-based score, lower rates of cardiovascular mortality were observed (adjusted HR 0.78; 95% CI 0.68–0.90).

Discussion

In this nationwide cohort study of 43 704 patients with HF across 80 Swedish hospitals between 2013 and 2019, we found that over 80% of the 2021 ESC QIs for HF could be calculated using registry data. Of those QIs, approximately half were associated with an improvement in long-term mortality from any or cardiovascular causes, particularly early follow-up after

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Table 2 Overall performance and hospital variation in performance according to the 2021 European Society of Cardiology quality indicators for heart failure

Quality indicator	Numerator (proportion receiving care)/denominator (eligible patients) (%)	Hospital variation, median (IQR)
Domain 1: Structural framework		
Main (1.1): Centres should have a dedicated multidisciplinary team to manage patients with HF	Not recorded	
Main (1.2): Centres should have dedicated trained healthcare professionals to deliver HF specific education to facilitate patient self-care	Not recorded	
Domain 2: Patient assessment		
Main (2.1): Proportion of patients with HF who have a documentation of their HF clinical type (HFrEF, HFmrEF, HFpEF)	39 786/43 704 (91.0)	93.2 (88.5–97.0)
Main (2.2): Proportion of patients with HF who have a documentation of their ECG findings	35 359/43 704 (80.9)	83.2 (75.1–89.0)
Main (2.3): Proportion of patients with HF who have their NPs measured	33 803/43 704 (77.3)	82.1 (69.5–92.6)
Main (2.4): Proportion of patients with HF who have their blood tests documented[a]	27 030/43 704 (61.8)	61.9 (43.5–76.9)
Main (2.5): Proportion of patients hospitalized with HF who have been referred for a cardiac rehabilitation programme	54/2374 (2.3)	1.4 (0.0–3.5)
Secondary (2.1): Proportion of patients hospitalized with HF who have a follow-up review by a healthcare professional after hospital discharge[a]	4097/4322 (94.8)	96.6 (91.0–99.2)
Domain 3: Initial treatment		
Main (3.1): Proportion of patients with HFrEF who are prescribed the beta-blocker bisoprolol, carvedilol, sustained-release metoprolol succinate, or nebivolol in the absence of any contraindications	19 968/20 174 (99.0)	99.4 (98.6–100.0)
Main (3.2): Proportion of patients with HFrEF who are prescribed an ACEI, ARB or ARNI in the absence of any contraindications	19 907/21 513 (92.5)	94.2 (89.9–97.1)
Main (3.3): Proportion of patients with HFrEF who are prescribed an MRA in the absence of any contraindications	9573/21 539 (44.4)	44.4 (37.0–54.0)
Main (3.4): Proportion of patients with HFrEF who are prescribed a SGLT2 inhibitor in the absence of any contraindications	Not recorded	
Main (3.5): Proportion of patients with HF who are prescribed loop diuretic therapy if they have evidence of fluid retention[a]	8018/8971 (89.4)	90.1 (85.6–92.3)
Domain 4: Therapy optimization		
Secondary (4.1): Proportion of symptomatic patients with HFrEF in sinus rhythm with a QRS duration ≥150 ms and LBBB QRS morphology and with LVEF <30% despite HF duration ≥6 months who are offered CRT[a]	416/610 (68.2)	64.7 (58.6–78.8)
Secondary (4.2): Proportion of symptomatic patients with HF, LVEF <30% despite HF duration ≥6 months who are offered primary prevention ICD[a]	586/2418 (24.2)	18.9 (13.6–26.9)
Domain 5: Assessment of HRQoL		
Secondary (5.1): Proportion of patients with HF who have an assessment of their HRQoL using a validated tool	15 785/43 704 (36.1)	33.0 (13.4–75.1)
Composite QI: Opportunity-based		
Opportunity-based: ≥50% attainment among patients with LVEF ≥40% (calculated based on individual QIs)[a]	15 098/18 155 (83.2)	86.3 (72.3–93.5)
Opportunity-based: ≥50% attainment among patients with LVEF <40% (calculated based on individual QIs)[a]	20 727/21 631 (95.8)	96.6 (93.6–98.7)
Composite QI: All-or-none		
All-or-none: Full attainment among patients with LVEF <40% (calculated based on individual QIs)[a]	8577/20 050 (42.8)	43.9 (34.4–51.5)

Hospital variation is presented as the median (interquartile range [IQR]) of the attainment (numerator/denominator) for each quality indicator at every hospital centre.
ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor–neprilysin inhibitor; CRT, cardiac resynchronization therapy; ECG, electrocardiogram; HF, heart failure; HFmrEF, heart failure with mildly reduced ejection fraction; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction; HRQoL, health-related quality of life; ICD, implantable cardioverter-defibrillator; LBBB, left bundle branch block; LVEF, left ventricular ejection fraction; MRA, mineralocorticoid receptor antagonist; NP, natriuretic peptide; QI, quality indicator; SGLT2, sodium–glucose cotransporter 2.
[a]Modified QIs based on available data in SwedeHF (details about modifications available in online supplementary *Table S3*). The opportunity-based score for patients with LVEF ≥40% includes the following QIs: main (2.2), main (2.3), main (2.4), main (2.5) and secondary (2.1). The opportunity-based score for patients with LVEF <40% includes the following QIs: main (2.2), main (2.3), main (2.4), main (2.5), secondary (2.1), main (3.1), main (3.2), main (3.3), secondary (4.1) and secondary (4.2). The all-or-none score for patients with LVEF <40% includes the following QIs: main (3.1), main (3.2), main (3.3).

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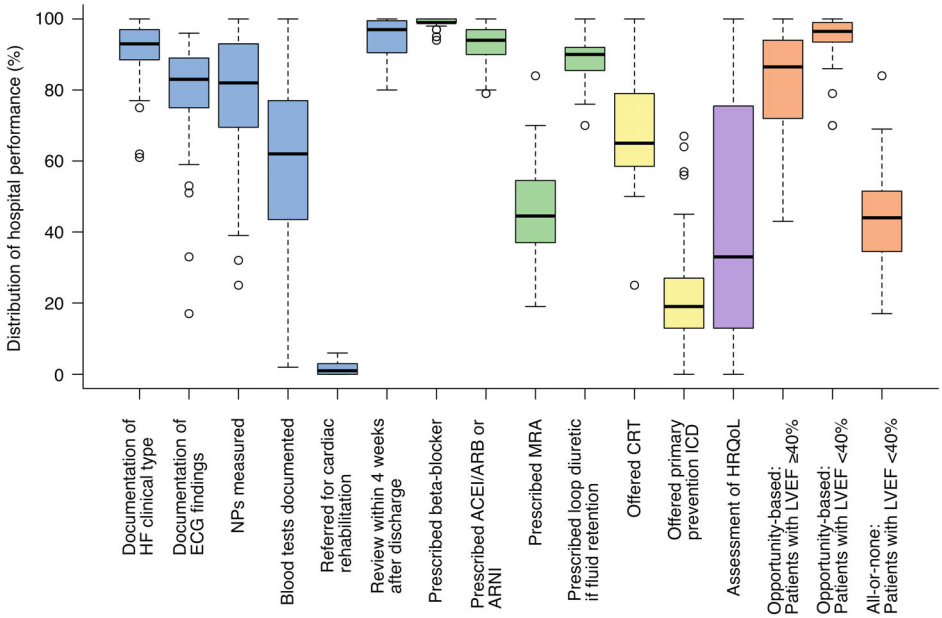

Figure 2 Distribution of hospital performance for the 2021 European Society of Cardiology quality indicators for heart failure (HF). Box plot with illustration of the minimum, maximum, sample median, and the first and third quartiles for each quality indicator. Data about structural quality indicators and sodium–glucose cotransporter 2 (SGLT2) inhibitors were not available in SwedeHF during the study period. ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor–neprilysin inhibitor; CRT, cardiac resynchronization therapy; ECG, electrocardiogram; HRQoL, health-related quality of life; ICD, implantable cardioverter-defibrillator; LVEF, left ventricular ejection fraction; MRA, mineralocorticoid receptor antagonist; NP, natriuretic peptide.

HF hospitalization and drug therapy. Higher attainment of the composite opportunity-based score for patients with HFrEF was associated with a reduction in the rates of all-cause and cardiovascular mortality at a median follow-up of 2 years. Although many of the QIs were possible to calculate and associated with lower rates of mortality, variation in hospital performance was present for many indicators. Thus, not only were the QIs feasible and valid measures of HF care quality, but they could also help evaluate care variation across regions and patient subgroups. Interventions that facilitate the implementation of the ESC QIs for HF in practice have the potential of improving clinical outcomes for patients with HF.

In recent years, implementation science has emerged to assess the impact of evidence-based interventions on the utilization of guideline-recommended therapies for HF.[15–17] However, integrating outcome QIs with process QIs is also important to improve HF quality of care.[2] Professional societies have established measures to benchmark quality against guideline recommendations and best practice.[9] The 2021 ESC QIs for HF are the first set of indicators developed by the ESC in collaboration with the Heart Failure Association and in parallel with the writing of the 2021 ESC Clinical Practice Guidelines for the management of adults with acute and chronic HF.[2,8]

Previous studies have evaluated the association between QIs and clinical outcomes for patients with HF.[18–26] However, these studies have primarily used the American College of Cardiology/American Heart Association (ACC/AHA) performance measures for HF which have been developed according to the American healthcare system specifications.[27,28] Moreover, prior studies included only a subset of HF patients (e.g. HFrEF) or captured specific outcomes (e.g. HRQoL).[19,20] In contrast, our study included all-comers with HF in both the inpatient and the outpatient settings using linked data from different resources.

Clinical registries have played an important role in illuminating the patterns of HF care over the years.[18–26] In 2007, the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients With Heart Failure (OPTIMIZE-HF) registry investigated the association between adherence to the ACC/AHA QIs for HF and outcomes, showing a reduction in mortality and rehospitalization with the prescription of ACEI/ARB and beta-blockers.[24] A further analysis from the OPTIMIZE-HF data showed that certain QIs (e.g. beta-blockers and ICD) were associated with a significant reduction in mortality at 1 year.[25] Similar findings were observed in studies from Europe, Asia and the US.[18–23] In the outpatient setting, the Improve the Use of Evidence-Based Heart Failure Therapies in the Outpatient Setting (IMPROVE HF) registry was one of the first studies to show that QIs such as ACEI/ARB, beta-blockers, anticoagulation for atrial fibrillation, CRT, ICD and patient education were associated with an improvement in long-term survival.[26] Our study extends the evaluation of the association between QIs and mortality to beyond 1 year and for both the in- and outpatient setting.

Composite QIs provide more reliable information about the quality of care delivered compared with individual indicators.[29] The 2021 ESC QIs for HF comprised one opportunity-based and one

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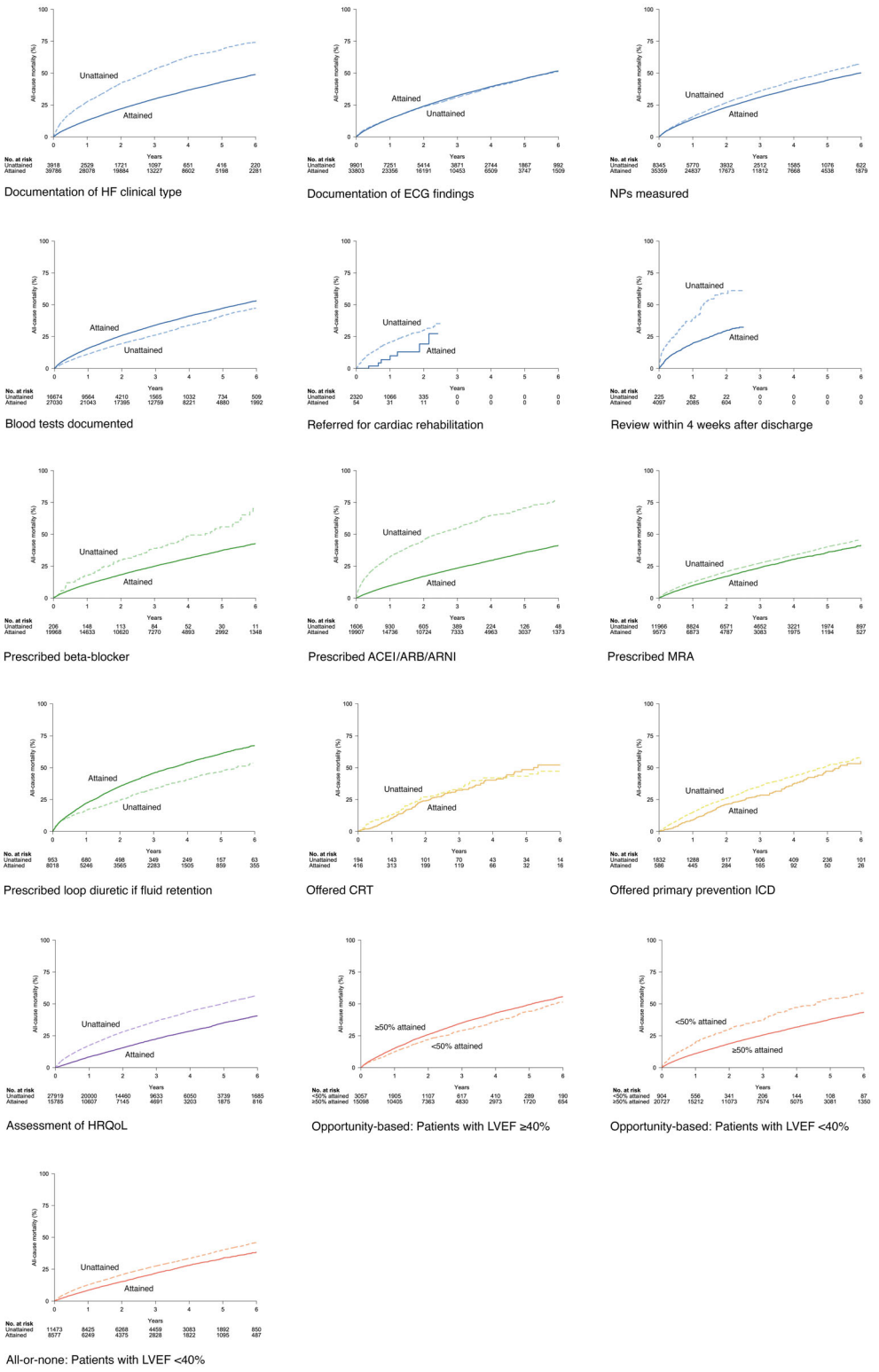

Figure 3 Kaplan–Meier plots for association of the 2021 European Society of Cardiology quality indicators for heart failure (HF) and all-cause mortality. ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor–neprilysin inhibitor; CRT, cardiac resynchronization therapy; ECG, electrocardiogram; HRQoL, health-related quality of life; ICD, implantable cardioverter-defibrillator; LVEF, left ventricular ejection fraction; MRA, mineralocorticoid receptor antagonist; NP, natriuretic peptide.

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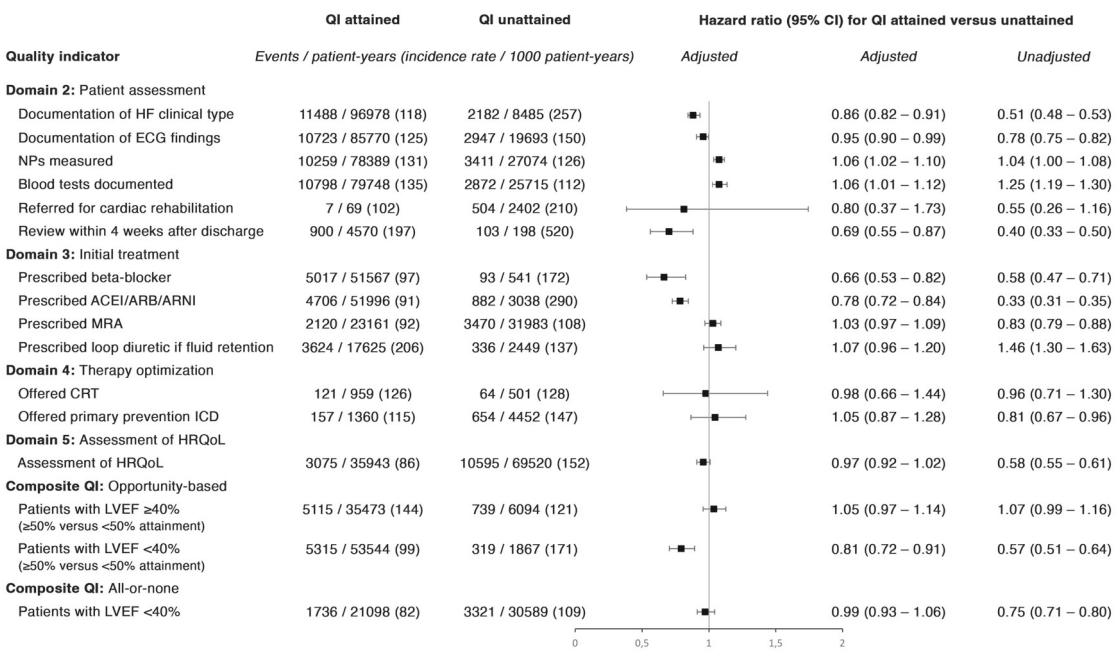

Figure 4 Association between the 2021 European Society of Cardiology quality indicators for heart failure (HF) and risk of all-cause mortality. Follow-up data available until 31 December 2019. Median (minimum−maximum) follow-up was 23.6 (0.0−83.9) months. In sensitivity analysis, when excluding patient with severe renal failure (estimated glomerular filtration rate <30 ml/min/1.73 m^2), the association between quality indicator (QI) attained versus unattained was similar as in the main analysis (adjusted hazard ratio 0.77 [95% confidence interval, CI 0.70−0.84] for prescribed angiotensin-converting enzyme inhibitor/angiotensin receptor blocker/angiotensin receptor−neprilysin inhibitor [ACEI/ARB/ARNI] and adjusted hazard ratio 1.04 [95% CI 0.98−1.11] for prescribed mineralocorticoid receptor antagonists [MRA]). CRT, cardiac resynchronization therapy; ECG, electrocardiogram; HRQoL, health-related quality of life; ICD, implantable cardioverter-defibrillator; LVEF, left ventricular ejection fraction; NP, natriuretic peptide.

all-or-none composite QI.[8] Our study showed that whilst attainment for the opportunity-based was high, this for the all-or-none composite was suboptimal for patients with HFrEF. The all-or-none is a recognized tool to identify gaps in care delivery and drive excellence.[30] Thus, our study showed room for improvement in the initiation of beneficial medications for HF when clinically appropriate. These results may be attributed by the relatively low prescription rates of MRA and may have been even lower if data were available for SGLT2 inhibitors.

On the other hand, our study showed little correlation between the attainment to the all-or-none composite QI and long-term mortality from any cause. When compared with the opportunity-based score, the latter had a significant association with mortality. However, this may be related to the relatively smaller sample size in the attainment group in the all-or-none composite compared with the opportunity-based score. Besides, the opportunity-based score comprised wider aspects of care such as an early follow-up and referral to cardiac rehabilitation after hospitalization with HF which may have had a role in the greater association with outcome.

Our finding that HFrEF management according to the opportunity-based composite QI was better during HF hospitalization compared with the outpatient setting highlights the room for improvement in ambulatory HF patients. Whilst this may be related to unmeasured confounders, it emphasises the opportunity to initiate guideline-recommended pharmacotherapies for HFrEF before hospital discharge.[2]

The results of our study might have consequences in terms of development/update of registries as well as QIs for HF. The QI related to prescription of SGLT2 inhibitors was not feasible to calculate in this study, but this variable has recently been added to the SwedeHF registry. Other QIs, such as the assessment of blood tests around the time of HF diagnosis, the assessment of HRQoL and the device implementation QIs were less feasible compared with other process QIs. This raises the question as to whether these aspects of HF care should be routinely collected in clinical registries or be used as QIs for HF.

Limitations

To our knowledge, this is the first study to report the feasibility of assessing ESC QIs for HF utilizing registry data, and to link QIs with clinically important outcomes such as all-cause and cardiovascular mortality. Despite this accomplishment, our study has some limitations. Ideally, assessment of QIs would require a dedicated survey with specific fields to capture all dimensions of the indicators. In this study, we utilized the ongoing longitudinal SwedeHF registry and the available variables within that register. As such, there were

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some missing data and three QIs were not possible to capture, five QIs had to be indirectly evaluated using slightly modified definitions and some QIs could only be captured after 2017 (referral for cardiac rehabilitation and review after discharge) (online supplementary *Table S3*). It is recognised that patients may have contraindications to some of the guideline-directed medical therapies for HF. However, data variables that capture these contraindications may not be available in clinical registries. Whilst we carefully assessed the eligibility criteria for each of the measured QIs from SwedeHF, not all contraindications could be identified resulting in an overestimation of the number of patients included in the denominator of these QIs. Thus, studies with dedicated questionaries capturing all QI specifications for medical therapies are warranted. For this purpose, variables necessary to calculate QIs have recently been published in the European Unified Registries for Heart Care Evaluation and Randomized Trials (EuroHeart) data standards for HF.[31] Owing to the observational nature of this study, the associations in this study cannot be interpreted as causal. When describing the correlation between QIs and outcomes, only associations were reported which does not necessarily prove causality and may be confounded by unknown factors. We used adjusted Cox regression analysis, but residual confounding cannot be excluded. As an example, the QIs assessing the measurement and documentation of natriuretic peptides and other blood tests were associated with poor outcome which might be related to residual confounding not accounted for in the adjusted Cox regression models. Also, the variation in the denominator size between the calculated QIs may have impacted the magnitude of the association between QIs and outcomes. When interpreting hospital performance in relation to QIs it is important to realize that the SwedeHF data underlying the calculation of indicators were collected a priori to the publication of the 2021 ESC QIs for HF and that the registry only covered 30.4% of the prevalent HF population in Sweden. As such, the observed hospital variation in this study for some QIs might be wider than what is to be expected if the indicators were adopted by SwedeHF and the data prospectively collected. Future studies might be able to determine the true hospital variation in performance once the QIs for HF are broadly accepted and adopted into national and international registries.

Conclusion

This study showed that the 2021 ESC QIs for HF are feasible and valid measures for evaluating HF care using data from national quality registries. We found that approximately half of the QIs were inversely associated with all-cause and cardiovascular mortality, and that there was potentially modifiable centre variation in HF quality of care. The ESC QIs for HF may be useful for benchmarking care quality and, by means of a learning health system, improve patient outcomes.

Supplementary Information

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

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Conflict of interest: G.B. reports, outside the submitted work, institutional research grants from Pfizer, expert committee and consulting fees to his institution from Bayer; honoraria for lectures and scientific advice from AstraZeneca, Boehringer Ingelheim, Novo Nordisk, Pfizer and Sanofi. U.D. reports, outside the submitted work, institutional research grants from AstraZeneca, Pfizer, Vifor, Boehringer Ingelheim, Boston Scientific, Roche Diagnostics; honoraria/consultancies from Amgen, Pfizer and AstraZeneca. C.H. reports consulting fees from Novartis, Roche Diagnostics and AnaCardio, research grants from Bayer and speaker and honoraria from MSD and Novartis; she is supported by the Swedish Research Council (grant 20 180 899). G.S. reports grants and personal fees from Vifor, AstraZeneca, grants and non-financial support from Boehringer Ingelheim, personal fees from Società Prodotti Antibiotici, Roche, Servier, GENESIS, Cytokinetics, Medtronic, grants from Novartis, Boston Scientific, Pharmacosmos, Merck, Bayer, outside the submitted work. C.P.G. reports, outside the submitted work, consultancy from AstraZeneca, Bayer, Bristol Myers Squibb, Boehringer Ingelheim, Chiesi, Daiichi Sankyo, Menarini, speaker fees from AstraZeneca, Menarini, Raisio Group, Wondr Medical, Zydus, editorship as Deputy Editor of European Heart Journal Quality of Care and Clinical Outcomes, Oxford University Press, grants from British Heart Foundation, National Institute for Health Research, Horizon 2020, Abbott Diabetes, Bristol Myers Squibb, advisory board from Amgen, Bayer, Bristol Myers Squibb, Boehringer Ingelheim, Chiesi, Daiichi Sankyo, iRhythm, Menarini, Novartis, leadership from NICE Indicator Advisory Committee, Chair ESC Quality Indicator Committee. L.H.L. reports none related to the present work; outside the present work: grants from AstraZeneca, Vifor, Boston Scientific, Boehringer Ingelheim, Novartis; consulting from Merck, Vifor, AstraZeneca, Bayer, Pharmacosmos, MedScape, Sanofi, Lexicon, Myokardia, Boehringer Ingelheim, Servier; speaker's honoraria from Abbott, MedScape, Radcliffe, AstraZeneca, Novartis, patent AnaCardio; stock ownership in AnaCardio. All other authors have nothing to disclose.

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