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ORIGINAL RESEARCH ARTICLE

Inequalities in heart failure care in a tax-financed universal healthcare system: a nationwide population-based cohort study

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Abstract

Aims Data on socioeconomic-related differences in heart failure (HF) care are sparse. Inequality in care may potentially contribute to a poor clinical outcome. We examined socioeconomic-related differences in quality of HF care among patients with incident HF with reduced ejection fraction (EF) (HFrEF).

Methods and results We conducted a nationwide population-based cohort study among patients with HFrEF (EF ≤40%) registered from January 2008 to October 2015 in the Danish Heart Failure Registry, a nationwide registry of patients with a first-time primary HF diagnosis. Associations between individual-level socioeconomic factors (cohabitation status, education, and family income) and the quality of HF care defined by six guideline-recommended process performance measures [New York Heart Association (NYHA) classification, treatment with angiotensin-converting-enzyme inhibitors (ACEI)/angiotensin receptor blockers (ARB), beta-blockers and mineralocorticoid receptor antagonists, exercise training, and patient education] were assessed using multiple imputation and multivariable logistic regression controlling for potential confounders. Among 17 122 HFrEF patients included, 15 290 patients had data on all six process performance measures. Living alone was associated with lower odds of NYHA classification [adjusted OR (aOR) 0.81; 95% confidence interval (CI): 0.72–0.90], prescription of ACEI/ARB (aOR 0.76; 95% CI: 0.68–0.88) and beta-blockers (aOR 0.84; 95% CI: 0.76–0.93), referral to exercise training (aOR 0.75; 95% CI: 0.69–0.81), and patient education (aOR 0.73; 95% CI: 0.67–0.80). Compared with high-level education, low-level education was associated with lower odds of NYHA classification (aOR 0.93; 95% CI: 0.79–1.11), treatment with ACEI/ARB (aOR 0.99; 95% CI: 0.81–1.20) and beta-blockers (aOR 0.93; 95% CI: 0.79–1.09), referral to exercise training (aOR 0.73; 95% CI: 0.65–0.82), and patient education (aOR 0.86, 95% CI: 0.75–0.98). An income in the lowest tertile was associated with lower odds of NYHA classification (aOR 0.67; 95% CI: 0.58–0.79), prescription of ACEI/ARB (aOR 0.80, 95% CI: 0.67–0.95) and beta-blockers (aOR 0.88, 95% CI: 0.86–1.01), referral to exercise training (aOR 0.59, 95% CI: 0.53–0.64), and patient education (aOR 0.66; 95% CI: 0.59–0.74) compared with an income in the highest tertile. Overall, no systematic differences were seen when the analyses were stratified by sex and age groups.

Conclusions Living alone, low-level education, and income in the lowest tertile were associated with reduced use of recommended processes of HF care among Danish HFrEF patients with a first-time primary HF diagnosis. Efforts are warranted to ensure guideline-recommended HF care to all HFrEF patients, irrespective of socioeconomic background.

Keywords Heart failure with reduced ejection fraction; Inequalities; Performance measures| registry; Social class; Socioeconomic factors| HFrEF

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Introduction

Worldwide, heart failure (HF) constitutes a major and increasing health burden affecting almost 37 million people.[1] The prevalence of HF is expected to increase substantially in the future due to the demographic development with ageing populations, increasing prevalence of cardiovascular risk factors, and improved survival from ischaemic heart disease.[2] Despite improvements in treatment and management in the last decades, HF is still associated with frequent hospitalization, high mortality, and impaired quality of life,[3] imposing a huge economic burden on healthcare systems.[4,5]

Low socioeconomic status is a strong predictor for the development of HF.[6] In addition, differences in readmission risk and mortality according to a level of income and socioeconomic deprivation have been reported in several studies among patients with HF, even in tax-financed well-fare state settings,[7–11] while socioeconomic deprivation, defined with the Index of Multiple Deprivation 2007, have not been found to be associated with mortality in one study.[12] Socioeconomic disparities in HF care may potentially contribute to the observed differences in mortality and readmission risk according to socioeconomic status. However, data on the relationship between socioeconomic status and HF care are sparse among patients with HF. We, therefore, performed a nationwide cohort study of patients with verified incident HF with reduced ejection fraction (HFrEF). This study aimed to examine the effect of individual-level markers of socioeconomic status on the quality of HF care among patients with incident HFrEF in a tax-financed universal healthcare system with free access to healthcare services for all citizens.

Methods

This study was based on linked data from the Danish Heart Failure Registry (DHFR)[13] and several other Danish nationwide population-based registries. All Danish residents have a personal and unique identification number, which enables direct and accurate linkage of individual-level information between public registries.[14]

Healthcare in Denmark

The Danish healthcare system works across three administrative levels: the state, the regions (five), and the municipalities (98). The state is responsible for the overall framework for the provision of health and elderly care, the five regions for the hospitals, the general practitioners and specialists in private practice, and the 98 municipalities for primary healthcare services as well as elderly care.[15]

Data sources

The DHFR was established in 2003 as a nationwide programme to monitor and improve the quality of care for patients with HF. Evidence-based performance measures related to process and outcome of care of incident HF were defined, and monitoring of fulfilment of the performance measures has been carried out since 2003. The DHFR includes data on adult residents with a hospitalization admission or contact with a hospital cardiology outpatient clinic with a first-time primary diagnosis of HF (International Classification of Diseases, 10th edition; 11.0, I13.0, I13.2, I42.0, I42.6, I42.7, I42.9, I50.0, I50.1, and 50.9) according to the European Cardiology Society definition of HF.[13,16] Patients with previously verified diagnosis and treatment of HF, isolated right-sided HF, and HF secondary to valvular heart disease, non-correctable structural heart disease, or tachycardia-induced HF are not included in the DHFR. To ensure the validity of the HF diagnosis, the decision to register a patient in the DHFR is made by a cardiologist. Reporting of data to the registry is mandatory for all Danish hospitals treating adult patients with incident HF.[13] The DHFR contains information on HF care as well as a range of sociodemographic, clinical, and lifestyle-related information. Since 2008, data completeness has been high.[13] We obtained data on the process performance measures (*Table 1*), age, sex, hospital setting at the time of diagnosis (inpatient/outpatient, left ventricular ejection fraction (LVEF) (<25%, 25% to 35%, >35%), New York Heart Association (NYHA) functional classification (I–IV), previous myocardial infarction (yes/no), previous stroke (yes/no), chronic obstructive pulmonary disease (yes/no), hypertension (yes/no), diabetes (yes/no), atrial fibrillation (yes/no), S-creatinine level ≥150 μmol/L (yes/no), alcohol consumption (>14/21 drinks per week for women and men, respectively), and smoking (yes/no) from the DHFR.[13]

The Danish National Patient Registry (DNPR)[17] holds administrative data (e.g. date of admission and discharge, acute or elective admission) and diagnoses on all somatic inpatient hospital contacts from 1977 to 1994; after 1994 also information on somatic and psychiatric inpatient, outpatient, and emergency contacts. Each hospital contact is registered with a primary diagnosis and one or more secondary diagnoses (ICD-8 until 1993 and after that ICD-10). We used data from the DNPR to (i) identify patients with previous acute myocardial infarction, stroke, and diabetes, (ii) calculate the modified Charlson co-morbidity index (CCI): score for each patient preceding the diagnosis of HF, excluding points for HF, and (iii) compute the number of prior inpatient and outpatient hospital contacts between 1 and 10 years before the HF diagnosis.

We obtained data on vital and migration status during follow-up from the Danish Civil Registration System, which has recorded changes in these variables for all Danish residents since 1968. Information on vital status is updated daily.[18]

Table 1 Process performance measures in the Danish Heart Failure Registry

Process performance measure	LVEF	Definition	Timeframe[a]
NYHA classification		Proportion of patients undergo NYHA classification	Within 12 weeks[b]
ACEI/ARB	≤40%	Proportion of patients treated with ACEI/ARB	Within 8 weeks
Beta-blockers	≤40%	Proportion of patients treated with beta-blockers	Within 12 weeks
MRA	≤35%	Proportion of patients treated with MRA	Within 12 weeks
Exercise training	≤40%	Proportion of patients started individual exercise training in a hospital or referred for exercise training in the municipality after a consultation with a hospital physiotherapist[c]	Within 12 weeks
Patient education	≤40%	Proportion of patients started a structured patient education (e.g. nutrition, exercise training, understanding medical treatment, risk factors, and HF symptoms)	Within 12 weeks

Processes of care monitored in the Danish Heart Failure Registry for patients with incident heart failure with reduced ventricular ejection fraction.
[a]The timeframe is defined from the date for admission to either hospital or outpatient clinic.
[b]The timeframe for NYHA classification was prolonged from discharge/first outpatient contact to 12 weeks in 2011.
[c]From 2008 to 2010, exercise training should have started in the hospital or in the municipality.

The National Prescription Registry has recorded information about prescriptions for drugs dispensed at all Danish community pharmacies since 1995.[19] We used the National Prescription Registry to identify redeemed prescriptions for antidepressant and antipsychotic drugs 12 months before HF diagnosis. Redemption of a prescription was understood as a gross measure of mental illness or vulnerability.

Statistics Denmark encompasses several registries containing detailed information on all citizens. The Central Population Register contains information on cohabitation status (household composition) and migration (baseline), with updates every quarter. Each year, since 1973, the Educational Attainment Register has recorded the highest education attained for every citizen. Data in the registry are considered of high validity. Misclassification is reported 0% to 3% by Statistics Denmark.[20] In 2003, the completeness of education information was 97% in persons aged 15 to 69 years and 75% in persons aged 70 years or older. The Family Income Register provides information on family income before tax by the end of December each year. Data on family income, the sum of individual incomes of all persons in the family, are mainly based on information from the Danish tax system. The Labor Force Statistics, established in 1980, contains information on individual-level labour market affiliation at the end of November each year. Data on primary affiliation with the labour market are register-based and follow the guidelines of the International Labor Organization. The coverage and validity of the registry data are deemed to be high.[21]

Study population

We included patients with incident HFrEF with LVEF $\leq$ 40% registered in the DHFR between 1 January 2008 and 31 October 2015. Further, we restricted the study population to (i) inpatients discharged alive and (ii) outpatients who have been discharged with HF as a secondary diagnosis within 30 days before their outpatient visit in order to establish a homogeneous HF population. Patient characteristics, for example, co-morbidities have been reported to vary depending on the care setting (inpatient or outpatient) where patients were first diagnosed with HF.[22]

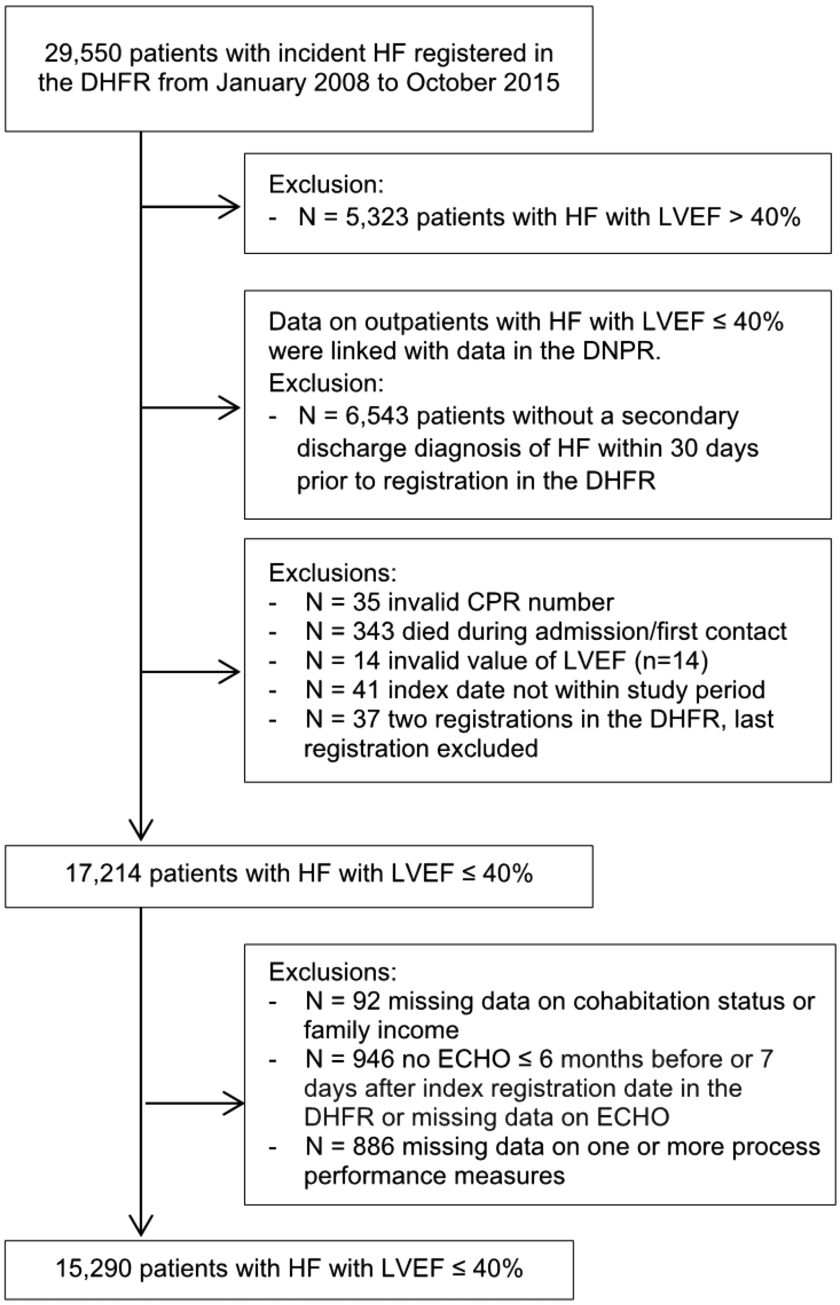
We identified inpatients directly from the data obtained from the DHFR. In addition, we identified those outpatients with HFrEF who had been hospitalized and discharged with HF as a secondary diagnosis within 30 days before the registration in the DHFR by linking patients' records with information from the DNPR.[17] A total of 17 214 patients met the inclusion criteria (*Figure 1*). Patients with missing data on cohabitation status and family income were excluded (n = 92).

In order to identify HFrEF with LVEF $\leq$ 40%, echocardiography is required. We, therefore, excluded patients who did not undergo echocardiography within 6 months before or 7 days after the date for admission to a hospital or outpatient clinic or had missing data on echocardiography (n = 946) as well as patients with missing data on all relevant process performance measures (e.g. no answer or date for fulfilment reported) (n = 886). Thus, data from 15 290 patients with incident HFrEF with LVEF $\leq$ 40% were available for further analysis (*Figure 1*).

Socioeconomic status

Socioeconomic status was assessed based on three individual-level markers: cohabitation status, highest education attained, and family income. Cohabitation status was measured as the household composition, that is, all persons enrolled at the address with their personal identification number (e.g. single man/woman, married couple/couple, and households consisting of several families) and categorized as living alone and cohabiting. The highest educational level attained was categorized according to the International Standard Classification of education 2011[23] and divided into

Figure 1 Patient selection flow-chart. CPR, civil personal registration; DNPR, Danish National Patient registry; ECHO, echocardiography; HF, heart failure; LVEF, left ventricular ejection fraction.



three educational levels: low-level education (primary and lower secondary level), mid-level education (upper secondary level), and high-level education (short-cycle tertiary, bachelor, master, and doctoral or equivalent level). Family income was measured as the annual gross income for all persons belonging to the same family on December 31 of the income year before the HF diagnosis. Family income was chosen, because it may better reflect the person's living conditions and consumption opportunities than personal income. We calculated the average yearly family income in the 5 years before the HF diagnosis. Mean family income was divided into tertiles of increasing income (low, medium, and high).

Quality of heart failure care

Quality of HF care was assessed using six individual evidence-based process performance measures[13] monitored

in the DHFR for patients with incident HFrEF: NYHA functional classification (yes/no), pharmacological treatment (yes/no) with angiotensin-converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB), beta-blockers, and mineralocorticoid receptor antagonists (MRA), referrals to individual exercise training (yes/no), and provided a structured patient education programme (yes/no).[13] The process performance measures were selected by a multidisciplinary expert panel to reflect key elements of clinical guideline recommendations on HF care for patients with incident HFrEF (*Table 1*). Moreover, the expert panel defined a timeframe for each process performance measure to capture the timeliness of the process (*Table 1*). Further, a composite score defined as the total number of fulfilled relevant care processes was calculated for each patient. The composite score was divided into 0–1, 2–3, 4, 5, and 6 performed care processes. Also, a composite score excluding NYHA classification was computed and divided into fulfilling 0–1, 2–3, 4, and 5 performance measures.

Statistical methods

Initially, we described the different patient characteristics for the overall study population and within each stratum of cohabitation status, education, and income, respectively. All variables were presented as frequencies and proportions, where continuous variables were grouped using appropriate cut-offs. Secondly, for each stratum of cohabitation status, educational level, and family income, we computed the crude relative risks for fulfilling 2–3, 4, 5, and 6 relevant HF care processes (six and five performance measures for LVEF $\leq$ 35% and LVEF $>$ 35, respectively) compared with the highest class within each socioeconomic status variable with the fulfilment of 0–1 performance measures as reference. The analyses were repeated excluding (i) the NYHA classification indicator and (ii) patients who died within 90 days from the first contact to minimize the risk of confounding by indication. Furthermore, we compared the proportion of patients fulfilling the individual performance measures according to socioeconomic factors. We computed unadjusted and adjusted odds ratios with 95% confidence intervals using logistic regression analysis.

We constructed a directed acyclic graph (DAG) for the association between income and HF care (Supporting Information, *Figure S1*) using DAGitty[24] to identify an appropriate set of variables to be considered in the analyses. Two adjusted models were used. First, we adjusted the crude odds ratios for age group, sex, NYHA class, CCI score, co-morbidities except for chronic obstructive pulmonary disease, and calendar year. We did not adjust for NYHA class in the models for the NYHA classification indicator, as these variables are highly correlated. Secondly, the analyses were stratified by age group, sex, patient type, and time period (2008–2010 and 2011–2016) to examine if these covariates modified the associations. Furthermore, we performed sensitivity analyses with additional adjustment for LVEF, region, and patient type, as well as mutual adjustment for the remaining socioeconomic factors. All variables included in the analyses were handled as categorical variables.

Our data encompassed low percentages of missing values (*Table 2*), and missing data were considered missing at random. We used multiple imputation by chained equations[25] to account for missing data on educational level and all potential confounders. Analyses were performed using 20 imputed datasets. The imputation models for missing data included all variables with missing data (*Table 2*), all variables used in the subsequent analytical models performed (i.e. outcome, socioeconomic factors, age group, sex, CCI score, myocardial infarction, stroke, diabetes, calendar year, LVEF, and patient type and region) as well as auxiliary variables (migration status at baseline, redeemed prescription of antidepressant or antipsychotic medication, number of somatic hospitalizations within the previous 10 years, and any admission in the last 12 months) predictive of missing values. Multiple imputation models were performed separately for each process performance measure. For comparison, a complete-case analysis was performed.

All statistical analyses were performed using Stata 15.1 (StataCorp, 2017, College Station, TX, USA). The study was approved by the Danish Data Protection Agency (R.no. 1-16-02-324-16) and the Danish Clinical Registries and conducted in accordance with the Declaration of Helsinki.[26]

Results

Socioeconomic factors and composite score for heart failure care

According to socioeconomic factors, baseline characteristics are presented in *Table 2* and the proportions of all composite scores according to socioeconomic factors in the Supporting Information, *Table S1*. Some correlation between the individual socioeconomic factors was observed. However, the overlap was in general modest, for example, 14% of the study population was living alone, low-level educated, and had an income in the lowest income tertile. Furthermore, 8% of the study population was cohabiting, had a high-level education, and an income in the highest income tertile.

Figure 2 shows the relative chance of fulfilling the six processes of HF care according to the individual socioeconomic factors. We found that patients living alone, with a low-level education, in the lowest and medium-income tertiles received poorer quality of care defined as the fulfilment of six process performance measures of HF care. The same pattern was observed in analyses when (i) excluding

Table 2 Baseline characteristics

	Total	Cohabitation status			Educational level			Family income		
		Living alone	Cohabitant	Missing	Low-level	Mid-level	High-level	Lowest tertile	Medium tertile	Highest tertile
Patients, *n* (%)	15 290	5892 (38.5%)	9398 (61.5)	752 (4.9)	6595 (43.1)	5725 (37.5)	2218 (14.5)	5097	5097	5096
Male	10 504 (68.7)	3424 (58.1)	7080 (75.3)	408 (54.3)	4075 (61.8)	4394 (76.8)	1627 (73.4)	2956 (58.0)	3633 (71.3)	3915 (76.8)
Age, years, *n* (%)										
≤65	4957 (32.4)	1657 (28.1)	3300 (35.1)	151 (20.1)	1750 (26.5)	2246 (39.2)	810 (36.5)	928 (18.2)	1198 (23.5)	2831 (55.5)
65–80	6728 (44.0)	2309 (39.2)	4419 (47.0)	161 (21.4)	3032 (46.0)	2547 (44.5)	988 (44.5)	2213 (43.4)	2667 (52.3)	1848 (36.3)
>80	3605 (23.6)	1926 (32.7)	1679 (17.9)	440 (58.5)	1813 (27.5)	932 (16.3)	420 (18.9)	1.956 (38.4)	1232 (24.2)	417 (8.2)
Migration status, *n* (%)										
Dane	14 494 (94.8)	5657 (96.0)	8837 (94.0)	581 (77.3)	6376 (96.7)	5467 (95.5)	2070 (93.3)	4781 (93.8)	4848 (95.1)	4865 (95.5)
Immigrant/descendent	796 (5.2)	235 (4.0)	539 (6.0)	171 (22.7)	219 (3.3)	258 (4.5)	148 (6.7)	316 (6.2)	249 (4.9)	231 (4.5)
LVEF, *n* (%)										
LVEF < 25%	4844 (31.7)	1912 (32.5)	2932 (31.2)	231 (30.7)	2019 (30.6)	1866 (32.6)	728 (32.8)	1563 (30.7)	1596 (31.3)	1685 (33.1)
25% ≤ LVEF ≤ 35%	7646 (50.0)	2919 (49.5)	4727 (50.3)	377 (50.1)	3343 (50.7)	2824 (49.3)	1102 (49.7)	2572 (50.4)	2566 (50.3)	2508 (49.2)
35% < LVEF ≤ 40%	2800 (18.3)	1061 (18.0)	1739 (18.5)	144 (19.2)	1233 (18.7)	1035 (18.1)	388 (17.5)	962 (18.9)	935 (18.4)	903 (17.7)
NYHA class, *n* (%)										
NYHA I	1593 (10.4)	524 (8.9)	1069 (11.4)	56 (7.5)	556 (8.4)	705 (12.3)	276 (12.4)	346 (6.8)	490 (9.6)	757 (14.9)
NYHA II	8057 (52.7)	2902 (49.3)	5155 (54.8)	293 (39.1)	3348 (50.8)	3173 (55.4)	1242 (56.0)	2417 (47.4)	2685 (52.7)	2955 (58.0)
NYHA III	3776 (24.7)	1623 (27.6)	2153 (22.9)	199 (26.5)	1.842 (27.9)	1250 (21.9)	485 (21.9)	1490 (29.3)	1301 (25.5)	985 (19.3)
NYHA IV	333 (2.2)	135 (2.3)	198 (2.1)	30 (4.0)	170 (2.6)	105 (1.8)	28 (1.3)	141 (2.7)	125 (2.4)	67 (1.3)
Missing	1531 (10.0)	708 (12.0)	823 (8.8)	174 (23.1)	678 (10.3)	492 (8.6)	187 (8.4)	703 (13.8)	496 (9.8)	332 (6.5)
CCI score, *n* (%)										
None (0)	1902 (12.4)	701 (11.9)	1201 (12.8)	77 (10.2)	773 (11.7)	752 (13.1)	300 (13.5)	512 (10.0)	576 (11.3)	811 (16.0)
Low (1–2)	7628 (49.9)	2833 (48.1)	4795 (51.0)	396 (52.7)	3116 (47.2)	2953 (51.6)	1163 (52.4)	2439 (47.9)	2438 (47.8)	2751 (54.0)
Moderate (3–4)	4517 (29.6)	1872 (31.8)	2659 (28.1)	237 (31.5)	2129 (32.3)	1566 (27.4)	585 (26.4)	1694 (33.2)	1598 (31.4)	1225 (24.0)
High ≥ 5	1243 (8.1)	486 (8.2)	758 (8.1)	42 (5.6)	577 (8.8)	454 (7.9)	170 (7.7)	452 (8.9)	485 (9.5)	306 (6.0)
Co-morbidities, *n* (%)										
Myocardial infarction	5247 (34.3)	1896 (32.2)	3351 (35.7)	240 (31.9)	2355 (35.7)	1976 (34.5)	676 (30.5)	1782 (35.0)	1853 (36.4)	1612 (31.6)
Stroke	1940 (12.7)	794 (13.5)	1146 (12.2)	106 (14.1)	902 (13.7)	675 (11.8)	257 (11.6)	731 (14.3)	743 (14.6)	466 (9.1)
COPD	2482 (16.2)	1078 (18.3)	1404 (14.9)	98 (13.0)	1247 (18.9)	852 (14.9)	285 (12.9)	994 (19.5)	910 (17.9)	578 (11.3)
Missing	205 (1.3)	85 (1.4)	120 (1.3)	8 (1.1)	59 (0.9)	79 (1.4)	59 (2.7)	51 (1.0)	73 (1.4)	81 (1.6)
Hypertension	5884 (38.5)	2317 (39.3)	3567 (38.0)	297 (39.5)	2596 (39.4)	2208 (38.6)	783 (35.3)	2033 (39.9)	2094 (41.1)	1757 (34.5)
Missing	107 (0.7)	47 (0.8)	60 (0.6)	6 (0.8)	33 (0.5)	39 (0.7)	29 (1.3)	25 (0.5)	46 (0.9)	36 (0.7)
Diabetes	3549 (23.2)	1392 (23.6)	2157 (23.0)	163 (21.7)	1661 (25.2)	1298 (22.7)	427 (19.3)	1289 (25.3)	1285 (25.2)	975 (19.1)
Atrial fibrillation	4480 (29.3)	1814 (30.8)	2666 (28.4)	248 (33.0)	1892 (28.7)	1645 (28.7)	695 (31.3)	1567 (30.7)	1569 (30.8)	1344 (26.4)
Missing	27 (0.2)									
S-Creatinin ≥ 150 μmol/L	1699 (11.1)	687 (11.7)	1012 (10.8)	118 (15.6)	817 (12.4)	562 (9.8)	202 (9.1)	705 (13.9)	625 (12.3)	369 (7.2)
Missing	10 (0.1)									
Smoking habits, *n* (%)										
Smoker	4318 (28.2)	1851 (31.4)	2467 (26.3)	161 (21.4)	2001 (30.4)	1685 (29.4)	471 (21.2)	1522 (29.9)	1415 (27.8)	1381 (27.1)
Missing	1401 (9.2)	586 (10.0)	815 (8.7)	135 (18.0)	585 (8.9)	475 (8.3)	206 (9.3)	546 (10.7)	442 (8.7)	413 (8.1)
Alcohol habits, *n* (%)										
>14/21 drinks per week	1336 (8.7)	587 (10.0)	749 (8.0)	55 (7.3)	451 (6.8)	604 (10.6)	226 (10.2)	426 (8.4)	402 (7.9)	508 (10.0)
Missing	1973 (12.9)	809 (13.7)	1164 (12.4)	147 (19.6)	897 (13.6)	646 (11.3)	283 (12.8)	741 (14.5)	670 (13.1)	562 (11.0)
Patient type										
Inpatient	8974 (58.7)	3689 (62.6)	5285 (56.2)	565 (75.1)	3889 (59.0)	3247 (56.7)	1273 (57.4)	3194 (62.7)	2928 (57.5)	2852 (56.0)
Outpatient	6316 (41.3)	2203 (37.4)	4113 (43.8)	187 (24.9)	2706 (43.3)	2478 (43.3)	945 (42.6)	1903 (37.3)	2169 (42.6)	2244 (44.0)
Antidepressant or psychotic medication, *n* (%)	2793 (18.3)	1252 (21.3)	1541 (16.4)	140 (18.6)	1314 (19.9)	940 (16.4)	399 (18.0)	1068 (21.0)	957 (18.8)	768 (15.1)

(*Continues*)

Table 2 (continued)

	Total	Cohabitation status			Educational level			Family income		
		Living alone	Cohabitant	Missing	Low-level	Mid-level	High-level	Lowest tertile	Medium tertile	Highest tertile
Previous somatic hospitalizations, 10 years, *n* (%)										
No admissions	2942 (19.2)	1107 (18.8)	1835 (19.5)	127 (16.9)	1196 (18.1)	1130 (19.7)	489 (22.1)	834 (16.3)	881 (17.3)	1227 (24.1)
1–2 admissions	5280 (34.5)	1944 (33.0)	3336 (35.5)	256 (34.0)	2185 (33.1)	2083 (36.4)	756 (34.1)	1670 (32.8)	1709 (33.5)	1901 (37.3)
3–9 admissions	5825 (38.1)	2329 (39.5)	3496 (37.2)	323 (43.0)	2651 (40.2)	2055 (35.9)	796 (35.9)	2144 (42.1)	2038 (40.0)	1643 (32.2)
10 admissions	1243 (8.1)	512 (8.7)	731 (7.8)	46 (6.1)	563 (8.6)	457 (8.0)	177 (8.0)	449 (8.8)	469 (9.2)	325 (6.4)
Any hospitalizations, previous 12 months, *n* (%)	8320 (54.4)	3155 (53.6)	5165 (55.0)	409 (54.7)	3655 (55.4)	3084 (53.9)	1172 (52.8)	2852 (56.0)	2849 (55.9)	2619 (51.4)
Employment status										
Employed	2737 (17.9)	744 (12.6)	1993 (21.2)	45 (6.0)	878 (13.3)	1331 (23.3)	483 (21.8)	312 (6.2)	631 (12.4)	1794 (35.2)
Pensioners	1349 (67.7)	4495 (76.3)	5854 (62.3)	602 (80.1)	5016 (76.1)	3467 (60.5)	1264 (56.9)	4364 (85.6)	3950 (77.5)	2035 (39.9)
Other/missing	2201 (14.4)	652 (11.1)	1549 (16.5)	104 (13.9)	701 (10.6)	926 (16.2)	470 (21.2)	419 (8.2)	515 (10.1)	1267 (24.9)
Region, *n* (%)										
Capital Region	4095 (26.8)	1711 (29.0)	2384 (25.4)	237 (31.5)	1.475 (22.4)	1601 (28.0)	782 (35.3)	1287 (25.3)	1369 (26.8)	1439 (28.2)
Zealand Region	3110 (20.3)	1.090 (18.5)	2020 (21.5)	115 (15.3)	1357 (20.6)	1238 (21.6)	400 (18.0)	990 (19.4)	1030 (20.2)	1090 (21.4)
Southern Denmark	3723 (24.3)	1424 (24.2)	2299 (24.5)	178 (23.6)	1705 (25.9)	1344 (23.5)	496 (22.4)	1297 (25.5)	1254 (24.6)	1172 (23.0)
Central Denmark	3161 (20.7)	1224 (20.8)	1937 (20.6)	150 (20.1)	1429 (21.7)	1.180 (20.6)	402 (18.1)	1091 (21.4)	1038 (20.4)	1032 (20.3)
North Denmark	1201 (7.9)	443 (7.5)	758 (8.0)	72 (9.5)	629 (9.5)	362 (6.3)	138 (6.2)	432 (8.4)	406 (8.0)	363 (7.1)

Baseline characteristics of 15 290 patients with first-time heart failure with left ventricular ejection fraction ≤ 40% overall and according to socioeconomic factors.
ACEI, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; CCI score, Charlson co-morbidity index score; COPD, chronic obstructive pulmonary disease; HF, heart failure; LVEF, left ventricular ejection fraction; MRA, mineralocorticoid receptor antagonists; NYHA, New York Heart Association.

the NYHA classification indicator and (ii) excluding patients who died within 90 days of the first contact (Supporting Information *Table S1*).

Socioeconomic factors and individual processes of heart failure care

The proportions of patients who received HF care that fulfilled the specific process performance measures are presented in the Supporting Information, *Table S2*. The highest percentage was observed for treatment with ACEI in all strata, cohabitation status, education and income, and ranged from 90.8% (living alone) to 94.6% (highest income tertile). The lowest proportion was observed for the referral to exercise training of 19.3% (lowest income tertile) and 35.6% (highest income tertile).

All logistic regression analyses for the individual process performance measures, in relation to socioeconomic factors, are presented in the Supporting Information, *Table S3*. The adjusted analyses showed that patients living alone were less likely to receive all processes of HF care, except treatment with MRA (*Figure 3*) compared with patients cohabiting. Living alone was associated with a higher chance of being prescribed MRA. However, the association was not statically significant. Compared with patients with high-level education, patients with low-level education had a lower chance of being NYHA classified, prescribed ACEI/ARB and beta-blocker therapy, referred to exercise training, and receiving patient education but had a higher chance of being prescribed MRA therapy. However, only the education-related differences in MRA therapy, exercise training, and patient education were statistically significant (*Figure 3*). Associations between mid-level education and fulfilling of the performance measures for HF care followed the same pattern as for low-level education, but no statistical significance was observed for exercise training. Patients in the lowest income tertile were less likely to be NYHA classified, to be treated with ACEI/ARB and beta-blockers, to be referred to exercise training, and to receive a structured patient education programme; they were, however, more likely to receive MRA therapy compared with patients in the highest income tertile. All associations were statistically significant, except with beta-blocker treatment (*Figure 4*). Medium income tertile was associated with a lower chance of being NYHA classified, treated with ACEI/ARB, referred to exercise training, and receiving patient education; however, the association with ACEI/ARB treatment was not statistically significant. Similarly, no statistically significant differences were observed for beta-blocker and MRA, although patients in the medium-income tertile had a higher chance of MRA treatment compared with patients in the highest income tertile. Overall, no systematic differences were seen when the analyses were stratified by sex, age groups, inpatient versus outpatient status, and years 2008 to 2010 versus 2011 to 2015 (data

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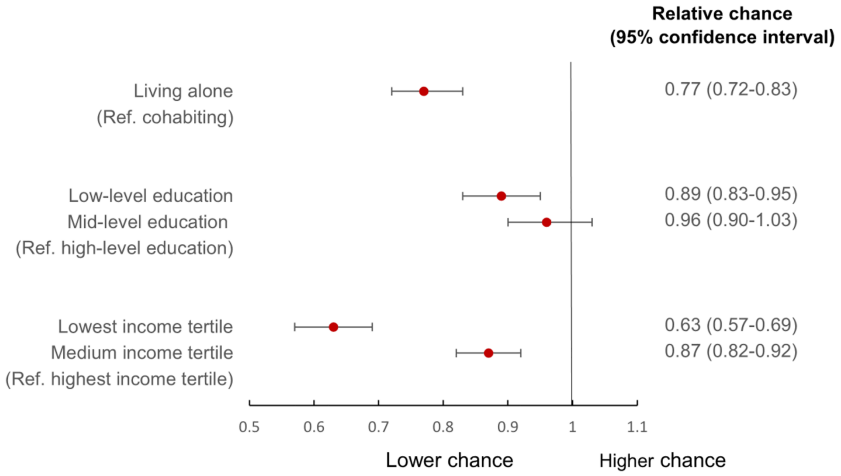
Figure 2 The relative chance for fulfilment of six process performance measures compared with fulfilment of 0–1 process performance measures according to socioeconomic factors.



not shown). After full adjustment (sensitivity analysis), living alone remained statistically significantly associated with a lower prescription of ACEI/ARB, beta-blockers, and less patient education. Low-level education persisted statistically significantly associated with less referral to exercise training, and lowest income tertile remained statistically significantly associated with less NYHA classification, referral to exercise training, and receiving patient education.

Discussion

Our results showed significant socioeconomic status-related differences in the quality of HF care among patients with verified incident HFrEF in Denmark. Living alone, low educational level, and lowest income tertile were associated with a poorer quality of care defined as lack of implementation of evidence-based guideline-recommend processes of HF care. In particular, documented NYHA classification, being provided exercise training, and structured patient education programme varied by socioeconomic factors. We observed that patients living alone were less likely to be treated with ACEI/ARB and beta-blockers, and patients in the lowest income tertile were less likely to be prescribed treatment with ACEI/ARB.

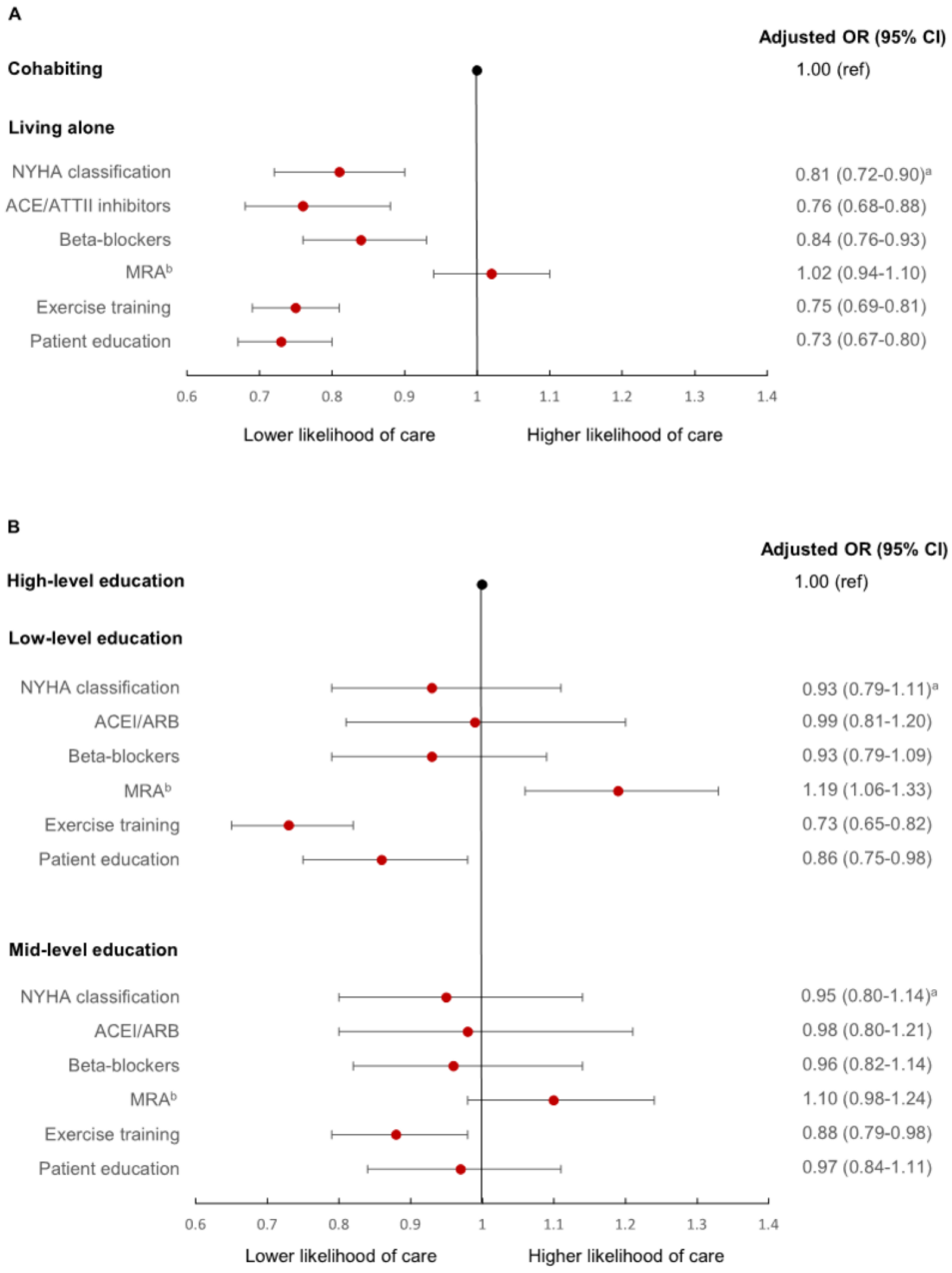
Socioeconomic factors and composite scores for process performance measures

The most substantial differences were found for patients in the lowest income tertile, where the RR of receiving all six relevant processes of HF care was 0.63 compared with patients in the highest income tertile. A similar pattern was observed for the medium income tertile, low-level education, and living alone. Inequity in HF care place socially deprived patients with HFrEF at double risk. Low socioeconomic status is a substantial risk factor of developing HF,[6] and recent studies indicate that income, poverty, and employment status is associated with a poor clinical outcome, for example, mortality and readmission among patients after being diagnosed with HF in universal healthcare systems.[7–10,27] Some studies have shown a relationship between HF care processes delivered (e.g. ACEI/ARB) and mortality and readmission among patients with HF, while other studies have not found this association.[28,29] Further, there may be a dose–response association between the fulfilment of performance measures and mortality.[30]

Our analyses revealed a gap in the quality of HF care provided by the Danish Healthcare system regardless of the causal mechanisms. We demonstrated that living alone was associated with a lower chance of receiving all HF care processes except treatment with MRA. One possible explanation for this finding may be that living alone is associated with less likelihood of planned follow-up in specialized HF clinics[31] providing evidence-based HF treatment, patient education, and referral for exercise training. Living/marital status is often considered a proxy for the level of social support delivered by a spouse or partner, family, or friends. Lack of social support might negatively impact patients' eagerness, motivation, and adherence to such a follow-up programme.

Cohabitation status is not the most frequently used measure of socioeconomic status. However, cohabitation status has been considered an important socioeconomic factor, and living alone is also often associated with a lower income. However, after adjusting for additional potential variables including income and education, living alone remained associated with a lower chance of treatment with ACEI/ARB,

Figure 3 Adjusted odds ratios for fulfilled performance measures for heart failure care according to (A) cohabitation status and (B) educational level. Variables used for adjustment included sex, age groups, NYHA class, Charlson co-morbidity score, myocardial infarction, stroke, hypertension, diabetes, atrial fibrillation, S-creatinine ≥150 μmol/L and calendar year. [a]No adjustment for NYHA class. [b]Left ventricular ejection fraction ≤ 35%. ACEI/ARB, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers; MRA, mineralocorticoid receptor antagonists; NYHA, New York Heart Association.

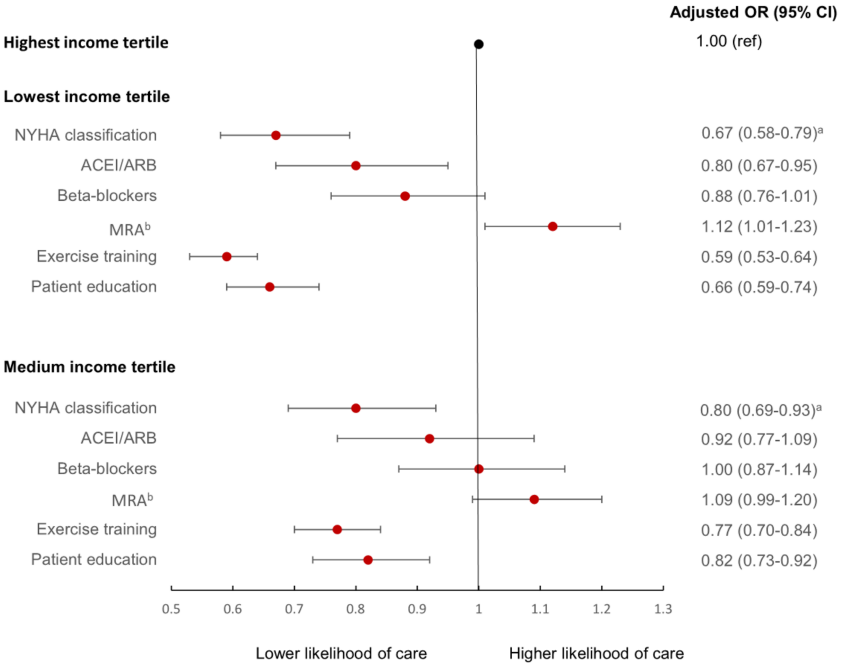


beta-blockers, and receiving patient education. Thus, our study supports the importance of including an assessment of cohabitation status when investigating equity in healthcare among patients with HFrEF. Lack of social support may contribute to poorer clinical outcomes among socioeconomically deprived patients with HF.

Socioeconomic factors and medical treatment

To the best of our knowledge, our study is the first to examine the impact of socioeconomic factors on the adherence to evidence-based, guideline-directed medical therapy in patients with incident HFrEF in a tax-financed healthcare

Figure 4 Adjusted odds ratios for fulfilled performance measures for heart failure care according to income. Variables used for adjustment included sex, age groups, NYHA class, Charlson co-morbidity score, myocardial infarction, stroke, hypertension, diabetes, atrial fibrillation, S-creatinine ≥ 50 μmol/L and calendar year. [a]No adjustment for NYHA class. [b]Left ventricular ejection fraction ≤ 35%. ACEI/ARB, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers; MRA, mineralocorticoid receptor antagonists; NYHA, New York Heart Association.



system. Most previous studies have primarily examined prescription or dispensation of ACEI/ARB, beta-blockers, and MRA among patients with HF irrespective of LVEF in hospital, outpatient, and primary care settings. Except for four studies,[11,12,32,33] most previous studies are based on older data collected at a time when patients with HF were not routinely treated with ACEI/ATII-inhibitors, beta-blockers, and MRA.[34–38] Thus, these 'early' studies may not be of relevance to current HF care.

We found an income-related difference in treatment with ACEI/ARB but not with beta-blockers. Unexpectedly, low income patients were more likely to be treated with MRA. Our findings regarding ACEI/ARB and MRA are contrary to previous studies. Two large Swedish studies,[32,33] reporting low income to be associated with a higher ACEI dispensation after hospitalization for HF[32] and a lower rate of MRA prescription among patients with HFrEF and HF duration ≥6 months from the Swedish HF registry,[33] respectively, compared with high-income patients. Contrary to our results, a UK study including 1802 outpatients with stable HF (LVEF ≤45%) for 3 months, treated with state of the art therapies in cardiology outpatient clinics, found comparable doses of prescribed ACEI/ARB and beta-blockers across deprivation quintiles.[11] Similarly, a large community study in the UK observed no differences in ACEI/ARB, beta-blockers, and MRA treatment between the most affluent and the most deprived patients with chronic HF.[12] It is particularly noteworthy with these contrary findings in two similar Scandinavian countries. However, differences in HF populations, organizational structure for HF management, and measurements used for socioeconomic status as well as for HF treatment may explain some of the differences in the results. Both UK studies used indicators of socioeconomic status based on area-level deprivation, which may lead to considerable misclassification of individual socioeconomic status. Thereby, the unadjusted association may be underestimated.[39] Moreover, the HF population by Witte *et al*. included outpatients with stable HF; thus, study population selection may have been related to the socioeconomic status of the patients and their HF treatment. A Swedish study has shown that patients with HF with planned follow-up in HF clinics were more likely treated with ACEI/ARB, beta-blockers, and MRA, married or cohabitating, with higher education and income. However, education and income were not statistically significantly associated in the adjusted analyses. Our results are inconclusive, and income was not consistently associated with prescribed guideline-recommend first-line medical therapy among incident patients with HFrEF.

We did not find any impact of educational level on treatment with ACEI/ARB, beta-blockers, and MRA, which corroborate findings in the two other Swedish studies.[32,33] Our study

demonstrated that living alone was associated with a lower prescription of ACEI/ARB and beta-blockers but not MRA. Similar results for MRA have been reported previously.[33] Overall, treatment with MRA did not appear to be particularly affected by socioeconomic variation, which may be explained by the fact that MRA is recommended for a select group of patients. Further, the MRA indicator was implemented in late 2007. Therefore, special attention may have been paid to providing this standardized treatment.

Some patients might have started treatment with ACEI/ARB, beta-blockers, and MRA after the defined timeframe, although early initiation of therapy is considered essential. Studies have reported that eligible patients with HFrEF who did not fulfil performance measures for treatment with ACEI/ARB and beta-blocker at hospital discharge were less likely to receive treatment within 60–90 days post-discharge.[40,41]

Socioeconomic factors and exercise training and patient education

In this study, 80.3% and 27.1%, respectively, of all patients newly diagnosed with HFrEF received structured patient education and were referred to supervised individual exercise training within the defined timeframe. After adjustment, we found that patients living alone, with a low-level education and lower incomes, were less likely to receive patient education and be referred to individual exercise training compared with patients cohabiting, with a high-level education, and with a high income. Thus, age, sex, symptom severity, and co-morbidity did not explain the association between socioeconomic factors and the delivered HF care. Existing studies report that low socioeconomic status patients are often less likely to be informed, willing to participate, and referred to cardiac rehabilitation.[42–44] Barriers to cardiac rehabilitation, for example, distance, costs, transportation issues, and lack of energy, have been reported to be more pronounced in patients with a low subjective financial status compared with those with a high subjective financial status.[44] Furthermore, it is known that the healthcare professionals' endorsement of and attitude towards cardiac rehabilitation are positively associated with referral to rehabilitation.[43] A recent Swedish study found that being married/cohabiting was associated with planned referral to follow-up in nurse-led HF clinics among inpatients and outpatients with HF, while no associations were found for level of education and income.[31]

Increased awareness of barriers in low socioeconomic status patients among clinicians regarding exercise training and patient education in patients with HFrEF seems necessary. New tools and approaches are needed to ensure equity in HF care and should also be addressed in strategies for the implementation of clinical guidelines.

Based on the results in the present study, healthcare systems responsible for treating patients with HFrEF should pay more attention to, explore and target efforts concerning potential barriers at an organization, provider and patient levels that impede high-quality care for incident HFrEF patients living alone, with a low-level education and with a low family income. Moreover, our study suggests a need to monitor process performance measures according to socioeconomic status to ensure equitable care for all patients. Two previous studies have reported conflicting results regarding the link between socioeconomic deprivation and risk of death among patients with HF receiving equitable treatment with HF medication.[11,12] Thus, it remains uncertain whether observed socioeconomic status-related differences in HFrEF care affect clinical outcomes following an HFrEF diagnosis. Such knowledge would be beneficial for developing healthcare strategies to reduce socioeconomic status-related differences in clinical outcomes.

Strengths and limitations

The strengths of our study are the use of a nationwide population-based design, prospectively recorded individual-level data, and the large sample of patients with a confirmed and well-defined diagnosis of HFrEF in a universal tax-financed healthcare system. Moreover, we were able to cover different domains of HF care (prognosis, medical treatment, patient education, and exercise training) and to link guideline-recommended processes of HF care and individual-level socioeconomic data, which in many international healthcare systems is impossible. However, the study was carried out in a universal healthcare system, which may limit the application of the results to other types of healthcare systems. Our study was based on data collected during routine clinical practice. This way of collecting data may potentially impact on the accuracy of the data collected. However, extensive efforts have been invested in ensuring completeness and data accuracy in the DHFR.[13] In addition, information about the NYHA class was measured within a 12-week timeframe from admission or first outpatient contact. Thus, there is a potential risk of misclassification in the NYHA class used for adjustment in analyses in this study.

In this study, we used multivariable adjustment, stratification, and multiple imputation to take potential confounding into account. We observed no important differences between the results when the unadjusted and adjusted analyses were restricted to patients with complete information on all covariates. However, there is a risk of residual confounding due to lack of data, for example, information on contraindications to the recommended anti-congestive therapy and patient preferences, which may have affected our results. In addition, data on physiological variables that are often important drivers in the clinical decision making, including blood

pressure and heart rate, could potentially further have improved our insights into the underlying mechanisms in our analysis. However, lack of these data is unlikely to have biased our results because these variables are more likely to be mediators between socioeconomic status and prescription of HF medication rather than confounding factors.[45]

Conclusions

Living alone, low-level education, and lower-income levels were associated with a lower chance of being referred for exercise training and receiving patient education among patients in a universal tax-financed healthcare system newly diagnosed with HFrEF. Thus, low socioeconomic status patients may be at double risk: first of all, to develop HF and secondly, to receive suboptimal HF care. Sustained and outreach efforts are needed to ensure the delivery of equitable care among patients with incident HFrEF.

Acknowledgements

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Conflict of interest

None declared.

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Supporting information

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

Figure S1. Directed acyclic graph (DAG) for the association between income and quality of heart failure care among patients with heart failure with reduced ejection fraction.

Table S1. *Proportions of patients with composite score[a] according to cohabitation status, educational level and income.*

Table S2. *Proportion of patients fulfilling specific relevant processes of heart failure care according to cohabitation status, educational level and income.*

Table S3. *Crude and adjusted odds ratios for the specific relevant processes of heart failure care according to cohabitation status, educational level and income.*

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