BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-051997
Article Type:	Original research
Date Submitted by the Author:	31-May-2021
Complete List of Authors:	Scholten, Mia; Center for Primary Health Care Research, Midlöv, Patrik ; Lund University, Clinical Sciences Malmo Halling, Anders; Lund University, Clinical sciences Malmo, CRC
Keywords:	Heart failure < CARDIOLOGY, EPIDEMIOLOGY, PRIMARY CARE, PUBLIC HEALTH

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Disparities in prevalence of heart failure according to multimorbidity level and socioeconomic status in Southern Sweden: a cross-sectional study

Mia Scholten,[1] Patrik Midlöv,[1] Anders Halling[1]

Abstract

Objective: The aim of this study was to compare the prevalence of heart failure in relation to multimorbidity and socioeconomic status of primary health care centres in southern Sweden.

Design: A cross-sectional cohort study.

Setting: The data were collected concerning diagnoses at each consultation in all primary health care centres and secondary health care in the southernmost county of Sweden.

Participants: The individuals living in southern Sweden (Scania) in year 2015 aged 20 years and older. The study population of 981388 inhabitants was divided into different categories including heart failure, multimorbidity, different levels of multimorbidity and into 10 CNI (Care Need Index) groups depending on the socioeconomic status of their listed primary health care centre.

Outcomes: Prevalence of heart failure was presented according to age, multimorbidity, multimorbidity level and socioeconomic status. Logistic regression was used to further

analyse the associations between heart failure, age, multimorbidity level and socioeconomic status in more complex models.

Results: The total prevalence of heart failure in the study population was 2.06%. The prevalence of heart failure increased with advancing age and the level of multimorbidity. 99.07% of the patients with heart failure fulfilled the criteria for multimorbidity. The individuals belonging to the deprived CNI percentiles were more likely to have higher proportion of inhabitants younger than 40 years and the opposite were true for primary health care centres with affluent CNI percentiles. Heart failure had a strong correlation with the socioeconomic status of the primary health care centres.

Conclusion: The patients with heart failure were strongly associated with having multimorbidity and socioeconomic deprivation. Many comorbidities could influence each other and may worsen the prognosis of heart failure, which necessitates prevention and early diagnosis in order to improve the quality of life and outcome in these patients.

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Strengths and limitations of this study

- Our large cohort with almost 1 million inhabitants included 20193 patients with heart failure and 377161 with multimorbidity in southern Sweden during the study period, which increases the validity of our results.
- The outcome data were based on clinical diagnoses registered by physicians, rather than self-reported data, which eliminated any recall bias.
- Many patients have diagnoses that are usually neglected by the patients and staff in the health care, because these do not impair their quality of life or prognosis, which constitutes a consistent error source to our statistics.
- As diastolic heart failure has none-specific symptoms at the onset, we suspect that many people were underdiagnosed regarding this condition.
- We had no data on the quality of health care in the neighbourhood.

Introduction

Heart failure (HF) and multimorbidity (MM) are leading causes of morbidity, hospitalizations, disability, and death in Western countries[2 3]. The prevalence of heart failure and multimorbidity increases with age and the cost of care and treatment constitutes a considerable burden on primary health care and on health care as a whole[2]. In high-income countries, HF is the most common diagnosis in hospitalized elderly patients aged >65 years[3]. In Sweden, 31% of medical expenditures were spent for HF patients with reduced ejection fraction (HFrEF) in primary health care, 29% for primary cardiac hospitalizations, and 40% were for noncardiac hospitalizations[4].

Heart failure is classified into two major groups: HF with reduced ejection fraction (HFrEF), and HF with preserved ejection fraction (HFpEF)[5]. Both HFrEF and HFpEF have the same clinical phenotype[6], but different pathophysiology and prognosis[7]. The systolic failure or HFrEF (or systolic dysfunction) is established when the left ventricle loses its ability to contract normally. The heart cannot pump with enough force to push enough blood into the circulation. HFrEF develops usually in response to larger-scale myocyte loss/dysfunction, with the most common aetiologies including acute myocardial infarction, genetic abnormalities, myocarditis or toxin effects (e.g. alcohol or chemotherapy)[8]. Diagnosis of systolic dysfunction is easier than the diagnosis of diastolic dysfunction due to the objective finding of reduced ejection fraction. HFpEF or diastolic HF (or diastolic dysfunction) is established when the left ventricle loses its ability to relax normally, because the muscle has become stiff. The heart cannot properly fill with blood during the resting period between each beat. The pathophysiologic derangements in HFpEF include concentric remodelling, ventricular-vascular stiffening and loss of ventricular-vascular reserve function are resulted from chronic pressure overload due to arterial hypertension[9]. Diastolic heart failure has preserved ejection fraction and often non-specific symptoms, and is preferably found among elderly, women, and patients with diabetes mellitus and hypertension[10-13].

Beside the risk factors like physical inactivity, obesity, chemotherapy, heritability and hyperlipidemia, which increases the incidence of heart failure, the incidence also varies with the patient's socioeconomic status (SES)[1 14-18]. Higher income has previously been

associated with a lower risk of developing heart failure[19]. Moreover, the risk factors for heart failure, such as hypertension and coronary heart disease, also vary with SES[20]. Heart failure is often a chronic complication of other cardiovascular comorbidities, particularly ischaemic heart disease, atrial fibrillation and valve dysfunctions[21]. Due to improved medical management, the age-adjusted incidence and prevalence of HF are decreasing, and the HF patients have got prolonged life expectancy[2]. Consequently, the absolute number of patients with HF has drastically increased, secondary to global ageing, as well as general population growth[22]. Although reliable estimates for middle-income and low-income nations are lacking, evidence from the current literature suggests that HF is the fastest growing cardiovascular condition globally[23 24].

The aetiology of HF is diverse and varies geographically worldwide: High-income countries are disproportionally affected by ischemic heart disease and COPD (chronic obstructive pulmonary disease) compared with low-income countries, which in turn are primarily affected by hypertensive heart disease, rheumatic heart disease, cardiomyopathy, and myocarditis[25]. More than two-thirds of all cases of HF can be attributed to four underlying conditions: ischaemic heart disease, COPD, hypertensive heart disease and rheumatic heart disease[2].

HF is often a chronic condition with insidious symptoms at the onset, which could make early and accurate diagnosis difficult. The diagnosis of heart failure requires three criteria to be fulfilled: typical clinical symptoms, such as dyspnoea, fatigue, exertional intolerance and oedema of the lower body, elevated BNP value and objective findings of impaired cardiac

function on echocardiography, myocardial scintigraphy, magnet resonance tomography or other imaging[12].

The aim of this study was to compare the prevalence of heart failure in relation to multimorbidity and socioeconomic status of primary health care centres in southern Sweden (Scania).

Methods

Setting and study population

Most residents in Sweden are listed to a primary health care centre, either a public or private health care centre. Scania is the southernmost county of Sweden with around 1.3 million inhabitants during year 2015[26]. The biggest city in southern Sweden (Scania) is Malmö with about 320000 inhabitants during the study period, ranked as the third largest city in Sweden[26]. About 1/3 of the residents in Malmö were born abroad representing most countries in the world[27]. Approximately ¼ of the whole study population were born abroad[28]. Almost half of the residents in Malmö (48.40%) were under 35 years during year 2015[29]. The study population comprised individuals aged 20 years and older living in southern Sweden (Scania) during the last week of year 2015. This age cut-off was chosen because the types of heart failure affecting children and younger people are pathologically distinct from those found in older adults.

Data source and measurements

The data that was used in this study was retrieved from the County Council health care register in southern Sweden (Scania) that contains anonymized registry information from the study population, including age, gender, socioeconomic status and diagnostic data.

The data were collected concerning diagnoses at each consultation in all primary health care centres and secondary health care. The study population was divided into age groups: 20, 30, 40, 50, 60, 70, 80+. The age group 20 included inhabitants aged 20 to 29 years, the age group 30 included inhabitants aged 30 to 39 years, and so on. The age group 80+ included all inhabitants from 80 years and over.

Diagnoses were recorded according the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD 10). Heart failure was identified if the diagnosis code I50 was recorded.

Multimorbidity

Multimorbidity (MM) was defined as coexistence of two or more chronic conditions in the same person. To measure multimorbidity, we used a method to identify chronic conditions developed by A Calderòn-Larrañaga *et al.* at the Aging Research Centre in Stockholm[30]. They

analysed the full list of ICD-10 codes on a four-digit level to define if a diagnosis is chronic or not in an elderly population. To determine if a condition is chronic or not the following key features were identified and discussed concerning their pertinence and suitability in older populations: duration, course, reversibility, treatment, and consequences. They were then grouped into 60 groups of chronic conditions. We applied their definition and list on chronic conditions to estimate the multimorbidity in our study population. All information about diagnoses for this 18-months period (July 2014 - December 2015) was obtained from electronic medical record database in the county council in southern Sweden (Scania). Multimorbidity was then estimated by counting the number of chronic conditions in each patient. To study the degree of MM in relation to the prevalence of HF, the patients were further divided into groups MM0 (less than two chronic conditions), MM1 (two to four chronic conditions), MM2 (five to nine chronic conditions) and MM3 (ten chronic conditions or more).

Socioeconomics

We used the term Care Need Index (CNI)[31] to divide the primary health care centres into 10 groups depending on their socioeconomic status in the last week of year 2015. CNI is based on different measures of a group, in this case the patients listed to different primary health care centres in southern Sweden (Scania). CNI 1 was assigned to those patients listed to primary health care centres who belonged to the most socioeconomically affluent percentile,

and CNI 10 was assigned to those patients listed to primary health care centres who belonged to the most socioeconomically deprived percentile[31].

Statistical analyses

We analysed data from 981388 (about a tenth of the Swedish population) inhabitants aged 20 years and older living in southern Sweden (Scania) during the last week of year 2015. Associations between the variables were studied using univariate and multivariate statistics.

We used frequencies, percentages and cross tabulations for descriptive analysis. Logistic regression was used to analyse the associations between the univariate and multivariate models. A p-value of < 0.05 was considered statistically significant. The predicted prevalence of heart failure was calculated as average marginal effects and contrasts using Delta-method. The different age distribution in all CNI percentiles were analysed with Lorenz plots.

We used STATA version 16.0 (Stata Corporation, Texas, USA) for statistical analyses.

Patient and Public Involvement

Data in the present study are based on anonymised information provided by the County Council of southern Sweden (Scania). They provided anonymised information for research purposes once the study had been approved by the Ethics Committee at Lund University.

The patients were not involved in the recruitment to the study by themselves. Due to the requirement of anonymised data, each individual could not be asked for consent to participate; active refusal of participation was instead applied. This was done by publishing information about the planned study in the Swedish local newspaper "Sydsvenskan". The advertisement outlined the study and contained information on how to contact the research manager (first author) to opt out of the study. The study results are published anonymised in group level, and cannot be disseminated to every study participant.

Results

The total prevalence of heart failure in the study population was found to be 2.06% (20193 patients) in year 2015. Heart failure was a rare disease under 40 years of age in the whole study population, but the prevalence increased substantially with advancing age, especially from 60 years of age, and reached 17.31% in the age group 80+ (Table 1). The individuals listed to primary health care centres with deprived CNI percentiles were more likely to have higher proportion of individuals younger than 40 years and the opposite were true for primary health care centres with affluent CNI percentiles. The primary health care centres with the most deprived CNI percentile had the lowest proportion of population from middle age, only 33.25% were 50 years and older, whereas the affluent CNI percentiles were likely to be dominated by individuals from 50 years and over (Table 1). The inequality of age distribution

between the most affluent and deprived CNI percentiles of primary health care centres is illustrated by Lorenz plots (Fig. 1).

Table 1. Prevalence of heart failure and multimorbidity in all age groups and CNI percentiles.

	age 20 - 29 years			age 30 - 39 years			age 40 - 49 years			age 50 - 59 years		
CNI	N(%)	HF(%)	MM(%)	N(%)	HF(%)	MM(%)	N(%)	HF(%)	MM(%)	N(%)	HF(%)	MM(%)
CNI 1	12866(11.53)	4(0.03)	2023(15.72)	17890(16.03)	10(0.06)	3541(19.79)	24753(22.20)	34(0.14)	6078(24.55)	17806(16.00)	88(0.49)	6739(37.85)
CNI 2	16173(14.61)	7(0.04)	2417(14.94)	16095(14.54)	4(0.02)	3234(20.09)	20750(18.70)	33(0.16)	5253(25.32)	18892(17.10)	94(0.50)	7288(38.58)
CNI 3	16970(17.97)	6(0.04)	2545(15.00)	15252(16.15)	10(0.07)	3040(19.93)	16596(17.60)	31(0.19)	4550(27.42)	14638(15.50)	102(0.70)	5793(39.58)
CNI 4	14112(16.16)	6(0.04)	2274(16.11)	13429(15.38)	11(0.08)	2763(20.57)	15769(18.10)	43(0.27)	4351(27.59)	14658(16.80)	121(0.83)	6033(41.16)
CNI 5	12796(17.01)	2(0.02)	2001(15.64)	13168(17.51)	7(0.05)	2713(20.60)	13879(18.50)	35(0.25)	3849(27.73)	12142(16.10)	74(0.61)	4969(40.92)
CNI 6	18134(17.52)	3(0.02)	2769(15.27)	15745(15.21)	8(0.05)	3105(19.72)	18285(17.70)	41(0.22)	4967(27.16)	16530(16.00)	109(0.66)	6695(40.50)
CNI 7	18045(20.67)	10(0.06)	2420(13.41)	14656(16.78)	10(0.07)	2678(18.27)	14400(16.50)	33(0.23)	3808(26.44)	12597(14.40)	93(0.74)	4996(39.66)
CNI 8	22405(19.63)	5(0.02)	3601(16.07)	21019(18.41)	19(0.09)	4360(20.74)	19268(16.90)	45(0.23)	5438(28.22)	17755(15.60)	145(0.82)	7313(41.19)
CNI 9	23116(22.34)	3(0.01)	3330(14.41)	21531(20.81)	11(0.05)	3976(18.47)	16388(15.80)	39(0.24)	4315(26.33)	14812(14.30)	103(0.70)	5929(40.03)
CNI 10	26259(28.03)	10(0.04)	3550(13.52)	21295(22.73)	16(0.08)	3946(18.53)	15007(16.00)	48(0.32)	4472(29.80)	12602(13.50)	119(0.94)	5457(43.30)

	age 60 - 69 years			age 70 - 79 years			age 80+ years		
CNI	N(%)	HF(%)	MM(%)	N(%)	HF(%)	MM(%)	N(%)	HF(%)	MM(%)
CNI 1	19358(17.34)	311(1.61)	11496(59.39)	13345(11.95)	682(5.11)	10446(78.28)	5615(5.03)	949(16.90)	5003(89.10)
CNI 2	19729(17.83)	361(1.83)	11345(57.50)	12752(11.52)	598(5.00)	9657(75.73)	6278(5.67)	977(15.60)	5443(86.70)
CNI 3	15383(16.29)	313(2.03)	9069(58.95)	10056(10.65)	624(6.21)	7783(77.40)	5553(5.88)	1001(18.00)	4896(88.17)
CNI 4	14826(16.98)	350(2.36)	8802(59.37)	9409(10.77)	630(6.70)	7188(76.39)	5122(5.87)	983(19.20)	4470(87.27)
CNI 5	11723(15.58)	256(2.18)	6850(58.43)	7333(9.75)	467(6.37)	5629(76.76)	4179(5.56)	805(19.30)	3686(88.20)
CNI 6	16438(15.88)	332(2.02)	9490(57.73)	11457(11.07)	619(5.40)	8786(76.69)	6895(6.66)	1109(16.10)	5948(86.27)
CNI 7	13119(15.02)	276(2.10)	7418(56.54)	8930(10.23)	543(6.08)	6735(75.42)	5570(6.38)	993(17.80)	4776(85.75)
CNI 8	17014(14.90)	346(2.03)	9778(57.47)	10651(9.33)	647(6.08)	8031(75.40)	6040(5.29)	1012(16.80)	5194(85.99)
CNI 9	12646(12.22)	334(2.64)	6948(54.94)	8915(8.62)	560(6.28)	6569(73.68)	6064(5.86)	979(16.10)	5014(82.68)
CNI 10	9304(9.93)	305(3.28)	5240(56.32)	5751(6.14)	528(9.18)	4106(71.40)	3450(3.68)	671(19.45)	2786(80.75)

CNI = Care Need Index, CNI 1= the most affluent percentile, CNI 10 = the most deprived percentile, HF = heart failure, MM= multimorbidity, N = number of individuals

Multimorbidity was present in 38.40% (377161 patients) of the study population and followed different patterns according to CNI percentiles of the primary health care centres. HF was strongly correlated to MM: 99.07% of the patients with HF fulfilled the criteria for multimorbidity. The prevalence of MM increased steadily with advancing age, from 14.89% in the age group 20 to 86.22% in the age group 80+ (Table 1). The prevalence of HF increased consistently with the MM level: the MM1(2-4 chronic conditions) group had 1.49% patients with HF, the MM2 (5-9 chronic conditions) group had 11.16% patients with HF, and the MM3 (>10 chronic conditions) group had 39.28% patients with HF (Fig. 2). If we consider the prevalence of heart failure in different groups of multimorbidity: 19.19% (3875 patients) of all patients with HF belonged to the MM1 group, 58.18% (11748 patients) belonged to the MM2 group and 21.70% (4382 patients) belonged to the MM3 group. The MM2 group as a whole was more than nine times larger than the MM3 group (105241 vs 11156 patients) (Table 2). The predicted prevalence of HF adjusted for age and MM level is shown in figure 2.

Table 2. Prevalence of heart failure in patients with different levels of multimorbidity in all age groups and CNI percentiles.

	age-group	MM0(%)	N	MM1(%)	N	MM2(%)	N	MM3(%)	N
CNI 1	20	0.01	1	0.11	2	0.74	1	0.00	0
	30	0.01	2	0.12	4	1.25	4	0.00	0
	40	0.02	3	0.32	17	1.77	12	9.09	2
	50	0.05	5	0.65	35	3.08	41	14.00	7
	60	0.06	5	0.99	77	4.75	164	26.32	65
	70	0.17	5	1.61	87	9.23	412	31.17	178
	80+	0.16	1	6.01	113	22.19	586	51.55	249

CNI 2	20	0.01	1	0.18	4	1.26	2	0.00	0
	30	0.00	0	0.10	3	0.38	1	0.00	0
	40	0.00	0	0.33	15	2.80	18	0.00	0
	50	0.02	2	0.75	44	2.96	40	15.69	8
	60	0.07	6	1.27	101	6.16	194	26.67	60
	70	0.16	5	1.57	85	9.90	374	38.33	174
	80+	0.24	2	6.71	159	22.38	586	50.33	230
CNI 3	20	0.01	1	0.08	2	1.86	3	0.00	0
	30	0.00	0	0.15	4	1.92	6	0.00	0
	40	0.01	1	0.39	15	2.12	14	6.25	1
	50	0.02	2	0.82	37	4.49	56	14.29	7
	60	0.06	4	1.31	80	6.34	174	25.35	55
	70	0.18	4	2.29	92	10.79	358	38.64	170
	80+	1.22	8	8.07	153	23.50	597	52.71	243
CNI 4	20	0.03	3	0.10	2	0.58	1	0.00	0
	30	0.01	1	0.24	6	1.35	4	0.00	0
	40	0.01	1	0.65	24	2.76	18	0.00	0
	50	0.03	3	1.08	49	4.25	60	14.06	9
	60	0.12	7	1.81	105	6.69	184	21.86	54
	70	0.00	0	3.23	118	11.51	357	35.96	155
	80+	0.92	6	8.95	163	28.41	637	43.49	177
CNI 5	20	0.01	1	0.00	0	0.74	1	0.00	0
	30	0.00	0	0.25	6	0.36	1	0.00	0
	40	0.02	2	0.40	13	2.94	17	15.00	3
	50	0.03	2	0.81	31	3.15	35	13.33	6
	60	0.06	3	1.29	59	7.12	151	25.44	43
	70	0.00	0	2.20	65	11.42	266	39.88	136
	80+	0.61	3	10.11	152	25.38	466	53.18	184
CNI 6	20	0.00	0	0.12	3	0.00	0	0.00	0
	30	0.02	2	0.18	5	0.34	1	0.00	0
	40	0.02	2	0.45	19	2.04	14	25.00	6
	50	0.02	2	0.69	36	4.36	61	15.63	10
	60	0.07	5	1.45	94	6.18	173	27.27	60
	70	0.15	4	1.95	93	10.39	370	34.16	152
	80+	0.63	6	6.34	162	23.55	689	53.96	252
CNI 7	20	0.01	1	0.22	5	2.41	4	0.00	0
	30	0.01	1	0.21	5	1.60	4	0.00	0
	40	0.02	2	0.37	12	2.79	15	16.67	4

	50	0.05	4	0.81	31	3.69	41	21.79	17
	60	0.09	5	1.46	74	6.96	151	23.96	46
	70	0.05	1	2.13	78	11.66	320	42.73	144
	80+	0.63	5	8.52	167	25.30	607	51.44	214
CNI 8	20	0.01	1	0.09	3	0.46	1	0.00	0
	30	0.00	0	0.33	13	1.37	6	0.00	0
	40	0.01	2	0.56	26	1.73	14	12.50	3
	50	0.07	7	0.86	49	4.62	72	21.52	17
	60	0.04	3	1.42	94	6.48	190	26.94	59
	70	0.15	4	2.36	101	12.10	404	33.74	138
	80+	0.83	7	7.22	157	23.63	614	55.71	234
CNI 9	20	0.01	1	0.06	2	0.00	0	0.00	0
	30	0.01	2	0.08	3	1.81	6	0.00	0
	40	0.01	1	0.55	20	1.84	12	27.27	6
	50	0.02	2	0.80	36	3.94	53	17.14	12
	60	0.04	2	1.59	75	9.22	188	35.75	69
	70	0.17	4	2.79	101	12.14	318	41.77	137
	80+	0.76	8	7.60	165	24.57	600	51.37	206
CNI10	20	0.01	2	0.12	4	2.05	4	0.00	0
	30	0.01	1	0.17	6	2.08	8	14.29	1
	40	0.04	4	0.46	17	2.73	21	20.69	6
	50	0.00	0	0.75	30	5.15	70	20.43	19
	60	0.07	3	1.94	65	9.91	170	39.88	67
	70	0.12	2	4.28	91	17.48	299	50.56	136
	80+	0.30	2	9.69	111	29.43	407	58.75	151

CNI= Care Need Index, CNI 1 = the most affluent percentile, CNI 10 = the most deprived percentile, MM0 = less than 2 chronic conditions, MM1= 2-4 chronic conditions, MM2 = 5-9 chronic conditions, MM3 = 10 or more chronic conditions, N = number of individuals

The prevalence of heart failure had a strong correlation with the SES of the primary health care centres (Fig. 3). The most significant disparity was between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was

significantly increased and almost twice as high as in the most affluent CNI percentile (Table 1). Although at much lower levels, significant disparities in prevalence of HF could be seen when comparing the most deprived CNI percentile with other CNI percentiles of the primary health care centres. The primary health care centres with the most deprived CNI percentile had the highest prevalence of HF from 40 years of age, although their prevalence of MM was lowest from 70 years of age. In contrast, the prevalence of HF in the most affluent CNI percentile remained relatively low in most age groups, even from 60 years of age as their prevalence of MM became highest (Table 1). The association between the prevalence of HF and the CNI percentiles followed different patterns compared to MM as shown in Table 1.

Discussion

The total prevalence of heart failure was about 2% in southern Sweden (Scania) in year 2015, which was the same as the prevalence in Sweden and other Western countries[32 33]. Heart failure was a rare disease under 40 years of age and increased substantially with advancing age. 99.07% of the patients with HF in our study population had multimorbidity, which could be explained by the diagnosis HF mostly constitutes a complication of other cardiovascular conditions[21 34]. With increasing level of multimorbidity, the prevalence of HF increased from 1.49% in the MM1(2-4 chronic conditions) group to 39.28% in the MM3 (more than 10 chronic conditions) group. The MM3 group had fewer patients, but a higher prevalence of HF than the MM2 group, which makes us to believe that the MM3 group had a higher mortality

in general. The prevalence of HF also had a strong association with the SES of primary health care centres with the most significant disparity between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was almost twice as high as in the most affluent CNI percentile. The individuals listed to primary health care centres with deprived CNI percentiles were more likely to have high proportion of inhabitants younger than 40 years, and the opposite were true for primary health care centres with affluent CNI percentiles. The primary health care centres with the most deprived CNI percentile had the lowest proportion of population (33.25%) from 50 years and the highest prevalence of HF from 40 years of age compared to the more affluent population, which makes us to suspect that they suffered from SES related multimorbidity with worse prognosis, including HF. The fact that the prevalence of HF was highest in the most deprived CNI percentile of primary health care centres with the lowest prevalence of MM among elderly indicates that HF is a disease associated with socioeconomic deprivation.

Heart failure is a common comorbidity in patients with COPD (chronic obstructive pulmonary disease)[35], with prevalence in 33.2% of women and 35.7% of men over 80 years of age[36]. In most countries, low SES is associated with higher prevalence of COPD and mortality[37]. The estimated mortality in patients with COPD and coexisting heart failure was seven times higher than in patients with COPD alone, thus HF was reported as the most common comorbidity noted in deceased patients hospitalized with COPD exacerbation[38]. Other comorbidities with

high impact on mortality in patients with HF including stroke, renal disease and diabetes mellitus[39], are strongly associated with low SES as well[40-42].

With respect to the global burden of ischaemic heart disease, the incidence of acute myocardial infarction worldwide is highest in Eastern Europe and Central Asia[43]. Compared to the Swedish population, the first-generation immigrants from Iraq and Bosnia had the highest incidence of HF, probably due to a higher incidence of coronary heart disease[5]. When this incidence of HF was further adjusted for SES, marital status and educational level, the hazard ratio for HF raised significantly compared to the immigrants from other countries. As many of these immigrants are socioeconomically highly disadvantaged in Sweden, these results support our findings. Interestingly, the HF risk pattern among the second-generation immigrants in most cases differed only marginally compared to their Swedish counterparts, indicating that their risk factor is not purely genetic, rather responsive to other factors[5].

A similar study in Scotland revealed that older people typically have more morbidities with lower functional status, whereas younger people are more often affected by combinations physical and mental health disorders. Except that the most affluent population being on average 2-5 years older at onset of morbidity (dependent on the disorder), comorbidities like coronary heart disease, diabetes mellitus, COPD, depression, painful disorders or cancer were more common in people living in deprived areas[44]. This could explain that people in the affluent areas suffered from multimorbidity with less disability and had better prognosis.

We do not know if multimorbidity causes socioeconomic deprivation or if low socioeconomic status causes multimorbidity. There is presumably an impact in both directions. Many people with multimorbidity do retire earlier, and have more socioeconomic consequences than the working population. Statistically, this group degrades in the socioeconomic status, which even may influence their family members. On the other hand, many people in the deprived areas have to accept a job which is more health challenging, and become multimorbid many years earlier than the affluent population.

Strengths and limitations

Our study has a number of strengths. Our large cohort with almost 1 million inhabitants included all patients with HF and MM in Scania during the study period, which increases the validity of our results. The outcome data were based on clinical diagnoses registered by physicians, rather than self-reported data, which eliminated any recall bias. Our findings have similarities with correlative studies in other countries[19 21], which increases the credibility of our results.

This study has certain limitations. We had no data on several risk factors for heart failure, such as smoking, obesity or physical inactivity. However, some prior works on SES and heart failure had adjusted for smoking and physical inactivity and still found an independent association[19]. We had no results of echocardiography, and thus could not divide into the type

of heart failure, i.e. systolic or diastolic HF. As diastolic heart failure has none-specific symptoms at the onset, we suspect that many people were underdiagnosed regarding this condition. Many patients have diagnoses that are usually neglected by the patients and staff in the health care, because these do not impair their quality of life or prognosis, which constitutes a consistent error source to our statistics. We had no data on the severity of HF and comorbidities, which have high impact on the mortality. We had no data on the quality of health care in the neighbourhood. Our results could be more accurate if the age group 80+ were divided into age group 80 and 90+, and analysed separately.

Conclusion

The prevalence of heart failure was strongly associated with multimorbidity, with higher prevalence of HF with increasing level of multimorbidity. The patients listed to the most socioeconomic deprived CNI percentile had the lowest proportion of population (33.25%) from 50 years and a significantly elevated risk of developing HF compared to the more affluent population in our study. Many comorbidities could influence each other and may worsen the prognosis of HF, which necessitates prevention and early diagnosis in order to improve the quality of life and outcome in these patients. We should focus on the prevention of the risk factors for HF, like a healthy life style with reduced psychological stress and smoking, better diet and more physical activities. Hopefully, these changes combined with innovated treatment of cardiac comorbidities will decrease the incidence of HF and MM. HF

is one of many conditions with poor prognosis associated with socioeconomic deprivation that challenges efficient preventive strategies and health policies.

Acknowledgements

We thank the County Council of southern Sweden (Scania) for providing the patient data enabling this study. We are indebted to Patrick Reilly for his expertise and invaluable advice in proofreading the manuscript.

Footnotes

Contributorship statement

In accordance with the Vancouver Protocol, AH was involved in data collection, design of the study, data analysis, editing the manuscript and student supervision. MS contributed with data collection, data analysis, writing and editing the manuscript. PM provided critical comment and feedback on the manuscript.

Competing interests

None declared.

Statement of funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data sharing statement

Scania County Council consented to publication of results using their data.

Availability of data and material

No further data available.

Statement of Ethics

The regional Ethical Review Board at Lund University (application no. 2018/778) approved the study.

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Figure legends

Fig. 1. The age distribution of individuals in southern Sweden (Scania) belonging to the most affluent CNI (CNI 1) and deprived (CNI 10) CNI (Care need index) percentiles.

Fig. 2 The predicted mean probability of heart failure adjusted for different age groups and multimorbidity levels with 95% confidence intervals.

MM0= less than 2 chronic conditions (not multimorbid)

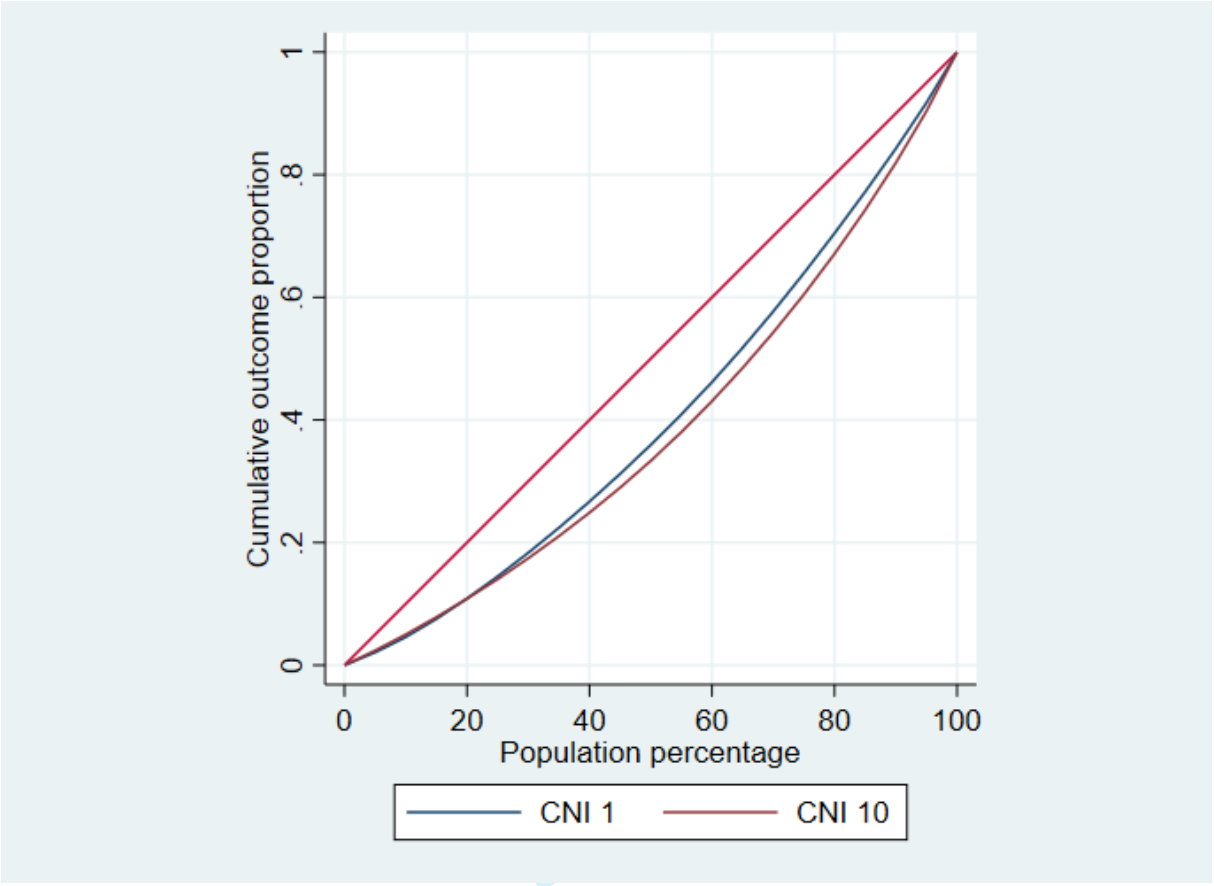
MM1= 2-4 chronic conditions

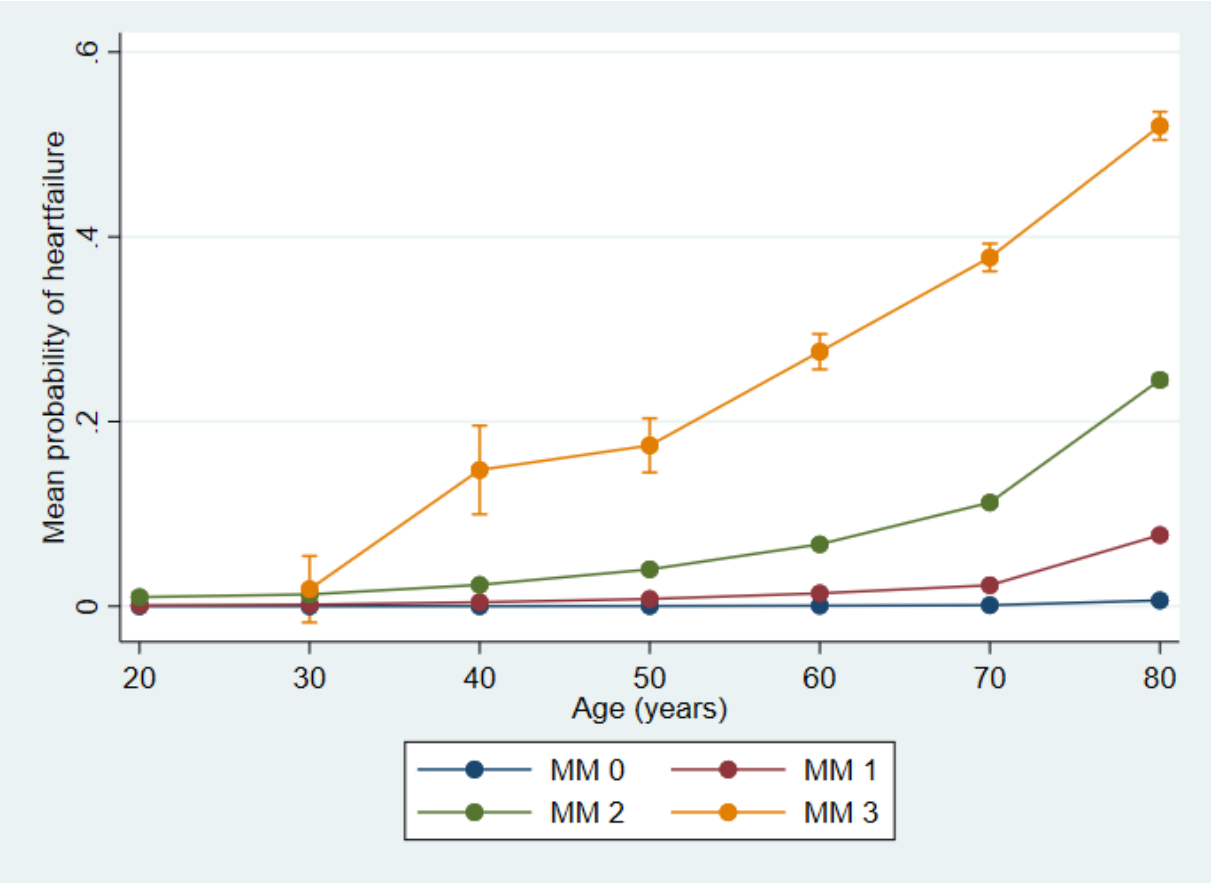
MM2 = 5-9 chronic conditions

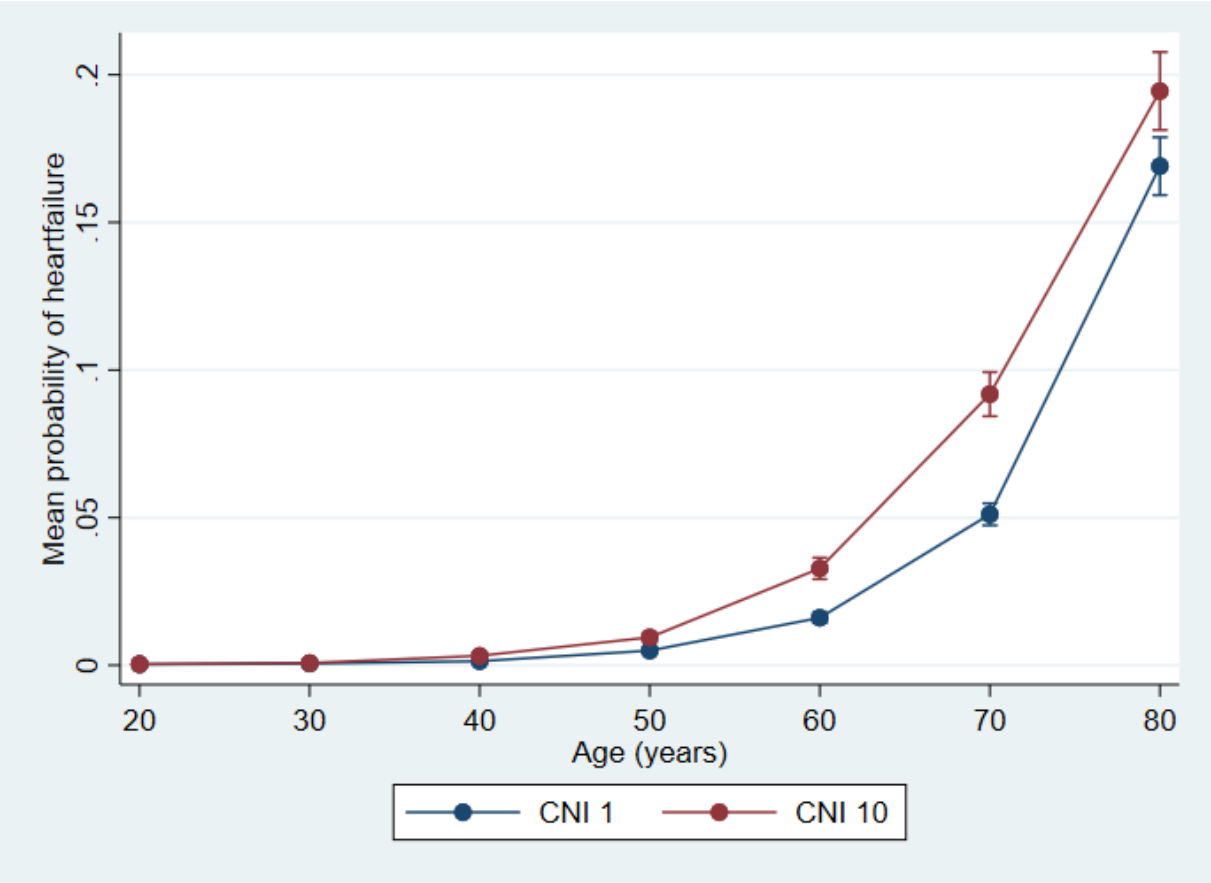
MM3 = 10 or more chronic conditions

Fig 3. Disparities in the predicted mean probability of heart failure adjusted for age between the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95% confidence intervals.

Wordcount for the abstract 300, and the body text of the manuscript 3246.







STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-6
Objectives	3	State specific objectives, including any prespecified hypotheses	
Methods			
Study design	4	Present key elements of study design early in the paper	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-14
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10-17
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14-17
Discussion			
Key results	18	Summarise key results with reference to study objectives	17-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20-21
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	21-22
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Disparities in prevalence of heart failure according to age, multimorbidity level and socioeconomic status in Southern Sweden: a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-051997.R1
Article Type:	Original research
Date Submitted by the Author:	09-Nov-2021
Complete List of Authors:	Scholten, Mia; Center for Primary Health Care Research, Midlöv, Patrik ; Lund University, Clinical Sciences Malmo Halling, Anders; Lund University, Clinical sciences Malmo, CRC
Primary Subject Heading:	Cardiovascular medicine
Secondary Subject Heading:	Epidemiology
Keywords:	Heart failure < CARDIOLOGY, EPIDEMIOLOGY, PRIMARY CARE, PUBLIC HEALTH

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Disparities in prevalence of heart failure according to age, multimorbidity level and socioeconomic status in Southern Sweden: a cross-sectional study

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Abstract

Objective: The aim of this study was to compare the prevalence of heart failure in relation to age, multimorbidity and socioeconomic status of primary health care centres in southern Sweden.

Design: A cross-sectional cohort study.

Setting: The data were collected concerning diagnoses at each consultation in all primary health care centres and secondary health care in the southernmost county of Sweden at the end of 2015.

Participants: The individuals living in southern Sweden in 2015 aged 20 years and older. The study population of 981383 inhabitants was divided into different categories including heart failure, multimorbidity, different levels of multimorbidity and into 10 CNI (Care Need Index) groups depending on the socioeconomic status of their listed primary health care centre.

Outcomes: Prevalence of heart failure was presented according to age, multimorbidity, multimorbidity level and socioeconomic status. Logistic regression was used to further analyse the associations between heart failure, age, multimorbidity level and socioeconomic status in more complex models.

Results: The total prevalence of heart failure in the study population was 2.06%. The prevalence of heart failure increased with advancing age and the level of multimorbidity. 99.07% of the patients with heart failure fulfilled the criteria for multimorbidity. The total prevalence of HF among the multimorbid patients was only 5.30%. Heart failure had a strong correlation with the socioeconomic status of the primary health care centres with the most significant disparity between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was approximately twice as high as in the most affluent CNI percentile.

Conclusion: The patients with heart failure were strongly associated with having multimorbidity. Heart failure patients was a small group of the multimorbid population associated with socioeconomic deprivation that challenges efficient preventive strategies and health policies.

Strengths and limitations of this study

- Our large cohort with almost 1 million inhabitants included 20193 patients with heart failure and 377161 with multimorbidity in southern Sweden during the study period, which increases the validity of our results.
- The outcome data were based on clinical diagnoses registered by physicians, rather than self-reported data, which eliminated any recall bias.
- Many patients have diagnoses that are usually neglected by the patients and staff in the health care, because these do not impair their quality of life or prognosis, which constitutes a consistent error source to our statistics.
- As heart failure has none-specific symptoms at the onset, we suspect that many people were underdiagnosed regarding this condition.
- We had no data on the quality of health care in the neighbourhood.

Introduction

Heart failure (HF) and multimorbidity (MM) are leading causes of morbidity, hospitalizations, disability, and death in Western countries[1 2]. The prevalence of heart failure and multimorbidity increases with age and the cost of care and treatment constitutes a considerable burden on primary health care and on health care as a whole[1]. In high-income countries, HF is the most common diagnosis in hospitalized elderly patients aged >65 years[2]. In Sweden, 31% of medical expenditures were spent for HF patients with reduced ejection fraction (HFrEF) in primary health care, 29% for primary cardiac hospitalizations, and 40% were for noncardiac hospitalizations[3].

Heart failure is classified into three major groups: HF with reduced ejection fraction (HFrEF), HF with midrange EF (HFmrEF), and HF with preserved ejection fraction (HFpEF)[4]. All subtypes of HF have the same clinical phenotype[5], but different pathophysiology and prognosis[6]. The systolic failure or HFrEF (or systolic dysfunction) is established when the left ventricle loses its ability to contract normally, resulting in EF < 40%. The heart cannot pump with enough force to push enough blood into the circulation. HFrEF develops usually in response to larger-scale myocyte loss/dysfunction, with the most common aetiologies including acute myocardial infarction, genetic abnormalities, myocarditis or toxin effects (e.g. alcohol or chemotherapy)[7]. Diagnosis of systolic dysfunction is easier than the diagnosis of diastolic dysfunction due to the objective finding of reduced ejection fraction. HFmrEF shares features with both HFrEF and HFpEF, including the aetiology, symptomatology, age of the patients and comorbidities[8]. Four diagnostic criteria are simultaneously required for HFmrEF: symptoms with or without signs of HF, LVEF of 40-49%. Elevated natriuretic peptides, and relevant structural heart disease: left ventricle hypertrophy or left atrial enlargement or

diastolic dysfunction[9]. HFpEF or diastolic HF (or diastolic dysfunction) is established when the left ventricle loses its ability to relax normally, because the muscle has become stiff. The heart cannot properly fill with blood during the resting period between each beat. The pathophysiologic derangements in HFpEF include concentric remodelling, ventricular-vascular stiffening and loss of ventricular-vascular reserve function are resulted from chronic pressure overload due to arterial hypertension[10]. Diastolic heart failure has preserved ejection fraction with LVEF ≥50%, and is preferably found among elderly, women, and patients with diabetes mellitus and hypertension[11-14].

Beside the risk factors like physical inactivity, obesity, chemotherapy, heritability and hyperlipidaemia, which increases the incidence of heart failure, the incidence also varies with the patient's socioeconomic status (SES)[15-20]. Higher income has previously been associated with a lower risk of developing heart failure[21]. Moreover, the risk factors for heart failure, such as hypertension and coronary heart disease, also vary with SES[22]. Heart failure is often a chronic complication of other cardiovascular comorbidities, particularly ischaemic heart disease, atrial fibrillation and valve dysfunctions[23]. Due to improved medical management, the age-adjusted incidence and prevalence of HF are decreasing, and the HF patients have got prolonged life expectancy[1]. Consequently, the absolute number of patients with HF has drastically increased, secondary to global ageing, as well as general population growth[24]. Although reliable estimates for middle-income and low-income nations are lacking, evidence from the current literature suggests that HF is the fastest growing cardiovascular condition globally[25 26].

The aetiology of HF is diverse and varies geographically worldwide: High-income countries are disproportionally affected by ischemic heart disease and COPD (chronic obstructive pulmonary disease) compared with low-income countries, which in turn are primarily affected

by hypertensive heart disease, rheumatic heart disease, cardiomyopathy, and myocarditis[27]. More than two-thirds of all cases of HF can be attributed to four underlying conditions: ischaemic heart disease, COPD, hypertensive heart disease and rheumatic heart disease[1].

HF is often a chronic condition with insidious symptoms at the onset, which could make early and accurate diagnosis difficult. The diagnosis of heart failure requires three criteria to be fulfilled: typical clinical symptoms, such as dyspnoea, fatigue, exertional intolerance and oedema of the lower body, elevated BNP value and objective findings of impaired cardiac function on echocardiography, myocardial scintigraphy, magnet resonance tomography or other imaging[13].

The aim of this study was to compare the prevalence of heart failure in relation to age, multimorbidity and socioeconomic status of primary health care centres in southern Sweden.

Methods

Setting and study population

Most residents in Sweden are listed at a primary health care centre, either a public or private health care centre. Scania is the southernmost county of Sweden with around 1.3 million inhabitants during year 2015[28]. Approximately ¼ of the study population were born abroad[29]. The biggest city in Scania is Malmö with about 320000 inhabitants during 2015, ranked as the third largest city in Sweden[28]. About 1/3 of the residents in Malmö were born abroad representing most countries in the world[30]. Almost half of the residents in Malmö (48.40%) were under 35 years during 2015[31]. The study population comprised individuals aged 20 years and older living in Scania during the last week of 2015. This age cut-off was chosen because

the types of heart failure affecting children and younger people are pathologically distinct from those found in older adults.

The study population was divided into age groups: 20, 30, 40, 50, 60, 70, 80+. The age group 20 included inhabitants aged 20 to 29 years, the age group 30 included inhabitants aged 30 to 39 years, and so on. The age group 80+ included all inhabitants from 80 years and over.

Data source and measurements

The data that was used in this study was retrieved from the County Council health care register in Scania that contains anonymised registry information from the study population, including age, gender, socioeconomic status and diagnostic data in the last week of 2015.

The data were collected concerning diagnoses at each consultation in all primary health care centres and secondary health care. Diagnoses were recorded according the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD 10). Heart failure was identified if the diagnosis code I50 was recorded, which comprised all subtypes of HF. Totally 152 primary health care centres were operating during 2015 in Scania, with on average 8587 listed patients (95% CI 7971.49 – 9292.88) including 133 patients with HF (95% CL 122.60 – 143.80) at each primary health care centre.

Multimorbidity

Multimorbidity (MM) was defined as coexistence of two or more chronic conditions in the same person, independently if cardiovascular or not. To measure multimorbidity, we used a method to identify chronic conditions developed by A Calderòn-Larrañaga *et al.* at the Aging

Research Centre in Stockholm[32]. They analysed the full list of ICD-10 codes on a four-digit level to define if a diagnosis is chronic or not in an elderly population. To determine if a condition is chronic or not the following key features were identified and discussed concerning their pertinence and suitability in older populations: duration, course, reversibility, treatment, and consequences. They were then grouped into 60 groups of chronic conditions if their duration exceeded 3 months. We applied their definition and list of chronic conditions to estimate the multimorbidity in our study population. All information about diagnoses was obtained from electronic medical record database in the county council in Scania. Multimorbidity was then estimated by counting the number of chronic conditions in each patient. To study the degree of MM in relation to the prevalence of HF, the patients were further divided into groups MM0 (less than two chronic conditions), MM1 (two to four chronic conditions), MM2 (five to nine chronic conditions) and MM3 (ten chronic conditions or more).

Socioeconomics

We used the term Care Need Index (CNI)[33] to divide the primary health care centres into 10 groups depending on their socioeconomic status. CNI is based on different measures of a group, in this case the patients listed to different primary health care centres in Scania. CNI 1 was assigned to those patients listed at primary health care centres who belonged to the most socioeconomically affluent percentile, and CNI 10 was assigned to those patients listed at primary health care centres who belonged to the most socioeconomically deprived percentile[33].

Statistical analyses

We analysed data from 981383 (about a tenth of the Swedish population) inhabitants aged 20 years and older living in Scania during the last week of 2015. Associations between the variables were studied using univariate and multivariate statistics.

We used frequencies, percentages and cross tabulations for descriptive analysis. The different age distribution in all CNI percentiles was analysed with Lorenz plots. Logistic regression was used to analyse the associations between the univariate and multivariate models. Only the linear predications of the fully adjusted models were shown in the figures.

A p-value of < 0.05 was considered statistically significant. The predicted mean probability of heart failure was calculated as average marginal effects using Delta-method.

We used STATA version 16.0 and 17.0 (Stata Corporation, Texas, USA) for statistical analyses.

Patient and Public Involvement

Data in the present study are based on anonymised information provided by the County Council of Scania. They provided anonymised information for research purposes once the study had been approved by the Ethics Committee at Lund University.

The study participants were not involved in the recruitment to the study by themselves. Due to the requirement of anonymised data, each individual could not be asked for consent to participate; active refusal of participation was instead applied. This was done by publishing information about the planned study in the Swedish local newspaper “Sydsvenskan”. The advertisement outlined the study and contained information on how to contact the research manager (first author) to opt out of the study. The study results are published anonymised in group level, and cannot be disseminated to every study participant.

Results

The total prevalence of heart failure in the study population was found to be 2.06% (20193 patients) in 2015. Heart failure was a rare disease under 40 years of age in the whole study population, but the prevalence increased at least twofold in all age groups and CNI percentiles from 30 years of age onwards and reached 17.31% in the age group 80+ (Table 1). The individuals listed at primary health care centres with deprived CNI percentiles were more likely to have higher proportion of individuals younger than 40 years and the opposite were true for primary health care centres with affluent CNI percentiles. The primary health care centres with the most deprived CNI percentile had the lowest proportion of population from middle age, only 33.25% were 50 years and older, whereas the affluent CNI percentiles were likely to be dominated by individuals from 50 years and over (Table 1). The inequality of age distribution between the most affluent and deprived CNI percentiles of primary health care centres is illustrated by Lorenz plots (Fig. 1).

Table 1. Prevalence of heart failure and multimorbidity in all age groups and CNI percentiles.

			Heartfailure (HF)							
			No		Yes					
			MM		**MM**					
CNI percentiles	Age	N	No	Yes	No	Yes	**MM (%)**	**HF (%)**	**HF with MM (%)**	**MM with HF (%)**
CNI 1	20	12 866	10842	2020	1	3	15.72	0.03	75.00	0.15
	30	17 890	14347	3533	2	8	19.79	0.06	80.00	0.23
	40	24 753	18672	6047	3	31	24.55	0.14	91.18	0.51
	50	17 806	11062	6656	5	83	37.85	0.49	94.32	1.23
	60	19 358	7857	11190	5	306	59.39	1.61	98.39	2.66
	70	13 345	2894	9769	5	677	78.28	5.11	99.27	6.48
	80	5 614	610	4055	1	948	89.12	16.90	99.89	18.95
CNI 2	20	16 173	13755	2411	1	6	14.94	0.04	85.71	0.25
	30	16 095	12861	3230	0	4	20.09	0.02	100.00	0.12
	40	20 750	15497	5220	0	33	25.32	0.16	100.00	0.63
	50	18 892	11602	7196	2	92	38.58	0.50	97.87	1.26
	60	19 729	8378	10990	6	355	57.50	1.83	98.34	3.13

	70	12 752	3090	9024	5	633	75.73	5.00	99.22	6.55
	80	6 278	833	4468	2	975	86.70	15.56	99.80	17.91
CNI 3	20	16 970	14424	2540	1	5	15.00	0.04	83.33	0.20
	30	15 252	12212	3030	0	10	19.93	0.07	100.00	0.33
	40	16 596	12045	4520	1	30	27.42	0.19	96.77	0.66
	50	14 638	8843	5693	2	100	39.58	0.70	98.04	1.73
	60	15 383	6310	8760	4	309	58.95	2.03	98.72	3.41
	70	10 056	2269	7163	4	620	77.40	6.21	99.36	7.97
	80	5 553	649	3903	8	993	88.17	18.03	99.20	20.28
CNI 4	20	14 112	11835	2271	3	3	16.11	0.04	50.00	0.13
	30	13 429	10665	2753	1	10	20.57	0.08	90.91	0.36
	40	15 769	11417	4309	1	42	27.59	0.27	97.67	0.97
	50	14 658	8622	5915	3	118	41.16	0.83	97.52	1.96
	60	14 826	6017	8459	7	343	59.37	2.36	98.00	3.90
	70	9 409	2221	6558	0	630	76.39	6.70	100.00	8.76
	80	5 122	646	3493	6	977	87.27	19.19	99.39	21.86
CNI 5	20	12 796	10794	2000	1	1	15.64	0.02	50.00	0.05
	30	13 168	10455	2706	0	7	20.60	0.05	100.00	0.26
	40	13 879	10028	3816	2	33	27.73	0.25	94.29	0.86
	50	12 142	7171	4897	2	72	40.92	0.61	97.30	1.45
	60	11 723	4870	6597	3	253	58.43	2.18	98.83	3.69
	70	7 333	1704	5162	0	467	76.76	6.37	100.00	8.30
	80	4 178	489	2884	3	802	88.22	19.27	99.63	21.76
CNI 6	20	18 134	15365	2766	0	3	15.27	0.02	100.00	0.11
	30	15 745	12638	3099	2	6	19.72	0.05	75.00	0.19
	40	18 285	13316	4928	2	39	27.16	0.22	95.12	0.79
	50	16 530	9833	6588	2	107	40.50	0.66	98.17	1.60
	60	16 438	6943	9163	5	327	57.73	2.02	98.49	3.45
	70	11 457	2667	8171	4	615	76.69	5.40	99.35	7.00
	80	6 894	940	4845	6	1103	86.28	16.09	99.46	18.54
CNI 7	20	18 045	15624	2411	1	9	13.41	0.06	90.00	0.37
	30	14 656	11977	2669	1	9	18.27	0.07	90.00	0.34
	40	14 400	10590	3777	2	31	26.44	0.23	93.94	0.81
	50	12 597	7597	4907	4	89	39.66	0.74	95.70	1.78
	60	13 119	5696	7147	5	271	56.54	2.10	98.19	3.65
	70	8 930	2194	6193	1	542	75.42	6.08	99.82	8.05
	80	5 569	788	3788	5	988	85.76	17.83	99.50	20.69
CNI 8	20	22 405	18803	3597	1	4	16.07	0.02	80.00	0.11
	30	21 019	16659	4341	0	19	20.74	0.09	100.00	0.44
	40	19 268	13828	5395	2	43	28.22	0.23	95.56	0.79
	50	17 755	10435	7175	7	138	41.19	0.82	95.17	1.89
	60	17 014	7233	9435	3	343	57.47	2.03	99.13	3.51
	70	10 651	2616	7388	4	643	75.40	6.07	99.38	8.01
	80	6 039	838	4189	7	1005	86.01	16.76	99.31	19.35
CNI 9	20	23 116	19785	3328	1	2	14.41	0.01	66.67	0.06
	30	21 531	17553	3967	2	9	18.47	0.05	81.82	0.23
	40	16 388	12072	4277	1	38	26.33	0.24	97.44	0.88
	50	14 812	8881	5828	2	101	40.03	0.70	98.06	1.70

	60	12 646	5696	6616	2	332	54.94	2.64	99.40	4.78
	70	8 915	2342	6013	4	556	73.68	6.28	99.29	8.46
	80	6 064	1042	4043	8	971	82.68	16.14	99.18	19.37
CNI 10	20	26 259	22707	3542	2	8	13.52	0.04	80.00	0.23
	30	21 295	17348	3931	1	15	18.53	0.08	93.75	0.38
	40	15 007	10531	4428	4	44	29.80	0.32	91.67	0.98
	50	12 602	7145	5338	0	119	43.30	0.94	100.00	2.18
	60	9 304	4061	4938	3	302	56.32	3.28	99.02	5.76
	70	5 751	1643	3580	2	526	71.40	9.18	99.62	12.81
	80	3 450	662	2117	2	669	80.75	19.45	99.70	24.01
All CNI percentiles	20	180 876	153934	26886	12	44	14.89	0.03	78.57	0.16
	30	170 080	136715	33259	9	97	19.61	0.06	91.51	0.29
	40	175 095	127996	46717	18	364	26.89	0.22	95.29	0.77
	50	152 432	91191	60193	29	1019	40.16	0.69	97.23	1.66
	60	149 540	63061	83295	43	3141	57.80	2.13	98.65	3.63
	70	98 599	23640	69021	29	5909	75.99	6.02	99.51	7.89
	80	54 761	7497	37785	48	9431	86.22	17.31	99.49	19.97
	Total	**981383**	**604034**	**357156**	**188**	**20005**	**38.43**	**2.06**	**99.07**	**5.30**

CNI = Care Need Index, CNI 1= the most affluent percentile, CNI 10 = the most deprived percentile, HF = heart failure, MM= multimorbidity, N = total number of individuals

MM (%) = total prevalence of multimorbidity

HF (%) = total prevalence of heart failure

HF with MM (%) = prevalence of heart failure with multimorbidity

MM with HF (%) = prevalence of multimorbidity with heart failure

Multimorbidity was present in 38.40% (377161 patients) of the study population and followed different patterns according to age groups and CNI percentiles of the primary health care centres (Table 1). HF was strongly correlated to MM: 99.07% of the patients with HF fulfilled the criteria for multimorbidity, independently of the age at their diagnosis. The prevalence of MM increased steadily with advancing age, from 14.89% in the age group 20 to 86.22% in the age group 80+ (Table 1). The prevalence of HF increased consistently with the MM level: the MM1(2-4 chronic conditions) group had 1.49% patients with HF, the MM2 (5-9 chronic conditions) group had 11.16% patients with HF, and the MM3 (>10 chronic conditions) group had 39.28% patients with HF. The total prevalence of HF among the multimorbid patients

was only 5.30% (20005 patients) (Table 1). The predicted mean probability of HF adjusted for age and MM level is shown in Figure 2.

If we consider the prevalence of heart failure in different levels of multimorbidity: 19.19% (3875 patients) of all patients with HF belonged to the MM1 group, 58.18% (11748 patients) belonged to the MM2 group and 21.70% (4382 patients) belonged to the MM3 group. The MM2 group as a whole was more than nine times larger than the MM3 group (105241 vs 11156 patients).

The prevalence of heart failure had a strong correlation with the SES of the primary health care centres (Fig. 3). The most significant disparity was between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was significantly increased and approximately twice as high as in the most affluent CNI percentile (Table 1). Although at much lower levels, significant disparities in prevalence of HF could be seen when comparing the most deprived CNI percentile with other CNI percentiles of the primary health care centres. The primary health care centres with the most deprived CNI percentile had the highest prevalence of HF from 40 years of age, although their prevalence of MM was lowest from 70 years of age. In contrast, the prevalence of HF in the most affluent CNI percentile remained relatively low in most age groups, even from 60 years of age as their prevalence of MM became highest (Table 1). Only 4.58% of the multimorbid individuals belonging to this CNI percentile had HF, which was lowest compared to the more deprived CNI percentiles. The association between the prevalence of HF and CNI percentiles followed different patterns compared to MM as shown in Table 1.

Discussion

The total prevalence of heart failure was about 2% in Scania during 2015, which was the same as the prevalence in Sweden and other Western countries[34 35]. A large part of the patients has HF diagnosis from primary- and secondary care, in both cases diagnosed following the diagnosis criteria for HF according to ESC (European Society of Cardiology) guidelines. Heart failure was a rare disease under 40 years of age and increased substantially with advancing age. 99.07% of the patients with HF in our study population had multimorbidity, which could be explained by the diagnosis HF mostly constitutes a complication of other cardiovascular conditions[23 36]. Multimorbidity was present in 38.40% of the study population, but included only 5.30% patients with HF. The high prevalence of MM could be explained by the socioeconomic difference within the study population and the considerable part of elderly with high prevalence of MM. With increasing level of multimorbidity, the prevalence of HF increased from 1.49% in the MM1(2-4 chronic conditions) group to 39.28% in the MM3 (more than 10 chronic conditions) group. The MM3 group had fewer patients, but a higher prevalence of HF than the MM2 group, which makes us to believe that the MM3 group had a higher mortality in general.

The patients are mostly listed at a primary health care centre close to their place of living. Most primary health care centres are public and organised similarly irrespective of CNI. The socioeconomic boundaries are quite sharp and agree with uptake areas of the different primary health care centres. The CNI category was an average socioeconomic level of the patients listed at the primary health care centres.

The prevalence of HF also had a strong association with the SES of primary health care centres with the most significant disparity between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was approximately twice as high as in the most affluent CNI percentile. The fact that the prevalence of HF was highest from 40 years of age in the most deprived CNI percentile of primary health care

centres indicates that HF is a disease associated with socioeconomic deprivation. The correlation was assessed visually as the difference in prevalence of HF was obvious between the most affluent and deprived CNI percentiles.

The individuals listed at primary health care centres with deprived CNI percentiles were more likely to have high proportion of inhabitants younger than 40 years, and the opposite were true for primary health care centres with affluent CNI percentiles. The primary health care centres with the most deprived CNI percentile had the lowest proportion of population (33.25%) from 50 years and the highest prevalence of HF from 40 years of age compared to the more affluent population, which makes us to suspect that they suffered from SES related multimorbidity with worse prognosis, including HF.

Heart failure is a common comorbidity in patients with COPD (chronic obstructive pulmonary disease)[37], with prevalence in 33.2% of women and 35.7% of men over 80 years of age[38]. In most countries, low SES is associated with higher prevalence of COPD and mortality[39]. The estimated mortality in patients with COPD and coexisting heart failure was seven times higher than in patients with COPD alone, thus HF was reported as the most common comorbidity noted in deceased patients hospitalized with COPD exacerbation[40]. Other comorbidities with high impact on mortality in patients with HF including stroke, renal disease and diabetes mellitus[41], are strongly associated with low SES as well[42-44].

With respect to the global burden of ischaemic heart disease, the incidence of acute myocardial infarction worldwide is highest in Eastern Europe and Central Asia[45]. Compared to the Swedish population, the first-generation immigrants from Iraq and Bosnia had the highest incidence of HF, probably due to a higher incidence of coronary heart disease[4]. When this incidence of HF was further adjusted for SES, marital status and educational level, the hazard ratio for HF raised significantly compared to the immigrants from other countries. As

many of these immigrants are socioeconomically highly disadvantaged in Sweden, these results support our findings. Interestingly, the HF risk pattern among the second-generation immigrants in most cases differed only marginally compared to their Swedish counterparts, indicating that their risk factor is not purely genetic, rather responsive to other factors[4].

A similar study in Scotland revealed that older people typically have more morbidities with lower functional status, whereas younger people are more often affected by combinations physical and mental health disorders. Except that the most affluent population being on average 2-5 years older at onset of morbidity (dependent on the disorder), comorbidities like coronary heart disease, diabetes mellitus, COPD, depression, painful disorders or cancer were more common in people living in deprived areas[46]. This could explain that people in the affluent areas suffered from multimorbidity with less disability and had better prognosis.

We do not know if multimorbidity causes socioeconomic deprivation or if low socioeconomic status causes multimorbidity. There is presumably an impact in both directions. Many people with multimorbidity do retire earlier, and have more socioeconomic consequences than the working population. Statistically, this group degrades in the socioeconomic status, which even may influence their family members. On the other hand, many people in the deprived areas have to accept a job which is more health challenging, and become multimorbid many years earlier than the affluent population.

Strengths and limitations

Our study has a number of strengths. Our large cohort with almost 1 million inhabitants included all patients with HF and MM in Scania during the study period, which increases the validity of our results. The outcome data were based on clinical diagnoses registered by physicians, rather than self-reported data, which eliminated any recall bias. Our findings have

similarities with correlative studies in other countries[21 23], which increases the credibility of our results.

This study has certain limitations. We had no data on several risk factors for heart failure, such as smoking, obesity or physical inactivity. However, some prior works on SES and heart failure had adjusted for smoking and physical inactivity and still found an independent association[21]. We had no results of echocardiography, and thus could not analyse the subtypes of heart failure in our study population. As heart failure has none-specific symptoms at the onset, we suspect that many people were underdiagnosed regarding this condition. Those patients with HF belonging to the MM0 group were probably underdiagnosed as well, because HF usually constitutes a complication of other comorbidities or treatment. Many patients have diagnoses that are usually neglected by the patients and staff in the health care, because these do not impair their quality of life or prognosis, which constitutes a consistent error source to our statistics. We had no data on the severity of HF and comorbidities, which have high impact on the mortality. We had no data on the quality of health care in the neighbourhood. Our results could be more accurate if the age group 80+ were divided into age group 80 and 90+, and analysed separately.

Conclusion

The prevalence of heart failure was strongly associated with multimorbidity, with increasing prevalence of HF with multimorbidity level. The patients listed at primary health care centres with the most socioeconomic deprived CNI percentile had a significantly elevated risk of developing HF and probably multimorbidity with worse prognosis, which resulted in the lowest proportion of population from 50 years compared to the more affluent population in

our study. HF patients was a small group of the multimorbid population associated with socioeconomic deprivation that challenges efficient preventive strategies and health policies.

Acknowledgements

We thank the County Council of Scania for providing the patient data enabling this study. We are indebted to Patrick Reilly for his expertise and invaluable advice in proofreading the manuscript.

Footnotes

Contributorship statement

In accordance with the Vancouver Protocol, AH was involved in data collection, design of the study, data analysis, editing the manuscript and student supervision. MS contributed with data collection, data analysis, writing and editing the manuscript. PM provided critical comment and feedback on the manuscript.

Competing interests

None declared.

Statement of funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data sharing statement

No further data available.

Data sharing statement in ScholarOne: Scania County council provided anonymized the data of the study population.

Availability of data and material

No further data available.

Statement of Ethics

The regional Ethical Review Board at Lund University (application no. 2018/778) approved the study.

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Figure legends

Fig. 1. The age distribution of individuals in Scania belonging to the most affluent CNI (CNI 1) and deprived (CNI 10) CNI (Care need index) percentiles using Lorenz plots.

Fig. 2 The predicted mean probability of heart failure adjusted for different age groups and multimorbidity levels with 95% confidence intervals using Delta methods.

MM0= less than 2 chronic conditions (not multimorbid)

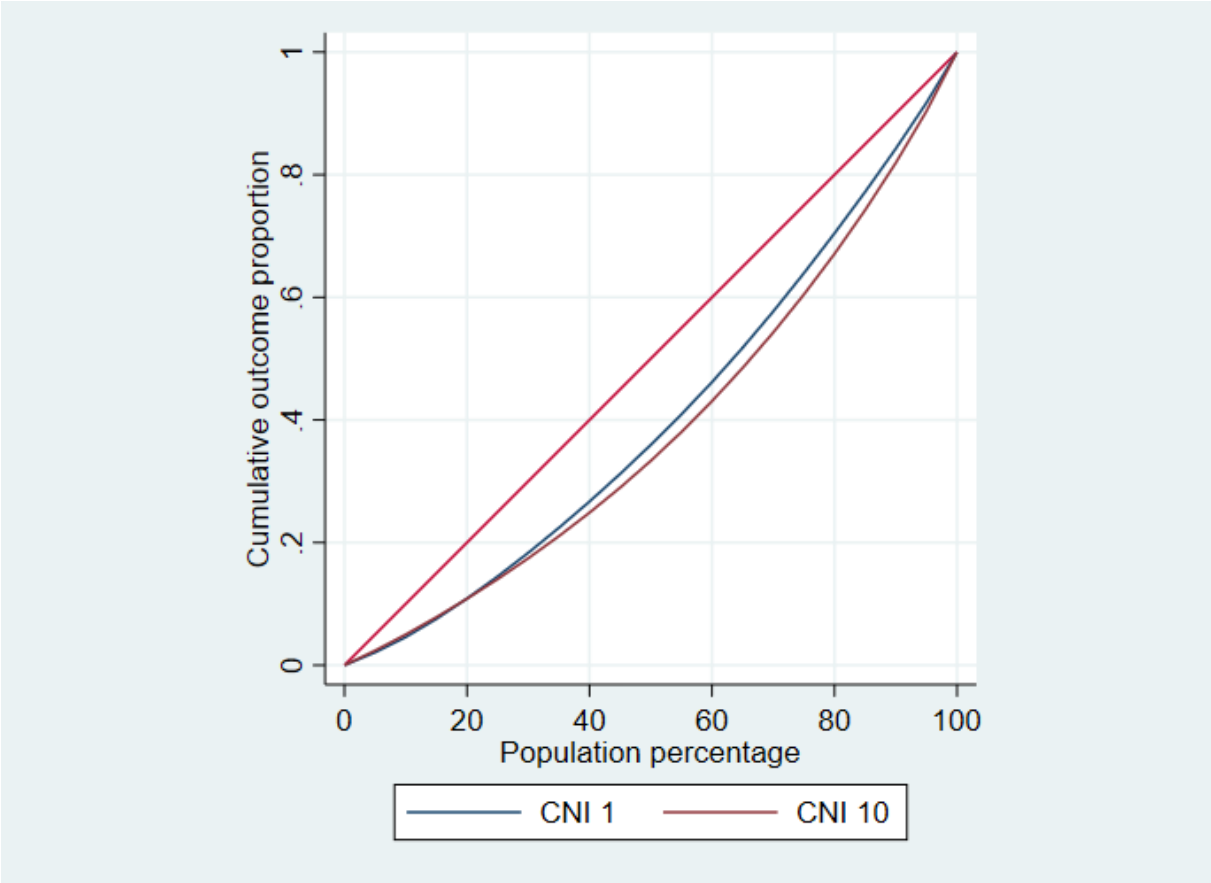
MM1= 2-4 chronic conditions

MM2 = 5-9 chronic conditions

MM3 = 10 or more chronic conditions

Fig 3. Disparities in the predicted mean probability of heart failure adjusted for age between the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95% confidence intervals using Delta methods.

Wordcount for the abstract 298, and the body text of the manuscript 3454.



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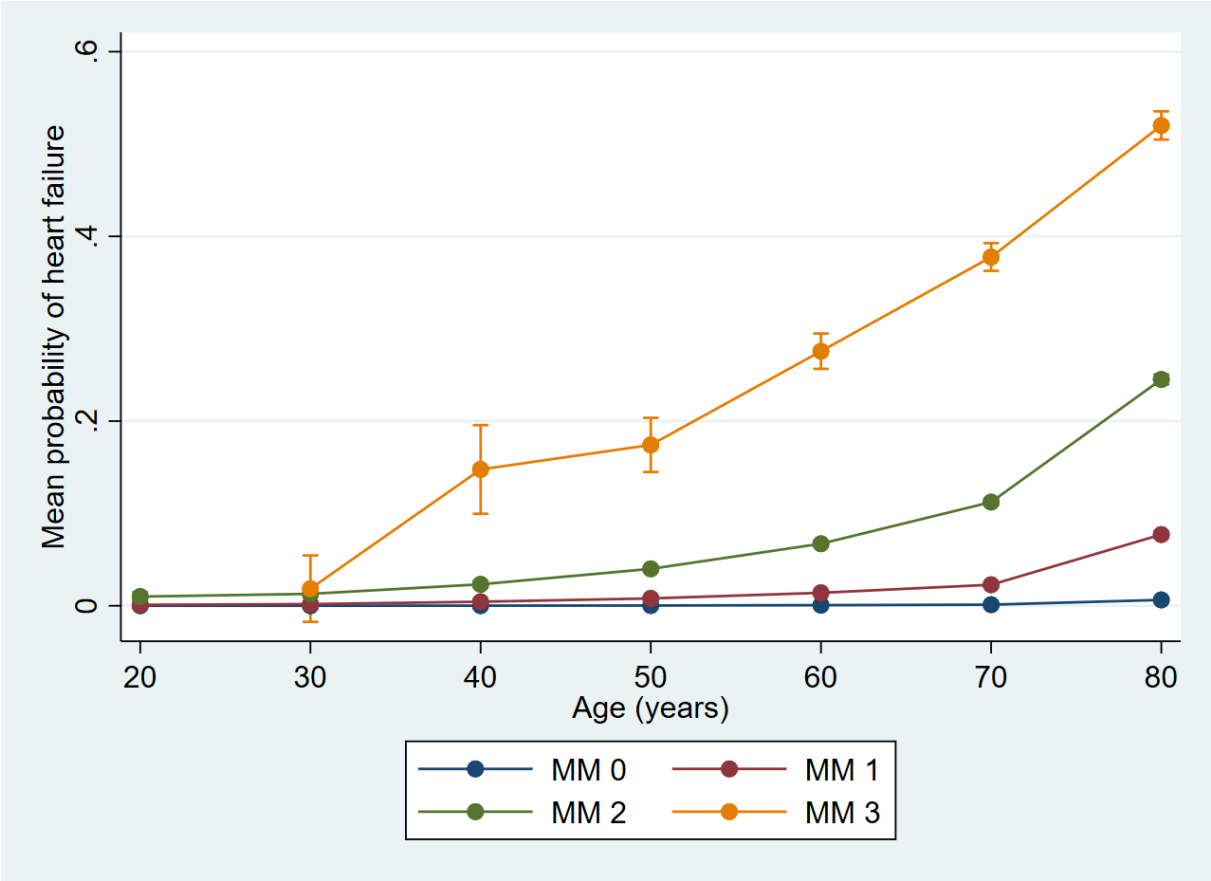

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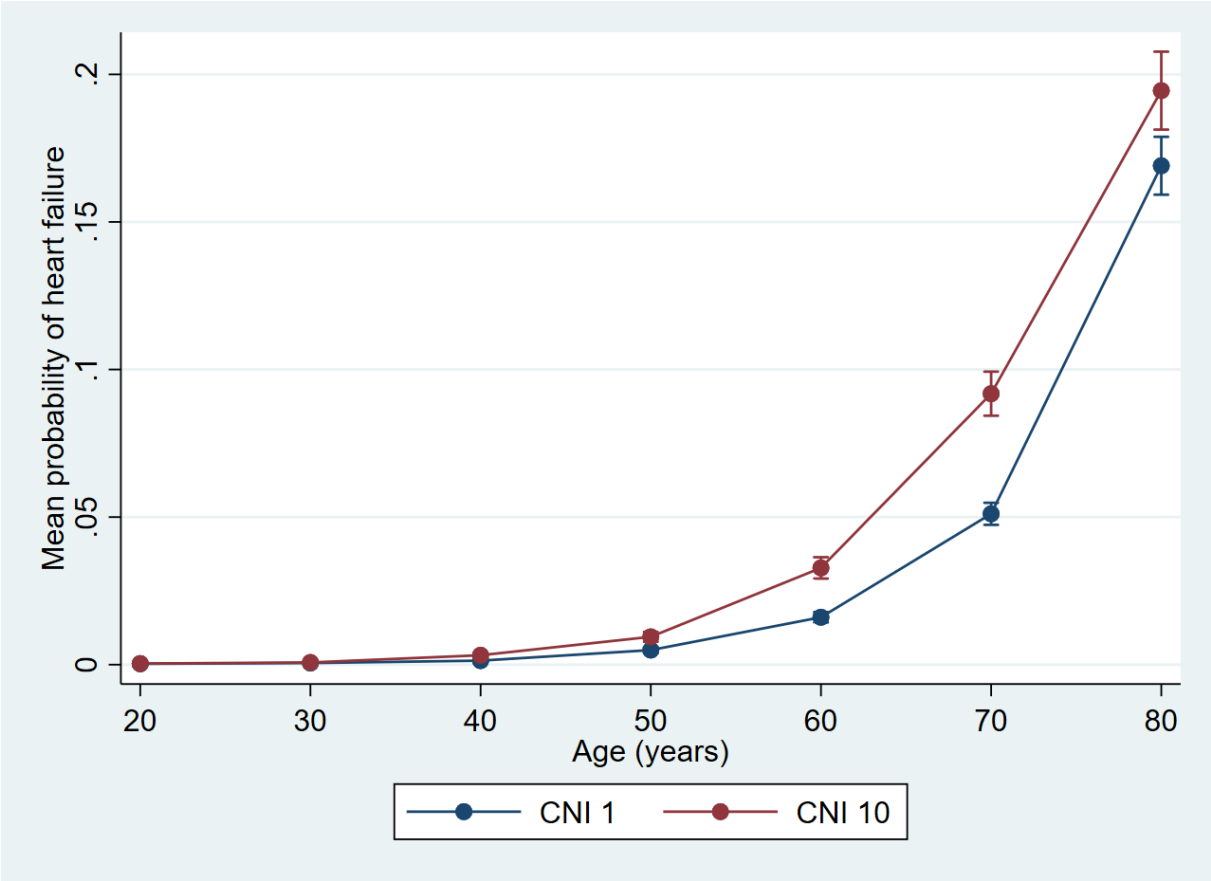

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-10
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-13
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-15
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16,18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Disparities in prevalence of heart failure according to age, multimorbidity level and socioeconomic status in Southern Sweden: a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-051997.R2
Article Type:	Original research
Date Submitted by the Author:	28-Dec-2021
Complete List of Authors:	Scholten, Mia; Center for Primary Health Care Research, Midlöv, Patrik ; Lund University, Clinical Sciences Malmo Halling, Anders; Lund University, Clinical sciences Malmo, CRC
Primary Subject Heading:	Cardiovascular medicine
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	Heart failure < CARDIOLOGY, EPIDEMIOLOGY, PRIMARY CARE, PUBLIC HEALTH, Adult cardiology < CARDIOLOGY

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Disparities in prevalence of heart failure according to age, multimorbidity level and socioeconomic status in Southern Sweden: a cross-sectional study

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Abstract

Objective: The aim of this study was to compare the prevalence of heart failure in relation to age, multimorbidity and socioeconomic status of primary health care centres in southern Sweden.

Design: A cross-sectional study.

Setting: The data were collected concerning diagnoses at each consultation in all primary health care centres and secondary health care in the southernmost county of Sweden at the end of 2015.

Participants: The individuals living in southern Sweden in 2015 aged 20 years and older. The study population of 981383 inhabitants was divided into different categories including heart failure, multimorbidity, different levels of multimorbidity and into 10 CNI (Care Need Index) groups depending on the socioeconomic status of their listed primary health care centre.

Outcomes: Prevalence of heart failure was presented according to age, multimorbidity, multimorbidity level and socioeconomic status. Logistic regression was used to further analyse the associations between heart failure, age, multimorbidity level and socioeconomic status in more complex models.

Results: The total prevalence of heart failure in the study population was 2.06%. The prevalence of heart failure increased with advancing age and the level of multimorbidity. 99.07% of the patients with heart failure fulfilled the criteria for multimorbidity. The total prevalence of HF among the multimorbid patients was only 5.30%. Heart failure had a strong correlation with the socioeconomic status of the primary health care centres with the most significant disparity between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was approximately twice as high as in the most affluent CNI percentile.

Conclusion: The patients with heart failure were strongly associated with having multimorbidity. Heart failure patients was a small group of the multimorbid population associated with socioeconomic deprivation that challenges efficient preventive strategies and health policies.

Strengths and limitations of this study

- Our large cohort with almost 1 million inhabitants included 20193 patients with heart failure and 377161 with multimorbidity in southern Sweden, which increases the validity of our results.
- The outcome data were based on clinical diagnoses registered by physicians, rather than self-reported data, which eliminated any recall bias.
- Many patients have diagnoses that are usually neglected by the patients and staff in the health care, because these do not impair their quality of life or prognosis, which constitutes a consistent error source to our statistics.
- As heart failure has none-specific symptoms at the onset, we suspect that many people were underdiagnosed regarding this condition.
- We had no data on the quality of health care in the neighbourhood.

Introduction

Heart failure (HF) and multimorbidity (MM) are leading causes of morbidity, hospitalizations, disability, and death in Western countries[1 2]. The prevalence of heart failure and multimorbidity increases with age and the cost of care and treatment constitutes a considerable burden on primary health care and on health care as a whole[1]. In high-income countries, HF is the most common diagnosis in hospitalized elderly patients aged >65 years[2]. In Sweden, 31% of medical expenditures were spent for HF patients with reduced ejection fraction (HFrEF) in primary health care, 29% for primary cardiac hospitalizations, and 40% were for noncardiac hospitalizations[3].

Heart failure is classified into three major groups: HF with reduced ejection fraction (HFrEF), HF with midrange EF (HFmrEF), and HF with preserved ejection fraction (HFpEF)[4]. All subtypes of HF have the same clinical phenotype[5], but different pathophysiology and prognosis[6]. The systolic failure or HFrEF (or systolic dysfunction) is established when the left ventricle loses its ability to contract normally, resulting in EF < 40%. The heart cannot pump with enough force to push enough blood into the circulation. HFrEF develops usually in response to larger-scale myocyte loss/dysfunction, with the most common aetiologies including acute myocardial infarction, genetic abnormalities, myocarditis or toxin effects (e.g. alcohol or chemotherapy)[7]. Diagnosis of systolic dysfunction is easier than the diagnosis of diastolic dysfunction due to the objective finding of reduced ejection fraction. HFmrEF shares features with both HFrEF and HFpEF, including the aetiology, symptomatology, age of the patients and comorbidities[8]. Four diagnostic criteria are simultaneously required for HFmrEF: symptoms with or without signs of HF, LVEF of 40-49%. Elevated natriuretic peptides, and relevant structural heart disease: left ventricle hypertrophy or left atrial enlargement or

diastolic dysfunction[9]. HFpEF or diastolic HF (or diastolic dysfunction) is established when the left ventricle loses its ability to relax normally, because the muscle has become stiff. The heart cannot properly fill with blood during the resting period between each beat. The pathophysiologic derangements in HFpEF include concentric remodelling, ventricular-vascular stiffening and loss of ventricular-vascular reserve function are resulted from chronic pressure overload due to arterial hypertension[10]. Diastolic heart failure has preserved ejection fraction with LVEF ≥50%, and is preferably found among elderly, women, and patients with diabetes mellitus and hypertension[11-14].

Beside the risk factors like physical inactivity, obesity, chemotherapy, heritability and hyperlipidaemia, which increases the incidence of heart failure, the incidence also varies with the patient's socioeconomic status (SES)[15-20]. Higher income has previously been associated with a lower risk of developing heart failure[21]. Moreover, the risk factors for heart failure, such as hypertension and coronary heart disease, also vary with SES[22]. Heart failure is often a chronic complication of other cardiovascular comorbidities, particularly ischaemic heart disease, atrial fibrillation and valve dysfunctions[23]. Due to improved medical management, the age-adjusted incidence and prevalence of HF are decreasing, and the HF patients have got prolonged life expectancy[1]. Consequently, the absolute number of patients with HF has drastically increased, secondary to global ageing, as well as general population growth[24]. Although reliable estimates for middle-income and low-income nations are lacking, evidence from the current literature suggests that HF is the fastest growing cardiovascular condition globally[25 26].

The aetiology of HF is diverse and varies geographically worldwide: High-income countries are disproportionally affected by ischemic heart disease and COPD (chronic obstructive pulmonary disease) compared with low-income countries, which in turn are primarily affected

by hypertensive heart disease, rheumatic heart disease, cardiomyopathy, and myocarditis[27]. More than two-thirds of all cases of HF can be attributed to four underlying conditions: ischaemic heart disease, COPD, hypertensive heart disease and rheumatic heart disease[1].

HF is often a chronic condition with insidious symptoms at the onset, which could make early and accurate diagnosis difficult. The diagnosis of heart failure requires three criteria to be fulfilled: typical clinical symptoms, such as dyspnoea, fatigue, exertional intolerance and oedema of the lower body, elevated BNP value and objective findings of impaired cardiac function on echocardiography, myocardial scintigraphy, magnet resonance tomography or other imaging[13].

The aim of this study was to compare the prevalence of heart failure in relation to age, multimorbidity and socioeconomic status of primary health care centres in southern Sweden.

Methods

Setting and study population

Most residents in Sweden are listed at a primary health care centre, either a public or private health care centre. Scania is the southernmost county of Sweden with around 1.3 million inhabitants during year 2015[28]. Approximately ¼ of the study population were born abroad[29]. The biggest city in Scania is Malmö with about 320000 inhabitants during 2015, ranked as the third largest city in Sweden[28]. About 1/3 of the residents in Malmö were born abroad representing most countries in the world[30]. Almost half of the residents in Malmö (48.40%) were under 35 years during 2015[31]. The study population comprised individuals aged 20 years and older living in Scania during the last week of 2015. This age cut-off was chosen because

the types of heart failure affecting children and younger people are pathologically distinct from those found in older adults.

The study population was divided into age groups: 20, 30, 40, 50, 60, 70, 80+. The age group 20 included inhabitants aged 20 to 29 years, the age group 30 included inhabitants aged 30 to 39 years, and so on. The age group 80+ included all inhabitants from 80 years and over.

Data source and measurements

The data that was used in this study was retrieved from the County Council health care register in Scania that contains anonymised registry information from the study population, including age, gender, socioeconomic status and diagnostic data in the last week of 2015.

The data were collected concerning diagnoses at each consultation in all primary health care centres and secondary health care. Diagnoses were recorded according the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD 10). Heart failure was identified if the diagnosis code I50 was recorded, which comprised all subtypes of HF. Totally 152 primary health care centres were operating during 2015 in Scania, with on average 8587 listed patients (95% CI 7971.49 – 9292.88) including 133 patients with HF (95% CL 122.60 – 143.80) at each primary health care centre.

Multimorbidity

Multimorbidity (MM) was defined as coexistence of two or more chronic conditions in the same person, independently if cardiovascular or not. To measure multimorbidity, we used a method to identify chronic conditions developed by A Calderòn-Larrañaga *et al.* at the Aging

Research Centre in Stockholm[32]. They analysed the full list of ICD-10 codes on a four-digit level to define if a diagnosis is chronic or not in an elderly population. To determine if a condition is chronic or not the following key features were identified and discussed concerning their pertinence and suitability in older populations: duration, course, reversibility, treatment, and consequences. They were then grouped into 60 groups of chronic conditions if their duration exceeded 3 months. We applied their definition and list of chronic conditions to estimate the multimorbidity in our study population. All information about diagnoses was obtained from electronic medical record database in the county council in Scania. Multimorbidity was then estimated by counting the number of chronic conditions in each patient. To study the degree of MM in relation to the prevalence of HF, the patients were further divided into groups MM0 (less than two chronic conditions), MM1 (two to four chronic conditions), MM2 (five to nine chronic conditions) and MM3 (ten chronic conditions or more).

Socioeconomics

We used the term Care Need Index (CNI)[33] to divide the primary health care centres into 10 groups depending on their socioeconomic status. CNI is based on different measures of a group, in this case the patients listed to different primary health care centres in Scania. CNI 1 was assigned to those patients listed at primary health care centres who belonged to the most socioeconomically affluent percentile, and CNI 10 was assigned to those patients listed at primary health care centres who belonged to the most socioeconomically deprived percentile[33].

Statistical analyses

We analysed data from 981383 (about a tenth of the Swedish population) inhabitants aged 20 years and older living in Scania during the last week of 2015. Associations between the variables were studied using univariate and multivariate statistics.

We used frequencies, percentages and cross tabulations for descriptive analysis. Logistic regression was used to analyse the associations between the univariate and multivariate models. Only the linear predications of the fully adjusted models were shown in the figures.

A p-value of < 0.05 was considered statistically significant. The predicted mean probability of heart failure was calculated as average marginal effects using Delta-method.

We used STATA version 16.0 and 17.0 (Stata Corporation, Texas, USA) for statistical analyses.

Patient and Public Involvement

Data in the present study are based on anonymised information provided by the County Council of Scania. They provided anonymised information for research purposes once the study had been approved by the Ethics Committee at Lund University.

The study participants were not involved in the recruitment to the study by themselves. Due to the requirement of anonymised data, each individual could not be asked for consent to participate; active refusal of participation was instead applied. This was done by publishing information about the planned study in the Swedish local newspaper “Sydsvenskan”. The advertisement outlined the study and contained information on how to contact the research manager (first author) to opt out of the study. The study results are published anonymised in group level, and cannot be disseminated to every study participant.

Results

The total prevalence of heart failure in the study population was found to be 2.06% (20193 patients) in 2015. Heart failure was a rare disease under 40 years of age in the whole study population, but the prevalence increased at least twofold in all age groups and CNI percentiles from 30 years of age onwards and reached 17.31% in the age group 80+ (Table 1). The individuals listed at primary health care centres with deprived CNI percentiles were more likely to have higher proportion of individuals younger than 40 years and the opposite were true for primary health care centres with affluent CNI percentiles. The primary health care centres with the most deprived CNI percentile had the lowest proportion of population from middle age, only 33.25% were 50 years and older, whereas the affluent CNI percentiles were likely to be dominated by individuals from 50 years and over (Table 1).

Table 1. Prevalence of heart failure and multimorbidity in all age groups and CNI percentiles.

			Heartfailure (HF)							
			No		Yes					
			MM		MM					
CNI percentiles	Age	N	No	Yes	No	Yes	MM (%)	HF (%)	HF with MM (%)	MM with HF (%)
CNI 1	20	12 866	10842	2020	1	3	15.72	0.03	75.00	0.15
	30	17 890	14347	3533	2	8	19.79	0.06	80.00	0.23
	40	24 753	18672	6047	3	31	24.55	0.14	91.18	0.51
	50	17 806	11062	6656	5	83	37.85	0.49	94.32	1.23
	60	19 358	7857	11190	5	306	59.39	1.61	98.39	2.66
	70	13 345	2894	9769	5	677	78.28	5.11	99.27	6.48
	80	5 614	610	4055	1	948	89.12	16.90	99.89	18.95
CNI 2	20	16 173	13755	2411	1	6	14.94	0.04	85.71	0.25
	30	16 095	12861	3230	0	4	20.09	0.02	100.00	0.12
	40	20 750	15497	5220	0	33	25.32	0.16	100.00	0.63
	50	18 892	11602	7196	2	92	38.58	0.50	97.87	1.26
	60	19 729	8378	10990	6	355	57.50	1.83	98.34	3.13
	70	12 752	3090	9024	5	633	75.73	5.00	99.22	6.55
	80	6 278	833	4468	2	975	86.70	15.56	99.80	17.91
CNI 3	20	16 970	14424	2540	1	5	15.00	0.04	83.33	0.20

	30	15 252	12212	3030	0	10	19.93	0.07	100.00	0.33
	40	16 596	12045	4520	1	30	27.42	0.19	96.77	0.66
	50	14 638	8843	5693	2	100	39.58	0.70	98.04	1.73
	60	15 383	6310	8760	4	309	58.95	2.03	98.72	3.41
	70	10 056	2269	7163	4	620	77.40	6.21	99.36	7.97
	80	5 553	649	3903	8	993	88.17	18.03	99.20	20.28
CNI 4	20	14 112	11835	2271	3	3	16.11	0.04	50.00	0.13
	30	13 429	10665	2753	1	10	20.57	0.08	90.91	0.36
	40	15 769	11417	4309	1	42	27.59	0.27	97.67	0.97
	50	14 658	8622	5915	3	118	41.16	0.83	97.52	1.96
	60	14 826	6017	8459	7	343	59.37	2.36	98.00	3.90
	70	9 409	2221	6558	0	630	76.39	6.70	100.00	8.76
	80	5 122	646	3493	6	977	87.27	19.19	99.39	21.86
CNI 5	20	12 796	10794	2000	1	1	15.64	0.02	50.00	0.05
	30	13 168	10455	2706	0	7	20.60	0.05	100.00	0.26
	40	13 879	10028	3816	2	33	27.73	0.25	94.29	0.86
	50	12 142	7171	4897	2	72	40.92	0.61	97.30	1.45
	60	11 723	4870	6597	3	253	58.43	2.18	98.83	3.69
	70	7 333	1704	5162	0	467	76.76	6.37	100.00	8.30
	80	4 178	489	2884	3	802	88.22	19.27	99.63	21.76
CNI 6	20	18 134	15365	2766	0	3	15.27	0.02	100.00	0.11
	30	15 745	12638	3099	2	6	19.72	0.05	75.00	0.19
	40	18 285	13316	4928	2	39	27.16	0.22	95.12	0.79
	50	16 530	9833	6588	2	107	40.50	0.66	98.17	1.60
	60	16 438	6943	9163	5	327	57.73	2.02	98.49	3.45
	70	11 457	2667	8171	4	615	76.69	5.40	99.35	7.00
	80	6 894	940	4845	6	1103	86.28	16.09	99.46	18.54
CNI 7	20	18 045	15624	2411	1	9	13.41	0.06	90.00	0.37
	30	14 656	11977	2669	1	9	18.27	0.07	90.00	0.34
	40	14 400	10590	3777	2	31	26.44	0.23	93.94	0.81
	50	12 597	7597	4907	4	89	39.66	0.74	95.70	1.78
	60	13 119	5696	7147	5	271	56.54	2.10	98.19	3.65
	70	8 930	2194	6193	1	542	75.42	6.08	99.82	8.05
	80	5 569	788	3788	5	988	85.76	17.83	99.50	20.69
CNI 8	20	22 405	18803	3597	1	4	16.07	0.02	80.00	0.11
	30	21 019	16659	4341	0	19	20.74	0.09	100.00	0.44
	40	19 268	13828	5395	2	43	28.22	0.23	95.56	0.79
	50	17 755	10435	7175	7	138	41.19	0.82	95.17	1.89
	60	17 014	7233	9435	3	343	57.47	2.03	99.13	3.51
	70	10 651	2616	7388	4	643	75.40	6.07	99.38	8.01
	80	6 039	838	4189	7	1005	86.01	16.76	99.31	19.35
CNI 9	20	23 116	19785	3328	1	2	14.41	0.01	66.67	0.06
	30	21 531	17553	3967	2	9	18.47	0.05	81.82	0.23
	40	16 388	12072	4277	1	38	26.33	0.24	97.44	0.88
	50	14 812	8881	5828	2	101	40.03	0.70	98.06	1.70
	60	12 646	5696	6616	2	332	54.94	2.64	99.40	4.78
	70	8 915	2342	6013	4	556	73.68	6.28	99.29	8.46
	80	6 064	1042	4043	8	971	82.68	16.14	99.18	19.37

CNI 10	20	26 259	22707	3542	2	8	13.52	0.04	80.00	0.23
	30	21 295	17348	3931	1	15	18.53	0.08	93.75	0.38
	40	15 007	10531	4428	4	44	29.80	0.32	91.67	0.98
	50	12 602	7145	5338	0	119	43.30	0.94	100.00	2.18
	60	9 304	4061	4938	3	302	56.32	3.28	99.02	5.76
	70	5 751	1643	3580	2	526	71.40	9.18	99.62	12.81
	80	3 450	662	2117	2	669	80.75	19.45	99.70	24.01
All CNI percentiles	20	180 876	153934	26886	12	44	14.89	0.03	78.57	0.16
	30	170 080	136715	33259	9	97	19.61	0.06	91.51	0.29
	40	175 095	127996	46717	18	364	26.89	0.22	95.29	0.77
	50	152 432	91191	60193	29	1019	40.16	0.69	97.23	1.66
	60	149 540	63061	83295	43	3141	57.80	2.13	98.65	3.63
	70	98 599	23640	69021	29	5909	75.99	6.02	99.51	7.89
	80	54 761	7497	37785	48	9431	86.22	17.31	99.49	19.97
	Total	**981383**	**604034**	**357156**	**188**	**20005**	**38.43**	**2.06**	**99.07**	**5.30**

CNI = Care Need Index, CNI 1= the most affluent percentile, CNI 10 = the most deprived percentile, HF = heart failure, MM= multimorbidity, N = total number of individuals

MM (%) = total prevalence of multimorbidity

HF (%) = total prevalence of heart failure

HF with MM (%) = prevalence of heart failure with multimorbidity

MM with HF (%) = prevalence of multimorbidity with heart failure

Multimorbidity was present in 38.40% (377161 patients) of the study population and followed different patterns according to age groups and CNI percentiles of the primary health care centres (Table 1). HF was strongly correlated to MM: 99.07% of the patients with HF fulfilled the criteria for multimorbidity, independently of the age at their diagnosis. The prevalence of MM increased steadily with advancing age, from 14.89% in the age group 20 to 86.22% in the age group 80+ (Table 1). The prevalence of HF increased consistently with the MM level: the MM1(2-4 chronic conditions) group had 1.49% patients with HF, the MM2 (5-9 chronic conditions) group had 11.16% patients with HF, and the MM3 (>10 chronic conditions) group had 39.28% patients with HF. The total prevalence of HF among the multimorbid patients was only 5.30% (20005 patients) (Table 1). The predicted mean probability of HF adjusted for age and MM level is shown in Figure 1.

If we consider the prevalence of heart failure in different levels of multimorbidity: 19.19% (3875 patients) of all patients with HF belonged to the MM1 group, 58.18% (11748 patients) belonged to the MM2 group and 21.70% (4382 patients) belonged to the MM3 group. The MM2 group as a whole was more than nine times larger than the MM3 group (105241 vs 11156 patients).

The prevalence of heart failure had a strong correlation with the SES of the primary health care centres (Figure 2). The most significant disparity was between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was significantly increased and approximately twice as high as in the most affluent CNI percentile (Table 1). Although at much lower levels, significant disparities in prevalence of HF could be observed when comparing the most deprived CNI percentile with other CNI percentiles of the primary health care centres. The primary health care centres with the most deprived CNI percentile had the highest prevalence of HF from 40 years of age, although their prevalence of MM was lowest from 70 years of age. In contrast, the prevalence of HF in the most affluent CNI percentile remained relatively low in most age groups, even from 60 years of age as their prevalence of MM became highest (Table 1). Only 4.58% of the multimorbid individuals belonging to this CNI percentile had HF, which was lowest compared to the more deprived CNI percentiles. The association between the prevalence of HF and CNI percentiles followed different patterns compared to MM as shown in Table 1.

Discussion

The total prevalence of heart failure was about 2% in Scania during 2015, which was the same as the prevalence in Sweden and other Western countries[34 35]. A large part of the patients has

HF diagnosis from primary- and secondary care, in both cases diagnosed following the diagnosis criteria for HF according to ESC (European Society of Cardiology) guidelines. Heart failure was a rare disease under 40 years of age and increased substantially with advancing age. 99.07% of the patients with HF in our study population had multimorbidity, which could be explained by the diagnosis HF mostly constitutes a complication of other cardiovascular conditions[23 36]. Multimorbidity was present in 38.40% of the study population, but included only 5.30% patients with HF. The high prevalence of MM could be explained by the socioeconomic difference within the study population and the considerable part of elderly with high prevalence of MM. With increasing level of multimorbidity, the prevalence of HF increased from 1.49% in the MM1(2-4 chronic conditions) group to 39.28% in the MM3 (more than 10 chronic conditions) group. The MM3 group had fewer patients, but a higher prevalence of HF than the MM2 group, which makes us to believe that the MM3 group had a higher mortality in general.

The patients are mostly listed at a primary health care centre close to their place of living. Most primary health care centres are public and organised similarly irrespective of CNI. The socioeconomic boundaries are quite sharp and agree with uptake areas of the different primary health care centres. The CNI category was an average socioeconomic level of the patients listed at the primary health care centres.

The prevalence of HF also had a strong association with the SES of primary health care centres with the most significant disparity between 40 and 80 years of age: the prevalence of HF in primary health care centres with the most deprived CNI percentile was approximately twice as high as in the most affluent CNI percentile. The fact that the prevalence of HF was highest from 40 years of age in the most deprived CNI percentile of primary health care centres indicates that HF is a disease associated with socioeconomic deprivation. The

correlation was assessed visually as the difference in prevalence of HF was obvious between the most affluent and deprived CNI percentiles.

The individuals listed at primary health care centres with deprived CNI percentiles were more likely to have high proportion of inhabitants younger than 40 years, and the opposite were true for primary health care centres with affluent CNI percentiles. The primary health care centres with the most deprived CNI percentile had the lowest proportion of population (33.25%) from 50 years and the highest prevalence of HF from 40 years of age compared to the more affluent population, which makes us to suspect that they suffered from SES related multimorbidity with worse prognosis, including HF.

Heart failure is common in multimorbid patients with COPD (chronic obstructive pulmonary disease)[37], with prevalence in 33.2% of women and 35.7% of men over 80 years of age[38]. In most countries, low SES is associated with higher prevalence of COPD and mortality[39]. The estimated mortality in patients with COPD and coexisting heart failure was seven times higher than in patients with COPD alone, thus the patients with these two conditions were reported with the highest mortality among patients hospitalized with COPD exacerbation[40]. Other conditions with high impact on mortality in patients with HF including stroke, renal disease and diabetes mellitus[41], are strongly associated with low SES as well[42-44].

With respect to the global burden of ischaemic heart disease, the incidence of acute myocardial infarction worldwide is highest in Eastern Europe and Central Asia[45]. Compared to the Swedish population, the first-generation immigrants from Iraq and Bosnia had the highest incidence of HF, probably due to a higher incidence of coronary heart disease[4]. When this incidence of HF was further adjusted for SES, marital status and educational level, the hazard ratio for HF raised significantly compared to the immigrants from other countries. As many of these immigrants are socioeconomically highly disadvantaged in Sweden, these

results support our findings. Interestingly, the HF risk pattern among the second-generation immigrants in most cases differed only marginally compared to their Swedish counterparts, indicating that their risk factor is not purely genetic, rather responsive to other factors[4].

A similar study in Scotland revealed that older people typically have more morbidities with lower functional status, whereas younger people are more often affected by combinations physical and mental health disorders. Except that the most affluent population being on average 2-5 years older at onset of morbidity (dependent on the disorder), conditions like coronary heart disease, diabetes mellitus, COPD, depression, painful disorders or cancer were more common in people living in deprived areas[46]. This could explain that people in the affluent areas suffered from multimorbidity with less disability and had better prognosis.

We do not know if multimorbidity causes socioeconomic deprivation or if low socioeconomic status causes multimorbidity. There is presumably an impact in both directions. Many people with multimorbidity do retire earlier, and have more socioeconomic consequences than the working population. Statistically, this group degrades in the socioeconomic status, which even may influence their family members. On the other hand, many people in the deprived areas have to accept a job which is more health challenging, and become multimorbid many years earlier than the affluent population.

Strengths and limitations

Our study has a number of strengths. Our large cohort with almost 1 million inhabitants included all patients with HF and MM in Scania during the study period, which increases the validity of our results. The outcome data were based on clinical diagnoses registered by physicians, rather than self-reported data, which eliminated any recall bias. Our findings have

similarities with correlative studies in other countries[21 23], which increases the credibility of our results.

This study has certain limitations. We had no data on several risk factors for heart failure, such as smoking, obesity or physical inactivity. However, some prior works on SES and heart failure had adjusted for smoking and physical inactivity and still found an independent association[21]. We had no results of echocardiography, and thus could not analyse the subtypes of heart failure in our study population. As heart failure has none-specific symptoms at the onset, we suspect that many people were underdiagnosed regarding this condition. Those patients with HF belonging to the MM0 group were probably underdiagnosed as well, because HF usually constitutes a complication of other diseases or treatments. Many patients have diagnoses that are usually neglected by the patients and staff in the health care, because these do not impair their quality of life or prognosis, which constitutes a consistent error source to our statistics. We had no data on the severity of HF and other conditions, which have high impact on the mortality. We had no data on the quality of health care in the neighbourhood. Our results could be more accurate if the age group 80+ were divided into age group 80 and 90+, and analysed separately.

Conclusion

The prevalence of heart failure was strongly associated with multimorbidity, with increasing prevalence of HF with multimorbidity level. The patients listed at primary health care centres with the most socioeconomic deprived CNI percentile had a significantly elevated risk of developing HF and probably multimorbidity with worse prognosis, which resulted in the lowest proportion of population from 50 years compared to the more affluent population in

our study. HF patients was a small group of the multimorbid population associated with socioeconomic deprivation that challenges efficient preventive strategies and health policies.

Acknowledgements

We thank the County Council of Scania for providing the patient data enabling this study. We are indebted to Patrick Reilly for his expertise and invaluable advice in proofreading the manuscript.

Footnotes

Contributorship statement

In accordance with the Vancouver Protocol, AH was involved in data collection, design of the study, data analysis, editing the manuscript and student supervision. MS contributed with data collection, data analysis, writing and editing the manuscript. PM provided critical comment and feedback on the manuscript.

Competing interests

None declared.

Statement of funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data sharing statement

No further data available.

Data sharing statement in ScholarOne: Scania County council provided anonymized data of the study population.

Availability of data and material

No further data available.

Statement of Ethics

The regional Ethical Review Board at Lund University (application no. 2018/778) approved the study.

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Figure legends

Figure 1. The predicted mean probability of heart failure adjusted for different age groups and multimorbidity levels with 95% confidence intervals using Delta methods.

MM0= less than 2 chronic conditions (not multimorbid)

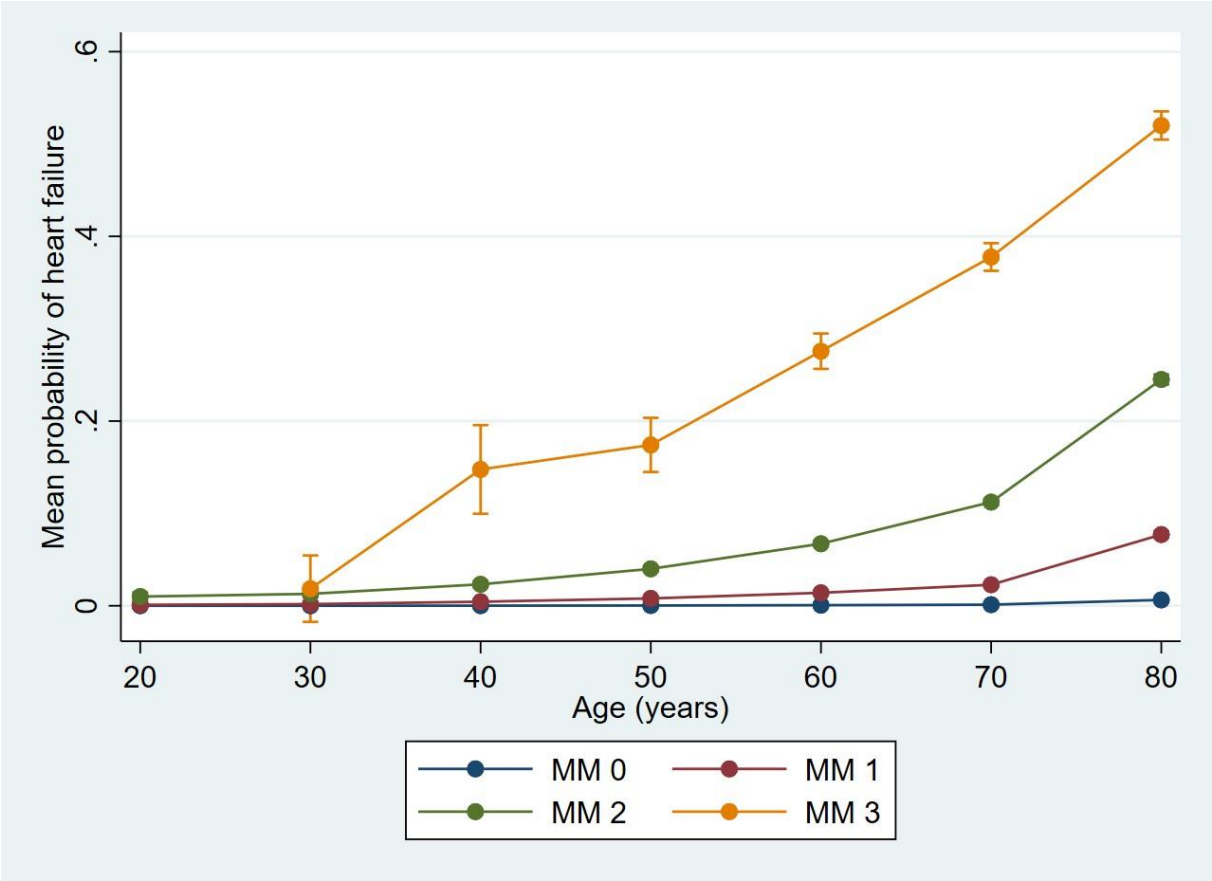
MM1= 2-4 chronic conditions

MM2 = 5-9 chronic conditions

MM3 = 10 or more chronic conditions

Figure 2. Disparities in the predicted mean probability of heart failure adjusted for age between the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95% confidence intervals using Delta methods.

Wordcount for the abstract 297, and the body text of the manuscript 3414.



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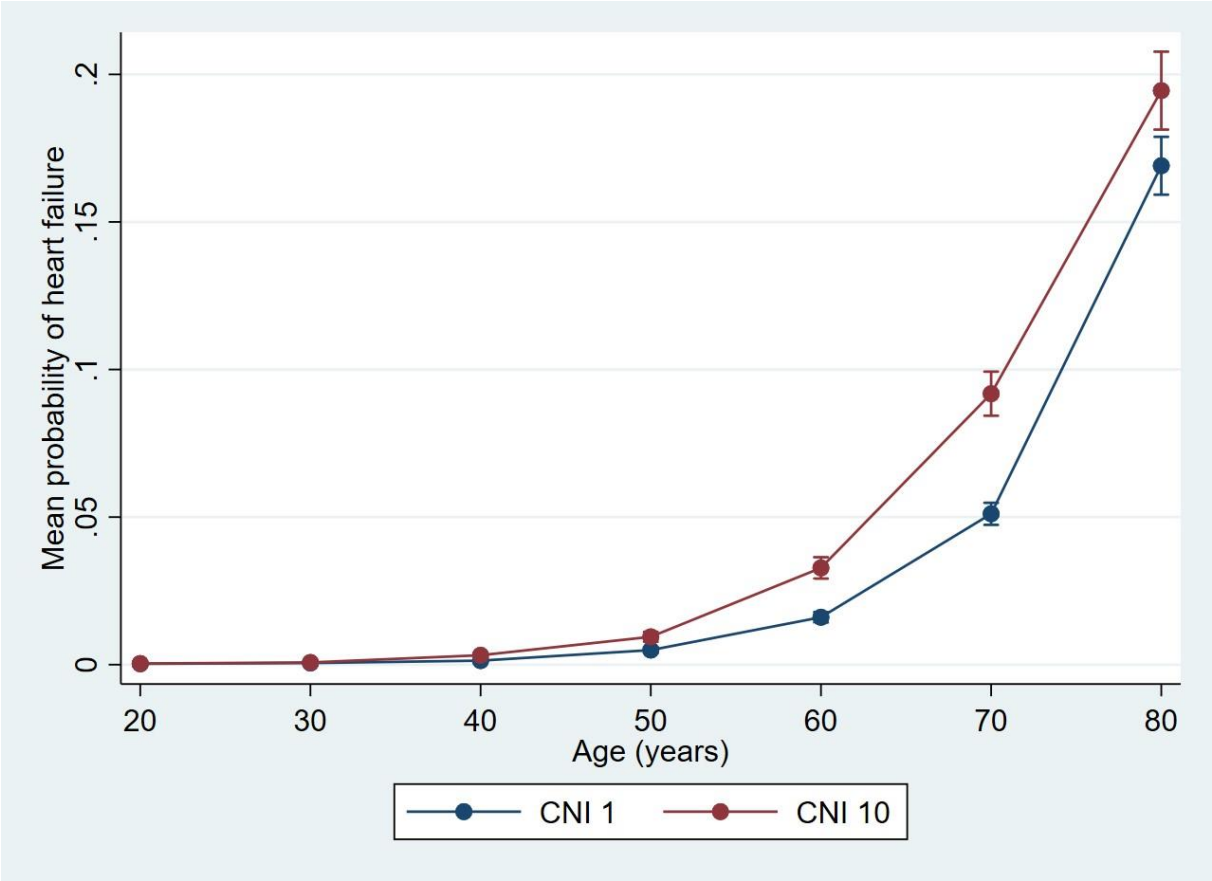

Figure 2. Disparities in the predicted mean probability of heart failure adjusted for age between the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95% confidence intervals using Delta-method.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-10
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-13
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-15
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16,18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.