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

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3 1 **Disparities in prevalence of heart failure according to multimorbidity level and**
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7 2 **socioeconomic status in Southern Sweden: a cross-sectional study**
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14 4 Mia Scholten,¹ Patrik Midlöv,¹ Anders Halling¹
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18 5 **Abstract**
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22 6 **Objective:** The aim of this study was to compare the prevalence of heart failure in relation to
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24 7 multimorbidity and socioeconomic status of primary health care centres in southern Sweden.
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28 8 **Design:** A cross-sectional cohort study.
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32 9 **Setting:** The data were collected concerning diagnoses at each consultation in all primary
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34 10 health care centres and secondary health care in the southernmost county of Sweden.
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38 11 **Participants:** The individuals living in southern Sweden (Scania) in year 2015 aged 20 years
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40 12 and older. The study population of 981388 inhabitants was divided into different categories
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42 13 including heart failure, multimorbidity, different levels of multimorbidity and into 10 CNI
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44 14 (Care Need Index) groups depending on the socioeconomic status of their listed primary
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46 15 health care centre.
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53 16 **Outcomes:** Prevalence of heart failure was presented according to age, multimorbidity,
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55 17 multimorbidity level and socioeconomic status. Logistic regression was used to further
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3 18 analyse the associations between heart failure, age, multimorbidity level and socioeconomic
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6 19 status in more complex models.
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10 20 **Results:** The total prevalence of heart failure in the study population was 2.06%. The
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12 21 prevalence of heart failure increased with advancing age and the level of multimorbidity.
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15 22 99.07% of the patients with heart failure fulfilled the criteria for multimorbidity. The
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18 23 individuals belonging to the deprived CNI percentiles were more likely to have higher
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21 24 proportion of inhabitants younger than 40 years and the opposite were true for primary health
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24 25 care centres with affluent CNI percentiles. Heart failure had a strong correlation with the
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27 26 socioeconomic status of the primary health care centres.
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30 27 **Conclusion:** The patients with heart failure were strongly associated with having
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33 28 multimorbidity and socioeconomic deprivation. Many comorbidities could influence each
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36 29 other and may worsen the prognosis of heart failure, which necessitates prevention and early
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39 30 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.

35

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 whole². In high-income countries, HF is the most common diagnosis in hospitalized elderly patients aged >65 years³. 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 hospitalizations⁴.

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3 45 Heart failure is classified into two major groups: HF with reduced ejection fraction (HFrEF),
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6 46 and HF with preserved ejection fraction (HFpEF)⁵. Both HFrEF and HFpEF have the same
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9 47 clinical phenotype⁶, but different pathophysiology and prognosis⁷. The systolic failure or
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12 48 HFrEF (or systolic dysfunction) is established when the left ventricle loses its ability to
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15 49 contract normally. The heart cannot pump with enough force to push enough blood into the
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18 50 circulation. HFrEF develops usually in response to larger-scale myocyte loss/dysfunction,
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21 51 with the most common aetiologies including acute myocardial infarction, genetic
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24 52 abnormalities, myocarditis or toxin effects (e.g. alcohol or chemotherapy)⁸. Diagnosis of
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27 53 systolic dysfunction is easier than the diagnosis of diastolic dysfunction due to the objective
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30 54 finding of reduced ejection fraction. HFpEF or diastolic HF (or diastolic dysfunction) is
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33 55 established when the left ventricle loses its ability to relax normally, because the muscle has
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36 56 become stiff. The heart cannot properly fill with blood during the resting period between each
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39 57 beat. The pathophysiologic derangements in HFpEF include concentric remodelling,
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42 58 ventricular-vascular stiffening and loss of ventricular-vascular reserve function are resulted
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45 59 from chronic pressure overload due to arterial hypertension⁹. Diastolic heart failure has
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48 60 preserved ejection fraction and often non-specific symptoms, and is preferably found among
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51 61 elderly, women, and patients with diabetes mellitus and hypertension¹⁰⁻¹³.
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54 62 Beside the risk factors like physical inactivity, obesity, chemotherapy, heritability and
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57 63 hyperlipidemia, which increases the incidence of heart failure, the incidence also varies with
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60 64 the patient's socioeconomic status (SES)¹⁴⁻¹⁸. Higher income has previously been

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3 65 associated with a lower risk of developing heart failure¹⁹. Moreover, the risk factors for heart
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6 66 failure, such as hypertension and coronary heart disease, also vary with SES²⁰. Heart failure is
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9 67 often a chronic complication of other cardiovascular comorbidities, particularly ischaemic
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12 68 heart disease, atrial fibrillation and valve dysfunctions²¹. Due to improved medical
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15 69 management, the age-adjusted incidence and prevalence of HF are decreasing, and the HF
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18 70 patients have got prolonged life expectancy². Consequently, the absolute number of patients
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21 71 with HF has drastically increased, secondary to global ageing, as well as general population
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24 72 growth²². Although reliable estimates for middle-income and low-income nations are lacking,
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27 73 evidence from the current literature suggests that HF is the fastest growing cardiovascular
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30 74 condition globally^{23 24}.

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33 75 The aetiology of HF is diverse and varies geographically worldwide: High-income countries
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36 76 are disproportionately affected by ischemic heart disease and COPD (chronic obstructive
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39 77 pulmonary disease) compared with low-income countries, which in turn are primarily affected
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42 78 by hypertensive heart disease, rheumatic heart disease, cardiomyopathy, and myocarditis²⁵.

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44 79 More than two-thirds of all cases of HF can be attributed to four underlying conditions:
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47 80 ischaemic heart disease, COPD, hypertensive heart disease and rheumatic heart disease².

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51 81 HF is often a chronic condition with insidious symptoms at the onset, which could make early
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54 82 and accurate diagnosis difficult. The diagnosis of heart failure requires three criteria to be
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57 83 fulfilled: typical clinical symptoms, such as dyspnoea, fatigue, exertional intolerance and
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60 84 oedema of the lower body, elevated BNP value and objective findings of impaired cardiac

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3 85 function on echocardiography, myocardial scintigraphy, magnet resonance tomography or
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6 86 other imaging¹².

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10 87 The aim of this study was to compare the prevalence of heart failure in relation to
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12 88 multimorbidity and socioeconomic status of primary health care centres in southern Sweden
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15 89 (Scania).

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20 21 22 23 91 **Methods**

24 25 26 92 **Setting and study population**

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30 93 Most residents in Sweden are listed to a primary health care centre, either a public or private
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33 94 health care centre. Scania is the southernmost county of Sweden with around 1.3 million
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36 95 inhabitants during year 2015²⁶. The biggest city in southern Sweden (Scania) is Malmö with
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39 96 about 320000 inhabitants during the study period, ranked as the third largest city in Sweden²⁶.
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42 97 About 1/3 of the residents in Malmö were born abroad representing most countries in the
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45 98 world²⁷. Approximately 1/4 of the whole study population were born abroad²⁸. Almost half of
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48 99 the residents in Malmö (48.40%) were under 35 years during year 2015²⁹. The study
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51 100 population comprised individuals aged 20 years and older living in southern Sweden (Scania)
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54 101 during the last week of year 2015. This age cut-off was chosen because the types of heart
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57 102 failure affecting children and younger people are pathologically distinct from those found in
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60 103 older adults.

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105 **Data source and measurements**

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

109 The data were collected concerning diagnoses at each consultation in all primary health care
110 centres and secondary health care. The study population was divided into age groups: 20, 30,
111 40, 50, 60, 70, 80+. The age group 20 included inhabitants aged 20 to 29 years, the age group
112 30 included inhabitants aged 30 to 39 years, and so on. The age group 80+ included all
113 inhabitants from 80 years and over.

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

117

118 **Multimorbidity**

119 Multimorbidity (MM) was defined as coexistence of two or more chronic conditions in the
120 same person. To measure multimorbidity, we used a method to identify chronic conditions
121 developed by A Calderòn-Larrañaga *et al.* at the Aging Research Centre in Stockholm³⁰. They

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3 122 analysed the full list of ICD-10 codes on a four-digit level to define if a diagnosis is chronic
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6 123 or not in an elderly population. To determine if a condition is chronic or not the following key
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9 124 features were identified and discussed concerning their pertinence and suitability in older
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12 125 populations: duration, course, reversibility, treatment, and consequences. They were then
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15 126 grouped into 60 groups of chronic conditions. We applied their definition and list on chronic
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18 127 conditions to estimate the multimorbidity in our study population. All information about
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21 128 diagnoses for this 18-months period (July 2014 - December 2015) was obtained from
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24 129 electronic medical record database in the county council in southern Sweden (Scania).
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26 130 Multimorbidity was then estimated by counting the number of chronic conditions in each
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29 131 patient. To study the degree of MM in relation to the prevalence of HF, the patients were
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32 132 further divided into groups MM0 (less than two chronic conditions), MM1 (two to four
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35 133 chronic conditions), MM2 (five to nine chronic conditions) and MM3 (ten chronic conditions
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38 134 or more).

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45 136 **Socioeconomics**

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49 137 We used the term Care Need Index (CNI)³¹ to divide the primary health care centres into 10
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52 138 groups depending on their socioeconomic status in the last week of year 2015. CNI is based
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55 139 on different measures of a group, in this case the patients listed to different primary health
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58 140 care centres in southern Sweden (Scania). CNI 1 was assigned to those patients listed to
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60 141 primary health care centres who belonged to the most socioeconomically affluent percentile,

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3 142 and CNI 10 was assigned to those patients listed to primary health care centres who belonged
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6 143 to the most socioeconomically deprived percentile³¹.
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13 145 **Statistical analyses**

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17 146 We analysed data from 981388 (about a tenth of the Swedish population) inhabitants aged 20
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20 147 years and older living in southern Sweden (Scania) during the last week of year 2015.
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23 148 Associations between the variables were studied using univariate and multivariate statistics.
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26 149 We used frequencies, percentages and cross tabulations for descriptive analysis. Logistic
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29 150 regression was used to analyse the associations between the univariate and multivariate
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32 151 models. A p-value of < 0.05 was considered statistically significant. The predicted prevalence
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35 152 of heart failure was calculated as average marginal effects and contrasts using Delta-method.
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38 153 The different age distribution in all CNI percentiles were analysed with Lorenz plots.
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41 154 We used STATA version 16.0 (Stata Corporation, Texas, USA) for statistical analyses.
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49 156 **Patient and Public Involvement**

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53 157 Data in the present study are based on anonymised information provided by the County
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56 158 Council of southern Sweden (Scania). They provided anonymised information for research
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59 159 purposes once the study had been approved by the Ethics Committee at Lund University.
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3 160 The patients were not involved in the recruitment to the study by themselves. Due to the
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6 161 requirement of anonymised data, each individual could not be asked for consent to participate;
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9 162 active refusal of participation was instead applied. This was done by publishing information
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12 163 about the planned study in the Swedish local newspaper “Sydsvenskan”. The advertisement
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15 164 outlined the study and contained information on how to contact the research manager (first
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18 165 author) to opt out of the study. The study results are published anonymised in group level, and
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21 166 cannot be disseminated to every study participant.
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26 168 **Results**

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30 169 The total prevalence of heart failure in the study population was found to be 2.06% (20193
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33 170 patients) in year 2015. Heart failure was a rare disease under 40 years of age in the whole
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36 171 study population, but the prevalence increased substantially with advancing age, especially
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39 172 from 60 years of age, and reached 17.31% in the age group 80+ (Table 1). The individuals
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42 173 listed to primary health care centres with deprived CNI percentiles were more likely to have
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45 174 higher proportion of individuals younger than 40 years and the opposite were true for primary
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48 175 health care centres with affluent CNI percentiles. The primary health care centres with the
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51 176 most deprived CNI percentile had the lowest proportion of population from middle age, only
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54 177 33.25% were 50 years and older, whereas the affluent CNI percentiles were likely to be
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57 178 dominated by individuals from 50 years and over (Table 1). The inequality of age distribution
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3 179 between the most affluent and deprived CNI percentiles of primary health care centres is
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6 180 illustrated by Lorenz plots (Fig. 1).
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8
9 181 Table 1. Prevalence of heart failure and multimorbidity in all age groups and CNI percentiles.
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CNI	age 20 - 29 years			age 30 - 39 years			age 40 - 49 years			age 50 - 59 years		
	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)

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CNI	age 60 - 69 years			age 70 - 79 years			age 80+ years		
	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)

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3 186 CNI = Care Need Index, CNI 1= the most affluent percentile, CNI 10 = the most deprived percentile, HF = heart failure, MM= multimorbidity, N
4 187 = number of individuals
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3 188 Multimorbidity was present in 38.40% (377161 patients) of the study population and followed
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6 189 different patterns according to CNI percentiles of the primary health care centres. HF was
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9 190 strongly correlated to MM: 99.07% of the patients with HF fulfilled the criteria for
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12 191 multimorbidity. The prevalence of MM increased steadily with advancing age, from 14.89%
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14
15 192 in the age group 20 to 86.22% in the age group 80+ (Table 1). The prevalence of HF
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18 193 increased consistently with the MM level: the MM1(2-4 chronic conditions) group had 1.49%
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21 194 patients with HF, the MM2 (5-9 chronic conditions) group had 11.16% patients with HF, and
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24 195 the MM3 (>10 chronic conditions) group had 39.28% patients with HF (Fig. 2). If we
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26
27 196 consider the prevalence of heart failure in different groups of multimorbidity: 19.19% (3875
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30 197 patients) of all patients with HF belonged to the MM1 group, 58.18% (11748 patients)
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33 198 belonged to the MM2 group and 21.70% (4382 patients) belonged to the MM3 group. The
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36 199 MM2 group as a whole was more than nine times larger than the MM3 group (105241 vs
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39 200 11156 patients) (Table 2). The predicted prevalence of HF adjusted for age and MM level is
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42 201 shown in figure 2.

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44 202 Table 2. Prevalence of heart failure in patients with different levels of multimorbidity in all
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47 203 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

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5	CNI 2	20	0.01	1	0.18	4	1.26	2	0.00	0
6		30	0.00	0	0.10	3	0.38	1	0.00	0
7		40	0.00	0	0.33	15	2.80	18	0.00	0
8		50	0.02	2	0.75	44	2.96	40	15.69	8
9		60	0.07	6	1.27	101	6.16	194	26.67	60
10		70	0.16	5	1.57	85	9.90	374	38.33	174
11		80+	0.24	2	6.71	159	22.38	586	50.33	230
12										
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14										
15	CNI 3	20	0.01	1	0.08	2	1.86	3	0.00	0
16		30	0.00	0	0.15	4	1.92	6	0.00	0
17		40	0.01	1	0.39	15	2.12	14	6.25	1
18		50	0.02	2	0.82	37	4.49	56	14.29	7
19		60	0.06	4	1.31	80	6.34	174	25.35	55
20		70	0.18	4	2.29	92	10.79	358	38.64	170
21		80+	1.22	8	8.07	153	23.50	597	52.71	243
22										
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24										
25	CNI 4	20	0.03	3	0.10	2	0.58	1	0.00	0
26		30	0.01	1	0.24	6	1.35	4	0.00	0
27		40	0.01	1	0.65	24	2.76	18	0.00	0
28		50	0.03	3	1.08	49	4.25	60	14.06	9
29		60	0.12	7	1.81	105	6.69	184	21.86	54
30		70	0.00	0	3.23	118	11.51	357	35.96	155
31		80+	0.92	6	8.95	163	28.41	637	43.49	177
32										
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34										
35	CNI 5	20	0.01	1	0.00	0	0.74	1	0.00	0
36		30	0.00	0	0.25	6	0.36	1	0.00	0
37		40	0.02	2	0.40	13	2.94	17	15.00	3
38		50	0.03	2	0.81	31	3.15	35	13.33	6
39		60	0.06	3	1.29	59	7.12	151	25.44	43
40		70	0.00	0	2.20	65	11.42	266	39.88	136
41		80+	0.61	3	10.11	152	25.38	466	53.18	184
42										
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46	CNI 6	20	0.00	0	0.12	3	0.00	0	0.00	0
47		30	0.02	2	0.18	5	0.34	1	0.00	0
48		40	0.02	2	0.45	19	2.04	14	25.00	6
49		50	0.02	2	0.69	36	4.36	61	15.63	10
50		60	0.07	5	1.45	94	6.18	173	27.27	60
51		70	0.15	4	1.95	93	10.39	370	34.16	152
52		80+	0.63	6	6.34	162	23.55	689	53.96	252
53										
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56	CNI 7	20	0.01	1	0.22	5	2.41	4	0.00	0
57		30	0.01	1	0.21	5	1.60	4	0.00	0
58		40	0.02	2	0.37	12	2.79	15	16.67	4
59										
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	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

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205 CNI= Care Need Index, CNI 1 = the most affluent percentile, CNI 10 = the most deprived

206 percentile, MM0 = less than 2 chronic conditions, MM1= 2-4 chronic conditions, MM2 = 5-9

207 chronic conditions, MM3 = 10 or more chronic conditions, N = number of individuals

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209 The prevalence of heart failure had a strong correlation with the SES of the primary health

210 care centres (Fig. 3). The most significant disparity was between 40 and 80 years of age: the

211 prevalence of HF in primary health care centres with the most deprived CNI percentile was

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3 212 significantly increased and almost twice as high as in the most affluent CNI percentile (Table
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6 213 1). Although at much lower levels, significant disparities in prevalence of HF could be seen
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9 214 when comparing the most deprived CNI percentile with other CNI percentiles of the primary
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12 215 health care centres. The primary health care centres with the most deprived CNI percentile
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15 216 had the highest prevalence of HF from 40 years of age, although their prevalence of MM was
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18 217 lowest from 70 years of age. In contrast, the prevalence of HF in the most affluent CNI
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21 218 percentile remained relatively low in most age groups, even from 60 years of age as their
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24 219 prevalence of MM became highest (Table 1). The association between the prevalence of HF
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26 220 and the CNI percentiles followed different patterns compared to MM as shown in Table 1.
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33 222 **Discussion**

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37 223 The total prevalence of heart failure was about 2% in southern Sweden (Scania) in year 2015,
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40 224 which was the same as the prevalence in Sweden and other Western countries^{32 33}. Heart
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43 225 failure was a rare disease under 40 years of age and increased substantially with advancing
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46 226 age. 99.07% of the patients with HF in our study population had multimorbidity, which could
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49 227 be explained by the diagnosis HF mostly constitutes a complication of other cardiovascular
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52 228 conditions^{21 34}. With increasing level of multimorbidity, the prevalence of HF increased from
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55 229 1.49% in the MM1(2-4 chronic conditions) group to 39.28% in the MM3 (more than 10
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58 230 chronic conditions) group. The MM3 group had fewer patients, but a higher prevalence of HF
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60 231 than the MM2 group, which makes us to believe that the MM3 group had a higher mortality

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3 232 in general. The prevalence of HF also had a strong association with the SES of primary health
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6 233 care centres with the most significant disparity between 40 and 80 years of age: the
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9 234 prevalence of HF in primary health care centres with the most deprived CNI percentile was
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12 235 almost twice as high as in the most affluent CNI percentile. The individuals listed to primary
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15 236 health care centres with deprived CNI percentiles were more likely to have high proportion of
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18 237 inhabitants younger than 40 years, and the opposite were true for primary health care centres
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21 238 with affluent CNI percentiles. The primary health care centres with the most deprived CNI
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24 239 percentile had the lowest proportion of population (33.25%) from 50 years and the highest
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27 240 prevalence of HF from 40 years of age compared to the more affluent population, which
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30 241 makes us to suspect that they suffered from SES related multimorbidity with worse prognosis,
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33 242 including HF. The fact that the prevalence of HF was highest in the most deprived CNI
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36 243 percentile of primary health care centres with the lowest prevalence of MM among elderly
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39 244 indicates that HF is a disease associated with socioeconomic deprivation.
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42 245 Heart failure is a common comorbidity in patients with COPD (chronic obstructive pulmonary
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45 246 disease)³⁵, with prevalence in 33.2% of women and 35.7% of men over 80 years of age³⁶. In
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48 247 most countries, low SES is associated with higher prevalence of COPD and mortality³⁷. The
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51 248 estimated mortality in patients with COPD and coexisting heart failure was seven times higher
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54 249 than in patients with COPD alone, thus HF was reported as the most common comorbidity
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57 250 noted in deceased patients hospitalized with COPD exacerbation³⁸. Other comorbidities with
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3 251 high impact on mortality in patients with HF including stroke, renal disease and diabetes

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6 252 mellitus³⁹, are strongly associated with low SES as well⁴⁰⁻⁴².

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10 253 With respect to the global burden of ischaemic heart disease, the incidence of acute

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12 254 myocardial infarction worldwide is highest in Eastern Europe and Central Asia⁴³. Compared

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15 255 to the Swedish population, the first-generation immigrants from Iraq and Bosnia had the

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18 256 highest incidence of HF, probably due to a higher incidence of coronary heart disease⁵. When

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21 257 this incidence of HF was further adjusted for SES, marital status and educational level, the

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24 258 hazard ratio for HF raised significantly compared to the immigrants from other countries. As

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27 259 many of these immigrants are socioeconomically highly disadvantaged in Sweden, these

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30 260 results support our findings. Interestingly, the HF risk pattern among the second-generation

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33 261 immigrants in most cases differed only marginally compared to their Swedish counterparts,

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36 262 indicating that their risk factor is not purely genetic, rather responsive to other factors⁵.

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39 263 A similar study in Scotland revealed that older people typically have more morbidities with

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42 264 lower functional status, whereas younger people are more often affected by combinations

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45 265 physical and mental health disorders. Except that the most affluent population being on

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48 266 average 2-5 years older at onset of morbidity (dependent on the disorder), comorbidities like

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51 267 coronary heart disease, diabetes mellitus, COPD, depression, painful disorders or cancer were

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54 268 more common in people living in deprived areas⁴⁴. This could explain that people in the

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57 269 affluent areas suffered from multimorbidity with less disability and had better prognosis.

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3 270 We do not know if multimorbidity causes socioeconomic deprivation or if low socioeconomic
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6 271 status causes multimorbidity. There is presumably an impact in both directions. Many people
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9 272 with multimorbidity do retire earlier, and have more socioeconomic consequences than the
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12 273 working population. Statistically, this group degrades in the socioeconomic status, which even
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15 274 may influence their family members. On the other hand, many people in the deprived areas
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18 275 have to accept a job which is more health challenging, and become multimorbid many years
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21 276 earlier than the affluent population.
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28 **Strengths and limitations**

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31 279 Our study has a number of strengths. Our large cohort with almost 1 million inhabitants
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34 280 included all patients with HF and MM in Scania during the study period, which increases the
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37 281 validity of our results. The outcome data were based on clinical diagnoses registered by
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40 282 physicians, rather than self-reported data, which eliminated any recall bias. Our findings have
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43 283 similarities with correlative studies in other countries^{19 21}, which increases the credibility of
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46 284 our results.
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49 285 This study has certain limitations. We had no data on several risk factors for heart failure,
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52 286 such as smoking, obesity or physical inactivity. However, some prior works on SES and heart
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55 287 failure had adjusted for smoking and physical inactivity and still found an independent
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58 288 association¹⁹. We had no results of echocardiography, and thus could not divide into the type
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3 289 of heart failure, i.e. systolic or diastolic HF. As diastolic heart failure has none-specific
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6 290 symptoms at the onset, we suspect that many people were underdiagnosed regarding this
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9 291 condition. Many patients have diagnoses that are usually neglected by the patients and staff in
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11
12 292 the health care, because these do not impair their quality of life or prognosis, which
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15 293 constitutes a consistent error source to our statistics. We had no data on the severity of HF and
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18 294 comorbidities, which have high impact on the mortality. We had no data on the quality of
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21 295 health care in the neighbourhood. Our results could be more accurate if the age group 80+
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24 296 were divided into age group 80 and 90+, and analysed separately.
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31 **Conclusion**

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34 299 The prevalence of heart failure was strongly associated with multimorbidity, with higher
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37 300 prevalence of HF with increasing level of multimorbidity. The patients listed to the most
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40 301 socioeconomic deprived CNI percentile had the lowest proportion of population (33.25%)
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43 302 from 50 years and a significantly elevated risk of developing HF compared to the more
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46 303 affluent population in our study. Many comorbidities could influence each other and may
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49 304 worsen the prognosis of HF, which necessitates prevention and early diagnosis in order to
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52 305 improve the quality of life and outcome in these patients. We should focus on the prevention
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55 306 of the risk factors for HF, like a healthy life style with reduced psychological stress and
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58 307 smoking, better diet and more physical activities. Hopefully, these changes combined with
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60 308 innovated treatment of cardiac comorbidities will decrease the incidence of HF and MM. HF

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3 309 is one of many conditions with poor prognosis associated with socioeconomic deprivation that
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6 310 challenges efficient preventive strategies and health policies.
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10 311

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14
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16
17
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19
20
21 315 in proofreading the manuscript.
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25 316

27 317 **Footnotes**

29 318 **Contributorship statement**

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33 319 In accordance with the Vancouver Protocol, AH was involved in data collection, design of the
34
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36 320 study, data analysis, editing the manuscript and student supervision. MS contributed with data
37
38
39 321 collection, data analysis, writing and editing the manuscript. PM provided critical comment
40
41
42 322 and feedback on the manuscript.
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45 323 **Competing interests**

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48
49 324 None declared.
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57
58
59 327 not-for-profit sectors.
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3 328 **Data sharing statement**
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7 329 Scania County Council consented to publication of results using their data.
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10 330 **Availability of data and material**
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14 331 No further data available.
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18 332 **Statement of Ethics**
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21 333 The regional Ethical Review Board at Lund University (application no. 2018/778) approved
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24 334 the study.
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32 336 **References**
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- 35
36 337 1. Halldin AK, Lissner L, Lernfelt B, et al. Impact of changes in physical activity or BMI on
37 338 risk of heart failure in women - the prospective population study of women in
38 339 Gothenburg. *Scand J Prim Health Care* 2020;38(1):56-65. doi:
39 340 10.1080/02813432.2020.1717083 [published Online First: 2020/02/01]
40 341 2. Ziaeeian B, Fonarow GC. Epidemiology and aetiology of heart failure. *Nat Rev Cardiol*
41 342 2016;13(6):368-78. doi: 10.1038/nrcardio.2016.25 [published Online First:
42 343 2016/03/05]
43 344 3. Braunwald E. The war against heart failure: the Lancet lecture. *Lancet*
44 345 2015;385(9970):812-24. doi: 10.1016/s0140-6736(14)61889-4 [published Online
45 346 First: 2014/12/04]
46 347 4. Mejhert M, Lindgren P, Schill O, et al. Long term health care consumption and cost
47 348 expenditure in systolic heart failure. *Eur J Intern Med* 2013;24(3):260-5. doi:
48 349 10.1016/j.ejim.2012.11.015 [published Online First: 2012/12/28]
49 350 5. Wandell P, Carlsson AC, Li X, et al. Heart failure in immigrant groups: a cohort study of
50 351 adults aged 45 years and over in Sweden. *Scand Cardiovasc J* 2018;52(6):292-300.
51 352 doi: 10.1080/14017431.2018.1546892 [published Online First: 2018/11/18]
52 353 6. Borlaug BA, Redfield MM. Diastolic and systolic heart failure are distinct phenotypes
53 354 within the heart failure spectrum. *Circulation* 2011;123(18):2006-13; discussion 14.
54 355 doi: 10.1161/circulationaha.110.954388 [published Online First: 2011/05/11]
55 356 7. Aziz F, Tk LA, Enweluzo C, et al. Diastolic heart failure: a concise review. *J Clin Med Res*
56 357 2013;5(5):327-34. doi: 10.4021/jocmr1532w [published Online First: 2013/08/30]
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41
42
43
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46
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51
52
53
54
55
56
57
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59
60

- 358 8. Hunt SA, Abraham WT, Chin MH, et al. 2009 focused update incorporated into the
359 ACC/AHA 2005 Guidelines for the Diagnosis and Management of Heart Failure in
360 Adults: a report of the American College of Cardiology Foundation/American Heart
361 Association Task Force on Practice Guidelines: developed in collaboration with the
362 International Society for Heart and Lung Transplantation. *Circulation*
363 2009;119(14):e391-479. doi: 10.1161/circulationaha.109.192065 [published Online
364 First: 2009/03/28]
- 365 9. Lakatta EG. Cardiovascular regulatory mechanisms in advanced age. *Physiol Rev*
366 1993;73(2):413-67. doi: 10.1152/physrev.1993.73.2.413 [published Online First:
367 1993/04/01]
- 368 10. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management
369 of heart failure: a report of the American College of Cardiology Foundation/American
370 Heart Association Task Force on practice guidelines. *Circulation* 2013;128(16):e240-
371 327. doi: 10.1161/CIR.0b013e31829e8776 [published Online First: 2013/06/07]
- 372 11. Andersson C, Vasan RS. Epidemiology of heart failure with preserved ejection fraction.
373 *Heart Fail Clin* 2014;10(3):377-88. doi: 10.1016/j.hfc.2014.04.003 [published Online
374 First: 2014/07/01]
- 375 12. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis and
376 treatment of acute and chronic heart failure: The Task Force for the diagnosis and
377 treatment of acute and chronic heart failure of the European Society of Cardiology
378 (ESC)Developed with the special contribution of the Heart Failure Association (HFA)
379 of the ESC. *Eur Heart J* 2016;37(27):2129-200. doi: 10.1093/eurheartj/ehw128
380 [published Online First: 2016/05/22]
- 381 13. Garcia M, Mulvagh SL, Merz CN, et al. Cardiovascular Disease in Women: Clinical
382 Perspectives. *Circ Res* 2016;118(8):1273-93. doi: 10.1161/circresaha.116.307547
383 [published Online First: 2016/04/16]
- 384 14. Agunbiade TA, Zaghlol RY, Barac A. Heart Failure in Relation to Anthracyclines and
385 Other Chemotherapies. *Methodist Debakey Cardiovasc J* 2019;15(4):243-49. doi:
386 10.14797/mdcj-15-4-243 [published Online First: 2020/01/29]
- 387 15. Halldin AK, Schaufelberger M, Lernfelt B, et al. Obesity in Middle Age Increases Risk of
388 Later Heart Failure in Women-Results From the Prospective Population Study of
389 Women and H70 Studies in Gothenburg, Sweden. *J Card Fail* 2017;23(5):363-69. doi:
390 10.1016/j.cardfail.2016.12.003 [published Online First: 2016/12/13]
- 391 16. Lindgren MP, PirouziFard M, Smith JG, et al. A Swedish Nationwide Adoption Study of
392 the Heritability of Heart Failure. *JAMA Cardiology* 2018;3(8):703-10. doi:
393 10.1001/jamacardio.2018.1919
- 394 17. Hawkins NM, Jhund PS, McMurray JJ, et al. Heart failure and socioeconomic status:
395 accumulating evidence of inequality. *Eur J Heart Fail* 2012;14(2):138-46. doi:
396 10.1093/eurjhf/hfr168 [published Online First: 2012/01/19]
- 397 18. Ramsay SE, Whincup PH, Papacosta O, et al. Inequalities in heart failure in older men:
398 prospective associations between socioeconomic measures and heart failure incidence
399 in a 10-year follow-up study. *European heart journal* 2014;35(7):442-47. doi:
400 10.1093/eurheartj/eh449
- 401 19. Akwo EA, Kabagambe EK, Harrell FE, Jr., et al. Neighborhood Deprivation Predicts
402 Heart Failure Risk in a Low-Income Population of Blacks and Whites in the
403 Southeastern United States. *Circ Cardiovasc Qual Outcomes* 2018;11(1):e004052.
404 doi: 10.1161/circoutcomes.117.004052 [published Online First: 2018/01/11]
- 405 20. Carlsson AC, Li X, Holzmann MJ, et al. Neighbourhood socioeconomic status and
406 coronary heart disease in individuals between 40 and 50 years. *Heart*

- 1
2
3 407 2016;102(10):775-82. doi: 10.1136/heartjnl-2015-308784 [published Online First:
4 408 2016/02/13]
- 5 409 21. Taylor CJ, Ryan R, Nichols L, et al. Survival following a diagnosis of heart failure in
6 410 primary care. *Fam Pract* 2017;34(2):161-68. doi: 10.1093/fampra/cmw145 [published
7 411 Online First: 2017/02/01]
- 8 412 22. Roth GA, Forouzanfar MH, Moran AE, et al. Demographic and epidemiologic drivers of
9 413 global cardiovascular mortality. *N Engl J Med* 2015;372(14):1333-41. doi:
10 414 10.1056/NEJMoa1406656 [published Online First: 2015/04/02]
- 11 415 23. Bennett DA, Eliaszk TK, Forbes A, et al. Study protocol: systematic review of the burden
12 416 of heart failure in low- and middle-income countries. *Syst Rev* 2012;1:59. doi:
13 417 10.1186/2046-4053-1-59 [published Online First: 2012/11/30]
- 14 418 24. Banerjee A, Mendis S. Heart failure: the need for global health perspective. *Curr Cardiol*
15 419 *Rev* 2013;9(2):97-8. doi: 10.2174/1573403x11309020001 [published Online First:
16 420 2013/05/25]
- 17 421 25. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for 1160
18 422 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global
19 423 Burden of Disease Study 2010. *Lancet* 2012;380(9859):2163-96. doi: 10.1016/s0140-
20 424 6736(12)61729-2 [published Online First: 2012/12/19]
- 21 425 26. Statistics Sweden y. Population by region, marital status, sex and year [internet]. Statistics
22 426 Sweden; [cited 2021 Mar 31]. Available from:
23 427 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/)
24 428 [A/BefolkningNy/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/).
- 25 429 27. Statistics Sweden y. Population by region, sex, region of birth and year [internet].
26 430 Statistics Sweden; [cited 2021 Mar 29]. Available from:
27 431 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_E/InrUtrFoddaRegAlKon/table/tableViewLayout1/)
28 432 [E/InrUtrFoddaRegAlKon/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_E/InrUtrFoddaRegAlKon/table/tableViewLayout1/).
- 29 433 28. Statistics Sweden y. Population by region, age, sex, region of birth and year [internet].
30 434 Statistics Sweden; [cited 2021 Mar 30]. Available from:
31 435 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_E/InrUtrFoddaRegAlKon/table/tableViewLayout1/)
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- 33 437 29. Statistics Sweden y. Population by region, marital status, age, sex and year [internet].
34 438 Statistics Sweden; [cited 2021 Mar 28]. Available from:
35 439 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/)
36 440 [A/BefolkningNy/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/).
- 37 441 30. Calderon-Larranaga A, Vetrano DL, Onder G, et al. Assessing and Measuring Chronic
38 442 Multimorbidity in the Older Population: A Proposal for Its Operationalization. *J*
39 443 *Gerontol A Biol Sci Med Sci* 2017;72(10):1417-23. doi: 10.1093/gerona/glw233
40 444 [published Online First: 2016/12/23]
- 41 445 31. Sundquist K, Malmström M, Johansson S-E, et al. Care Need Index, a useful tool for the
42 446 distribution of primary health care resources. *Journal of Epidemiology and Community*
43 447 *Health* 2003;57(5):347-52. doi: 10.1136/jech.57.5.347
- 44 448 32. Zarrinkoub R, Wettermark B, Wandell P, et al. The epidemiology of heart failure, based
45 449 on data for 2.1 million inhabitants in Sweden. *Eur J Heart Fail* 2013;15(9):995-1002.
46 450 doi: 10.1093/eurjhf/hft064 [published Online First: 2013/05/07]
- 47 451 33. Savarese G, D'Amario D. Sex Differences in Heart Failure. *Adv Exp Med Biol*
48 452 2018;1065:529-44. doi: 10.1007/978-3-319-77932-4_32 [published Online First:
49 453 2018/07/28]
- 50 454 34. Gimeno-Miguel A, Gracia Gutiérrez A, Poblador-Plou B, et al. Multimorbidity patterns in
51 455 patients with heart failure: an observational Spanish study based on electronic health

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2
3 456 records. *BMJ Open* 2019;9(12):e033174. doi: 10.1136/bmjopen-2019-033174
4 457 [published Online First: 2019/12/26]
5 458 35. Rutten FH, Cramer MJ, Grobbee DE, et al. Unrecognized heart failure in elderly patients
6 459 with stable chronic obstructive pulmonary disease. *Eur Heart J* 2005;26(18):1887-94.
7 460 doi: 10.1093/eurheartj/ehi291 [published Online First: 2005/04/30]
8 461 36. Almagro P, Calbo E, de Echagüen AO, et al. Mortality after hospitalization for COPD.
9 462 *Chest* 2002;121(5):1441-48.
10 463 37. Pleasants RA, Riley IL, Mannino DM. Defining and targeting health disparities in chronic
11 464 obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis* 2016;11:2475-96.
12 465 doi: 10.2147/copd.S79077 [published Online First: 2016/10/28]
13 466 38. Kaszuba E, Odeberg H, Råstam L, et al. Heart failure and levels of other comorbidities in
14 467 patients with chronic obstructive pulmonary disease in a Swedish population: a
15 468 register-based study. *BMC research notes* 2016;9(1):215.
16 469 39. Joffe SW, Webster K, McManus DD, et al. Improved survival after heart failure: a
17 470 community-based perspective. *J Am Heart Assoc* 2013;2(3):e000053. doi:
18 471 10.1161/jaha.113.000053 [published Online First: 2013/05/17]
19 472 40. Vart P, Grams ME, Ballew SH, et al. Socioeconomic status and risk of kidney
20 473 dysfunction: the Atherosclerosis Risk in Communities study. *Nephrol Dial Transplant*
21 474 2019;34(8):1361-68. doi: 10.1093/ndt/gfy142 [published Online First: 2018/06/14]
22 475 41. Marshall IJ, Wang Y, Crichton S, et al. The effects of socioeconomic status on stroke risk
23 476 and outcomes. *Lancet Neurol* 2015;14(12):1206-18. doi: 10.1016/s1474-
24 477 4422(15)00200-8 [published Online First: 2015/11/20]
25 478 42. Wändell P, Carlsson AC, Gasevic D, et al. Neighbourhood socio-economic status and all-
26 479 cause mortality in adults with atrial fibrillation: A cohort study of patients treated in
27 480 primary care in Sweden. *Int J Cardiol* 2016;202:776-81. doi:
28 481 10.1016/j.ijcard.2015.09.027 [published Online First: 2015/10/17]
29 482 43. Moran AE, Forouzanfar MH, Roth GA, et al. The global burden of ischemic heart disease
30 483 in 1990 and 2010: the Global Burden of Disease 2010 study. *Circulation*
31 484 2014;129(14):1493-501. doi: 10.1161/circulationaha.113.004046 [published Online
32 485 First: 2014/02/28]
33 486 44. Barnett K, Mercer SW, Norbury M, et al. Epidemiology of multimorbidity and
34 487 implications for health care, research, and medical education: a cross-sectional study.
35 488 *Lancet* 2012;380(9836):37-43. doi: 10.1016/s0140-6736(12)60240-2 [published
36 489 Online First: 2012/05/15]
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492 **Figure legends**

493 Fig. 1. The age distribution of individuals in southern Sweden (Scania) belonging to the most
494 affluent CNI (CNI 1) and deprived (CNI 10) CNI (Care need index) percentiles.
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1
2
3 496 Fig. 2 The predicted mean probability of heart failure adjusted for different age groups and
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5 497 multimorbidity levels with 95% confidence intervals.
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8 498 MM0= less than 2 chronic conditions (not multimorbid)
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11 499 MM1= 2-4 chronic conditions
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14 500 MM2 = 5-9 chronic conditions
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18 501 MM3 = 10 or more chronic conditions
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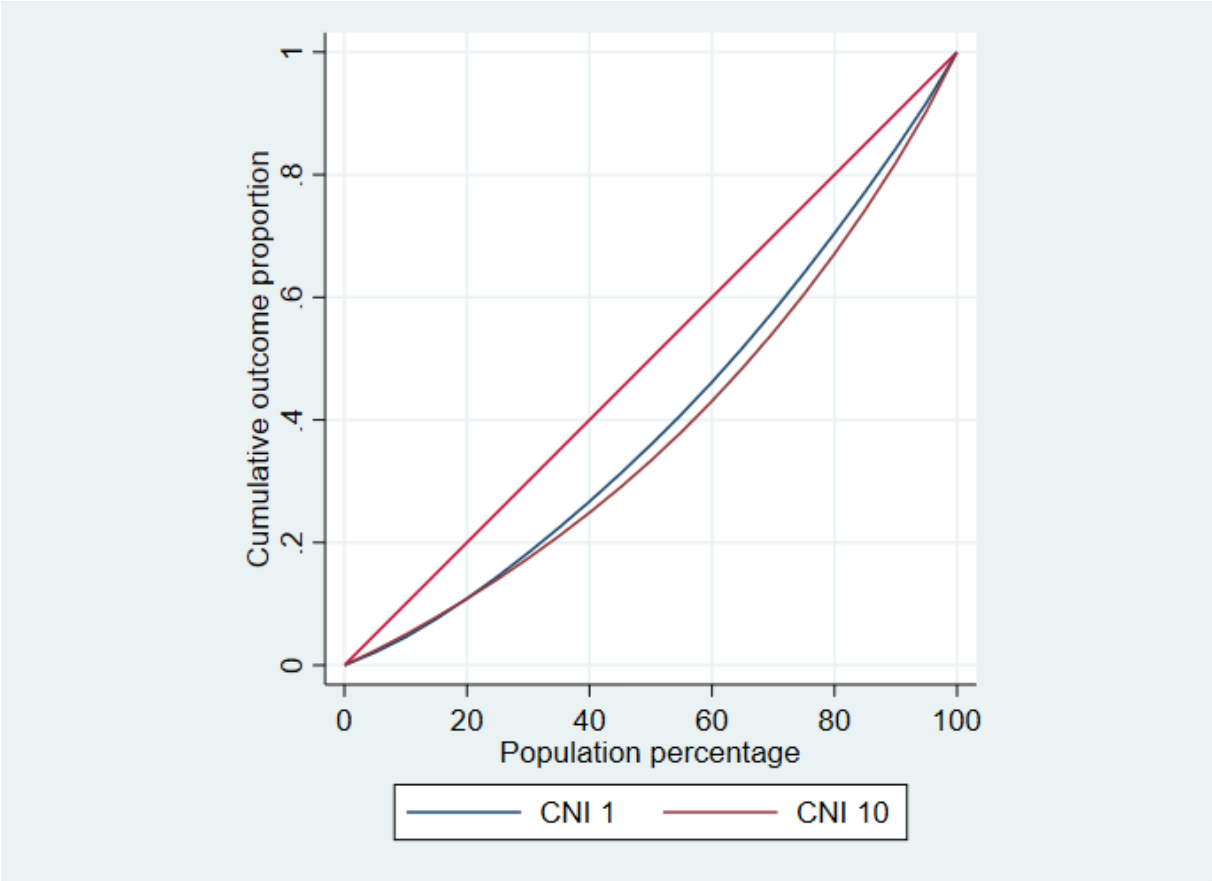
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23 503 Fig 3. Disparities in the predicted mean probability of heart failure adjusted for age between
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25 504 the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95%
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27 505 confidence intervals.
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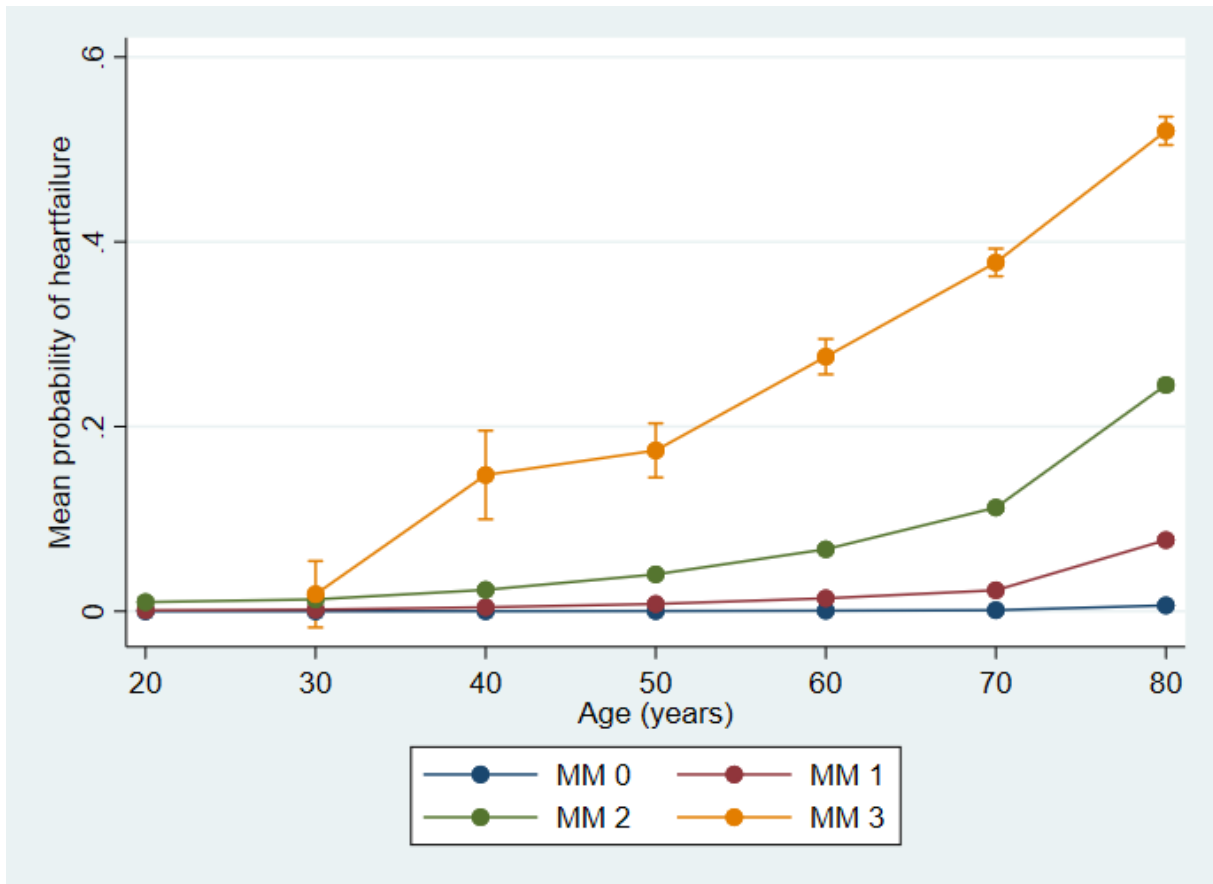
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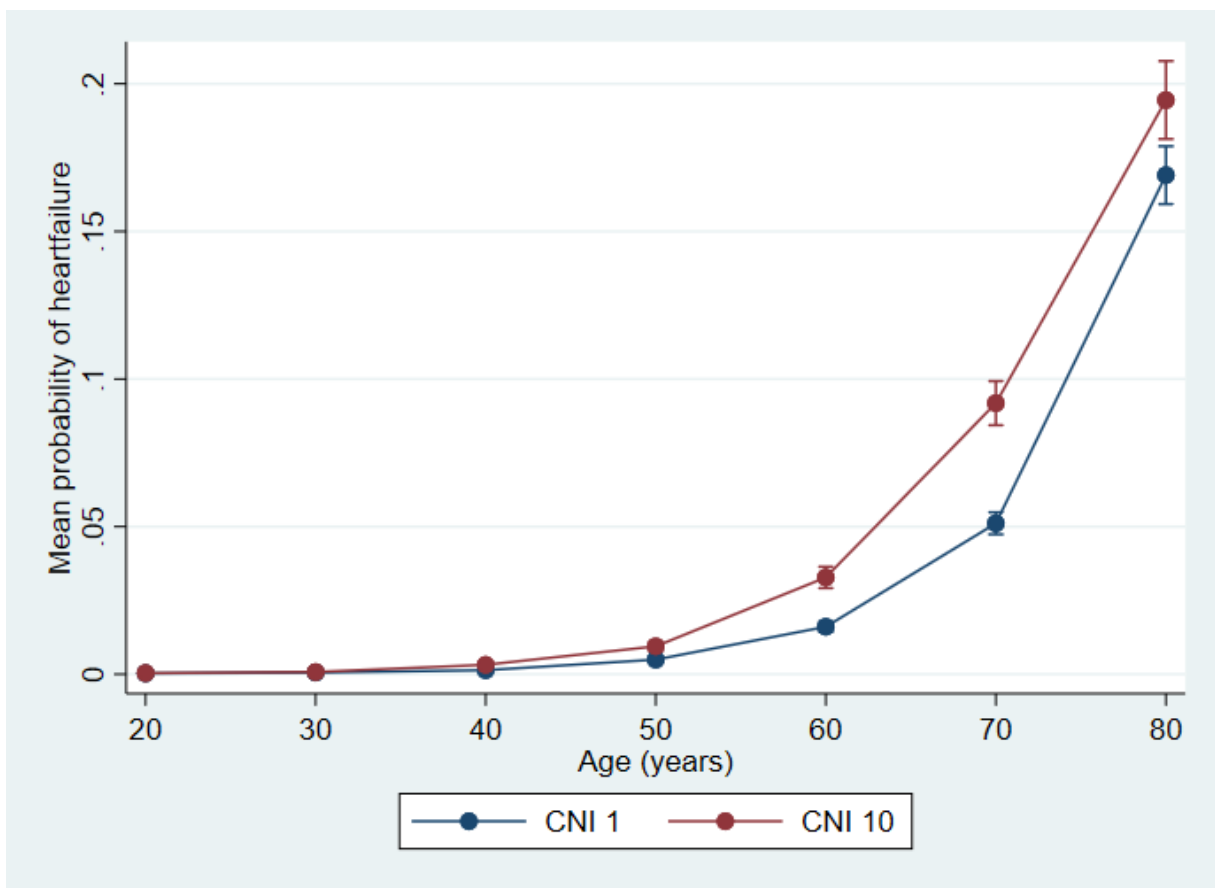


Review only



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Review only

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	

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		(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

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Secondary Subject Heading:	Epidemiology
Keywords:	Heart failure < CARDIOLOGY, EPIDEMIOLOGY, PRIMARY CARE, PUBLIC HEALTH

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3 1 **Disparities in prevalence of heart failure according to age, multimorbidity level and**
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6 2 **socioeconomic status in Southern Sweden: a cross-sectional study**
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12 4 Mia Scholten,¹ Patrik Midlöv,¹ Anders Halling¹
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18 6 ¹Department of Clinical Sciences Malmö, Lund university, SE-205 02, Malmö, Sweden
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22 7 **Correspondence to** Mia Scholten; Mia.Scholten@med.lu.se
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28 9 **Abstract**
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31 10 **Objective:** The aim of this study was to compare the prevalence of heart failure in relation to
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33 11 age, multimorbidity and socioeconomic status of primary health care centres in southern
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35 12 Sweden.
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39 13 **Design:** A cross-sectional cohort study.
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42 14 **Setting:** The data were collected concerning diagnoses at each consultation in all primary
43
44 15 health care centres and secondary health care in the southernmost county of Sweden at the end
45
46 16 of 2015.
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50 17 **Participants:** The individuals living in southern Sweden in 2015 aged 20 years and older.
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52 18 The study population of 981383 inhabitants was divided into different categories including
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54 19 heart failure, multimorbidity, different levels of multimorbidity and into 10 CNI (Care Need
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56 20 Index) groups depending on the socioeconomic status of their listed primary health care
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58 21 centre.
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3 22 **Outcomes:** Prevalence of heart failure was presented according to age, multimorbidity,
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5 23 multimorbidity level and socioeconomic status. Logistic regression was used to further
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7 24 analyse the associations between heart failure, age, multimorbidity level and socioeconomic
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9 25 status in more complex models.
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13 26 **Results:** The total prevalence of heart failure in the study population was 2.06%. The
14
15 27 prevalence of heart failure increased with advancing age and the level of multimorbidity.
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17 28 99.07% of the patients with heart failure fulfilled the criteria for multimorbidity. The total
18
19 29 prevalence of HF among the multimorbid patients was only 5.30%. Heart failure had a strong
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21 30 correlation with the socioeconomic status of the primary health care centres with the most
22
23 31 significant disparity between 40 and 80 years of age: the prevalence of HF in primary health
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25 32 care centres with the most deprived CNI percentile was approximately twice as high as in the
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27 33 most affluent CNI percentile.
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32 34 **Conclusion:** The patients with heart failure were strongly associated with having
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34 35 multimorbidity. Heart failure patients was a small group of the multimorbid population
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36 36 associated with socioeconomic deprivation that challenges efficient preventive strategies and
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38 37 health policies.
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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 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.

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41 Introduction

42 Heart failure (HF) and multimorbidity (MM) are leading causes of morbidity, hospitalizations,
43 disability, and death in Western countries^{1 2}. The prevalence of heart failure and
44 multimorbidity increases with age and the cost of care and treatment constitutes a
45 considerable burden on primary health care and on health care as a whole¹. In high-income
46 countries, HF is the most common diagnosis in hospitalized elderly patients aged >65 years².
47 In Sweden, 31% of medical expenditures were spent for HF patients with reduced ejection
48 fraction (HFrEF) in primary health care, 29% for primary cardiac hospitalizations, and 40%
49 were for noncardiac hospitalizations³.

50 Heart failure is classified into three major groups: HF with reduced ejection fraction (HFrEF),
51 HF with midrange EF (HFmrEF), and HF with preserved ejection fraction (HFpEF)⁴. All
52 subtypes of HF have the same clinical phenotype⁵, but different pathophysiology and
53 prognosis⁶. The systolic failure or HFrEF (or systolic dysfunction) is established when the left
54 ventricle loses its ability to contract normally, resulting in EF < 40%. The heart cannot pump
55 with enough force to push enough blood into the circulation. HFrEF develops usually in
56 response to larger-scale myocyte loss/dysfunction, with the most common aetiologies
57 including acute myocardial infarction, genetic abnormalities, myocarditis or toxin effects (e.g.
58 alcohol or chemotherapy)⁷. Diagnosis of systolic dysfunction is easier than the diagnosis of
59 diastolic dysfunction due to the objective finding of reduced ejection fraction. HFmrEF shares
60 features with both HFrEF and HFpEF, including the aetiology, symptomatology, age of the
61 patients and comorbidities⁸. Four diagnostic criteria are simultaneously required for HFmrEF:
62 symptoms with or without signs of HF, LVEF of 40-49%. Elevated natriuretic peptides, and
63 relevant structural heart disease: left ventricle hypertrophy or left atrial enlargement or

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3 64 diastolic dysfunction⁹. HFpEF or diastolic HF (or diastolic dysfunction) is established when
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5 65 the left ventricle loses its ability to relax normally, because the muscle has become stiff. The
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8 66 heart cannot properly fill with blood during the resting period between each beat. The
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10 67 pathophysiologic derangements in HFpEF include concentric remodelling, ventricular-
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12 68 vascular stiffening and loss of ventricular-vascular reserve function are resulted from chronic
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15 69 pressure overload due to arterial hypertension¹⁰. Diastolic heart failure has preserved ejection
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17 70 fraction with LVEF $\geq 50\%$, and is preferably found among elderly, women, and patients with
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19 71 diabetes mellitus and hypertension¹¹⁻¹⁴.

22 72 Beside the risk factors like physical inactivity, obesity, chemotherapy, heritability and
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24 73 hyperlipidaemia, which increases the incidence of heart failure, the incidence also varies with
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27 74 the patient's socioeconomic status (SES)¹⁵⁻²⁰. Higher income has previously been
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30 75 associated with a lower risk of developing heart failure²¹. Moreover, the risk factors for heart
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32 76 failure, such as hypertension and coronary heart disease, also vary with SES²². Heart failure is
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35 77 often a chronic complication of other cardiovascular comorbidities, particularly ischaemic
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37 78 heart disease, atrial fibrillation and valve dysfunctions²³. Due to improved medical
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39 79 management, the age-adjusted incidence and prevalence of HF are decreasing, and the HF
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41 80 patients have got prolonged life expectancy¹. Consequently, the absolute number of patients
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44 81 with HF has drastically increased, secondary to global ageing, as well as general population
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46 82 growth²⁴. Although reliable estimates for middle-income and low-income nations are lacking,
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49 83 evidence from the current literature suggests that HF is the fastest growing cardiovascular
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51 84 condition globally^{25 26}.

54 85 The aetiology of HF is diverse and varies geographically worldwide: High-income countries
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56 86 are disproportionately affected by ischemic heart disease and COPD (chronic obstructive
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58 87 pulmonary disease) compared with low-income countries, which in turn are primarily affected
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3 88 by hypertensive heart disease, rheumatic heart disease, cardiomyopathy, and myocarditis²⁷.

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5 89 More than two-thirds of all cases of HF can be attributed to four underlying conditions:

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7 90 ischaemic heart disease, COPD, hypertensive heart disease and rheumatic heart disease¹.

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10 91 HF is often a chronic condition with insidious symptoms at the onset, which could make early

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12 92 and accurate diagnosis difficult. The diagnosis of heart failure requires three criteria to be

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14 93 fulfilled: typical clinical symptoms, such as dyspnoea, fatigue, exertional intolerance and

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16 94 oedema of the lower body, elevated BNP value and objective findings of impaired cardiac

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18 95 function on echocardiography, myocardial scintigraphy, magnet resonance tomography or

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20 96 other imaging¹³.

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25 97 The aim of this study was to compare the prevalence of heart failure in relation to age,

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27 98 multimorbidity and socioeconomic status of primary health care centres in southern Sweden.

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32 33 34 100 **Methods**

35 36 37 101 **Setting and study population**

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40 102 Most residents in Sweden are listed at a primary health care centre, either a public or private

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42 103 health care centre. Scania is the southernmost county of Sweden with around 1.3 million

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44 104 inhabitants during year 2015²⁸. Approximately ¼ of the study population were born abroad²⁹.

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46 105 The biggest city in Scania is Malmö with about 320000 inhabitants during 2015, ranked as the

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48 106 third largest city in Sweden²⁸. About 1/3 of the residents in Malmö were born abroad

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50 107 representing most countries in the world³⁰. Almost half of the residents in Malmö (48.40%)

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52 108 were under 35 years during 2015³¹. The study population comprised individuals aged 20 years

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54 109 and older living in Scania during the last week of 2015. This age cut-off was chosen because

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3 110 the types of heart failure affecting children and younger people are pathologically distinct
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5 111 from those found in older adults.
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8 112 The study population was divided into age groups: 20, 30, 40, 50, 60, 70, 80+. The age group
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10 113 20 included inhabitants aged 20 to 29 years, the age group 30 included inhabitants aged 30 to
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12 114 39 years, and so on. The age group 80+ included all inhabitants from 80 years and over.
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19 116 **Data source and measurements**

22 117 The data that was used in this study was retrieved from the County Council health care
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24 118 register in Scania that contains anonymised registry information from the study population,
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26 119 including age, gender, socioeconomic status and diagnostic data in the last week of 2015.
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30 120 The data were collected concerning diagnoses at each consultation in all primary health care
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32 121 centres and secondary health care. Diagnoses were recorded according the International
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34 122 Statistical Classification of Diseases and Related Health Problems version 10 (ICD 10). Heart
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36 123 failure was identified if the diagnosis code I50 was recorded, which comprised all subtypes of
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38 124 HF. Totally 152 primary health care centres were operating during 2015 in Scania, with on
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40 125 average 8587 listed patients (95% CI 7971.49 – 9292.88) including 133 patients with HF
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42 126 (95% CL 122.60 – 143.80) at each primary health care centre.
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50 128 **Multimorbidity**

53 129 Multimorbidity (MM) was defined as coexistence of two or more chronic conditions in the
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55 130 same person, independently if cardiovascular or not. To measure multimorbidity, we used a
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57 131 method to identify chronic conditions developed by A Calderòn-Larrañaga *et al.* at the Aging
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3 132 Research Centre in Stockholm³². They analysed the full list of ICD-10 codes on a four-digit
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5 133 level to define if a diagnosis is chronic or not in an elderly population. To determine if a
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7 134 condition is chronic or not the following key features were identified and discussed
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10 135 concerning their pertinence and suitability in older populations: duration, course, reversibility,
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12 136 treatment, and consequences. They were then grouped into 60 groups of chronic conditions if
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14 137 their duration exceeded 3 months. We applied their definition and list of chronic conditions to
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17 138 estimate the multimorbidity in our study population. All information about diagnoses was
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19 139 obtained from electronic medical record database in the county council in Scania.
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21 140 Multimorbidity was then estimated by counting the number of chronic conditions in each
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24 141 patient. To study the degree of MM in relation to the prevalence of HF, the patients were
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26 142 further divided into groups MM0 (less than two chronic conditions), MM1 (two to four
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28 143 chronic conditions), MM2 (five to nine chronic conditions) and MM3 (ten chronic conditions
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31 144 or more).

146 **Socioeconomics**

147 We used the term Care Need Index (CNI)³³ to divide the primary health care centres into 10
148 groups depending on their socioeconomic status. CNI is based on different measures of a
149 group, in this case the patients listed to different primary health care centres in Scania. CNI 1
150 was assigned to those patients listed at primary health care centres who belonged to the most
151 socioeconomically affluent percentile, and CNI 10 was assigned to those patients listed at
152 primary health care centres who belonged to the most socioeconomically deprived
153 percentile³³.

155 **Statistical analyses**

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2
3 156 We analysed data from 981383 (about a tenth of the Swedish population) inhabitants aged 20
4
5 157 years and older living in Scania during the last week of 2015. Associations between the
6
7 158 variables were studied using univariate and multivariate statistics.
8
9

10
11 159 We used frequencies, percentages and cross tabulations for descriptive analysis. The different
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13
14 160 age distribution in all CNI percentiles was analysed with Lorenz plots. Logistic regression
15
16 161 was used to analyse the associations between the univariate and multivariate models. Only the
17
18 162 linear predications of the fully adjusted models were shown in the figures.
19

20
21 163 A p-value of < 0.05 was considered statistically significant. The predicted mean probability of
22
23 164 heart failure was calculated as average marginal effects using Delta-method.
24
25

26
27 165 We used STATA version 16.0 and 17.0 (Stata Corporation, Texas, USA) for statistical
28
29 166 analyses.
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33 34 35 168 **Patient and Public Involvement**

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38 169 Data in the present study are based on anonymised information provided by the County
39
40 170 Council of Scania. They provided anonymised information for research purposes once the
41
42 171 study had been approved by the Ethics Committee at Lund University.
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45
46 172 The study participants were not involved in the recruitment to the study by themselves. Due to
47
48 173 the requirement of anonymised data, each individual could not be asked for consent to
49
50 174 participate; active refusal of participation was instead applied. This was done by publishing
51
52 175 information about the planned study in the Swedish local newspaper "Sydsvenskan". The
53
54 176 advertisement outlined the study and contained information on how to contact the research
55
56 177 manager (first author) to opt out of the study. The study results are published anonymised in
57
58 178 group level, and cannot be disseminated to every study participant.
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179

180 **Results**

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

193

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

CNI percentiles	Age	N	Heartfailure (HF)				MM (%)	HF (%)	HF with MM (%)	MM with HF (%)
			No		Yes					
			MM		MM					
			No	Yes	No	Yes				
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

1											
2											
3											
4		70	12 752	3090	9024	5	633	75.73	5.00	99.22	6.55
5		80	6 278	833	4468	2	975	86.70	15.56	99.80	17.91
6	CNI 3	20	16 970	14424	2540	1	5	15.00	0.04	83.33	0.20
7		30	15 252	12212	3030	0	10	19.93	0.07	100.00	0.33
8		40	16 596	12045	4520	1	30	27.42	0.19	96.77	0.66
9		50	14 638	8843	5693	2	100	39.58	0.70	98.04	1.73
10		60	15 383	6310	8760	4	309	58.95	2.03	98.72	3.41
11		70	10 056	2269	7163	4	620	77.40	6.21	99.36	7.97
12		80	5 553	649	3903	8	993	88.17	18.03	99.20	20.28
13	CNI 4	20	14 112	11835	2271	3	3	16.11	0.04	50.00	0.13
14		30	13 429	10665	2753	1	10	20.57	0.08	90.91	0.36
15		40	15 769	11417	4309	1	42	27.59	0.27	97.67	0.97
16		50	14 658	8622	5915	3	118	41.16	0.83	97.52	1.96
17		60	14 826	6017	8459	7	343	59.37	2.36	98.00	3.90
18		70	9 409	2221	6558	0	630	76.39	6.70	100.00	8.76
19		80	5 122	646	3493	6	977	87.27	19.19	99.39	21.86
20	CNI 5	20	12 796	10794	2000	1	1	15.64	0.02	50.00	0.05
21		30	13 168	10455	2706	0	7	20.60	0.05	100.00	0.26
22		40	13 879	10028	3816	2	33	27.73	0.25	94.29	0.86
23		50	12 142	7171	4897	2	72	40.92	0.61	97.30	1.45
24		60	11 723	4870	6597	3	253	58.43	2.18	98.83	3.69
25		70	7 333	1704	5162	0	467	76.76	6.37	100.00	8.30
26		80	4 178	489	2884	3	802	88.22	19.27	99.63	21.76
27	CNI 6	20	18 134	15365	2766	0	3	15.27	0.02	100.00	0.11
28		30	15 745	12638	3099	2	6	19.72	0.05	75.00	0.19
29		40	18 285	13316	4928	2	39	27.16	0.22	95.12	0.79
30		50	16 530	9833	6588	2	107	40.50	0.66	98.17	1.60
31		60	16 438	6943	9163	5	327	57.73	2.02	98.49	3.45
32		70	11 457	2667	8171	4	615	76.69	5.40	99.35	7.00
33		80	6 894	940	4845	6	1103	86.28	16.09	99.46	18.54
34	CNI 7	20	18 045	15624	2411	1	9	13.41	0.06	90.00	0.37
35		30	14 656	11977	2669	1	9	18.27	0.07	90.00	0.34
36		40	14 400	10590	3777	2	31	26.44	0.23	93.94	0.81
37		50	12 597	7597	4907	4	89	39.66	0.74	95.70	1.78
38		60	13 119	5696	7147	5	271	56.54	2.10	98.19	3.65
39		70	8 930	2194	6193	1	542	75.42	6.08	99.82	8.05
40		80	5 569	788	3788	5	988	85.76	17.83	99.50	20.69
41	CNI 8	20	22 405	18803	3597	1	4	16.07	0.02	80.00	0.11
42		30	21 019	16659	4341	0	19	20.74	0.09	100.00	0.44
43		40	19 268	13828	5395	2	43	28.22	0.23	95.56	0.79
44		50	17 755	10435	7175	7	138	41.19	0.82	95.17	1.89
45		60	17 014	7233	9435	3	343	57.47	2.03	99.13	3.51
46		70	10 651	2616	7388	4	643	75.40	6.07	99.38	8.01
47		80	6 039	838	4189	7	1005	86.01	16.76	99.31	19.35
48	CNI 9	20	23 116	19785	3328	1	2	14.41	0.01	66.67	0.06
49		30	21 531	17553	3967	2	9	18.47	0.05	81.82	0.23
50		40	16 388	12072	4277	1	38	26.33	0.24	97.44	0.88
51		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
All CNI percentiles	80	3 450	662	2117	2	669	80.75	19.45	99.70	24.01
	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

195

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

198 MM (%) = total prevalence of multimorbidity

199 HF (%) = total prevalence of heart failure

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

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

202

203 Multimorbidity was present in 38.40% (377161 patients) of the study population and followed

204 different patterns according to age groups and CNI percentiles of the primary health care

205 centres (Table 1). HF was strongly correlated to MM: 99.07% of the patients with HF fulfilled

206 the criteria for multimorbidity, independently of the age at their diagnosis. The prevalence of

207 MM increased steadily with advancing age, from 14.89% in the age group 20 to 86.22% in the

208 age group 80+ (Table 1). The prevalence of HF increased consistently with the MM level: the

209 MM1(2-4 chronic conditions) group had 1.49% patients with HF, the MM2 (5-9 chronic

210 conditions) group had 11.16% patients with HF, and the MM3 (>10 chronic conditions) group

211 had 39.28% patients with HF. The total prevalence of HF among the multimorbid patients

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2
3 212 was only 5.30% (20005 patients) (Table 1). The predicted mean probability of HF adjusted
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5 213 for age and MM level is shown in Figure 2.

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7 214 If we consider the prevalence of heart failure in different levels of multimorbidity: 19.19%
8
9 215 (3875 patients) of all patients with HF belonged to the MM1 group, 58.18% (11748 patients)
10
11 216 belonged to the MM2 group and 21.70% (4382 patients) belonged to the MM3 group. The
12
13 217 MM2 group as a whole was more than nine times larger than the MM3 group (105241 vs
14
15 218 11156 patients).

16
17 219
18
19 220 The prevalence of heart failure had a strong correlation with the SES of the primary health
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21 221 care centres (Fig. 3). The most significant disparity was between 40 and 80 years of age: the
22
23 222 prevalence of HF in primary health care centres with the most deprived CNI percentile was
24
25 223 significantly increased and approximately twice as high as in the most affluent CNI percentile
26
27 224 (Table 1). Although at much lower levels, significant disparities in prevalence of HF could be
28
29 225 seen when comparing the most deprived CNI percentile with other CNI percentiles of the
30
31 226 primary health care centres. The primary health care centres with the most deprived CNI
32
33 227 percentile had the highest prevalence of HF from 40 years of age, although their prevalence of
34
35 228 MM was lowest from 70 years of age. In contrast, the prevalence of HF in the most affluent
36
37 229 CNI percentile remained relatively low in most age groups, even from 60 years of age as their
38
39 230 prevalence of MM became highest (Table 1). Only 4.58% of the multimorbid individuals
40
41 231 belonging to this CNI percentile had HF, which was lowest compared to the more deprived
42
43 232 CNI percentiles. The association between the prevalence of HF and CNI percentiles followed
44
45 233 different patterns compared to MM as shown in Table 1.

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47 234

48 49 235 **Discussion**

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3 236 The total prevalence of heart failure was about 2% in Scania during 2015, which was the same
4
5 237 as the prevalence in Sweden and other Western countries^{34 35}. A large part of the patients has
6
7 238 HF diagnosis from primary- and secondary care, in both cases diagnosed following the
8
9 239 diagnosis criteria for HF according to ESC (European Society of Cardiology) guidelines.
10
11 240 Heart failure was a rare disease under 40 years of age and increased substantially with
12
13 241 advancing age. 99.07% of the patients with HF in our study population had multimorbidity,
14
15 242 which could be explained by the diagnosis HF mostly constitutes a complication of other
16
17 243 cardiovascular conditions^{23 36}. Multimorbidity was present in 38.40% of the study population,
18
19 244 but included only 5.30% patients with HF. The high prevalence of MM could be explained by
20
21 245 the socioeconomic difference within the study population and the considerable part of elderly
22
23 246 with high prevalence of MM. With increasing level of multimorbidity, the prevalence of HF
24
25 247 increased from 1.49% in the MM1(2-4 chronic conditions) group to 39.28% in the MM3
26
27 248 (more than 10 chronic conditions) group. The MM3 group had fewer patients, but a higher
28
29 249 prevalence of HF than the MM2 group, which makes us to believe that the MM3 group had a
30
31 250 higher mortality in general.
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38 251 The patients are mostly listed at a primary health care centre close to their place of living.
39
40 252 Most primary health care centres are public and organised similarly irrespective of CNI. The
41
42 253 socioeconomic boundaries are quite sharp and agree with uptake areas of the different primary
43
44 254 health care centres. The CNI category was an average socioeconomic level of the patients
45
46 255 listed at the primary health care centres.
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50 256 The prevalence of HF also had a strong association with the SES of primary health care
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52 257 centres with the most significant disparity between 40 and 80 years of age: the prevalence of
53
54 258 HF in primary health care centres with the most deprived CNI percentile was approximately
55
56 259 twice as high as in the most affluent CNI percentile. The fact that the prevalence of HF was
57
58 260 highest from 40 years of age in the most deprived CNI percentile of primary health care
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3 261 centres indicates that HF is a disease associated with socioeconomic deprivation. The
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5 262 correlation was assessed visually as the difference in prevalence of HF was obvious between
6
7 263 the most affluent and deprived CNI percentiles.
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10 264 The individuals listed at primary health care centres with deprived CNI percentiles were more
11
12 265 likely to have high proportion of inhabitants younger than 40 years, and the opposite were
13
14 266 true for primary health care centres with affluent CNI percentiles. The primary health care
15
16 267 centres with the most deprived CNI percentile had the lowest proportion of population
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18 268 (33.25%) from 50 years and the highest prevalence of HF from 40 years of age compared to
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20 269 the more affluent population, which makes us to suspect that they suffered from SES related
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22 270 multimorbidity with worse prognosis, including HF.
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27 271 Heart failure is a common comorbidity in patients with COPD (chronic obstructive pulmonary
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29 272 disease)³⁷, with prevalence in 33.2% of women and 35.7% of men over 80 years of age³⁸. In
30
31 273 most countries, low SES is associated with higher prevalence of COPD and mortality³⁹. The
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33 274 estimated mortality in patients with COPD and coexisting heart failure was seven times higher
34
35 275 than in patients with COPD alone, thus HF was reported as the most common comorbidity
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37 276 noted in deceased patients hospitalized with COPD exacerbation⁴⁰. Other comorbidities with
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39 277 high impact on mortality in patients with HF including stroke, renal disease and diabetes
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41 278 mellitus⁴¹, are strongly associated with low SES as well⁴²⁻⁴⁴.
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46 279 With respect to the global burden of ischaemic heart disease, the incidence of acute
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48 280 myocardial infarction worldwide is highest in Eastern Europe and Central Asia⁴⁵. Compared
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50 281 to the Swedish population, the first-generation immigrants from Iraq and Bosnia had the
51
52 282 highest incidence of HF, probably due to a higher incidence of coronary heart disease⁴. When
53
54 283 this incidence of HF was further adjusted for SES, marital status and educational level, the
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56 284 hazard ratio for HF raised significantly compared to the immigrants from other countries. As
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3 285 many of these immigrants are socioeconomically highly disadvantaged in Sweden, these
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5 286 results support our findings. Interestingly, the HF risk pattern among the second-generation
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7 287 immigrants in most cases differed only marginally compared to their Swedish counterparts,
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9 288 indicating that their risk factor is not purely genetic, rather responsive to other factors⁴.

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13 289 A similar study in Scotland revealed that older people typically have more morbidities with
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15 290 lower functional status, whereas younger people are more often affected by combinations
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17 291 physical and mental health disorders. Except that the most affluent population being on
18
19 292 average 2-5 years older at onset of morbidity (dependent on the disorder), comorbidities like
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21 293 coronary heart disease, diabetes mellitus, COPD, depression, painful disorders or cancer were
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23 294 more common in people living in deprived areas⁴⁶. This could explain that people in the
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25 295 affluent areas suffered from multimorbidity with less disability and had better prognosis.

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30 296 We do not know if multimorbidity causes socioeconomic deprivation or if low socioeconomic
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32 297 status causes multimorbidity. There is presumably an impact in both directions. Many people
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34 298 with multimorbidity do retire earlier, and have more socioeconomic consequences than the
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36 299 working population. Statistically, this group degrades in the socioeconomic status, which even
37
38 300 may influence their family members. On the other hand, many people in the deprived areas
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40 301 have to accept a job which is more health challenging, and become multimorbid many years
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42 302 earlier than the affluent population.

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48 49 50 304 **Strengths and limitations**

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53 305 Our study has a number of strengths. Our large cohort with almost 1 million inhabitants
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55 306 included all patients with HF and MM in Scania during the study period, which increases the
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57 307 validity of our results. The outcome data were based on clinical diagnoses registered by
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59 308 physicians, rather than self-reported data, which eliminated any recall bias. Our findings have

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3 309 similarities with correlative studies in other countries^{21 23}, which increases the credibility of
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5 310 our results.

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7
8 311 This study has certain limitations. We had no data on several risk factors for heart failure,
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10 312 such as smoking, obesity or physical inactivity. However, some prior works on SES and heart
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12 313 failure had adjusted for smoking and physical inactivity and still found an independent
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14 314 association²¹. We had no results of echocardiography, and thus could not analyse the subtypes
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16 315 of heart failure in our study population. As heart failure has none-specific symptoms at the
17
18 316 onset, we suspect that many people were underdiagnosed regarding this condition. Those
19
20 317 patients with HF belonging to the MM0 group were probably underdiagnosed as well,
21
22 318 because HF usually constitutes a complication of other comorbidities or treatment. Many
23
24 319 patients have diagnoses that are usually neglected by the patients and staff in the health care,
25
26 320 because these do not impair their quality of life or prognosis, which constitutes a consistent
27
28 321 error source to our statistics. We had no data on the severity of HF and comorbidities, which
29
30 322 have high impact on the mortality. We had no data on the quality of health care in the
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32 323 neighbourhood. Our results could be more accurate if the age group 80+ were divided into age
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34 324 group 80 and 90+, and analysed separately.

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42 43 44 326 **Conclusion**

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47 327 The prevalence of heart failure was strongly associated with multimorbidity, with increasing
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49 328 prevalence of HF with multimorbidity level. The patients listed at primary health care centres
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51 329 with the most socioeconomic deprived CNI percentile had a significantly elevated risk of
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53 330 developing HF and probably multimorbidity with worse prognosis, which resulted in the
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55 331 lowest proportion of population from 50 years compared to the more affluent population in
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3 332 our study. HF patients was a small group of the multimorbid population associated with
4
5 333 socioeconomic deprivation that challenges efficient preventive strategies and health policies.
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9 334

10 11 12 335 **Acknowledgements**

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14
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16
17 337 are indebted to Patrick Reilly for his expertise and invaluable advice in proofreading the
18
19 338 manuscript.
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24 25 26 340 **Footnotes**

27 28 29 341 **Contributorship statement**

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31
32 342 In accordance with the Vancouver Protocol, AH was involved in data collection, design of the
33
34 343 study, data analysis, editing the manuscript and student supervision. MS contributed with data
35
36 344 collection, data analysis, writing and editing the manuscript. PM provided critical comment
37
38 345 and feedback on the manuscript.
39
40
41

42 43 346 **Competing interests**

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45
46 347 None declared.
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48

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51
52 349 This research received no specific grant from any funding agency in the public, commercial or
53
54 350 not-for-profit sectors.
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57 351 **Data sharing statement** 58 59 60

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3 352 No further data available.
4

5 353 Data sharing statement in ScholarOne: Scania County council provided anonymized the data
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7
8 354 of the study population.
9

10 355 **Availability of data and material**

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14 356 No further data available.
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16 357 **Statement of Ethics**

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20 358 The regional Ethical Review Board at Lund University (application no. 2018/778) approved
21
22 359 the study.
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27 28 361 **References**

29
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31
32 362 [dataset]1. Ziaieian B, Fonarow GC. Epidemiology and aetiology of heart failure. *Nat Rev*
33 363 *Cardiol* 2016;13(6):368-78. doi: 10.1038/nrcardio.2016.25 [published Online First:
34 364 2016/03/05]

35 365 [dataset]2. Braunwald E. The war against heart failure: the Lancet lecture. *Lancet*
36 366 2015;385(9970):812-24. doi: 10.1016/s0140-6736(14)61889-4 [published Online
37 367 First: 2014/12/04]

38 368 [dataset]3. Mejhert M, Lindgren P, Schill O, et al. Long term health care consumption and
39 369 cost expenditure in systolic heart failure. *Eur J Intern Med* 2013;24(3):260-5. doi:
40 370 10.1016/j.ejim.2012.11.015 [published Online First: 2012/12/28]

41 371 [dataset]4. Wandell P, Carlsson AC, Li X, et al. Heart failure in immigrant groups: a cohort
42 372 study of adults aged 45 years and over in Sweden. *Scand Cardiovasc J*
43 373 2018;52(6):292-300. doi: 10.1080/14017431.2018.1546892 [published Online First:
44 374 2018/11/18]

45 375 [dataset]5. Borlaug BA, Redfield MM. Diastolic and systolic heart failure are distinct
46 376 phenotypes within the heart failure spectrum. *Circulation* 2011;123(18):2006-13;
47 377 discussion 14. doi: 10.1161/circulationaha.110.954388 [published Online First:
48 378 2011/05/11]

49 379 [dataset]6. Aziz F, Tk LA, Enweluzo C, et al. Diastolic heart failure: a concise review. *J Clin*
50 380 *Med Res* 2013;5(5):327-34. doi: 10.4021/jocmr1532w [published Online First:
51 381 2013/08/30]

52 382 [dataset]7. Hunt SA, Abraham WT, Chin MH, et al. 2009 focused update incorporated into
53 383 the ACC/AHA 2005 Guidelines for the Diagnosis and Management of Heart Failure in
54 384 Adults: a report of the American College of Cardiology Foundation/American Heart
55 385 Association Task Force on Practice Guidelines: developed in collaboration with the
56 386 International Society for Heart and Lung Transplantation. *Circulation*

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2
3 387 2009;119(14):e391-479. doi: 10.1161/circulationaha.109.192065 [published Online
4 388 First: 2009/03/28]
5 389 [dataset]8. Savarese G, Stolfo D, Sinagra G, et al. Heart failure with mid-range or mildly
6 390 reduced ejection fraction. *Nat Rev Cardiol* 2021;1-17. doi: 10.1038/s41569-021-
7 391 00605-5 [published Online First: 2021/09/08]
8 392 [dataset]9. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis
9 393 and treatment of acute and chronic heart failure: The Task Force for the diagnosis and
10 394 treatment of acute and chronic heart failure of the European Society of Cardiology
11 395 (ESC). Developed with the special contribution of the Heart Failure Association
12 396 (HFA) of the ESC. *Eur J Heart Fail* 2016;18(8):891-975. doi: 10.1002/ejhf.592
13 397 [published Online First: 2016/05/22]
14 398 [dataset]10. Lakatta EG. Cardiovascular regulatory mechanisms in advanced age. *Physiol Rev*
15 399 1993;73(2):413-67. doi: 10.1152/physrev.1993.73.2.413 [published Online First:
16 400 1993/04/01]
17 401 [dataset]11. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the
18 402 management of heart failure: a report of the American College of Cardiology
19 403 Foundation/American Heart Association Task Force on practice guidelines.
20 404 *Circulation* 2013;128(16):e240-327. doi: 10.1161/CIR.0b013e31829e8776 [published
21 405 Online First: 2013/06/07]
22 406 [dataset]12. Andersson C, Vasan RS. Epidemiology of heart failure with preserved ejection
23 407 fraction. *Heart Fail Clin* 2014;10(3):377-88. doi: 10.1016/j.hfc.2014.04.003
24 408 [published Online First: 2014/07/01]
25 409 [dataset]13. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the
26 410 diagnosis and treatment of acute and chronic heart failure: The Task Force for the
27 411 diagnosis and treatment of acute and chronic heart failure of the European Society of
28 412 Cardiology (ESC) Developed with the special contribution of the Heart Failure
29 413 Association (HFA) of the ESC. *Eur Heart J* 2016;37(27):2129-200. doi:
30 414 10.1093/eurheartj/ehw128 [published Online First: 2016/05/22]
31 415 [dataset]14. Garcia M, Mulvagh SL, Merz CN, et al. Cardiovascular Disease in Women:
32 416 Clinical Perspectives. *Circ Res* 2016;118(8):1273-93. doi:
33 417 10.1161/circresaha.116.307547 [published Online First: 2016/04/16]
34 418 [dataset]15. Agunbiade TA, Zaghlool RY, Barac A. Heart Failure in Relation to Anthracyclines
35 419 and Other Chemotherapies. *Methodist Debaquey Cardiovasc J* 2019;15(4):243-49. doi:
36 420 10.14797/mdcj-15-4-243 [published Online First: 2020/01/29]
37 421 [dataset]16. Halldin AK, Schaufelberger M, Lernfelt B, et al. Obesity in Middle Age
38 422 Increases Risk of Later Heart Failure in Women-Results From the Prospective
39 423 Population Study of Women and H70 Studies in Gothenburg, Sweden. *J Card Fail*
40 424 2017;23(5):363-69. doi: 10.1016/j.cardfail.2016.12.003 [published Online First:
41 425 2016/12/13]
42 426 [dataset]17. Lindgren MP, PirouziFard M, Smith JG, et al. A Swedish Nationwide Adoption
43 427 Study of the Heritability of Heart Failure. *JAMA Cardiology* 2018;3(8):703-10. doi:
44 428 10.1001/jamacardio.2018.1919
45 429 [dataset]18. Hawkins NM, Jhund PS, McMurray JJ, et al. Heart failure and socioeconomic
46 430 status: accumulating evidence of inequality. *Eur J Heart Fail* 2012;14(2):138-46. doi:
47 431 10.1093/eurjhf/hfr168 [published Online First: 2012/01/19]
48 432 [dataset]19. Ramsay SE, Whincup PH, Papacosta O, et al. Inequalities in heart failure in older
49 433 men: prospective associations between socioeconomic measures and heart failure
50 434 incidence in a 10-year follow-up study. *European heart journal* 2014;35(7):442-47.
51 435 doi: 10.1093/eurheartj/eh449
52
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2
3 436 [dataset]20. Halldin AK, Lissner L, Lernfelt B, et al. Impact of changes in physical activity or
4 437 BMI on risk of heart failure in women - the prospective population study of women in
5 438 Gothenburg. *Scand J Prim Health Care* 2020;38(1):56-65. doi:
6 439 10.1080/02813432.2020.1717083 [published Online First: 2020/02/01]
- 7
8 440 [dataset]21. Akwo EA, Kabagambe EK, Harrell FE, Jr., et al. Neighborhood Deprivation
9 441 Predicts Heart Failure Risk in a Low-Income Population of Blacks and Whites in the
10 442 Southeastern United States. *Circ Cardiovasc Qual Outcomes* 2018;11(1):e004052.
11 443 doi: 10.1161/circoutcomes.117.004052 [published Online First: 2018/01/11]
- 12 444 [dataset]22. Carlsson AC, Li X, Holzmann MJ, et al. Neighbourhood socioeconomic status
13 445 and coronary heart disease in individuals between 40 and 50 years. *Heart*
14 446 2016;102(10):775-82. doi: 10.1136/heartjnl-2015-308784 [published Online First:
15 447 2016/02/13]
- 16
17 448 [dataset]23. Taylor CJ, Ryan R, Nichols L, et al. Survival following a diagnosis of heart
18 449 failure in primary care. *Fam Pract* 2017;34(2):161-68. doi: 10.1093/fampra/cmw145
19 450 [published Online First: 2017/02/01]
- 20 451 [dataset]24. Roth GA, Forouzanfar MH, Moran AE, et al. Demographic and epidemiologic
21 452 drivers of global cardiovascular mortality. *N Engl J Med* 2015;372(14):1333-41. doi:
22 453 10.1056/NEJMoa1406656 [published Online First: 2015/04/02]
- 23 454 [dataset]25. Bennett DA, Elias TK, Forbes A, et al. Study protocol: systematic review of the
24 455 burden of heart failure in low- and middle-income countries. *Syst Rev* 2012;1:59. doi:
25 456 10.1186/2046-4053-1-59 [published Online First: 2012/11/30]
- 26 457 [dataset]26. Banerjee A, Mendis S. Heart failure: the need for global health perspective. *Curr*
27 458 *Cardiol Rev* 2013;9(2):97-8. doi: 10.2174/1573403x11309020001 [published Online
28 459 First: 2013/05/25]
- 29 460 [dataset]27. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for
30 461 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the
31 462 Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2163-96. doi:
32 463 10.1016/s0140-6736(12)61729-2 [published Online First: 2012/12/19]
- 33 464 [dataset]28. Statistics Sweden y. Population by region, marital status, sex and year [internet].
34 465 Statistics Sweden; [cited 2021 Mar 31]. Available from:
35 466 http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101
36 467 [A/BefolkningNy/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101).
- 37 468 [dataset]29. Statistics Sweden y. Population by region, age, sex, region of birth and year
38 469 [internet]. Statistics Sweden; [cited 2021 Mar 30]. Available from:
39 470 http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101
40 471 [E/InrUtrFoddaRegAlKon/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101).
- 41 472 [dataset]30. Statistics Sweden y. Population by region, sex, region of birth and year [internet].
42 473 Statistics Sweden; [cited 2021 Mar 29]. Available from:
43 474 http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101
44 475 [E/InrUtrFoddaRegAlKon/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101).
- 45 476 [dataset]31. Statistics Sweden y. Population by region, marital status, age, sex and year
46 477 [internet]. Statistics Sweden; [cited 2021 Mar 28]. Available from:
47 478 http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101
48 479 [A/BefolkningNy/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101).
- 49 480 [dataset]32. Calderon-Larranaga A, Vetrano DL, Onder G, et al. Assessing and Measuring
50 481 Chronic Multimorbidity in the Older Population: A Proposal for Its
51 482 Operationalization. *J Gerontol A Biol Sci Med Sci* 2017;72(10):1417-23. doi:
52 483 10.1093/gerona/glw233 [published Online First: 2016/12/23]
- 53
54
55
56
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2
3 484 [dataset]33. Sundquist K, Malmström M, Johansson S-E, et al. Care Need Index, a useful tool
4 485 for the distribution of primary health care resources. *Journal of Epidemiology and*
5 486 *Community Health* 2003;57(5):347-52. doi: 10.1136/jech.57.5.347
6
7 487 [dataset]34. Zarrinkoub R, Wettermark B, Wandell P, et al. The epidemiology of heart failure,
8 488 based on data for 2.1 million inhabitants in Sweden. *Eur J Heart Fail* 2013;15(9):995-
9 489 1002. doi: 10.1093/eurjhf/hft064 [published Online First: 2013/05/07]
10 490 [dataset]35. Savarese G, D'Amarico D. Sex Differences in Heart Failure. *Adv Exp Med Biol*
11 491 2018;1065:529-44. doi: 10.1007/978-3-319-77932-4_32 [published Online First:
12 492 2018/07/28]
13 493 [dataset]36. Gimeno-Miguel A, Gracia Gutiérrez A, Poblador-Plou B, et al. Multimorbidity
14 494 patterns in patients with heart failure: an observational Spanish study based on
15 495 electronic health records. *BMJ Open* 2019;9(12):e033174. doi: 10.1136/bmjopen-
16 496 2019-033174 [published Online First: 2019/12/26]
17 497 [dataset]37. Rutten FH, Cramer MJ, Grobbee DE, et al. Unrecognized heart failure in elderly
18 498 patients with stable chronic obstructive pulmonary disease. *Eur Heart J*
19 499 2005;26(18):1887-94. doi: 10.1093/eurheartj/ehi291 [published Online First:
20 500 2005/04/30]
21
22 501 [dataset]38. Almagro P, Calbo E, de Echaguién AO, et al. Mortality after hospitalization for
23 502 COPD. *Chest* 2002;121(5):1441-48.
24 503 [dataset]39. Pleasants RA, Riley IL, Mannino DM. Defining and targeting health disparities in
25 504 chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis*
26 505 2016;11:2475-96. doi: 10.2147/copd.S79077 [published Online First: 2016/10/28]
27 506 [dataset]40. Kaszuba E, Odeberg H, Råstam L, et al. Heart failure and levels of other
28 507 comorbidities in patients with chronic obstructive pulmonary disease in a Swedish
29 508 population: a register-based study. *BMC research notes* 2016;9(1):215.
30 509 [dataset]41. Joffe SW, Webster K, McManus DD, et al. Improved survival after heart failure:
31 510 a community-based perspective. *J Am Heart Assoc* 2013;2(3):e000053. doi:
32 511 10.1161/jaha.113.000053 [published Online First: 2013/05/17]
33 512 [dataset]42. Vart P, Grams ME, Ballew SH, et al. Socioeconomic status and risk of kidney
34 513 dysfunction: the Atherosclerosis Risk in Communities study. *Nephrol Dial Transplant*
35 514 2019;34(8):1361-68. doi: 10.1093/ndt/gfy142 [published Online First: 2018/06/14]
36 515 [dataset]43. Marshall IJ, Wang Y, Crichton S, et al. The effects of socioeconomic status on
37 516 stroke risk and outcomes. *Lancet Neurol* 2015;14(12):1206-18. doi: 10.1016/s1474-
38 517 4422(15)00200-8 [published Online First: 2015/11/20]
39 518 [dataset]44. Wändell P, Carlsson AC, Gasevic D, et al. Neighbourhood socio-economic status
40 519 and all-cause mortality in adults with atrial fibrillation: A cohort study of patients
41 520 treated in primary care in Sweden. *Int J Cardiol* 2016;202:776-81. doi:
42 521 10.1016/j.ijcard.2015.09.027 [published Online First: 2015/10/17]
43 522 [dataset]45. Moran AE, Forouzanfar MH, Roth GA, et al. The global burden of ischemic heart
44 523 disease in 1990 and 2010: the Global Burden of Disease 2010 study. *Circulation*
45 524 2014;129(14):1493-501. doi: 10.1161/circulationaha.113.004046 [published Online
46 525 First: 2014/02/28]
47 526 [dataset]46. Barnett K, Mercer SW, Norbury M, et al. Epidemiology of multimorbidity and
48 527 implications for health care, research, and medical education: a cross-sectional study.
49 528 *Lancet* 2012;380(9836):37-43. doi: 10.1016/s0140-6736(12)60240-2 [published
50 529 Online First: 2012/05/15]
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3 532 **Figure legends**
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5 533 Fig. 1. The age distribution of individuals in Scania belonging to the most affluent CNI (CNI
6 1) and deprived (CNI 10) CNI (Care need index) percentiles using Lorenz plots.
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13 536 Fig. 2 The predicted mean probability of heart failure adjusted for different age groups and
14 multimorbidity levels with 95% confidence intervals using Delta methods.
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18 538 MM0= less than 2 chronic conditions (not multimorbid)

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21 539 MM1= 2-4 chronic conditions

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34 543 Fig 3. Disparities in the predicted mean probability of heart failure adjusted for age between
35 the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95%
36 confidence intervals using Delta methods.
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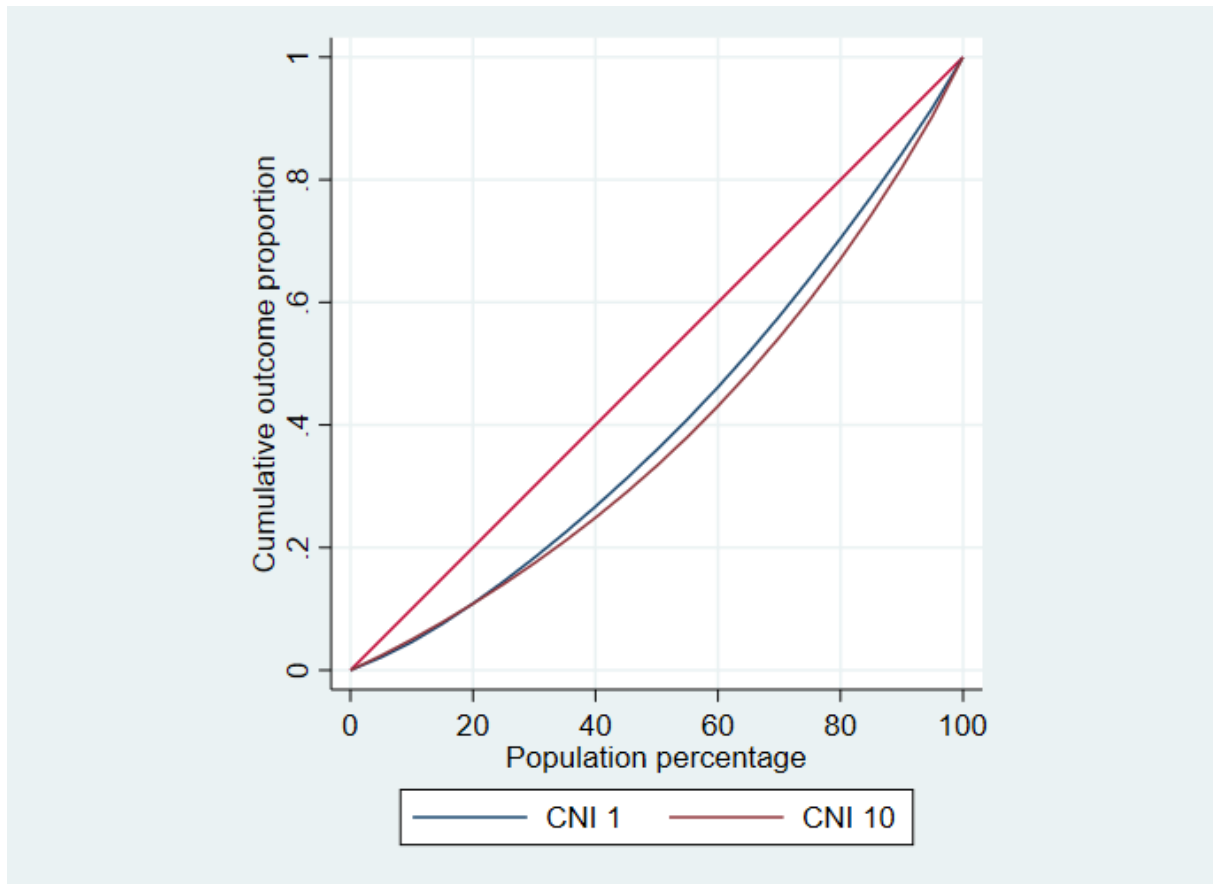


Fig. 1. The age distribution of individuals in Scania belonging to the most affluent CNI (CNI 1) and deprived (CNI 10) CNI (Care need index) percentiles using Lorenz plots.

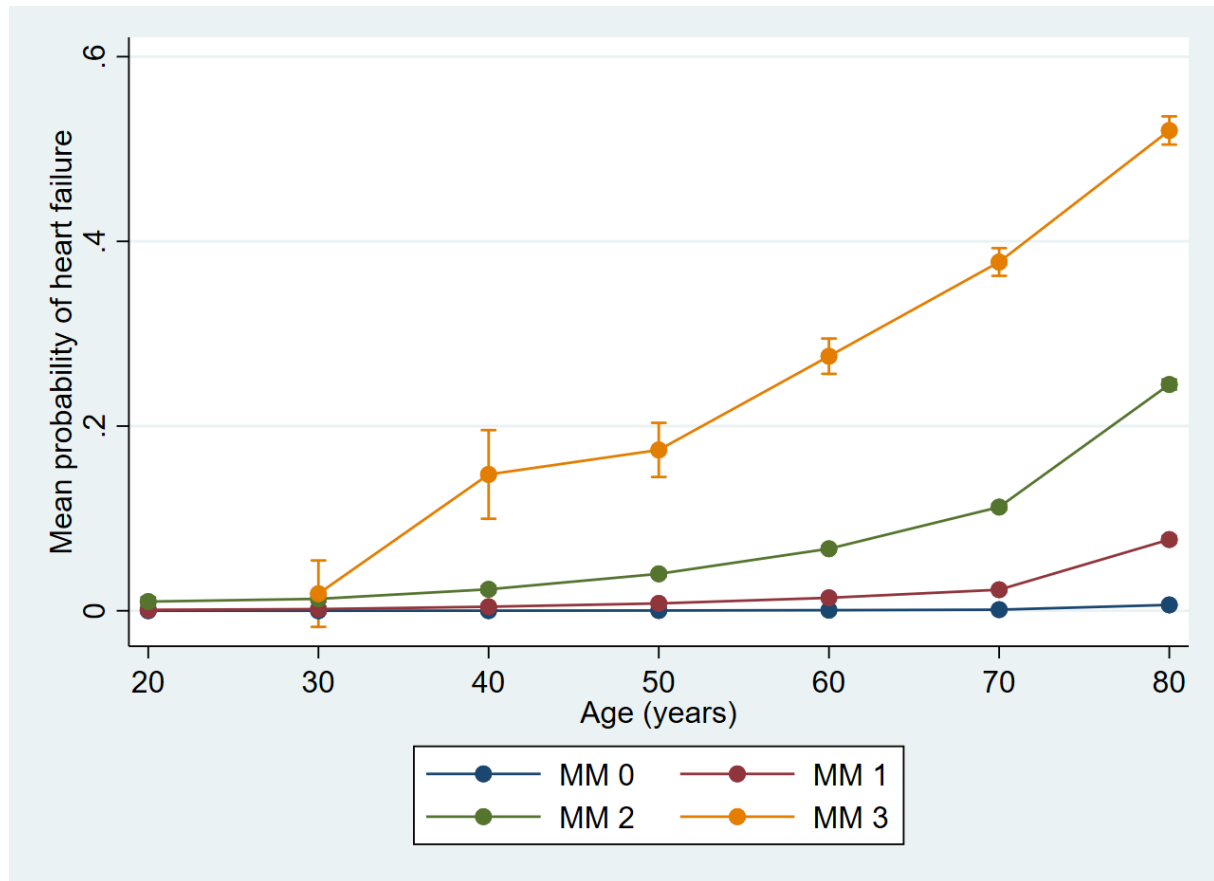


Fig. 2 The predicted mean probability of heart failure adjusted for different age groups and multimorbidity levels with 95% confidence intervals using Delta-method.

MM0= less than 2 chronic conditions (not multimorbid)

MM1= 2-4 chronic conditions

MM2 = 5-9 chronic conditions

MM3 = 10 or more chronic conditions

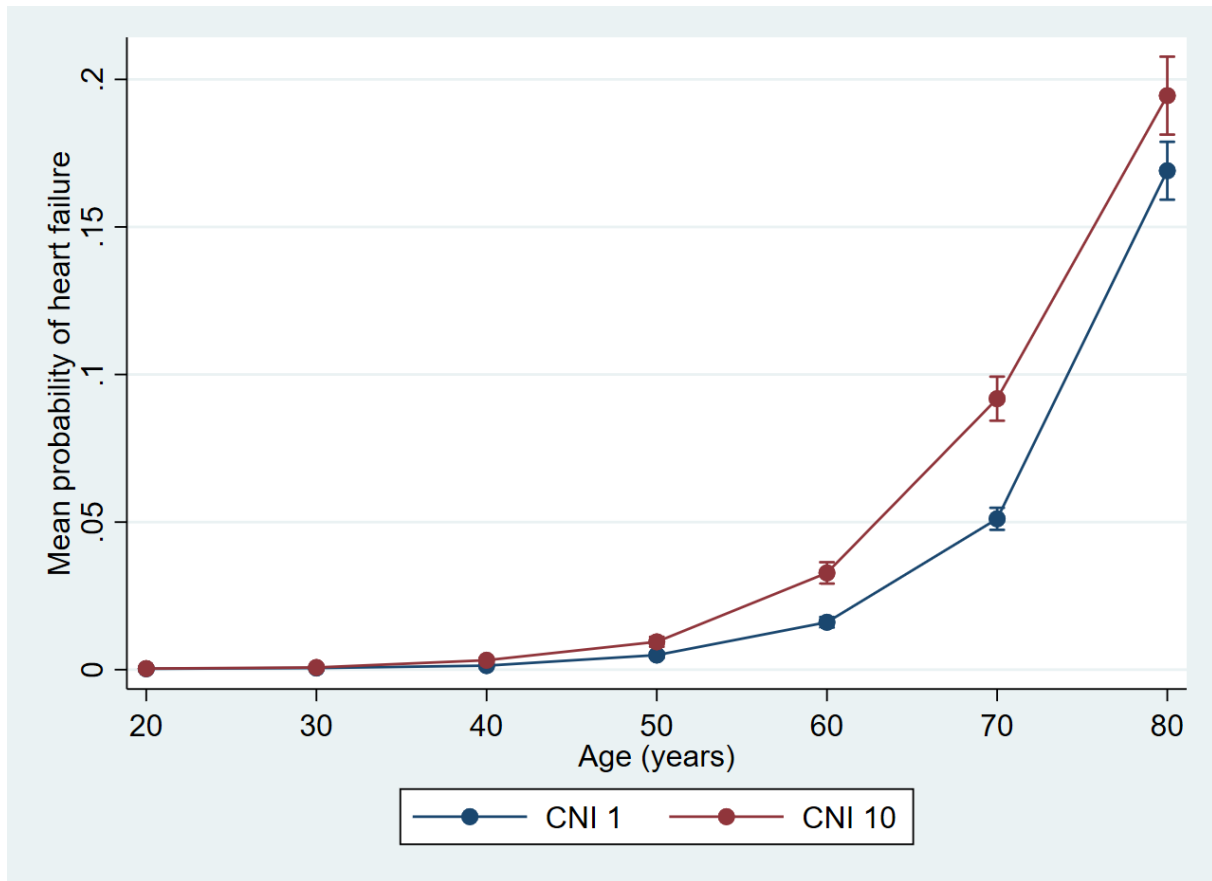


Fig 3. Disparities in the predicted mean probability of heart failure adjusted for age between the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95% confidence intervals using Delta-method.

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60STROBE 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

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Keywords:	Heart failure < CARDIOLOGY, EPIDEMIOLOGY, PRIMARY CARE, PUBLIC HEALTH, Adult cardiology < CARDIOLOGY

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3 1 **Disparities in prevalence of heart failure according to age, multimorbidity level and**
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6 2 **socioeconomic status in Southern Sweden: a cross-sectional study**
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12 4 Mia Scholten,¹ Patrik Midlöv,¹ Anders Halling¹
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22 7 **Correspondence to** Mia Scholten; Mia.Scholten@med.lu.se
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28 9 **Abstract**
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31 10 **Objective:** The aim of this study was to compare the prevalence of heart failure in relation to
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33 11 age, multimorbidity and socioeconomic status of primary health care centres in southern
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35 12 Sweden.
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39 13 **Design:** A cross-sectional study.
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42 14 **Setting:** The data were collected concerning diagnoses at each consultation in all primary
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44 15 health care centres and secondary health care in the southernmost county of Sweden at the end
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46 16 of 2015.
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50 17 **Participants:** The individuals living in southern Sweden in 2015 aged 20 years and older.
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52 18 The study population of 981383 inhabitants was divided into different categories including
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54 19 heart failure, multimorbidity, different levels of multimorbidity and into 10 CNI (Care Need
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56 20 Index) groups depending on the socioeconomic status of their listed primary health care
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3 22 **Outcomes:** Prevalence of heart failure was presented according to age, multimorbidity,
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5 23 multimorbidity level and socioeconomic status. Logistic regression was used to further
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7 24 analyse the associations between heart failure, age, multimorbidity level and socioeconomic
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9 25 status in more complex models.
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13 26 **Results:** The total prevalence of heart failure in the study population was 2.06%. The
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15 27 prevalence of heart failure increased with advancing age and the level of multimorbidity.
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17 28 99.07% of the patients with heart failure fulfilled the criteria for multimorbidity. The total
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19 29 prevalence of HF among the multimorbid patients was only 5.30%. Heart failure had a strong
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21 30 correlation with the socioeconomic status of the primary health care centres with the most
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23 31 significant disparity between 40 and 80 years of age: the prevalence of HF in primary health
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25 32 care centres with the most deprived CNI percentile was approximately twice as high as in the
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27 33 most affluent CNI percentile.
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32 34 **Conclusion:** The patients with heart failure were strongly associated with having
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34 35 multimorbidity. Heart failure patients was a small group of the multimorbid population
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36 36 associated with socioeconomic deprivation that challenges efficient preventive strategies and
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38 37 health policies.
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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, 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.

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56 41 **Introduction**
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9 42 Heart failure (HF) and multimorbidity (MM) are leading causes of morbidity, hospitalizations,
10 43 disability, and death in Western countries^{1 2}. The prevalence of heart failure and
11 44 multimorbidity increases with age and the cost of care and treatment constitutes a
12 45 considerable burden on primary health care and on health care as a whole¹. In high-income
13 46 countries, HF is the most common diagnosis in hospitalized elderly patients aged >65 years².
14 47 In Sweden, 31% of medical expenditures were spent for HF patients with reduced ejection
15 48 fraction (HFrEF) in primary health care, 29% for primary cardiac hospitalizations, and 40%
16 49 were for noncardiac hospitalizations³.

17 50 Heart failure is classified into three major groups: HF with reduced ejection fraction (HFrEF),
18 51 HF with midrange EF (HFmrEF), and HF with preserved ejection fraction (HFpEF)⁴. All
19 52 subtypes of HF have the same clinical phenotype⁵, but different pathophysiology and
20 53 prognosis⁶. The systolic failure or HFrEF (or systolic dysfunction) is established when the left
21 54 ventricle loses its ability to contract normally, resulting in EF < 40%. The heart cannot pump
22 55 with enough force to push enough blood into the circulation. HFrEF develops usually in
23 56 response to larger-scale myocyte loss/dysfunction, with the most common aetiologies
24 57 including acute myocardial infarction, genetic abnormalities, myocarditis or toxin effects (e.g.
25 58 alcohol or chemotherapy)⁷. Diagnosis of systolic dysfunction is easier than the diagnosis of
26 59 diastolic dysfunction due to the objective finding of reduced ejection fraction. HFmrEF shares
27 60 features with both HFrEF and HFpEF, including the aetiology, symptomatology, age of the
28 61 patients and comorbidities⁸. Four diagnostic criteria are simultaneously required for HFmrEF:
29 62 symptoms with or without signs of HF, LVEF of 40-49%. Elevated natriuretic peptides, and
30 63 relevant structural heart disease: left ventricle hypertrophy or left atrial enlargement or
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3 64 diastolic dysfunction⁹. HFpEF or diastolic HF (or diastolic dysfunction) is established when
4
5 65 the left ventricle loses its ability to relax normally, because the muscle has become stiff. The
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8 66 heart cannot properly fill with blood during the resting period between each beat. The
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10 67 pathophysiologic derangements in HFpEF include concentric remodelling, ventricular-
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12 68 vascular stiffening and loss of ventricular-vascular reserve function are resulted from chronic
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14
15 69 pressure overload due to arterial hypertension¹⁰. Diastolic heart failure has preserved ejection
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17 70 fraction with LVEF $\geq 50\%$, and is preferably found among elderly, women, and patients with
18
19 71 diabetes mellitus and hypertension¹¹⁻¹⁴.

22 72 Beside the risk factors like physical inactivity, obesity, chemotherapy, heritability and
23
24 73 hyperlipidaemia, which increases the incidence of heart failure, the incidence also varies with
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26
27 74 the patient's socioeconomic status (SES)¹⁵⁻²⁰. Higher income has previously been
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29
30 75 associated with a lower risk of developing heart failure²¹. Moreover, the risk factors for heart
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32 76 failure, such as hypertension and coronary heart disease, also vary with SES²². Heart failure is
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34
35 77 often a chronic complication of other cardiovascular comorbidities, particularly ischaemic
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37 78 heart disease, atrial fibrillation and valve dysfunctions²³. Due to improved medical
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39
40 79 management, the age-adjusted incidence and prevalence of HF are decreasing, and the HF
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42 80 patients have got prolonged life expectancy¹. Consequently, the absolute number of patients
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44 81 with HF has drastically increased, secondary to global ageing, as well as general population
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46 82 growth²⁴. Although reliable estimates for middle-income and low-income nations are lacking,
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48
49 83 evidence from the current literature suggests that HF is the fastest growing cardiovascular
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51 84 condition globally^{25 26}.

54 85 The aetiology of HF is diverse and varies geographically worldwide: High-income countries
55
56 86 are disproportionately affected by ischemic heart disease and COPD (chronic obstructive
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59 87 pulmonary disease) compared with low-income countries, which in turn are primarily affected
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3 88 by hypertensive heart disease, rheumatic heart disease, cardiomyopathy, and myocarditis²⁷.

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5 89 More than two-thirds of all cases of HF can be attributed to four underlying conditions:

6
7 90 ischaemic heart disease, COPD, hypertensive heart disease and rheumatic heart disease¹.

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10 91 HF is often a chronic condition with insidious symptoms at the onset, which could make early

11
12 92 and accurate diagnosis difficult. The diagnosis of heart failure requires three criteria to be

13
14 93 fulfilled: typical clinical symptoms, such as dyspnoea, fatigue, exertional intolerance and

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16 94 oedema of the lower body, elevated BNP value and objective findings of impaired cardiac

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18 95 function on echocardiography, myocardial scintigraphy, magnet resonance tomography or

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20 96 other imaging¹³.

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25 97 The aim of this study was to compare the prevalence of heart failure in relation to age,

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27 98 multimorbidity and socioeconomic status of primary health care centres in southern Sweden.

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32 33 34 100 **Methods**

35 36 37 101 **Setting and study population**

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40 102 Most residents in Sweden are listed at a primary health care centre, either a public or private

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42 103 health care centre. Scania is the southernmost county of Sweden with around 1.3 million

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44 104 inhabitants during year 2015²⁸. Approximately $\frac{1}{4}$ of the study population were born abroad²⁹.

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46 105 The biggest city in Scania is Malmö with about 320000 inhabitants during 2015, ranked as the

47
48 106 third largest city in Sweden²⁸. About $\frac{1}{3}$ of the residents in Malmö were born abroad

49
50 107 representing most countries in the world³⁰. Almost half of the residents in Malmö (48.40%)

51
52 108 were under 35 years during 2015³¹. The study population comprised individuals aged 20 years

53
54 109 and older living in Scania during the last week of 2015. This age cut-off was chosen because

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3 110 the types of heart failure affecting children and younger people are pathologically distinct
4
5 111 from those found in older adults.
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8 112 The study population was divided into age groups: 20, 30, 40, 50, 60, 70, 80+. The age group
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10 113 20 included inhabitants aged 20 to 29 years, the age group 30 included inhabitants aged 30 to
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12 114 39 years, and so on. The age group 80+ included all inhabitants from 80 years and over.
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19 116 **Data source and measurements**

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21
22 117 The data that was used in this study was retrieved from the County Council health care
23
24 118 register in Scania that contains anonymised registry information from the study population,
25
26 119 including age, gender, socioeconomic status and diagnostic data in the last week of 2015.
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30 120 The data were collected concerning diagnoses at each consultation in all primary health care
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32 121 centres and secondary health care. Diagnoses were recorded according the International
33
34 122 Statistical Classification of Diseases and Related Health Problems version 10 (ICD 10). Heart
35
36 123 failure was identified if the diagnosis code I50 was recorded, which comprised all subtypes of
37
38 124 HF. Totally 152 primary health care centres were operating during 2015 in Scania, with on
39
40 125 average 8587 listed patients (95% CI 7971.49 – 9292.88) including 133 patients with HF
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42 126 (95% CL 122.60 – 143.80) at each primary health care centre.
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50 128 **Multimorbidity**

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53 129 Multimorbidity (MM) was defined as coexistence of two or more chronic conditions in the
54
55 130 same person, independently if cardiovascular or not. To measure multimorbidity, we used a
56
57 131 method to identify chronic conditions developed by A Calderòn-Larrañaga *et al.* at the Aging
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1
2
3 132 Research Centre in Stockholm³². They analysed the full list of ICD-10 codes on a four-digit
4
5 133 level to define if a diagnosis is chronic or not in an elderly population. To determine if a
6
7 134 condition is chronic or not the following key features were identified and discussed
8
9
10 135 concerning their pertinence and suitability in older populations: duration, course, reversibility,
11
12 136 treatment, and consequences. They were then grouped into 60 groups of chronic conditions if
13
14 137 their duration exceeded 3 months. We applied their definition and list of chronic conditions to
15
16
17 138 estimate the multimorbidity in our study population. All information about diagnoses was
18
19 139 obtained from electronic medical record database in the county council in Scania.
20
21 140 Multimorbidity was then estimated by counting the number of chronic conditions in each
22
23
24 141 patient. To study the degree of MM in relation to the prevalence of HF, the patients were
25
26 142 further divided into groups MM0 (less than two chronic conditions), MM1 (two to four
27
28 143 chronic conditions), MM2 (five to nine chronic conditions) and MM3 (ten chronic conditions
29
30
31 144 or more).

146 **Socioeconomics**

147 We used the term Care Need Index (CNI)³³ to divide the primary health care centres into 10
148 groups depending on their socioeconomic status. CNI is based on different measures of a
149 group, in this case the patients listed to different primary health care centres in Scania. CNI 1
150 was assigned to those patients listed at primary health care centres who belonged to the most
151 socioeconomically affluent percentile, and CNI 10 was assigned to those patients listed at
152 primary health care centres who belonged to the most socioeconomically deprived
153 percentile³³.

155 **Statistical analyses**

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3 156 We analysed data from 981383 (about a tenth of the Swedish population) inhabitants aged 20
4
5 157 years and older living in Scania during the last week of 2015. Associations between the
6
7 158 variables were studied using univariate and multivariate statistics.

9
10 159 We used frequencies, percentages and cross tabulations for descriptive analysis. Logistic
11
12 160 regression was used to analyse the associations between the univariate and multivariate
13
14 161 models. Only the linear predications of the fully adjusted models were shown in the figures.

15
16 162 A p-value of < 0.05 was considered statistically significant. The predicted mean probability of
17
18 163 heart failure was calculated as average marginal effects using Delta-method.

19
20 164 We used STATA version 16.0 and 17.0 (Stata Corporation, Texas, USA) for statistical
21
22 165 analyses.

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24 166

25 26 167 **Patient and Public Involvement**

27
28 168 Data in the present study are based on anonymised information provided by the County
29
30 169 Council of Scania. They provided anonymised information for research purposes once the
31
32 170 study had been approved by the Ethics Committee at Lund University.

33
34 171 The study participants were not involved in the recruitment to the study by themselves. Due to
35
36 172 the requirement of anonymised data, each individual could not be asked for consent to
37
38 173 participate; active refusal of participation was instead applied. This was done by publishing
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40 174 information about the planned study in the Swedish local newspaper "Sydsvenskan". The
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42 175 advertisement outlined the study and contained information on how to contact the research
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44 176 manager (first author) to opt out of the study. The study results are published anonymised in
45
46 177 group level, and cannot be disseminated to every study participant.

178

179 **Results**

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

190

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

CNI percentiles	Age	N	Heartfailure (HF)				MM (%)	HF (%)	HF with MM (%)	MM with HF (%)
			No		Yes					
			MM	MM	MM	MM				
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
	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

1											
2											
3											
4		30	15 252	12212	3030	0	10	19.93	0.07	100.00	0.33
5		40	16 596	12045	4520	1	30	27.42	0.19	96.77	0.66
6		50	14 638	8843	5693	2	100	39.58	0.70	98.04	1.73
7		60	15 383	6310	8760	4	309	58.95	2.03	98.72	3.41
8		70	10 056	2269	7163	4	620	77.40	6.21	99.36	7.97
9		80	5 553	649	3903	8	993	88.17	18.03	99.20	20.28
10											
11	CNI 4	20	14 112	11835	2271	3	3	16.11	0.04	50.00	0.13
12		30	13 429	10665	2753	1	10	20.57	0.08	90.91	0.36
13		40	15 769	11417	4309	1	42	27.59	0.27	97.67	0.97
14		50	14 658	8622	5915	3	118	41.16	0.83	97.52	1.96
15		60	14 826	6017	8459	7	343	59.37	2.36	98.00	3.90
16		70	9 409	2221	6558	0	630	76.39	6.70	100.00	8.76
17		80	5 122	646	3493	6	977	87.27	19.19	99.39	21.86
18											
19	CNI 5	20	12 796	10794	2000	1	1	15.64	0.02	50.00	0.05
20		30	13 168	10455	2706	0	7	20.60	0.05	100.00	0.26
21		40	13 879	10028	3816	2	33	27.73	0.25	94.29	0.86
22		50	12 142	7171	4897	2	72	40.92	0.61	97.30	1.45
23		60	11 723	4870	6597	3	253	58.43	2.18	98.83	3.69
24		70	7 333	1704	5162	0	467	76.76	6.37	100.00	8.30
25		80	4 178	489	2884	3	802	88.22	19.27	99.63	21.76
26											
27	CNI 6	20	18 134	15365	2766	0	3	15.27	0.02	100.00	0.11
28		30	15 745	12638	3099	2	6	19.72	0.05	75.00	0.19
29		40	18 285	13316	4928	2	39	27.16	0.22	95.12	0.79
30		50	16 530	9833	6588	2	107	40.50	0.66	98.17	1.60
31		60	16 438	6943	9163	5	327	57.73	2.02	98.49	3.45
32		70	11 457	2667	8171	4	615	76.69	5.40	99.35	7.00
33		80	6 894	940	4845	6	1103	86.28	16.09	99.46	18.54
34											
35	CNI 7	20	18 045	15624	2411	1	9	13.41	0.06	90.00	0.37
36		30	14 656	11977	2669	1	9	18.27	0.07	90.00	0.34
37		40	14 400	10590	3777	2	31	26.44	0.23	93.94	0.81
38		50	12 597	7597	4907	4	89	39.66	0.74	95.70	1.78
39		60	13 119	5696	7147	5	271	56.54	2.10	98.19	3.65
40		70	8 930	2194	6193	1	542	75.42	6.08	99.82	8.05
41		80	5 569	788	3788	5	988	85.76	17.83	99.50	20.69
42											
43	CNI 8	20	22 405	18803	3597	1	4	16.07	0.02	80.00	0.11
44		30	21 019	16659	4341	0	19	20.74	0.09	100.00	0.44
45		40	19 268	13828	5395	2	43	28.22	0.23	95.56	0.79
46		50	17 755	10435	7175	7	138	41.19	0.82	95.17	1.89
47		60	17 014	7233	9435	3	343	57.47	2.03	99.13	3.51
48		70	10 651	2616	7388	4	643	75.40	6.07	99.38	8.01
49		80	6 039	838	4189	7	1005	86.01	16.76	99.31	19.35
50											
51	CNI 9	20	23 116	19785	3328	1	2	14.41	0.01	66.67	0.06
52		30	21 531	17553	3967	2	9	18.47	0.05	81.82	0.23
53		40	16 388	12072	4277	1	38	26.33	0.24	97.44	0.88
54		50	14 812	8881	5828	2	101	40.03	0.70	98.06	1.70
55		60	12 646	5696	6616	2	332	54.94	2.64	99.40	4.78
56		70	8 915	2342	6013	4	556	73.68	6.28	99.29	8.46
57		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	

192

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

195 MM (%) = total prevalence of multimorbidity

196 HF (%) = total prevalence of heart failure

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

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

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200

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

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3 212 If we consider the prevalence of heart failure in different levels of multimorbidity: 19.19%
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5 213 (3875 patients) of all patients with HF belonged to the MM1 group, 58.18% (11748 patients)
6
7 214 belonged to the MM2 group and 21.70% (4382 patients) belonged to the MM3 group. The
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9 215 MM2 group as a whole was more than nine times larger than the MM3 group (105241 vs
10
11 216 11156 patients).

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13
14 217
15
16 218 The prevalence of heart failure had a strong correlation with the SES of the primary health
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18 219 care centres (Figure 2). The most significant disparity was between 40 and 80 years of age:
19
20 220 the prevalence of HF in primary health care centres with the most deprived CNI percentile
21
22 221 was significantly increased and approximately twice as high as in the most affluent CNI
23
24 222 percentile (Table 1). Although at much lower levels, significant disparities in prevalence of
25
26 223 HF could be observed when comparing the most deprived CNI percentile with other CNI
27
28 224 percentiles of the primary health care centres. The primary health care centres with the most
29
30 225 deprived CNI percentile had the highest prevalence of HF from 40 years of age, although their
31
32 226 prevalence of MM was lowest from 70 years of age. In contrast, the prevalence of HF in the
33
34 227 most affluent CNI percentile remained relatively low in most age groups, even from 60 years
35
36 228 of age as their prevalence of MM became highest (Table 1). Only 4.58% of the multimorbid
37
38 229 individuals belonging to this CNI percentile had HF, which was lowest compared to the more
39
40 230 deprived CNI percentiles. The association between the prevalence of HF and CNI percentiles
41
42 231 followed different patterns compared to MM as shown in Table 1.

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51 52 53 233 **Discussion**

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56 234 The total prevalence of heart failure was about 2% in Scania during 2015, which was the same
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58 235 as the prevalence in Sweden and other Western countries^{34 35}. A large part of the patients has
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3 236 HF diagnosis from primary- and secondary care, in both cases diagnosed following the
4
5 237 diagnosis criteria for HF according to ESC (European Society of Cardiology) guidelines.
6
7 238 Heart failure was a rare disease under 40 years of age and increased substantially with
8
9 239 advancing age. 99.07% of the patients with HF in our study population had multimorbidity,
10
11 240 which could be explained by the diagnosis HF mostly constitutes a complication of other
12
13 241 cardiovascular conditions^{23 36}. Multimorbidity was present in 38.40% of the study population,
14
15 242 but included only 5.30% patients with HF. The high prevalence of MM could be explained by
16
17 243 the socioeconomic difference within the study population and the considerable part of elderly
18
19 244 with high prevalence of MM. With increasing level of multimorbidity, the prevalence of HF
20
21 245 increased from 1.49% in the MM1(2-4 chronic conditions) group to 39.28% in the MM3
22
23 246 (more than 10 chronic conditions) group. The MM3 group had fewer patients, but a higher
24
25 247 prevalence of HF than the MM2 group, which makes us to believe that the MM3 group had a
26
27 248 higher mortality in general.

28
29 249 The patients are mostly listed at a primary health care centre close to their place of living.
30
31 250 Most primary health care centres are public and organised similarly irrespective of CNI. The
32
33 251 socioeconomic boundaries are quite sharp and agree with uptake areas of the different primary
34
35 252 health care centres. The CNI category was an average socioeconomic level of the patients
36
37 253 listed at the primary health care centres.

38
39 254 The prevalence of HF also had a strong association with the SES of primary health care
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41 255 centres with the most significant disparity between 40 and 80 years of age: the prevalence of
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43 256 HF in primary health care centres with the most deprived CNI percentile was approximately
44
45 257 twice as high as in the most affluent CNI percentile. The fact that the prevalence of HF was
46
47 258 highest from 40 years of age in the most deprived CNI percentile of primary health care
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49 259 centres indicates that HF is a disease associated with socioeconomic deprivation. The
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3 260 correlation was assessed visually as the difference in prevalence of HF was obvious between
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5 261 the most affluent and deprived CNI percentiles.
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8 262 The individuals listed at primary health care centres with deprived CNI percentiles were more
9
10 263 likely to have high proportion of inhabitants younger than 40 years, and the opposite were
11
12 264 true for primary health care centres with affluent CNI percentiles. The primary health care
13
14 265 centres with the most deprived CNI percentile had the lowest proportion of population
15
16 266 (33.25%) from 50 years and the highest prevalence of HF from 40 years of age compared to
17
18 267 the more affluent population, which makes us to suspect that they suffered from SES related
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20 268 multimorbidity with worse prognosis, including HF.
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25 269 Heart failure is common in multimorbid patients with COPD (chronic obstructive pulmonary
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27 270 disease)³⁷, with prevalence in 33.2% of women and 35.7% of men over 80 years of age³⁸. In
28
29 271 most countries, low SES is associated with higher prevalence of COPD and mortality³⁹. The
30
31 272 estimated mortality in patients with COPD and coexisting heart failure was seven times higher
32
33 273 than in patients with COPD alone, thus the patients with these two conditions were reported
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35 274 with the highest mortality among patients hospitalized with COPD exacerbation⁴⁰. Other
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37 275 conditions with high impact on mortality in patients with HF including stroke, renal disease
38
39 276 and diabetes mellitus⁴¹, are strongly associated with low SES as well⁴²⁻⁴⁴.
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44 277 With respect to the global burden of ischaemic heart disease, the incidence of acute
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46 278 myocardial infarction worldwide is highest in Eastern Europe and Central Asia⁴⁵. Compared
47
48 279 to the Swedish population, the first-generation immigrants from Iraq and Bosnia had the
49
50 280 highest incidence of HF, probably due to a higher incidence of coronary heart disease⁴. When
51
52 281 this incidence of HF was further adjusted for SES, marital status and educational level, the
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54 282 hazard ratio for HF raised significantly compared to the immigrants from other countries. As
55
56 283 many of these immigrants are socioeconomically highly disadvantaged in Sweden, these
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3 284 results support our findings. Interestingly, the HF risk pattern among the second-generation
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5 285 immigrants in most cases differed only marginally compared to their Swedish counterparts,
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7 286 indicating that their risk factor is not purely genetic, rather responsive to other factors⁴.
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10 287 A similar study in Scotland revealed that older people typically have more morbidities with
11
12 288 lower functional status, whereas younger people are more often affected by combinations
13
14 289 physical and mental health disorders. Except that the most affluent population being on
15
16 290 average 2-5 years older at onset of morbidity (dependent on the disorder), conditions like
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18 291 coronary heart disease, diabetes mellitus, COPD, depression, painful disorders or cancer were
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20 292 more common in people living in deprived areas⁴⁶. This could explain that people in the
21
22 293 affluent areas suffered from multimorbidity with less disability and had better prognosis.
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27 294 We do not know if multimorbidity causes socioeconomic deprivation or if low socioeconomic
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29 295 status causes multimorbidity. There is presumably an impact in both directions. Many people
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31 296 with multimorbidity do retire earlier, and have more socioeconomic consequences than the
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33 297 working population. Statistically, this group degrades in the socioeconomic status, which even
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35 298 may influence their family members. On the other hand, many people in the deprived areas
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37 299 have to accept a job which is more health challenging, and become multimorbid many years
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39 300 earlier than the affluent population.
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46 47 302 **Strengths and limitations**

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49
50 303 Our study has a number of strengths. Our large cohort with almost 1 million inhabitants
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52 304 included all patients with HF and MM in Scania during the study period, which increases the
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54 305 validity of our results. The outcome data were based on clinical diagnoses registered by
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56 306 physicians, rather than self-reported data, which eliminated any recall bias. Our findings have
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3 307 similarities with correlative studies in other countries^{21 23}, which increases the credibility of
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5 308 our results.

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8 309 This study has certain limitations. We had no data on several risk factors for heart failure,
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10 310 such as smoking, obesity or physical inactivity. However, some prior works on SES and heart
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12 311 failure had adjusted for smoking and physical inactivity and still found an independent
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14 312 association²¹. We had no results of echocardiography, and thus could not analyse the subtypes
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16 313 of heart failure in our study population. As heart failure has none-specific symptoms at the
17
18 314 onset, we suspect that many people were underdiagnosed regarding this condition. Those
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20 315 patients with HF belonging to the MM0 group were probably underdiagnosed as well,
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22 316 because HF usually constitutes a complication of other diseases or treatments. Many patients
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24 317 have diagnoses that are usually neglected by the patients and staff in the health care, because
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26 318 these do not impair their quality of life or prognosis, which constitutes a consistent error
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28 319 source to our statistics. We had no data on the severity of HF and other conditions, which
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30 320 have high impact on the mortality. We had no data on the quality of health care in the
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32 321 neighbourhood. Our results could be more accurate if the age group 80+ were divided into age
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34 322 group 80 and 90+, and analysed separately.

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42 43 44 324 **Conclusion**

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47 325 The prevalence of heart failure was strongly associated with multimorbidity, with increasing
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49 326 prevalence of HF with multimorbidity level. The patients listed at primary health care centres
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51 327 with the most socioeconomic deprived CNI percentile had a significantly elevated risk of
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53 328 developing HF and probably multimorbidity with worse prognosis, which resulted in the
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55 329 lowest proportion of population from 50 years compared to the more affluent population in
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3 330 our study. HF patients was a small group of the multimorbid population associated with
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5 331 socioeconomic deprivation that challenges efficient preventive strategies and health policies.
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10 11 12 333 **Acknowledgements**

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14
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16
17 335 are indebted to Patrick Reilly for his expertise and invaluable advice in proofreading the
18
19 336 manuscript.
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24 25 26 338 **Footnotes**

27 28 29 339 **Contributorship statement**

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31
32 340 In accordance with the Vancouver Protocol, AH was involved in data collection, design of the
33
34 341 study, data analysis, editing the manuscript and student supervision. MS contributed with data
35
36 342 collection, data analysis, writing and editing the manuscript. PM provided critical comment
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38 343 and feedback on the manuscript.
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44 45 46 345 **Competing interests**

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50 51 52 347 **Statement of funding**

53
54 348 This research received no specific grant from any funding agency in the public, commercial or
55
56 349 not-for-profit sectors.
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60 61 62 349 **Data sharing statement**

350 No further data available.

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

353 **Availability of data and material**

354 No further data available.

355 **Statement of Ethics**

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

359 **References**

- 360 [dataset]1. Ziaieian B, Fonarow GC. Epidemiology and aetiology of heart failure. *Nat Rev*
361 *Cardiol* 2016;13(6):368-78. doi: 10.1038/nrcardio.2016.25 [published Online First:
362 2016/03/05]
- 363 [dataset]2. Braunwald E. The war against heart failure: the Lancet lecture. *Lancet*
364 2015;385(9970):812-24. doi: 10.1016/s0140-6736(14)61889-4 [published Online
365 First: 2014/12/04]
- 366 [dataset]3. Mejhert M, Lindgren P, Schill O, et al. Long term health care consumption and
367 cost expenditure in systolic heart failure. *Eur J Intern Med* 2013;24(3):260-5. doi:
368 10.1016/j.ejim.2012.11.015 [published Online First: 2012/12/28]
- 369 [dataset]4. Wandell P, Carlsson AC, Li X, et al. Heart failure in immigrant groups: a cohort
370 study of adults aged 45 years and over in Sweden. *Scand Cardiovasc J*
371 2018;52(6):292-300. doi: 10.1080/14017431.2018.1546892 [published Online First:
372 2018/11/18]
- 373 [dataset]5. Borlaug BA, Redfield MM. Diastolic and systolic heart failure are distinct
374 phenotypes within the heart failure spectrum. *Circulation* 2011;123(18):2006-13;
375 discussion 14. doi: 10.1161/circulationaha.110.954388 [published Online First:
376 2011/05/11]
- 377 [dataset]6. Aziz F, Tk LA, Enweluzo C, et al. Diastolic heart failure: a concise review. *J Clin*
378 *Med Res* 2013;5(5):327-34. doi: 10.4021/jocmr1532w [published Online First:
379 2013/08/30]
- 380 [dataset]7. Hunt SA, Abraham WT, Chin MH, et al. 2009 focused update incorporated into
381 the ACC/AHA 2005 Guidelines for the Diagnosis and Management of Heart Failure in
382 Adults: a report of the American College of Cardiology Foundation/American Heart
383 Association Task Force on Practice Guidelines: developed in collaboration with the
384 International Society for Heart and Lung Transplantation. *Circulation*

- 1
2
3 385 2009;119(14):e391-479. doi: 10.1161/circulationaha.109.192065 [published Online
4 386 First: 2009/03/28]
5 387 [dataset]8. Savarese G, Stolfo D, Sinagra G, et al. Heart failure with mid-range or mildly
6 388 reduced ejection fraction. *Nat Rev Cardiol* 2021;1-17. doi: 10.1038/s41569-021-
7 389 00605-5 [published Online First: 2021/09/08]
8 390 [dataset]9. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis
9 391 and treatment of acute and chronic heart failure: The Task Force for the diagnosis and
10 392 treatment of acute and chronic heart failure of the European Society of Cardiology
11 393 (ESC). Developed with the special contribution of the Heart Failure Association
12 394 (HFA) of the ESC. *Eur J Heart Fail* 2016;18(8):891-975. doi: 10.1002/ejhf.592
13 395 [published Online First: 2016/05/22]
14 396 [dataset]10. Lakatta EG. Cardiovascular regulatory mechanisms in advanced age. *Physiol Rev*
15 397 1993;73(2):413-67. doi: 10.1152/physrev.1993.73.2.413 [published Online First:
16 398 1993/04/01]
17 399 [dataset]11. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the
18 400 management of heart failure: a report of the American College of Cardiology
19 401 Foundation/American Heart Association Task Force on practice guidelines.
20 402 *Circulation* 2013;128(16):e240-327. doi: 10.1161/CIR.0b013e31829e8776 [published
21 403 Online First: 2013/06/07]
22 404 [dataset]12. Andersson C, Vasan RS. Epidemiology of heart failure with preserved ejection
23 405 fraction. *Heart Fail Clin* 2014;10(3):377-88. doi: 10.1016/j.hfc.2014.04.003
24 406 [published Online First: 2014/07/01]
25 407 [dataset]13. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the
26 408 diagnosis and treatment of acute and chronic heart failure: The Task Force for the
27 409 diagnosis and treatment of acute and chronic heart failure of the European Society of
28 410 Cardiology (ESC) Developed with the special contribution of the Heart Failure
29 411 Association (HFA) of the ESC. *Eur Heart J* 2016;37(27):2129-200. doi:
30 412 10.1093/eurheartj/ehw128 [published Online First: 2016/05/22]
31 413 [dataset]14. Garcia M, Mulvagh SL, Merz CN, et al. Cardiovascular Disease in Women:
32 414 Clinical Perspectives. *Circ Res* 2016;118(8):1273-93. doi:
33 415 10.1161/circresaha.116.307547 [published Online First: 2016/04/16]
34 416 [dataset]15. Agunbiade TA, Zaghlol RY, Barac A. Heart Failure in Relation to Anthracyclines
35 417 and Other Chemotherapies. *Methodist Debaquey Cardiovasc J* 2019;15(4):243-49. doi:
36 418 10.14797/mdcj-15-4-243 [published Online First: 2020/01/29]
37 419 [dataset]16. Halldin AK, Schaufelberger M, Lernfelt B, et al. Obesity in Middle Age
38 420 Increases Risk of Later Heart Failure in Women-Results From the Prospective
39 421 Population Study of Women and H70 Studies in Gothenburg, Sweden. *J Card Fail*
40 422 2017;23(5):363-69. doi: 10.1016/j.cardfail.2016.12.003 [published Online First:
41 423 2016/12/13]
42 424 [dataset]17. Lindgren MP, PirouziFard M, Smith JG, et al. A Swedish Nationwide Adoption
43 425 Study of the Heritability of Heart Failure. *JAMA Cardiology* 2018;3(8):703-10. doi:
44 426 10.1001/jamacardio.2018.1919
45 427 [dataset]18. Hawkins NM, Jhund PS, McMurray JJ, et al. Heart failure and socioeconomic
46 428 status: accumulating evidence of inequality. *Eur J Heart Fail* 2012;14(2):138-46. doi:
47 429 10.1093/eurjhf/hfr168 [published Online First: 2012/01/19]
48 430 [dataset]19. Ramsay SE, Whincup PH, Papacosta O, et al. Inequalities in heart failure in older
49 431 men: prospective associations between socioeconomic measures and heart failure
50 432 incidence in a 10-year follow-up study. *European heart journal* 2014;35(7):442-47.
51 433 doi: 10.1093/eurheartj/eh449
52
53
54
55
56
57
58
59
60

- 1
2
3 434 [dataset]20. Halldin AK, Lissner L, Lernfelt B, et al. Impact of changes in physical activity or
4 435 BMI on risk of heart failure in women - the prospective population study of women in
5 436 Gothenburg. *Scand J Prim Health Care* 2020;38(1):56-65. doi:
6 437 10.1080/02813432.2020.1717083 [published Online First: 2020/02/01]
- 7
8 438 [dataset]21. Akwo EA, Kabagambe EK, Harrell FE, Jr., et al. Neighborhood Deprivation
9 439 Predicts Heart Failure Risk in a Low-Income Population of Blacks and Whites in the
10 440 Southeastern United States. *Circ Cardiovasc Qual Outcomes* 2018;11(1):e004052.
11 441 doi: 10.1161/circoutcomes.117.004052 [published Online First: 2018/01/11]
- 12 442 [dataset]22. Carlsson AC, Li X, Holzmann MJ, et al. Neighbourhood socioeconomic status
13 443 and coronary heart disease in individuals between 40 and 50 years. *Heart*
14 444 2016;102(10):775-82. doi: 10.1136/heartjnl-2015-308784 [published Online First:
15 445 2016/02/13]
- 16
17 446 [dataset]23. Taylor CJ, Ryan R, Nichols L, et al. Survival following a diagnosis of heart
18 447 failure in primary care. *Fam Pract* 2017;34(2):161-68. doi: 10.1093/fampra/cmw145
19 448 [published Online First: 2017/02/01]
- 20 449 [dataset]24. Roth GA, Forouzanfar MH, Moran AE, et al. Demographic and epidemiologic
21 450 drivers of global cardiovascular mortality. *N Engl J Med* 2015;372(14):1333-41. doi:
22 451 10.1056/NEJMoa1406656 [published Online First: 2015/04/02]
- 23 452 [dataset]25. Bennett DA, Elias TK, Forbes A, et al. Study protocol: systematic review of the
24 453 burden of heart failure in low- and middle-income countries. *Syst Rev* 2012;1:59. doi:
25 454 10.1186/2046-4053-1-59 [published Online First: 2012/11/30]
- 26 455 [dataset]26. Banerjee A, Mendis S. Heart failure: the need for global health perspective. *Curr*
27 456 *Cardiol Rev* 2013;9(2):97-8. doi: 10.2174/1573403x11309020001 [published Online
28 457 First: 2013/05/25]
- 29 458 [dataset]27. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for
30 459 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the
31 460 Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2163-96. doi:
32 461 10.1016/s0140-6736(12)61729-2 [published Online First: 2012/12/19]
- 33 462 [dataset]28. Statistics Sweden y. Population by region, marital status, sex and year [internet].
34 463 Statistics Sweden; [cited 2021 Mar 31]. Available from:
35 464 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/)
36 465 [A/BefolkningNy/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/).
- 37 466 [dataset]29. Statistics Sweden y. Population by region, age, sex, region of birth and year
38 467 [internet]. Statistics Sweden; [cited 2021 Mar 30]. Available from:
39 468 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_E/InrUtrFoddaRegAlKon/table/tableViewLayout1/)
40 469 [E/InrUtrFoddaRegAlKon/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_E/InrUtrFoddaRegAlKon/table/tableViewLayout1/).
- 41 470 [dataset]30. Statistics Sweden y. Population by region, sex, region of birth and year [internet].
42 471 Statistics Sweden; [cited 2021 Mar 29]. Available from:
43 472 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_E/InrUtrFoddaRegAlKon/table/tableViewLayout1/)
44 473 [E/InrUtrFoddaRegAlKon/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_E/InrUtrFoddaRegAlKon/table/tableViewLayout1/).
- 45 474 [dataset]31. Statistics Sweden y. Population by region, marital status, age, sex and year
46 475 [internet]. Statistics Sweden; [cited 2021 Mar 28]. Available from:
47 476 [http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/)
48 477 [A/BefolkningNy/table/tableViewLayout1/](http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101_A/BefolkningNy/table/tableViewLayout1/).
- 49 478 [dataset]32. Calderon-Larranaga A, Vetrano DL, Onder G, et al. Assessing and Measuring
50 479 Chronic Multimorbidity in the Older Population: A Proposal for Its
51 480 Operationalization. *J Gerontol A Biol Sci Med Sci* 2017;72(10):1417-23. doi:
52 481 10.1093/gerona/glw233 [published Online First: 2016/12/23]
- 53
54
55
56
57
58
59
60

- 1
2
3 482 [dataset]33. Sundquist K, Malmström M, Johansson S-E, et al. Care Need Index, a useful tool
4 483 for the distribution of primary health care resources. *Journal of Epidemiology and*
5 484 *Community Health* 2003;57(5):347-52. doi: 10.1136/jech.57.5.347
- 6
7 485 [dataset]34. Zarrinkoub R, Wettermark B, Wandell P, et al. The epidemiology of heart failure,
8 486 based on data for 2.1 million inhabitants in Sweden. *Eur J Heart Fail* 2013;15(9):995-
9 487 1002. doi: 10.1093/eurjhf/hft064 [published Online First: 2013/05/07]
- 10
11 488 [dataset]35. Savarese G, D'Amaro D. Sex Differences in Heart Failure. *Adv Exp Med Biol*
12 489 2018;1065:529-44. doi: 10.1007/978-3-319-77932-4_32 [published Online First:
13 490 2018/07/28]
- 14
15 491 [dataset]36. Gimeno-Miguel A, Gracia Gutiérrez A, Poblador-Plou B, et al. Multimorbidity
16 492 patterns in patients with heart failure: an observational Spanish study based on
17 493 electronic health records. *BMJ Open* 2019;9(12):e033174. doi: 10.1136/bmjopen-
18 494 2019-033174 [published Online First: 2019/12/26]
- 19
20 495 [dataset]37. Rutten FH, Cramer MJ, Grobbee DE, et al. Unrecognized heart failure in elderly
21 496 patients with stable chronic obstructive pulmonary disease. *Eur Heart J*
22 497 2005;26(18):1887-94. doi: 10.1093/eurheartj/ehi291 [published Online First:
23 498 2005/04/30]
- 24
25 499 [dataset]38. Almagro P, Calbo E, de Echaguién AO, et al. Mortality after hospitalization for
26 500 COPD. *Chest* 2002;121(5):1441-48.
- 27
28 501 [dataset]39. Pleasants RA, Riley IL, Mannino DM. Defining and targeting health disparities in
29 502 chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis*
30 503 2016;11:2475-96. doi: 10.2147/copd.S79077 [published Online First: 2016/10/28]
- 31
32 504 [dataset]40. Kaszuba E, Odeberg H, Råstam L, et al. Heart failure and levels of other
33 505 comorbidities in patients with chronic obstructive pulmonary disease in a Swedish
34 506 population: a register-based study. *BMC research notes* 2016;9(1):215.
- 35
36 507 [dataset]41. Joffe SW, Webster K, McManus DD, et al. Improved survival after heart failure:
37 508 a community-based perspective. *J Am Heart Assoc* 2013;2(3):e000053. doi:
38 509 10.1161/jaha.113.000053 [published Online First: 2013/05/17]
- 39
40 510 [dataset]42. Vart P, Grams ME, Ballew SH, et al. Socioeconomic status and risk of kidney
41 511 dysfunction: the Atherosclerosis Risk in Communities study. *Nephrol Dial Transplant*
42 512 2019;34(8):1361-68. doi: 10.1093/ndt/gfy142 [published Online First: 2018/06/14]
- 43
44 513 [dataset]43. Marshall IJ, Wang Y, Crichton S, et al. The effects of socioeconomic status on
45 514 stroke risk and outcomes. *Lancet Neurol* 2015;14(12):1206-18. doi: 10.1016/s1474-
46 515 4422(15)00200-8 [published Online First: 2015/11/20]
- 47
48 516 [dataset]44. Wändell P, Carlsson AC, Gasevic D, et al. Neighbourhood socio-economic status
49 517 and all-cause mortality in adults with atrial fibrillation: A cohort study of patients
50 518 treated in primary care in Sweden. *Int J Cardiol* 2016;202:776-81. doi:
51 519 10.1016/j.ijcard.2015.09.027 [published Online First: 2015/10/17]
- 52
53 520 [dataset]45. Moran AE, Forouzanfar MH, Roth GA, et al. The global burden of ischemic heart
54 521 disease in 1990 and 2010: the Global Burden of Disease 2010 study. *Circulation*
55 522 2014;129(14):1493-501. doi: 10.1161/circulationaha.113.004046 [published Online
56 523 First: 2014/02/28]
- 57
58 524 [dataset]46. Barnett K, Mercer SW, Norbury M, et al. Epidemiology of multimorbidity and
59 525 implications for health care, research, and medical education: a cross-sectional study.
60 526 *Lancet* 2012;380(9836):37-43. doi: 10.1016/s0140-6736(12)60240-2 [published
527 Online First: 2012/05/15]

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3 530 **Figure legends**
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5 531 Figure 1. The predicted mean probability of heart failure adjusted for different age groups and
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7 532 multimorbidity levels with 95% confidence intervals using Delta methods.
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10 533 MM0= less than 2 chronic conditions (not multimorbid)
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26 538 Figure 2. Disparities in the predicted mean probability of heart failure adjusted for age
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28 539 between the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile
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30 540 with 95% confidence intervals using Delta methods.
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36 542 Wordcount for the abstract 297, and the body text of the manuscript 3414.
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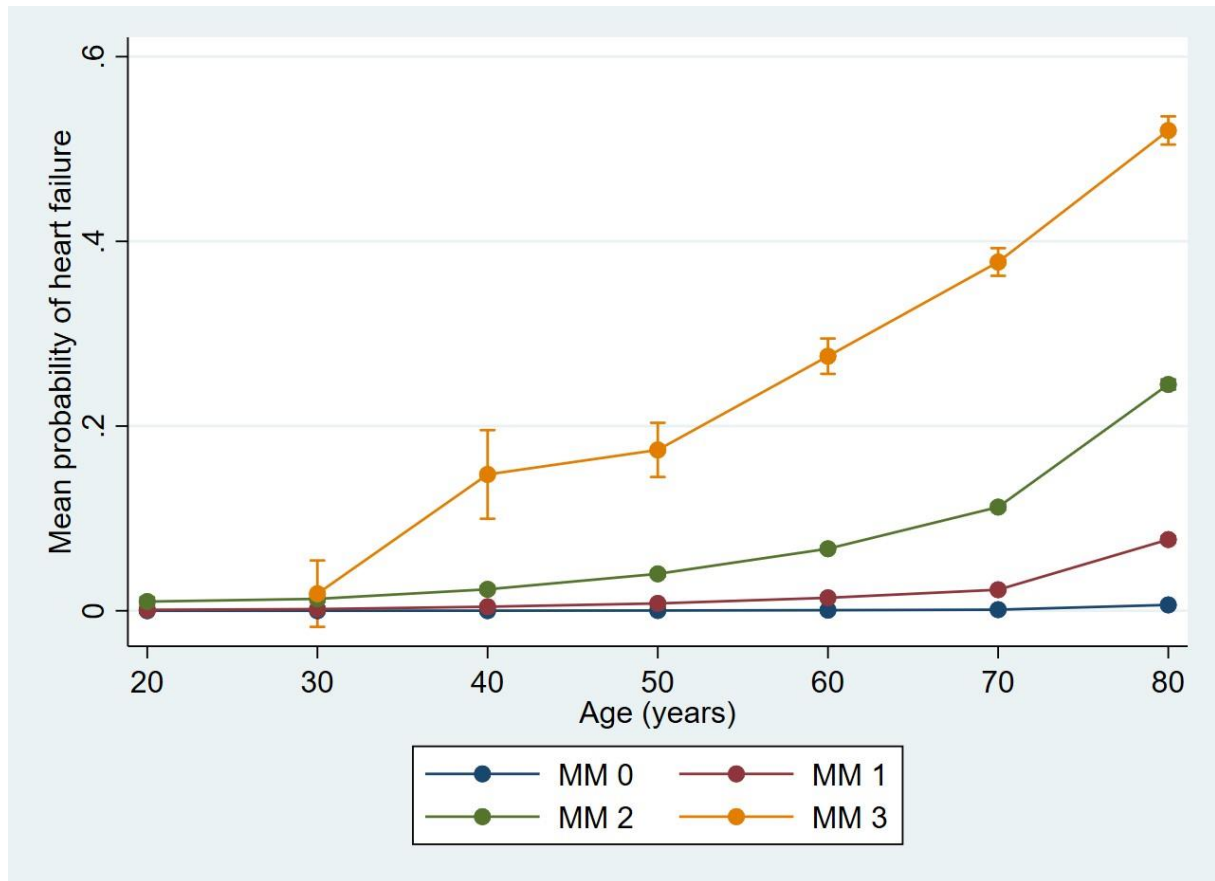


Figure 1. The predicted mean probability of heart failure adjusted for different age groups and multimorbidity levels with 95% confidence intervals using Delta-method.

MM0= less than 2 chronic conditions (not multimorbid)

MM1= 2-4 chronic conditions

MM2 = 5-9 chronic conditions

MM3 = 10 or more chronic conditions

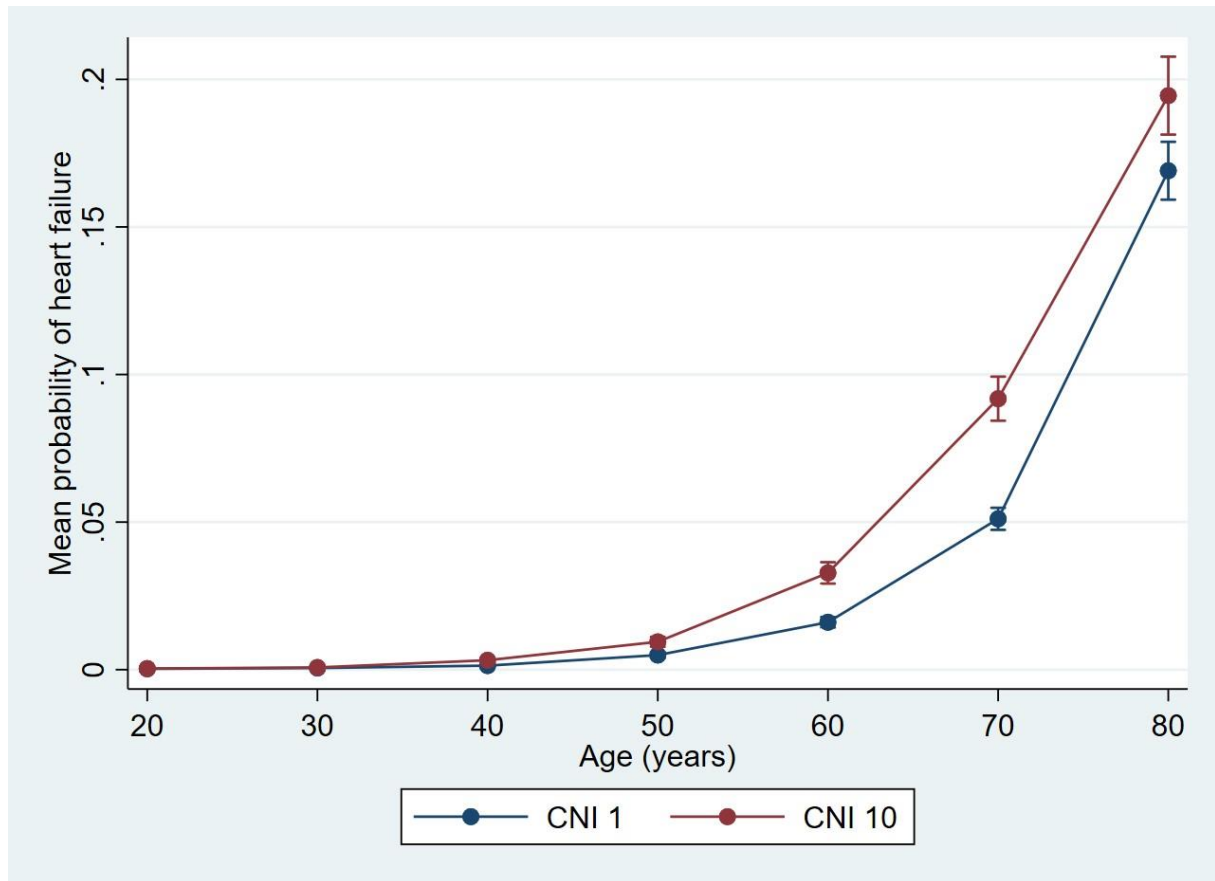


Figure 2. Disparities in the predicted mean probability of heart failure adjusted for age between the most affluent (CNI 1) and deprived (CNI 10) CNI (Care Need Index) percentile with 95% confidence intervals using Delta-method.

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.