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Influence of socio-economic status on the referral process to cardiac rehabilitation following acute coronary syndrome : a cross-sectional study

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57 24 **Word count:** 2303 words
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25 Abstract

26 **Objective:** to assess socio-economic predictors for referral to CR after incident ACS by dividing the entire
27 referral process into three phases (1. informed about CR, 2. willingness to participate in CR, and 3.
28 assigned CR setting).

29 **Design:** Cross-sectional study

30 **Setting:** Department of Cardiology at a Danish University Hospital from 1 January 2011 to 31 December
31 2014

32 **Participants:** A total of 1229 patients assessed for CR during hospitalisation with ACS were
33 prospectively registered in the Rehab-North Register from 2011-2014. Socio-economic status (SES) was
34 assessed using data from national registers, concerning: personal income, occupational status,
35 educational level, and civil status. Patients were excluded if in one of the following criteria were fulfilled: 1)
36 missing data on SES, or 2) acceptable reason for not informing patients about CR, including treatment with
37 coronary artery bypass graft, transfer to another hospital, still under treatment, or death.

38 **Main outcome measures:** Outcomes were defined by dividing the referral process into three phases: 1.
39 being informed about CR, 2. willingness to participate, and 3. assigned CR setting (in-hospital
40 /community centre) after ACS.

41 **Results:** A total of 854 (69.5 %) patients were referred to CR. After adjustment for age, gender,
42 diagnosis and comorbidity, high income level had the strongest association of referral to CR in all three
43 phases (informed about CR: OR 2.17, 95% CI: 1.0- 4.64; willingness to participate in CR: OR 1.55, 95% CI:
44 1.02-2.35; assigned in-hospital CR: OR 1.47, 95% CI: 0.91-2.36). High educational level showed similar
45 tendencies but did not reach statistical significance. The results did not vary according to gender.

46 **Conclusion:** This is the first study to investigate the entire referral process to CR using a three-phase
47 structure. It suggests income and education to influence all phases in the referral process to CR after
48 suffering ACS.

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4 49 **Keywords:** Myocardial Infarction, Adult Cardiology, Cardiac Epidemiology

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6 50 **Strengths and limitations of this study**

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9 51 - This is the first study to investigate the referral process to cardiac rehabilitation (CR) using a
10
11 52 three phase structure (information about CR, willingness to participate in CR, assigned CR
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13 53 setting) rather than the person-level), which provides better knowledge in understanding why
14
15 54 social inequality persists in referral to cardiac rehabilitation.
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18 55 - Socio-economic variables were provided by highly validated Danish register data using the
19
20 56 unique 10-digit civil registration number that is given to all Danish citizens.
21
22 57 - Multiple regression analyses were used to minimise potential confounding.
23
24
25 58 - Data was not gathered for specific scientific purposes and it cannot be ruled out that not all
26
27 59 patients admitted with ACS were identified. However, such loss was considered unsystematic
28
29 60 and unintended and should not pose a problem for bias introduction.
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31

32
33 61 **Introduction**

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35
36 62 Low socio-economic status (SES) is associated with higher risk of developing Ischemic Heart Disease and
37
38 63 a poorer subsequent outcome, including a higher risk of recurrent cardiovascular events and cardiac-
39
40 64 related mortality.(1–5) Cardiac rehabilitation (CR) is an important step to reduce disease outcomes and
41
42 65 is an integral part of ischemic heart disease care as it aims to improve quality of life as well as patients'
43
44 66 physical, psychological, and social functioning.(4)
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47 67 CR comprises exercise therapy, psychological consulting, treatment-targeted therapy, and life-style
48
49 68 changing modules (dietary modification, and smoking cessation).(4) The program is a coordinated effort
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51 69 made by cardiologists, nurses, physiotherapists, dietitians, and eventually occupational therapists. If
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53 70 needed, psychologists, social workers, or priests may be included as well.(4)
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4 71 The efficacy of CR in reducing cardiovascular mortality and risk of hospital readmissions is well-
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6 72 documented.(6–8) It therefore seems irrational that international research in general continues to find
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8 73 CR referral, participation, and completion rates to be unsatisfactory.(9–13)
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10 74 Different socio-economic characteristics (income, educational level, occupational status, cohabiting
11
12 75 status) are shown to be associated with CR underutilization.(14) Low income and educational level have
13
14 76 irrespectively of type of health care system repeatedly been associated with limited participation and
15
16 77 completion rate.(11,15) It is consequently of major importance to eliminate the socio-economic
17
18 78 differences in CR if the inequality in ischemic disease burden is to be reduced.
19
20 79 Obstacles in referral to CR among patients with lower SES may be due to both personal- and system-
21
22 80 level barriers.(16) However, vulnerable elements in the referral process prone to socio-economic
23
24 81 inequality among patients with acute coronary syndrome (ACS) remain unexplored. By dividing the
25
26 82 referral process into three phases, it is possible to evaluate if such inequality is the result of selection of
27
28 83 patients at the system-level (information about CR, place of referral) rather than the person-level (wish
29
30 84 to participate in CR). To our knowledge, no study has analysed the entire referral process using such
31
32 85 three-phase structure while controlling for confounders in a population of patients surviving ACS.
33
34 86 Therefore, the objective of this study was to investigate how SES is associated with the patients'
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36 87 chances of 1) being informed about CR, 2) willingness to participate, and 3) assigned CR setting (in-
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38 88 hospital or community centre).
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45 89 **Methods**

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48 90 The study followed the STROBE guidelines for cross-sectional studies.(17)
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50 91 **Study design**

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53 92 This population-based study used data from the Rehab-North Register. Its content has previously been
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55 93 described.(16) In short, the Rehab-North Register holds data on all patients hospitalised at the
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4 94 Department of Cardiology, Aalborg University Hospital from 1 January 2011 to 31 December 2014 with
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6 95 a diagnosis of ACS. All were assessed for eligibility to CR using a questionnaire.(16)
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9 96 In Denmark, CR fully or partially takes place in-hospital or at community centres. In-hospital CR is
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11 97 reserved for high-risk patients and is structured with a more complex intervention. The Danish Public
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13 98 Health System is tax paid, enabling CR to be free of charge for the patient.
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16 99 **Patient and Public involvement statement**

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19 100 No patients were involved in the design, or conduct, or reporting, or dissemination plans of our
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21 101 research.
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23 102 **Study Population**

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25
26 103 The study population was identified in the Rehab-North Register as patients diagnosed with ACS (ICD-
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28 104 10: DI200, DI21). The registered diagnosis by Rehab-North was verified by linking data from the Rehab-
29
30 105 North register with the Danish National Patient Register (NPR) and the Danish Register of Causes of
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32 106 Death.(18) If any discrepancy arose, the diagnosis registered in the NPR was selected.
33

34
35 107 Patients were excluded if in one of the following criteria were fulfilled: 1) missing data on SES 2)
36
37 108 acceptable reason for not informing patients about CR, including treatment with coronary artery bypass
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39 109 graft, transfer to another hospital, still under treatment, or death.
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43 44 111 **Socio-economic status**

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46 112 Different indicators of SES (personal income, occupational status, educational level, and civil status)
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48 113 were chosen, due to a priori knowledge about their proposed mechanisms associated to the outcome
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50 114 variable. Ascertainment of socio-economic variables from national registers was done by linkage of a
51
52 115 unique personal number given to all Danish residents.
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55 116 The Income Statistics Register provided information regarding both disposable personal income (low,
56
57 117 medium, high) calculated for the calendar year before disease onset, and occupational status
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4 118 (employed, unemployed/out of workforce) set for the calendar year before disease onset.(19) A
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6 119 person's highest obtained educational level (low, medium, high) was based on the International
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8 120 Standard Classification of Education (ISCED)(20) from the Student's Register(21), and civil status
9
10 121 (married/partnership, divorced/unmarried /widow) from the Civil Registration System (CRS).(22)

122 **Outcomes**

123 Outcomes were defined by dividing the referral process into three phases: 1. being informed about CR,
124 2. willingness to participate, and 3. assigned CR setting (in-hospital /community centre) after ACS.

125 All outcome information gathering were done during the patients' hospitalisation and included in the
126 questionnaires that founded the Rehab-North Register.

127 As regional guidelines determined setting for CR: patients suffering ST-Elevated Myocardial Infarction
128 (STEMI) or complicated Non-ST-Elevated Myocardial Infarction (NSTEMI) were offered in-hospital CR
129 whereas patients with uncomplicated NSTEMI and Unstable Angina Pectoris (UAP) were offered CR in a
130 community centre, we intended to investigate whether this structure was followed.

131 **Covariates**

132 The analysis model was constructed with a directed acyclic graph to reduce confounding (online
133 supplementary material, figure 1).

134 Age was registered at time of diagnosis and categorized into three groups: < 65 years, 65-74 years, and
135 ≥ 75 years. Information regarding age and gender was gathered from the CRS.(22) Comorbidity
136 diagnoses were defined by the Charlson Comorbidity Index (CCI) and drawn from the NPR.(23)

137 **Statistical analysis**

138 Baseline characteristics of study population were summarised by frequencies and percentages. The
139 association between socio-economic exposure variables and being informed about CR, willingness to
140 participate, and assigned CR setting was assessed by crude (model 1) and multiple logistic regression
141 adjusted for confounders (age, gender, diagnosis, CCI) (model 2). Results were presented in odds ratios

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4 142 (OR) with 95% confidence intervals (95% CI). Potential effect modification by gender was assessed by
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6 143 stratification and likelihood-ratio tests as studies have found females to experience lower rates of
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8 144 referral to CR compared to males.(10,24) Statistical analyses were performed using Stata Software
9
10 145 (v.15.1; Stata Corp. College Station, TX).

13 146 **Results**

16 147 Of the original cohort of 1721 patients diagnosed with ACS, only patients with no missing socio-
17
18 148 economic variables, and no acceptable reasons for not being informed about CR were included in the
19
20 149 study (online supplementary material, figure 2). This resulted in a study population comprising 1229
21
22 150 patients (73.8% male). The patients' baseline characteristics, stratified by diagnosis, are presented in
23
24 151 table 1. STEMI patients were relatively younger and still an available workforce with higher income. In
25
26 152 the study population, 1123 (91.4%) patients were informed about CR of which 854 (76.0%) patients
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28 153 subsequently agreed to participate in the program. Of those, 349 (40.9%) patients were referred to CR
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30 154 in a community centre and 505 (59.1%) patients were referred to in-hospital CR (figure 1).

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Table 1: Characteristics of study population stratified by diagnosis

	Full population	STEMI	NSTEMI	UAP
Characteristics	n = 1229	n = 402	n = 711	n = 116
Male (n, %)	907 (73.8)	322 (80.1)	503 (70.7)	82 (70.7)
Age Group (years)				
< 65	591 (48.1)	227 (56.5)	308 (43.3)	56 (48.3)
65-74	371 (30.2)	116 (28.9)	215 (30.2)	40 (34.5)
≥ 75	267 (21.7)	59 (14.7)	188 (26.4)	20 (17.2)
Civil status (n, %)				
Married/Partnership	793 (64.5)	253 (62.9)	449 (63.2)	91 (78.4)
Divorced/Unmarried/Widow	436 (35.5)	149 (37.1)	262 (36.8)	25 (21.6)
Occupational status (n, %)				
Employed	479 (39.0)	195 (48.5)	240 (33.8)	44 (37.9)
Unemployed/Retired	750 (61.0)	207 (51.5)	471 (66.2)	72 (62.1)
Educational level (n, %)				
Low	516 (42.0)	144 (35.8)	322 (45.3)	50 (43.1)
Medium	539 (43.9)	201 (50.0)	293 (41.2)	45 (38.8)
High	174 (14.2)	57 (14.2)	96 (13.5)	21 (18.1)
Gross income, tertile (n, %)				
Low	405 (33.0)	113 (28.1)	251 (35.3)	41 (35.3)
Medium	406 (33.0)	124 (30.8)	247 (34.7)	35 (30.2)
High	418 (34.0)	165 (41.0)	213 (30.0)	40 (34.5)
Charlson Comorbidity Index				
Low (0 points)	1088 (88.5)	358 (89.1)	630 (88.6)	100 (86.2)
Moderate/High (>0 points)	141 (11.5)	44 (10.9)	81 (11.4)	16 (13.8)

156 STEMI: ST-elevated myocardial infarction; NSTEMI: non-ST-elevated myocardial infarction; UAP: unstable angina

157 pectoris

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4 158 **Phase 1: SES and being informed about CR**

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6 159 Higher income and educational level had positive crude associations with being informed about CR.

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8 160 Whereas, being unemployed/retired had a negative association (table 2). These associations were

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10 161 greatly reduced after adjustment for age, gender, diagnosis, and CCI. The adjusted regression analysis

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12 162 found high income to be associated with being informed about CR (OR 2.17, 95% CI: 1.01; 4.64). High

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14 163 educational level was also associated with being informed about CR although the association did not

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16 164 reach statistical significance.

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19 **Table 2:** Logistic regression model for being informed about cardiac rehabilitation

	n, (%)	Unadjusted		Multivariable adjusted*	
		OR	95% CI	OR	95% CI
Observations	1123 (100.0)				
Civil status					
Married/Partnership	469 (41.8)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	654 (58.2)	0.64	0.43-0.95	0.76	0.49-1.19
Occupational status					
Employed	735 (65.4)	1 (ref.)		1 (ref.)	
Unemployed/Retired	388 (34.6)	0.15	0.07-0.28	0.46	0.20-1.07
Educational level					
Low	452 (40.2)	1 (ref.)		1 (ref.)	
Medium	505 (45.0)	2.10	1.36-3.25	1.17	0.72-1.89
High	166 (14.8)	2.94	1.38-6.26	1.60	0.72-3.54
Income, tertiles					
Low	342 (30.5)	1 (ref.)		1 (ref.)	
Medium	374 (33.3)	2.15	1.37-3.38	1.40	0.86-2.28
High	407 (36.2)	6.82	3.54-13.14	2.17	1.01-4.64

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* Adjusted for age, gender, diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

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4 166 **Phase 2: SES and willingness to participate in CR**

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6 167 High income, high educational level, and being single-living (divorced/unmarried/widow) were all
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8 168 associated with a higher likelihood of willingness to participate in CR in the crude analyses (table 3).
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10 169 After adjustment, high income level had the highest OR (OR 1.55, 95% CI: 1.02; 2.35) in relation to
11
12 170 willingness to participate. A similar pattern was observed for high educational level although the
13
14 171 association was not statistically significant (OR 1.60, 95% CI: 0.78; 1.88). Likewise, being single-living
15
16 172 was also associated with willingness to participate in CR, although, the estimates did not reach
17
18 173 statistical significance (OR 1.28, 95% CI: 0.93; 1.76).
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22 **Table 3:** Logistic regression model for willingness to participate in cardiac rehabilitation

	n (%)	Unadjusted		Multiple adjustment*	
		OR	95% CI	OR	95% CI
Observations	854 (100.0)				
Civil status					
Married/Partnership	388 (45.4)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	466 (54.6)	1.33	0.99-1.79	1.28	0.93-1.76
Occupational status					
Employed	546 (63.9)	1 (ref.)		1 (ref.)	
Unemployed/Retired	308 (36.1)	0.52	0.39-0.69	0.93	0.62-1.40
Educational level					
Low	322 (37.7)	1 (ref.)		1 (ref.)	
Medium	405 (47.4)	1.64	1.21-2.20	1.36	0.98-1.88
High	127 (14.9)	1.31	0.87-1.99	1.21	0.78-1.88
Income, tertiles					
Low	229 (26.8)	1 (ref.)		1 (ref.)	
Medium	288 (33.7)	1.65	1.19-2.30	1.35	0.94-1.94
High	337 (39.5)	2.38	1.69-3.34	1.55	1.02-2.35

* Adjusted for age, gender, diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

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175 Phase 3: SES and assigned CR setting

176 Table 4 shows the association of SES on being assigned to in-hospital CR compared to CR in a
 177 community centre. High income was associated with referral to being assigned to in-hospital CR (OR:
 178 2.10, 95% CI: 1.49; 2.97) but the association was attenuated after adjustment for confounders (income:
 179 adjusted OR: 1.47, 95% CI: 0.91; 2.36).

Table 4: Logistic regression model for assigned cardiac rehabilitation setting

	n (%)	Unadjusted		Multiple adjustment*	
		OR	95% CI	OR	95% CI
Observations	505 (100.0)				
Civil status					
Married/Partnership	268 (53.1)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	237 (46.9)	1.13	0.85-1.51	1.20	0.84-1.69
Occupational status					
Employed	317 (62.8)	1 (ref.)		1 (ref.)	
Unemployed/Retired	188 (37.2)	0.46	0.35-0.61	0.75	0.49-1.15
Educational level					
Low	177 (35.0)	1 (ref.)		1 (ref.)	
Medium	248 (49.1)	1.29	0.96-1.74	0.90	0.63-1.30
High	80 (15.8)	1.39	0.91-2.13	1.20	0.72-1.99
Income, tertiles					
Low	115 (22.8)	1 (ref.)		1 (ref.)	
Medium	161 (31.9)	1.26	0.89-1.78	1.14	0.73-1.78
High	229 (45.3)	2.10	1.49-2.97	1.47	0.91-2.36

* Adjusted for age, gender, diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

180 **Supplementary analyses**

181 The analyses were stratified by gender in a supplementary analysis. The results were not substantially
182 different from the main analysis.

183 **Discussion**

184 In this study, the referral process to CR was assessed using a three-phase structure: 1. informed about
185 CR, 2. willingness to participate in CR, and 3. assigned CR setting. We observed patients with low SES to
186 have lower odds of being informed about CR, lower willingness to participate in CR, and to be less often
187 assigned in-hospital CR. Specifically, high income was associated with referral to CR in all phases of the
188 referral process. Moreover, high educational level had a similar pattern, but the association did not
189 reach statistical significance.

190 Overall, 69.5% of the patients were referred to CR, which is in accordance with earlier findings (22-
191 81.5%).(9,10,24,25) Notably, in one study strikingly 86% was referred to CR after usage of a social
192 differentiated intervention program.(26) However, it would be difficult to reproduce such a result in an
193 observational study without this specific purpose.

194 In international studies younger age, male gender, living with a partner, high educational level, and high
195 gross income were found to be predictors of CR referral.(10,25,27) This inequality in CR referral causes
196 concern as participation helps patients implement needed behavioural changes, which reduces cardiac-
197 related deaths.(6) Patients with low SES often have biological, behavioural, and psychosocial
198 disadvantages that may accelerate risk of cardiovascular diseases. Therefore, the need of referral,
199 attendance, and completion of CR should be prioritized in this patient group.(1,2) Our results found
200 high income and high educational level to be associated with higher OR's throughout the referral
201 process. We found single-living to be potentially associated with the willingness to participate in CR. If
202 such an association is reproducible in later studies, then attention should focus on these patients
203 without a partner, who less often receive referral to CR, which has been attributed to lack of social

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4 204 support.(27) It is highly important that patients are well-informed about CR to make a well-considered
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6 205 decision regarding participation.
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8 206 An earlier study, assessed by crude analyses the referral process to CR on patients hospitalised for a
9
10 207 diverse range of incidental cardiac diseases and observed similar socio-economic determinants as
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12 208 predictors for referral as seen in this present study.(16)
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17 210 Definition of SES is a conceptual challenge often solved by use of personal/family income, educational
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19 211 level, civil status, and/or occupation. There is no consensus on which parameters to use as indicators of
20
21 212 SES. It has been argued to use single variables as proxy measurements for SES despite different causal
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23 213 pathways. However, others find it problematic only to estimate SES by one parameter, as this may
24
25 214 increase the risk of residual confounding by unmeasured socio-economic circumstances.(1,28)
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28 215 Moreover, the effect of socio-economic variables seems rather outcome-related and is suggested not to
29
30 216 be used interchangeably without thorough consideration.(29) As our central interest was to investigate
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32 217 the impact of SES on the referral process to CR, and therefore use SES as exposure variable, we a priori
33
34 218 hypothesized the different variables all to be linked to our outcome measures. The risk of such an
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36 219 approach was the introduction of collinearity. However, research finds e.g. educational level,
37
38 220 occupation, and income to measure different phenomena, to have different causal mechanisms, and in
39
40 221 part to be explained by other socio-economic parameters.(29,30) Since literature finds income,
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42 222 educational level, occupational status, and civil status to be important determinants for referral,
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44 223 participation, and completion of CR, it seemed most appropriate to include all variables in order to
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46 224 answer our research questions. The consequence of this approach was that we cannot get a single
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48 225 estimate that illustrates the effect of SES.
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55 227 Some caution must be taken when interpreting the results of our study. Firstly, data was not gathered
56
57 228 for specific scientific purposes and it cannot be ruled out that some patients admitted with ACS were
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4 229 not included in the Rehab-North Register. However, such loss was considered unsystematic and
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6 230 unintended and should not pose a problem for bias introduction. Secondly, use of register data
7
8 231 minimized risk of information bias, due to nationwide good algorithms for correct diagnosis coding.
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10 232 Despite linkage to other registers, risk of residual or unmeasured confounding may be present.(31)
11
12 233 Thirdly, there may be a risk of residual or unaccounted confounding, if data on confounding variables
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14 234 was not classified with adequate precision. Fourthly, several of the results only showed weak
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16 235 association, which most likely was a consequence of the rather small study population. Therefore, it
17
18 236 cannot be assumed that there was no association and use of a national cohort may find more
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20 237 conclusive results.
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24 238 Participation and completion rates of in-hospital CR and CR in community centres remained unexplored
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26 239 as our study only focused on the referral process to CR.
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29 240 **Conclusion**

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32 241 High income and educational level were associated with a larger chance of being informed about CR,
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34 242 willingness to participate in CR, and assigned in-hospital CR in patients with ACS.
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41

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43
44
45 246 of the data. CBG, MNJ, and MLL analysed and interpreted the data. SPJ, SR, and THO contributed to
46
47 247 interpretation. CBG drafted the initial manuscript and all authors critically revised the manuscript and
48
49 248 gave final approval.
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52 249 **Ethics:** The study is approved by the Danish Data Protection Agency (project number: 2008-58-0028)
53
54
55 250 and the Danish Patient Safety Authority (3-3013-2763/1). In Denmark, no written consent is needed for
56
57 251 use of such register-based data.
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6
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9 254 the study.

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11 255 **Competing interest:** None declared

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15 256 **Data sharing statement:** No additional data available

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20 258 **References**

- 21
22
23 259 1. Havranek EP, Mujahid MS, Barr DA, et al. Social determinants of risk and outcomes for
24
25 260 cardiovascular disease: A scientific statement from the American Heart Association. *Circulation*.
26
27 261 2015;132(9):873–98.
- 28
29
30 262 2. Schultz WM, Kelli HM, Lisko JC, et al. Socioeconomic Status and Cardiovascular Outcomes.
31
32 263 *Circulation* [Internet]. 2018;137(20):2166–78.
- 33
34
35 264 3. Ohm J, Skoglund PH, Discacciati A, et al. Socioeconomic status predicts second cardiovascular
36
37 265 event in 29,226 survivors of a first myocardial infarction. *Eur J Prev Cardiol*. 2018;25(9):985–93.
- 38
39
40
41 266 4. Piepoli MF, Corra U, Adamopoulos S, et al. Secondary prevention in the clinical management of
42
43 267 patients with cardiovascular diseases . Core components , standards and outcome measures for
44
45 268 referral and delivery. *Eur J Prev Cardiol*. 2014;21(6):664–81.
- 46
47
48 269 5. Rasmussen JN, Rasmussen S, Gislason GH, et al. Mortality after acute myocardial infarction
49
50 270 according to income and education. *J Epidemiol Community Health*. 2006;60(4):351–6.
- 51
52
53 271 6. Anderson L, Oldridge N, Thompson DR, et al. Exercise-Based Cardiac Rehabilitation for Coronary
54
55 272 Heart Disease. *J Am Coll Cardiol*. 2016;67(1):1–12.
- 56
57
58 273 7. Anderson LJ, Taylor RS. Cardiac rehabilitation for people with heart disease: An overview of
59
60

- 1
2
3
4 274 Cochrane systematic reviews. *Int J Cardiol.* 2014;177(2):348–61.
5
6 275 8. Rauch B, Davos CH, Doherty P, et al. The prognostic effect of cardiac rehabilitation in the era of
7
8 acute revascularisation and statin therapy: A systematic review and meta-analysis of randomized
9 276
10 and non-randomized studies - The Cardiac Rehabilitation Outcome Study (CROS). *Eur J Prev*
11 277
12 *Cardiol.* 2016;23(18):1914–39.
13 278
14
15
16 279 9. Sumner J, Grace SL, Doherty P. Predictors of Cardiac Rehabilitation Utilization in England :
17
18 280 Results From the National Audit. *J Am Heart Assoc.* 2016;1–7.
19
20
21 281 10. Colella TJ, Gravely S, Marzolini S, et al. Sex bias in referral of women to outpatient cardiac
22
23 282 rehabilitation? A meta-analysis. *Eur J Prev Cardiol.* 2015;22(4):423–41.
24
25
26 283 11. Martin B-J, Hauer T, Arena R, et al. Cardiac Rehabilitation Attendance and Outcomes in Coronary
27
28 284 Artery Disease Patients. *Circulation.* 2012;126(6):677–87.
29
30
31 285 12. Piepoli MF, Hoes AW, Agewall S, et al. 2016 European Guidelines on cardiovascular disease
32
33 286 prevention in clinical practice. *Eur Heart J.* 2016;37(29):2315–81.
34
35
36 287 13. Smith SC, Benjamin EJ, Bonow RO, et al. AHA/ACCF secondary prevention and risk reduction
37
38 288 therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update: A
39
40 289 guideline from the American Heart Association and American College of Cardiology Foundation.
41
42 290 *Circulation.* 2011;124(22):2458–73.
43
44
45
46 291 14. Gaalema DE, Elliott RJ, Morford ZH, et al. Effect of Socioeconomic Status on Propensity to
47
48 292 Change Risk Behaviors Following Myocardial Infarction : Implications for Healthy Lifestyle
49
50 293 Medicine. *Prog Cardiovasc Dis [Internet].* 2017;60(1):159–68.
51
52
53
54 294 15. Nielsen KM, Faergeman O, Foldspang A, et al. Cardiac rehabilitation: Health characteristics and
55
56 295 socio-economic status among those who do not attend. *Eur J Public Health.* 2008;18(5):479–83.
57
58
59 296 16. Graversen CB, Eichhorst R, Ravn L, et al. Social inequality and barriers to cardiac rehabilitation in
60

- 1
2
3
4 297 the rehab-North register. *Scand Cardiovasc J* [Internet]. 2017;51(6):316–22.
5
6 298 17. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies
7
8 299 in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin*
9
10 300 *Epidemiol.* 2008;61(4):344–9.
11
12
13 301 18. Madsen M, Davidsen M, Rasmussen S, et al. The validity of the diagnosis of acute myocardial
14
15 302 infarction in routine statistics: A comparison of mortality and hospital discharge data with the
16
17 303 Danish MONICA registry. *J Clin Epidemiol.* 2003;56(2):124–30.
18
19
20 304 19. Baadsgaard M, Quitzau J. Danish registers on personal income and transfer payments. *Scand J*
21
22 305 *Public Health.* 2011;39(7):103–5.
23
24
25 306 20. Eurostat Statistics Explained. International Standard Classification of Education (ISCED). URL:
26
27 307 [https://ec.europa.eu/eurostat/statistics-](https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_(ISCED))
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29 308 [explained/index.php/International_Standard_Classification_of_Education_\(ISCED\)](https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_(ISCED)). Access date:
30
31 309 November 7, 2019.
32
33
34 310 21. Jensen VM, Rasmussen a. W. Danish education registers. *Scand J Public Health.* 2011;39(7
35
36 311 *Suppl):91–4.*
37
38
39 312 22. Pedersen CB. The Danish Civil Registration System. *Scand J Public Health.* 2011;39(7 suppl):22–5.
40
41
42 313 23. Thygesen SK, Christiansen CF, Lash TL, et al. Predictive value of coding of diagnoses in the
43
44 314 charlson comorbidity index in the Danish national registry of patients. *Pharmacoepidemiol Drug*
45
46 315 *Saf.* 2009;18 (S1):S189.
47
48
49 316 24. Colbert JD, Martin B-J, Haykowsky MJ, et al. Cardiac rehabilitation referral, attendance and
50
51 317 mortality in women. *Eur J Prev Cardiol.* 2014;22(8):979–86.
52
53
54 318 25. Brown TM, Hernandez AF, Bittner V, et al. Predictors of Cardiac Rehabilitation Referral in
55
56 319 Coronary Artery Disease Patients. Findings From the American Heart Association’s Get With The
57
58
59
60

- 1
2
3
4 320 Guidelines Program. *J Am Coll Cardiol*. 2009;54(6):515–21.
5
6 321 26. Meillier LK, Nielsen KM, Larsen FB, et al. Socially differentiated cardiac rehabilitation: Can we
7
8 322 improve referral, attendance and adherence among patients with first myocardial infarction?
9
10 323 *Scand J Public Health*. 2012;40(3):286–93.
11
12
13
14 324 27. Cortés O, Arthur HM. Determinants of referral to cardiac rehabilitation programs in patients
15
16 325 with coronary artery disease: A systematic review. *Am Heart J*. 2006;151(2):249–56.
17
18
19 326 28. Galobardes B, Shaw M, Lawlor DA, et al. Indicators of socioeconomic position (part 1). *J*
20
21 327 *Epidemiol Community Health*. 2006;60(1):7–12.
22
23
24 328 29. Geyer S, Hemström Ö, Peter R, et al. Education, income, and occupational class cannot be used
25
26 329 interchangeably in social epidemiology. Empirical evidence against a common practice. *J*
27
28 330 *Epidemiol Community Health*. 2006;60(9):804–10.
29
30
31 331 30. Lahelma E, Martikainen P, Laaksonen M, et al. Pathways between socioeconomic determinants
32
33 332 of health. *J Epidemiol Community Health*. 2004;58(4):327–32.
34
35
36 333 31. Schmidt M, Schmidt SAJ, Sandegaard JL, et al. The Danish National patient registry: A review of
37
38 334 content, data quality, and research potential. *Clin Epidemiol*. 2015;7:449–90.
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45 336 **Figure legends:**

46
47 337 Figure 1: Flowchart of the referral process to cardiac rehabilitation
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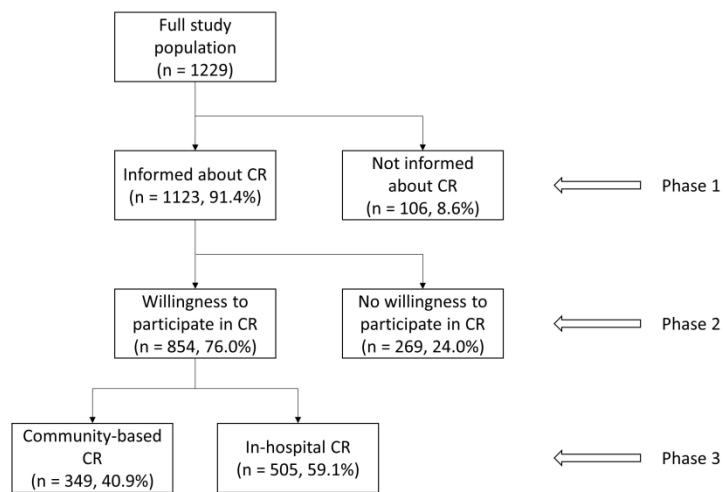


Figure 1: Flowchart of the referral process to cardiac rehabilitation

338x190mm (300 x 300 DPI)

Online supplementary material

Figure S1: Directed acyclic graph

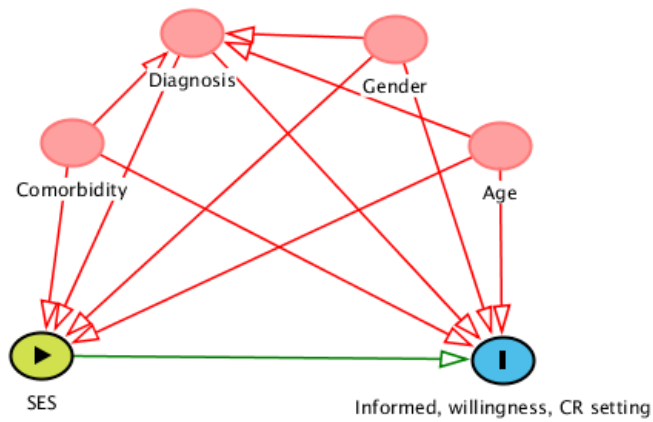
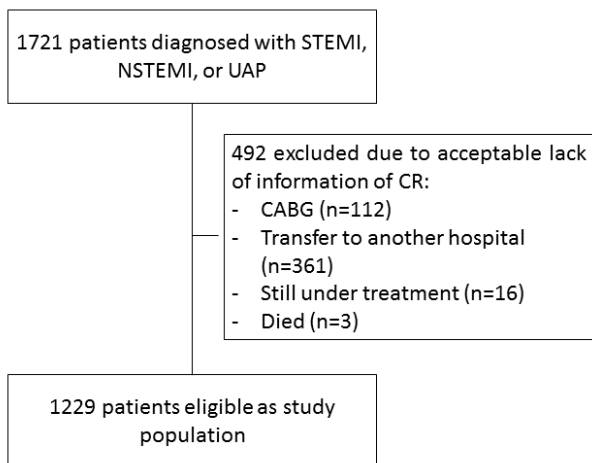


Figure S2: Flowchart of study population



STEMI: ST-Elevated Myocardial Infarction; NSTEMI: Non-ST-Elevated Myocardial Infarction; UAP: Unstable Angina Pectoris; CR: cardiac rehabilitation; CABG: coronary artery bypass graft

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
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
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
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
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

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60**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 (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 (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —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

Discussion

Key results	18	Summarise key results with reference to study objectives
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
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

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
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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

Influence of socio-economic status on the referral process to cardiac rehabilitation following acute coronary syndrome: a cross-sectional study

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4 1 **Title: Influence of socio-economic status on the referral process to cardiac**
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6 2 **rehabilitation following acute coronary syndrome: a cross-sectional study**
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43
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47 19 **Disclaimers, if any:**

48
49 20 None
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51 21 **Corresponding author:**

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53 22 Christina Boesgaard Graversen, postal address: Holger Danskes Vej 73, 2nd Floor Left, 2000
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55 23 Frederiksberg, DK, mail: c.graversen@rn.dk
56

57 24 **Word count:** 3349 words
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25 Abstract

26 **Objective:** to evaluate the association between socio-economic status (SES) and referral to cardiac
27 rehabilitation (CR) after incident acute coronary syndrome (ACS) by dividing the referral process into
28 three phases (1. informed about CR, 2. willingness to participate in CR, and 3. assigned CR setting).

29 **Design:** Cross-sectional study.

30 **Setting:** Department of Cardiology at a Danish University Hospital from 1 January 2011 to 31 December
31 2014.

32 **Participants:** A total of 1229 patients assessed for CR during hospitalisation with ACS were
33 prospectively registered in the Rehab-North Register from 2011-2014. SES was assessed using data
34 from national registers, concerning: personal income, occupational status, educational level, and civil
35 status. Patients were excluded if in one of the following criteria were fulfilled: 1) missing data on SES, or
36 2) acceptable reason for not informing patients about CR (treatment with coronary artery bypass graft,
37 transfer to another hospital, still under treatment, or death).

38 **Main outcome measures:** Outcomes were defined by dividing the referral process into three phases: 1.
39 informed about CR, 2. willingness to participate, and 3. assigned CR setting (in-hospital /community
40 centre) after ACS.

41 **Results:** A total of 854 (69.5 %) patients were referred to CR. After adjustment for age, gender, ACS
42 diagnosis (ST-Elevated Myocardial Infarction, Non-ST-Elevated Myocardial Infarction, Unstable Angina
43 Pectoris) and comorbidity, high income had the strongest association of referral to CR in all three
44 phases (informed about CR: OR 2.17, 95% CI: 1.0- 4.64; willingness to participate in CR: OR 1.55, 95% CI:
45 1.02-2.35; assigned in-hospital CR: OR 1.47, 95% CI: 0.91-2.36). Educational level showed similar
46 tendencies, however not statistically significant. The results did not vary according to gender.

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4 47 **Conclusion:** This is the first study to investigate the referral process to CR using a three-phase structure.

5
6 48 It suggests income and education to influence all phases in the referral process to CR after ACS.

7
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9 49 **Keywords:** Acute Myocardial Infarction, Cardiac Rehabilitation, Referral Process, Socio-economic Status

10 11 50 **Strengths and limitations of this study**

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14 51 - This is the first study to investigate the referral process to cardiac rehabilitation (CR) using a
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16 52 three phase structure (1. informed about CR, 2. willingness to participate in CR, and 3. assigned
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18 53 CR setting) which provides better knowledge in understanding why social inequality persists in
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21 54 referral to CR.
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23 55 - Socio-economic variables were provided by highly validated Danish register data using the
24
25 56 unique 10-digit civil registration number that is given to all Danish citizens.
- 26
27 57 - Multivariable logistic regression analyses were used to minimise potential confounding.
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30 58 - Data was not gathered for specific scientific purposes and it cannot be ruled out that not all
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32 59 patients admitted with Acute Coronary Syndrome were identified. However, such loss was
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35 60 considered unsystematic and unintended and should not pose a problem for bias introduction.

36 37 38 61 **Introduction**

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41 62 Low socio-economic status (SES) is associated with higher risk of developing Ischemic Heart Disease
42
43 63 (IHD) and poorer subsequent outcome, including higher risk of recurrent cardiovascular events and
44
45 64 cardiac-related mortality.(1–5) Cardiac rehabilitation (CR) is an important step to reduce disease
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48 65 outcomes and is an integral part of IHD care as it aims to improve quality of life as well as patients'
49
50 66 physical, psychological, and social functioning.(4)

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52 67 CR comprises exercise therapy, psychological consulting, treatment-targeted therapy, and life-style
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54 68 changing modules (dietary modification, and smoking cessation).(4) The program is a coordinated effort
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57 69 made by cardiologists, nurses, physiotherapists, dietitians, and eventually occupational therapists. If
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59 70 needed, psychologists, social workers, or priests may be included as well.(4)

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4 71 The efficacy of CR in reducing cardiovascular mortality and risk of hospital readmissions is well-
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6 72 documented.(6–8) It therefore seems irrational that international research in general continues to find
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8 73 CR “referral” or “participation and completion” rates to be unsatisfactory.(9–13)
9
10 74 Different socio-economic characteristics (income, educational level, occupational status, civil status) are
11
12 75 shown to be associated with CR underutilization.(14) Low income and educational level have
13
14 76 irrespectively of type of health care system repeatedly been associated with limited participation and
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16 77 completion rate.(11,15) It is consequently of major importance to eliminate the socio-economic
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18 78 differences in CR if the inequality in IHD burden is to be reduced.
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20 79 Obstacles in referral and participation to CR among patients with lower SES may be due to system-level
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22 80 and personal barriers.(16) System-level barriers covers physicians recommendations, the interaction
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24 81 with the healthcare team, and misconceptions about CR. Personal barriers includes perception about
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26 82 IHD and CR, and belief about the ability to control IHD. (16) However, vulnerable elements in the
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28 83 referral process prone to socio-economic inequality among patients with ACS remain unexplored. By
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30 84 dividing the referral process into three phases, it is possible to evaluate if such inequality is the result of
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32 85 selection of patients at the system-level (the process of informing patients about CR and the setting of
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34 86 CR that patients are referred to) rather than the person-level (patients’ own willingness to participate in
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36 87 CR). To our knowledge, no study has analysed the entire referral process using such three-phase
37
38 88 structure while controlling for confounders in a population of patients surviving ACS. Therefore, the
39
40 89 objective of this study was to investigate how SES is associated with the patients’ chances of 1) being
41
42 90 informed about CR, 2) willingness to participate, and 3) assigned CR setting (in-hospital or community
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44 91 centre). Phase 3 was determined by regional guidelines: patients suffering ST-Elevated Myocardial
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46 92 Infarction (STEMI) or complicated Non-ST-Elevated Myocardial Infarction (NSTEMI) were offered in-
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48 93 hospital CR whereas patients with uncomplicated NSTEMI and Unstable Angina Pectoris (UAP) were
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50 94 offered CR in a community centre).
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96 **Methods**

97 The study followed the STROBE guidelines for cross-sectional studies.(17)

98 **Study design**

99 This population-based study used data from the Rehab-North Register. Its content has previously been
100 described.(18) In short, the Rehab-North Register holds data on all patients hospitalised at the
101 Department of Cardiology, Aalborg University Hospital from 1 January 2011 to 31 December 2014 with
102 a diagnosis of ACS. All were assessed for eligibility to CR using a questionnaire.(18)

103 In Denmark, CR fully or partially takes place in-hospital or at community centres. In-hospital CR is
104 reserved for high-risk patients and is structured with a more complex intervention. The Danish Public
105 Health System is tax paid, enabling CR to be free of charge for the patient.

106 **Patient and Public involvement statement**

107 No patients were involved in the design, or conduct, or reporting, or dissemination plans of our
108 research.

109 **Study Population**

110 The study population was identified in the Rehab-North Register as patients diagnosed with ACS (ICD-
111 10: I20.0, I21.). The registered diagnosis was verified by linking data from the Rehab-North Register
112 with the Danish National Patient Register (NPR) and the Danish Register of Causes of Death.(19) If any
113 discrepancy arose, the diagnosis registered in the NPR was selected. Patients were excluded if in one of
114 the following criteria were fulfilled: 1) missing data on SES 2) acceptable reason for not informing
115 patients about CR, including treatment with coronary artery bypass graft, transfer to another hospital,
116 still under treatment, or death. Patients who underwent coronary artery bypass grafting was informed
117 about CR at the Thoracic Surgery Department performing the operation. Patients who were 'transferred

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4 118 to another hospital' received information about CR at other cardiology departments. We were not able
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6 119 to receive confirmation regarding referral to CR in this patient group.

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8 120 The study population and referral design using three phases is illustrated in figure 1.

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10 121 **Socio-economic status**

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12 122 Different indicators of SES (personal income, occupational status, educational level, and civil status)
13
14 123 were chosen, due to a priori knowledge about their proposed mechanisms associated to the outcome
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16 124 variable. Ascertainment of socio-economic variables from national registers was done by linkage of a
17
18 125 unique personal number given to all Danish residents.

19
20 126 The Income Statistics Register provided information regarding both disposable personal income (low,
21
22 127 medium, high) calculated for the calendar year before disease onset, and occupational status
23
24 128 (employed, unemployed/out of workforce) set for the calendar year before disease onset.(20) A
25
26 129 person's highest obtained educational level (low, medium, high) was based on the International
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28 130 Standard Classification of Education (ISCED)(21) from the Student's Register(22), and civil status
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30 131 (married/partnership, divorced/unmarried /widow) from the Civil Registration System (CRS).(23)

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35 132 **Outcomes**

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37 133 Outcomes were defined by dividing the referral process into three phases: 1. informed about CR, 2.
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39 134 willingness to participate, and 3. assigned CR setting (in-hospital /community centre) after ACS.
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41 135 All outcome information gathering were done during the patients' hospitalisation and included in the
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43 136 questionnaires that founded the Rehab-North Register.

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47 137 **Covariates**

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49 138 The selection of covariates to be included in the multivariable analyses was done based on directed
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51 139 acyclic graph (not shown).
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53 140 Age was registered at time of diagnosis and categorized into three groups: < 65 years, 65-74 years, and
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55 141 ≥ 75 years. Information regarding age and gender was gathered from the CRS.(23) Comorbidity
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4 142 diagnoses were defined by the Charlson Comorbidity Index (CCI), but only diagnoses from the year 2011
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6 143 until hospitalisation were accessible. Comorbidity diagnoses was drawn from the NPR.(24) In general,
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8 144 patients with NSTEMI and UAP are less likely referred to CR compared to patients with STEMI.(25)
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10 145 Therefore, to get an accurate estimate of the impacts of patients' SES on CR referral, ACS diagnosis
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12 146 (STEMI, NSTEMI, UAP) were included as a covariate.(25)
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17 148 **Statistical analysis**

19 149 Baseline characteristics of study population were summarised by frequencies and percentages. The
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22 150 association between socio-economic variables and being informed about CR, willingness to participate,
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24 151 and assigned CR setting was assessed by crude (model 1) and multivariable logistic regression adjusted
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26 152 for confounders (age, gender, ACS diagnosis, CCI) (model 2). Results were presented in odds ratios (OR)
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28 153 with 95% confidence intervals (95% CI). Potential effect modification by gender was assessed by
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30 154 stratification and likelihood-ratio tests as studies have found females to experience lower rates of
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32 155 referral to CR compared to males.(10,26) Statistical analyses were performed using Stata Software
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34
35 156 (v.15.1; Stata Corp. College Station, TX).
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38 157 **Results**

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41 158 Of the original cohort of 1822 patients diagnosed with ACS, only patients with no missing socio-
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43 159 economic variables, and no acceptable reasons for not being informed about CR were included in the
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45 160 study (figure 1). This resulted in a study population comprising 1229 patients (73.8% male). The
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47 161 patients' baseline characteristics, stratified by diagnosis, are presented in table 1. STEMI patients were
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49 162 relatively younger and still an available workforce with higher income. In the study population, 1123
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51 163 (91.4%) patients were informed about CR of which 854 (76.0%) patients subsequently agreed to
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53 164 participate in the program. Of those, 349 (40.9%) patients were referred to CR in a community centre
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55 165 and 505 (59.1%) patients were referred to in-hospital CR (figure 1).
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Table 1: Characteristics of study population stratified by diagnosis

	Full population	STEMI	NSTEMI	UAP
Characteristics	n = 1229	n = 402	n = 711	n = 116
Male (n, %)	907 (73.8)	322 (80.1)	503 (70.7)	82 (70.7)
Age Group (years)				
< 65	591 (48.1)	227 (56.5)	308 (43.3)	56 (48.3)
65-74	371 (30.2)	116 (28.9)	215 (30.2)	40 (34.5)
≥ 75	267 (21.7)	59 (14.7)	188 (26.4)	20 (17.2)
Civil status (n, %)				
Married/Partnership	793 (64.5)	253 (62.9)	449 (63.2)	91 (78.4)
Divorced/Unmarried/Widow	436 (35.5)	149 (37.1)	262 (36.8)	25 (21.6)
Occupational status (n, %)				
Employed	479 (39.0)	195 (48.5)	240 (33.8)	44 (37.9)
Unemployed/out of workforce	750 (61.0)	207 (51.5)	471 (66.2)	72 (62.1)
Educational level (n, %)				
Low	516 (42.0)	144 (35.8)	322 (45.3)	50 (43.1)
Medium	539 (43.9)	201 (50.0)	293 (41.2)	45 (38.8)
High	174 (14.2)	57 (14.2)	96 (13.5)	21 (18.1)
Income, tertile (n, %)				
Low	405 (33.0)	113 (28.1)	251 (35.3)	41 (35.3)
Medium	406 (33.0)	124 (30.8)	247 (34.7)	35 (30.2)
High	418 (34.0)	165 (41.0)	213 (30.0)	40 (34.5)
Charlson Comorbidity Index				
Low (0 points)	1088 (88.5)	358 (89.1)	630 (88.6)	100 (86.2)
Moderate/High (>0 points)	141 (11.5)	44 (10.9)	81 (11.4)	16 (13.8)

167 STEMI: ST-elevated myocardial infarction; NSTEMI: non-ST-elevated myocardial infarction; UAP: unstable angina

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4 169 **Phase 1: SES and being informed about CR**

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6 170 Higher income and educational level had positive crude associations with being informed about CR
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8 171 whereas being unemployed/retired or single-living had a negative association (table 2). These
9
10 172 associations were greatly reduced after adjustment for age, gender, ACS diagnosis, and CCI. The
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12 173 adjusted regression analysis found high income to be associated with being informed about CR (OR
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14 174 2.17, 95% CI: 1.01; 4.64). High educational level was also associated with being informed about CR
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16 175 although the association did not reach statistical significance (OR: 1.60, 95% CI: 0.72-3.54).
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20 **Table 2:** Logistic regression model for being informed about cardiac rehabilitation, n = 1229

	n, (%)	Unadjusted		Multivariable adjusted*	
		OR	95% CI	OR	95% CI
Observations	1123 (91.4)				
Civil status					
Married/Partnership	469 (38.2)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	654 (53.2)	0.64	0.43-0.95	0.76	0.49-1.19
Occupational status					
Employed	735 (59.8)	1 (ref.)		1 (ref.)	
Unemployed/out of workforce	388 (31.6)	0.15	0.07-0.28	0.46	0.20-1.07
Educational level					
Low	452 (36.8)	1 (ref.)		1 (ref.)	
Medium	505 (41.1)	2.10	1.36-3.25	1.17	0.72-1.89
High	166 (13.5)	2.94	1.38-6.26	1.60	0.72-3.54
Income, tertiles					
Low	342 (27.8)	1 (ref.)		1 (ref.)	
Medium	374 (30.4)	2.15	1.37-3.38	1.40	0.86-2.28
High	407 (33.1)	6.82	3.54-13.14	2.17	1.01-4.64

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56 * Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence
57 interval
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4 **177 Phase 2: SES and willingness to participate in CR**

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6 **178** High income, high educational level, and being single-living (divorced/unmarried/widow) were all
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8 **179** associated with a higher likelihood of willingness to participate in CR in the crude analyses (table 3).
9
10 **180** Being unemployed/retired was negatively associated with being willing to participate in CR. After
11
12 **181** adjustment, high income level had the highest OR (OR 1.55, 95% CI: 1.02; 2.35) in relation to willingness
13
14 **182** to participate. A similar pattern was observed for high educational level although the association was
15
16 **183** not statistically significant (OR 1.60, 95% CI: 0.78; 1.88). Likewise, being single-living was also associated
17
18 **184** with willingness to participate in CR, although, the estimates did not reach statistical significance (OR
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20 **185** 1.28, 95% CI: 0.93; 1.76).
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24 **Table 3:** Logistic regression model for willingness to participate in cardiac rehabilitation, n = 1123

	n (%)	Unadjusted		Multivariable adjusted*	
		OR	95% CI	OR	95% CI
Observations	854 (76.0)				
Civil status					
Married/Partnership	388 (34.6)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	466 (41.5)	1.33	0.99-1.79	1.28	0.93-1.76
Occupational status					
Employed	546 (48.6)	1 (ref.)		1 (ref.)	
Unemployed/out of workforce	308 (27.4)	0.52	0.39-0.69	0.93	0.62-1.40
Educational level					
Low	322 (28.7)	1 (ref.)		1 (ref.)	
Medium	405 (36.1)	1.64	1.21-2.20	1.36	0.98-1.88
High	127 (11.3)	1.31	0.87-1.99	1.21	0.78-1.88
Income, tertiles					
Low	229 (20.4)	1 (ref.)		1 (ref.)	

Medium	288 (25.6)	1.65	1.19-2.30	1.35	0.94-1.94
High	337 (30.0)	2.38	1.69-3.34	1.55	1.02-2.35

* Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

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187 Phase 3: SES and assigned CR setting

188 Table 4 shows the association of SES on being assigned to in-hospital CR compared to CR in a

189 community centre. High income was significantly associated with assignment to in-hospital CR (OR:

190 2.10, 95% CI: 1.49; 2.97) but the association was attenuated after adjustment for confounders (income:

191 adjusted OR: 1.47, 95% CI: 0.91; 2.36).

Table 4: Logistic regression model for assigned cardiac rehabilitation setting, n = 854

	n (%)	Unadjusted		Multivariable adjusted*	
		OR	95% CI	OR	95% CI
Observations	505 (59.1)				
Civil status					
Married/Partnership	268 (31.4)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	237 (27.8)	1.13	0.85-1.51	1.20	0.84-1.69
Occupational status					
Employed	317 (37.1)	1 (ref.)		1 (ref.)	
Unemployed/out of workforce	188 (22.0)	0.46	0.35-0.61	0.75	0.49-1.15
Educational level					
Low	177 (20.7)	1 (ref.)		1 (ref.)	
Medium	248 (29.0)	1.29	0.96-1.74	0.90	0.63-1.30
High	80 (9.4)	1.39	0.91-2.13	1.20	0.72-1.99
Income, tertiles					
Low	115 (13.5)	1 (ref.)		1 (ref.)	
Medium	161 (18.9)	1.26	0.89-1.78	1.14	0.73-1.78

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4 High 229 (26.8) 2.10 1.49-2.97 1.47 0.91-2.36

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6 * Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI:
7 confidence interval

8 9 192 **Supplementary analyses**

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11 193 The analyses were stratified by gender in a supplementary analysis. The results were not substantially
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13 194 different from the main analysis (not shown).

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15 195 The baseline characteristics of patients being excluded from the study population was obtained (online
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17 196 supplementary material, table 1). After multivariable logistic regression, patients being excluded from
18
19 197 the study population to have significantly lower SES compared to the patients being included (online
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21 198 supplementary material, table 2).

22 23 24 25 199 **Discussion**

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27 200 In this study, the referral process to CR was assessed using a three-phase structure: 1. informed about
28
29 201 CR, 2. willingness to participate in CR, and 3. assigned CR setting. After adjustment, high income was
30
31 202 the only variable statistical significantly associated with referral to CR in phase 1 and 2, and
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33 203 insignificantly associated with phase 3 of the referral process. High educational level had a similar
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35 204 pattern, but the association did not reach statistical significance.

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37 205 Overall, 69.5% of the patients were referred to CR, which is in accordance with earlier findings (22-
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39 206 81.5%).(9,10,25,26) Notably, in one study strikingly 86% was referred to CR after usage of a social
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41 207 differentiated intervention program.(27) However, it would be difficult to reproduce such a result in an
42
43 208 observational study without this specific purpose.

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45 209 The finding of patients' income and educational level to be associated with all three phases the referral
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47 210 process to CR may be explained by 'the Nordic Paradox' observed in the Nordic European
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49 211 countries.(28,29) These countries, covering Denmark, Norway, Sweden, and Finland, are 'welfare
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51 212 states' with equal access to health care which theoretically ought to diminish the importance of
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53 213 patients' level of income and education regarding access to health care services. However, this is not
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4 214 the case as inequality e.g. in mortality, persists.(29) Although income inequality is smaller in the Nordic
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6 215 countries, this still covers over inequality in wealth, housing condition, and material living conditions,
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8 216 and are used together with educational level to assess latent socio-economic factors (health literacy,
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10 217 greater burden of behavioral and biological risk factors, and reduced access to quality care and
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12 218 medication).(30) Thus, our finding may imply such latent socio-economic factors to be important in the
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15 219 referral process to CR.

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17 220 We found single-living to be potentially associated with the willingness to participate in CR. If such an
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19 221 association is reproducible in later studies, then attention should focus on these patients without a
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21 222 partner, who less often receive referral to CR, which has been attributed to lack of social support.(31)

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25 223 International studies find younger age, male gender, living with a partner, high educational level, and
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27 224 high gross income to be predictors of CR referral.(10,25,31) This inequality in CR referral causes concern
28
29 225 as participation helps patients implement needed behavioural changes, which reduces cardiac-related
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31 226 deaths.(6) Patients with low SES often have biological, behavioural, and psychosocial disadvantages
32
33 227 that may accelerate risk of cardiovascular diseases. Therefore, the need of referral, attendance, and
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35 228 completion of CR should be prioritized in this patient group.(1,2)

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38 229 By splitting the referral process into three phases, new insights regarding importance of taking patients
39
40 230 SES into consideration when referring them to CR was gained. Our results show the importance of being
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42 231 aware of system-level barriers present in the referral process. Moreover, identifying those patients who
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44 232 need more motivation before being willing to enter a CR programme is highly important. In that way,
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46 233 patients are well-informed about CR and able to make a well-considered decision regarding
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48 234 participation.

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52 235 Definition of SES is a conceptual challenge often solved by use of personal/family income, educational
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54 236 level, civil status, and/or occupation. There is no consensus on which parameters to use as indicators of
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56 237 SES. It has been argued to use single variables as proxy measurements for SES despite different causal
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4 238 pathways. However, others find it problematic only to estimate SES by one parameter, as this may
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6 239 increase the risk of residual confounding by unmeasured socio-economic circumstances.(1,32)
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8 240 Moreover, the effect of socio-economic variables seems rather outcome-related and is suggested not to
9
10 241 be used interchangeably without thorough consideration.(33) As our central interest was to investigate
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12 242 the impact of SES on the referral process to CR, and therefore use SES as exposure variable, we a priori
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14 243 hypothesized the different variables all to be linked to our outcome measures. The risk of such an
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16 244 approach was the introduction of collinearity. However, research finds e.g. educational level,
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18 245 occupation, and income to measure different phenomena, to have different causal mechanisms, and in
19
20 246 part to be explained by other socio-economic parameters.(33,34) Since literature finds income,
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22 247 educational level, occupational status, and civil status to be important determinants for referral,
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24 248 participation, and completion of CR, it seemed most appropriate to include all variables in order to
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26 249 answer our research questions. The consequence of this approach was that we cannot get a single
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28 250 estimate that illustrates the effect of SES.
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32
33 251 Some caution must be taken when interpreting the results of our study. Firstly, data was not gathered
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35 252 for specific scientific purposes and it cannot be ruled out that some patients admitted with ACS were
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37 253 not included in the Rehab-North Register. However, such loss was considered unsystematic and
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39 254 unintended and should not pose a problem for bias introduction. Moreover, the non-response analysis
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41 255 found excluded patients to have lower SES compared to the included study population. As exclusion
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43 256 was due to clinical implications (patients were to receive CR referral elsewhere), this should not pose a
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45 257 problem for participation bias introduction in our study population.
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48 258 Secondly, use of register data minimized risk of information bias, due to nationwide good algorithms for
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50 259 correct diagnosis coding. Despite linkage to other registers, risk of residual or unmeasured confounding
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52 260 may be present.(35) Thirdly, there may be a risk of residual or unaccounted confounding, if data on
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54 261 confounding variables was not classified with adequate precision. The CCI variable may be inaccurate
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4 262 which is caused by the limited time-frame for inclusion of comorbidities. This increases the risk of
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6 263 unaccounted confounding and should be taken into consideration when interpreting the results.
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8 264 Participation and completion rates of in-hospital CR and CR in community centres remained unexplored
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10 265 as our study only focused on the referral process to CR.
11

12 266 **Conclusion**

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15 267 High income and educational level were associated with a larger chance of being informed about CR,
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17 268 willingness to participate in CR, and assigned in-hospital CR in patients with ACS.
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24 270 **Acknowledgements:** None

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28
29 272 of the data. CBG, MNJ, and MLL analysed and interpreted the data. SPJ, SR, and THO contributed to
30
31 273 interpretation. CBG drafted the initial manuscript and all authors critically revised the manuscript and
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33 274 gave final approval.
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36 275 **Ethics:** The study is approved by the Danish Data Protection Agency (project number: 2008-58-0028)
37
38
39 276 and the Danish Patient Safety Authority (3-3013-2763/1). In Denmark, no written consent is needed for
40
41 277 use of such register-based data.
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45
46
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48
49 280 the study.
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52 281 **Competing interest:** None declared
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55 282 **Data sharing statement:** No additional data available
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References

1. Havranek EP, Mujahid MS, Barr DA, Blair I V., Cohen MS, Cruz-Flores S, et al. Social determinants of risk and outcomes for cardiovascular disease: A scientific statement from the American Heart Association. *Circulation*. 2015;132(9):873–98.
2. Schultz WM, Kelli HM, Lisko JC, Varghese T, Shen J, Sandesara P, et al. Socioeconomic Status and Cardiovascular Outcomes. *Circulation*. 2018;137(20):2166–78.
3. Ohm J, Skoglund PH, Discacciati A, Sundström J, Hambraeus K, Jernberg T, et al. Socioeconomic status predicts second cardiovascular event in 29,226 survivors of a first myocardial infarction. *Eur J Prev Cardiol*. 2018;25(9):985–93.
4. Piepoli MF, Corra U, Adamopoulos S, Benzer W, Bjarnason-wehrens B, Cupples M, et al. Secondary prevention in the clinical management of patients with cardiovascular diseases . Core components , standards and outcome measures for referral and delivery. *Eur J Prev Cardiol*. 2014;21(6):664–81.
5. Rasmussen JN, Rasmussen S, Gislason GH, Buch P, Abildstrom SZ, Køber L, et al. Mortality after acute myocardial infarction according to income and education. *J Epidemiol Community Health*. 2006;60(4):351–6.
6. Anderson L, Oldridge N, Thompson DR, Zwisler A-D, Rees K, Martin N, et al. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease. *J Am Coll Cardiol*. 2016;67(1):1–12.
7. Anderson LJ, Taylor RS. Cardiac rehabilitation for people with heart disease: An overview of Cochrane systematic reviews. *Int J Cardiol*. 2014;177(2):348–61.
8. Rauch B, Davos CH, Doherty P, Saure D, Metzendorf MI, Salzwedel A, et al. The prognostic effect of cardiac rehabilitation in the era of acute revascularisation and statin therapy: A systematic review and meta-analysis of randomized and non-randomized studies - The Cardiac

- 1
2
3
4 307 Rehabilitation Outcome Study (CROS). *Eur J Prev Cardiol.* 2016;23(18):1914–39.
5
6 308 9. Sumner J, Grace SL, Doherty P. Predictors of Cardiac Rehabilitation Utilization in England :
7
8 309 Results From the National Audit. *J Am Heart Assoc.* 2016;5:1–8.
9
10
11 310 10. Colella TJ, Gravely S, Marzolini S, Grace SL, Francis JA, Oh P, et al. Sex bias in referral of women
12
13 311 to outpatient cardiac rehabilitation? A meta-analysis. *Eur J Prev Cardiol.* 2015;22(4):423–41.
14
15
16 312 11. Martin B-J, Hauer T, Arena R, Austford LD, Galbraith PD, Lewin a. M, et al. Cardiac Rehabilitation
17
18 313 Attendance and Outcomes in Coronary Artery Disease Patients. *Circulation.* 2012;126(6):677–87.
19
20
21 314 12. Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, et al. 2016 European
22
23 315 Guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J.*
24
25 316 2016;37(29):2315–81.
26
27
28 317 13. Smith SC, Benjamin EJ, Bonow RO, Braun LT, Creager MA, Franklin BA, et al. AHA/ACCF
29
30 318 secondary prevention and risk reduction therapy for patients with coronary and other
31
32 319 atherosclerotic vascular disease: 2011 update: A guideline from the American Heart Association
33
34 320 and American College of Cardiology Foundation. *Circulation.* 2011;124(22):2458–73.
35
36
37 321 14. Gaalema DE, Elliott RJ, Morford ZH, Higgins ST, Ades PA. Effect of Socioeconomic Status on
38
39 322 Propensity to Change Risk Behaviors Following Myocardial Infarction : Implications for Healthy
40
41 323 Lifestyle Medicine. *Prog Cardiovasc Dis.* 2017;60(1):159–68.
42
43
44 324 15. Nielsen KM, Faergeman O, Foldspang A, Larsen ML. Cardiac rehabilitation: Health characteristics
45
46 325 and socio-economic status among those who do not attend. *Eur J Public Health.* 2008;18(5):479–
47
48 326 83.
49
50
51 327 16. Neubeck L, Freedman S Ben, Clark AM, Briffa T, Bauman A, Redfern J. Participating in cardiac
52
53 328 rehabilitation: A systematic review and meta-synthesis of qualitative data. *Eur J Prev Cardiol.*
54
55 329 2012;19(3):494–503.
56
57
58
59
60

- 1
2
3
4 330 17. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening
5
6 331 the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for
7
8 332 reporting observational studies. *J Clin Epidemiol*. 2008;61(4):344–9.
9
10
11 333 18. Graversen CB, Eichhorst R, Ravn L, Christiansen SR, Johansen MB, Larsen ML, et al. Social
12
13 334 inequality and barriers to cardiac rehabilitation in the rehab-North register. *Scand Cardiovasc J*.
14
15 335 2017;51(6):316–22.
16
17
18 336 19. Madsen M, Davidsen M, Rasmussen S, Abildstrom SZ, Osler M. The validity of the diagnosis of
19
20 337 acute myocardial infarction in routine statistics: A comparison of mortality and hospital
21
22 338 discharge data with the Danish MONICA registry. *J Clin Epidemiol*. 2003;56(2):124–30.
23
24
25 339 20. Baadsgaard M, Quitzau J. Danish registers on personal income and transfer payments. *Scand J*
26
27 340 *Public Health*. 2011;39(7):103–5.
28
29
30 341 21. Eurostat Statistics Explained. International Standard Classification of Education (ISCED)
31
32 342 [Internet]. Available from: [https://ec.europa.eu/eurostat/statistics-](https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_%28ISCED%29)
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34 343 [explained/index.php/International_Standard_Classification_of_Education_%28ISCED%29](https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_%28ISCED%29)
35
36
37 344 22. Jensen VM, Rasmussen a. W. Danish education registers. *Scand J Public Health*. 2011;39(7
38
39 345 Suppl):91–4.
40
41
42 346 23. Pedersen CB. The Danish Civil Registration System. *Scand J Public Health*. 2011;39(7 suppl):22–5.
43
44
45 347 24. Thygesen SK, Christiansen CF, Lash TL, Christensen S, Sorensen HT. Predictive value of coding of
46
47 348 diagnoses in the charlson comorbidity index in the Danish national registry of patients.
48
49 349 *Pharmacoepidemiol Drug Saf*. 2009;18 (S1):S189.
50
51
52 350 25. Brown TM, Hernandez AF, Bittner V, Cannon CP, Ellrodt G, Liang L, et al. Predictors of Cardiac
53
54 351 Rehabilitation Referral in Coronary Artery Disease Patients. Findings From the American Heart
55
56 352 Association’s Get With The Guidelines Program. *J Am Coll Cardiol*. 2009;54(6):515–21.
57
58
59
60

- 1
2
3
4 353 26. Colbert JD, Martin B-J, Haykowsky MJ, Hauer TL, Austford LD, Arena RA, et al. Cardiac
5
6 354 rehabilitation referral, attendance and mortality in women. *Eur J Prev Cardiol.* 2014;22(8):979–
7
8 355 86.
9
10
11 356 27. Meillier LK, Nielsen KM, Larsen FB, Larsen ML. Socially differentiated cardiac rehabilitation: Can
12
13 357 we improve referral, attendance and adherence among patients with first myocardial infarction?
14
15 358 *Scand J Public Health.* 2012;40(3):286–93.
16
17
18 359 28. Mackenbach JP. The persistence of social inequalities in modern welfare states: the explanation
19
20 360 of a paradox. *Soc Sci Med.* 2012;75:761–9.
21
22
23 361 29. Mackenbach JP. Nordic paradox, Southern miracle, Eastern disaster: Persistence of inequalities
24
25 362 in mortality in Europe. *Eur J Public Health.* 2017;27:14–7.
26
27
28 363 30. Tromp J, Collins S. Universal healthcare but not universal access? *Eur J Prev Cardiol.*
29
30 364 2019;27(1);75-8.s
31
32
33 365 31. Cortés O, Arthur HM. Determinants of referral to cardiac rehabilitation programs in patients
34
35 366 with coronary artery disease: A systematic review. *Am Heart J.* 2006;151(2):249–56.
36
37
38 367 32. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Smith GD. Indicators of socioeconomic position
39
40 368 (part 1). *J Epidemiol Community Health.* 2006;60(1):7–12.
41
42
43 369 33. Geyer S, Hemström Ö, Peter R, Vågerö D. Education, income, and occupational class cannot be
44
45 370 used interchangeably in social epidemiology. Empirical evidence against a common practice. *J*
46
47 371 *Epidemiol Community Health.* 2006;60(9):804–10.
48
49
50
51 372 34. Lahelma E, Martikainen P, Laaksonen M, Aittomäki A. Pathways between socioeconomic
52
53 373 determinants of health. *J Epidemiol Community Health.* 2004;58(4):327–32.
54
55
56 374 35. Schmidt M, Schmidt SAJ, Sandegaard JL, Ehrenstein V, Pedersen L, Sørensen HT. The Danish
57
58 375 National patient registry: A review of content, data quality, and research potential. *Clin*
59
60

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376 Epidemiol. 2015;7:449–90.

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378 **Figure legends:**

379 Figure 1: Flowchart of the referral process to cardiac rehabilitation

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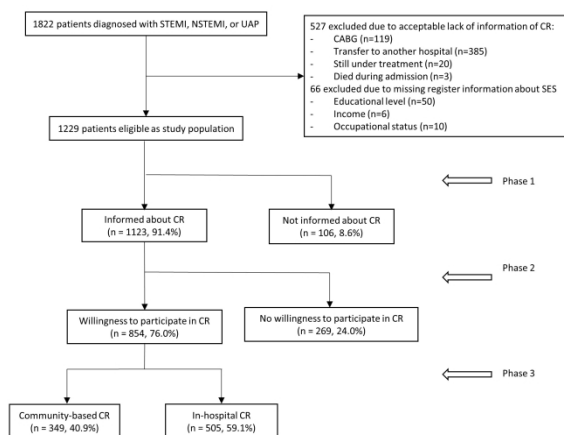


Figure 1: Flowchart of the referral process to cardiac rehabilitation

338x190mm (300 x 300 DPI)

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4 **ONLINE SUPPLEMENTARY MATERIAL**
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6
7 **Table S1:** Baseline Characteristics of excluded patients

	Excluded
Characteristics	n = 593
Male (n, %)	423
Age Group (years)	
< 65	242
65-74	171
≥ 75	180
Civil status (n, %)	
Married/Partnership	378
Divorced/Unmarried/Widow	>210
Missing	<5
Occupational status (n, %)	
Employed	158
Unemployed/out of workforce	417
Missing	18
Educational level (n, %)	
Low	256
Medium	200
High	52
Missing	72
Income, tertile (n, %)	
Low	245
Medium	197
High	>145
Missing	<5
Charlson Comorbidity Index	
Low (0 points)	421
Moderate/High (>0 points)	75
Missing	97

Table S2: Logistic regression model for those excluded compared with those included in the study population,
n = 1822

	n, (%)	Unadjusted		Multivariable adjusted*	
		OR	95% CI	OR	95% CI
Observations	593 (32.5)				
Civil status					
Married/Partnership	378 (20.7)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	>210 (>11.5)	1.02	0.83-1.25	0.85	0.67-1.07
Missing	<5 (<1)				
Occupational status					
Employed	158 (8.7)	1 (ref.)		1 (ref.)	
Unemployed/Retired	417 (22.9)	1.69	1.36-2.09	1.54	1.14-2.08
Missing	18 (1.0)				
Educational level					
Low	256 (14.1)	1 (ref.)		1 (ref.)	
Medium	200 (10.1)	0.77	0.61-0.96	0.77	0.61-0.97
High	49 (2.7)	0.59	0.42-0.84	0.60	0.41-0.87
Missing	72 (4.0)				
Income, tertiles					
Low	245 (13.4)	1 (ref.)		1 (ref.)	
Medium	197 (10.8)	0.71	0.56-0.90	0.77	0.59-1.01
High	>145 (>7.9)	0.46	0.36-0.59	0.55	0.40-0.75
Missing	<5 (<0.3)				

* Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
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	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7-8
		(c) Explain how missing data were addressed	5
		(d) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(e) Describe any sensitivity analyses	7-8
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	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	6
Outcome data	15*	Report numbers of outcome events or summary measures	6+8
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	9-12
		(b) Report category boundaries when continuous variables were categorized	9-12
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
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	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
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	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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.

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6 2 **rehabilitation following acute coronary syndrome: a cross-sectional study**
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58 24 **Word count:** 3373 words
59
60

25 Abstract

26 **Objective:** to evaluate the association between socio-economic status (SES) and referral to cardiac
27 rehabilitation (CR) after incident acute coronary syndrome (ACS) by dividing the referral process into
28 three phases (1. informed about CR, 2. willingness to participate in CR, and 3. assigned CR setting).

29 **Design:** Cross-sectional study.

30 **Setting:** Department of Cardiology at a Danish University Hospital from 1 January 2011 to 31 December
31 2014.

32 **Participants:** A total of 1229 patients assessed for CR during hospitalisation with ACS were
33 prospectively registered in the Rehab-North Register from 2011-2014. SES was assessed using data
34 from national registers, concerning: personal income, occupational status, educational level, and civil
35 status. Patients were excluded if in one of the following criteria were fulfilled: 1) missing data on SES, or
36 2) acceptable reason for not informing patients about CR (treatment with coronary artery bypass graft,
37 transfer to another hospital, still under treatment, or death).

38 **Main outcome measures:** Outcomes were defined by dividing the referral process into three phases: 1.
39 informed about CR, 2. willingness to participate, and 3. assigned CR setting (in-hospital /community
40 centre) after ACS.

41 **Results:** A total of 854 (69.5 %) patients were referred to CR. After adjustment for age, gender, ACS
42 diagnosis (ST-Elevated Myocardial Infarction, Non-ST-Elevated Myocardial Infarction, Unstable Angina
43 Pectoris) and comorbidity, high income had the strongest association of referral to CR in all three
44 phases (informed about CR: OR 2.17, 95% CI: 1.0- 4.64; willingness to participate in CR: OR 1.55, 95% CI:
45 1.02-2.35; assigned in-hospital CR: OR 1.47, 95% CI: 0.91-2.36). Educational level showed similar
46 tendencies, however not statistically significant. The results did not vary according to gender.

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4 47 **Conclusion:** This is the first study to investigate the referral process to CR using a three-phase structure.

5
6 48 It suggests income and education to influence all phases in the referral process to CR after ACS.

7
8
9 49 **Keywords:** Acute Myocardial Infarction, Cardiac Rehabilitation, Referral Process, Socio-economic Status

10 11 50 **Strengths and limitations of this study**

- 12
13
14 51 - This is the first study to investigate the referral process to cardiac rehabilitation (CR) using a
- 15
16 52 three-phase structure (1. informed about CR, 2. willingness to participate in CR, and 3. assigned
- 17
18 53 CR setting) which provides better knowledge in understanding why social inequality persists in
- 19
20 54 referral to CR.
- 21
22
23 55 - Socio-economic variables were provided by highly validated Danish register data using the
- 24
25 56 unique 10-digit civil registration number that is given to all Danish citizens.
- 26
27 57 - Multivariable logistic regression analyses were used to minimise potential confounding.
- 28
29
30 58 - Data was not gathered for specific scientific purposes and it cannot be ruled out that not all
- 31
32 59 patients admitted with Acute Coronary Syndrome were identified. However, such loss was
- 33
34 60 considered unsystematic and unintended and should not pose a problem for bias introduction.
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37

38 61 **Introduction**

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40
41 62 Low socio-economic status (SES) is associated with higher risk of developing Ischemic Heart Disease

42
43 63 (IHD) and poorer subsequent outcome, including higher risk of recurrent cardiovascular events and

44
45 64 cardiac-related mortality.(1–5) Cardiac rehabilitation (CR) is an important step to reduce disease

46
47 65 outcomes and is an integral part of IHD care as it aims to improve quality of life as well as patients’

48
49 66 physical, psychological, and social functioning.(4)

50
51
52 67 CR comprises exercise therapy, psychological consulting, treatment-targeted therapy, and life-style

53
54 68 changing modules (dietary modification, and smoking cessation).(4) The program is a coordinated effort

55
56 69 made by cardiologists, nurses, physiotherapists, dietitians, and eventually occupational therapists. If

57
58 70 needed, psychologists, social workers, or priests may be included as well.(4)

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4 71 The efficacy of CR in reducing cardiovascular mortality and risk of hospital readmissions is well-
5
6 72 documented.(6–8) It therefore seems irrational that international research in general continues to find
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8 73 CR “referral” or “participation and completion” rates to be unsatisfactory.(9–13)
9
10 74 Different socio-economic characteristics (income, educational level, occupational status, civil status) are
11
12 75 shown to be associated with CR underutilization.(14) Low income and educational level have
13
14 76 irrespectively of type of health care system repeatedly been associated with limited participation and
15
16 77 completion rate.(11,15) It is consequently of major importance to eliminate the socio-economic
17
18 78 differences in CR if the inequality in IHD burden is to be reduced.
19
20
21 79 Obstacles in referral and participation to CR among patients with lower SES may be due to system-level
22
23 80 and personal barriers.(16) System-level barriers covers physicians recommendations, the interaction
24
25 81 with the healthcare team, and misconceptions about CR. Personal barriers includes perception about
26
27 82 IHD and CR, and belief about the ability to control IHD.(16) However, vulnerable elements in the
28
29 83 referral process prone to socio-economic inequality among patients with Acute Coronary Syndrome
30
31 84 (ACS) remain unexplored. By dividing the referral process into three phases, it is possible to evaluate if
32
33 85 such inequality is the result of selection of patients at the system-level (the process of informing
34
35 86 patients about CR and the setting of CR that patients are referred to) rather than the person-level
36
37 87 (patients’ own willingness to participate in CR). To our knowledge, no study has analysed the entire
38
39 88 referral process using such three-phase structure while controlling for confounders in a population of
40
41 89 patients surviving ACS. Therefore, the objective of this study was to investigate how SES is associated
42
43 90 with the patients’ chances of 1) being informed about CR, 2) willingness to participate, and 3) assigned
44
45 91 CR setting (in-hospital or community centre). Phase 3 was determined by regional guidelines: patients
46
47 92 suffering ST-Elevated Myocardial Infarction (STEMI) or complicated Non-ST-Elevated Myocardial
48
49 93 Infarction (NSTEMI) were offered in-hospital CR whereas patients with uncomplicated NSTEMI and
50
51 94 Unstable Angina Pectoris (UAP) were offered CR in a community centre).
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96 **Methods**

97 The study followed the STROBE guidelines for cross-sectional studies.(17)

98 **Study design**

99 This population-based study used data from the Rehab-North Register. Its content has previously been
100 described.(18) In short, the Rehab-North Register holds data on all patients hospitalised at the
101 Department of Cardiology, Aalborg University Hospital from 1 January 2011 to 31 December 2014 with
102 a diagnosis of ACS. All were assessed for eligibility to CR using a questionnaire.(18)

103 In Denmark, CR fully or partially takes place in-hospital or at community centres. In-hospital CR is
104 reserved for high-risk patients and is structured with a more complex intervention. The Danish Public
105 Health System is tax paid, enabling CR to be free of charge for the patient.

106 **Patient and Public involvement statement**

107 No patients were involved in the design, or conduct, or reporting, or dissemination plans of our
108 research.

109 **Study Population**

110 The study population was identified in the Rehab-North Register as patients diagnosed with ACS (ICD-
111 10: I20.0, I21.). The registered diagnosis was verified by linking data from the Rehab-North Register
112 with the Danish National Patient Register (NPR) and the Danish Register of Causes of Death.(19) If any
113 discrepancy arose, the diagnosis registered in the NPR was selected. Patients were excluded if in one of
114 the following criteria were fulfilled: 1) missing data on SES 2) acceptable reason for not informing
115 patients about CR, including treatment with coronary artery bypass graft, transfer to another hospital,
116 still under treatment, or death. Patients who underwent coronary artery bypass grafting was informed
117 about CR at the Thoracic Surgery Department performing the operation. Patients who were 'transferred

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2
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4 118 to another hospital' received information about CR at other cardiology departments. We were not able
5
6 119 to receive confirmation regarding referral to CR in this patient group.

7
8 120 The study population and referral design using three phases is illustrated in figure 1.

9 10 121 **Socio-economic status**

11
12 122 Different indicators of SES (personal income, occupational status, educational level, and civil status)
13
14 123 were chosen, due to a priori knowledge about their proposed mechanisms associated to the outcome
15
16 124 variable. Ascertainment of socio-economic variables from national registers was done by linkage of a
17
18 125 unique personal number given to all Danish residents.

19
20 126 The Income Statistics Register provided information regarding both disposable personal income (low,
21
22 127 medium, high) calculated for the calendar year before disease onset, and occupational status
23
24 128 (employed, unemployed/out of workforce) set for the calendar year before disease onset.(20) A
25
26 129 person's highest obtained educational level (low, medium, high) was based on the International
27
28 130 Standard Classification of Education (ISCED)(21) from the Student's Register(22), and civil status
29
30 131 (married/partnership, divorced/unmarried /widow) from the Civil Registration System (CRS).(23)

31 32 33 34 35 132 **Outcomes**

36
37 133 Outcomes were defined by dividing the referral process into three phases: 1. informed about CR, 2.
38
39 134 willingness to participate, and 3. assigned CR setting (in-hospital /community centre) after ACS.
40
41 135 All outcome information gathering were done during the patients' hospitalisation and included in the
42
43 136 questionnaires that founded the Rehab-North Register.

44 45 46 47 48 137 **Covariates**

49
50 138 The selection of covariates to be included in the multivariable analyses was done based on directed
51
52 139 acyclic graph (not shown). Age was registered at time of diagnosis and categorized into three groups: <
53
54 140 65 years, 65-74 years, and \geq 75 years. Information regarding age and gender was gathered from the
55
56 141 CRS.(23) Comorbidity diagnoses were defined by the Charlson Comorbidity Index (CCI), but only

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4 142 diagnoses from the year 2011 until hospitalisation were accessible. Comorbidity diagnoses was drawn
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6 143 from the NPR.(24) In general, patients with NSTEMI and UAP are less likely referred to CR compared to
7
8 144 patients with STEMI.(25) Therefore, to get an accurate estimate of the impacts of patients' SES on CR
9
10 145 referral, ACS diagnosis (STEMI, NSTEMI, UAP) were included as a covariate.(25)
11

12 146 **Statistical analysis**

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14
15 147 Baseline characteristics of study population were summarised by frequencies and percentages. The
16
17 148 association between socio-economic variables and being informed about CR, willingness to participate,
18
19 149 and assigned CR setting was assessed by crude (model 1) and multivariable logistic regression adjusted
20
21 150 for confounders (age, gender, ACS diagnosis, CCI) (model 2). Results were presented in odds ratios (OR)
22
23 151 with 95% confidence intervals (95% CI). Potential effect modification by gender was assessed by
24
25 152 stratification and likelihood-ratio tests as studies have found females to experience lower rates of
26
27 153 referral to CR compared to males.(10,26) Statistical analyses were performed using Stata Software
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29 154 (v.15.1; Stata Corp. College Station, TX).
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33

34 155 **Results**

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36
37 156 Of the original cohort of 1822 patients diagnosed with ACS, only patients with no missing socio-
38
39 157 economic variables, and no acceptable reasons for not being informed about CR were included in the
40
41 158 study (figure 1). This resulted in a study population comprising 1229 patients (73.8% male). The
42
43 159 patients' baseline characteristics, stratified by diagnosis, are presented in table 1. STEMI patients were
44
45 160 relatively younger and still an available workforce with higher income. In the study population, 1123
46
47 161 (91.4%) patients were informed about CR of which 854 (76.0%) patients subsequently agreed to
48
49 162 participate in the program. Of those, 349 (40.9%) patients were referred to CR in a community centre
50
51 163 and 505 (59.1%) patients were referred to in-hospital CR (figure 1).
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57 **Table 1:** Characteristics of study population stratified by diagnosis
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59
60

	Full population	STEMI	NSTEMI	UAP
Characteristics	n = 1229	n = 402	n = 711	n = 116
Male (n, %)	907 (73.8)	322 (80.1)	503 (70.7)	82 (70.7)
Age Group (years)				
< 65	591 (48.1)	227 (56.5)	308 (43.3)	56 (48.3)
65-74	371 (30.2)	116 (28.9)	215 (30.2)	40 (34.5)
≥ 75	267 (21.7)	59 (14.7)	188 (26.4)	20 (17.2)
Civil status (n, %)				
Married/Partnership	793 (64.5)	253 (62.9)	449 (63.2)	91 (78.4)
Divorced/Unmarried/Widow	436 (35.5)	149 (37.1)	262 (36.8)	25 (21.6)
Occupational status (n, %)				
Employed	479 (39.0)	195 (48.5)	240 (33.8)	44 (37.9)
Unemployed/out of workforce	750 (61.0)	207 (51.5)	471 (66.2)	72 (62.1)
Educational level (n, %)				
Low	516 (42.0)	144 (35.8)	322 (45.3)	50 (43.1)
Medium	539 (43.9)	201 (50.0)	293 (41.2)	45 (38.8)
High	174 (14.2)	57 (14.2)	96 (13.5)	21 (18.1)
Income, tertile (n, %)				
Low	405 (33.0)	113 (28.1)	251 (35.3)	41 (35.3)
Medium	406 (33.0)	124 (30.8)	247 (34.7)	35 (30.2)
High	418 (34.0)	165 (41.0)	213 (30.0)	40 (34.5)
Charlson Comorbidity Index				
Low (0 points)	1088 (88.5)	358 (89.1)	630 (88.6)	100 (86.2)
Moderate/High (>0 points)	141 (11.5)	44 (10.9)	81 (11.4)	16 (13.8)

165 STEMI: ST-elevated myocardial infarction; NSTEMI: non-ST-elevated myocardial infarction; UAP: unstable angina
 166 pectoris

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4 167 **Phase 1: SES and being informed about CR**

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6 168 Higher income and educational level had positive crude associations with being informed about CR

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8 169 whereas being unemployed/out of workforce or single-living had a negative association (table 2). These

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10 170 associations were greatly reduced after adjustment for age, gender, ACS diagnosis, and CCI. The

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12 171 adjusted regression analysis found high income to be associated with being informed about CR (OR

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14 172 2.17, 95% CI: 1.01; 4.64). High educational level was also associated with being informed about CR

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16 173 although the association did not reach statistical significance (OR: 1.60, 95% CI: 0.72-3.54).

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22 **Table 2:** Logistic regression model for being informed about cardiac rehabilitation, n = 1229

	Full study population n, (%)	Informed about CR n, (%)	Unadjusted		Multivariable adjusted*	
			OR	95% CI	OR	95% CI
Observations	1229 (100)	1123 (91.4)				
Civil status						
Married/Partnership	793 (64.5)	735 (59.8)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	436 (35.5)	388 (31.6)	0.64	0.43-0.95	0.76	0.49-1.19
Occupational status						
Employed	479 (39.0)	469 (38.2)	1 (ref.)		1 (ref.)	
Unemployed/out of workforce	750 (61.0)	654 (53.2)	0.15	0.07-0.28	0.46	0.20-1.07
Educational level						
Low	516 (42.0)	452 (36.8)	1 (ref.)		1 (ref.)	
Medium	539 (43.9)	505 (41.1)	2.10	1.36-3.25	1.17	0.72-1.89
High	174 (14.2)	166 (13.5)	2.94	1.38-6.26	1.60	0.72-3.54
Income, tertiles						
Low	405 (33.0)	342 (27.8)	1 (ref.)		1 (ref.)	
Medium	406 (33.0)	374 (30.4)	2.15	1.37-3.38	1.40	0.86-2.28

High 418 (34.0) 407 (33.1) 6.82 3.54-13.14 2.17 1.01-4.64

* Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

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Phase 2: SES and willingness to participate in CR

High income, high educational level, and being single-living (divorced/unmarried/widow) were all

associated with a higher likelihood of willingness to participate in CR in the crude analyses (table 3).

Being unemployed/retired was negatively associated with being willing to participate in CR. After

adjustment, high income level had the highest OR (OR 1.55, 95% CI: 1.02; 2.35) in relation to willingness

to participate. A similar pattern was observed for high educational level although the association was

not statistically significant (OR 1.21, 95% CI: 0.78; 1.88). Likewise, being single-living was also associated

with willingness to participate in CR, although, the estimates did not reach statistical significance (OR

1.28, 95% CI: 0.93; 1.76).

Table 3: Logistic regression model for willingness to participate in cardiac rehabilitation, n = 1123

	Full study population n, (%)	Willingness to participate in CR n, (%)	Unadjusted		Multivariable adjusted*	
			OR	95% CI	OR	95% CI
Observations	1229 (100)	854 (76.0)				
Civil status						
Married/Partnership	793 (64.5)	546 (48.6)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	436 (35.5)	308 (27.4)	1.33	0.99-1.79	1.28	0.93-1.76
Occupational status						
Employed	479 (39.0)	388 (34.6)	1 (ref.)		1 (ref.)	
Unemployed/out of workforce	750 (61.0)	466 (41.5)	0.52	0.39-0.69	0.93	0.62-1.40
Educational level						
Low	516 (42.0)	322 (28.7)	1 (ref.)		1 (ref.)	
Medium	539 (43.9)	405 (36.1)	1.64	1.21-2.20	1.36	0.98-1.88

High	174 (14.2)	127 (11.3)	1.31	0.87-1.99	1.21	0.78-1.88
Income, tertiles						
Low	405 (33.0)	229 (20.4)	1 (ref.)		1 (ref.)	
Medium	406 (33.0)	288 (25.6)	1.65	1.19-2.30	1.35	0.94-1.94
High	418 (34.0)	337 (30.0)	2.38	1.69-3.34	1.55	1.02-2.35

* Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

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186 Phase 3: SES and assigned CR setting

187 Table 4 shows the association of SES on being assigned to in-hospital CR compared to CR in a
 188 community centre. High income was significantly associated with assignment to in-hospital CR (OR:
 189 2.10, 95% CI: 1.49; 2.97) but the association was attenuated after adjustment for confounders (income:
 190 adjusted OR: 1.47, 95% CI: 0.91; 2.36).

Table 4: Logistic regression model for assigned cardiac rehabilitation setting, n = 854

	Full study population n, (%)	Assigned CR-setting n, (%)	Unadjusted		Multivariable adjusted*	
			OR	95% CI	OR	95% CI
Observations	1229 (100)	505 (59.1)				
Civil status						
Married/Partnership	793 (64.5)	317 (37.1)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	436 (35.5)	188 (22.0)	1.13	0.85-1.51	1.20	0.84-1.69
Occupational status						
Employed	479 (39.0)	268 (31.4)	1 (ref.)		1 (ref.)	
Unemployed/out of workforce	750 (61.0)	237 (27.8)	0.46	0.35-0.61	0.75	0.49-1.15
Educational level						
Low	516 (42.0)	177 (20.7)	1 (ref.)		1 (ref.)	
Medium	539 (43.9)	248 (29.0)	1.29	0.96-1.74	0.90	0.63-1.30

High	174 (14.2)	80 (9.4)	1.39	0.91-2.13	1.20	0.72-1.99
Income, tertiles						
Low	405 (33.0)	115 (13.5)	1 (ref.)		1 (ref.)	
Medium	406 (33.0)	161 (18.9)	1.26	0.89-1.78	1.14	0.73-1.78
High	418 (34.0)	229 (26.8)	2.10	1.49-2.97	1.47	0.91-2.36

* Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

191 Supplementary analyses

192 The analyses were stratified by gender in a supplementary analysis. The results were not substantially
193 different from the main analysis (not shown).

194 The baseline characteristics of patients being excluded from the study population was obtained (online
195 supplementary material, table 1). After multivariable logistic regression, patients being excluded from
196 the study population to have significantly lower SES compared to the patients being included (online
197 supplementary material, table 2).

198 Discussion

199 In this study, the referral process to CR was assessed using a three-phase structure: 1. informed about
200 CR, 2. willingness to participate in CR, and 3. assigned CR setting. After adjustment, high income was
201 the only variable statistical significantly associated with referral to CR in phase 1 and 2, and
202 insignificantly associated with phase 3 of the referral process. High educational level had a similar
203 pattern, but the association did not reach statistical significance.

204 Overall, 69.5% of the patients were referred to CR, which is in accordance with earlier findings (22-
205 81.5%).(9,10,25,26) Notably, in one study strikingly 86% was referred to CR after usage of a social
206 differentiated intervention program.(27) However, it would be difficult to reproduce such a result in an
207 observational study without this specific purpose.

208 The finding of patients' income and educational level to be associated with all three phases the referral
209 process to CR may be explained by 'the Nordic Paradox' observed in the Nordic European

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4 210 countries.(28,29) These countries, covering Denmark, Norway, Sweden, and Finland, are 'welfare
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6 211 states' with equal access to health care which theoretically ought to diminish the importance of
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8 212 patients' level of income and education regarding access to health care services. However, this is not
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10 213 the case as inequality e.g. in mortality, persists.(29) Although income inequality is smaller in the Nordic
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12 214 countries, this still covers over inequality in wealth, housing condition, and material living conditions,
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14 215 and are used together with educational level to assess latent socio-economic factors (health literacy,
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16 216 greater burden of behavioral and biological risk factors, and reduced access to quality care and
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18 217 medication).(30) Thus, our finding may imply such latent socio-economic factors to be important in the
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21 218 referral process to CR.

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24 219 We found single-living to be potentially associated with the willingness to participate in CR. If such an
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26 220 association is reproducible in later studies, then attention should focus on these patients without a
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28 221 partner, who less often receive referral to CR, which has been attributed to lack of social support.(31)
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31 222 International studies find younger age, male gender, living with a partner, high educational level, and
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33 223 high gross income to be predictors of CR referral.(10,25,31) This inequality in CR referral causes concern
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35 224 as participation helps patients implement needed behavioural changes, which reduces cardiac-related
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37 225 deaths.(6) Patients with low SES often have biological, behavioural, and psychosocial disadvantages
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39 226 that may accelerate risk of cardiovascular diseases. Therefore, the need of referral, attendance, and
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41 227 completion of CR should be prioritized in this patient group.(1,2)

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45 228 By splitting the referral process into three phases, new insights regarding importance of taking patients
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47 229 SES into consideration when referring them to CR was gained. Our results show the importance of being
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49 230 aware of system-level barriers present in the referral process. Moreover, identifying those patients who
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51 231 need more motivation before being willing to enter a CR programme is highly important. In that way,
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53 232 patients are well-informed about CR and able to make a well-considered decision regarding
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55 233 participation.
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4 234 Definition of SES is a conceptual challenge often solved by use of personal/family income, educational
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6 235 level, civil status, and/or occupation. There is no consensus on which parameters to use as indicators of
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8 236 SES. It has been argued to use single variables as proxy measurements for SES despite different causal
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10 237 pathways. However, others find it problematic only to estimate SES by one parameter, as this may
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12 238 increase the risk of residual confounding by unmeasured socio-economic circumstances.(1,32)
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14 239 Moreover, the effect of socio-economic variables seems rather outcome-related and is suggested not to
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16 240 be used interchangeably without thorough consideration.(33) As our central interest was to investigate
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18 241 the impact of SES on the referral process to CR, and therefore use SES as exposure variable, we a priori
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20 242 hypothesized the different variables all to be linked to our outcome measures. The risk of such an
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22 243 approach was the introduction of collinearity. However, research finds e.g. educational level,
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24 244 occupation, and income to measure different phenomena, to have different causal mechanisms, and in
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26 245 part to be explained by other socio-economic parameters.(33,34) Since literature finds income,
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28 246 educational level, occupational status, and civil status to be important determinants for referral,
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30 247 participation, and completion of CR, it seemed most appropriate to include all variables in order to
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32 248 answer our research questions. The consequence of this approach was that we cannot get a single
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34 249 estimate that illustrates the effect of SES.
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40 250 Some caution must be taken when interpreting the results of our study. Firstly, data was not gathered
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42 251 for specific scientific purposes and it cannot be ruled out that some patients admitted with ACS were
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44 252 not included in the Rehab-North Register. However, such loss was considered unsystematic and
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46 253 unintended and should not pose a problem for bias introduction. Moreover, the non-response analysis
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48 254 found excluded patients to have lower SES compared to the included study population. As exclusion
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50 255 was due to clinical implications (patients were to receive CR referral elsewhere), this should not pose a
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52 256 problem for participation bias introduction in our study population.
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54 257 Secondly, use of register data minimized risk of information bias, due to nationwide good algorithms for
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56 258 correct diagnosis coding. Despite linkage to other registers, risk of residual or unmeasured confounding
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4 259 may be present.⁽³⁵⁾ Thirdly, there may be a risk of residual or unaccounted confounding, if data on
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6 260 confounding variables was not classified with adequate precision. The CCI variable may be inaccurate
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8 261 which is caused by the limited timeframe for inclusion of comorbidities. This increases the risk of
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10 262 unaccounted confounding and should be taken into consideration when interpreting the results.
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12 263 Participation and completion rates of in-hospital CR and CR in community centres remained unexplored
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15 264 as our study only focused on the referral process to CR.
16

17 265 **Conclusion**

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20 266 High income and educational level were associated with a larger chance of being informed about CR,
21
22 267 willingness to participate in CR, and assigned in-hospital CR in patients with ACS.
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28 269 **Acknowledgements:** None

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31 270 **Contributorship statement:** CBG, RE, and MLL contributed to study design and acquisition
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33
34 271 of the data. CBG, MBJ, and MLL analysed and interpreted the data. SPJ, SR, and THO contributed to
35
36 272 interpretation. CBG drafted the initial manuscript and all authors critically revised the manuscript and
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38 273 gave final approval.
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41 274 **Ethics:** The study is approved by the Danish Data Protection Agency (project number: 2008-58-0028)
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44 275 and the Danish Patient Safety Authority (3-3013-2763/1). In Denmark, no written consent is needed for
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46 276 use of such register-based data.
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50
51 278 Foundation grant number: 18-R123-A8283-22081. The funders had no role in planning or conducting
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53 279 the study.
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56 280 **Competing interest:** None declared
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4 281 **Data sharing statement:** No data are available. Danish law dictates data access only to be
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7 282 available to researchers directly responsible for study conduction.
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11 284 **References**

- 12
13
14 285 1. Havranek EP, Mujahid MS, Barr DA, Blair I V., Cohen MS, Cruz-Flores S, et al. Social determinants
15
16 286 of risk and outcomes for cardiovascular disease: A scientific statement from the American Heart
17
18 287 Association. *Circulation*. 2015;132(9):873–98.
19
20
21
22 288 2. Schultz WM, Kelli HM, Lisko JC, Varghese T, Shen J, Sandesara P, et al. Socioeconomic Status and
23
24 289 Cardiovascular Outcomes. *Circulation*. 2018;137(20):2166–78.
25
26
27 290 3. Ohm J, Skoglund PH, Discacciati A, Sundström J, Hambraeus K, Jernberg T, et al. Socioeconomic
28
29 291 status predicts second cardiovascular event in 29,226 survivors of a first myocardial infarction.
30
31 292 *Eur J Prev Cardiol*. 2018;25(9):985–93.
32
33
34 293 4. Piepoli MF, Corra U, Adamopoulos S, Benzer W, Bjarnason-wehrens B, Cupples M, et al.
35
36 294 Secondary prevention in the clinical management of patients with cardiovascular diseases . Core
37
38 295 components , standards and outcome measures for referral and delivery. *Eur J Prev Cardiol*.
39
40 296 2014;21(6):664–81.
41
42
43
44 297 5. Rasmussen JN, Rasmussen S, Gislason GH, Buch P, Abildstrom SZ, Køber L, et al. Mortality after
45
46 298 acute myocardial infarction according to income and education. *J Epidemiol Community Health*.
47
48 299 2006;60(4):351–6.
49
50
51 300 6. Anderson L, Oldridge N, Thompson DR, Zwisler A-D, Rees K, Martin N, et al. Exercise-Based
52
53 301 Cardiac Rehabilitation for Coronary Heart Disease. *J Am Coll Cardiol*. 2016;67(1):1–12.
54
55
56 302 7. Anderson LJ, Taylor RS. Cardiac rehabilitation for people with heart disease: An overview of
57
58 303 Cochrane systematic reviews. *Int J Cardiol*. 2014;177(2):348–61.
59
60

- 1
2
3
4 304 8. Rauch B, Davos CH, Doherty P, Saure D, Metzendorf MI, Salzwedel A, et al. The prognostic effect
5
6 305 of cardiac rehabilitation in the era of acute revascularisation and statin therapy: A systematic
7
8 306 review and meta-analysis of randomized and non-randomized studies - The Cardiac
9
10 307 Rehabilitation Outcome Study (CROS). *Eur J Prev Cardiol.* 2016;23(18):1914–39.
- 11
12
13 308 9. Sumner J, Grace SL, Doherty P. Predictors of Cardiac Rehabilitation Utilization in England :
14
15 309 Results From the National Audit. *J Am Heart Assoc.* 2016;5:1–8.
- 16
17
18 310 10. Colella TJ, Gravely S, Marzolini S, Grace SL, Francis JA, Oh P, et al. Sex bias in referral of women
19
20 311 to outpatient cardiac rehabilitation? A meta-analysis. *Eur J Prev Cardiol.* 2015;22(4):423–41.
- 21
22
23 312 11. Martin B-J, Hauer T, Arena R, Austford LD, Galbraith PD, Lewin a. M, et al. Cardiac Rehabilitation
24
25 313 Attendance and Outcomes in Coronary Artery Disease Patients. *Circulation.* 2012;126(6):677–87.
- 26
27
28 314 12. Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, et al. 2016 European
29
30 315 Guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J.*
31
32 316 2016;37(29):2315–81.
- 33
34
35 317 13. Smith SC, Benjamin EJ, Bonow RO, Braun LT, Creager MA, Franklin BA, et al. AHA/ACCF
36
37 318 secondary prevention and risk reduction therapy for patients with coronary and other
38
39 319 atherosclerotic vascular disease: 2011 update: A guideline from the American Heart Association
40
41 320 and American College of Cardiology Foundation. *Circulation.* 2011;124(22):2458–73.
- 42
43
44 321 14. Gaalema DE, Elliott RJ, Morford ZH, Higgins ST, Ades PA. Effect of Socioeconomic Status on
45
46 322 Propensity to Change Risk Behaviors Following Myocardial Infarction : Implications for Healthy
47
48 323 Lifestyle Medicine. *Prog Cardiovasc Dis.* 2017;60(1):159–68.
- 49
50
51 324 15. Nielsen KM, Faergeman O, Foldspang A, Larsen ML. Cardiac rehabilitation: Health characteristics
52
53 325 and socio-economic status among those who do not attend. *Eur J Public Health.* 2008;18(5):479–
54
55 326 83.
- 56
57
58
59
60

- 1
2
3
4 327 16. Neubeck L, Freedman S Ben, Clark AM, Briffa T, Bauman A, Redfern J. Participating in cardiac
5
6 328 rehabilitation: A systematic review and meta-synthesis of qualitative data. *Eur J Prev Cardiol.*
7
8 329 2012;19(3):494–503.
9
10
11 330 17. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening
12
13 331 the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for
14
15 332 reporting observational studies. *J Clin Epidemiol.* 2008;61(4):344–9.
16
17
18 333 18. Graversen CB, Eichhorst R, Ravn L, Christiansen SR, Johansen MB, Larsen ML, et al. Social
19
20 334 inequality and barriers to cardiac rehabilitation in the rehab-North register. *Scand Cardiovasc J.*
21
22 335 2017;51(6):316–22.
23
24
25 336 19. Madsen M, Davidsen M, Rasmussen S, Abildstrom SZ, Osler M. The validity of the diagnosis of
26
27 337 acute myocardial infarction in routine statistics: A comparison of mortality and hospital
28
29 338 discharge data with the Danish MONICA registry. *J Clin Epidemiol.* 2003;56(2):124–30.
30
31
32
33 339 20. Baadsgaard M, Quitzau J. Danish registers on personal income and transfer payments. *Scand J*
34
35 340 *Public Health.* 2011;39(7):103–5.
36
37
38 341 21. Eurostat Statistics Explained. International Standard Classification of Education (ISCED)
39
40 342 [Internet]. Available from: [https://ec.europa.eu/eurostat/statistics-](https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_%28ISCED%29)
41
42 343 [explained/index.php/International_Standard_Classification_of_Education_%28ISCED%29](https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_%28ISCED%29)
43
44
45 344 22. Jensen VM, Rasmussen a. W. Danish education registers. *Scand J Public Health.* 2011;39(7
46
47 345 Suppl):91–4.
48
49
50 346 23. Pedersen CB. The Danish Civil Registration System. *Scand J Public Health.* 2011;39(7 suppl):22–5.
51
52
53 347 24. Thygesen SK, Christiansen CF, Lash TL, Christensen S, Sorensen HT. Predictive value of coding of
54
55 348 diagnoses in the charlson comorbidity index in the Danish national registry of patients.
56
57 349 *Pharmacoepidemiol Drug Saf.* 2009;18 (S1):S189.
58
59
60

- 1
2
3
4 350 25. Brown TM, Hernandez AF, Bittner V, Cannon CP, Ellrodt G, Liang L, et al. Predictors of Cardiac
5
6 351 Rehabilitation Referral in Coronary Artery Disease Patients. Findings From the American Heart
7
8 352 Association's Get With The Guidelines Program. *J Am Coll Cardiol*. 2009;54(6):515–21.
9
10
11 353 26. Colbert JD, Martin B-J, Haykowsky MJ, Hauer TL, Austford LD, Arena RA, et al. Cardiac
12
13 354 rehabilitation referral, attendance and mortality in women. *Eur J Prev Cardiol*. 2014;22(8):979–
14
15 355 86.
16
17
18 356 27. Meillier LK, Nielsen KM, Larsen FB, Larsen ML. Socially differentiated cardiac rehabilitation: Can
19
20 357 we improve referral, attendance and adherence among patients with first myocardial infarction?
21
22
23 358 *Scand J Public Health*. 2012;40(3):286–93.
24
25
26 359 28. Mackenbach JP. The persistence of social inequalities in modern welfare states: the explanation
27
28 360 of a paradox. *Soc Sci Med*. 2012;75:761–9.
29
30
31 361 29. Mackenbach JP. Nordic paradox, Southern miracle, Eastern disaster: Persistence of inequalities
32
33 362 in mortality in Europe. *Eur J Public Health*. 2017;27:14–7.
34
35
36 363 30. Tromp J, Collins S. Universal healthcare but not universal access? *Eur J Prev Cardiol*.
37
38 364 2019;27(1);75-8.s
39
40
41 365 31. Cortés O, Arthur HM. Determinants of referral to cardiac rehabilitation programs in patients
42
43 366 with coronary artery disease: A systematic review. *Am Heart J*. 2006;151(2):249–56.
44
45
46 367 32. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Smith GD. Indicators of socioeconomic position
47
48 368 (part 1). *J Epidemiol Community Health*. 2006;60(1):7–12.
49
50
51 369 33. Geyer S, Hemström Ö, Peter R, Vågerö D. Education, income, and occupational class cannot be
52
53 370 used interchangeably in social epidemiology. Empirical evidence against a common practice. *J*
54
55 371 *Epidemiol Community Health*. 2006;60(9):804–10.
56
57
58 372 34. Lahelma E, Martikainen P, Laaksonen M, Aittomäki A. Pathways between socioeconomic
59
60

- 1
2
3
4 373 determinants of health. *J Epidemiol Community Health*. 2004;58(4):327–32.
5
6 374 35. Schmidt M, Schmidt SAJ, Sandegaard JL, Ehrenstein V, Pedersen L, Sørensen HT. The Danish
7
8
9 375 National patient registry: A review of content, data quality, and research potential. *Clin*
10
11 376 *Epidemiol*. 2015;7:449–90.
12
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17 378 **Figure legends:**

19 379 Figure 1: Flowchart of the referral process to cardiac rehabilitation.

20 380 STEMI: ST-Elevated-Myocardial Infarction, NSTEMI: Non-ST-Elevated-Myocardial Infarction, UAP:

21 381 Unstable Angina Pectoris, CR: Cardiac rehabilitation, CABG: Coronary artery bypass graft, SES: Socio-

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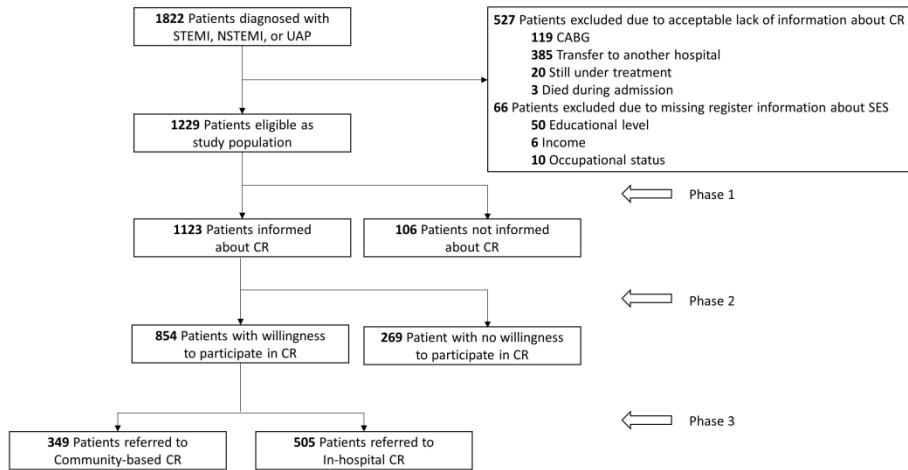


Figure 1: Flowchart of the referral process to cardiac rehabilitation.
 STEMI: ST-Elevated-Myocardial Infarction, NSTEMI: Non-ST-Elevated-Myocardial Infarction, UAP: Unstable Angina Pectoris, CR: Cardiac rehabilitation, CABG: Coronary artery bypass graft, SES: Socio-economic Status

338x190mm (300 x 300 DPI)

1
2
3
4 **ONLINE SUPPLEMENTARY MATERIAL**
5

6
7 **Table S1:** Baseline Characteristics of excluded patients

	Excluded
Characteristics	n = 593
Male (n, %)	423
Age Group (years)	
< 65	242
65-74	171
≥ 75	180
Civil status (n, %)	
Married/Partnership	378
Divorced/Unmarried/Widow	>210
Missing	<5
Occupational status (n, %)	
Employed	158
Unemployed/out of workforce	417
Missing	18
Educational level (n, %)	
Low	256
Medium	200
High	52
Missing	72
Income, tertile (n, %)	
Low	245
Medium	197
High	>145
Missing	<5
Charlson Comorbidity Index	
Low (0 points)	421
Moderate/High (>0 points)	75
Missing	97

Table S2: Logistic regression model for those excluded compared with those included in the study population,
n = 1822

	n, (%)	Unadjusted		Multivariable adjusted*	
		OR	95% CI	OR	95% CI
Observations	593 (32.5)				
Civil status					
Married/Partnership	378 (20.7)	1 (ref.)		1 (ref.)	
Divorced/Unmarried/Widow	>210 (>11.5)	1.02	0.83-1.25	0.85	0.67-1.07
Missing	<5 (<1)				
Occupational status					
Employed	158 (8.7)	1 (ref.)		1 (ref.)	
Unemployed/Retired	417 (22.9)	1.69	1.36-2.09	1.54	1.14-2.08
Missing	18 (1.0)				
Educational level					
Low	256 (14.1)	1 (ref.)		1 (ref.)	
Medium	200 (10.1)	0.77	0.61-0.96	0.77	0.61-0.97
High	49 (2.7)	0.59	0.42-0.84	0.60	0.41-0.87
Missing	72 (4.0)				
Income, tertiles					
Low	245 (13.4)	1 (ref.)		1 (ref.)	
Medium	197 (10.8)	0.71	0.56-0.90	0.77	0.59-1.01
High	>145 (>7.9)	0.46	0.36-0.59	0.55	0.40-0.75
Missing	<5 (<0.3)				

* Adjusted for age, gender, ACS diagnosis, Charlson Comorbidity Index. OR: odds ratio; CI: confidence interval

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
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	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7-8
		(c) Explain how missing data were addressed	5
		(d) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(e) Describe any sensitivity analyses	7-8
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	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	6
Outcome data	15*	Report numbers of outcome events or summary measures	6+8
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	9-12
		(b) Report category boundaries when continuous variables were categorized	9-12
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
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	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
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	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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.