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Effects of managed care on the proportion of inappropriate elective diagnostic coronary angiographies in non-emergency patients, a retrospective cross-sectional analysis

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5 2 **coronary angiographies in non-emergency patients, a retrospective cross-**
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7 3 **sectional analysis**
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23 **Abstract**

24 Objective

25 Existing guidelines recommend non-invasive ischemia testing (NIIT) for the majority
26 of patients with suspected ischemic heart disease in a non-emergency setting. A
27 substantial amount of these patients undergoes diagnostic coronary angiography
28 (CA) without therapeutic intervention inappropriately. The aim of this study was to
29 evaluate the effect of voluntary health care plans with limited access on the
30 proportion of patients without NIIT prior to elective purely diagnostic CA.

31 Design, setting and participants:

32 Retrospective cross-sectional analysis of insurance claims data from 2012 to 2015.
33 Data for this study included mandatory and voluntary health insurance claims from
34 approximately 1.2 million patients enrolled with the Helsana Insurance Group.
35 Inclusion criteria: patients undergoing CA. Exclusion criteria: Patients <18 years,
36 incomplete coverage of mandatory basic health insurance, acute cardiac ischemia
37 and emergency procedures, therapeutic CA (coronary angioplasty/stenting or
38 coronary artery by-pass grafting). The effect of voluntary health care plans with
39 limited health access (gate keeping (GK) and managed care (MC) capitation plans)
40 on the proportion of NIIT undertaken within two months before diagnostic CA was
41 assessed by means of multiple logistic regression analysis, controlled for other
42 influencing factors.

43 Results

44 9173 patients matched in- and exclusion criteria. 33.2% (3044) did not receive NIIT
45 before CA. MC was independently associated with a higher proportion of NIIT
46 ($p < 0.001$, OR 1.17), when additionally controlled for age, sex, language area,
47 insurance coverage, inpatient treatment, cardiovascular medication, number of
48 chronic comorbidities and high risk status (patients having received therapeutic

1
2
3 49 cardiac intervention within 1 month after or 18 months prior to diagnostic CA). GK
4
5 50 plans showed no significant association with the rate of NIIT ($p=0.07$, OR 1.11).
6

7 Conclusions

8
9 52 In a non-gate keeping health care system voluntary MC insurance plans with
10
11 53 capitation are able to reduce inappropriate use of diagnostic CA stronger than GK or
12
13 54 basic insurance plans.
14

15 55

16 56

17 **Article summary**

- 18 57
- 19 58 - Highly relevant topic concerning inappropriate use of a potentially harmful and
 - 20 59 expensive procedure such as the CA
 - 21 60 - Only scarce data on non-emergency CA exists in literature
 - 22 61 - Data originates from a single health insurance group in Switzerland, although
 - 23 62 one of the largest in the country, including data on mandatory health insurance
 - 24 63 claims from approximately 1.2 million patients
 - 25 64 - No data on socioeconomic status and clinical information is available
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40 **Key Words**

- 41 67 - Elective coronary angiography
- 42 68 - Managed care
- 43 69 - Inappropriate
- 44 70 - Voluntary health care plans
- 45 71 - Limited access insurance models
- 46 72 - Non-invasive ischemia testing
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73 Introduction

74 Existing guidelines¹⁻⁷ recommend non-invasive ischemia testing (NIIT) for the
75 majority of patients with suspected ischemic heart disease in a non-emergency
76 setting. Nevertheless, a substantial amount of these patients undergo diagnostic
77 coronary angiography (CA) without therapeutic intervention inappropriately and are
78 therefore exposed to unnecessary risks without any clinical benefit⁸⁻¹⁵. In a non-gate
79 keeping health care system such as Switzerland hardly any steering mechanisms
80 exist, to ensure that potentially harmful and expensive procedures are only performed
81 in case of correct indication. The admitting physician (mainly general practitioner or
82 cardiologist) usually gives the indication for the intervention and the performing
83 invasive centers rarely decline assigned patients due to economic reasons or in order
84 not to disagree with the admitting physician.

85 Besides the mandatory healthcare plans, offering unlimited access to almost all
86 sectors of the health care system including specialist and emergency care,
87 alternative voluntary health care plans with various degrees of restriction in exchange
88 to premium reduction can be chosen from. These voluntary health care plans can be
89 summarized into two main groups: 1) gate keeping (GK) plans with steering
90 mechanisms, such as mandatory consultation of an insurance hotline for example,
91 and 2) managed care (MC) plans with capitation. Previous studies showed a lower
92 prevalence of potentially inappropriate medication use in elderly patients and a lower
93 disease specific hospitalization rate in chronically ill patients enrolled in a MC plan
94 compared to non-MC patients^{16 17}. No data on the association between NIIT and
95 various types of health care plans in Switzerland exist.

96 The aim of this study was therefore to evaluate the effect of voluntary GK or MC
97 health care plans on the proportion of patients without NIIT prior to elective purely
98 diagnostic CA without therapeutic intervention. We performed a retrospective

1
2
3 99 analysis of insurance claims data on diagnostic procedures undertaken within two
4
5 100 months before CA depending on the health care plan.
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7 101
8
9 102

11 103 **Materials and Methods**

13 104 Setting

15 105 Swiss residents are obliged to enroll in a mandatory health insurance, which covers
16
17 106 all health care costs besides deductibles. Depending on the insurance model chosen,
18
19 107 annual deductibles for adults vary between 300 and 2500 Swiss Francs. A patient
20
21 108 copayment of 10% of all costs up to a maximum of 700 Swiss Francs per year is
22
23 109 payable independent of the chosen insurance model. Currently residents can chose
24
25 110 a mandatory health insurance from 53 different insurance companies. In general, in
26
27 111 Switzerland no gate-keeping system exists, meaning that patients have unlimited
28
29 112 access to all healthcare providers, unless they are voluntarily insured in a limited
30
31 113 access model. Patients agree to a restriction of choice or limited access in exchange
32
33 114 of lower premiums. In such limited access models, the general practitioner or an
34
35 115 insurance telephone hotline have to be consulted, before contacting a specialist or
36
37 116 another institution such as a hospital. In case of emergency, this regulation is
38
39 117 overruled. Compared to other health care systems, the Swiss system is more
40
41 118 inpatient treatment oriented due to co-financing of inpatient treatments by
42
43 119 governmental institutions.
44
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50 121 Subjects, data collection and measurements

52 122 Data for this study included mandatory health insurance claims from approximately
53
54 123 1.2 million patients, which live all over Switzerland and were enrolled with the
55
56 124 Helsana Group. Data on patients undergoing CA in the years 2012 to 2015 were

1
2
3 125 retrospectively analyzed. Detailed TARMED (Standard billing rate for outpatient
4
5 126 medical care in Switzerland, version 2014) and Diagnosis Related Groups (DRG,
6
7 127 version 2012) positions can be found in the Supplemental Material.
8
9
10

11 128

12 129 *Inclusion criteria*

- 13
14 130 - Diagnostic CA performed in the years 2012 to 2015. If in this time interval
15
16 131 patients received more than one CA, only the first CA was taken into
17
18 132 consideration.
19

20 133

21 134 *Exclusion criteria*

- 22
23
24 135 - incomplete coverage of mandatory basic health insurance 18 months before
25
26 136 and/or 1 month after CA
27
28
29 137 - Patients <18 years
30
31 138 - Acute cardiac ischemia and/or emergency procedures
32
33 139 - Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass
34
35 140 grafting)
36

37 141

38 142 *Measurements*

- 39
40
41 143 - Patient characteristics: sex, age, language area and type of insurance
42
43 144 coverage (deductible class, supplementary private hospital insurance,
44
45 145 managed care insurance model)
46
47
48 146 - Setting of CA: inpatient or outpatient
49
50 147 - NIIT performed within two months prior to CA (stress-ECG, echocardiography,
51
52 148 stress echocardiography, scintigraphy, computer tomography, heart MRI)
53
54
55 149 - Cardiovascular Medication grouped according to Anatomical-Therapeutic-
56
57 150 Chemical-Classification (ATC)¹⁸
58

- 151 ○ Group 1: Aspirin, platelet aggregation inhibitors
- 152 ○ Group 2: statins, lipid modifying agents
- 153 ○ Group 3: antihypertensives, diuretics, beta blocking agents, calcium
- 154 channel blockers, agents acting on the renin-angiotensin system
- 155 ○ Group 4: antidiabetics
- 156 ○ Group 5: antianginous drugs
- 157 ○ Group 6: antithrombotics
- 158 - Number of chronic conditions according to Pharmaceutical cost groups PCG ¹⁹
- 159 ²⁰
- 160 ○ Group 1: $pcg_n < 3$ 0, 1 or 2 PCGs
- 161 ○ Group 2: $pcg_n < 5$ 3 to 4 PCGs
- 162 ○ Group 3: $pcg_n < 7$ 5 to 6 PCGs
- 163 ○ Group 4: $pcg_n \geq 7$ 7 or more PCGs

165 *Sensitivity Analysis with high-risk patients*

166 We performed a sensitivity analysis of our data by defining a subgroup of patients as
167 high risk with supposed cardiac disease, if having received therapeutic cardiac
168 intervention/diagnosis within one month after and/or 18 months prior to diagnostic
169 CA.

171 Processing and analyzing data

172 Data was checked for eligibility and completeness and subjected to a set of
173 predefined plausibility tests. These included checks for contradictory data, duplication
174 and plausibility of time measurements.

1
2
3 175 Statistical analysis

4
5 176 Descriptive statistical techniques were used to provide a general profile of the study
6
7 177 population and grouped into patients with mandatory health insurance with no limited
8
9 178 access health care plans versus voluntary limited access health care plans consisting
10
11 179 of the two subgroups GK and MC. These data were presented as means in the case
12
13 180 of continuous variables and as percentages in case of categorical variables.

14
15 181 Differences with respect to age, sex, deductible class, supplementary private hospital
16
17 182 insurance coverage, language area, inpatient CA, cardiac medication class according
18
19 183 to ATC, number of chronic medical conditions identified using PCGs and high risk
20
21 184 status (patients having received therapeutic cardiac intervention/diagnosis within one
22
23 185 month after and/or 18 months prior to diagnostic CA) were analyzed with a
24
25 186 nonparametric analysis of variance (Kruskal-Wallis test for continuous variables and
26
27 187 chi-square tests for categorical variables). We developed several statistical models to
28
29 188 evaluate the major outcome of receiving NIIT within two months prior CA depending
30
31 189 on the health care plan. Two different models were investigated: 1) using the federal
32
33 190 definition of voluntary health care plans which includes all insurance plans with
34
35 191 limited health care access, meaning GK as well as managed MC plans. 2) GK versus
36
37 192 MC plans. In order to assess patient-level effects the following additional
38
39 193 independent variables were included in the models: age, sex, deductible class,
40
41 194 supplementary private hospital insurance coverage, language area, inpatient CA,
42
43 195 cardiac medication class according to ATC, number of chronic medical conditions
44
45 196 identified using PCGs and high risk status. The strength of associations was
46
47 197 measured by the odds ratio (OR) and the respective 95% confidence intervals (CI).
48
49 198 The level of significance was set at 0.05. All statistical analyses were performed
50
51 199 using R version 3.3.1 (2016-06-21) (R Foundation for Statistical Computing, Vienna,
52
53 200 Austria)^{21 22}.

201 Ethics approval

202 According to the national ethical and legal regulation, an ethical approval was not
 203 needed. Permission to access the study data was provided by the Helsana Group.
 204 Since data was anonymized, no consent of patients was required.

207 **Results**208 Population

209 During the observed period a total of 19'032 therapeutic CA performed on 14'833
 210 patients were registered in the Helsana data warehouse. 12'078 CA were eligible for
 211 analysis. According to the exclusion criteria (multiple exclusion criteria possible per
 212 person), we excluded 5 patients since they were under the age of 18 years, 828
 213 patients due to an incomplete coverage of mandatory basic health insurance during
 214 the necessary observation period, 360 emergency procedures, 1'922 therapeutic CA
 215 (coronary angioplasty/stenting or coronary artery by-pass grafting). In total, 9'173
 216 patients remained for analysis.

217 The descriptive statistics of the study population can be seen in Table 1. From the
 218 9'173 patients representing the study population 5'587 were male (60.9%, mean age
 219 66.4 years) and 3'586 were female (39.1%, mean age 68.7 years).

221 Table 1 Descriptive statistics of the study population grouped into non-limited and
 222 limited health care access insurance plans (GK and MC)

	Non-limited access			Limited access		
	Total	No NIIT	With NIIT	Total	No NIIT	With NIIT
Count	5'258	1'818 (34.6%)	3'440 (65.4%)	3'915	1'226 (31.3%)	2'689 (68.7%)

High Risk (= 1)	2'696 (51.3%)	1'006 (55.3%)	1'690 (49.1%)	***	1'814 (46.3%)	593 (48.4%)	1'221 (45.4%)	
Age (mean)	67.7 (11.6)	68.1 (12.8)	67.6 (10.9)	**	66.7 (11.6)	66.5 (12.8)	66.8 (11.0)	
Sex (fem)	2'089 (39.7%)	738 (40.6%)	1'351 (39.3%)		1'497 (38.2%)	467 (38.1%)	1'030 (38.3%)	
Deductible								
300	3'617 (68.8%)	1'262 (69.4%)	2'355 (68.5%)		2'504 (64.0%)	799 (65.2%)	1'705 (63.4%)	
500	1'143 (21.7%)	394 (21.7%)	749 (21.8%)		850 (21.7%)	250 (20.4%)	600 (22.3%)	
1000	116 (2.2%)	45 (2.5%)	71 (2.1%)		167 (4.3%)	54 (4.4%)	113 (4.2%)	
1500	186 (3.5%)	59 (3.2%)	127 (3.7%)		153 (3.9%)	47 (3.8%)	106 (3.9%)	
2000	19 (0.4%)	5 (0.3%)	14 (0.4%)		35 (0.9%)	5 (0.4%)	30 (1.1%)	
2500	177 (3.4%)	53 (2.9%)	124 (3.6%)		206 (5.3%)	71 (5.8%)	135 (5.0%)	
Private	1'418 (27.0%)	493 (27.1%)	925 (26.9%)		866 (22.1%)	262 (21.4%)	604 (22.5%)	
Latin	1'607 (30.6%)	541 (29.8%)	1'066 (31.0%)		832 (21.3%)	250 (20.4%)	582 (21.6%)	
Inpatient	2'931 (55.7%)	1'166 (64.1%)	1'765 (51.3%)	***	2'180 (55.7%)	798 (65.1%)	1'382 (51.4%)	***
ATC								
1	2'442 (46.4%)	704 (38.7%)	1'738 (50.5%)	***	1'840 (47.0%)	460 (37.5%)	1'380 (51.3%)	***
2	1'792 (34.1%)	576 (31.7%)	1'216 (35.3%)	**	1'347 (34.4%)	370 (30.2%)	977 (36.3%)	***
3	3'306 (62.9%)	1'114 (61.3%)	2'192 (63.7%)		2'387 (61.0%)	681 (55.5%)	1'706 (63.4%)	***
4	787 (15.0%)	277 (15.2%)	510 (14.8%)		489 (12.5%)	152 (12.4%)	337 (12.5%)	
5	825 (15.7%)	281 (15.5%)	544 (15.8%)		508 (13.0%)	168 (13.7%)	340 (12.6%)	
6	3'467 (65.9%)	1'038 (57.1%)	2'429 (70.6%)	***	2'492 (63.7%)	667 (54.4%)	1'825 (67.9%)	***
PCG				**				
<3	1'277 (24.3%)	434 (23.9%)	843 (24.5%)		1'268 (32.4%)	394 (32.1%)	874 (32.5%)	

3-4	1'967 (37.4%)	634 (34.9%)	1'333 (38.8%)	1'463 (37.4%)	435 (35.5%)	1'028 (38.2%)
5-6	1'339 (25.5%)	467 (25.7%)	872 (25.3%)	840 (21.5%)	276 (22.5%)	564 (21.0%)
>6	675 (12.8%)	283 (15.6%)	392 (11.4%)	344 (8.8%)	121 (9.9%)	223 (8.3%)

223

224 *NIIT: Non-invasive ischemia testing. Deductible class in Swiss Francs. Private:*
 225 *supplementary private hospital insurance, Latin: French or Italian part of Switzerland*
 226 *compared to German part. CA: coronary angiography, ATC: Anatomical-Therapeutic-*
 227 *Chemical-Classification group 1 = Aspirin, platelet aggregation inhibitors, 2 = statins,*
 228 *lipid modifying agents, 3 = antihypertensives, diuretics, beta blocking agents, calcium*
 229 *channel blockers, agents acting on the renin-angiotensin system, 4 = antidiabetics, 5*
 230 *= antianginous drugs, 6: antithrombotics, PCG: number of chronic conditions*
 231 *according to pharmaceutical cost groups. High risk patients: having received*
 232 *therapeutic cardiac intervention within one month after or 18 months prior to*
 233 *diagnostic CA. Significance no NIIT vs with NIIT within non limited access and limited*
 234 *access group: *** p<0.0001, ** p<0.001, *p<0.01.*

235

236 Patients insured in mandatory basic health care plans were slightly older (67.7 (11.6)
 237 vs. 66.6 (11.6) years, p<0.0001), chose the lowest possible deductible of 300 Francs
 238 more often (3'617 (68.8%) vs. 2'504 (64.0%), p<0.001), were enrolled in a
 239 supplementary private hospital insurance more often (1'418 (27.0%) vs. 866 (22.1%),
 240 p<0.0001), had more antidiabetics (787 (15%) vs 489 (12.5%), p<0.0001) and
 241 antianginal medication (825 (15.7%) vs 508 (13.0%), p<0.0001), more PCGs (4.1
 242 (2.1) vs. 3.6 (2.0), p<0.0001) and had more often a high risk status (2'696 (51.3%) vs.
 243 1'814 (46.3%), p<0.0001), compared to patients insured in voluntary limited access

244 health care plans. Concerning the other patient characteristics, no differences
245 existed.

246

247 Non-invasive ischemia testing

248 488 (33.8 %) of patients without NIIT had a conventional ECG prior to CA, in the high
249 risk population this was the case in 722 (45.2%) ($p<0.0001$). Patients insured in
250 limited access health care models underwent the NIITs stress-ECG + transthoracic
251 echocardiography significantly more often before CA (1'750 (44.7%) vs. 2'039 (38.8
252 %) $p<0.0001$, and 2'044 (52.2%) and 2'528 (48.1%), $p<0.0001$) than patients with
253 basic insurance. The remaining types of NIIT were rarely performed and only showed
254 a significant difference in the use of scintigraphy (basic insurance 131 (2.5%) vs.
255 limited access models 64 (1.6%), $p<0.001$).

256

257 Determinants for non-invasive ischemia testing

258 Patients with MC health care plans were 17% significantly more likely to receive NIIT
259 before CA compared to patients with mandatory health care plans, when controlled
260 for the confounders age, sex, language area, insurance coverage, inpatient
261 treatment, cardiovascular medication, number of chronic comorbidities and high risk
262 status (OR 1.17, $p<0.001$). GK insurance models did not show any significant
263 influence on the chance of receiving NIIT (OR 1.11, $p=0.071$). The distribution of NIIT
264 performed according to health care plan can be appreciated in Figure 1.

265

266 Figure 1: Distribution of NIIT performed according to health care plan.

267 *OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders*
268 *age, sex, language area, insurance coverage, inpatient treatment, cardiovascular*

269 medication, number of chronic comorbidities and high risk status. * $p < 0.001$ (OR
270 1.17) for managed care compared to standard health care plan.

271

272 Following determinants were also independently significantly associated with
273 receiving NIIT: the use of platelet aggregation inhibitors, antithrombotic and
274 antihypertensive medication, being privately insured and a deductible of 2000 SFR.

275 Following determinants were significantly associated with not receiving NIIT: high-risk
276 status, a high number of chronic comorbidities as well as inpatient treatment (Table
277 2).

278

279 Table 2: Determinants for receiving non-invasive ischemia testing before coronary
280 angiography

	se	or	sig
281 Intercept	0.156353	NA	**
282 Age (years)	0.002069	1.003	
283 Sex (female)	0.047562	1.062	
284 Deductible Class (Swiss Francs, Reference 300)			
285 500	0.057142	1.020	
286 1000	0.132115	0.865	
287 1500	0.125301	1.075	
288 2000	0.356787	2.177	*
289 2500	0.118825	1.022	
290 Private	0.054254	1.140	*
291 French or Italian part of Switzerland	0.055272	0.937	
292 Inpatient CA	0.052856	0.599	***
293 ATC group			

295	1	0.065923	1.423	***
296	2	0.053149	1.023	
297	3	0.049768	1.104	*
298	4	0.068884	0.974	
299	5	0.065494	0.994	
300	6	0.069080	1.184	*
301	PCG (reference <3)			
302	<5	0.060711	1.058	
303	<7	0.069882	0.928	
304	>=7	0.088073	0.742	***
305	Limited access models (reference standard health insurance)			
306	Managed Care	0.057877	1.171	**
307	Gate Keeping	0.059874	1.114	
308	High risk cardiac status	0.046443	0.836	***

310 *se: standard error, or: odds ratio, sig: significance: *** p<0.0001, ** p<0.001 *p<0.01,*

311 *Private: supplementary private hospital insurance, CA: coronary angiography, ATC:*

312 *Anatomical-Therapeutic-Chemical-Classification group 1 = Aspirin, platelet*

313 *aggregation inhibitors, 2 = statins, lipid modifying agents, 3 = antihypertensives,*

314 *diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-*

315 *angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6: antithrombotics,*

316 *PCG: number of chronic conditions according to pharmaceutical cost groups. High*

317 *risk patients: having received therapeutic cardiac intervention within one month after*

318 *or 18 months prior to diagnostic CA.*

319 Discussion

320 In our study population of elective CA with no therapeutic consequence (no coronary
321 angioplasty/stenting or coronary artery bypass grafting) one third did not receive NIIT
322 before diagnostic CA. MC was independently significantly associated with a higher
323 proportion of NIIT when additionally controlled for potential confounders. GK plans
324 showed no significant association with the rate of NIIT.

325

326 Effects of limited access health care plans on treatment quality

327 It has been assumed that patients insured in limited access health care plans
328 undergo less diagnostic procedures or interventions due to budget considerations. In
329 our study, this hypothesis is refuted. Patients insured in limited access health care
330 plans not only underwent a more appropriate diagnostic pathway than regularly
331 insured patients did, they even received more non-invasive diagnostic testing, which
332 resulted in less inadequate CA. Our findings are in line with studies showing that
333 being insured in MC models is associated with a survival benefit by promoting better
334 preventive and higher quality of care²³⁻²⁵. Especially among Medicare beneficiaries,
335 which are prone to multimorbidity, this effect has been shown²⁶. These models have
336 also shown lower prevalence of potentially inappropriate medication use in elderly
337 patients and a lower disease specific hospitalization rate in chronically ill patients¹⁶
338¹⁷.

339 Our study raises the question why patients in limited access health care plans
340 receive a more appropriate diagnostic pathway in this clinical situation of stable
341 angina pectoris. There has been evidence for and against the theory that patients
342 enrolled in a MC insurance model are healthier due to biased selection²⁷⁻³⁶ and
343 commercial considerations of the MC insurer^{37 38}. In our study population patients
344 insured in limited access plans showed some evidence of being healthier than

1
2
3 345 regularly insured patients. Nevertheless being insured only in MC but not GK plans
4
5 346 was *independently* associated with a higher rate of NIIT, controlled for all the
6
7 347 differences in patient characteristics. It is clear that physicians participating in MC
8
9 348 plans are obliged to keep diagnostic and treatment costs as low as possible while
10
11 349 keeping up with quality concerns. One could therefore argue that it is cheaper to not
12
13 350 to choose a diagnostic detour over NIIT instead of choosing the straight forward way
14
15 351 of sending a patient to the more invasive CA which offers a clear answer to an
16
17 352 uncertain clinical situation including the option of therapeutic action. It seems that MC
18
19 353 health care providers have understood what Meara et al. have summed up
20
21 354 accurately: "Reductions in spending for patients must be a result of decreases in the
22
23 355 provision of services. If these are needed services, quality of care will decline.
24
25 356 Alternatively, quality of care might be higher in low expenditure areas if differences in
26
27 357 spending result from reductions in unnecessary or inappropriate services³⁹". Besides
28
29 358 this intuitive statement there has been scientific evidence that a diagnostic detour is
30
31 359 worthwhile taking, since it sums up in reduced peri and post interventional costs
32
33 360 without loss in quality¹¹. Our study is not able to answer the questions why patients
34
35 361 in limited access models received a more appropriate diagnostic approach. One can
36
37 362 only hypothesize that coordination of care is straighter forward in the limited access
38
39 363 setting and the indication for invasive and expensive diagnostic procedures is more
40
41 364 thoroughly scrutinized especially in the GK models, which include capitation.
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48 366 Determinants for NIIT

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50 367 Even though simple echocardiography with no stress testing does not actually qualify
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52 368 as a NIIT, we chose to include this diagnostic procedure due to following
53
54 369 considerations: some cardiologists might argue that patients with dyskinesia in simple
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56 370 echocardiography are likely to have relevant coronary pathology therefore offering an

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3 371 argument for CA besides the clinical evaluation. Our theory is supported by the “2014
4
5 372 ESC/EACTS Guidelines on Myocardial Revascularization which state: “regional wall
6
7 373 motion abnormalities may be detected in simple echocardiography, which increase
8
9 374 the likelihood of coronary artery disease”. Since the inclusion of this additional test
10
11 375 leads to underestimation of “real” NIIT performed, the findings only strengthen our
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13 376 hypothesis.

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15 377 Since our study lacks clinical data, only indirect hints by means of PCG and ATC
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17 378 codes as well as other confounders are available to assess clinical reasoning. The
18
19 379 association between the use of platelet aggregation inhibitors or antithrombotic
20
21 380 agents and antihypertensive medication with receiving NIIT before CA suggest a
22
23 381 reasonable deliberation in the sense of estimating pretest probability when deciding
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25 382 on optimal diagnostic strategy. The same counts for the association of high-risk
26
27 383 status and a larger number of chronic comorbidities as determinants for not receiving
28
29 384 NIIT prior to elective CA. This finding is consistent with two US studies indicating that
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31 385 risk stratification was performed, considering the higher likelihood of a coronary
32
33 386 pathology in patients with known coronary heart disease^{8 10}. In our study, non-clinical
34
35 387 factors seem to influence decision-making processes concerning diagnostic
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37 388 pathways, reflected by the findings that being privately insured and a deductible of
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39 389 2000 SFR were positively and inpatient treatment negatively independently
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41 390 associated with NIIT.

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45 392 Reinforcing quality control mechanisms in a non-gate keeping health care system

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48 393 Besides the existing voluntary steering mechanisms such limited access health care
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50 394 plans guided by patient’s preferences only, more alternative steering mechanisms
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52 395 have to be implemented in non-gate keeping health care systems, in order to
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54 396 minimize the influence of non-clinical factors on medical decision making, which

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3 397 might lead to inappropriate and possibly dangerous health care utilization as well as
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5 398 increasing expenditures. A positive example here fore is the implementation of
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7 399 national registries ⁴⁰ combined with quality initiatives, such as the in 2009 published
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9 400 Appropriate Use Criteria for Coronary Revascularization ^{9 40 41}. In 2011, the registry
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11 401 started giving feedbacks on the participating hospital's performance concerning
12
13 402 appropriateness of CA including a benchmarking against other participating
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15 403 institutions. At the same time the American Board of Internal Medicine's Choosing
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17 404 Wisely initiative launched national quality improvement campaigns, identifying CA
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19 405 appropriateness as a key area for intervention ⁴². As a consequence insurance
20
21 406 companies incorporated measures of CA appropriateness into pay-for-performance
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23 407 programs ⁴³ and reimbursement was declined for certain CA identified as
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25 408 inappropriate ⁴⁴. The combination of implementing national registries combined with
26
27 409 quality initiatives had been proven amazingly effective, showing a decrease of non-
28
29 410 acute CA classified as inappropriate from 26.2% to 13.3% ⁴⁵. In Switzerland currently
30
31 411 no registries on CA exist, hence other solutions for influencing treatment pathways
32
33 412 have to be developed besides offering voluntary limited access health care plans. A
34
35 413 possible alternative solution to the conundrum of reducing costs without cutting
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37 414 quality seems hence to be paying for outcomes instead of volume. As the findings of
38
39 415 our study suggest, a possible approach is to raise the market share of MC to such a
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41 416 volume that it might also affect care for fee-for-service patients ³⁹. As Meara et al
42
43 417 have summarized, the effects have been show to play in a variety of ways: more MC
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45 418 in a market might lower expenditures by reducing the number of specialists, and
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47 419 thereby the number of specialists' services provided ^{46 47} by encouraging more
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49 420 conservative practice patterns ^{46 47}, or by slowing the diffusion of more costly
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51 421 technologies ^{46 48}.
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423 Strengths and limitations

424 Only scarce data on non-emergency CA exists in literature. The only data found
425 originates from the US among Medicare as well as commercially insured patients and
426 from Switzerland, both non-gate keeping health care systems. Whether the
427 proportion of inappropriate diagnostic CA from our study can be translated to other
428 non-gate keeping health care systems is difficult to estimate, since substantial
429 variation in the proportion of non-acute PCIs considered inappropriate across
430 hospitals can be found, ranging from about 6% to 70%^{8 10 14 15 45}. From a previous
431 study from Switzerland¹² similar proportions were found, suggesting generalizability
432 of our data. The current study seems even more representative than the previous
433 Swiss study, since it included data over a longer time-period with consecutively larger
434 amount of patients and corresponding data. Since the study is based on insurance
435 claims data, no data on socioeconomic status and clinical information is available.

436

437 **Conclusions**

438 In a non-gate keeping health care system voluntary MC insurance plans with
439 capitation are able to reduce inappropriate use of diagnostic CA stronger than GK or
440 basic insurance plans.

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446 American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association,
447 Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons.
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588

589 **Competing interests**

590 Oliver Reich and Andri Signorell are employed by the Helsana Group. The sponsor
591 had no role in the planning, conducting or submission of this manuscript. These
592 authors declare no conflict of interest. Helsana Group shall have no liability to any
593 third party in respect to the contents of this article. All the other authors have no
594 conflicts of interests or financial disclosures to declare.

595

596 **Authors Contributions**

597 Conceived and designed the experiments: CC, OR, AS, SNJ, TR, OS. Performed the
598 experiments: CC, OR, AS. Analyzed the data: CC, OR, AS, SNJ, TR, OS. Wrote the
599 paper: CC, edited and approved the paper: CC, OR, AS, SNJ, TR, OS.

600

601 **Consent for publication**

602 Since data were completely anonymized, no patient consent was necessary.

603

604 **Availability of data and materials**

605 Individual data cannot be made fully available on the internet because the study is
606 based on claims data of the Helsana Group, the owner of the data. Thus, data
607 underlie data protection and privacy restrictions. These restrictions prohibit the
608 insurer from sharing the collected data. Data analysis was performed within the

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3 609 premises of the Helsana research group by the statistician AS in collaboration with
4
5 610 the authors OR and CC and administrative permission was received to access de-
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7 611 identified data by the researchers from the University of Zurich.
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For peer review only

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3 1 **Supplemental Material**

4
5 2 Supplemental Methods/Definitions

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9 4 1) Inclusion Criteria

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11 5 Tarmed 17.071

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23 11 DRG F49D

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25 12 F49E

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27 13 F49F

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31 14 If two coronary angiographies (CA) were performed on the same day at the same
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33 15 provider, the intervention is counted once.

34
35 16 If the CA was performed twice at the same day but different providers the CA counts
36
37 17 twice (both concerning the inpatients positions (Diagnosis related Groups (DRG)) and
38
39 18 the outpatient positions (Standard billing rate for outpatient medical care in
40
41 19 Switzerland (TARMED))

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44 20 If during 2012-2015 patients received more than one CA, only the first CA was taken
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46 21 into consideration.

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3 1 2) Exclusion Criteria

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5 2 Acute cardiac ischemia and/or emergency procedures Tarmed 0.2510
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7 3 0.2520
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9 4 0.2540
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11 5 0.2560
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13 6 0.2580
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15 7 35.0610
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18 8 DRG F41A
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20 9 F41B
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24 11 Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting,
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26 12 without myocardial infarction) Tarmed 17.1110
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28 13 17.1240
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31 14 DRG F15Z
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33 15 F19Z
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35 16 F24B
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37 17 F49A
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39 18 F49C
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41 19 F52A
42
43 20 F52B
44
45 21 F54Z
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47 22 F56A
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49 23 F56B
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51 24 F57A
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53 25 F57B
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55 26 F58Z
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3 1 F59A
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5 2 F59B
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7 3 Incomplete coverage of mandatory basic health insurance 18 months before and/or 1
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9 4 month after CA
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11 5 Patients <18 years
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18 8 3) Diagnostic Procedures
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20 9 Tarmed 17.0010: Electrocardiogram (ECG): not considered as NIIT, only in
21
22 10 combination with other NIIT
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24 11 17.0050: Cardiac intervention with medication under continuous
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26 12 registration of ECG: not considered as NIIT, only in combination with
27
28 13 another NIIT
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30 14 17.0060: ECG performed by specialist outside of the practice or
31
32 15 hospital: not considered as NIIT, only in combination with another NIIT
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34 16 17.0080 and 17.0090: Stress-ECG
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36 17 17.0210: Echocardiography, transthoracic, qualitative and quantitative
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38 18 examination of adult
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40 19 17.0280: Stressechocardiography, physical stress
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42 20 17.0290: Stressechocardiography, medication stress
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44 21 31.0260: Scintigraphy physiologically triggered
45
46 22 39.4060: Computed tomography of entire thorax and/or sternoclavicular
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48 23 joint
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50 24 39.5100 Heart MRI
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52 25 DRG No separate codes available for inpatient diagnostic procedures, only
53
54 26 for therapeutic interventions
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3 1 4) High risk patients

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5 2 Patients having received therapeutic cardiac intervention within one month after or 18
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7 3 months prior to diagnostic CA

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9 4 Tarmed 0.2510

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17 8 0.2580

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21 10 17.1110

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23 11 17.1240

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25 12 And all 18.001 until/including 18.0740

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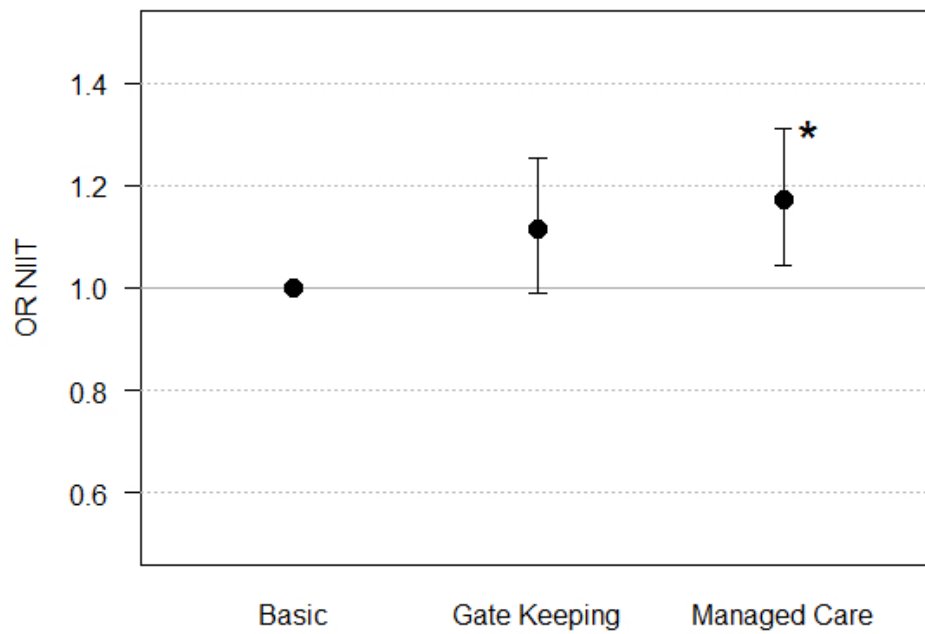


Figure 1: Distribution of NIIT performed according to health care plan.

OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high risk status. * $p < 0.001$ (OR 1.17) for managed care compared to standard health care plan.

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5 **Reporting statement: STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cross-sectional studies**
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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, 2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3, 4
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	2, 4, 5
Methods			
Study design	4	Present key elements of study design early in the paper	5-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-8
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	7, 8
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, 8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7, 8
		(b) Describe any methods used to examine subgroups and interactions	7, 8
		(c) Explain how missing data were addressed	7, 8
		(d) If applicable, describe analytical methods taking account of sampling strategy	6-8
		(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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	9-14 9-14 Not applicable
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	9-14 9-14
Outcome data	15*	Report numbers of outcome events or summary measures	9-14
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	9-14 Not applicable Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
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	23

*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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BMJ Open

Effects of managed care on the proportion of inappropriate elective diagnostic coronary angiographies in non-emergency patients in Switzerland, a retrospective cross-sectional analysis

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Keywords:	- Elective coronary angiography, - Managed care, - Inappropriate, - Voluntary health care plans, - Limited access insurance models, - Non-invasive ischemia testing

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3 1 **Effects of managed care on the proportion of inappropriate elective diagnostic**
4 **coronary angiographies in non-emergency patients in Switzerland, a**
5 **retrospective cross-sectional analysis**
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48 22 Word count : 3533
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23 **Abstract**

24 Objective

25 Guidelines recommend non-invasive ischemia testing (NIIT) for the majority of
26 patients with suspected ischemic heart disease in a non-emergency setting. A
27 substantial amount of these patients undergoes diagnostic coronary angiography
28 (CA) without therapeutic intervention inappropriately due to lacking preceding NIIT.

29 The aim of this study was to evaluate the effect of voluntary health care models with
30 limited access on the proportion of patients without NIIT prior to elective purely
31 diagnostic CA.

32 Design:

33 Retrospective cross-sectional analysis of insurance claims data from 2012 to 2015.
34 Data included claims of basic and voluntary health care models from approximately
35 1.2 million patients enrolled with the Helsana Insurance Group. Voluntary health care
36 models with limited health access are divided into gate keeping (GK) and managed
37 care (MC) capitation models. Inclusion criteria: patients undergoing CA. Exclusion
38 criteria: Patients <18 years, incomplete health insurance data coverage, acute
39 cardiac ischemia and emergency procedures, therapeutic CA (coronary
40 angioplasty/stenting or coronary artery by-pass grafting). The effect of voluntary
41 health care models on the proportion of NIIT undertaken within two months before
42 diagnostic CA was assessed by means of multiple logistic regression analysis,
43 controlled for influencing factors.

44 Results

45 9173 patients matched in- and exclusion criteria. 33.2% (3044) did not receive NIIT
46 before CA. MC was independently associated with a higher proportion of NIIT
47 ($p < 0.001$, OR 1.17, CI 1.045 - 1.312), when additionally controlled for demographics,
48 insurance coverage, inpatient treatment, cardiovascular medication, chronic

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3 49 comorbidities, high-risk status (patients with therapeutic cardiac intervention 1 month
4
5 50 after or 18 months prior to diagnostic CA). GK models showed no significant
6
7 51 association with the rate of NIIT ($p=0.07$, OR 1.11, CI 0.991 - 1.253).
8

9 52 Conclusions

10
11 53 In a non-gate keeping health care system voluntary MC health care models with
12
13 54 capitation are able to reduce inappropriate use of diagnostic CA stronger than GK or
14
15 55 basic models.
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22 58 **Article summary**

- 23
24 59 - Highly relevant topic concerning inappropriate use of a potentially harmful and
25
26 60 expensive procedure such as the CA
27
28 61 - Only scarce data on non-emergency CA exists in literature
29
30
31 62 - Data originates from a single health insurance group in Switzerland, although
32
33 63 one of the largest in the country, including data on health insurance claims
34
35 64 from approximately 1.2 million patients
36
37 65 - No data on socioeconomic status and clinical information is available
38
39
40
41

42 67 **Key Words**

- 43
44 68 - Elective coronary angiography
45
46 69 - Managed care
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48 70 - Gate keeping
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50 71 - Inappropriate
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52 72 - Voluntary health care models
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54 73 - Limited access insurance models
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56 74 - Non-invasive ischemia testing
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75 Introduction

76 Existing guidelines¹⁻⁷ recommend non-invasive ischemia testing (NIIT) for the
77 majority of patients with suspected ischemic heart disease in a non-emergency
78 setting. Nevertheless, a substantial amount of these patients undergo diagnostic
79 coronary angiography (CA) without therapeutic intervention inappropriately, and are
80 therefore exposed to unnecessary risks without any clinical benefit⁸⁻¹⁵. In a non-gate
81 keeping health care system such as Switzerland, hardly any steering mechanisms
82 exist to ensure that potentially harmful and expensive procedures are only performed
83 in case of correct indication. The admitting physician (mainly general practitioner or
84 cardiologist) usually sets the indication for the intervention and the performing
85 invasive centers rarely decline assigned patients due to economic reasons or in order
86 not to disagree with the admitting physician.

87 Besides the basic healthcare models, offering unlimited access to almost all sectors
88 of the health care system including specialist and emergency care, alternative
89 voluntary health care models with various degrees of restriction in exchange to
90 premium reduction can be chosen from. These voluntary health care models can be
91 summarized into two main groups: 1) gate keeping (GK) models with steering
92 mechanisms, such as basic consultation of an insurance hotline for example, and 2)
93 managed care (MC) models with capitation. Previous studies showed a lower
94 prevalence of potentially inappropriate medication use in elderly patients and a lower
95 disease specific hospitalization rate in chronically ill patients enrolled in a MC model
96 compared to non-MC patients^{16 17}. No data on the association between NIIT and
97 various types of health care models in Switzerland exist.

98 The aim of this study was therefore to evaluate the effect of voluntary GK or MC
99 health care models on the proportion of patients without NIIT prior to elective purely
100 diagnostic CA without therapeutic intervention. The study includes a retrospective

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3 101 analysis of insurance claims data on diagnostic procedures undertaken within two
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5 102 months before CA depending on the health care model.
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10 105 **Materials and Methods**

11 106 Setting

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13
14
15 107 Swiss residents are obliged to enroll in a basic health care model, which covers all
16
17 108 costs besides deductibles. Depending on the model chosen, annual deductibles for
18
19 109 adults vary between 300 and 2500 Swiss Francs. A patient copayment of 10% of all
20
21 110 costs up to a maximum of 700 Swiss Francs per year is payable independent of the
22
23 111 chosen health care model. Currently residents can chose a basic health care model
24
25 112 from 53 different insurance companies. In general, in Switzerland no gate-keeping
26
27 113 system exists, meaning that patients have unlimited access to all healthcare
28
29 114 providers, unless they are voluntarily insured in a limited access model. Patients
30
31 115 agree to a restriction of choice or limited access in exchange of lower premiums. In
32
33 116 such limited access models, the general practitioner or an insurance telephone
34
35 117 hotline have to be consulted before contacting a specialist or another institution such
36
37 118 as a hospital. In case of emergency, this regulation is overruled. In Switzerland, the
38
39 119 currently existing limited access models can be summarized into two types of
40
41 120 models: 1) GK models with steering mechanisms, such as prior consultation of a
42
43 121 telemedicine center for example, and 2) MC models with capitation. In the capitation
44
45 122 system, the health insurance company reimburses the health care providers, usually
46
47 123 physician networks, with a set amount for each enrolled patient assigned to them per
48
49 124 period of time, whether or not that person seeks care. The remuneration is based on
50
51 125 the average expected health care utilization of each individual patient, with greater
52
53 126 payment for patients with significant medical history or chronic conditions. Compared
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127 to other health care systems, the Swiss system is more inpatient treatment oriented
128 due to co-financing of inpatient treatments by governmental institutions

129

130 Subjects, data collection and measurements

131 Data for this study included health insurance claims from approximately 1.2 million
132 patients, which live all over Switzerland and were enrolled with the Helsana Group.

133 Data on patients undergoing CA in the years 2012 to 2015 were retrospectively
134 analyzed. Detailed TAR MED (Standard billing rate for outpatient medical care in
135 Switzerland, version 2014) and Diagnosis Related Groups (DRG, version 2012)
136 positions are specified in the Supplemental Material.

137 *Inclusion criteria*

- 138 - Diagnostic CA performed in the years 2012 to 2015. If in this time interval
139 patients received more than one CA, only the first CA was taken into
140 consideration.

141 *Exclusion criteria*

- 142 - incomplete insurance data coverage 18 months before and/or 1 month after
143 CA (due to e.g. change of insurance company, military services, death)
- 144 - Patients <18 years
- 145 - Acute cardiac ischemia and/or emergency procedures
- 146 - Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass
147 grafting)

148 *Measurements*

- 149 - Patient characteristics: sex, age, language area and type of insurance
150 coverage (deductible class, supplementary private hospital insurance, MC
151 health care model)
- 152 - Setting of CA: inpatient or outpatient

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2
3 153 - NIIT performed within two months prior to CA (stress-ECG, echocardiography,
4
5 154 stress echocardiography, scintigraphy, computed tomography, cardiac MRI)
6
7 155 - Cardiovascular Medication grouped according to Anatomical-Therapeutic-
8
9 156 Chemical-Classification (ATC) ¹⁸
10
11 157 ○ Group 1: Aspirin, platelet aggregation inhibitors
12
13 158 ○ Group 2: statins, lipid modifying agents
14
15 159 ○ Group 3: antihypertensives, diuretics, beta blocking agents, calcium
16
17 160 channel blockers, agents acting on the renin-angiotensin system
18
19
20 161 ○ Group 4: antidiabetics
21
22 162 ○ Group 5: antianginous drugs
23
24 163 ○ Group 6: antithrombotics
25
26 164 - Number of chronic conditions according to Pharmaceutical cost groups PCG ¹⁹
27
28 165 ²⁰
29
30
31 166 ○ Group 1: pcg_n < 3 0, 1 or 2 PCGs
32
33 167 ○ Group 2: pcg_n < 5 3 to 4 PCGs
34
35 168 ○ Group 3: pcg_n < 7 5 to 6 PCGs
36
37 169 ○ Group 4: pcg_n ≥ 7 7 or more PCGs
38

170 *Sensitivity Analysis with high-risk patients*

171 We performed a sensitivity analysis of our data by defining a subgroup of patients as
172 high-risk with supposed cardiac disease, if having received therapeutic cardiac
173 intervention/diagnosis within one month after and/or 18 months prior to diagnostic
174 CA.

176 Patient and public involvement

177 Neither patients nor the public were involved in the study design.

178

179 Processing and analyzing data

180 Data was checked for eligibility and completeness and subjected to a set of
181 predefined plausibility tests. These included checks for contradictory data, duplication
182 and plausibility of time measurements.

183

184 Statistical analysis

185 Descriptive statistical techniques were used, to provide a general profile of the study
186 population and grouped into patients with non-limited versus limited access health
187 care models, consisting of the two subgroups GK and MC. These data were
188 presented as means in the case of continuous variables and as percentages in case
189 of categorical variables. Differences with respect to age, sex, deductible class,
190 supplementary private hospital insurance coverage, language area, inpatient CA,
191 cardiac medication class according to ATC, number of chronic medical conditions
192 identified using PCGs and high-risk status (patients having received therapeutic
193 cardiac intervention/diagnosis within one month after and/or 18 months prior to
194 diagnostic CA) were analyzed with a nonparametric analysis of variance (Kruskal-
195 Wallis test for continuous variables and chi-square tests for categorical variables).
196 We performed a logistic regression analysis to evaluate the independent association
197 between receiving NIIT within two months prior to CA and the various health care
198 models. In order to assess patient-level effects the following additional independent
199 variables were included in the models: age, sex, deductible class, supplementary
200 private hospital insurance coverage, language area, inpatient CA, cardiac medication
201 class according to ATC, number of chronic medical conditions identified using PCGs
202 and high-risk status. The strength of associations was measured by the odds ratio
203 (OR) and the respective 95% confidence intervals (CI). The level of significance was

204 set at 0.05. All statistical analyses were performed using R version 3.3.1 (2016-06-
205 21) (R Foundation for Statistical Computing, Vienna, Austria)^{21 22}.

206 Ethics approval

207 According to the national ethical and legal regulation, an ethical approval was not
208 needed. Permission to access the study data was provided by the Helsana Group.
209 Since data was anonymized, no consent of patients was required.

210

211

212 **Results**

213 Population

214 During the observed period a total of 19'032 therapeutic CA performed on 14'833
215 patients were registered in the Helsana data warehouse. 12'078 CA were eligible for
216 analysis. According to the exclusion criteria (multiple exclusion criteria possible per
217 person), we excluded 5 patients since they were under the age of 18 years, 828
218 patients due to incomplete coverage of health insurance data during the necessary
219 observation period, 360 emergency procedures, 1'922 therapeutic CA (coronary
220 angioplasty/stenting or coronary artery by-pass grafting). In total, 9'173 patients
221 remained for analysis.

222 The descriptive statistics of the study population are listed in Table 1. From the 9'173
223 patients representing the study population 5'587 were male (60.9%, mean age 66.4
224 years) and 3'586 were female (39.1%, mean age 68.7 years).

225 **Table 1** Descriptive statistics of the study population grouped into non-limited and limited access health care models (GK and MC)

	Non-limited access (n=5'258)			Limited access (n=3'915)			
	No NIIT (n=1'818)	With NIIT (n=3'440)		GK (n=1'816)		MC (n=2'099)	
				No NIIT (n=574)	With NIIT (n=1'242)	No NIIT (n=652)	With NIIT (n=1'447)
High-Risk (= 1)	1'006	1'690	***	287	577	306	644
Age (mean)	68.1 (12.8)	67.6 (10.9)	**	66.4 (12.5)	66.9 (10.6)	66.6 (13.1)	66.6 (11.4)
Sex (fem)	738	1'351		213	483	254	547
Deductible							
300	1'262	2'355		357	743	442	962
500	394	749		134	310	116	290
1000	45	71		26	65	28	48
1500	59	127		24	51	23	55
2000	5	14		2	14	3	16
2500	53	124		31	59	40	76

Private	493	925		120	288		142	316	
Latin	541	1'066		195	466		55	116	
Inpatient	1'166	1'765	***	357	584	***	441	798	***
ATC									
1	704	1'738	***	219	648	***	241	732	***
2	576	1'216	**	175	465	**	195	512	*
3	1'114	2'192		316	755	**	365	931	***
4	277	510		72	152		80	185	
5	281	544		89	162		79	178	
6	1'038	2'429	***	319	840	***	348	985	***
PCG			**						
<3	434	843		175	372		203	444	
3-4	634	1'333		200	474		221	557	
5-6	467	872		145	295		150	304	

>6	283	392		54	101		78	142	
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*NIIT: Non-invasive ischemia testing. GK: Gate keeping, MC: Managed care: Deductible class in Swiss Francs. Private: supplementary private hospital insurance, Latin: French or Italian part of Switzerland compared to German part. CA: coronary angiography, ATC: Anatomical-Therapeutic-Chemical-Classification group 1 = Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3 = antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6: antithrombotics, PCG: number of chronic conditions according to pharmaceutical cost groups. High-risk patients: having received therapeutic cardiac intervention within one month after or 18 months prior to diagnostic CA. Significance no NIIT vs with NIIT within nonlimited access and limited access group: *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.01$.*

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3 234 Patients insured in basic health care models were slightly older (67.7 (11.6) vs. 66.6
4
5 235 (11.6) years, $p<0.0001$), chose the lowest possible deductible of 300 Francs more
6
7 236 often (3'617 (68.8%) vs. 2'504 (64.0%), $p<0.001$), were enrolled in a supplementary
8
9 237 private hospital insurance more often (1'418 (27.0%) vs. 866 (22.1%), $p<0.0001$), had
10
11 238 more antidiabetics (787 (15%) vs 489 (12.5%), $p<0.0001$) and antianginal medication
12
13 239 (825 (15.7%) vs 508 (13.0%), $p<0.0001$), more PCGs (4.1 (2.1) vs. 3.6 (2.0),
14
15 240 $p<0.0001$) and had more often a high-risk status (2'696 (51.3%) vs. 1'814 (46.3%),
16
17 241 $p<0.0001$), compared to patients insured in limited access models. Concerning the
18
19 242 other patient characteristics, no differences existed.
20
21
22
23

24 Non-invasive ischemia testing

25
26 245 488 (33.8 %) of patients without NIIT had a conventional ECG prior to CA, in the
27
28 246 high-risk population this was the case in 722 (45.2%) ($p<0.0001$). The most NIITs
29
30 247 stress-ECG + transthoracic echocardiography were performed significantly more
31
32 248 often before CA in patients insured in limited access compared to non-limited access
33
34 249 models (1'750 (44.7%) vs. 2'039 (38.8 %) $p<0.0001$, and 2'044 (52.2%) and 2'528
35
36 250 (48.1%), $p<0.0001$). The remaining types of NIIT were rarely performed and only
37
38 251 showed a significant difference in the use of scintigraphy (non-limited 131 (2.5%) vs.
39
40 252 limited access models 64 (1.6%), $p<0.001$).
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46 Determinants for non-invasive ischemia testing

47
48 255 Patients with MC models were 17% significantly more likely to receive NIIT before CA
49
50 256 compared to patients with non-limited models, when controlled for the confounders
51
52 257 age, sex, language area, insurance coverage, inpatient treatment, cardiovascular
53
54 258 medication, number of chronic comorbidities and high-risk status (OR 1.17, $p<0.001$).
55
56 259 GK models did not show any significant influence on the chance of receiving NIIT
57
58
59
60

260 (OR 1.11, $p=0.071$). The distribution of NIIT performed according to health care
 261 model can be appreciated in Figure 1.

262

263 Figure 1: Distribution of NIIT performed according to health care model.

264 *OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders*
 265 *age, sex, language area, insurance coverage, inpatient treatment, cardiovascular*
 266 *medication, number of chronic comorbidities and high-risk status. * $p<0.001$ (OR*
 267 *1.17) for managed care model compared to non-limited access model (Reference).*

268

269 Following determinants were also independently significantly associated with
 270 receiving NIIT: the use of platelet aggregation inhibitors, antithrombotic and
 271 antihypertensive medication, being supplementary privately insured and a deductible
 272 of 2000 SFR. Following determinants were significantly associated with not receiving
 273 NIIT: high-risk status, a high number of chronic comorbidities as well as inpatient
 274 treatment (Table 2).

275

276 Table 2: Determinants for receiving non-invasive ischemia testing before coronary
 277 angiography

	CI	OR	Sig
279 Age (years)	0.998 - 1.007	1.003	
280 Sex (female)	0.967 - 1.166	1.062	
281 Deductible Class (Swiss Francs, Reference 300)			
282 500	0.912 - 1.141	1.020	
283 1000	0.667 - 1.120	0.865	
284 1500	0.841 - 1.374	1.075	
285 2000	1.082 - 4.381	2.177	*

286	2500	0.809 - 1.289	1.022	
287	Private	1.025 - 1.267	1.140	*
288	French or Italian part of Switzerland	0.841 - 1.044	0.937	
289	Inpatient CA	0.540 - 0.664	0.599	***
290	ATC group			
291	1	1.251 - 1.620	1.423	***
292	2	0.922 - 1.135	1.023	
293	3	1.002 - 1.218	1.104	*
294	4	0.851 - 1.115	0.974	
295	5	0.874 - 1.130	0.994	
296	6	1.034 - 1.356	1.184	*
297	PCG (reference <3)			
298	<5	0.940 - 1.192	1.058	
299	<7	0.809 - 1.064	0.928	
300	>=7	0.624 - 0.881	0.742	***
301	Limited access models (reference non-limited access)			
302	Managed Care	1.045 - 1.312	1.171	**
303	Gate Keeping	0.991 - 1.253	1.114	
304	High-risk cardiac status	0.046443	0.836	***
305	<i>CI: confidence interval, OR: odds ratio, Sig: significance: *** p<0.0001, ** p<0.001</i>			
306	<i>*p<0.01, Private: supplementary private hospital insurance, CA: coronary</i>			
307	<i>angiography, ATC: Anatomical-Therapeutic-Chemical-Classification group 1 =</i>			
308	<i>Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3 =</i>			
309	<i>antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents</i>			
310	<i>acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6:</i>			
311	<i>antithrombotics, PCG: number of chronic conditions according to pharmaceutical cost</i>			

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3 312 *groups. High-risk patients: having received therapeutic cardiac intervention within*
4
5 313 *one month after or 18 months prior to diagnostic CA.*
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9 315

11 316 **Discussion**

13 317 In our study population of elective CA with no therapeutic consequence (no coronary
14
15 318 angioplasty/stenting or coronary artery bypass grafting) one third did not receive NIIT
16
17 319 before diagnostic CA. MC was independently significantly associated with a higher
18
19 320 proportion of NIIT when additionally controlled for potential confounders. GK models
20
21 321 showed no significant association with the rate of NIIT.
22
23 322

26 323 Effects of limited access health care models on treatment quality

28 324 In our study, emergency CA were excluded and the study population consisted of
29
30 325 patients undergoing purely diagnostic elective CA with no therapeutic consequence
31
32 326 (e.g. no coronary angioplasty/stenting or coronary artery by-pass grafting). The study
33
34 327 population therefore represents a selection of patients with at least stable CHD or no
35
36 328 CHD at all. From a previous study among this selection of patients we know, that
37
38 329 37.5% did not receive any NIIT at all before elective CA with no therapeutic
39
40 330 consequence, suggesting a substantial overuse of a potentially harmful and
41
42 331 inappropriate diagnostic intervention¹². It has been assumed that patients insured in
43
44 332 limited access health care models undergo less diagnostic procedures or
45
46 333 interventions due to budget considerations, especially in capitated health care
47
48 334 models. In our study, this hypothesis is clearly refuted. Patients with stable angina
49
50 335 pectoris insured in limited access health care models underwent a more appropriate
51
52 336 diagnostic pathway than regularly insured patients did, meaning in a stable clinical
53
54 337 situation they were subjected to significantly more non-invasive diagnostic testing,
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3 338 therefore reducing inadequate CA. Our findings are in line with another study from
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5 339 the Swiss health care system, which also showed higher referral rates among MC
6
7 340 patients compared to patients insured in basic health care models²³. One reason for
8
9 341 that finding could be that general practitioners in most networks are forced to
10
11 342 consider evidence based guidelines, which is not mandatory for general practitioners
12
13 343 which are not member of a network . Other studies showed that being insured in MC
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15 344 models is associated with a survival benefit by promoting better preventive and
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17 345 higher quality of care²⁴⁻²⁶. Especially among Medicare beneficiaries, which are prone
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19 346 to multimorbidity, this effect has been shown²⁷. These models have also shown
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21 347 lower prevalence of potentially inappropriate medication use in elderly patients and a
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23 348 lower disease specific hospitalization rate in chronically ill patients^{16 17}.
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26 349 Our study raises the question why patients in limited access health care models
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28 350 receive a more appropriate diagnostic pathway in this clinical situation of stable
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30 351 angina pectoris. There has been evidence for and against the theory that patients
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32 352 enrolled in a MC health care model are healthier due to biased selection²⁸⁻³⁷ and
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34 353 commercial considerations of the MC insurer^{38 39}. In our study population, patients
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36 354 insured in limited access models showed some evidence of being healthier than
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38 355 regularly insured patients. Nevertheless being insured only in MC but not GK models
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40 356 was *independently* associated with a higher rate of NIIT, controlled for all the
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42 357 differences in patient characteristics. It is clear that physicians participating in MC
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44 358 models are obliged to keep diagnostic and treatment costs as low as possible while
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46 359 keeping up with quality concerns. One could therefore argue that it is cheaper to not
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48 360 to choose a diagnostic detour over NIIT instead of choosing the straight forward way
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50 361 of sending a patient to the more invasive CA, which offers a clear answer to an
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52 362 uncertain clinical situation including the option of therapeutic action. It seems that MC
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54 363 health care providers have understood what Meara et al. have summed up

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3 364 accurately: “Reductions in spending for patients must be a result of decreases in the
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5 365 provision of services. If these are needed services, quality of care will decline.
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7 366 Alternatively, quality of care might be higher in low expenditure areas if differences in
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9 367 spending result from reductions in unnecessary or inappropriate services⁴⁰. Besides
10
11 368 this intuitive statement there has been scientific evidence that a diagnostic detour is
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13 369 worthwhile taking, since it sums up in reduced peri and post interventional costs
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15 370 without loss in quality¹¹. Our study is not able to answer the questions why patients
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17 371 in limited access models received a more appropriate diagnostic approach. One can
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19 372 only hypothesize that a more rigorous coordination of care, as performed in the MC
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21 373 models, is straighter forward and the indication for invasive and expensive diagnostic
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23 374 procedures is more thoroughly scrutinized.
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376 Determinants for NIIT

377 Even though simple echocardiography with no stress testing does not actually qualify
378 as a NIIT, we chose to include this diagnostic procedure due to following
379 considerations: some cardiologists might argue that patients with dyskinesia in simple
380 echocardiography are likely to have relevant coronary pathology therefore offering an
381 argument for CA besides the clinical evaluation. Our theory is supported by the “2014
382 ESC/EACTS Guidelines on Myocardial Revascularization which state: “regional wall
383 motion abnormalities may be detected in simple echocardiography, which increase
384 the likelihood of coronary artery disease”. Since the inclusion of this additional test
385 leads to underestimation of “real” NIIT performed, the findings only strengthen our
386 hypothesis.

387 Since our study lacks clinical data, only indirect hints by means of PCG and ATC
388 codes as well as other confounders are available to assess clinical reasoning. The
389 association between the use of platelet aggregation inhibitors or antithrombotic

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3 390 agents and antihypertensive medication with receiving NIIT before CA suggest a
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5 391 reasonable deliberation in the sense of estimating pretest probability when deciding
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7 392 on optimal diagnostic strategy. The same counts for the association of high-risk
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9 393 status and a larger number of chronic comorbidities as determinants for not receiving
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11 394 NIIT prior to elective CA. This finding is consistent with two US studies indicating that
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13 395 risk stratification was performed, considering the higher likelihood of a coronary
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15 396 pathology in patients with known coronary heart disease^{8 10}. In our study, also non-
16
17 397 clinical factors seem to influence decision-making processes concerning diagnostic
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19 398 pathways, reflected by the findings that being privately insured and a deductible of
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21 399 2000 SFR were positively and inpatient treatment negatively independently
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23 400 associated with NIIT.

24
25 401 As previously observed in another Swiss study analyzing inappropriate use of
26
27 402 arthroscopic meniscal surgery in degenerative knee disease⁴¹, a substantial amount
28
29 403 of the patients in our sample underwent CA as inpatients in contrast to other health
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31 404 care settings. This finding is most likely explained by differences in the organization
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33 405 of the health care system in Switzerland. Here regional governments subsidize
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35 406 inpatient treatment covering approximately 50% of total costs, and patients with
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37 407 supplementary private insurance receive a substantially higher reimbursement when
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39 408 treated as inpatients. Nevertheless, in the regression analysis with the outcome
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41 409 proportion of NIIT, we controlled for potential confounders, such as inpatient
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43 410 treatment as well. The results therefore seem robust concerning the question
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45 411 whether limited access health care models have a significant impact on the
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47 412 appropriateness of the diagnostic approach.

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54 414 Reinforcing quality control mechanisms in a non-gate keeping health care system

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3 415 Besides the existing voluntary steering mechanisms such limited access health care
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5 416 models guided by patient's preferences only, more alternative steering mechanisms
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7 417 have to be implemented in non-gate keeping health care systems, in order to
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9 418 minimize the influence of non-clinical factors on medical decision making, which
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11 419 might lead to inappropriate and possibly dangerous health care utilization as well as
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13 420 increasing expenditures. A positive example for alternative steering mechanisms is
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15 421 the implementation of national registries⁴² combined with quality initiatives, such as
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17 422 the in 2009 published Appropriate Use Criteria for Coronary Revascularization^{9 42 43}.
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19 423 In 2011, the registry started giving feedbacks on the participating hospital's
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21 424 performance concerning appropriateness of CA including a benchmarking against
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23 425 other participating institutions. At the same time the American Board of Internal
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25 426 Medicine's Choosing Wisely initiative launched national quality improvement
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27 427 campaigns, identifying CA appropriateness as a key area for intervention⁴⁴. As a
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29 428 consequence insurance companies incorporated measures of CA appropriateness
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31 429 into pay-for-performance programs⁴⁵ and reimbursement was declined for certain
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33 430 CA identified as inappropriate⁴⁶. The combination of implementing national registries
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35 431 combined with quality initiatives had been proven amazingly effective, showing a
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37 432 decrease of non-acute CA classified as inappropriate from 26.2% to 13.3%⁴⁷. In
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39 433 Switzerland currently no registries on CA exist, hence other solutions for influencing
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41 434 treatment pathways have to be developed, besides offering voluntary limited access
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43 435 health care models. A possible alternative solution to the conundrum of reducing
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45 436 costs without cutting quality seems hence to be paying for outcomes instead of
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47 437 volume. As the findings of our study suggest, a possible approach is to raise the
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49 438 market share of MC to such a volume that it might also affect care for fee-for-service
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51 439 patients⁴⁰. As Meara et al have summarized, the effects have been show to play in a
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53 440 variety of ways: more MC in a market might lower expenditures by reducing the
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3 441 number of specialists, and thereby the number of specialists' services provided^{48 49}
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5 442 by encouraging more conservative practice patterns^{48 49}, or by slowing the diffusion
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7 443 of more costly technologies^{48 50}.

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10 445 Strengths and limitations

11 446 Only scarce data on non-emergency CA exists in literature. The only data found
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13 447 originates from the US among Medicare as well as commercially insured patients and
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15 448 from Switzerland, both non-gate keeping health care systems. Whether the
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17 449 proportion of inappropriate diagnostic CA from our study can be translated to other
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19 450 non-gate keeping health care systems is difficult to estimate, since substantial
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21 451 variation in the proportion of non-acute PCIs considered inappropriate across
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23 452 hospitals can be found, ranging from about 6% to 70%^{8 10 14 15 47}. From a previous
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25 453 study from Switzerland 12 similar proportions were found, suggesting generalizability
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27 454 of our data. The current study seems even more representative than the previous
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29 455 Swiss study, since it included data over a longer time-period with consecutively larger
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31 456 amount of patients and corresponding data. Since the study is based on insurance
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33 457 claims data, no data on socioeconomic status and clinical information is available.
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35 458 Given that this is a cross-sectional observational study, rather than an interventional
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37 459 one, the only conclusions that we can draw are of association rather than causation.
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39 460 Due to the study design, unfortunately no estimations on clinical outcome parameters
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41 461 can be made. For example, in order to explore clinical appropriateness, the
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43 462 proportion of CA's avoided by performing NIIT would be of great interest. As a
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45 463 substitute for clinical data, ATC and PCG are used, offering only indirect information
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47 464 on comorbidities. On the other hand PCGs represent a strength, since they have
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49 465 been shown to directly correlate with associated health care costs¹⁹. Due to data
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51 466 structure, it is not possible to distinguish between CT angiography (including
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3 467 intravenous contrast) and CT without intravenous contrast. Therefore, all CTs of the
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5 468 chest were included in analysis. Since the inclusion of this broader NIIT definition
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7 469 leads to underestimation of “real” NIIT performed, the findings only strengthen our
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9 470 hypothesis.

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12 13 472 **Conclusions**

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15 473 In a non-gate keeping health care system voluntary MC health care models with
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17 474 capitation are able to reduce inappropriate use of diagnostic CA stronger than GK or
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19 475 basic models.
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481 American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association,
482 Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons.
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628

629 **Competing interests**

630 Oliver Reich and Andri Signorell are employed by the Helsana Group. The sponsor
631 had no role in the planning, conducting or submission of this manuscript. These
632 authors declare no conflict of interest. Helsana Group shall have no liability to any
633 third party in respect to the contents of this article. All the other authors have no
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635

636 **Authors Contributions**

637 Conceived and designed the experiments: CC, OR, AS, SNJ, TR, OS. Performed the
638 experiments: CC, OR, AS. Analyzed the data: CC, OR, AS, SNJ, TR, OS. Wrote the
639 paper: CC, edited and approved the paper: CC, OR, AS, SNJ, TR, OS.

640

641 **Consent for publication**

642 Since data were completely anonymized, no patient consent was necessary.

643

644 **Availability of data and materials**

645 Individual data cannot be made fully available on the internet because the study is
646 based on claims data of the Helsana Group, the owner of the data. Thus, data
647 underlie data protection and privacy restrictions. These restrictions prohibit the
648 insurer from sharing the collected data. Data analysis was performed within the

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3 649 premises of the Helsana research group by the statistician AS in collaboration with
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5 650 the authors OR and CC and administrative permission was received to access de-
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7 651 identified data by the researchers from the University of Zurich.
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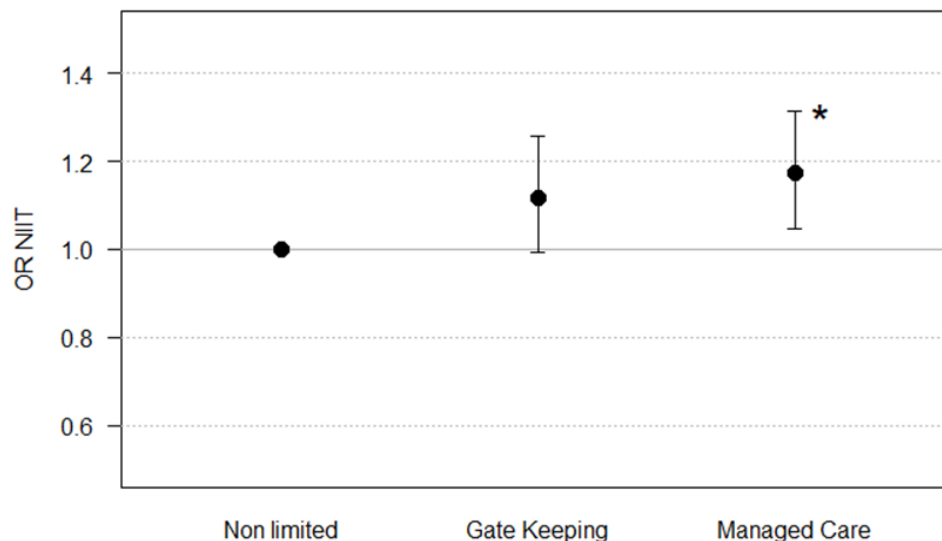
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13 654 **Figure Legend**

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16 655 Figure 1: Distribution of NIIT performed according to health care model.

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18 656 *OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders*
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20 657 *age, sex, language area, insurance coverage, inpatient treatment, cardiovascular*
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22 658 *medication, number of chronic comorbidities and high-risk status. * $p < 0.001$ (OR*
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24 659 *1.17) for managed care model compared to non-limited access model (Reference).*
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OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high- risk status. * $p < 0.001$ (OR 1.17) for managed care model compared to standard health care plannon-limited access model (Reference).

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3 **1 Supplemental Material**

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5 **2 Supplemental Methods/Definitions**

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10 **4 1) Inclusion Criteria**

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26 **11 DRG F49D**

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28 **12 F49E**

29
30
31 **13 F49F**

32
33 **14 If two coronary angiographies (CA) were performed on the same day at the same**
34
35 **15 provider, the intervention is counted once.**

36
37 **16 If the CA was performed twice at the same day but different providers the CA counts**
38
39 **17 twice (both concerning the inpatients positions (Diagnosis related Groups (DRG)) and**
40
41 **18 the outpatient positions (Standard billing rate for outpatient medical care in**
42
43 **19 Switzerland (TARMED))**

44
45
46 **20 If during 2012-2015 patients received more than one CA, only the first CA was taken**
47
48 **21 into consideration.**

1
2
3 1 2) Exclusion Criteria
4

5	2	Acute cardiac ischemia and/or emergency procedures	Tarmed	0.2510
6				
7	3			0.2520
8				
9	4			0.2540
10				
11	5			0.2560
12				
13	6			0.2580
14				
15	7			35.0610
16				
17	8		DRG	F41A
18				
19	9			F41B
20				
21	10			
22				
23	11	Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting,		
24		without myocardial infarction)	Tarmed	17.1110
25	12			17.1240
26				
27	13		DRG	F15Z
28				F19Z
29	14			F24B
30				F49A
31	15			F49C
32				F52A
33	16			F52B
34				F54Z
35	17			F56A
36				F56B
37	18			F57A
38				F57B
39	19			F58Z
40				
41	20			
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1		
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3	1	F59A
4		
5	2	F59B
6		
7		
8	3	Incomplete coverage of mandatory basic health insurance 18 months before and/or 1
9		
10	4	month after CA
11		
12	5	Patients <18 years
13		
14	6	
15		
16		
17	7	
18		
19	8	<u>3) Diagnostic Procedures</u>
20		
21	9	Tarmed 17.0010: Electrocardiogram (ECG): not considered as NIIT, only in
22		
23		
24	10	combination with other NIIT
25		
26	11	17.0050: Cardiac intervention with medication under continuous
27		
28	12	registration of ECG: not considered as NIIT, only in combination with
29		
30	13	another NIIT
31		
32		
33	14	17.0060: ECG performed by specialist outside of the practice or
34		
35	15	hospital: not considered as NIIT, only in combination with another NIIT
36		
37		
38	16	17.0080 and 17.0090: Stress-ECG
39		
40	17	17.0210: Echocardiography, transthoracic, qualitative and quantitative
41		
42	18	examination of adult
43		
44	19	17.0280: Stressechocardiography, physical stress
45		
46		
47	20	17.0290: Stressechocardiography, medication stress
48		
49	21	31.0260: Scintigraphy physiologically triggered
50		
51	22	39.4060: Computed tomography of entire thorax and/or sternoclavicular
52		
53		
54	23	joint
55		
56	24	39.5100 Heart MRI
57		
58	25	DRG No separate codes available for inpatient diagnostic procedures, only
59		
60	26	for therapeutic interventions

1
2
3 1 4) High risk patients
4

5 2 Patients having received therapeutic cardiac intervention within one month after or 18
6
7 3 months prior to diagnostic CA
8

9
10 4 Tarmed 0.2510
11

12 5 0.2520
13

14 6 0.2540
15

16 7 0.2560
17

18 8 0.2580
19

20 9 35.0610
21

22 10 17.1110
23

24 11 17.1240
25

26 12 And all 18.001 until/including 18.0740
27

28 13 DRG all Chapter F
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BMJ Open

Effects of managed care on the proportion of inappropriate elective diagnostic coronary angiographies in non-emergency patients in Switzerland, a retrospective cross-sectional analysis

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Manuscripts

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3 1 **Effects of managed care on the proportion of inappropriate elective diagnostic**
4 **coronary angiographies in non-emergency patients in Switzerland, a**
5 **retrospective cross-sectional analysis**
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23 **Abstract**

24 Objective

25 Guidelines recommend non-invasive ischemia testing (NIIT) for the majority of
26 patients with suspected ischemic heart disease in a non-emergency setting. A
27 substantial amount of these patients undergoes diagnostic coronary angiography
28 (CA) without therapeutic intervention inappropriately due to lacking preceding NIIT.

29 The aim of this study was to evaluate the effect of voluntary health care models with
30 limited access on the proportion of patients without NIIT prior to elective purely
31 diagnostic CA.

32 Design:

33 Retrospective cross-sectional analysis of insurance claims data from 2012 to 2015.
34 Data included claims of basic and voluntary health care models from approximately
35 1.2 million patients enrolled with the Helsana Insurance Group. Voluntary health care
36 models with limited health access are divided into gate keeping (GK) and managed
37 care (MC) capitation models. Inclusion criteria: patients undergoing CA. Exclusion
38 criteria: Patients <18 years, acute cardiac ischemia and emergency procedures,
39 therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting).
40 The effect of voluntary health care models on the proportion of NIIT undertaken
41 within two months before diagnostic CA was assessed by means of multiple logistic
42 regression analysis, controlled for influencing factors.

43 Results

44 9173 patients matched inclusion criteria. 33.2% (3044) did not receive NIIT before
45 CA. Compared to basic health care models MC was independently associated with a
46 higher proportion of NIIT ($p < 0.001$, OR 1.17, CI 1.045 - 1.312), when additionally
47 controlled for demographics, insurance coverage, inpatient treatment, cardiovascular
48 medication, chronic comorbidities, high-risk status (patients with therapeutic cardiac

1
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3 49 intervention 1 month after or 18 months prior to diagnostic CA). GK models showed
4
5 50 no significant association with the rate of NIIT ($p=0.07$, OR 1.11, CI 0.991 - 1.253).
6

7 Conclusions

8
9 52 In a non-gate keeping health care system voluntary MC health care models with
10
11 53 capitation were associated with a reduced inappropriate use of diagnostic CA
12
13 54 compared to basic models.
14

15
16 55

17 **Strengths and Limitations**

- 18
19
20 57 - Highly relevant topic concerning inappropriate use of a potentially harmful and
21
22 58 expensive procedure such as the CA
23
24 59 - Only scarce data on non-emergency CA exists in literature originating from
25
26 60 different health care settings
27
28 61 - Data originates from a single health insurance group in Switzerland, although
29
30 62 one of the largest in the country, including data on health insurance claims
31
32 63 from approximately 1.2 million patients.
33
34 64 - No data on socioeconomic status and clinical information is available
35
36 65

37 **Key Words**

- 38
39
40 67 - Elective coronary angiography
41
42 68 - Managed care
43
44 69 - Gate keeping
45
46 70 - Inappropriate
47
48 71 - Voluntary health care models
49
50 72 - Limited access insurance models
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52 73 - Non-invasive ischemia testing
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57 **Introduction**

1
2
3 75 Existing guidelines ¹⁻⁷ recommend non-invasive ischemia testing (NIIT) for the
4
5 76 majority of patients with suspected ischemic heart disease in a non-emergency
6
7 77 setting. Nevertheless, a substantial amount of these patients undergo diagnostic
8
9 78 coronary angiography (CA) without therapeutic intervention inappropriately, and are
10
11 79 therefore exposed to unnecessary risks without any clinical benefit ⁸⁻¹⁵. In a non-gate
12
13 80 keeping health care system such as Switzerland, hardly any steering mechanisms
14
15 81 exist to ensure that potentially harmful and expensive procedures are only performed
16
17 82 in case of correct indication. The admitting physician (mainly general practitioner or
18
19 83 cardiologist) usually sets the indication for the intervention and the performing
20
21 84 invasive centers rarely decline assigned patients due to economic reasons or in order
22
23 85 not to disagree with the admitting physician.
24
25

26 86 Besides the basic healthcare models, offering unlimited access to almost all sectors
27
28 87 of the health care system including specialist and emergency care, alternative
29
30 88 voluntary health care models with various degrees of restriction in exchange to
31
32 89 premium reduction can be chosen from. These voluntary health care models can be
33
34 90 summarized into two main groups: 1) gate keeping (GK) models with steering
35
36 91 mechanisms, such as basic consultation of an insurance hotline for example, and 2)
37
38 92 managed care (MC) models with capitation. Previous studies showed a lower
39
40 93 prevalence of potentially inappropriate medication use in elderly patients and a lower
41
42 94 disease specific hospitalization rate in chronically ill patients enrolled in a MC model
43
44 95 compared to non-MC patients ^{16 17}. No data on the association between NIIT and
45
46 96 various types of health care models in Switzerland exist.
47
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49
50 97 The aim of this study was therefore to evaluate the effect of voluntary GK or MC
51
52 98 health care models on the proportion of patients without NIIT prior to elective purely
53
54 99 diagnostic CA without therapeutic intervention. The study includes a retrospective
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3 100 analysis of insurance claims data on diagnostic procedures undertaken within two
4
5 101 months before CA depending on the health care model.

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9 103

10 104 **Materials and Methods**

11 105 Setting

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13
14
15 106 Swiss residents are obliged to enroll in a basic health care model, which covers all
16
17 107 costs besides deductibles. Depending on the model chosen, annual deductibles for
18
19 108 adults vary between 300 and 2500 Swiss Francs. A patient copayment of 10% of all
20
21 109 costs up to a maximum of 700 Swiss Francs per year is payable independent of the
22
23 110 chosen health care model. Currently residents can chose a basic health care model
24
25 111 from 53 different insurance companies. In general, in Switzerland no gate-keeping
26
27 112 system exists, meaning that patients have unlimited access to all healthcare
28
29 113 providers, unless they are voluntarily insured in a limited access model. Patients
30
31 114 agree to a restriction of choice or limited access in exchange of lower premiums. In
32
33 115 such limited access models, the general practitioner or an insurance telephone
34
35 116 hotline have to be consulted before contacting a specialist or another institution such
36
37 117 as a hospital. In case of emergency, this regulation is overruled. In Switzerland, the
38
39 118 currently existing limited access models can be summarized into two types of
40
41 119 models: 1) GK models with steering mechanisms, such as prior consultation of a
42
43 120 telemedicine center for example, and 2) MC models with capitation. In the capitation
44
45 121 system, the health insurance company reimburses the health care providers, usually
46
47 122 physician networks, with a set amount for each enrolled patient assigned to them per
48
49 123 period of time, whether or not that person seeks care. The remuneration is based on
50
51 124 the average expected health care utilization of each individual patient, with greater
52
53 125 payment for patients with significant medical history or chronic conditions. Compared

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126 to other health care systems, the Swiss system is more inpatient treatment oriented
127 due to co-financing of inpatient treatments by governmental institutions

128

129 Subjects, data collection and measurements

130 Data for this study included health insurance claims from approximately 1.2 million
131 patients, which live all over Switzerland and were enrolled with the Helsana Group.
132 Data on patients undergoing CA in the years 2012 to 2015 were retrospectively
133 analyzed. Data was considered for analysis if insurance coverage was complete
134 within 18 months before and/or 1 month after CA. 828 patients were not considered
135 due to incomplete coverage of health insurance data during the necessary
136 observation period (due to e.g. change of insurance company, military services,
137 death). Detailed TAR MED (Standard billing rate for outpatient medical care in
138 Switzerland, version 2014) and Diagnosis Related Groups (DRG, version 2012)
139 positions are specified in the Appendix 1.

140 *Inclusion criteria*

- 141 - Diagnostic CA performed in the years 2012 to 2015. If in this time interval
142 patients received more than one CA, only the first CA was taken into
143 consideration.

144 *Exclusion criteria*

- 145 - Patients <18 years
- 146 - Acute cardiac ischemia and/or emergency procedures
- 147 - Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass
148 grafting)

149 *Measurements*

- 150 - Patient characteristics: sex, age, language area and type of insurance
151 coverage (deductible class, supplementary private hospital insurance, MC

- 1
2
3 152 health care model)
- 4
5 153 - Setting of CA: inpatient or outpatient
- 6
7 154 - NIIT performed within two months prior to CA (stress-ECG, echocardiography,
8
9 155 stress echocardiography, scintigraphy, computed tomography, cardiac MRI)
- 10
11 156 - Cardiovascular Medication grouped according to Anatomical-Therapeutic-
12
13 157 Chemical-Classification (ATC) ¹⁸
- 14
15
16 158 ○ Group 1: Aspirin, platelet aggregation inhibitors
- 17
18 159 ○ Group 2: statins, lipid modifying agents
- 19
20 160 ○ Group 3: antihypertensives, diuretics, beta blocking agents, calcium
21
22 161 channel blockers, agents acting on the renin-angiotensin system
- 23
24 162 ○ Group 4: antidiabetics
- 25
26 163 ○ Group 5: antianginous drugs
- 27
28 164 ○ Group 6: antithrombotics
- 29
30
31 165 - Number of chronic conditions according to Pharmaceutical cost groups PCG ¹⁹
32
33 166 ²⁰
- 34
35 167 ○ Group 1: $pcg_n < 3$ 0, 1 or 2 PCGs
- 36
37 168 ○ Group 2: $pcg_n < 5$ 3 to 4 PCGs
- 38
39 169 ○ Group 3: $pcg_n < 7$ 5 to 6 PCGs
- 40
41 170 ○ Group 4: $pcg_n \geq 7$ 7 or more PCGs

171 *Sensitivity Analysis with high-risk patients*

172 We performed a sensitivity analysis of our data by defining a subgroup of patients as
173 high-risk with supposed cardiac disease, if having received therapeutic cardiac
174 intervention/diagnosis within one month after and/or 18 months prior to diagnostic
175 CA.

176

177 Patient and public involvement

1
2
3 178 Neither patients nor the public were involved in the study design.

4
5 179

6
7 180 Processing and analyzing data

8
9 181 Data were checked for eligibility and completeness and subjected to a set of
10
11 182 predefined plausibility tests. These included checks for contradictory data, duplication
12
13 183 and plausibility of time measurements.

14
15
16 184

17
18 185 Statistical analysis

19
20 186 Descriptive statistical techniques (Table 1) were used, to provide a general profile of
21
22 187 the study population and grouped into totally three groups of patients: patients with
23
24 188 non-limited and limited access health care models (GK and MC). The descriptive
25
26 189 statistics were performed pairwise for each health care model separately. These data
27
28 190 were presented as means in the case of continuous variables and as percentages in
29
30 191 case of categorical variables.

31
32
33 192 Differences within the health care models (Appendix 2) with respect to the continuous
34
35 193 variable age were analyzed with a nonparametric analysis of variance Kruskal-Wallis
36
37 194 test. The variables with two levels (sex, high-risk status (patients having received
38
39 195 therapeutic cardiac intervention/diagnosis within one month after and/or 18 months
40
41 196 prior to diagnostic CA), supplementary private hospital insurance coverage, language
42
43 197 area, inpatient CA, medication class according to ATC) were analyzed with an exact
44
45 198 fisher test. The number of chronic medical conditions identified using PCG and the
46
47 199 deductible class were compared with a chi square test.

48
49
50 200 We performed a logistic regression analysis to evaluate the independent association
51
52 201 between receiving NIIT within two months prior to CA and the various health care
53
54 202 models (Figure 1 and Table 2). In order to assess patient-level effects, the following
55
56 203 additional independent variables were included in the regression analysis: age, sex,

1
2
3 204 deductible class, supplementary private hospital insurance coverage, language area,
4
5 205 inpatient CA, cardiac medication class according to ATC, number of chronic medical
6
7 206 conditions identified using PCGs and high-risk status. Goodness of fit measures for
8
9 207 the model were: Nagelkerke 0.051, BrierScore 0.213, C-Statistic 0.618. The strength
10
11 208 of associations was measured by the odds ratio (OR) and the respective 95%
12
13 209 confidence intervals (CI). The level of significance was set at 0.05. All statistical
14
15 210 analyses were performed using R version 3.3.1 (2016-06-21) (R Foundation for
16
17 211 Statistical Computing, Vienna, Austria)^{21 22}.

212 213 Ethics approval

214 According to the national ethical and legal regulation, an ethical approval was not
25
26 215 needed. Permission to access the study data was provided by the Helsana Group.
27
28 216 Since data was anonymized, no consent of patients was required.

217 218 219 **Results**

220 Population

221 During the observed period a total of 19'032 therapeutic CA performed on 14'833
222 patients were registered in the Helsana data warehouse. 12'078 CA were eligible for
223 analysis. According to the exclusion criteria (multiple exclusion criteria possible per
244
245 224 person), we excluded 5 patients since they were under the age of 18 years, 360
246
247 225 emergency procedures, 1'922 therapeutic CA (coronary angioplasty/stenting or
248
249 226 coronary artery by-pass grafting). In total, 9'173 patients remained for analysis.
250
251 227 The descriptive statistics of the study population are listed in Table 1. From the 9'173
252
253 228 patients representing the study population 5'587 were male (60.9%, mean age 66.4
254
255 229 years) and 3'586 were female (39.1%, mean age 68.7 years).

230 **Table 1 Descriptive statistics of the study population grouped into non-limited and limited access health care models (GK and MC)**

	Non-limited access (n=5'258)			Limited access (n=3'915)						
	No NIIT (n=1'818)	With NIIT (n=3'440)		GK (n=1'816)			MC (n=2'099)			
				No NIIT (n=574)	With NIIT (n=1'242)		No NIIT (n=652)	With NIIT (n=1'447)		
High-Risk	1'006	1'692	*** 2	287	577		2	306	644	2
Age (mean)	68.1 (12.8)	67.6 (10.9)	** 1	66.4 (12.5)	66.9 (10.6)		1	66.6 (13.1)	66.6 (11.4)	1
Sex (fem)	738	1'351	2	213	483		2	254	547	2
Deductible			3				3			3
300	1'262	2'355		357	743			442	962	
500	394	749		134	310			116	290	
1000	45	71		26	65			28	48	
1500	59	127		24	51			23	55	
2000	5	14		2	14			3	16	
2500	53	124		31	59			40	76	

Private	493	925	2	120	288	2	142	316	2
Latin	541	1'066	2	195	466	2	55	116	2
Inpatient	1'166	1'765	*** 2	357	584	***	441	798	***
ATC 1	704	1'738	*** 2	219	648	*** 2	241	732	*** 2
2	576	1'216	** 2	175	465	** 2	195	512	* 2
3	1'114	2'192	2	316	755	** 2	365	931	*** 2
4	277	510	2	72	152	2	80	185	2
5	281	544	2	89	162	2	79	178	2
6	1'038	2'429	*** 2	319	840	*** 2	348	985	*** 2
PCG			** 3			3			3
<3	412	768		175	372		203	444	
3-4	624	1342		200	474		221	557	
5-6	478	893		145	295		150	304	
>6	304	437		54	101		78	142	

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5 232 *NIIT: Non-invasive ischemia testing. GK: Gate keeping, MC: Managed care: Deductible class in Swiss Francs. Private: supplementary*
6
7 233 *private hospital insurance, Latin: French or Italian part of Switzerland compared to German part. CA: coronary angiography, ATC:*
8
9 234 *Anatomical-Therapeutic-Chemical-Classification group 1 = Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3*
10
11 235 *= antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system, 4 =*
12
13 236 *antidiabetics, 5 = antianginous drugs, 6: antithrombotics (Categorical variable, an individual can be positive for several ATC groups).*
14
15
16 237 *PCG: number of chronic conditions according to pharmaceutical cost groups. High-risk patients: having received therapeutic cardiac*
17
18 238 *intervention within one month after or 18 months prior to diagnostic CA. Significance no NIIT vs with NIIT within non-limited access*
19
20 239 *and limited access group: *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.01$. ¹) Kruskal-Wallis test, ²) Fisher exact test, ³) Chi-Square test, pairwise*
21
22 240 *comparisons between NIIT and no NIIT for each health insurance model separately.*
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3 241 Patients insured in basic health care models were slightly older (67.7 (11.6) vs. 66.6
4
5 242 (11.6) years, $p<0.0001$), chose the lowest possible deductible of 300 Francs more
6
7 243 often (3'617 (68.8%) vs. 2'504 (64.0%), $p<0.001$), were enrolled in a supplementary
8
9 244 private hospital insurance more often (1'418 (27.0%) vs. 866 (22.1%), $p<0.0001$), had
10
11 245 more antidiabetics (787 (15%) vs 489 (12.5%), $p<0.0001$) and antianginal medication
12
13 246 (825 (15.7%) vs 508 (13.0%), $p<0.0001$), more PCGs (4.1 (2.1) vs. 3.6 (2.0),
14
15 247 $p<0.0001$) and had more often a high-risk status (2'696 (51.3%) vs. 1'814 (46.3%),
16
17 248 $p<0.0001$), compared to patients insured in limited access models (Appendix 2).
18
19 249 Concerning the other patient characteristics, no differences existed.
20
21
22
23

250

251 Non-invasive ischemia testing

252 488 (33.8 %) of patients without NIIT had a conventional ECG prior to CA, in the
253 high-risk population this was the case in 722 (45.2%) ($p<0.0001$, data not shown).
254 The most NIITs stress-ECG + transthoracic echocardiography were performed
255 significantly more often before CA in patients insured in limited access compared to
256 non-limited access models (1'750 (44.7%) vs. 2'039 (38.8 %) $p<0.0001$, and 2'044
257 (52.2%) and 2'528 (48.1%), $p<0.0001$, data not shown). The remaining types of NIIT
258 were rarely performed and only showed a significant difference in the use of
259 scintigraphy (non-limited 131 (2.5%) vs. limited access models 64 (1.6%), $p<0.001$,
260 data not shown). The distribution of the non-invasive ischemia testing are depicted in
261 Appendix 3.
262

263

263 Determinants for non-invasive ischemia testing

264 Patients with MC models were 17% significantly more likely to receive NIIT before CA
265 compared to patients with non-limited models, when controlled for the confounders
266 age, sex, language area, insurance coverage, inpatient treatment, cardiovascular

267 medication, number of chronic comorbidities and high-risk status (OR 1.17, $p < 0.001$).
 268 GK models did not show any significant influence on the chance of receiving NIIT
 269 (OR 1.11, $p = 0.071$). The distribution of NIIT performed according to health care
 270 model can be appreciated in Figure 1.

271

272 Figure 1: Distribution of NIIT performed according to health care model.

273 *OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders*
 274 *age, sex, language area, insurance coverage, inpatient treatment, cardiovascular*
 275 *medication, number of chronic comorbidities and high-risk status. * $p < 0.001$ (OR*
 276 *1.17) for managed care model compared to non-limited access model (Reference).*

277

278 Following determinants were also independently significantly associated with
 279 receiving NIIT: the use of platelet aggregation inhibitors, antithrombotic and
 280 antihypertensive medication, being supplementary privately insured and a deductible
 281 of 2000 SFR. Following determinants were significantly associated with not receiving
 282 NIIT: high-risk status, a high number of chronic comorbidities as well as inpatient
 283 treatment (Table 2).

284

285 Table 2: Determinants for receiving non-invasive ischemia testing before coronary
 286 angiography

	CI	OR	Sig
288 Age (years)	0.998 - 1.007	1.003	
289 Sex (female)	0.967 - 1.166	1.062	
290 Deductible Class (Swiss Francs, Reference 300)			
291 500	0.912 - 1.141	1.020	
292 1000	0.667 - 1.120	0.865	

1					
2					
3	293	1500	0.841 - 1.374	1.075	
4					
5	294	2000	1.082 - 4.381	2.177	*
6					
7	295	2500	0.809 - 1.289	1.022	
8					
9	296	Private	1.025 - 1.267	1.140	*
10					
11	297	French or Italian part of Switzerland	0.841 - 1.044	0.937	
12					
13	298	Inpatient CA	0.540 - 0.664	0.599	***
14					
15	299	ATC group 1-6			
16					
17					
18	300	1	1.251 - 1.620	1.423	***
19					
20	301	2	0.922 - 1.135	1.023	
21					
22	302	3	1.002 - 1.218	1.104	*
23					
24	303	4	0.851 - 1.115	0.974	
25					
26	304	5	0.874 - 1.130	0.994	
27					
28	305	6	1.034 - 1.356	1.184	*
29					
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31	306	PCG (reference <3)			
32					
33	307	<5	0.940 - 1.192	1.058	
34					
35	308	<7	0.809 - 1.064	0.928	
36					
37	309	>=7	0.624 - 0.881	0.742	***
38					
39	310	Limited access models (reference non-limited access)			
40					
41	311	Managed Care	1.045 - 1.312	1.171	**
42					
43	312	Gate Keeping	0.991 - 1.253	1.114	
44					
45					
46	313	High-risk cardiac status	0.046443	0.836	***
47					
48	314	<i>CI: confidence interval, OR: odds ratio, Sig: significance: *** p<0.0001, ** p<0.001</i>			
49					
50	315	<i>*p<0.01, Private: supplementary private hospital insurance, CA: coronary</i>			
51					
52	316	<i>angiography, ATC: Anatomical-Therapeutic-Chemical-Classification group 1 =</i>			
53					
54	317	<i>Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3 =</i>			
55					
56	318	<i>antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents</i>			
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3 319 *acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6:*
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5 320 *antithrombotics (Categorical variable, an individual can be positive for several ATC*
6
7 321 *groups). PCG: number of chronic conditions according to pharmaceutical cost*
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9 322 *groups. High-risk patients: having received therapeutic cardiac intervention within*
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11 323 *one month after or 18 months prior to diagnostic CA.*

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15 325 **Discussion**

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18 326 In our study population of elective CA with no therapeutic consequence (no coronary
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20 327 angioplasty/stenting or coronary artery bypass grafting) one third did not receive NIIT
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22 328 before diagnostic CA. MC was independently significantly associated with a higher
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24 329 proportion of NIIT when additionally controlled for potential confounders. GK models
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26 330 showed no significant association with the rate of NIIT.

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30 332 Effects of limited access health care models on treatment quality

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33 333 In our study, emergency CA were excluded and the study population consisted of
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35 334 patients undergoing purely diagnostic elective CA with no therapeutic consequence
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37 335 (e.g. no coronary angioplasty/stenting or coronary artery by-pass grafting). The study
38
39 336 population therefore represents a selection of patients with at least stable CHD or no
40
41 337 CHD at all. From a previous study among this selection of patients we know, that
42
43 338 37.5% did not receive any NIIT at all before elective CA with no therapeutic
44
45 339 consequence, suggesting a substantial overuse of a potentially harmful and
46
47 340 inappropriate diagnostic intervention¹². It has been assumed that patients insured in
48
49 341 limited access health care models undergo less diagnostic procedures or
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51 342 interventions due to budget considerations, especially in capitated health care
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53 343 models. In our study, this hypothesis is clearly refuted. Patients with stable angina
54
55 344 pectoris insured in limited access health care models underwent a more appropriate

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3 345 diagnostic pathway than regularly insured patients did, meaning in a stable clinical
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5 346 situation they were subjected to significantly more non-invasive diagnostic testing,
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7 347 therefore reducing inadequate CA. Our findings are in line with another study from
8
9 348 the Swiss health care system, which also showed higher referral rates among MC
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11 349 patients compared to patients insured in basic health care models²³. One reason for
12
13 350 the more appropriate diagnostic pathway found in MC patients might be the aspect of
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15 351 membership in a general practitioners network. In most parts of Switzerland, general
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17 352 practitioners can only offer MC insurance models to their patients, if they are member
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19 353 in a general practitioners network. These networks offer evidence-based guidelines,
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21 354 which the general practitioners are obliged to respect when initiating treatment.
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23 355 Depending on the network, more or less rigorous quality control mechanisms exist to
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25 356 check whether the guidelines are followed, when applicable. General practitioners,
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27 357 which are not member in a network, therefore are less bound to evidence based
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29 358 treatment pathways.. Other studies showed that being insured in MC models is
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31 359 associated with a survival benefit by promoting better preventive and higher quality of
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33 360 care²⁴⁻²⁶. Especially among Medicare beneficiaries, which are prone to
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35 361 multimorbidity, this effect has been shown²⁷. These models have also shown lower
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37 362 prevalence of potentially inappropriate medication use in elderly patients and a lower
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39 363 disease specific hospitalization rate in chronically ill patients^{16 17}.
40
41 364 Our study raises the question why patients in limited access health care models
42
43 365 receive a more appropriate diagnostic pathway in this clinical situation of stable
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45 366 angina pectoris. There has been evidence for and against the theory that patients
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47 367 enrolled in a MC health care model are healthier due to biased selection²⁸⁻³⁷ and
48
49 368 commercial considerations of the MC insurer^{38 39}. In our study population, patients
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51 369 insured in limited access models showed some evidence of being healthier than
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53 370 regularly insured patients. Nevertheless being insured only in MC but not GK models
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3 371 was *independently* associated with a higher rate of NIIT, controlled for all the
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5 372 differences in patient characteristics. It is clear that physicians participating in MC
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7 373 models are obliged to keep diagnostic and treatment costs as low as possible while
8
9 374 keeping up with quality concerns. One could therefore argue that it is cheaper to not
10
11 375 to choose a diagnostic detour over NIIT instead of choosing the straight forward way
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13 376 of sending a patient to the more invasive CA, which offers a clear answer to an
14
15 377 uncertain clinical situation including the option of therapeutic action. It seems that MC
16
17 378 health care providers have understood what Meara et al. have summed up
18
19 379 accurately: "Reductions in spending for patients must be a result of decreases in the
20
21 380 provision of services. If these are needed services, quality of care will decline.
22
23 381 Alternatively, quality of care might be higher in low expenditure areas if differences in
24
25 382 spending result from reductions in unnecessary or inappropriate services⁴⁰". Besides
26
27 383 this intuitive statement there has been scientific evidence that a diagnostic detour is
28
29 384 worthwhile taking, since it sums up in reduced peri and post interventional costs
30
31 385 without loss in quality¹¹. Our study is not able to answer the questions why patients
32
33 386 in limited access models received a more appropriate diagnostic approach. One can
34
35 387 only hypothesize that a more rigorous coordination of care, as performed in the MC
36
37 388 models, is straighter forward and the indication for invasive and expensive diagnostic
38
39 389 procedures is more thoroughly scrutinized.
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46 Determinants for NIIT

47
48 392 Even though simple echocardiography with no stress testing does not actually qualify
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50 393 as a NIIT, we chose to include this diagnostic procedure due to following
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52 394 considerations: some cardiologists might argue that patients with dyskinesia in simple
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54 395 echocardiography are likely to have relevant coronary pathology therefore offering an
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56 396 argument for CA besides the clinical evaluation. Our theory is supported by the "2014
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3 397 ESC/EACTS Guidelines on Myocardial Revascularization which state: “regional wall
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5 398 motion abnormalities may be detected in simple echocardiography, which increase
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7 399 the likelihood of coronary artery disease”.

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9 400 Since our study lacks clinical data, only indirect hints by means of PCG and ATC
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11 401 codes as well as other confounders are available to assess clinical reasoning. The
12
13 402 association between the use of platelet aggregation inhibitors or antithrombotic
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15 403 agents and antihypertensive medication with receiving NIIT before CA suggest a
16
17 404 reasonable deliberation in the sense of estimating pretest probability when deciding
18
19 405 on optimal diagnostic strategy. The same counts for the association of high-risk
20
21 406 status and a larger number of chronic comorbidities as determinants for not receiving
22
23 407 NIIT prior to elective CA. This finding is consistent with two US studies indicating that
24
25 408 risk stratification was performed, considering the higher likelihood of a coronary
26
27 409 pathology in patients with known coronary heart disease^{8 10}. In our study, also non-
28
29 410 clinical factors seem to influence decision-making processes concerning diagnostic
30
31 411 pathways, reflected by the findings that being privately insured and a deductible of
32
33 412 2000 SFR were positively and inpatient treatment negatively independently
34
35 413 associated with NIIT.

36
37 414 As previously observed in another Swiss study analyzing inappropriate use of
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39 415 arthroscopic meniscal surgery in degenerative knee disease⁴¹, a substantial amount
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41 416 of the patients in our sample underwent CA as inpatients in contrast to other health
42
43 417 care settings. This finding is most likely explained by differences in the organization
44
45 418 of the health care system in Switzerland. Here regional governments subsidize
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47 419 inpatient treatment covering approximately 50% of total costs, and patients with
48
49 420 supplementary private insurance receive a substantially higher reimbursement when
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51 421 treated as inpatients. Nevertheless, in the regression analysis with the outcome
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53 422 proportion of NIIT, we controlled for potential confounders, such as inpatient
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3 423 treatment as well. The results therefore seem robust concerning the question
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5 424 whether limited access health care models have a significant impact on the
6
7 425 appropriateness of the diagnostic approach.
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11 427 Reinforcing quality control mechanisms in a non-gate keeping health care system

13 428 Besides the existing voluntary steering mechanisms such limited access health care
14
15 429 models guided by patient's preferences only, more alternative steering mechanisms
16
17 430 have to be implemented in non-gate keeping health care systems, in order to
18
19 431 minimize the influence of non-clinical factors on medical decision making, which
20
21 432 might lead to inappropriate and possibly dangerous health care utilization as well as
22
23 433 increasing expenditures. A positive example for alternative steering mechanisms is
24
25 434 the implementation of national registries⁴² combined with quality initiatives, such as
26
27 435 the in 2009 published Appropriate Use Criteria for Coronary Revascularization^{9 42 43}.
28
29 436 In 2011, the registry started giving feedbacks on the participating hospital's
30
31 437 performance concerning appropriateness of CA including a benchmarking against
32
33 438 other participating institutions. At the same time the American Board of Internal
34
35 439 Medicine's Choosing Wisely initiative launched national quality improvement
36
37 440 campaigns, identifying CA appropriateness as a key area for intervention⁴⁴. As a
38
39 441 consequence insurance companies incorporated measures of CA appropriateness
40
41 442 into pay-for-performance programs⁴⁵ and reimbursement was declined for certain
42
43 443 CA identified as inappropriate⁴⁶. The combination of implementing national registries
44
45 444 combined with quality initiatives had been proven amazingly effective, showing a
46
47 445 decrease of non-acute CA classified as inappropriate from 26.2% to 13.3%⁴⁷. In
48
49 446 Switzerland currently no registries on CA exist, hence other solutions for influencing
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51 447 treatment pathways have to be developed, besides offering voluntary limited access
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53 448 health care models. A possible alternative solution to the conundrum of reducing
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3 449 costs without cutting quality seems hence to be paying for outcomes instead of
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5 450 volume. As the findings of our study suggest, a possible approach is to raise the
6
7 451 market share of MC to such a volume that it might also affect care for fee-for-service
8
9 452 patients⁴⁰. As Meara et al have summarized, the effects have been show to play in a
10
11 453 variety of ways: more MC in a market might lower expenditures by reducing the
12
13 454 number of specialists, and thereby the number of specialists' services provided^{48 49}
14
15 455 by encouraging more conservative practice patterns^{48 49}, or by slowing the diffusion
16
17 456 of more costly technologies^{48 50}.

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19
20 45721 458 Strengths and limitations

22
23 459 Only scarce data on non-emergency CA exists in literature. The only data found
24
25 460 originates from the US among Medicare as well as commercially insured patients and
26
27 461 from Switzerland, both non-gate keeping health care systems. Whether the
28
29 462 proportion of inappropriate diagnostic CA from our study can be translated to other
30
31 463 non-gate keeping health care systems is difficult to estimate, since substantial
32
33 464 variation in the proportion of non-acute PCIs considered inappropriate across
34
35 465 hospitals can be found, ranging from about 6% to 70%^{8 10 14 15 47}. From a previous
36
37 466 study from Switzerland¹² similar proportions were found, suggesting generalizability
38
39 467 of our data. The current study seems even more representative than the previous
40
41 468 Swiss study, since it included data over a longer time-period with consecutively larger
42
43 469 amount of patients and corresponding data. Nevertheless, caution should be used
44
45 470 when generalizing to larger populations due to the data being limited to only one,
46
47 471 even if the largest health insurance company in Switzerland, due to exclusion criteria
48
49 472 and the retrospective study design. Since the study is based on insurance claims
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51 473 data, no data on socioeconomic status and clinical information is available. Given
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53 474 that this is a cross-sectional observational study, rather than an interventional one,
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3 475 the only conclusions that we can draw are of association rather than causation. Due
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5 476 to the study design, unfortunately no estimations on clinical outcome parameters can
6
7 477 be made. For example, in order to explore clinical appropriateness, the proportion of
8
9 478 CA's avoided by performing NIIT would be of great interest. As a substitute for clinical
10
11 479 data, ATC and PCG are used, offering only indirect information on comorbidities. On
12
13 480 the other hand PCGs represent a strength, since they have been shown to directly
14
15 481 correlate with associated health care costs¹⁹. Due to data structure, it is not possible
16
17 482 to distinguish between CT angiography (including intravenous contrast) and CT
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19 483 without intravenous contrast. Therefore, all CTs of the chest were included in
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21 484 analysis.
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29 487 **Conclusions**

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31 488 In a non-gate keeping health care system voluntary MC health care models with
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33 489 capitation were associated with a reduced inappropriate use of diagnostic CA
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35 490 compared to basic models.
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643

644 **Competing interests**

645 Oliver Reich and Andri Signorell are employed by the Helsana Group. The sponsor
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650

651 **Authors Contributions**

652 Conceived and designed the experiments: CC, OR, AS, SNJ, TR, OS. Performed the
653 experiments: CC, OR, AS. Analyzed the data: CC, OR, AS, SNJ, TR, OS. Wrote the
654 paper: CC, edited and approved the paper: CC, OR, AS, SNJ, TR, OS.

655

656 **Consent for publication**

657 Since data were completely anonymized, no patient consent was necessary.

658

659 **Availability of data and materials**

660 Individual data cannot be made fully available on the internet because the study is
661 based on claims data of the Helsana Group, the owner of the data. Thus, data
662 underlie data protection and privacy restrictions. These restrictions prohibit the
663 insurer from sharing the collected data. Data analysis was performed within the

1
2
3 664 premises of the Helsana research group by the statistician AS in collaboration with
4
5 665 the authors OR and CC and administrative permission was received to access de-
6
7 666 identified data by the researchers from the University of Zurich.
8

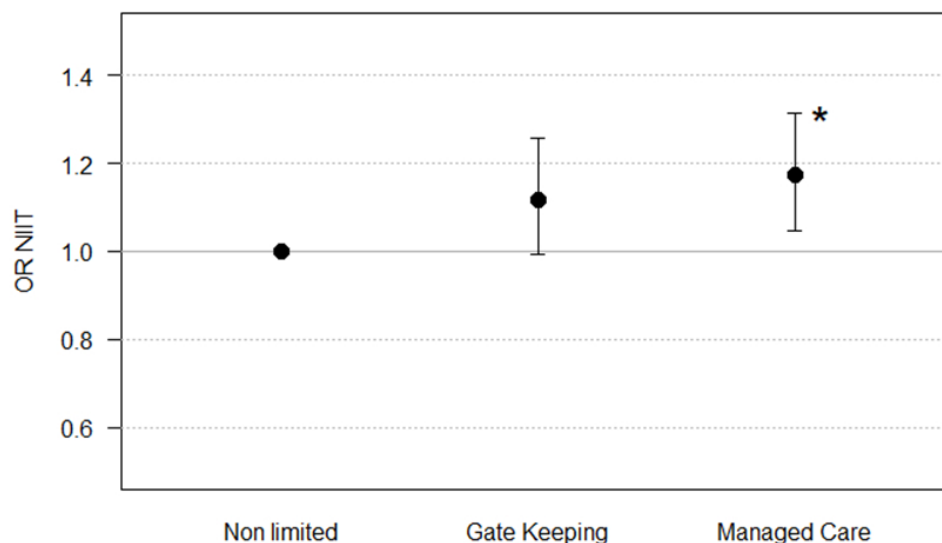
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13 669 **Figure Legend**

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15
16 670 Figure 1: Distribution of NIIT performed according to health care model.

17
18 671 *OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders*
19
20 672 *age, sex, language area, insurance coverage, inpatient treatment, cardiovascular*
21
22 673 *medication, number of chronic comorbidities and high-risk status. * $p < 0.001$ (OR*
23
24 674 *1.17) for managed care model compared to non-limited access model (Reference).*
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OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high- risk status. * $p < 0.001$ (OR 1.17) for managed care model compared to standard health care plannon-limited access model (Reference).

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3 **1 Supplemental Material**

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5 **2 Supplemental Methods/Definitions**

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10 **4 1) Inclusion Criteria**

11
12 **5 Tarmed 17.071**

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15 **6 17.074**

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17 **7 17.101**

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19 **8 17.109**

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21 **9 17.181**

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24 **10 17.182**

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26 **11 DRG F49D**

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28 **12 F49E**

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31 **13 F49F**

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33 **14 If two coronary angiographies (CA) were performed on the same day at the same**
34
35 **15 provider, the intervention is counted once.**

36
37 **16 If the CA was performed twice at the same day but different providers the CA counts**
38
39 **17 twice (both concerning the inpatients positions (Diagnosis related Groups (DRG)) and**
40
41 **18 the outpatient positions (Standard billing rate for outpatient medical care in**
42
43 **19 Switzerland (TARMED))**

44
45
46 **20 If during 2012-2015 patients received more than one CA, only the first CA was taken**
47
48 **21 into consideration.**

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2
3 1 2) Exclusion Criteria
4

5	2	Acute cardiac ischemia and/or emergency procedures	Tarmed	0.2510
6				
7	3			0.2520
8				
9	4			0.2540
10				
11	5			0.2560
12				
13	6			0.2580
14				
15	7			35.0610
16				
17	8		DRG	F41A
18				
19	9			F41B
20				
21	10			
22				
23	11	Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting,		
24				
25	12	without myocardial infarction)	Tarmed	17.1110
26				
27	13			17.1240
28				
29	14		DRG	F15Z
30				
31	15			F19Z
32				
33	16			F24B
34				
35	17			F49A
36				
37	18			F49C
38				
39	19			F52A
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41	20			F52B
42				
43	21			F54Z
44				
45	22			F56A
46				
47	23			F56B
48				
49	24			F57A
50				
51	25			F57B
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53	26			F58Z
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3	1	F59A
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5	2	F59B
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8	3	Incomplete coverage of mandatory basic health insurance 18 months before and/or 1
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10	4	month after CA
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12	5	Patients <18 years
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14	6	
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17	7	
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19	8	<u>3) Diagnostic Procedures</u>
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21	9	Tarmed 17.0010: Electrocardiogram (ECG): not considered as NIIT, only in
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23		
24	10	combination with other NIIT
25		
26	11	17.0050: Cardiac intervention with medication under continuous
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28	12	registration of ECG: not considered as NIIT, only in combination with
29		
30	13	another NIIT
31		
32		
33	14	17.0060: ECG performed by specialist outside of the practice or
34		
35	15	hospital: not considered as NIIT, only in combination with another NIIT
36		
37		
38	16	17.0080 and 17.0090: Stress-ECG
39		
40	17	17.0210: Echocardiography, transthoracic, qualitative and quantitative
41		
42	18	examination of adult
43		
44	19	17.0280: Stressechocardiography, physical stress
45		
46		
47	20	17.0290: Stressechocardiography, medication stress
48		
49	21	31.0260: Scintigraphy physiologically triggered
50		
51	22	39.4060: Computed tomography of entire thorax and/or sternoclavicular
52		
53		
54	23	joint
55		
56	24	39.5100 Heart MRI
57		
58	25	DRG No separate codes available for inpatient diagnostic procedures, only
59		
60	26	for therapeutic interventions

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3 1 4) High risk patients
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5 2 Patients having received therapeutic cardiac intervention within one month after or 18
6
7 3 months prior to diagnostic CA
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10 4 Tarmed 0.2510
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12 5 0.2520
13

14 6 0.2540
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16 7 0.2560
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18 8 0.2580
19

20 9 35.0610
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22 10 17.1110
23

24 11 17.1240
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26 12 And all 18.001 until/including 18.0740
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Appendix 2

Descriptive Differences in the study population non-limited vs. limited access modes

	Total	Non-limited access	Limited access	
n	9'173	5'258 (57.3%)	3'915 (42.7%)	
Sex (fem)	3'586 (39.1%)	2'089 (39.7%)	1'497 (38.2%)	²
Age (mean)	67.3 (11.610)	67.7 (11.582)	66.6 (11.620)	*** ¹
Deductible				*** ³
300	6'121 (66.7%)	3'617 (68.8%)	2'504 (64.0%)	
500	1'993 (21.7%)	1'143 (21.7%)	850 (21.7%)	
1000	283 (3.1%)	116 (2.2%)	167 (4.3%)	
1500	339 (3.7%)	186 (3.5%)	153 (3.9%)	
2000	54 (0.6%)	19 (0.4%)	35 (0.9%)	
2500	383 (4.2%)	177 (3.4%)	206 (5.3%)	
Private Canton	2'284 (24.9%)	1'418 (27.0%)	866 (22.1%)	*** ² *** ³
AG	717 (7.8%)	377 (7.2%)	340 (8.7%)	
AI	13 (0.1%)	8 (0.2%)	5 (0.1%)	
AR	46 (0.5%)	26 (0.5%)	20 (0.5%)	
BE	1'489 (16.2%)	664 (12.6%)	825 (21.1%)	
BL	200 (2.2%)	129 (2.5%)	71 (1.8%)	
BS	72 (0.8%)	53 (1.0%)	19 (0.5%)	
FR	259 (2.8%)	196 (3.7%)	63 (1.6%)	
GE	427 (4.7%)	285 (5.4%)	142 (3.6%)	
GL	54 (0.6%)	29 (0.6%)	25 (0.6%)	
GR	152 (1.7%)	86 (1.6%)	66 (1.7%)	
JU	21 (0.2%)	13 (0.2%)	8 (0.2%)	
LU	304 (3.3%)	156 (3.0%)	148 (3.8%)	
NE	98 (1.1%)	69 (1.3%)	29 (0.7%)	
NW	37 (0.4%)	25 (0.5%)	12 (0.3%)	
OW	34 (0.4%)	17 (0.3%)	17 (0.4%)	
SG	343 (3.7%)	168 (3.2%)	175 (4.5%)	
SH	126 (1.4%)	67 (1.3%)	59 (1.5%)	
SO	473 (5.2%)	220 (4.2%)	253 (6.5%)	
SZ	194 (2.1%)	124 (2.4%)	70 (1.8%)	
TG	347 (3.8%)	152 (2.9%)	195 (5.0%)	
TI	721 (7.9%)	429 (8.2%)	292 (7.5%)	
UR	48 (0.5%)	22 (0.4%)	26 (0.7%)	
VD	598 (6.5%)	412 (7.8%)	186 (4.8%)	
VS	315 (3.4%)	203 (3.9%)	112 (2.9%)	
ZG	138 (1.5%)	84 (1.6%)	54 (1.4%)	
ZH	1'947 (21.2%)	1'244 (23.7%)	703 (18.0%)	
atc_1	4'282 (46.7%)	2'442 (46.4%)	1'840 (47.0%)	²
atc_2	3'139 (34.2%)	1'792 (34.1%)	1'347 (34.4%)	²
atc_3	5'693 (62.1%)	3'306 (62.9%)	2'387 (61.0%)	²
atc_4	1'276 (13.9%)	787 (15.0%)	489 (12.5%)	*** ²
atc_5	1'333 (14.5%)	825 (15.7%)	508 (13.0%)	*** ²
NIIT				
ekg	4'914 (53.6%)	2'822 (53.7%)	2'092 (53.4%)	²
kmedint	8 (0.1%)	4 (0.1%)	4 (0.1%)	²
ekgext	23 (0.3%)	15 (0.3%)	8 (0.2%)	²
bekgarb	8 (0.1%)	3 (0.1%)	5 (0.1%)	²
bekgergo	3'789 (41.3%)	2'039 (38.8%)	1'750 (44.7%)	*** ²
echokard	4'572 (49.8%)	2'528 (48.1%)	2'044 (52.2%)	*** ²
echophys	137 (1.5%)	81 (1.5%)	56 (1.4%)	²
echomed	131 (1.4%)	69 (1.3%)	62 (1.6%)	²
szin	195 (2.1%)	131 (2.5%)	64 (1.6%)	** ²
Ct	643 (7.0%)	387 (7.4%)	256 (6.5%)	²
mri	283 (3.1%)	173 (3.3%)	110 (2.8%)	²

	pcg_n	3.883 (2.029)	4.060 (2.058)	3.644 (1.965)	*** 1
	pcg				*** 3
	<3	2'545 (27.7%)	1'277 (24.3%)	1'268 (32.4%)	
	3-4	3'430 (37.4%)	1'967 (37.4%)	1'463 (37.4%)	
	5-6	2'179 (23.8%)	1'339 (25.5%)	840 (21.5%)	
	>6	1'019 (11.1%)	675 (12.8%)	344 (8.8%)	
	Highrisk	4'510 (49.2%)	2'696 (51.3%)	1'814 (46.3%)	*** 2
	Inpatient	5'111 (55.7%)	2'931 (55.7%)	2'180 (55.7%)	2
	CA				
	17.0710	12 (0.1%)	7 (0.1%)	5 (0.1%)	
	17.0710,17.0740	6 (0.1%)	6 (0.1%)	0 (0.0%)	
	17.0710,17.0740,17.1010	218 (2.4%)	136 (2.6%)	82 (2.1%)	
	17.0710,17.0740,17.1010,17.1810	2 (0.0%)	1 (0.0%)	1 (0.0%)	
	17.0710,17.0740,17.1010,17.1810,F49D	2'960 (32.3%)	1'663 (31.6%)	1'297 (33.1%)	
	17.0710,17.0740,17.1010,17.1810,F49E	0 (0.0%)	0 (0.0%)	0 (0.0%)	
	17.0710,17.0740,17.1010,17.1810,F49F	2 (0.0%)	1 (0.0%)	1 (0.0%)	
	17.0710,17.0740,17.1010,17.1810,F49F	2 (0.0%)	0 (0.0%)	2 (0.1%)	
	17.0710,17.0740,17.1010,17.1820	1 (0.0%)	0 (0.0%)	1 (0.0%)	
	17.0710,17.0740,17.1090	78 (0.9%)	44 (0.8%)	34 (0.9%)	
	17.0710,17.0740,17.1090,17.1810	363 (4.0%)	219 (4.2%)	144 (3.7%)	
	17.0710,17.0740,17.1810	25 (0.3%)	17 (0.3%)	8 (0.2%)	
	17.0710,17.1010	1 (0.0%)	0 (0.0%)	1 (0.0%)	
	17.0710,17.1010,17.1810	39 (0.4%)	23 (0.4%)	16 (0.4%)	
	17.0710,17.1010,17.1810,F49F	3 (0.0%)	2 (0.0%)	1 (0.0%)	
	17.0710,17.1090	1 (0.0%)	1 (0.0%)	0 (0.0%)	
	17.0710,17.1090,17.1810	14 (0.2%)	5 (0.1%)	9 (0.2%)	
	17.0710,17.1810	232 (2.5%)	133 (2.5%)	99 (2.5%)	
	17.0740	7 (0.1%)	5 (0.1%)	2 (0.1%)	
	17.0740,17.1010	4 (0.0%)	3 (0.1%)	1 (0.0%)	
	17.0740,17.1010,17.1810	9 (0.1%)	6 (0.1%)	3 (0.1%)	
	17.0740,17.1090,17.1810	3 (0.0%)	3 (0.1%)	0 (0.0%)	
	17.0740,17.1810	1 (0.0%)	1 (0.0%)	0 (0.0%)	
	17.1010,17.1810	3 (0.0%)	3 (0.1%)	0 (0.0%)	
	17.1810	83 (0.9%)	51 (1.0%)	32 (0.8%)	
	F49D	475 (5.2%)	281 (5.3%)	194 (5.0%)	
	F49E	711 (7.8%)	373 (7.1%)	338 (8.6%)	
	F49E,F49F	0 (0.0%)	0 (0.0%)	0 (0.0%)	
	F49F	3'918 (42.7%)	2'274 (43.2%)	1'644 (42.0%)	

Deductible class in Swiss Francs. Private: supplementary private hospital insurance, ATC: Anatomical-Therapeutic-Chemical-Classification group 1 = Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3 = antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6: antithrombotics. NIIT: Non-invasive ischemia testing, PCG: number of chronic conditions according to pharmaceutical cost groups. High-risk patients: having received therapeutic cardiac intervention within one month after or 18 months prior to diagnostic CA: coronary angiography. Significance non-limited vs limited access group: *** p<0.0001, ** p<0.001, *p<0.01. 1) Kruskal-Wallis test, 2) Fisher exact test, 3) Chi-Square test

Detailed Tarmed positions can also be appreciated in Appendix 1.

NIIT:

ekg	17.0010 Electrocardiogram (ECG)
kmedint	17.0050 Cardiac intervention with medication under continuous registration of ECG
ekgext	17.0060 ECG performed by specialist outside of the practice or hospital
bekgarb	17.0080 Stress-ECG
bekgergo	17.0090 Stress-ECG
echokard	17.0210 Echocardiography, transthoracic, qualitative and quantitative
echophys	17.0280 Stressechocardiography, physical stress
echomed	17.0290 Stressechocardiography, medication stress
szin	31.0260 Scintigraphy physiologically triggered
ct	39.4060 Computed tomography of entire thorax and/or sternoclavicular joint
mri	39.5100 Heart MRI

Appendix 3 a) and b)

a) Overall distribution of the non-invasive ischemia testing

level	freq	perc	cumfreq	cumperc
	3'044	33.2%	3'044	33.2%
bekgergo, echokard	2'360	25.7%	5'404	58.9%
echokard	1'494	16.3%	6'898	75.2%
bekgergo	952	10.4%	7'850	85.6%
ct	204	2.2%	8'054	87.8%
bekgergo, echokard, ct	165	1.8%	8'219	89.6%
echokard, ct	153	1.7%	8'372	91.3%
mri	120	1.3%	8'492	92.6%
echokard, echophys	70	0.8%	8'562	93.3%
echokard, mri	64	0.7%	8'626	94.0%
bekgergo, chokard, mri	62	0.7%	8'688	94.7%
bekgergo, ct	50	0.5%	8'738	95.3%
echokard, echomed	44	0.5%	8'782	95.7%
bekgergo, szin	43	0.5%	8'825	96.2%
bekgergo,echokard, szin	42	0.5%	8'867	96.7%
echophys	40	0.4%	8'907	97.1%
szin	39	0.4%	8'946	97.5%
echomed	37	0.4%	8'983	97.9%
bekgergo, echokard, echomed	35	0.4%	9'018	98.3%
echokard, szin	25	0.3%	9'043	98.6%
bekgergo, mri	23	0.3%	9'066	98.8%
bekgergo, echokard, szin, ct	15	0.2%	9'081	99.0%
echokard, szin, ct	14	0.2%	9'095	99.1%
bekgergo, echokard, echophys	11	0.1%	9'106	99.3%
bekgergo, szin, ct	10	0.1%	9'116	99.4%
bekgergo, echomed	7	0.1%	9'123	99.5%
bekgergo, echophys	7	0.1%	9'130	99.5%
ct, mri	6	0.1%	9'136	99.6%
echophys, ct	5	0.1%	9'141	99.7%
szin, ct	5	0.1%	9'146	99.7%
bekgarb, echokard	4	0.0%	9'150	99.7%
echomed, ct	4	0.0%	9'154	99.8%
echokard, ct, mri	3	0.0%	9'157	99.8%
echokard, echophys, ct	3	0.0%	9'160	99.9%
bekgarb	2	0.0%	9'162	99.9%
bekgergo, echokard, ct, mri	2	0.0%	9'164	99.9%
bekgergo, echokard, echomed, ct	2	0.0%	9'166	99.9%
bekgarb, bekgergo, echokard	1	0.0%	9'167	99.9%
bekgarb, bekgerg	1	0.0%	9'168	99.9%
bekgergo, ct, mri	1	0.0%	9'169	100.0%
echokard, echomed, ct	1	0.0%	9'170	100.0%
echokard, echomed, szin	1	0.0%	9'171	100.0%
echokard, echophys, mri	1	0.0%	9'172	100.0%
szin, mri	1	0.0%	9'173	100.0%

b) Distribution of the non-invasive ischemia testing according to health care model

	freq			p.col		
	MC	GK	Basic	MC	GK	Basic
	652	574	1'818	31.1%	31.6%	34.6%
bekgarb, bekgergo, echokard	1	0	0	0.0%	0.0%	0.0%
bekgarb, bekgergo	0	1	0	0.0%	0.1%	0.0%
bekgarb, echokard	0	1	3	0.0%	0.1%	0.1%
bekgarb	1	1	0	0.0%	0.1%	0.0%
bekgergo	237	181	534	11.3%	10.0%	10.2%
bekgergo, ct	10	12	28	0.5%	0.7%	0.5%
bekgergo, ct, mri	0	0	1	0.0%	0.0%	0.0%
bekgergo, echokard	647	488	1'225	30.8%	26.9%	23.3%
bekgergo, echokard, ct	48	22	95	2.3%	1.2%	1.8%
bekgergo, echokard, ct, mri	0	1	1	0.0%	0.1%	0.0%
bekgergo, echokard, echomed	12	10	13	0.6%	0.6%	0.2%
bekgergo, echokard, echomed, ct	1	1	0	0.0%	0.1%	0.0%
bekgergo, echokard, echophys	3	0	8	0.1%	0.0%	0.2%
bekgergo, echokard, mri	8	15	39	0.4%	0.8%	0.7%
bekgergo, echokard, szin	7	4	31	0.3%	0.2%	0.6%
bekgergo, echokard, szin, ct	3	2	10	0.1%	0.1%	0.2%
bekgergo, echomed	0	3	4	0.0%	0.2%	0.1%
bekgergo, echophys	1	1	5	0.0%	0.1%	0.1%
bekgergo, mri	3	4	16	0.1%	0.2%	0.3%
bekgergo, szin	8	9	26	0.4%	0.5%	0.5%
bekgergo, szin, ct	4	3	3	0.2%	0.2%	0.1%
ct	33	41	130	1.6%	2.3%	2.5%
ct, mri	0	1	5	0.0%	0.1%	0.1%
echokard	298	316	880	14.2%	17.4%	16.7%
echokard, ct	29	31	93	1.4%	1.7%	1.8%
echokard, ct, mri	3	0	0	0.1%	0.0%	0.0%
echokard, echomed	11	9	24	0.5%	0.5%	0.5%
echokard, echomed, ct	0	0	1	0.0%	0.0%	0.0%
echokard, echomed, szin	0	0	1	0.0%	0.0%	0.0%
echokard, echophys	14	15	41	0.7%	0.8%	0.8%
echokard, echophys, ct	1	1	1	0.0%	0.1%	0.0%
echokard, echophys, mri	1	0	0	0.0%	0.0%	0.0%
echokard, mri	12	19	33	0.6%	1.0%	0.6%
echokard, szin	1	4	20	0.0%	0.2%	0.4%
echokard, szin, ct	5	0	9	0.2%	0.0%	0.2%
echomed	9	5	23	0.4%	0.3%	0.4%
echomed, ct	1	0	3	0.0%	0.0%	0.1%
echophys	6	11	23	0.3%	0.6%	0.4%
echophys, ct	2	0	3	0.1%	0.0%	0.1%
mri	22	21	77	1.0%	1.2%	1.5%
szin	4	9	26	0.2%	0.5%	0.5%
szin, ct	1	0	4	0.0%	0.0%	0.1%
szin, mri	0	0	1	0.0%	0.0%	0.0%

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3 MC: Managed Care, GK: Gate Keeping.

4 Detailed Tarmed positions can also be appreciated in Appendix 1:

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NIIT	Tarmed position
ekg	17.0010 Electrocardiogram (ECG)
kmedint	17.0050 Cardiac intervention with medication under continuous registration of ECG
Ekgext	17.0060 ECG performed by specialist outside of the practice or hospital
bekgarb	17.0080 Stress-ECG
bekgergo	17.0090 Stress-ECG
echokard	17.0210 Echocardiography, transthoracic, qualitative and quantitative
echophys	17.0280 Stressechocardiography, physical stress
echomed	17.0290 Stressechocardiography, medication stress
szin	31.0260 Scintigraphy physiologically triggered
ct	39.4060 Computed tomography of entire thorax and/or sternoclavicular joint
mri	39.5100 Heart MRI

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5 **Reporting statement: STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cross-sectional studies**
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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, 2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3, 4
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	2, 4, 5
Methods			
Study design	4	Present key elements of study design early in the paper	5-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-8
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	7, 8
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, 8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7, 8
		(b) Describe any methods used to examine subgroups and interactions	7, 8
		(c) Explain how missing data were addressed	7, 8
		(d) If applicable, describe analytical methods taking account of sampling strategy	6-8
		(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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	9-14 9-14 Not applicable
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	9-14 9-14
Outcome data	15*	Report numbers of outcome events or summary measures	9-14
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	9-14 Not applicable Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
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	23

*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

Effects of managed care on the proportion of inappropriate elective diagnostic coronary angiographies in non-emergency patients in Switzerland, a retrospective cross-sectional analysis

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Primary Subject Heading:	Health services research
Secondary Subject Heading:	Medical management, Cardiovascular medicine, Diagnostics
Keywords:	- Elective coronary angiography, - Managed care, - Inappropriate, - Voluntary health care plans, - Limited access insurance models, - Non-invasive ischemia testing

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Manuscripts

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3 1 **Effects of managed care on the proportion of inappropriate elective diagnostic**
4 **coronary angiographies in non-emergency patients in Switzerland, a**
5 **retrospective cross-sectional analysis**
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48 22 Word count: 3533
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23 **Abstract**

24 Objective

25 Guidelines recommend non-invasive ischemia testing (NIIT) for the majority of
26 patients with suspected ischemic heart disease in a non-emergency setting. A
27 substantial amount of these patients undergoes diagnostic coronary angiography
28 (CA) without therapeutic intervention inappropriately due to lacking preceding NIIT.
29 The aim of this study was to evaluate the effect of voluntary health care models with
30 limited access on the proportion of patients without NIIT prior to elective purely
31 diagnostic CA.

32 Design:

33 Retrospective cross-sectional analysis of insurance claims data from 2012 to 2015.
34 Data included claims of basic and voluntary health care models from approximately
35 1.2 million patients enrolled with the Helsana Insurance Group. Voluntary health care
36 models with limited health access are divided into gate keeping (GK) and managed
37 care (MC) capitation models. Inclusion criteria: patients undergoing CA. Exclusion
38 criteria: Patients <18 years, incomplete health insurance data coverage, acute
39 cardiac ischemia and emergency procedures, therapeutic CA (coronary
40 angioplasty/stenting or coronary artery by-pass grafting). The effect of voluntary
41 health care models on the proportion of NIIT undertaken within two months before
42 diagnostic CA was assessed by means of multiple logistic regression analysis,
43 controlled for influencing factors.

44 Results

45 9173 patients matched inclusion criteria. 33.2% (3044) did not receive NIIT before
46 CA. Compared to basic health care models MC was independently associated with a
47 higher proportion of NIIT ($p < 0.001$, OR 1.17, CI 1.045 - 1.312), when additionally
48 controlled for demographics, insurance coverage, inpatient treatment, cardiovascular

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3 49 medication, chronic comorbidities, high-risk status (patients with therapeutic cardiac
4
5 50 intervention 1 month after or 18 months prior to diagnostic CA). GK models showed
6
7 51 no significant association with the rate of NIIT ($p=0.07$, OR 1.11, CI 0.991 - 1.253).
8

9 52 Conclusions

10
11 53 In a non-gate keeping health care system voluntary MC health care models with
12
13 54 capitation were associated with a reduced inappropriate use of diagnostic CA
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15
16 55 compared to GK or basic models.
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18 56 19 20 57 **Strengths and Limitations**

- 21
22 58 - Highly relevant topic concerning inappropriate use of a potentially harmful and
23
24 59 expensive procedure such as the CA
25
26 60 - Only scarce data on non-emergency CA exists in literature originating from
27
28 61 different health care settings
29
30 62 - Data originates from a single health insurance group in Switzerland, although
31
32 63 one of the largest in the country, including data on health insurance claims
33
34 64 from approximately 1.2 million patients No data on socioeconomic status and
35
36 65 clinical information is available
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42 67 **Key Words**

- 43
44 68 - Elective coronary angiography
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46 69 - Managed care
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48 70 - Gate keeping
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50 71 - Inappropriate
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52 72 - Voluntary health care models
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54 73 - Limited access insurance models
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56 74 - Non-invasive ischemia testing
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75 Introduction

76 Existing guidelines¹⁻⁷ recommend non-invasive ischemia testing (NIIT) for the
77 majority of patients with suspected ischemic heart disease in a non-emergency
78 setting. Nevertheless, a substantial amount of these patients undergo diagnostic
79 coronary angiography (CA) without therapeutic intervention inappropriately, and are
80 therefore exposed to unnecessary risks without any clinical benefit⁸⁻¹⁵. In a non-gate
81 keeping health care system such as Switzerland, hardly any steering mechanisms
82 exist to ensure that potentially harmful and expensive procedures are only performed
83 in case of correct indication. The admitting physician (mainly general practitioner or
84 cardiologist) usually sets the indication for the intervention and the performing
85 invasive centers rarely decline assigned patients due to economic reasons or in order
86 not to disagree with the admitting physician.

87 Besides the basic healthcare models, offering unlimited access to almost all sectors
88 of the health care system including specialist and emergency care, alternative
89 voluntary health care models with various degrees of restriction in exchange to
90 premium reduction can be chosen from. These voluntary health care models can be
91 summarized into two main groups: 1) gate keeping (GK) models with steering
92 mechanisms, such as basic consultation of an insurance hotline for example, and 2)
93 managed care (MC) models with capitation. Previous studies showed a lower
94 prevalence of potentially inappropriate medication use in elderly patients and a lower
95 disease specific hospitalization rate in chronically ill patients enrolled in a MC model
96 compared to non-MC patients^{16 17}. No data on the association between NIIT and
97 various types of health care models in Switzerland exist.

98 The aim of this study was therefore to evaluate the effect of voluntary GK or MC
99 health care models on the proportion of patients without NIIT prior to elective purely
100 diagnostic CA without therapeutic intervention. The study includes a retrospective

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3 101 analysis of insurance claims data on diagnostic procedures undertaken within two
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5 102 months before CA depending on the health care model.
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10 11 12 105 **Materials and Methods**

13 14 106 Setting

15 107 Swiss residents are obliged to enroll in a basic health care model, which covers all
16 108 costs besides deductibles. Depending on the model chosen, annual deductibles for
17 109 adults vary between 300 and 2500 Swiss Francs. A patient copayment of 10% of all
18 110 costs up to a maximum of 700 Swiss Francs per year is payable independent of the
19 111 chosen health care model. Currently residents can chose a basic health care model
20 112 from 53 different insurance companies. In general, in Switzerland no gate-keeping
21 113 system exists, meaning that patients have unlimited access to all healthcare
22 114 providers, unless they are voluntarily insured in a limited access model. Patients
23 115 agree to a restriction of choice or limited access in exchange of lower premiums. In
24 116 such limited access models, the general practitioner or an insurance telephone
25 117 hotline have to be consulted before contacting a specialist or another institution such
26 118 as a hospital. In case of emergency, this regulation is overruled. In Switzerland, the
27 119 currently existing limited access models can be summarized into two types of
28 120 models: 1) GK models with steering mechanisms, such as prior consultation of a
29 121 telemedicine center for example, and 2) MC models with capitation. In the capitation
30 122 system, the health insurance company reimburses the health care providers, usually
31 123 physician networks, with a set amount for each enrolled patient assigned to them per
32 124 period of time, whether or not that person seeks care. The remuneration is based on
33 125 the average expected health care utilization of each individual patient, with greater
34 126 payment for patients with significant medical history or chronic conditions. Compared

127 to other health care systems, the Swiss system is more inpatient treatment oriented
128 due to co-financing of inpatient treatments by governmental institutions

129

130 Subjects, data collection and measurements

131 Data for this study included health insurance claims from approximately 1.2 million
132 patients, which live all over Switzerland and were enrolled with the Helsana Group.

133 Data on patients undergoing CA in the years 2012 to 2015 were retrospectively
134 analyzed. Data was considered for analysis if insurance coverage was complete
135 within 18 months before and/or 1 month after CA. 828 of 12'078 (6.8%) of patients
136 were not considered due to incomplete coverage of health insurance data during the
137 necessary observation period (due to e.g. change of insurance company, military
138 services, death). Hence, data on 11'250 patients remained for analysis before
139 exclusion criteria. Detailed TARMED (Standard billing rate for outpatient medical care
140 in Switzerland, version 2014) and Diagnosis Related Groups (DRG, version 2012)
141 positions are specified in Appendix 1.

142

143 - *Inclusion criteria* Diagnostic CA performed in the years 2012 to 2015. If in this
144 time interval patients received more than one CA, only the first CA was taken
145 into consideration (n=11'250)

146 *Exclusion criteria*

- 147 - Patients <18 years
- 148 - Acute cardiac ischemia and/or emergency procedures
- 149 - Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass
150 grafting)

151 *Measurements*

152 - Patient characteristics: sex, age, language area and type of insurance

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3 153 coverage (deductible class, supplementary private hospital insurance, MC
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5 154 health care model)
6
7 155 - Setting of CA: inpatient or outpatient
8
9 156 - NIIT performed within two months prior to CA (stress-ECG, echocardiography,
10
11 157 stress echocardiography, scintigraphy, computed tomography, cardiac MRI)
12
13 158 - Cardiovascular Medication grouped according to Anatomical-Therapeutic-
14
15 159 Chemical-Classification (ATC)¹⁸
16
17
18 160 ○ Group 1: Aspirin, platelet aggregation inhibitors
19
20 161 ○ Group 2: statins, lipid modifying agents
21
22 162 ○ Group 3: antihypertensives, diuretics, beta blocking agents, calcium
23
24 163 channel blockers, agents acting on the renin-angiotensin system
25
26 164 ○ Group 4: antidiabetics
27
28 165 ○ Group 5: antianginous drugs
29
30 166 ○ Group 6: antithrombotics
31
32
33 167 - Number of chronic conditions according to Pharmaceutical cost groups PCG¹⁹
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35 168 ²⁰
36
37 169 ○ Group 1: pcg_n < 3 0, 1 or 2 PCGs
38
39 170 ○ Group 2: pcg_n < 5 3 to 4 PCGs
40
41 171 ○ Group 3: pcg_n < 7 5 to 6 PCGs
42
43 172 ○ Group 4: pcg_n ≥ 7 7 or more PCGs
44
45

173 *Sensitivity Analysis with high-risk patients*

174 We performed a sensitivity analysis of our data by defining a subgroup of patients as
175 high-risk with supposed cardiac disease, if having received therapeutic cardiac
176 intervention/diagnosis within one month after and/or 18 months prior to diagnostic
177 CA.

178 Patient and public involvement

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3 179 Neither patients nor the public were involved in the study design.

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7 181 Statistical analysis

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9 182 Descriptive statistical techniques (Table 1) were used, to provide a general profile of
10
11 183 the study population and grouped into totally three groups of patients: patients with
12
13 184 non-limited and limited access health care models (GK and MC). The descriptive
14
15 185 statistics were performed pairwise for each health care model separately. These data
16
17 186 were presented as means in the case of continuous variables and as percentages in
18
19 187 case of categorical variables.

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22 188 Differences within the health care models (Appendix 2) with respect to the continuous
23
24 189 variable age were analyzed with a nonparametric analysis of variance Kruskal-Wallis
25
26 190 test. The variables with two levels (sex, high-risk status (patients having received
27
28 191 therapeutic cardiac intervention/diagnosis within one month after and/or 18 months
29
30 192 prior to diagnostic CA), supplementary private hospital insurance coverage, language
31
32 193 area, inpatient CA, cardiac medication class according to ATC) were analyzed with
33
34 194 an exact fisher test. The number of chronic medical conditions identified using PCG
35
36 195 and the deductible class were compared with a chi square test. ,

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38
39 196 We performed a logistic regression analysis to evaluate the independent association
40
41 197 between receiving NIIT within two months prior to CA and the various health care
42
43 198 models (Figure 1 and Table 2). In order to assess patient-level effects, the following
44
45 199 additional independent variables were included in the regression analysis: age, sex,
46
47 200 deductible class, supplementary private hospital insurance coverage, language area,
48
49 201 inpatient CA, cardiac medication class according to ATC, number of chronic medical
50
51 202 conditions identified using PCGs and high-risk status. Goodness of fit measures for
52
53 203 the model were: Nagelkerke 0.05075414, BrierScore 0.2134051, C-Statistic 0.618.

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56 204 The strength of associations was measured by the odds ratio (OR) and the

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3 205 respective 95% confidence intervals (CI). The level of significance was set at 0.05. All
4
5 206 statistical analyses were performed using R version 3.3.1 (2016-06-21) (R
6
7 207 Foundation for Statistical Computing, Vienna, Austria)^{21 22}.
8

9 208

11 209 Ethics approval

13 210 According to the national ethical and legal regulation, an ethical approval was not
14
15 211 needed. Permission to access the study data was provided by the Helsana Group.
16
17 212 Since data was anonymized, no consent of patients was required.
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24 215 **Results**

26 216 Population

28 217 During the observed period a total of 19'032 therapeutic CA performed on 14'833
29
30 218 patients were registered in the Helsana data warehouse. 11'250 CA were eligible for
31
32 219 analysis. According to the exclusion criteria (multiple exclusion criteria possible per
33
34 220 person therefore the exclusions cannot be summed up), we excluded 5 patients since
35
36 221 they were under the age of 18 years, 360 emergency procedures, 1'922 therapeutic
37
38 222 CA (coronary angioplasty/stenting or coronary artery by-pass grafting). In total, 9'173
39
40 223 patients remained for analysis.
41

42 224 The descriptive statistics of the study population are listed in Table 1. From the 9'173
43
44 225 patients representing the study population 5'587 were male (60.9%, mean age 66.4
45
46 226 years) and 3'586 were female (39.1%, mean age 68.7 years).
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227 **Table 1** Descriptive statistics of the study population grouped into non-limited and limited access health care models (GK and MC)

	Non-limited access (n=5'258)			Limited access (n=3'915)					
	No NIIT (n=1'818)	With NIIT (n=3'440)		GK (n=1'816)		MC (n=2'099)			
				No NIIT (n=574)	With NIIT (n=1'242)	No NIIT (n=652)	With NIIT (n=1'447)		
High-Risk (= 1)	1'006	1'692	2	287	577	2	306	644	2
Age (mean)	68.1 (12.8)	67.6 (10.9)	** 1	66.4 (12.5)	66.9 (10.6)	1	66.6 (13.1)	66.6 (11.4)	1
Sex (fem)	738	1'351	2	213	483	2	254	547	2
Deductible			3			3			3
300	1'262	2'355		357	743		442	962	
500	394	749		134	310		116	290	
1000	45	71		26	65		28	48	
1500	59	127		24	51		23	55	
2000	5	14		2	14		3	16	
2500	53	124		31	59		40	76	

Private	493	925	2	120	288	2	142	316	2
Latin	541	1'066	2	195	466	2	55	116	2
Inpatient	1'166	1'765	*** 2	357	584	***	441	798	***
ATC 1	704	1'738	*** 2	219	648	*** 2	241	732	*** 2
2	576	1'216	** 2	175	465	** 2	195	512	* 2
3	1'114	2'192	2	316	755	** 2	365	931	*** 2
4	277	510	2	72	152	2	80	185	2
5	281	544	2	89	162	2	79	178	2
6	1'038	2'429	*** 2	319	840	*** 2	348	985	*** 2
PCG			** 3			3			3
<3	412	768		175	372		203	444	
3-4	624	1342		200	474		221	557	
5-6	478	893		145	295		150	304	
>6	304	437		54	101		78	142	

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5 229 *NIIT: Non-invasive ischemia testing. GK: Gate keeping, MC: Managed care: Deductible class in Swiss Francs. Private: supplementary*
6
7 230 *private hospital insurance, Latin: French or Italian part of Switzerland compared to German part. CA: coronary angiography, ATC:*
8
9 231 *Anatomical-Therapeutic-Chemical-Classification group 1 = Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3*
10
11 232 *= antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system, 4 =*
12
13 233 *antidiabetics, 5 = antianginous drugs, 6: antithrombotics (Categorical variable, an individual can be positive for several ATC groups).*
14
15
16 234 *PCG: number of chronic conditions according to pharmaceutical cost groups. High-risk patients: having received therapeutic cardiac*
17
18 235 *intervention within one month after or 18 months prior to diagnostic CA. Significance no NIIT vs with NIIT within nonlimited access and*
19
20 236 *limited access group: *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.01$. 1) Kruskal-Wallis test, 2) Fisher exact test, 3) Chi-Square test, pairwise*
21
22 237 *comparisons between NIIT and no NIIT for each health insurance model separately.*
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3 238 Patients insured in basic health care models were slightly older (67.7 (11.6) vs. 66.6
4
5 239 (11.6) years, $p < 0.0001$), chose the lowest possible deductible of 300 Francs more
6
7 240 often (3'617 (68.8%) vs. 2'504 (64.0%), $p < 0.001$), were enrolled in a supplementary
8
9 241 private hospital insurance more often (1'418 (27.0%) vs. 866 (22.1%), $p < 0.0001$), had
10
11 242 more antidiabetics (787 (15%) vs 489 (12.5%), $p < 0.0001$) and antianginal medication
12
13 243 (825 (15.7%) vs 508 (13.0%), $p < 0.0001$), more PCGs (4.1 (2.1) vs. 3.6 (2.0),
14
15 244 $p < 0.0001$) and had more often a high-risk status (2'696 (51.3%) vs. 1'814 (46.3%),
16
17 245 $p < 0.0001$), compared to patients insured in limited access models (Appendix 2).
18
19 246 Concerning the other patient characteristics, no differences existed.
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23

24 248 Non-invasive ischemia testing

25
26 249 3'044 patients had no NIIT (1'455 without and 1'599 with high-risk). 488 of 1'445
27
28 250 (33.8 %) of patients without NIIT had a conventional ECG prior to CA, in the high-risk
29
30 251 population this was the case in 722 of 1'599 (45.2%) ($p < 0.0001$, data not shown).
31
32 252 The most NIITs stress-ECG + transthoracic echocardiography were performed
33
34 253 significantly more often before CA in patients insured in limited access compared to
35
36 254 non-limited access models (1'750 (44.7%) vs. 2'039 (38.8 %) $p < 0.0001$, and 2'044
37
38 255 (52.2%) and 2'528 (48.1%), $p < 0.0001$, data not shown). The remaining types of NIIT
39
40 256 were rarely performed and only showed a significant difference in the use of
41
42 257 scintigraphy (non-limited 131 (2.5%) vs. limited access models 64 (1.6%), $p < 0.001$,
43
44 258 data not shown). The distribution of the non-invasive ischemia testing are depicted in
45
46 259 Appendix 3).
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51 261 Determinants for non-invasive ischemia testing

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53 262 Patients with MC models had a significantly higher OR of 17% to receive NIIT before
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55 263 CA compared to patients with non-limited models, when controlled for the
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264 confounders age, sex, language area, insurance coverage, inpatient treatment,
 265 cardiovascular medication, number of chronic comorbidities and high-risk status (OR
 266 1.17, $p < 0.001$). GK models did not show any significant influence on the chance of
 267 receiving NIIT (OR 1.11, $p = 0.071$). The distribution of NIIT performed according to
 268 health care model can be appreciated in Figure 1.

269
 270 Figure 1: Distribution of NIIT performed according to health care model.

271 *OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders*
 272 *age, sex, language area, insurance coverage, inpatient treatment, cardiovascular*
 273 *medication, number of chronic comorbidities and high-risk status. * $p < 0.001$ (OR*
 274 *1.17) for managed care model compared to non-limited access model (Reference).*

275
 276 Following determinants were also independently significantly associated with
 277 receiving NIIT: the use of platelet aggregation inhibitors, antithrombotic and
 278 antihypertensive medication, being supplementary privately insured and a deductible
 279 of 2000 SFR. Following determinants were significantly associated with not receiving
 280 NIIT: high-risk status, a high number of chronic comorbidities as well as inpatient
 281 treatment (Table 2).

282
 283 Table 2: Determinants for receiving non-invasive ischemia testing before coronary
 284 angiography

	CI	OR	Sig
286 Age (years)	0.998 - 1.007	1.003	
287 Sex (female)	0.967 - 1.166	1.062	
288 Deductible Class (Swiss Francs, Reference 300)			
289 500	0.912 - 1.141	1.020	

1					
2					
3	290	1000	0.667 - 1.120	0.865	
4					
5	291	1500	0.841 - 1.374	1.075	
6					
7	292	2000	1.082 - 4.381	2.177	*
8					
9	293	2500	0.809 - 1.289	1.022	
10					
11	294	Private	1.025 - 1.267	1.140	*
12					
13	295	French or Italian part of Switzerland	0.841 - 1.044	0.937	
14					
15	296	Inpatient CA	0.540 - 0.664	0.599	***
16					
17	297	ATC group 1-6			
18					
19					
20	298	1	1.251 - 1.620	1.423	***
21					
22	299	2	0.922 - 1.135	1.023	
23					
24	300	3	1.002 - 1.218	1.104	*
25					
26	301	4	0.851 - 1.115	0.974	
27					
28	302	5	0.874 - 1.130	0.994	
29					
30	303	6	1.034 - 1.356	1.184	*
31					
32					
33	304	PCG (reference <3)			
34					
35	305	<5	0.940 - 1.192	1.058	
36					
37	306	<7	0.809 - 1.064	0.928	
38					
39	307	>=7	0.624 - 0.881	0.742	***
40					
41					
42	308	Limited access models (reference non-limited access)			
43					
44	309	Managed Care	1.045 - 1.312	1.171	**
45					
46	310	Gate Keeping	0.991 - 1.253	1.114	
47					
48	311	High-risk cardiac status	0.046443	0.836	***
49					
50	312	<i>CI: confidence interval, OR: odds ratio, Sig: significance: *** p<0.0001, ** p<0.001</i>			
51					
52	313	<i>*p<0.01, Private: supplementary private hospital insurance, CA: coronary</i>			
53					
54	314	<i>angiography, ATC: Anatomical-Therapeutic-Chemical-Classification group 1 =</i>			
55					
56	315	<i>Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3 =</i>			
57					
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3 316 *antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents*
4
5 317 *acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6:*
6
7 318 *antithrombotics (Categorical variable, an individual can be positive for several ATC*
8
9 319 *groups). PCG: number of chronic conditions according to pharmaceutical cost*
10
11 320 *groups. High-risk patients: having received therapeutic cardiac intervention within*
12
13 321 *one month after or 18 months prior to diagnostic CA.*
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323 **Discussion**

324 In our study population of elective CA with no therapeutic consequence (no coronary
325 angioplasty/stenting or coronary artery bypass grafting) one third did not receive NIIT
326 before diagnostic CA. MC was independently significantly associated with a higher
327 proportion of NIIT when additionally controlled for potential confounders. GK models
328 showed no significant association with the rate of NIIT.
329

330

330 Effects of limited access health care models on treatment quality

331 In our study, emergency CA were excluded and the study population consisted of
332 patients undergoing purely diagnostic elective CA with no therapeutic consequence
333 (e.g. no coronary angioplasty/stenting or coronary artery by-pass grafting). The study
334 population therefore represents a selection of patients with at least stable CHD or no
335 CHD at all. From a previous study among this selection of patients we know, that
336 37.5% did not receive any NIIT at all before elective CA with no therapeutic
337 consequence, suggesting a substantial overuse of a potentially harmful and
338 inappropriate diagnostic intervention¹². It has been assumed that patients insured in
339 limited access health care models undergo less diagnostic procedures or
340 interventions due to budget considerations, especially in capitated health care
341 models. In our study, this hypothesis is clearly refuted. Patients with stable angina

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3 342 pectoris insured in limited access health care models underwent a more appropriate
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5 343 diagnostic pathway than regularly insured patients did, meaning in a stable clinical
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7 344 situation they were subjected to significantly more non-invasive diagnostic testing,
8
9 345 therefore reducing inadequate CA. Our findings are in line with another study from
10
11 346 the Swiss health care system, which also showed higher referral rates among MC
12
13 347 patients compared to patients insured in basic health care models²³. One reason for
14
15 348 the more appropriate diagnostic pathway found in MC patients might be the aspect of
16
17 349 membership in a general practitioners network. In most parts of Switzerland, general
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19 350 practitioners can only offer MC insurance models to their patients, if they are member
20
21 351 in a general practitioners network. These networks offer evidence-based guidelines,
22
23 352 which the general practitioners are obliged to respect when initiating treatment.
24
25 353 Depending on the network, more or less rigorous quality control mechanisms exist to
26
27 354 check whether the guidelines are followed, when applicable. General practitioners,
28
29 355 which are not member in a network, therefore are less bound to evidence based
30
31 356 treatment pathways.. Other studies showed that being insured in MC models is
32
33 357 associated with a survival benefit by promoting better preventive and higher quality of
34
35 358 care²⁴⁻²⁶. Especially among Medicare beneficiaries, which are prone to
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37 359 multimorbidity, this effect has been shown²⁷. These models have also shown lower
38
39 360 prevalence of potentially inappropriate medication use in elderly patients and a lower
40
41 361 disease specific hospitalization rate in chronically ill patients^{16 17}.
42
43 362 Our study raises the question why patients in limited access health care models
44
45 363 receive a more appropriate diagnostic pathway in this clinical situation of stable
46
47 364 angina pectoris. There has been evidence for and against the theory that patients
48
49 365 enrolled in a MC health care model are healthier due to biased selection²⁸⁻³⁷ and
50
51 366 commercial considerations of the MC insurer^{38 39}. In our study population, patients
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53 367 insured in limited access models showed some evidence of being healthier than
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3 368 regularly insured patients. Nevertheless being insured only in MC but not GK models
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5 369 was *independently* associated with a higher rate of NIIT, controlled for all the
6
7 370 differences in patient characteristics. It is clear that physicians participating in MC
8
9 371 models are obliged to keep diagnostic and treatment costs as low as possible while
10
11 372 keeping up with quality concerns. One could therefore argue that it is cheaper to not
12
13 373 to choose a diagnostic detour over NIIT instead of choosing the straight forward way
14
15 374 of sending a patient to the more invasive CA, which offers a clear answer to an
16
17 375 uncertain clinical situation including the option of therapeutic action. It seems that MC
18
19 376 health care providers have understood what Meara et al. have summed up
20
21 377 accurately: "Reductions in spending for patients must be a result of decreases in the
22
23 378 provision of services. If these are needed services, quality of care will decline.
24
25 379 Alternatively, quality of care might be higher in low expenditure areas if differences in
26
27 380 spending result from reductions in unnecessary or inappropriate services⁴⁰". Besides
28
29 381 this intuitive statement there has been scientific evidence that a diagnostic detour is
30
31 382 worthwhile taking, since it sums up in reduced peri and post interventional costs
32
33 383 without loss in quality¹¹. Our study is not able to answer the questions why patients
34
35 384 in limited access models received a more appropriate diagnostic approach. One can
36
37 385 only hypothesize that a more rigorous coordination of care, as performed in the MC
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39 386 models, is straighter forward and the indication for invasive and expensive diagnostic
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41 387 procedures is more thoroughly scrutinized.
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48 389 Determinants for NIIT

49
50 390 Even though simple echocardiography with no stress testing does not actually qualify
51
52 391 as a NIIT, we chose to include this diagnostic procedure due to following
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54 392 considerations: some cardiologists might argue that patients with dyskinesia in simple
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56 393 echocardiography are likely to have relevant coronary pathology therefore offering an
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3 394 argument for CA besides the clinical evaluation. Our theory is supported by the “2014
4
5 395 ESC/EACTS Guidelines on Myocardial Revascularization which state: “regional wall
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7 396 motion abnormalities may be detected in simple echocardiography, which increase
8
9 397 the likelihood of coronary artery disease”.

10
11 398 Since our study lacks clinical data, only indirect hints by means of PCG and ATC
12
13 399 codes as well as other confounders are available to assess clinical reasoning. The
14
15 400 association between the use of platelet aggregation inhibitors or antithrombotic
16
17 401 agents and antihypertensive medication with receiving NIIT before CA suggest a
18
19 402 reasonable deliberation in the sense of estimating pretest probability when deciding
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21 403 on optimal diagnostic strategy. The same counts for the association of high-risk
22
23 404 status and a larger number of chronic comorbidities as determinants for not receiving
24
25 405 NIIT prior to elective CA. This finding is consistent with two US studies indicating that
26
27 406 risk stratification was performed, considering the higher likelihood of a coronary
28
29 407 pathology in patients with known coronary heart disease^{8 10}. In our study, also non-
30
31 408 clinical factors seem to influence decision-making processes concerning diagnostic
32
33 409 pathways, reflected by the findings that being privately insured and a deductible of
34
35 410 2000 SFR were positively and inpatient treatment negatively independently
36
37 411 associated with NIIT.

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41 412 As previously observed in another Swiss study analyzing inappropriate use of
42
43 413 arthroscopic meniscal surgery in degenerative knee disease⁴¹, a substantial amount
44
45 414 of the patients in our sample underwent CA as inpatients in contrast to other health
46
47 415 care settings. This finding is most likely explained by differences in the organization
48
49 416 of the health care system in Switzerland. Here regional governments subsidize
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51 417 inpatient treatment covering approximately 50% of total costs, and patients with
52
53 418 supplementary private insurance receive a substantially higher reimbursement when
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55 419 treated as inpatients. Nevertheless, in the regression analysis with the outcome

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3 420 proportion of NIIT, we controlled for potential confounders, such as inpatient
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5 421 treatment as well. The results therefore seem robust concerning the question
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7 422 whether limited access health care models have a significant impact on the
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9 423 appropriateness of the diagnostic approach.
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11 424

12 13 425 Reinforcing quality control mechanisms in a non-gate keeping health care system

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15 426 Besides the existing voluntary steering mechanisms such limited access health care
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17 427 models guided by patient's preferences only, more alternative steering mechanisms
18
19 428 have to be implemented in non-gate keeping health care systems, in order to
20
21 429 minimize the influence of non-clinical factors on medical decision making, which
22
23 430 might lead to inappropriate and possibly dangerous health care utilization as well as
24
25 431 increasing expenditures. A positive example for alternative steering mechanisms is
26
27 432 the implementation of national registries⁴² combined with quality initiatives, such as
28
29 433 the in 2009 published Appropriate Use Criteria for Coronary Revascularization^{9 42 43}.
30
31 434 In 2011, the registry started giving feedbacks on the participating hospital's
32
33 435 performance concerning appropriateness of CA including a benchmarking against
34
35 436 other participating institutions. At the same time the American Board of Internal
36
37 437 Medicine's Choosing Wisely initiative launched national quality improvement
38
39 438 campaigns, identifying CA appropriateness as a key area for intervention⁴⁴. As a
40
41 439 consequence insurance companies incorporated measures of CA appropriateness
42
43 440 into pay-for-performance programs⁴⁵ and reimbursement was declined for certain
44
45 441 CA identified as inappropriate⁴⁶. The combination of implementing national registries
46
47 442 combined with quality initiatives had been proven amazingly effective, showing a
48
49 443 decrease of non-acute CA classified as inappropriate from 26.2% to 13.3%⁴⁷. In
50
51 444 Switzerland currently no registries on CA exist, hence other solutions for influencing
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53 445 treatment pathways have to be developed, besides offering voluntary limited access
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3 446 health care models. A possible alternative solution to the conundrum of reducing
4
5 447 costs without cutting quality seems hence to be paying for outcomes instead of
6
7 448 volume. As the findings of our study suggest, a possible approach is to raise the
8
9 449 market share of MC to such a volume that it might also affect care for fee-for-service
10
11 450 patients⁴⁰. As Meara et al have summarized, the effects have been show to play in a
12
13 451 variety of ways: more MC in a market might lower expenditures by reducing the
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15 452 number of specialists, and thereby the number of specialists' services provided^{48 49}
16
17 453 by encouraging more conservative practice patterns^{48 49}, or by slowing the diffusion
18
19 454 of more costly technologies^{48 50}.

455

456 Strengths and limitations

457 Only scarce data on non-emergency CA exists in literature. The only data found
458 originates from the US among Medicare as well as commercially insured patients and
459 from Switzerland, both non-gate keeping health care systems. Whether the
460 proportion of inappropriate diagnostic CA from our study can be translated to other
461 non-gate keeping health care systems is difficult to estimate, since substantial
462 variation in the proportion of non-acute PCIs considered inappropriate across
463 hospitals can be found, ranging from about 6% to 70%^{8 10 14 15 47}. From a previous
464 study from Switzerland¹² similar proportions were found, suggesting generalizability
465 of our data. The current study seems even more representative than the previous
466 Swiss study, since it included data over a longer time-period with consecutively larger
467 amount of patients and corresponding data. Nevertheless, caution should be used
468 when generalizing to larger populations due to the data being limited to only one,
469 even if the largest health insurance company in Switzerland, due to exclusion criteria
470 and the retrospective study design. Since the study is based on insurance claims
471 data, no data on socioeconomic status and clinical information is available. Given

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3 472 that this is a cross-sectional observational study, rather than an interventional one,
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5 473 the only conclusions that we can draw are of association rather than causation. Due
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7 474 to the study design, unfortunately no estimations on clinical outcome parameters can
8
9 475 be made. For example, in order to explore clinical appropriateness, the proportion of
10
11 476 CA's avoided by performing NIIT would be of great interest. As a substitute for clinical
12
13 477 data, ATC and PCG are used, offering only indirect information on comorbidities. On
14
15 478 the other hand PCGs represent a strength, since they have been shown to directly
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17 479 correlate with associated health care costs¹⁹. Due to data structure, it is not possible
18
19 480 to distinguish between CT angiography (including intravenous contrast) and CT
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21 481 without intravenous contrast. Therefore, all CTs of the chest were included in
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23 482 analysis.
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31 485 **Conclusions**

32
33 486 In a non-gate keeping health care system voluntary MC health care models with
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35 487 capitation were associated with a reduced inappropriate use of diagnostic CA
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37 488 compared to GK or basic models.
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641

642 **Competing interests**

643 Oliver Reich and Andri Signorell are employed by the Helsana Group. The sponsor
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648

649 **Authors Contributions**

650 Conceived and designed the experiments: CC, OR, AS, SNJ, TR, OS. Performed the
651 experiments: CC, OR, AS. Analyzed the data: CC, OR, AS, SNJ, TR, OS. Wrote the
652 paper: CC, edited and approved the paper: CC, OR, AS, SNJ, TR, OS.

653

654 **Consent for publication**

655 Since data were completely anonymized, no patient consent was necessary.

656

657 **Availability of data and materials**

658 Individual data cannot be made fully available on the internet because the study is
659 based on claims data of the Helsana Group, the owner of the data. Thus, data
660 underlie data protection and privacy restrictions. These restrictions prohibit the
661 insurer from sharing the collected data. Data analysis was performed within the

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2
3 662 premises of the Helsana research group by the statistician AS in collaboration with
4
5 663 the authors OR and CC and administrative permission was received to access de-
6
7 664 identified data by the researchers from the University of Zurich.
8

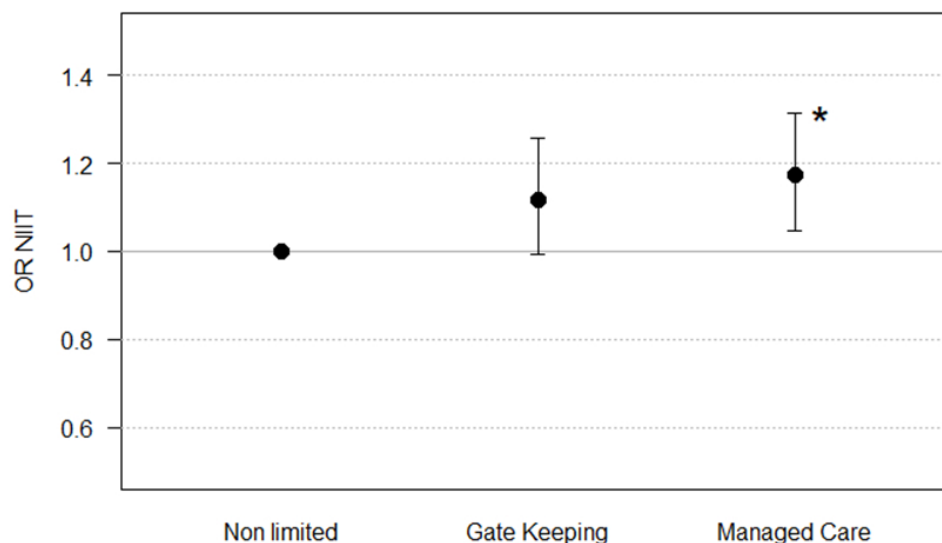
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13 667 **Figure Legend**

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15
16 668 Figure 1: Distribution of NIIT performed according to health care model.

17
18 669 *OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders*
19
20 670 *age, sex, language area, insurance coverage, inpatient treatment, cardiovascular*
21
22 671 *medication, number of chronic comorbidities and high-risk status. * $p < 0.001$ (OR*
23
24 672 *1.17) for managed care model compared to non-limited access model (Reference).*
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OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high- risk status. * $p < 0.001$ (OR 1.17) for managed care model compared to standard health care plannon-limited access model (Reference).

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1 **Supplemental Material**

2 Supplemental Methods/Definitions

4 1) Inclusion Criteria

5 Tarmed 17.071

6 17.074

7 17.101

8 17.109

9 17.181

10 17.182

11 DRG F49D

12 F49E

13 F49F

14 If two coronary angiographies (CA) were performed on the same day at the same
15 provider, the intervention is counted once.

16 If the CA was performed twice at the same day but different providers the CA counts
17 twice (both concerning the inpatients positions (Diagnosis related Groups (DRG)) and
18 the outpatient positions (Standard billing rate for outpatient medical care in
19 Switzerland (TARMED))

20 If during 2012-2015 patients received more than one CA, only the first CA was taken
21 into consideration.

1
2
3 1 2) Exclusion Criteria
4

5	2	Acute cardiac ischemia and/or emergency procedures	Tarmed	0.2510
6				
7	3			0.2520
8				
9				
10	4			0.2540
11				
12	5			0.2560
13				
14	6			0.2580
15				
16				
17	7			35.0610
18				
19	8		DRG	F41A
20				
21	9			F41B
22				
23				
24	10			
25				
26	11	Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting,		
27				
28	12	without myocardial infarction)	Tarmed	17.1110
29				
30				17.1240
31	13			
32				
33	14		DRG	F15Z
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35	15			F19Z
36				
37				F24B
38	16			
39				
40	17			F49A
41				
42	18			F49C
43				
44				F52A
45	19			
46				
47	20			F52B
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49	21			F54Z
50				
51	22			F56A
52				
53				F56B
54	23			
55				
56	24			F57A
57				
58	25			F57B
59				
60	26			F58Z

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3	1	F59A
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5	2	F59B
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8	3	Incomplete coverage of mandatory basic health insurance 18 months before and/or 1
9		
10	4	month after CA
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12	5	Patients <18 years
13		
14	6	
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17	7	
18		
19	8	<u>3) Diagnostic Procedures</u>
20		
21	9	Tarmed 17.0010: Electrocardiogram (ECG): not considered as NIIT, only in
22		
23		
24	10	combination with other NIIT
25		
26	11	17.0050: Cardiac intervention with medication under continuous
27		
28	12	registration of ECG: not considered as NIIT, only in combination with
29		
30	13	another NIIT
31		
32		
33	14	17.0060: ECG performed by specialist outside of the practice or
34		
35	15	hospital: not considered as NIIT, only in combination with another NIIT
36		
37		
38	16	17.0080 and 17.0090: Stress-ECG
39		
40	17	17.0210: Echocardiography, transthoracic, qualitative and quantitative
41		
42	18	examination of adult
43		
44	19	17.0280: Stressechocardiography, physical stress
45		
46		
47	20	17.0290: Stressechocardiography, medication stress
48		
49	21	31.0260: Scintigraphy physiologically triggered
50		
51	22	39.4060: Computed tomography of entire thorax and/or sternoclavicular
52		
53		
54	23	joint
55		
56	24	39.5100 Heart MRI
57		
58	25	DRG No separate codes available for inpatient diagnostic procedures, only
59		
60	26	for therapeutic interventions

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1 4) High risk patients

2 Patients having received therapeutic cardiac intervention within one month after or 18
3 months prior to diagnostic CA

4 Tarmed 0.2510

5 0.2520

6 0.2540

7 0.2560

8 0.2580

9 35.0610

10 17.1110

11 17.1240

12 And all 18.001 until/including 18.0740

13 DRG all Chapter F

For peer review only

Appendix 2

Descriptive Differences in the study population non-limited vs. limited access modes

	Total	Non-limited access	Limited access	
n	9'173	5'258 (57.3%)	3'915 (42.7%)	
Sex (fem)	3'586 (39.1%)	2'089 (39.7%)	1'497 (38.2%)	²
Age (mean)	67.3 (11.610)	67.7 (11.582)	66.6 (11.620)	*** ¹
Deductible				*** ³
300	6'121 (66.7%)	3'617 (68.8%)	2'504 (64.0%)	
500	1'993 (21.7%)	1'143 (21.7%)	850 (21.7%)	
1000	283 (3.1%)	116 (2.2%)	167 (4.3%)	
1500	339 (3.7%)	186 (3.5%)	153 (3.9%)	
2000	54 (0.6%)	19 (0.4%)	35 (0.9%)	
2500	383 (4.2%)	177 (3.4%)	206 (5.3%)	
Private	2'284 (24.9%)	1'418 (27.0%)	866 (22.1%)	*** ²
Canton				*** ³
AG	717 (7.8%)	377 (7.2%)	340 (8.7%)	
AI	13 (0.1%)	8 (0.2%)	5 (0.1%)	
AR	46 (0.5%)	26 (0.5%)	20 (0.5%)	
BE	1'489 (16.2%)	664 (12.6%)	825 (21.1%)	
BL	200 (2.2%)	129 (2.5%)	71 (1.8%)	
BS	72 (0.8%)	53 (1.0%)	19 (0.5%)	
FR	259 (2.8%)	196 (3.7%)	63 (1.6%)	
GE	427 (4.7%)	285 (5.4%)	142 (3.6%)	
GL	54 (0.6%)	29 (0.6%)	25 (0.6%)	
GR	152 (1.7%)	86 (1.6%)	66 (1.7%)	
JU	21 (0.2%)	13 (0.2%)	8 (0.2%)	
LU	304 (3.3%)	156 (3.0%)	148 (3.8%)	
NE	98 (1.1%)	69 (1.3%)	29 (0.7%)	
NW	37 (0.4%)	25 (0.5%)	12 (0.3%)	
OW	34 (0.4%)	17 (0.3%)	17 (0.4%)	
SG	343 (3.7%)	168 (3.2%)	175 (4.5%)	
SH	126 (1.4%)	67 (1.3%)	59 (1.5%)	
SO	473 (5.2%)	220 (4.2%)	253 (6.5%)	
SZ	194 (2.1%)	124 (2.4%)	70 (1.8%)	
TG	347 (3.8%)	152 (2.9%)	195 (5.0%)	
TI	721 (7.9%)	429 (8.2%)	292 (7.5%)	
UR	48 (0.5%)	22 (0.4%)	26 (0.7%)	
VD	598 (6.5%)	412 (7.8%)	186 (4.8%)	
VS	315 (3.4%)	203 (3.9%)	112 (2.9%)	
ZG	138 (1.5%)	84 (1.6%)	54 (1.4%)	
ZH	1'947 (21.2%)	1'244 (23.7%)	703 (18.0%)	
atc_1	4'282 (46.7%)	2'442 (46.4%)	1'840 (47.0%)	²
atc_2	3'139 (34.2%)	1'792 (34.1%)	1'347 (34.4%)	²
atc_3	5'693 (62.1%)	3'306 (62.9%)	2'387 (61.0%)	²
atc_4	1'276 (13.9%)	787 (15.0%)	489 (12.5%)	*** ²
atc_5	1'333 (14.5%)	825 (15.7%)	508 (13.0%)	*** ²
NIIT				
ekg	4'914 (53.6%)	2'822 (53.7%)	2'092 (53.4%)	²
kmedint	8 (0.1%)	4 (0.1%)	4 (0.1%)	²
ekgext	23 (0.3%)	15 (0.3%)	8 (0.2%)	²
bekgarb	8 (0.1%)	3 (0.1%)	5 (0.1%)	²
bekgergo	3'789 (41.3%)	2'039 (38.8%)	1'750 (44.7%)	*** ²
echokard	4'572 (49.8%)	2'528 (48.1%)	2'044 (52.2%)	*** ²
echophys	137 (1.5%)	81 (1.5%)	56 (1.4%)	²
echomed	131 (1.4%)	69 (1.3%)	62 (1.6%)	²
szin	195 (2.1%)	131 (2.5%)	64 (1.6%)	** ²
Ct	643 (7.0%)	387 (7.4%)	256 (6.5%)	²
mri	283 (3.1%)	173 (3.3%)	110 (2.8%)	²

pcg_n	3.883 (2.029)	4.060 (2.058)	3.644 (1.965)	*** 1
pcg				*** 3
<3	2'545 (27.7%)	1'277 (24.3%)	1'268 (32.4%)	
3-4	3'430 (37.4%)	1'967 (37.4%)	1'463 (37.4%)	
5-6	2'179 (23.8%)	1'339 (25.5%)	840 (21.5%)	
>6	1'019 (11.1%)	675 (12.8%)	344 (8.8%)	
Highrisk	4'510 (49.2%)	2'696 (51.3%)	1'814 (46.3%)	*** 2
Inpatient	5'111 (55.7%)	2'931 (55.7%)	2'180 (55.7%)	2
CA				
17.0710	12 (0.1%)	7 (0.1%)	5 (0.1%)	
17.0710,17.0740	6 (0.1%)	6 (0.1%)	0 (0.0%)	
17.0710,17.0740,17.1010	218 (2.4%)	136 (2.6%)	82 (2.1%)	
17.0710,17.0740,17.1010,17.1810	2 (0.0%)	1 (0.0%)	1 (0.0%)	
17.0710,17.0740,17.1010,17.1810	2'960 (32.3%)	1'663 (31.6%)	1'297 (33.1%)	
17.0710,17.0740,17.1010,17.1810,F49D	0 (0.0%)	0 (0.0%)	0 (0.0%)	
17.0710,17.0740,17.1010,17.1810,F49E	2 (0.0%)	1 (0.0%)	1 (0.0%)	
17.0710,17.0740,17.1010,17.1810,F49F	2 (0.0%)	0 (0.0%)	2 (0.1%)	
17.0710,17.0740,17.1010,17.1820	1 (0.0%)	0 (0.0%)	1 (0.0%)	
17.0710,17.0740,17.1090	78 (0.9%)	44 (0.8%)	34 (0.9%)	
17.0710,17.0740,17.1090,17.1810	363 (4.0%)	219 (4.2%)	144 (3.7%)	
17.0710,17.0740,17.1810	25 (0.3%)	17 (0.3%)	8 (0.2%)	
17.0710,17.1010	1 (0.0%)	0 (0.0%)	1 (0.0%)	
17.0710,17.1010,17.1810	39 (0.4%)	23 (0.4%)	16 (0.4%)	
17.0710,17.1010,17.1810,F49F	3 (0.0%)	2 (0.0%)	1 (0.0%)	
17.0710,17.1090	1 (0.0%)	1 (0.0%)	0 (0.0%)	
17.0710,17.1090,17.1810	14 (0.2%)	5 (0.1%)	9 (0.2%)	
17.0710,17.1810	232 (2.5%)	133 (2.5%)	99 (2.5%)	
17.0740	7 (0.1%)	5 (0.1%)	2 (0.1%)	
17.0740,17.1010	4 (0.0%)	3 (0.1%)	1 (0.0%)	
17.0740,17.1010,17.1810	9 (0.1%)	6 (0.1%)	3 (0.1%)	
17.0740,17.1090,17.1810	3 (0.0%)	3 (0.1%)	0 (0.0%)	
17.0740,17.1810	1 (0.0%)	1 (0.0%)	0 (0.0%)	
17.1010,17.1810	3 (0.0%)	3 (0.1%)	0 (0.0%)	
17.1810	83 (0.9%)	51 (1.0%)	32 (0.8%)	
F49D	475 (5.2%)	281 (5.3%)	194 (5.0%)	
F49E	711 (7.8%)	373 (7.1%)	338 (8.6%)	
F49E,F49F	0 (0.0%)	0 (0.0%)	0 (0.0%)	
F49F	3'918 (42.7%)	2'274 (43.2%)	1'644 (42.0%)	

Deductible class in Swiss Francs. Private: supplementary private hospital insurance, ATC: Anatomical-Therapeutic-Chemical-Classification group 1 = Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3 = antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6: antithrombotics. NIIT: Non-invasive ischemia testing, PCG: number of chronic conditions according to pharmaceutical cost groups. High-risk patients: having received therapeutic cardiac intervention within one month after or 18 months prior to diagnostic CA: coronary angiography. Significance non-limited vs limited access group: *** p<0.0001, ** p<0.001, *p<0.01. 1) Kruskal-Wallis test, 2) Fisher exact test, 3) Chi-Square test

Detailed Tarmed positions can also be appreciated in Appendix 1.

NIIT:

ekg	17.0010 Electrocardiogram (ECG)
kmedint	17.0050 Cardiac intervention with medication under continuous registration of ECG
ekgext	17.0060 ECG performed by specialist outside of the practice or hospital
bekgarb	17.0080 Stress-ECG
bekgergo	17.0090 Stress-ECG
echokard	17.0210 Echocardiography, transthoracic, qualitative and quantitative
echophys	17.0280 Stressechocardiography, physical stress
echomed	17.0290 Stressechocardiography, medication stress
szin	31.0260 Scintigraphy physiologically triggered
ct	39.4060 Computed tomography of entire thorax and/or sternoclavicular joint
mri	39.5100 Heart MRI

Appendix 3 a) and b)

a) Overall distribution of the non-invasive ischemia testing

level	freq	perc	cumfreq	cumperc
	3'044	33.2%	3'044	33.2%
bekgergo, echokard	2'360	25.7%	5'404	58.9%
echokard	1'494	16.3%	6'898	75.2%
bekgergo	952	10.4%	7'850	85.6%
ct	204	2.2%	8'054	87.8%
bekgergo, echokard, ct	165	1.8%	8'219	89.6%
echokard, ct	153	1.7%	8'372	91.3%
mri	120	1.3%	8'492	92.6%
echokard, echophys	70	0.8%	8'562	93.3%
echokard, mri	64	0.7%	8'626	94.0%
bekgergo, chokard, mri	62	0.7%	8'688	94.7%
bekgergo, ct	50	0.5%	8'738	95.3%
echokard, echomed	44	0.5%	8'782	95.7%
bekgergo, szin	43	0.5%	8'825	96.2%
bekgergo,echokard, szin	42	0.5%	8'867	96.7%
echophys	40	0.4%	8'907	97.1%
szin	39	0.4%	8'946	97.5%
echomed	37	0.4%	8'983	97.9%
bekgergo, echokard, echomed	35	0.4%	9'018	98.3%
echokard, szin	25	0.3%	9'043	98.6%
bekgergo, mri	23	0.3%	9'066	98.8%
bekgergo, echokard, szin, ct	15	0.2%	9'081	99.0%
echokard, szin, ct	14	0.2%	9'095	99.1%
bekgergo, echokard, echophys	11	0.1%	9'106	99.3%
bekgergo, szin, ct	10	0.1%	9'116	99.4%
bekgergo, echomed	7	0.1%	9'123	99.5%
bekgergo, echophys	7	0.1%	9'130	99.5%
ct, mri	6	0.1%	9'136	99.6%
echophys, ct	5	0.1%	9'141	99.7%
szin, ct	5	0.1%	9'146	99.7%
bekgarb, echokard	4	0.0%	9'150	99.7%
echomed, ct	4	0.0%	9'154	99.8%
echokard, ct, mri	3	0.0%	9'157	99.8%
echokard, echophys, ct	3	0.0%	9'160	99.9%
bekgarb	2	0.0%	9'162	99.9%
bekgergo, echokard, ct, mri	2	0.0%	9'164	99.9%
bekgergo, echokard, echomed, ct	2	0.0%	9'166	99.9%
bekgarb, bekgergo, echokard	1	0.0%	9'167	99.9%
bekgarb, bekgerg	1	0.0%	9'168	99.9%
bekgergo, ct, mri	1	0.0%	9'169	100.0%
echokard, echomed, ct	1	0.0%	9'170	100.0%
echokard, echomed, szin	1	0.0%	9'171	100.0%
echokard, echophys, mri	1	0.0%	9'172	100.0%
szin, mri	1	0.0%	9'173	100.0%

b) Distribution of the non-invasive ischemia testing according to health care model

	freq			p.col		
	MC	GK	Basic	MC	GK	Basic
	652	574	1'818	31.1%	31.6%	34.6%
bekgarb, bekgergo, echokard	1	0	0	0.0%	0.0%	0.0%
bekgarb, bekgergo	0	1	0	0.0%	0.1%	0.0%
bekgarb, echokard	0	1	3	0.0%	0.1%	0.1%
bekgarb	1	1	0	0.0%	0.1%	0.0%
bekgergo	237	181	534	11.3%	10.0%	10.2%
bekgergo, ct	10	12	28	0.5%	0.7%	0.5%
bekgergo, ct, mri	0	0	1	0.0%	0.0%	0.0%
bekgergo, echokard	647	488	1'225	30.8%	26.9%	23.3%
bekgergo, echokard, ct	48	22	95	2.3%	1.2%	1.8%
bekgergo, echokard, ct, mri	0	1	1	0.0%	0.1%	0.0%
bekgergo, echokard, echomed	12	10	13	0.6%	0.6%	0.2%
bekgergo, echokard, echomed, ct	1	1	0	0.0%	0.1%	0.0%
bekgergo, echokard, echophys	3	0	8	0.1%	0.0%	0.2%
bekgergo, echokard, mri	8	15	39	0.4%	0.8%	0.7%
bekgergo, echokard, szin	7	4	31	0.3%	0.2%	0.6%
bekgergo, echokard, szin, ct	3	2	10	0.1%	0.1%	0.2%
bekgergo, echomed	0	3	4	0.0%	0.2%	0.1%
bekgergo, echophys	1	1	5	0.0%	0.1%	0.1%
bekgergo, mri	3	4	16	0.1%	0.2%	0.3%
bekgergo, szin	8	9	26	0.4%	0.5%	0.5%
bekgergo, szin, ct	4	3	3	0.2%	0.2%	0.1%
ct	33	41	130	1.6%	2.3%	2.5%
ct, mri	0	1	5	0.0%	0.1%	0.1%
echokard	298	316	880	14.2%	17.4%	16.7%
echokard, ct	29	31	93	1.4%	1.7%	1.8%
echokard, ct, mri	3	0	0	0.1%	0.0%	0.0%
echokard, echomed	11	9	24	0.5%	0.5%	0.5%
echokard, echomed, ct	0	0	1	0.0%	0.0%	0.0%
echokard, echomed, szin	0	0	1	0.0%	0.0%	0.0%
echokard, echophys	14	15	41	0.7%	0.8%	0.8%
echokard, echophys, ct	1	1	1	0.0%	0.1%	0.0%
echokard, echophys, mri	1	0	0	0.0%	0.0%	0.0%
echokard, mri	12	19	33	0.6%	1.0%	0.6%
echokard, szin	1	4	20	0.0%	0.2%	0.4%
echokard, szin, ct	5	0	9	0.2%	0.0%	0.2%
echomed	9	5	23	0.4%	0.3%	0.4%
echomed, ct	1	0	3	0.0%	0.0%	0.1%
echophys	6	11	23	0.3%	0.6%	0.4%
echophys, ct	2	0	3	0.1%	0.0%	0.1%
mri	22	21	77	1.0%	1.2%	1.5%
szin	4	9	26	0.2%	0.5%	0.5%
szin, ct	1	0	4	0.0%	0.0%	0.1%
szin, mri	0	0	1	0.0%	0.0%	0.0%

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3 MC: Managed Care, GK: Gate Keeping.

4 Detailed Tarmed positions can also be appreciated in Appendix 1:

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NIIT	Tarmed position
ekg	17.0010 Electrocardiogram (ECG)
kmedint	17.0050 Cardiac intervention with medication under continuous registration of ECG
Ekgext	17.0060 ECG performed by specialist outside of the practice or hospital
bekgarb	17.0080 Stress-ECG
bekgergo	17.0090 Stress-ECG
echokard	17.0210 Echocardiography, transthoracic, qualitative and quantitative
echophys	17.0280 Stressechocardiography, physical stress
echomed	17.0290 Stressechocardiography, medication stress
szin	31.0260 Scintigraphy physiologically triggered
ct	39.4060 Computed tomography of entire thorax and/or sternoclavicular joint
mri	39.5100 Heart MRI

1 **Reporting statement: 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, 2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3, 4
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	2, 4, 5
Methods			
Study design	4	Present key elements of study design early in the paper	5-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-8
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	7, 8
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, 8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7, 8
		(b) Describe any methods used to examine subgroups and interactions	7, 8
		(c) Explain how missing data were addressed	7, 8
		(d) If applicable, describe analytical methods taking account of sampling strategy	6-8
		(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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	9-14 9-14 Not applicable
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	9-14 9-14
Outcome data	15*	Report numbers of outcome events or summary measures	9-14
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	9-14 Not applicable Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
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	23

*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