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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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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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Abstract

Objective

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

Design, setting and participants:

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

Results

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

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

Conclusions

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

Article summary

- Highly relevant topic concerning inappropriate use of a potentially harmful and expensive procedure such as the CA
- Only scarce data on non-emergency CA exists in literature
- Data originates from a single health insurance group in Switzerland, although one of the largest in the country, including data on mandatory health insurance claims from approximately 1.2 million patients
- No data on socioeconomic status and clinical information is available

Key Words

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

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Introduction

Existing guidelines [1-7] recommend non-invasive ischemia testing (NIIT) for the majority of patients with suspected ischemic heart disease in a non-emergency setting. Nevertheless, a substantial amount of these patients undergo diagnostic coronary angiography (CA) without therapeutic intervention inappropriately and are therefore exposed to unnecessary risks without any clinical benefit [8-15]. In a non-gate keeping health care system such as Switzerland hardly any steering mechanisms exist, to ensure that potentially harmful and expensive procedures are only performed in case of correct indication. The admitting physician (mainly general practitioner or cardiologist) usually gives the indication for the intervention and the performing invasive centers rarely decline assigned patients due to economic reasons or in order not to disagree with the admitting physician.

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

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

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analysis of insurance claims data on diagnostic procedures undertaken within two months before CA depending on the health care plan.

Materials and Methods

Setting

Swiss residents are obliged to enroll in a mandatory health insurance, which covers all health care costs besides deductibles. Depending on the insurance model chosen, annual deductibles for adults vary between 300 and 2500 Swiss Francs. A patient copayment of 10% of all costs up to a maximum of 700 Swiss Francs per year is payable independent of the chosen insurance model. Currently residents can chose a mandatory health insurance from 53 different insurance companies. In general, in Switzerland no gate-keeping system exists, meaning that patients have unlimited access to all healthcare providers, unless they are voluntarily insured in a limited access model. Patients agree to a restriction of choice or limited access in exchange of lower premiums. In such limited access models, the general practitioner or an insurance telephone hotline have to be consulted, before contacting a specialist or another institution such as a hospital. In case of emergency, this regulation is overruled. Compared to other health care systems, the Swiss system is more inpatient treatment oriented due to co-financing of inpatient treatments by governmental institutions.

Subjects, data collection and measurements

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

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retrospectively analyzed. Detailed TARMED (Standard billing rate for outpatient medical care in Switzerland, version 2014) and Diagnosis Related Groups (DRG, version 2012) positions can be found in the Supplemental Material.

Inclusion criteria

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

Exclusion criteria

- incomplete coverage of mandatory basic health insurance 18 months before and/or 1 month after CA
- Patients <18 years
- Acute cardiac ischemia and/or emergency procedures
- Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting)

Measurements

- Patient characteristics: sex, age, language area and type of insurance coverage (deductible class, supplementary private hospital insurance, managed care insurance model)
- Setting of CA: inpatient or outpatient
- NIIT performed within two months prior to CA (stress-ECG, echocardiography, stress echocardiography, scintigraphy, computer tomography, heart MRI)
- Cardiovascular Medication grouped according to Anatomical-Therapeutic-Chemical-Classification (ATC) [18]

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- Group 1: Aspirin, platelet aggregation inhibitors
- Group 2: statins, lipid modifying agents
- Group 3: antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system
- Group 4: antidiabetics
- Group 5: antianginous drugs
- Gruop 6: antithrombotics

- Number of chronic conditions according to Pharmaceutical cost groups PCG [19] [20]
  - Group 1: pcg_n < 3 0, 1 or 2 PCGs
  - Group 2: pcg_n < 5 3 to 4 PCGs
  - Group 3: pcg_n < 7 5 to 6 PCGs
  - Group 4: pcg_n ≥ 7 7 or more PCGs

Sensitivity Analysis with high-risk patients

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

Processing and analyzing data

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

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Statistical analysis

Descriptive statistical techniques were used to provide a general profile of the study population and grouped into patients with mandatory health insurance with no limited access health care plans versus voluntary limited access health care plans consisting of the two subgroups GK and MC. These data were presented as means in the case of continuous variables and as percentages in case of categorical variables. Differences with respect to age, sex, deductible class, supplementary private hospital insurance coverage, language area, inpatient CA, cardiac medication class according to ATC, number of chronic medical conditions identified using PCGs and high risk status (patients having received therapeutic cardiac intervention/diagnosis within one month after and/or 18 months prior to diagnostic CA) were analyzed with a nonparametric analysis of variance (Kruskal-Wallis test for continuous variables and chi-square tests for categorical variables). We developed several statistical models to evaluate the major outcome of receiving NIIT within two months prior CA depending on the health care plan. Two different models were investigated: 1) using the federal definition of voluntary health care plans which includes all insurance plans with limited health care access, meaning GK as well as managed MC plans. 2) GK versus MC plans. In order to assess patient-level effects the following additional independent variables were included in the models: age, sex, deductible class, supplementary private hospital insurance coverage, language area, inpatient CA, cardiac medication class according to ATC, number of chronic medical conditions identified using PCGs and high risk status. The strength of associations was measured by the odds ratio (OR) and the respective 95% confidence intervals (CI). The level of significance was set at 0.05. All statistical analyses were performed using R version 3.3.1 (2016-06-21) (R Foundation for Statistical Computing, Vienna, Austria) [21 22].

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Ethics approval

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

Results

Population

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

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

Table 1 Descriptive statistics of the study population grouped into non-limited and 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%)	

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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%)	

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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%)	

*NIIT: Non-invasive ischemia testing. 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 non limited access and limited access group: *** p<0.0001, ** p<0.001, *p<0.01.*

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

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

Non-invasive ischemia testing

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

Determinants for non-invasive ischemia testing

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

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

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*medication, number of chronic comorbidities and high risk status. * p<0.001 8 (OR 1.17) for managed care compared to standard health care plan.*

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

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

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

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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 | ***

309

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.*

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Discussion

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

Effects of limited access health care plans on treatment quality

It has been assumed that patients insured in limited access health care plans undergo less diagnostic procedures or interventions due to budget considerations. In our study, this hypothesis is refuted. Patients insured in limited access health care plans not only underwent a more appropriate diagnostic pathway than regularly insured patients did, they even received more non-invasive diagnostic testing, which resulted in less inadequate CA. Our findings are in line with studies showing that being insured in MC models is associated with a survival benefit by promoting better preventive and higher quality of care [23-25]. Especially among Medicare beneficiaries, which are prone to multimorbidity, this effect has been shown [26]. These models have also shown lower prevalence of potentially inappropriate medication use in elderly patients and a lower disease specific hospitalization rate in chronically ill patients [16 17].

Our study raises the question why patients in limited access health care plans receive a more appropriate diagnostic pathway in this clinical situation of stable angina pectoris. There has been evidence for and against the theory that patients enrolled in a MC insurance model are healthier due to biased selection [27-36] and commercial considerations of the MC insurer [37 38]. In our study population patients insured in limited access plans showed some evidence of being healthier than

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regularly insured patients. Nevertheless being insured only in MC but not GK plans was *independently* associated with a higher rate of NIIT, controlled for all the differences in patient characteristics. It is clear that physicians participating in MC plans are obliged to keep diagnostic and treatment costs as low as possible while keeping up with quality concerns. One could therefore argue that it is cheaper to not to choose a diagnostic detour over NIIT instead of choosing the straight forward way of sending a patient to the more invasive CA which offers a clear answer to an uncertain clinical situation including the option of therapeutic action. It seems that MC health care providers have understood what Meara et al. have summed up accurately: "Reductions in spending for patients must be a result of decreases in the provision of services. If these are needed services, quality of care will decline. Alternatively, quality of care might be higher in low expenditure areas if differences in spending result from reductions in unnecessary or inappropriate services [39]". Besides this intuitive statement there has been scientific evidence that a diagnostic detour is worthwhile taking, since it sums up in reduced peri and post interventional costs without loss in quality [11]. Our study is not able to answer the questions why patients in limited access models received a more appropriate diagnostic approach. One can only hypothesize that coordination of care is straighter forward in the limited access setting and the indication for invasive and expensive diagnostic procedures is more thoroughly scrutinized especially in the GK models, which include capitation.

Determinants for NIIT

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

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argument for CA besides the clinical evaluation. Our theory is supported by the "2014 ESC/EACTS Guidelines on Myocardial Revascularization which state: "regional wall motion abnormalities may be detected in simple echocardiography, which increase the likelihood of coronary artery disease". Since the inclusion of this additional test leads to underestimation of "real" NIIT performed, the findings only strengthen our hypothesis.

Since our study lacks clinical data, only indirect hints by means of PCG and ATC codes as well as other confounders are available to assess clinical reasoning. The association between the use of platelet aggregation inhibitors or antithrombotic agents and antihypertensive medication with receiving NIIT before CA suggest a reasonable deliberation in the sense of estimating pretest probability when deciding on optimal diagnostic strategy. The same counts for the association of high-risk status and a larger number of chronic comorbidities as determinants for not receiving NIIT prior to elective CA. This finding is consistent with two US studies indicating that risk stratification was performed, considering the higher likelihood of a coronary pathology in patients with known coronary heart disease [8 10]. In our study, non-clinical factors seem to influence decision-making processes concerning diagnostic pathways, reflected by the findings that being privately insured and a deductible of 2000 SFR were positively and inpatient treatment negatively independently associated with NIIT.

<u>Reinforcing quality control mechanisms in a non-gate keeping health care system</u>

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

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might lead to inappropriate and possibly dangerous health care utilization as well as increasing expenditures. A positive example here fore is the implementation of national registries [40] combined with quality initiatives, such as the in 2009 published Appropriate Use Criteria for Coronary Revascularization [9 40 41]. In 2011, the registry started giving feedbacks on the participating hospital's performance concerning appropriateness of CA including a benchmarking against other participating institutions. At the same time the American Board of Internal Medicine's Choosing Wisely initiative launched national quality improvement campaigns, identifying CA appropriateness as a key area for intervention [42]. As a consequence insurance companies incorporated measures of CA appropriateness into pay-for-performance programs [43] and reimbursement was declined for certain CA identified as inappropriate [44]. The combination of implementing national registries combined with quality initiatives had been proven amazingly effective, showing a decrease of non-acute CA classified as inappropriate from 26.2% to 13.3% [45]. In Switzerland currently no registries on CA exist, hence other solutions for influencing treatment pathways have to be developed besides offering voluntary limited access health care plans. A possible alternative solution to the conundrum of reducing costs without cutting quality seems hence to be paying for outcomes instead of volume. As the findings of our study suggest, a possible approach is to raise the market share of MC to such a volume that it might also affect care for fee-for-service patients [39]. As Meara et al have summarized, the effects have been show to play in a variety of ways: more MC in a market might lower expenditures by reducing the number of specialists, and thereby the number of specialists' services provided [46 47] by encouraging more conservative practice patterns [46 47], or by slowing the diffusion of more costly technologies [46 48].

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Strengths and limitations

Only scarce data on non-emergency CA exists in literature. The only data found originates from the US among Medicare as well as commercially insured patients and from Switzerland, both non-gate keeping health care systems. Whether the proportion of inappropriate diagnostic CA from our study can be translated to other non-gate keeping health care systems is difficult to estimate, since substantial variation in the proportion of non-acute PCIs considered inappropriate across hospitals can be found, ranging from about 6% to 70% [8 10 14 15 45]. From a previous study from Switzerland [12] similar proportions were found, suggesting generalizability of our data. The current study seems even more representative than the previous Swiss study, since it included data over a longer time-period with consecutively larger amount of patients and corresponding data. Since the study is based on insurance claims data, no data on socioeconomic status and clinical information is available.

Conclusions

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

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Competing interests

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

Authors Contributions

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

Consent for publication

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

Availability of data and materials

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

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premises of the Helsana research group by the statistician AS in collaboration with the authors OR and CC and administrative permission was received to access de-identified data by the researchers from the University of Zurich.

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Supplemental Material

Supplemental Methods/Definitions

1) Inclusion Criteria

Tarmed	17.071
	17.074
	17.101
	17.109
	17.181
	17.182
DRG	F49D
	F49E
	F49F

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

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

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

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2) Exclusion Criteria

Acute cardiac ischemia and/or emergency procedures	Tarmed	0.2510
		0.2520
		0.2540
		0.2560
		0.2580
		35.0610
	DRG	F41A
		F41B
Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting, without myocardial infarction)	Tarmed	17.1110
		17.1240
	DRG	F15Z
		F19Z
		F24B
		F49A
		F49C
		F52A
		F52B
		F54Z
		F56A
		F56B
		F57A
		F57B
		F58Z

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F59A

F59B

Incomplete coverage of mandatory basic health insurance 18 months before and/or 1 month after CA

Patients <18 years

3) Diagnostic Procedures

Tarmed	17.0010: Electrocardiogram (ECG): not considered as NIIT, only in combination with other NIIT
	17.0050: Cardiac intervention with medication under continuous registration of ECG: not considered as NIIT, only in combination with another NIIT
	17.0060: ECG performed by specialist outside of the practice or hospital: not considered as NIIT, only in combination with another NIIT
	17.0080 and 17.0090: Stress-ECG
	17.0210: Echocardiography, transthoracic, qualitative and quantitative examination of adult
	17.0280: Stressechocardiography, physical stress
	17.0290: Stressechocardiography, medication stress
	31.0260: Scintigraphy physiologically triggered
	39.4060: Computed tomography of entire thorax and/or sternoclavicular joint
	39.5100 Heart MRI
DRG	No separate codes available for inpatient diagnostic procedures, only for therapeutic interventions

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4) High risk patients

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

Tarmed	0.2510
	0.2520
	0.2540
	0.2560
	0.2580
	35.0610
	17.1110
	17.1240
	And all 18.001until/including 18.0740
DRG	all Chapter F

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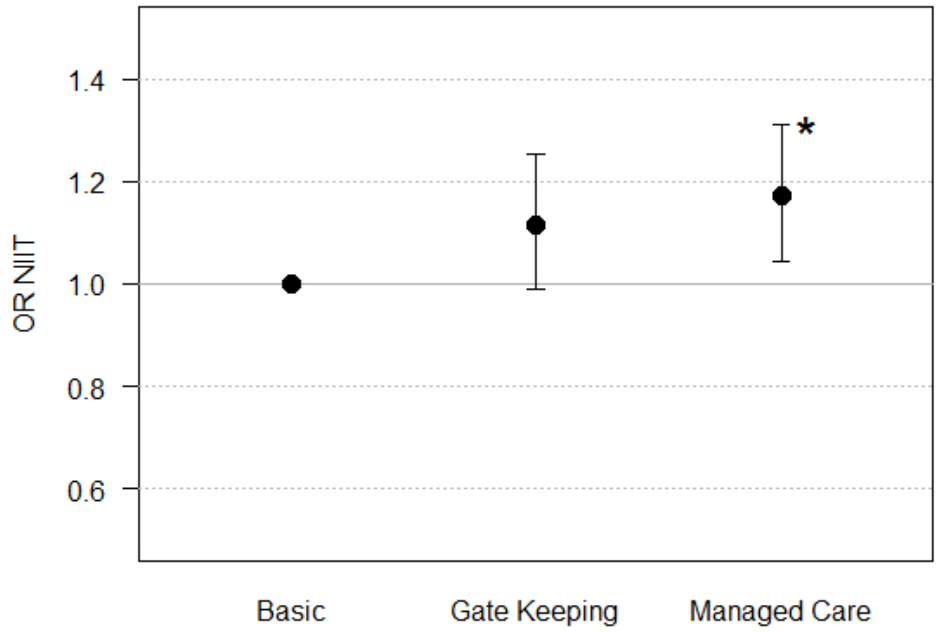

Figure 1: Distribution of NIIT performed according to health care plan.
OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high risk status. * p<0.001 8 (OR 1.17) for managed care compared to standard health care plan.

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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			

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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	9-14
		(b) Give reasons for non-participation at each stage	9-14
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-14
		(b) Indicate number of participants with missing data for each variable of interest	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	9-14
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	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.

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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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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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Abstract

Objective

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

Design:

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

Results

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

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

Conclusions

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

Article summary

- Highly relevant topic concerning inappropriate use of a potentially harmful and expensive procedure such as the CA
- Only scarce data on non-emergency CA exists in literature
- Data originates from a single health insurance group in Switzerland, although one of the largest in the country, including data on health insurance claims from approximately 1.2 million patients
- No data on socioeconomic status and clinical information is available

Key Words

- Elective coronary angiography
- Managed care
- Gate keeping
- Inappropriate
- Voluntary health care models
- Limited access insurance models
- Non-invasive ischemia testing

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Introduction

Existing guidelines [1-7] recommend non-invasive ischemia testing (NIIT) for the majority of patients with suspected ischemic heart disease in a non-emergency setting. Nevertheless, a substantial amount of these patients undergo diagnostic coronary angiography (CA) without therapeutic intervention inappropriately, and are therefore exposed to unnecessary risks without any clinical benefit [8-15]. In a non-gate keeping health care system such as Switzerland, hardly any steering mechanisms exist to ensure that potentially harmful and expensive procedures are only performed in case of correct indication. The admitting physician (mainly general practitioner or cardiologist) usually sets the indication for the intervention and the performing invasive centers rarely decline assigned patients due to economic reasons or in order not to disagree with the admitting physician.

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

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

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analysis of insurance claims data on diagnostic procedures undertaken within two months before CA depending on the health care model.

Materials and Methods

Setting

Swiss residents are obliged to enroll in a basic health care model, which covers all costs besides deductibles. Depending on the model chosen, annual deductibles for adults vary between 300 and 2500 Swiss Francs. A patient copayment of 10% of all costs up to a maximum of 700 Swiss Francs per year is payable independent of the chosen health care model. Currently residents can chose a basic health care model from 53 different insurance companies. In general, in Switzerland no gate-keeping system exists, meaning that patients have unlimited access to all healthcare providers, unless they are voluntarily insured in a limited access model. Patients agree to a restriction of choice or limited access in exchange of lower premiums. In such limited access models, the general practitioner or an insurance telephone hotline have to be consulted before contacting a specialist or another institution such as a hospital. In case of emergency, this regulation is overruled. In Switzerland, the currently existing limited access models can be summarized into two types of models: 1) GK models with steering mechanisms, such as prior consultation of a telemedicine center for example, and 2) MC models with capitation. In the capitation system, the health insurance company reimburses the health care providers, usually physician networks, with a set amount for each enrolled patient assigned to them per period of time, whether or not that person seeks care. The remuneration is based on the average expected health care utilization of each individual patient, with greater payment for patients with significant medical history or chronic conditions. Compared

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

Subjects, data collection and measurements

Data for this study included health insurance claims from approximately 1.2 million patients, which live all over Switzerland and were enrolled with the Helsana Group. Data on patients undergoing CA in the years 2012 to 2015 were retrospectively analyzed. Detailed TARMED (Standard billing rate for outpatient medical care in Switzerland, version 2014) and Diagnosis Related Groups (DRG, version 2012) positions are specifoed in the Supplemental Material.

Inclusion criteria

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

Exclusion criteria

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

Measurements

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

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- NIIT performed within two months prior to CA (stress-ECG, echocardiography, stress echocardiography, scintigraphy, computed tomography, cardiac MRI)
- Cardiovascular Medication grouped according to Anatomical-Therapeutic-Chemical-Classification (ATC) [18]
    - Group 1: Aspirin, platelet aggregation inhibitors
    - Group 2: statins, lipid modifying agents
    - Group 3: antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system
    - Group 4: antidiabetics
    - Group 5: antianginous drugs
    - Gruop 6: antithrombotics
- Number of chronic conditions according to Pharmaceutical cost groups PCG [19] [20]
    - Group 1: pcg_n < 3 0, 1 or 2 PCGs
    - Group 2: pcg_n < 5 3 to 4 PCGs
    - Group 3: pcg_n < 7 5 to 6 PCGs
    - Group 4: pcg_n ≥ 7 7 or more PCGs

Sensitivity Analysis with high-risk patients

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

Patient and public involvement

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

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Processing and analyzing data

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

Statistical analysis

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

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set at 0.05. All statistical analyses were performed using R version 3.3.1 (2016-06-21) (R Foundation for Statistical Computing, Vienna, Austria) [21 22].

Ethics approval

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

Results

Population

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

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

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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)					
				GK (n=1'816)			MC (n=2'099)		
	No NIIT (n=1'818)	With NIIT (n=3'440)		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	

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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	

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>6	283	392		54	101		78	142	

*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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Patients insured in basic health care models were slightly older (67.7 (11.6) vs. 66.6 (11.6) years, p<0.0001), chose the lowest possible deductible of 300 Francs more often (3'617 (68.8%) vs. 2'504 (64.0%), p<0.001), were enrolled in a supplementary private hospital insurance more often (1'418 (27.0%) vs. 866 (22.1%), p<0.0001), had more antidiabetics (787 (15%) vs 489 (12.5%), p<0.0001) and antianginal medication (825 (15.7%) vs 508 (13.0%), p<0.0001), more PCGs (4.1 (2.1) vs. 3.6 (2.0), p<0.0001) and had more often a high-risk status (2'696 (51.3%) vs. 1'814 (46.3%), p<0.0001), compared to patients insured in limited access models. Concerning the other patient characteristics, no differences existed.

Non-invasive ischemia testing

488 (33.8 %) of patients without NIIT had a conventional ECG prior to CA, in the high-risk population this was the case in 722 (45.2%) (p<0.0001). The most NIITs stress-ECG + transthoracic echocardiography were performed significantly more often before CA in patients insured in limited access compared to non-limited access models (1'750 (44.7%) vs. 2'039 (38.8 %) p<0.0001, and 2'044 (52.2%) and 2'528 (48.1%), p<0.0001). The remaining types of NIIT were rarely performed and only showed a significant difference in the use of scintigraphy (non-limited 131 (2.5%) vs. limited access models 64 (1.6%), p<0.001).

Determinants for non-invasive ischemia testing

Patients with MC models were 17% significantly more likely to receive NIIT before CA compared to patients with non-limited models, when controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high-risk status (OR 1.17, p<0.001). GK models did not show any significant influence on the chance of receiving NIIT

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

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

*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 non-limited access model (Reference).*

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

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

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

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2500		0.809 - 1.289	1.022	
Private		1.025 - 1.267	1.140	*
French or Italian part of Switzerland		0.841 - 1.044	0.937	
Inpatient CA		0.540 - 0.664	0.599	***
ATC group				
1		1.251 - 1.620	1.423	***
2		0.922 - 1.135	1.023	
3		1.002 - 1.218	1.104	*
4		0.851 - 1.115	0.974	
5		0.874 - 1.130	0.994	
6		1.034 - 1.356	1.184	*
PCG (reference <3)				
<5		0.940 - 1.192	1.058	
<7		0.809 - 1.064	0.928	
>=7		0.624 - 0.881	0.742	***
Limited access models (reference non-limited access)				
Managed Care		1.045 - 1.312	1.171	**
Gate Keeping		0.991 - 1.253	1.114	
High-risk cardiac status		0.046443	0.836	***

*CI: confidence interval, OR: odds ratio, Sig: significance: *** p<0.0001, ** p<0.001 *p<0.01, Private: supplementary private hospital insurance, 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*

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groups. High-risk patients: having received therapeutic cardiac intervention within one month after or 18 months prior to diagnostic CA.

Discussion

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

Effects of limited access health care models on treatment quality

In our study, emergency CA were excluded and the study population consisted of patients undergoing purely diagnostic elective CA with no therapeutic consequence (e.g. no coronary angioplasty/stenting or coronary artery by-pass grafting). The study population therefore represents a selection of patients with at least stable CHD or no CHD at all. From a previous study among this selection of patients we know, that 37.5% did not receive any NIIT at all before elective CA with no therapeutic consequence, suggesting a substantial overuse of a potentially harmful and inappropriate diagnostic intervention [12]. It has been assumed that patients insured in limited access health care models undergo less diagnostic procedures or interventions due to budget considerations, especially in capitated health care models. In our study, this hypothesis is clearly refuted. Patients with stable angina pectoris insured in limited access health care models underwent a more appropriate diagnostic pathway than regularly insured patients did, meaning in a stable clinical situation they were subjected to significantly more non-invasive diagnostic testing,

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therefore reducing inadequate CA. Our findings are in line with another study from the Swiss health care system, which also showed higher referral rates among MC patients compared to patients insured in basic health care models [23]. One reason for that finding could be that general practitioners in most networks are forced to consider evidence based guidelines, which is not mandatory for general practitioners which are not member of a network . Other studies showed that being insured in MC models is associated with a survival benefit by promoting better preventive and higher quality of care [24-26]. Especially among Medicare beneficiaries, which are prone to multimorbidity, this effect has been shown [27]. These models have also shown lower prevalence of potentially inappropriate medication use in elderly patients and a lower disease specific hospitalization rate in chronically ill patients [16 17].

Our study raises the question why patients in limited access health care models receive a more appropriate diagnostic pathway in this clinical situation of stable angina pectoris. There has been evidence for and against the theory that patients enrolled in a MC health care model are healthier due to biased selection [28-37] and commercial considerations of the MC insurer [38 39]. In our study population, patients insured in limited access models showed some evidence of being healthier than regularly insured patients. Nevertheless being insured only in MC but not GK models was *independently* associated with a higher rate of NIIT, controlled for all the differences in patient characteristics. It is clear that physicians participating in MC models are obliged to keep diagnostic and treatment costs as low as possible while keeping up with quality concerns. One could therefore argue that it is cheaper to not to choose a diagnostic detour over NIIT instead of choosing the straight forward way of sending a patient to the more invasive CA, which offers a clear answer to an uncertain clinical situation including the option of therapeutic action. It seems that MC health care providers have understood what Meara et al. have summed up

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accurately: “Reductions in spending for patients must be a result of decreases in the provision of services. If these are needed services, quality of care will decline. Alternatively, quality of care might be higher in low expenditure areas if differences in spending result from reductions in unnecessary or inappropriate services [40]”. Besides this intuitive statement there has been scientific evidence that a diagnostic detour is worthwhile taking, since it sums up in reduced peri and post interventional costs without loss in quality [11]. Our study is not able to answer the questions why patients in limited access models received a more appropriate diagnostic approach. One can only hypothesize that a more rigorous coordination of care, as performed in the MC models, is straighter forward and the indication for invasive and expensive diagnostic procedures is more thoroughly scrutinized.

Determinants for NIIT

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

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

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agents and antihypertensive medication with receiving NIIT before CA suggest a reasonable deliberation in the sense of estimating pretest probability when deciding on optimal diagnostic strategy. The same counts for the association of high-risk status and a larger number of chronic comorbidities as determinants for not receiving NIIT prior to elective CA. This finding is consistent with two US studies indicating that risk stratification was performed, considering the higher likelihood of a coronary pathology in patients with known coronary heart disease [8 10]. In our study, also non-clinical factors seem to influence decision-making processes concerning diagnostic pathways, reflected by the findings that being privately insured and a deductible of 2000 SFR were positively and inpatient treatment negatively independently associated with NIIT.

As previously observed in another Swiss study analyzing inappropriate use of arthroscopic meniscal surgery in degenerative knee disease [41], a substantial amount of the patients in our sample underwent CA as inpatients in contrast to other health care settings. This finding is most likely explained by differences in the organization of the health care system in Switzerland. Here regional governments subsidize inpatient treatment covering approximately 50% of total costs, and patients with supplementary private insurance receive a substantially higher reimbursement when treated as inpatients. Nevertheless, in the regression analysis with the outcome proportion of NIIT, we controlled for potential confounders, such as inpatient treatment as well. The results therefore seem robust concerning the question whether limited access health care models have a significant impact on the appropriateness of the diagnostic approach.

<u>Reinforcing quality control mechanisms in a non-gate keeping health care system</u>

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Besides the existing voluntary steering mechanisms such limited access health care models guided by patient's preferences only, more alternative steering mechanisms have to be implemented in non-gate keeping health care systems, in order to minimize the influence of non-clinical factors on medical decision making, which might lead to inappropriate and possibly dangerous health care utilization as well as increasing expenditures. A positive example for alternative steering mechanisms is the implementation of national registries [42] combined with quality initiatives, such as the in 2009 published Appropriate Use Criteria for Coronary Revascularization [9 42 43]. In 2011, the registry started giving feedbacks on the participating hospital's performance concerning appropriateness of CA including a benchmarking against other participating institutions. At the same time the American Board of Internal Medicine's Choosing Wisely initiative launched national quality improvement campaigns, identifying CA appropriateness as a key area for intervention [44]. As a consequence insurance companies incorporated measures of CA appropriateness into pay-for-performance programs [45] and reimbursement was declined for certain CA identified as inappropriate [46]. The combination of implementing national registries combined with quality initiatives had been proven amazingly effective, showing a decrease of non-acute CA classified as inappropriate from 26.2% to 13.3% [47]. In Switzerland currently no registries on CA exist, hence other solutions for influencing treatment pathways have to be developed, besides offering voluntary limited access health care models. A possible alternative solution to the conundrum of reducing costs without cutting quality seems hence to be paying for outcomes instead of volume. As the findings of our study suggest, a possible approach is to raise the market share of MC to such a volume that it might also affect care for fee-for-service patients [40]. As Meara et al have summarized, the effects have been show to play in a variety of ways: more MC in a market might lower expenditures by reducing the

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number of specialists, and thereby the number of specialists' services provided [48 49] by encouraging more conservative practice patterns [48 49], or by slowing the diffusion of more costly technologies [48 50].

Strengths and limitations

Only scarce data on non-emergency CA exists in literature. The only data found originates from the US among Medicare as well as commercially insured patients and from Switzerland, both non-gate keeping health care systems. Whether the proportion of inappropriate diagnostic CA from our study can be translated to other non-gate keeping health care systems is difficult to estimate, since substantial variation in the proportion of non-acute PCIs considered inappropriate across hospitals can be found, ranging from about 6% to 70% [8 10 14 15 47]. From a previous study from Switzerland 12 similar proportions were found, suggesting generalizability of our data. The current study seems even more representative than the previous Swiss study, since it included data over a longer time-period with consecutively larger amount of patients and corresponding data. Since the study is based on insurance claims data, no data on socioeconomic status and clinical information is available. Given that this is a cross-sectional observational study, rather than an interventional one, the only conclusions that we can draw are of association rather than causation. Due to the study design, unfortunately no estimations on clinical outcome parameters can be made. For example, in order to explore clinical appropriateness, the proportion of CA's avoided by performing NIIT would be of great interest. As a substitute for clinical data, ATC and PCG are used, offering only indirect information on comorbidities. On the other hand PCGs represent a strength, since they have been shown to directly correlate with associated health care costs [19]. Due to data structure, it is not possible to distinguish between CT angiography (including

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intravenous contrast) and CT without intravenous contrast. Therefore, all CTs of the chest were included in analysis. Since the inclusion of this broader NIIT definition leads to underestimation of "real" NIIT performed, the findings only strengthen our hypothesis.

Conclusions

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

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Competing interests

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

Authors Contributions

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

Consent for publication

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

Availability of data and materials

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

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premises of the Helsana research group by the statistician AS in collaboration with the authors OR and CC and administrative permission was received to access de-identified data by the researchers from the University of Zurich.

Figure Legend

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

*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 non-limited access model (Reference).*

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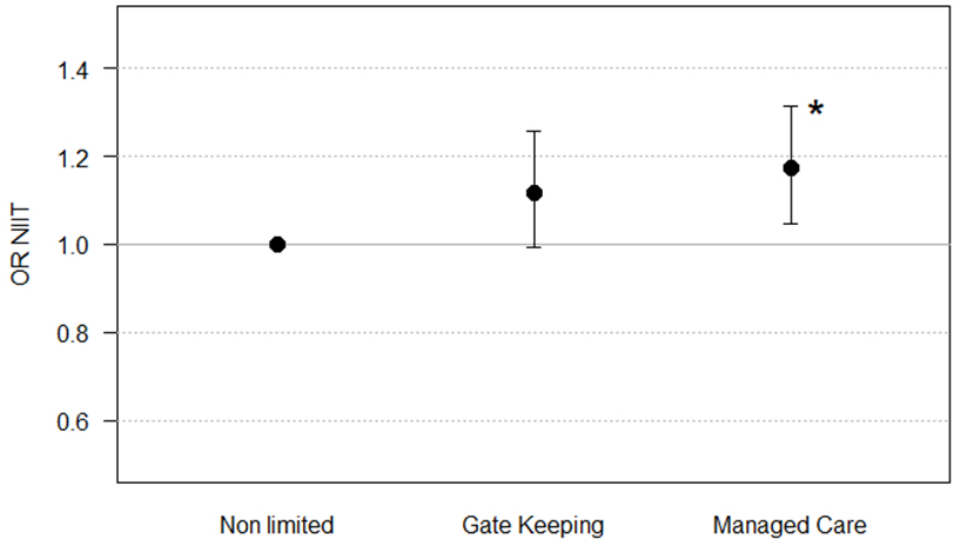

OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high- risk status. * p<0.001 8 (OR 1.17) for managed care model compared to standard health care plannon-limited access model (Reference).

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Supplemental Material

Supplemental Methods/Definitions

1) Inclusion Criteria

Tarmed	17.071
	17.074
	17.101
	17.109
	17.181
	17.182
DRG	F49D
	F49E
	F49F

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

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

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

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2) Exclusion Criteria

Acute cardiac ischemia and/or emergency procedures	Tarmed	0.2510
		0.2520
		0.2540
		0.2560
		0.2580
		35.0610
	DRG	F41A
		F41B
Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting, without myocardial infarction)	Tarmed	17.1110
		17.1240
	DRG	F15Z
		F19Z
		F24B
		F49A
		F49C
		F52A
		F52B
		F54Z
		F56A
		F56B
		F57A
		F57B
		F58Z

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F59A

F59B

Incomplete coverage of mandatory basic health insurance 18 months before and/or 1 month after CA

Patients <18 years

3) Diagnostic Procedures

Tarmed	17.0010: Electrocardiogram (ECG): not considered as NIIT, only in combination with other NIIT
	17.0050: Cardiac intervention with medication under continuous registration of ECG: not considered as NIIT, only in combination with another NIIT
	17.0060: ECG performed by specialist outside of the practice or hospital: not considered as NIIT, only in combination with another NIIT
	17.0080 and 17.0090: Stress-ECG
	17.0210: Echocardiography, transthoracic, qualitative and quantitative examination of adult
	17.0280: Stressechocardiography, physical stress
	17.0290: Stressechocardiography, medication stress
	31.0260: Scintigraphy physiologically triggered
	39.4060: Computed tomography of entire thorax and/or sternoclavicular joint
	39.5100 Heart MRI
DRG	No separate codes available for inpatient diagnostic procedures, only for therapeutic interventions

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4) High risk patients

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

Tarmed	0.2510
	0.2520
	0.2540
	0.2560
	0.2580
	35.0610
	17.1110
	17.1240
	And all 18.001until/including 18.0740
DRG	all Chapter F

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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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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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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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Abstract

Objective

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

Design:

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

Results

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

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

Conclusions

In a non-gate keeping health care system voluntary MC health care models with capitation were associated with a reduced inappropriate use of diagnostic CA compared to basic models.

Strengths and Limitations

- Highly relevant topic concerning inappropriate use of a potentially harmful and expensive procedure such as the CA
- Only scarce data on non-emergency CA exists in literature originating from different health care settings
- Data originates from a single health insurance group in Switzerland, although one of the largest in the country, including data on health insurance claims from approximately 1.2 million patients.
- No data on socioeconomic status and clinical information is available

Key Words

- Elective coronary angiography
- Managed care
- Gate keeping
- Inappropriate
- Voluntary health care models
- Limited access insurance models
- Non-invasive ischemia testing

Introduction

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Existing guidelines [1-7] recommend non-invasive ischemia testing (NIIT) for the majority of patients with suspected ischemic heart disease in a non-emergency setting. Nevertheless, a substantial amount of these patients undergo diagnostic coronary angiography (CA) without therapeutic intervention inappropriately, and are therefore exposed to unnecessary risks without any clinical benefit [8-15]. In a non-gate keeping health care system such as Switzerland, hardly any steering mechanisms exist to ensure that potentially harmful and expensive procedures are only performed in case of correct indication. The admitting physician (mainly general practitioner or cardiologist) usually sets the indication for the intervention and the performing invasive centers rarely decline assigned patients due to economic reasons or in order not to disagree with the admitting physician.

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

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

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analysis of insurance claims data on diagnostic procedures undertaken within two months before CA depending on the health care model.

Materials and Methods

Setting

Swiss residents are obliged to enroll in a basic health care model, which covers all costs besides deductibles. Depending on the model chosen, annual deductibles for adults vary between 300 and 2500 Swiss Francs. A patient copayment of 10% of all costs up to a maximum of 700 Swiss Francs per year is payable independent of the chosen health care model. Currently residents can chose a basic health care model from 53 different insurance companies. In general, in Switzerland no gate-keeping system exists, meaning that patients have unlimited access to all healthcare providers, unless they are voluntarily insured in a limited access model. Patients agree to a restriction of choice or limited access in exchange of lower premiums. In such limited access models, the general practitioner or an insurance telephone hotline have to be consulted before contacting a specialist or another institution such as a hospital. In case of emergency, this regulation is overruled. In Switzerland, the currently existing limited access models can be summarized into two types of models: 1) GK models with steering mechanisms, such as prior consultation of a telemedicine center for example, and 2) MC models with capitation. In the capitation system, the health insurance company reimburses the health care providers, usually physician networks, with a set amount for each enrolled patient assigned to them per period of time, whether or not that person seeks care. The remuneration is based on the average expected health care utilization of each individual patient, with greater payment for patients with significant medical history or chronic conditions. Compared

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

Subjects, data collection and measurements

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

Inclusion criteria

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

Exclusion criteria

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

Measurements

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

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health care model)

- Setting of CA: inpatient or outpatient
- NIIT performed within two months prior to CA (stress-ECG, echocardiography, stress echocardiography, scintigraphy, computed tomography, cardiac MRI)
- Cardiovascular Medication grouped according to Anatomical-Therapeutic-Chemical-Classification (ATC) [18]
    - Group 1: Aspirin, platelet aggregation inhibitors
    - Group 2: statins, lipid modifying agents
    - Group 3: antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system
    - Group 4: antidiabetics
    - Group 5: antianginous drugs
    - Group 6: antithrombotics
- Number of chronic conditions according to Pharmaceutical cost groups PCG [19] [20]
    - Group 1: pcg_n < 3 0, 1 or 2 PCGs
    - Group 2: pcg_n < 5 3 to 4 PCGs
    - Group 3: pcg_n < 7 5 to 6 PCGs
    - Group 4: pcg_n ≥ 7 7 or more PCGs

Sensitivity Analysis with high-risk patients

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

Patient and public involvement

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

Processing and analyzing data

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

Statistical analysis

Descriptive statistical techniques (Table 1) were used, to provide a general profile of the study population and grouped into totally three groups of patients: patients with non-limited and limited access health care models (GK and MC). The descriptive statistics were performed pairwise for each health care model separately. These data were presented as means in the case of continuous variables and as percentages in case of categorical variables.

Differences within the health care models (Appendix 2) with respect to the continuous variable age were analyzed with a nonparametric analysis of variance Kruskal-Wallis test. The variables with two levels (sex, high-risk status (patients having received therapeutic cardiac intervention/diagnosis within one month after and/or 18 months prior to diagnostic CA), supplementary private hospital insurance coverage, language area, inpatient CA, medication class according to ATC) were analyzed with an exact fisher test. The number of chronic medical conditions identified using PCG and the deductible class were compared with a chi square test.

We performed a logistic regression analysis to evaluate the independent association between receiving NIIT within two months prior to CA and the various health care models (Figure 1 and Table 2). In order to assess patient-level effects, the following additional independent variables were included in the regression analysis: age, sex,

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deductible class, supplementary private hospital insurance coverage, language area, inpatient CA, cardiac medication class according to ATC, number of chronic medical conditions identified using PCGs and high-risk status. Goodness of fit measures for the model were: Nagelkerke 0.051, BrierScore 0.213, C-Statistic 0.618. The strength of associations was measured by the odds ratio (OR) and the respective 95% confidence intervals (CI). The level of significance was set at 0.05. All statistical analyses were performed using R version 3.3.1 (2016-06-21) (R Foundation for Statistical Computing, Vienna, Austria) [21 22].

Ethics approval

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

Results

Population

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

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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)**					
				GK (n=1'816)			**MC (n=2'099)**		
	No NIIT (n=1'818)	**With NIIT (n=3'440)**		**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	

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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	

231

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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 (Categorical variable, an individual can be positive for several ATC groups). 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 non-limited access 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 comparisons between NIIT and no NIIT for each health insurance model separately.*

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Patients insured in basic health care models were slightly older (67.7 (11.6) vs. 66.6 (11.6) years, p<0.0001), chose the lowest possible deductible of 300 Francs more often (3'617 (68.8%) vs. 2'504 (64.0%), p<0.001), were enrolled in a supplementary private hospital insurance more often (1'418 (27.0%) vs. 866 (22.1%), p<0.0001), had more antidiabetics (787 (15%) vs 489 (12.5%), p<0.0001) and antianginal medication (825 (15.7%) vs 508 (13.0%), p<0.0001), more PCGs (4.1 (2.1) vs. 3.6 (2.0), p<0.0001) and had more often a high-risk status (2'696 (51.3%) vs. 1'814 (46.3%), p<0.0001), compared to patients insured in limited access models (Appendix 2). Concerning the other patient characteristics, no differences existed.

Non-invasive ischemia testing

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

Determinants for non-invasive ischemia testing

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

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

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

*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 non-limited access model (Reference).*

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

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

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

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	1500	0.841 - 1.374	1.075	
	2000	1.082 - 4.381	2.177	*
	2500	0.809 - 1.289	1.022	
	Private	1.025 - 1.267	1.140	*
	French or Italian part of Switzerland	0.841 - 1.044	0.937	
	Inpatient CA	0.540 - 0.664	0.599	***
	ATC group 1-6			
	1	1.251 - 1.620	1.423	***
	2	0.922 - 1.135	1.023	
	3	1.002 - 1.218	1.104	*
	4	0.851 - 1.115	0.974	
	5	0.874 - 1.130	0.994	
	6	1.034 - 1.356	1.184	*
	PCG (reference <3)			
	<5	0.940 - 1.192	1.058	
	<7	0.809 - 1.064	0.928	
	>=7	0.624 - 0.881	0.742	***
	Limited access models (reference non-limited access)			
	Managed Care	1.045 - 1.312	1.171	**
	Gate Keeping	0.991 - 1.253	1.114	
	High-risk cardiac status	0.046443	0.836	***

*CI: confidence interval, OR: odds ratio, Sig: significance: *** p<0.0001, ** p<0.001 *p<0.01, Private: supplementary private hospital insurance, 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*

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acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6: antithrombotics (Categorical variable, an individual can be positive for several ATC groups). 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.

Discussion

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

Effects of limited access health care models on treatment quality

In our study, emergency CA were excluded and the study population consisted of patients undergoing purely diagnostic elective CA with no therapeutic consequence (e.g. no coronary angioplasty/stenting or coronary artery by-pass grafting). The study population therefore represents a selection of patients with at least stable CHD or no CHD at all. From a previous study among this selection of patients we know, that 37.5% did not receive any NIIT at all before elective CA with no therapeutic consequence, suggesting a substantial overuse of a potentially harmful and inappropriate diagnostic intervention [12]. It has been assumed that patients insured in limited access health care models undergo less diagnostic procedures or interventions due to budget considerations, especially in capitated health care models. In our study, this hypothesis is clearly refuted. Patients with stable angina pectoris insured in limited access health care models underwent a more appropriate

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diagnostic pathway than regularly insured patients did, meaning in a stable clinical situation they were subjected to significantly more non-invasive diagnostic testing, therefore reducing inadequate CA. Our findings are in line with another study from the Swiss health care system, which also showed higher referral rates among MC patients compared to patients insured in basic health care models [23]. One reason for the more appropriate diagnostic pathway found in MC patients might be the aspect of membership in a general practitioners network. In most parts of Switzerland, general practitioners can only offer MC insurance models to their patients, if they are member in a general practitioners network. These networks offer evidence-based guidelines, which the general practitioners are obliged to respect when initiating treatment. Depending on the network, more or less rigorous quality control mechanisms exist to check whether the guidelines are followed, when applicable. General practitioners, which are not member in a network, therefore are less bound to evidence based treatment pathways.. Other studies showed that being insured in MC models is associated with a survival benefit by promoting better preventive and higher quality of care [24-26]. Especially among Medicare beneficiaries, which are prone to multimorbidity, this effect has been shown [27]. These models have also shown lower prevalence of potentially inappropriate medication use in elderly patients and a lower disease specific hospitalization rate in chronically ill patients [16 17].

Our study raises the question why patients in limited access health care models receive a more appropriate diagnostic pathway in this clinical situation of stable angina pectoris. There has been evidence for and against the theory that patients enrolled in a MC health care model are healthier due to biased selection [28-37] and commercial considerations of the MC insurer [38 39]. In our study population, patients insured in limited access models showed some evidence of being healthier than regularly insured patients. Nevertheless being insured only in MC but not GK models

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was *independently* associated with a higher rate of NIIT, controlled for all the differences in patient characteristics. It is clear that physicians participating in MC models are obliged to keep diagnostic and treatment costs as low as possible while keeping up with quality concerns. One could therefore argue that it is cheaper to not to choose a diagnostic detour over NIIT instead of choosing the straight forward way of sending a patient to the more invasive CA, which offers a clear answer to an uncertain clinical situation including the option of therapeutic action. It seems that MC health care providers have understood what Meara et al. have summed up accurately: "Reductions in spending for patients must be a result of decreases in the provision of services. If these are needed services, quality of care will decline. Alternatively, quality of care might be higher in low expenditure areas if differences in spending result from reductions in unnecessary or inappropriate services [40]". Besides this intuitive statement there has been scientific evidence that a diagnostic detour is worthwhile taking, since it sums up in reduced peri and post interventional costs without loss in quality [11]. Our study is not able to answer the questions why patients in limited access models received a more appropriate diagnostic approach. One can only hypothesize that a more rigorous coordination of care, as performed in the MC models, is straighter forward and the indication for invasive and expensive diagnostic procedures is more thoroughly scrutinized.

Determinants for NIIT

Even though simple echocardiography with no stress testing does not actually qualify as a NIIT, we chose to include this diagnostic procedure due to following considerations: some cardiologists might argue that patients with dyskinesia in simple echocardiography are likely to have relevant coronary pathology therefore offering an argument for CA besides the clinical evaluation. Our theory is supported by the "2014

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ESC/EACTS Guidelines on Myocardial Revascularization which state: “regional wall motion abnormalities may be detected in simple echocardiography, which increase the likelihood of coronary artery disease”.

Since our study lacks clinical data, only indirect hints by means of PCG and ATC codes as well as other confounders are available to assess clinical reasoning. The association between the use of platelet aggregation inhibitors or antithrombotic agents and antihypertensive medication with receiving NIIT before CA suggest a reasonable deliberation in the sense of estimating pretest probability when deciding on optimal diagnostic strategy. The same counts for the association of high-risk status and a larger number of chronic comorbidities as determinants for not receiving NIIT prior to elective CA. This finding is consistent with two US studies indicating that risk stratification was performed, considering the higher likelihood of a coronary pathology in patients with known coronary heart disease [8 10]. In our study, also non-clinical factors seem to influence decision-making processes concerning diagnostic pathways, reflected by the findings that being privately insured and a deductible of 2000 SFR were positively and inpatient treatment negatively independently associated with NIIT.

As previously observed in another Swiss study analyzing inappropriate use of arthroscopic meniscal surgery in degenerative knee disease [41], a substantial amount of the patients in our sample underwent CA as inpatients in contrast to other health care settings. This finding is most likely explained by differences in the organization of the health care system in Switzerland. Here regional governments subsidize inpatient treatment covering approximately 50% of total costs, and patients with supplementary private insurance receive a substantially higher reimbursement when treated as inpatients. Nevertheless, in the regression analysis with the outcome proportion of NIIT, we controlled for potential confounders, such as inpatient

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treatment as well. The results therefore seem robust concerning the question whether limited access health care models have a significant impact on the appropriateness of the diagnostic approach.

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

Besides the existing voluntary steering mechanisms such limited access health care models guided by patient's preferences only, more alternative steering mechanisms have to be implemented in non-gate keeping health care systems, in order to minimize the influence of non-clinical factors on medical decision making, which might lead to inappropriate and possibly dangerous health care utilization as well as increasing expenditures. A positive example for alternative steering mechanisms is the implementation of national registries [42] combined with quality initiatives, such as the in 2009 published Appropriate Use Criteria for Coronary Revascularization [9 42 43]. In 2011, the registry started giving feedbacks on the participating hospital's performance concerning appropriateness of CA including a benchmarking against other participating institutions. At the same time the American Board of Internal Medicine's Choosing Wisely initiative launched national quality improvement campaigns, identifying CA appropriateness as a key area for intervention [44]. As a consequence insurance companies incorporated measures of CA appropriateness into pay-for-performance programs [45] and reimbursement was declined for certain CA identified as inappropriate [46]. The combination of implementing national registries combined with quality initiatives had been proven amazingly effective, showing a decrease of non-acute CA classified as inappropriate from 26.2% to 13.3% [47]. In Switzerland currently no registries on CA exist, hence other solutions for influencing treatment pathways have to be developed, besides offering voluntary limited access health care models. A possible alternative solution to the conundrum of reducing

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costs without cutting quality seems hence to be paying for outcomes instead of volume. As the findings of our study suggest, a possible approach is to raise the market share of MC to such a volume that it might also affect care for fee-for-service patients [40]. As Meara et al have summarized, the effects have been show to play in a variety of ways: more MC in a market might lower expenditures by reducing the number of specialists, and thereby the number of specialists' services provided [48 49] by encouraging more conservative practice patterns [48 49], or by slowing the diffusion of more costly technologies [48 50].

Strengths and limitations

Only scarce data on non-emergency CA exists in literature. The only data found originates from the US among Medicare as well as commercially insured patients and from Switzerland, both non-gate keeping health care systems. Whether the proportion of inappropriate diagnostic CA from our study can be translated to other non-gate keeping health care systems is difficult to estimate, since substantial variation in the proportion of non-acute PCIs considered inappropriate across hospitals can be found, ranging from about 6% to 70% [8 10 14 15 47]. From a previous study from Switzerland [12] similar proportions were found, suggesting generalizability of our data. The current study seems even more representative than the previous Swiss study, since it included data over a longer time-period with consecutively larger amount of patients and corresponding data. Nevertheless, caution should be used when generalizing to larger populations due to the data being limited to only one, even if the largest health insurance company in Switzerland, due to exclusion criteria and the retrospective study design. Since the study is based on insurance claims data, no data on socioeconomic status and clinical information is available. Given that this is a cross-sectional observational study, rather than an interventional one,

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the only conclusions that we can draw are of association rather than causation. Due to the study design, unfortunately no estimations on clinical outcome parameters can be made. For example, in order to explore clinical appropriateness, the proportion of CA's avoided by performing NIIT would be of great interest. As a substitute for clinical data, ATC and PCG are used, offering only indirect information on comorbidities. On the other hand PCGs represent a strength, since they have been shown to directly correlate with associated health care costs [19]. Due to data structure, it is not possible to distinguish between CT angiography (including intravenous contrast) and CT without intravenous contrast. Therefore, all CTs of the chest were included in analysis.

Conclusions

In a non-gate keeping health care system voluntary MC health care models with capitation were associated with a reduced inappropriate use of diagnostic CA compared to basic models.

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Competing interests

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

Authors Contributions

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

Consent for publication

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

Availability of data and materials

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

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premises of the Helsana research group by the statistician AS in collaboration with the authors OR and CC and administrative permission was received to access de-identified data by the researchers from the University of Zurich.

Figure Legend

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

*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 non-limited access model (Reference).*

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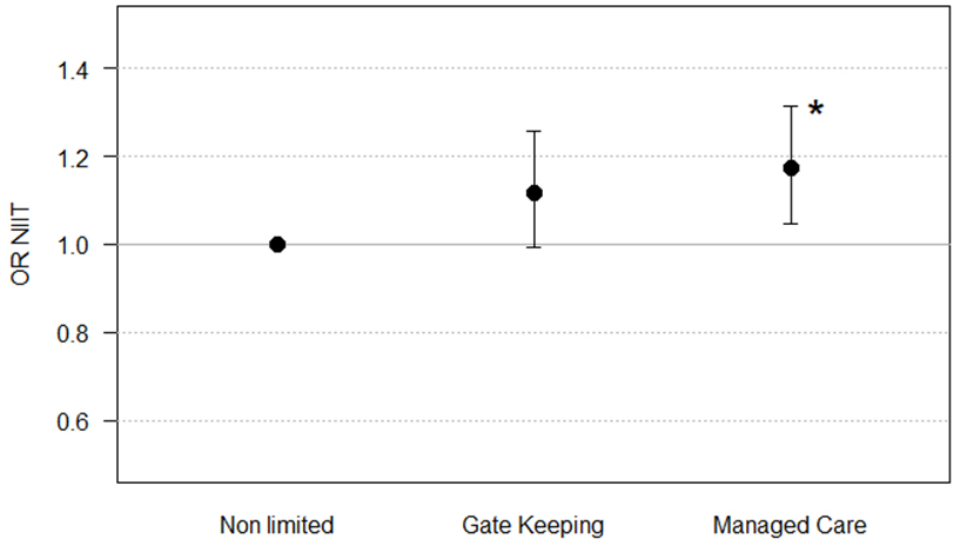

OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high- risk status. * p<0.001 8 (OR 1.17) for managed care model compared to standard health care plannon-limited access model (Reference).

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Supplemental Material

Supplemental Methods/Definitions

1) Inclusion Criteria

Tarmed	17.071
	17.074
	17.101
	17.109
	17.181
	17.182
DRG	F49D
	F49E
	F49F

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

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

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

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2) Exclusion Criteria

Acute cardiac ischemia and/or emergency procedures	Tarmed	0.2510
		0.2520
		0.2540
		0.2560
		0.2580
		35.0610
	DRG	F41A
		F41B
Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting, without myocardial infarction)	Tarmed	17.1110
		17.1240
	DRG	F15Z
		F19Z
		F24B
		F49A
		F49C
		F52A
		F52B
		F54Z
		F56A
		F56B
		F57A
		F57B
		F58Z

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F59A

F59B

Incomplete coverage of mandatory basic health insurance 18 months before and/or 1 month after CA

Patients <18 years

3) Diagnostic Procedures

Tarmed	17.0010: Electrocardiogram (ECG): not considered as NIIT, only in combination with other NIIT
	17.0050: Cardiac intervention with medication under continuous registration of ECG: not considered as NIIT, only in combination with another NIIT
	17.0060: ECG performed by specialist outside of the practice or hospital: not considered as NIIT, only in combination with another NIIT
	17.0080 and 17.0090: Stress-ECG
	17.0210: Echocardiography, transthoracic, qualitative and quantitative examination of adult
	17.0280: Stressechocardiography, physical stress
	17.0290: Stressechocardiography, medication stress
	31.0260: Scintigraphy physiologically triggered
	39.4060: Computed tomography of entire thorax and/or sternoclavicular joint
	39.5100 Heart MRI
DRG	No separate codes available for inpatient diagnostic procedures, only for therapeutic interventions

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4) High risk patients

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

Tarmed	0.2510
	0.2520
	0.2540
	0.2560
	0.2580
	35.0610
	17.1110
	17.1240
	And all 18.001until/including 18.0740
DRG	all Chapter F

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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	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

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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%)	
17.0710,17.0740,17.1010,17.1090,17.1810	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. 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

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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%

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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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MC: Managed Care, GK: Gate Keeping.
Detailed Tarmed positions can also be appreciated in Appendix 1:

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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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			

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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	9-14
		(b) Give reasons for non-participation at each stage	9-14
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-14
		(b) Indicate number of participants with missing data for each variable of interest	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	9-14
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	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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Secondary Subject Heading:	Medical management, Cardiovascular medicine, Diagnostics
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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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Abstract

Objective

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

Design:

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

Results

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

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

Conclusions

In a non-gate keeping health care system voluntary MC health care models with capitation were associated with a reduced inappropriate use of diagnostic CA compared to GK or basic models.

Strengths and Limitations

- Highly relevant topic concerning inappropriate use of a potentially harmful and expensive procedure such as the CA
- Only scarce data on non-emergency CA exists in literature originating from different health care settings
- Data originates from a single health insurance group in Switzerland, although one of the largest in the country, including data on health insurance claims from approximately 1.2 million patientsNo data on socioeconomic status and clinical information is available

Key Words

- Elective coronary angiography
- Managed care
- Gate keeping
- Inappropriate
- Voluntary health care models
- Limited access insurance models
- Non-invasive ischemia testing

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Introduction

Existing guidelines [1-7] recommend non-invasive ischemia testing (NIIT) for the majority of patients with suspected ischemic heart disease in a non-emergency setting. Nevertheless, a substantial amount of these patients undergo diagnostic coronary angiography (CA) without therapeutic intervention inappropriately, and are therefore exposed to unnecessary risks without any clinical benefit [8-15]. In a non-gate keeping health care system such as Switzerland, hardly any steering mechanisms exist to ensure that potentially harmful and expensive procedures are only performed in case of correct indication. The admitting physician (mainly general practitioner or cardiologist) usually sets the indication for the intervention and the performing invasive centers rarely decline assigned patients due to economic reasons or in order not to disagree with the admitting physician.

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

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

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analysis of insurance claims data on diagnostic procedures undertaken within two months before CA depending on the health care model.

Materials and Methods

Setting

Swiss residents are obliged to enroll in a basic health care model, which covers all costs besides deductibles. Depending on the model chosen, annual deductibles for adults vary between 300 and 2500 Swiss Francs. A patient copayment of 10% of all costs up to a maximum of 700 Swiss Francs per year is payable independent of the chosen health care model. Currently residents can chose a basic health care model from 53 different insurance companies. In general, in Switzerland no gate-keeping system exists, meaning that patients have unlimited access to all healthcare providers, unless they are voluntarily insured in a limited access model. Patients agree to a restriction of choice or limited access in exchange of lower premiums. In such limited access models, the general practitioner or an insurance telephone hotline have to be consulted before contacting a specialist or another institution such as a hospital. In case of emergency, this regulation is overruled. In Switzerland, the currently existing limited access models can be summarized into two types of models: 1) GK models with steering mechanisms, such as prior consultation of a telemedicine center for example, and 2) MC models with capitation. In the capitation system, the health insurance company reimburses the health care providers, usually physician networks, with a set amount for each enrolled patient assigned to them per period of time, whether or not that person seeks care. The remuneration is based on the average expected health care utilization of each individual patient, with greater payment for patients with significant medical history or chronic conditions. Compared

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

Subjects, data collection and measurements

Data for this study included health insurance claims from approximately 1.2 million patients, which live all over Switzerland and were enrolled with the Helsana Group. Data on patients undergoing CA in the years 2012 to 2015 were retrospectively analyzed. Data was considered for analysis if insurance coverage was complete within 18 months before and/or 1 month after CA. 828 of 12'078 (6.8%) of patients were not considered due to incomplete coverage of health insurance data during the necessary observation period (due to e.g. change of insurance company, military services, death). Hence, data on 11'250 patients remained for analysis before exclusion criteria. Detailed TARMED (Standard billing rate for outpatient medical care in Switzerland, version 2014) and Diagnosis Related Groups (DRG, version 2012) positions are specified in Appendix 1.

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

Exclusion criteria

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

Measurements

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

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coverage (deductible class, supplementary private hospital insurance, MC health care model)

- Setting of CA: inpatient or outpatient
- NIIT performed within two months prior to CA (stress-ECG, echocardiography, stress echocardiography, scintigraphy, computed tomography, cardiac MRI)
- Cardiovascular Medication grouped according to Anatomical-Therapeutic-Chemical-Classification (ATC) [18]
    - Group 1: Aspirin, platelet aggregation inhibitors
    - Group 2: statins, lipid modifying agents
    - Group 3: antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system
    - Group 4: antidiabetics
    - Group 5: antianginous drugs
    - Group 6: antithrombotics
- Number of chronic conditions according to Pharmaceutical cost groups PCG [19] [20]
    - Group 1: pcg_n < 3 0, 1 or 2 PCGs
    - Group 2: pcg_n < 5 3 to 4 PCGs
    - Group 3: pcg_n < 7 5 to 6 PCGs
    - Group 4: pcg_n ≥ 7 7 or more PCGs

Sensitivity Analysis with high-risk patients

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

Patient and public involvement

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

Statistical analysis

Descriptive statistical techniques (Table 1) were used, to provide a general profile of the study population and grouped into totally three groups of patients: patients with non-limited and limited access health care models (GK and MC). The descriptive statistics were performed pairwise for each health care model separately. These data were presented as means in the case of continuous variables and as percentages in case of categorical variables.

Differences within the health care models (Appendix 2) with respect to the continuous variable age were analyzed with a nonparametric analysis of variance Kruskal-Wallis test. The variables with two levels (sex, high-risk status (patients having received therapeutic cardiac intervention/diagnosis within one month after and/or 18 months prior to diagnostic CA), supplementary private hospital insurance coverage, language area, inpatient CA, cardiac medication class according to ATC) were analyzed with an exact fisher test. The number of chronic medical conditions identified using PCG and the deductible class were compared with a chi square test. ,

We performed a logistic regression analysis to evaluate the independent association between receiving NIIT within two months prior to CA and the various health care models (Figure 1 and Table 2). In order to assess patient-level effects, the following additional independent variables were included in the regression analysis: age, sex, deductible class, supplementary private hospital insurance coverage, language area, inpatient CA, cardiac medication class according to ATC, number of chronic medical conditions identified using PCGs and high-risk status. Goodness of fit measures for the model were: Nagelkerke 0.05075414, BrierScore 0.2134051, C-Statistic 0.618.

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

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respective 95% confidence intervals (CI). The level of significance was set at 0.05. All statistical analyses were performed using R version 3.3.1 (2016-06-21) (R Foundation for Statistical Computing, Vienna, Austria) [21 22].

Ethics approval

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

Results

Population

During the observed period a total of 19'032 therapeutic CA performed on 14'833 patients were registered in the Helsana data warehouse. 11'250 CA were eligible for analysis. According to the exclusion criteria (multiple exclusion criteria possible per person therefore the exclusions cannot be summed up), we excluded 5 patients since they were under the age of 18 years, 360 emergency procedures, 1'922 therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting). In total, 9'173 patients remained for analysis.

The descriptive statistics of the study population are listed in Table 1. From the 9'173 patients representing the study population 5'587 were male (60.9%, mean age 66.4 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)**					
				GK (n=1'816)			**MC (n=2'099)**		
	No NIIT (n=1'818)	**With NIIT (n=3'440)**		**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	

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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	

228

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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 (Categorical variable, an individual can be positive for several ATC groups). 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. ¹) Kruskal-Wallis test, ²) Fisher exact test, ³) Chi-Square test, pairwise comparisons between NIIT and no NIIT for each health insurance model separately.*

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Patients insured in basic health care models were slightly older (67.7 (11.6) vs. 66.6 (11.6) years, p<0.0001), chose the lowest possible deductible of 300 Francs more often (3'617 (68.8%) vs. 2'504 (64.0%), p<0.001), were enrolled in a supplementary private hospital insurance more often (1'418 (27.0%) vs. 866 (22.1%), p<0.0001), had more antidiabetics (787 (15%) vs 489 (12.5%), p<0.0001) and antianginal medication (825 (15.7%) vs 508 (13.0%), p<0.0001), more PCGs (4.1 (2.1) vs. 3.6 (2.0), p<0.0001) and had more often a high-risk status (2'696 (51.3%) vs. 1'814 (46.3%), p<0.0001), compared to patients insured in limited access models (Appendix 2). Concerning the other patient characteristics, no differences existed.

Non-invasive ischemia testing

3'044 patients had no NIIT (1'455 without and 1'599 with high-risk). 488 of 1'445 (33.8 %) of patients without NIIT had a conventional ECG prior to CA, in the high-risk population this was the case in 722 of 1'599 (45.2%) (p<0.0001, data not shown). The most NIITs stress-ECG + transthoracic echocardiography were performed significantly more often before CA in patients insured in limited access compared to non-limited access models (1'750 (44.7%) vs. 2'039 (38.8 %) p<0.0001, and 2'044 (52.2%) and 2'528 (48.1%), p<0.0001, data not shown). The remaining types of NIIT were rarely performed and only showed a significant difference in the use of scintigraphy (non-limited 131 (2.5%) vs. limited access models 64 (1.6%), p<0.001, data not shown). The distribution of the non-invasive ischemia testing are depicted in Appendix 3).

Determinants for non-invasive ischemia testing

Patients with MC models had a significantly higher OR of 17%to receive NIIT before CA compared to patients with non-limited models, when controlled for the

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confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high-risk status (OR 1.17, p<0.001). GK models did not show any significant influence on the chance of receiving NIIT (OR 1.11, p=0.071). The distribution of NIIT performed according to health care model can be appreciated in Figure 1.

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

*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 non-limited access model (Reference).*

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

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

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

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	1000	0.667 - 1.120	0.865	
	1500	0.841 - 1.374	1.075	
	2000	1.082 - 4.381	2.177	*
	2500	0.809 - 1.289	1.022	
	Private	1.025 - 1.267	1.140	*
	French or Italian part of Switzerland	0.841 - 1.044	0.937	
	Inpatient CA	0.540 - 0.664	0.599	***
	ATC group 1-6			
	1	1.251 - 1.620	1.423	***
	2	0.922 - 1.135	1.023	
	3	1.002 - 1.218	1.104	*
	4	0.851 - 1.115	0.974	
	5	0.874 - 1.130	0.994	
	6	1.034 - 1.356	1.184	*
	PCG (reference <3)			
	<5	0.940 - 1.192	1.058	
	<7	0.809 - 1.064	0.928	
	>=7	0.624 - 0.881	0.742	***
	Limited access models (reference non-limited access)			
	Managed Care	1.045 - 1.312	1.171	**
	Gate Keeping	0.991 - 1.253	1.114	
	High-risk cardiac status	0.046443	0.836	***

*CI: confidence interval, OR: odds ratio, Sig: significance: *** p<0.0001, ** p<0.001 *p<0.01, Private: supplementary private hospital insurance, CA: coronary angiography, ATC: Anatomical-Therapeutic-Chemical-Classification group 1 = Aspirin, platelet aggregation inhibitors, 2 = statins, lipid modifying agents, 3 =*

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antihypertensives, diuretics, beta blocking agents, calcium channel blockers, agents acting on the renin-angiotensin system, 4 = antidiabetics, 5 = antianginous drugs, 6: antithrombotics (Categorical variable, an individual can be positive for several ATC groups). 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.

Discussion

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

Effects of limited access health care models on treatment quality

In our study, emergency CA were excluded and the study population consisted of patients undergoing purely diagnostic elective CA with no therapeutic consequence (e.g. no coronary angioplasty/stenting or coronary artery by-pass grafting). The study population therefore represents a selection of patients with at least stable CHD or no CHD at all. From a previous study among this selection of patients we know, that 37.5% did not receive any NIIT at all before elective CA with no therapeutic consequence, suggesting a substantial overuse of a potentially harmful and inappropriate diagnostic intervention [12]. It has been assumed that patients insured in limited access health care models undergo less diagnostic procedures or interventions due to budget considerations, especially in capitated health care models. In our study, this hypothesis is clearly refuted. Patients with stable angina

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pectoris insured in limited access health care models underwent a more appropriate diagnostic pathway than regularly insured patients did, meaning in a stable clinical situation they were subjected to significantly more non-invasive diagnostic testing, therefore reducing inadequate CA. Our findings are in line with another study from the Swiss health care system, which also showed higher referral rates among MC patients compared to patients insured in basic health care models [23]. One reason for the more appropriate diagnostic pathway found in MC patients might be the aspect of membership in a general practitioners network. In most parts of Switzerland, general practitioners can only offer MC insurance models to their patients, if they are member in a general practitioners network. These networks offer evidence-based guidelines, which the general practitioners are obliged to respect when initiating treatment. Depending on the network, more or less rigorous quality control mechanisms exist to check whether the guidelines are followed, when applicable. General practitioners, which are not member in a network, therefore are less bound to evidence based treatment pathways.. Other studies showed that being insured in MC models is associated with a survival benefit by promoting better preventive and higher quality of care [24-26]. Especially among Medicare beneficiaries, which are prone to multimorbidity, this effect has been shown [27]. These models have also shown lower prevalence of potentially inappropriate medication use in elderly patients and a lower disease specific hospitalization rate in chronically ill patients [16 17].

Our study raises the question why patients in limited access health care models receive a more appropriate diagnostic pathway in this clinical situation of stable angina pectoris. There has been evidence for and against the theory that patients enrolled in a MC health care model are healthier due to biased selection [28-37] and commercial considerations of the MC insurer [38 39]. In our study population, patients insured in limited access models showed some evidence of being healthier than

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regularly insured patients. Nevertheless being insured only in MC but not GK models was *independently* associated with a higher rate of NIIT, controlled for all the differences in patient characteristics. It is clear that physicians participating in MC models are obliged to keep diagnostic and treatment costs as low as possible while keeping up with quality concerns. One could therefore argue that it is cheaper to not to choose a diagnostic detour over NIIT instead of choosing the straight forward way of sending a patient to the more invasive CA, which offers a clear answer to an uncertain clinical situation including the option of therapeutic action. It seems that MC health care providers have understood what Meara et al. have summed up accurately: "Reductions in spending for patients must be a result of decreases in the provision of services. If these are needed services, quality of care will decline. Alternatively, quality of care might be higher in low expenditure areas if differences in spending result from reductions in unnecessary or inappropriate services [40]". Besides this intuitive statement there has been scientific evidence that a diagnostic detour is worthwhile taking, since it sums up in reduced peri and post interventional costs without loss in quality [11]. Our study is not able to answer the questions why patients in limited access models received a more appropriate diagnostic approach. One can only hypothesize that a more rigorous coordination of care, as performed in the MC models, is straighter forward and the indication for invasive and expensive diagnostic procedures is more thoroughly scrutinized.

Determinants for NIIT

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

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argument for CA besides the clinical evaluation. Our theory is supported by the "2014 ESC/EACTS Guidelines on Myocardial Revascularization which state: "regional wall motion abnormalities may be detected in simple echocardiography, which increase the likelihood of coronary artery disease".

Since our study lacks clinical data, only indirect hints by means of PCG and ATC codes as well as other confounders are available to assess clinical reasoning. The association between the use of platelet aggregation inhibitors or antithrombotic agents and antihypertensive medication with receiving NIIT before CA suggest a reasonable deliberation in the sense of estimating pretest probability when deciding on optimal diagnostic strategy. The same counts for the association of high-risk status and a larger number of chronic comorbidities as determinants for not receiving NIIT prior to elective CA. This finding is consistent with two US studies indicating that risk stratification was performed, considering the higher likelihood of a coronary pathology in patients with known coronary heart disease [8 10]. In our study, also non-clinical factors seem to influence decision-making processes concerning diagnostic pathways, reflected by the findings that being privately insured and a deductible of 2000 SFR were positively and inpatient treatment negatively independently associated with NIIT.

As previously observed in another Swiss study analyzing inappropriate use of arthroscopic meniscal surgery in degenerative knee disease [41], a substantial amount of the patients in our sample underwent CA as inpatients in contrast to other health care settings. This finding is most likely explained by differences in the organization of the health care system in Switzerland. Here regional governments subsidize inpatient treatment covering approximately 50% of total costs, and patients with supplementary private insurance receive a substantially higher reimbursement when treated as inpatients. Nevertheless, in the regression analysis with the outcome

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proportion of NIIT, we controlled for potential confounders, such as inpatient treatment as well. The results therefore seem robust concerning the question whether limited access health care models have a significant impact on the appropriateness of the diagnostic approach.

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

Besides the existing voluntary steering mechanisms such limited access health care models guided by patient's preferences only, more alternative steering mechanisms have to be implemented in non-gate keeping health care systems, in order to minimize the influence of non-clinical factors on medical decision making, which might lead to inappropriate and possibly dangerous health care utilization as well as increasing expenditures. A positive example for alternative steering mechanisms is the implementation of national registries [42] combined with quality initiatives, such as the in 2009 published Appropriate Use Criteria for Coronary Revascularization [9 42 43]. In 2011, the registry started giving feedbacks on the participating hospital's performance concerning appropriateness of CA including a benchmarking against other participating institutions. At the same time the American Board of Internal Medicine's Choosing Wisely initiative launched national quality improvement campaigns, identifying CA appropriateness as a key area for intervention [44]. As a consequence insurance companies incorporated measures of CA appropriateness into pay-for-performance programs [45] and reimbursement was declined for certain CA identified as inappropriate [46]. The combination of implementing national registries combined with quality initiatives had been proven amazingly effective, showing a decrease of non-acute CA classified as inappropriate from 26.2% to 13.3% [47]. In Switzerland currently no registries on CA exist, hence other solutions for influencing treatment pathways have to be developed, besides offering voluntary limited access

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health care models. A possible alternative solution to the conundrum of reducing costs without cutting quality seems hence to be paying for outcomes instead of volume. As the findings of our study suggest, a possible approach is to raise the market share of MC to such a volume that it might also affect care for fee-for-service patients [40]. As Meara et al have summarized, the effects have been show to play in a variety of ways: more MC in a market might lower expenditures by reducing the number of specialists, and thereby the number of specialists' services provided [48 49] by encouraging more conservative practice patterns [48 49], or by slowing the diffusion of more costly technologies [48 50].

Strengths and limitations

Only scarce data on non-emergency CA exists in literature. The only data found originates from the US among Medicare as well as commercially insured patients and from Switzerland, both non-gate keeping health care systems. Whether the proportion of inappropriate diagnostic CA from our study can be translated to other non-gate keeping health care systems is difficult to estimate, since substantial variation in the proportion of non-acute PCIs considered inappropriate across hospitals can be found, ranging from about 6% to 70% [8 10 14 15 47]. From a previous study from Switzerland [12] similar proportions were found, suggesting generalizability of our data. The current study seems even more representative than the previous Swiss study, since it included data over a longer time-period with consecutively larger amount of patients and corresponding data. Nevertheless, caution should be used when generalizing to larger populations due to the data being limited to only one, even if the largest health insurance company in Switzerland, due to exclusion criteria and the retrospective study design. Since the study is based on insurance claims data, no data on socioeconomic status and clinical information is available. Given

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that this is a cross-sectional observational study, rather than an interventional one, the only conclusions that we can draw are of association rather than causation. Due to the study design, unfortunately no estimations on clinical outcome parameters can be made. For example, in order to explore clinical appropriateness, the proportion of CA's avoided by performing NIIT would be of great interest. As a substitute for clinical data, ATC and PCG are used, offering only indirect information on comorbidities. On the other hand PCGs represent a strength, since they have been shown to directly correlate with associated health care costs [19]. Due to data structure, it is not possible to distinguish between CT angiography (including intravenous contrast) and CT without intravenous contrast. Therefore, all CTs of the chest were included in analysis.

Conclusions

In a non-gate keeping health care system voluntary MC health care models with capitation were associated with a reduced inappropriate use of diagnostic CA compared to GK or basic models.

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Competing interests

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

Authors Contributions

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

Consent for publication

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

Availability of data and materials

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

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premises of the Helsana research group by the statistician AS in collaboration with the authors OR and CC and administrative permission was received to access de-identified data by the researchers from the University of Zurich.

Figure Legend

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

*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 non-limited access model (Reference).*

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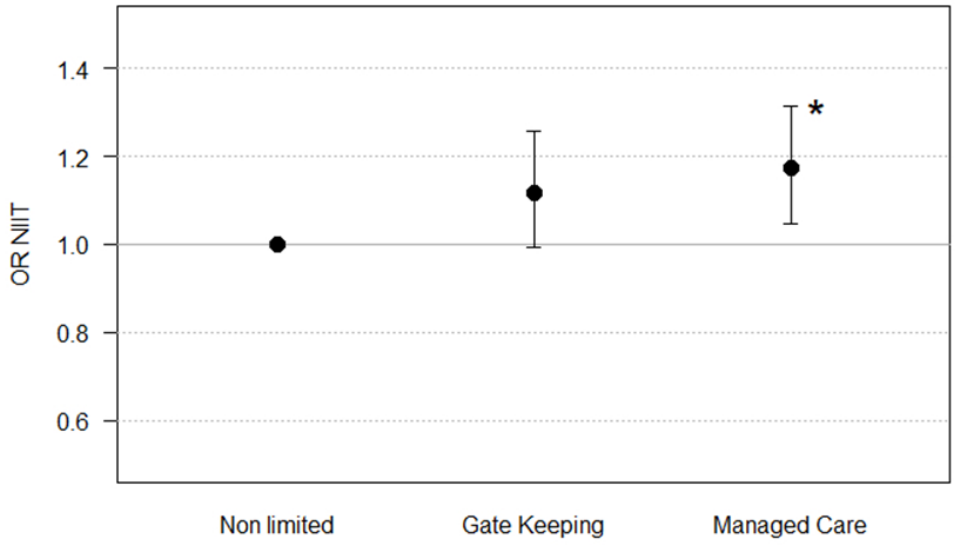

OR NIIT: odds ratio for non-invasive ischemia testing controlled for the confounders age, sex, language area, insurance coverage, inpatient treatment, cardiovascular medication, number of chronic comorbidities and high- risk status. * p<0.001 8 (OR 1.17) for managed care model compared to standard health care plannon-limited access model (Reference).

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Supplemental Material

Supplemental Methods/Definitions

1) Inclusion Criteria

Tarmed	17.071
	17.074
	17.101
	17.109
	17.181
	17.182
DRG	F49D
	F49E
	F49F

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

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

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

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2) Exclusion Criteria

Acute cardiac ischemia and/or emergency procedures	Tarmed	0.2510
		0.2520
		0.2540
		0.2560
		0.2580
		35.0610
	DRG	F41A
		F41B
Therapeutic CA (coronary angioplasty/stenting or coronary artery by-pass grafting, without myocardial infarction)	Tarmed	17.1110
		17.1240
	DRG	F15Z
		F19Z
		F24B
		F49A
		F49C
		F52A
		F52B
		F54Z
		F56A
		F56B
		F57A
		F57B
		F58Z

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F59A

F59B

Incomplete coverage of mandatory basic health insurance 18 months before and/or 1 month after CA

Patients <18 years

3) Diagnostic Procedures

Tarmed	17.0010: Electrocardiogram (ECG): not considered as NIIT, only in combination with other NIIT
	17.0050: Cardiac intervention with medication under continuous registration of ECG: not considered as NIIT, only in combination with another NIIT
	17.0060: ECG performed by specialist outside of the practice or hospital: not considered as NIIT, only in combination with another NIIT
	17.0080 and 17.0090: Stress-ECG
	17.0210: Echocardiography, transthoracic, qualitative and quantitative examination of adult
	17.0280: Stressechocardiography, physical stress
	17.0290: Stressechocardiography, medication stress
	31.0260: Scintigraphy physiologically triggered
	39.4060: Computed tomography of entire thorax and/or sternoclavicular joint
	39.5100 Heart MRI
DRG	No separate codes available for inpatient diagnostic procedures, only for therapeutic interventions

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4) High risk patients

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

Tarmed	0.2510
	0.2520
	0.2540
	0.2560
	0.2580
	35.0610
	17.1110
	17.1240
	And all 18.001until/including 18.0740
DRG	all Chapter F

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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	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

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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%)	
17.0710,17.0740,17.1010,17.1090,17.1810	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. 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

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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%

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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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MC: Managed Care, GK: Gate Keeping.
Detailed Tarmed positions can also be appreciated in Appendix 1:

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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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			

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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	9-14
		(b) Give reasons for non-participation at each stage	9-14
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-14
		(b) Indicate number of participants with missing data for each variable of interest	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	9-14
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	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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