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The impact of basic vs private health insurance status on treatments and outcomes of ST-elevation myocardial infarction patients in Switzerland: insights from the AMIS Plus registry

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Summary

BACKGROUND: Large disparities in treatments and outcomes of ST-elevation myocardial infarction (STEMI) patients driven by insurance status have been reported. However, it is unknown whether this applies to Switzerland, a country characterised by an overall high income, mandatory basic health insurance covering virtually all treatments and the option of a supplementary private health insurance allowing for full institution and doctor choice as well as a higher service standard. This study aimed to assess the impact of insurance status on treatments and outcomes in STEMI patients in Switzerland.

METHODS: STEMI patients enrolled in the nationwide Acute Myocardial Infarction in Switzerland (AMIS) Plus registry between 2005 and 2023 were analysed. We compared patients with basic health insurance only to those with supplementary private health insurance with respect to optimal medical therapy, percutaneous coronary intervention (PCI) and outcomes. Primary outcome measures were rates of optimal medical therapy and full guideline-recommended treatment (FGRT) (defined as optimal medical therapy plus PCI). Secondary outcome measures were in-hospital all-cause mortality, major adverse cardiac and cerebrovascular events (MACCE), length of stay and 1-year all-cause mortality after discharge. Multivariate logistic mixed-effects models examined whether insurance type influenced treatments and outcomes.

RESULTS: Among 16,463 patients, 13,023 (79.1%) had only basic health insurance. Patients with basic health insurance only were younger, more often males and had higher rates of obesity, diabetes and active smoking, but lower rates of cancer than supplementary private health insurance patients. In addition, they more often received optimal medical therapy and FGRT. Patients with basic health insurance only had higher rates of in-hospital mortality and MACCE. However, after adjusting for covariates, no statistically significant associations were identified between insurance type and access to optimal medical therapy or FGRT, in-hospital mortality, MACCE, length of stay or 1-year mortality after discharge.

CONCLUSION: In this study, we observed no significant association between insurance status and treatments or outcomes of STEMI patients, suggesting a high level of equity in acute cardiac care in Switzerland.

Introduction

Acute myocardial infarction (AMI) remains a major global health burden, claiming millions of lives each year and disrupting communities worldwide. Recent advancements in the detection and treatment of AMI and particularly ST-elevation myocardial infarction (STEMI), have significantly improved outcomes and quality of life of affected patients [1, 2]. Socioeconomic factors, such as income, education and insurance status, have been reported to influence quality of care and outcomes of STEMI patients [3, 4]. The current work focuses on the impact of insurance status on treatment and outcomes of STEMI patients in Switzerland.

In Switzerland, a universal basic health insurance covering virtually all in-hospital and outpatient treatments is mandatory [5]. Additionally, optional supplementary private health insurance plans can be acquired, allowing patients to access any hospital (private or public) and any doctor, and at the same time to have higher standard non-medical services such as single-bed hospital accommodation. Socioeconomic factors do affect patients' decisions to acquire supplementary private health insurance because they constitute an expensive complement of an already costly basic health insurance [6]. The Swiss Federal Office of Health reported that 20.7% of in-hospital patients had supplementary private health insurance in 2022 [7]. According to a recent national report, Swiss patients with supplementary private health insurance were older, better educated, had a higher income and comparable or better health than those with basic health insurance [8].

In Switzerland, the influence of insurance type on treatments and outcomes among AMI patients has not been investigated. Therefore, we sought to assess the impact of insurance coverage (basic health insurance only vs additional supplementary private health insurance) on hospital treatments and outcomes of STEMI patients by analysing the Acute Myocardial Infarction in Switzerland (AMIS Plus) registry database.

Methods

Study design

AMIS Plus, the ongoing, open-ended AMI registry in Switzerland was founded in 1997 by the Swiss Societies of Cardiology, Internal Medicine and Intensive Care. Since its inception, 84 hospitals of a total of 103 Swiss acute care centres have voluntarily been part of the AMIS Plus Project and submitted anonymised data of patients with AMI either temporarily or continuously. Data are collected and submitted by physicians and trained study nurses of participating hospitals according to a questionnaire covering more than 380 variables for each AMI patient. The questionnaire comprises patient characteristics including risk factors and comorbidities, regular pre-admission medications, in-hospital treatments, complications and outcomes, and discharge medications. The members of the AMIS Plus data centre, located at the Institute for Epidemiology, Biostatistics and Prevention at the University of Zurich, checkthe submitted data for plausibility and completeness. In case of ambiguities or incompleteness of data, physicians or study nurses are queried to guarantee the quality of data. The project is conducted in accordance with the Declaration of Helsinki regarding investigations on humans and was approved by the Supra-Regional Ethics Committee for Clinical Studies, the Swiss Board for Data Security and all individual Cantonal Ethics Commissions (ClinicalTrials.gov identifier: NCT01305785). A detailed description of the AMIS Plus registry has been previously published [9].

Study population

For the present analysis, all patients admitted to Swiss hospitals between 2005 and 2023 with a diagnosis of STEMI and information regarding their health insurance status were included. Patients were diagnosed with STEMI if they had typical ischaemic symptoms, a significant increase in biomarkers according to hospital-specific cut-off levels for MI, and if the initial ECG displayed an ST-segment elevation and/or a new left bundle branch block. Diagnoses were made in accordance with the guideline recommendations in effect at the time of inclusion. Patients with symptom onset in hospital (i.e. who were already hospitalised due to a non-AMI cause before the AMI occurred), or who were transferred from or to another hospital were excluded (the latter because those patients frequently have missing valuable information). Health insurance status, namely "basic" or "private" insurance, was obtained from administrative hospital records. Patients with semiprivate health insurance were allocated to the supplementary private health insurance group.

Definitions of variables used in the analysis

Family history was defined as a family history of ischaemic heart disease in a first-degree relative younger than 60 years. Current smoker was defined as having smoked at least 100 cigarettes in a lifetime and being an active smoker at the time of STEMI. The risk factors diabetes, arterial hypertension and dyslipidaemia were defined as per previous or new diagnosis by a physician and/or corresponding treatment. Comorbidities were defined according to the Charlson Comorbidity Index [10, 11]. Anaemia was defined as a blood haemoglobin level lower than 13 g/dl for males or 12 g/dl for females. The Killip classification described a patient's clinical status at admission, ranging from Killip class I (no clinical signs of heart failure) to Killip class IV (cardiogenic shock) [12]. Left ventricular ejection fraction (LVEF) was considered impaired if ventriculography reported an LVEF <35% and/or if echocardiography reported an LVEF <30%. Multivessel disease was established via angiography. In this work, optimal medical therapy was defined as the administration of all guideline-recommended medications (aspirin, $P2Y_{12}$ receptor antagonists, lipid-lowering drugs, beta-blockers and renin-angiotensin-aldosterone system blockers), as assessed in-hospital and at discharge [13–17]. Full guideline-recommended treatment (FGRT) was defined as the combination of optimal medical therapy and PCI [13, 14, 17].

Outcome measures

The primary outcome measures of this study were the rates of immediately administered optimal medical therapy and full guideline-recommended treatment. The secondary outcome measures were in-hospital all-cause mortality, in-hospital major adverse cardiac and cerebrovascular events (MACCE), length of stay in days and 1-year all-cause mortality after discharge. MACCE was defined as either in-hospital death of any cause, reinfarction or any cerebrovascular event as an in-hospital complication. One-year all-cause mortality was assessed via a standardised telephone interview at least one year after the initial AMI, to which patients had granted their formal consent during the initial hospitalisation.

Statistical analysis

For baseline characteristics, binary and categorical variables are displayed as counts and Pearson's chi-squared test was employed for group comparisons. Continuous parameters are displayed as medians with interquartile ranges and groups were compared using Mann-Whitney U tests. Then, to test the effect of insurance status on treatments, multivariable logistic mixed-effects models were fitted, with immediate optimal medical therapy and full guideline-recommended treatment as the binary response variables.Insurance type, age, sex, obesity, Killip class greater than 2, previous AMI, diabetes, cancer, dyslipidaemia, arterial hypertension, current smoking, maximum in-hospital creatine kinase (CK), glycaemia, multivessel disease and impaired LVEF constituted fixed covariates, whereas hospital was considered the only random covariate (random intercept, but not random slopes) in the model to account for hospital-specific guidelines and practices with regards to optimal medical therapy and full guideline-recommended treatment. To analyse the effect of insurance status on different outcomes, the same covariates as before and immediate full guideline-recommended treatment were used to fit logistic mixed-effects models with in-hospital all-cause mortality and MACCE as response variables, and a generalised linear mixed-effects model with log-links and following a Gamma distribution with length of in-hospital stay as the response variable, respectively. For 1-year mortality, we fitted the same model as for the other outcomes; for this outcome, however, we used full guideline-recommended treatment at discharge instead of immediate full guideline-recommended treatment as a covariate. Temporal trends of the individual immediate optimal medical therapy drugs and PCI as well as immediate full guideline-recommended treatment, stratified by insurance type, were assessed using the Cochrane-Mantel-Haenszel test, with admission year as an ordered stratification variable. The test evaluated the presence of a linear association of the treatments across time. The threshold for statistical significance for all analyses was set to 0.005 as proposed by previous publications [18, 19]. Statistical analyses were performed using R (version 4.4.0) with packages *tidyverse, foreign*, *haven*, *gtsummary*, *flextable*, *labelled*, *tidytable*, *lme4*, *nlme* and *lmerTest*, and IBM SPSS version 29.0.0.0. For further information about the analytical code, please contact the corresponding author.

Results

Between January 2005 and December 2023, 27,155 STEMI patients from 68 Swiss hospitals were enrolled in AMIS Plus. After excluding 10,692 patients transferred from/to another hospital or with symptom onset while in hospital, 16,463 patients constituted the population for this study. Of these patients, 13,023 (79.1%) had basic health insurance only while 3440 (20.9%) had supplementary private health insurance coverage. Baseline characteristics of the study population according to insurance status are shown in table 1.

Table 1: Baseline characteristics of STEMI patients according to insurance status.

Characteristic	n	Insurance category			
		Overall: n = 16,463 [1]	Basic: n = 13,023 [1]	Private: n = 3440 [1]	p-value
Age in years, median (IQR)	16,463	65 (56–76)	64 (55–75)	69 (60–78)	**<0.001** [2]
Sex, n (%)	16,463				**<0.001** [3]
… Male		12,236 (74.3%)	9760 (74.9%)	2476 (72.0%)	
… Female		4227 (25.7%)	3263 (25.1%)	964 (28.0%)	
Typical symptoms, n (%)	15,861	14,330 (90.3%)	11,346 (90.6%)	2984 (89.5%)	0.072[3]
Out-of-hospital cardiac arrest prior to hospitalisation, n (%)	16,463	1299 (7.9%)	1100 (8.5%)	199 (5.8%)	**<0.001** [3]
Symptom onset to first medical contact in min, median (IQR)	9912	95 (40–270)	95 (40–265)	95 (40–300)	0.5[2]
Symptom onset to hospital admission in min, median (IQR)	13,759	140 (79–325)	140 (78–316)	145 (80–349)	0.2[2]
Killip class >2, n (%)	16,401	1444 (8.8%)	1203 (9.3%)	241 (7.0%)	**<0.001** [3]
Risk factors					
Family history (in first-degree relative <60 years), n (%)	13,300	4367 (32.8%)	3481 (33.2%)	886 (31.5%)	0.089[3]
Arterial hypertension, n (%)	15,511	9195 (59.3%)	7206 (59.0%)	1989 (60.4%)	0.13[3]
Dyslipidaemia, n (%)	14,521	8873 (61.1%)	7002 (61.3%)	1871 (60.3%)	0.3[3]
BMI, median (IQR)	14,936	26.2 (24.0–29.1)	26.2 (24.1–29.3)	26.0 (23.8–28.7)	**<0.001** [2]
BMI >30 (obesity), n (%)	14,936	2990 (20.0%)	2437 (20.7%)	553 (17.6%)	**<0.001** [3]
Current smoker, n (%)	14,707	5962 (40.5%)	5024 (43.1%)	938 (30.7%)	**<0.001** [3]
Comorbidities					
Previous AMI, n (%)	16,080	2178 (13.5%)	1752 (13.8)	426 (12.6%)	0.070[3]
Heart failure, n (%)	16,072	407 (2.5%)	327 (2.6%)	80 (2.4%)	0.5[3]
Peripheral vascular disease, n (%)	16,072	612 (3.8%)	491 (3.9%)	121 (3.6%)	0.4[3]
Cerebrovascular disease, n (%)	16,072	735 (4.6%)	569 (4.5%)	166 (4.9%)	0.3[3]
Hemiplegia, n (%)	16,072	68 (0.4%)	53 (0.4%)	15 (0.4%)	0.8[3]
Dementia, n (%)	16,072	289 (1.8%)	236 (1.9%)	53 (1.6%)	0.3[3]
Chronic lung disease, n (%)	16,072	795 (5.0%)	651 (5.1%)	144 (4.3%)	0.038[3]
Connective tissue disease, n (%)	16,072	190 (1.2%)	133 (1.1%)	57 (1.7%)	**0.002** [3]
Peptic ulcer disease, n (%)	16,072	204 (1.3%)	159 (1.3%)	45 (1.3%)	0.7[3]
Liver disease, n (%)	16,072	162 (1.0%)	136 (1.1%)	26 (0.8%)	0.12[3]
Diabetes, n (%)	15,657	2964 (18.9%)	2418 (19.6%)	546 (16.5%)	**<0.001** [3]
Moderate-to-severe renal disease, n (%)	16,073	1020 (6.4%)	814 (6.4%)	206 (6.1%)	0.5[3]
Cancer, n (%)	16,072	814 (5.1%)	582 (4.6%)	232 (6.9%)	**<0.001** [3]
CCI >1, n (%)	16,072	3098 (19.3%)	2434 (19.2%)	664 (19.6%)	0.5[3]
Anaemia, n (%)	10,708	1560 (14.6%)	1244 (14.4%)	316 (15.3%)	0.3[3]
Impaired LVEF, n (%)	14,726	1448 (9.8%)	1185 (10.2%)	263 (8.5%)	**0.005** [3]
Multivessel disease, n (%)	14,944	8693 (58.2%)	6876 (58.1%)	1817 (58.3%)	0.8[3]
Immediate therapy					
Aspirin, n (%)	16,428	15,886 (96.7%)	12,566 (96.7%)	3320 (96.7%)	0.9[3]
$P2Y_{12}$ receptor antagonist, n (%)	16,044	14,614 (91.1%)	11,547 (90.9%)	3067 (91.7%)	0.2[3]
Beta-blocker, n (%)	16,326	9233 (56.6%)	7311 (56.6%)	1922 (56.3%)	0.7[3]
Vasopressor, n (%)	16,158	1903 (11.8%)	1559 (12.2%)	344 (10.1%)	**<0.001** [3]
ACEI or ARB, n (%)	16,281	9565 (58.7%)	7614 (59.2%)	1951 (57.2%)	0.034[3]
Statin, n (%)	16,352	12,810 (78.3%)	10,102 (78.1%)	2708 (79.1%)	0.2[3]
PCI, n (%)	16,281	14,542 (89.3%)	11,509 (89.3%)	3033 (89.4%)	0.8[3]
Door-to-balloon time for PCI in min, median (IQR)	13,202	62 (33–111)	60 (31–108)	71 (36–128)	**<0.001** [2]
Optimal medical therapy, n (%)	15,812	5878 (37.2%)	4797 (38.4%)	1081 (32.7%)	**<0.001** [3]
Full guideline-recommended treatment, n (%)	15,812	5617 (35.5%)	4576 (36.6%)	1041 (31.5%)	**<0.001** [3]
Laboratory variables					
Maximum creatine kinase during hospitalisation (IU/l), median (IQR)	15,851	1175 (438–2528)	1206 (450–2602)	1033 (393–2264)	**<0.001** [2]

Glycaemia (on admission, mmol/l), median (IQR)	14,151	7.6 (6.4–9.8)	7.6 (6.4–9.8)	7.5 (6.4–9.4)	**<0.001** [2]
CRP (on admission, mg/l), median (IQR)	11,582	5 (2–10)	5 (2–10)	4 (2–9)	0.016[2]
Discharge therapy					
Aspirin, n (%)	15,123	14,705 (97.2%)	11,575 (97.4%)	3130 (96.6%)	0.013[3]
$P2Y_{12}$ receptor antagonist, n (%)	15,009	14,040 (93.5%)	11,058 (93.8%)	2982 (92.8%)	0.047[3]
Beta-blocker, n (%)	15,098	12,423 (82.3%)	9888 (83.3%)	2535 (78.5%)	**<0.001** [3]
ACEI or ARB, n (%)	15,076	13,236 (87.8%)	10,504 (88.6%)	2732 (84.7%)	**<0.001** [3]
Statin, n (%)	15,096	14,110 (93.5%)	11,135 (93.9%)	2975 (91.9%)	**<0.001** [3]
Optimal medical therapy, n (%)	14,882	9808 (65.9%)	7904 (67.6%)	1904 (59.7%)	**<0.001** [3]
Full guideline-recommended treatment, n (%)	14,882	9484 (63.7%)	7643 (65.4%)	1841 (57.7%)	**<0.001** [3]

[1] Median (IQR) or n (%)
[2] Mann-Whitney U test
[3] Pearson's chi-squared test
Abbreviations: ACEI: angiotensin-converting enzyme inhibitor; AMI: acute myocardial infarction; ARB: angiotensin II receptor blocker; BMI: body mass index; CCI: Charlson's Comorbidity Index; CRP: C-reactive protein; IQR: interquartile range; LVEF: left ventricular ejection fraction; PCI: percutaneous coronary intervention; STEMI: ST-elevation myocardial infarction.

Patients with basic health insurance only were younger and more often male compared to supplementary private health insurance patients. In addition, patients with basic health insurance only had higher rates of obesity, diabetes and were more often active smokers than supplementary private health insurance patients. Conversely, patients with basic health insurance only less often had connective tissue disease or cancer than supplementary private health insurance patients. While no differences in the delay between symptom onset and hospital admission were observed among the groups, the frequency of out-of-hospital cardiac arrest was higher in patients with basic health insurance. In addition, basic health insurance only patients more frequently had Killip class >2 and impaired LVEF at presentation. In terms of immediate drug therapy, no group differences were found regarding the administration of aspirin, $P2Y_{12}$ receptor antagonists and lipid-lowering drugs. Similarly, no statistically significant differences in angiotensin-converting enzyme inhibitors (ACEIs), angiotensin II receptor blockers (ARBs) or beta-blockers were observed. As far as immediate optimal medical therapy is concerned, patients with basic health insurance only were more likely to receive all five drugs (i.e. aspirin, $P2Y_{12}$ receptor antagonists, lipid-lowering drugs, beta-blockers and renin-angiotensin-aldosterone system blockers), whereas supplementary private health insurance patients more often received four or three of the recommended drugs (5 drugs: 38.4% vs 32.7%; 4 drugs: 27.6% vs 34.0%; 3 drugs: 18.8% vs 20.4%; p <0.001). Immediate full guideline-recommended treatment administration was more prevalent in basic health insurance patients than in supplementary private health insurance patients. At discharge, patients with basic health insurance more often received beta-blockers, statins, ACEIs or ARBs, optimal medical therapy and full guideline-recommended treatment. Administration of optimal medical therapy and full guideline-recommended treatment at discharge were much more prevalent compared to immediate treatment for both insurance groups. Supplementary private health insurance patients had longer median delays between admission and PCI while there were no differences in terms of PCI rates between the groups.

Laboratory analyses revealed that patients with basic health insurance only had a higher median maximum CK level, indicating greater extent of myocardial injury, and higher median levels of glycaemia than supplementary private health insurance patients.

Median [interquartile range] hospital duration was 5 [4–9] days for patients with basic health insurance and 6 [4– 9] days for supplementary private health insurance patients, respectively (p = 0.019) (table 2).

Table 2: Complications and outcomes of STEMI patients according to insurance status.

Complication/outcome	n	Insurance category			
		Overall: n = 16,463[1]	**Basic:** n = 13,023[1]	**Private:** n = 3440[1]	**p-value**
Cardiogenic shock (developed during hospitalisation), n (%)	16,424	738 (4.5%)	611 (4.7%)	127 (3.7%)	0.012[3]
Re-infarction, n (%)	16,424	156 (1.0%)	127 (1.0%)	29 (0.9%)	0.5[3]
Cerebrovascular event, n (%)	16,424	139 (0.9%)	115 (0.9%)	24 (0.7%)	0.3[3]
MACCE, n (%)	16,424	1501 (9.1%)	1264 (9.7%)	237 (6.9%)	**<0.001** [3]
In-hospital all-cause mortality, n (%)	16,463	1317 (8.0%)	1120 (8.6%)	197 (5.7%)	**<0.001** [3]
Length of stay in days, median (IQR)	16,452	5.0 (4.0–9.0)	5.0 (4.0–9.0)	6.0 (4.0–9.0)	0.019[2]
1-year all-cause mortality after discharge, n (%)	5979	174 (2.9%)	138 (2.9%)	36 (2.8%)	0.8[3]

[1] Median (interquartile range) or n (%)
[2] Mann-Whitney U test
[3] Pearson's chi-squared test
Abbreviations: IQR: interquartile range; MACCE: major adverse cardiac and cerebrovascular events; STEMI: ST-elevation myocardial infarction.

Unadjusted rates of in-hospital all-cause mortality (8.6% vs 5.7%, p <0.001) and MACCE (9.7% vs 6.9%, p <0.001) were higher among patients with basic health insurance compared to those with supplementary private health insurance, while 1-year all-cause mortality after discharge did not differ between the groups (2.9% vs 2.8%, p = 0.8). However, the results of the multivariable mixed-effects model revealed no statistically significant association between basic health insurance and the administration of immediate optimal medical therapy (adjusted odds ratio [OR]: 1.05; 95% CI: 0.93–1.19; p = 0.40), nor between basic health insurance and immediate full guideline-recommended treatment (adjusted OR: 1.03; 95% CI: 0.92–1.17; p = 0.59) (table 3).

Table 3: Results from multivariable logistic mixed-effects regression analyses for immediate optimal medical therapy and full guideline-recommended treatment (n = 8651)

Characteristic	Optimal medical therapy			Full guideline-recommended treatment		
	OR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
(Intercept)	1.26	0.83–1.90	0.28	1.21	0.80–1.83	0.37
Insurance type [Basic]	1.05	0.93–1.19	0.40	1.03	0.92–1.17	0.59
Age (years)	0.99	0.98–0.99	<0.001	0.99	0.98–0.99	<0.001
Sex [Male]	1.09	0.98–1.22	0.12	1.10	0.98–1.24	0.09
BMI >30 (Obesity)	1.03	0.92–1.16	0.58	1.03	0.92–1.15	0.64
Killip class >2	0.51	0.41–0.64	<0.001	0.51	0.41–0.64	<0.001
Impaired LVEF	0.85	0.71–1.02	0.073	0.84	0.70–1.01	0.058
Multivessel disease	1.08	0.98–1.19	0.10	1.08	0.98–1.19	0.10
Previous AMI	1.12	0.97–1.29	0.13	1.11	0.96–1.28	0.17
Diabetes	1.22	1.06–1.40	0.005	1.18	1.02–1.35	0.022
Cancer	0.86	0.69–1.09	0.22	0.89	0.70–1.12	0.31
Current smoker	0.81	0.73–0.90	<0.001	0.82	0.74–0.90	<0.001
Dyslipidaemia	1.07	0.96–1.18	0.23	1.09	0.98–1.21	0.12
Arterial hypertension	1.32	1.19–1.46	<0.001	1.31	1.18–1.45	<0.001
Maximum CK (max. level during hospitalisation, IU/l)	1.00	1.00–1.00	0.086	1.00	1.00–1.00	0.037
Glycaemia (on admission, mmol/l)	0.97	0.96–0.98	<0.001	0.97	0.96–0.99	<0.001

Abbreviations: AMI: acute myocardial infarction; BMI: body mass index; CI: confidence interval; CK: creatine kinase; LVEF: left ventricular ejection fraction; OR: odds ratio.

Similar results were observed in a secondary analysis looking into optimal medical therapy and full guideline-recommended treatment at discharge (table S1 in the appendix). Furthermore, there was no statistically significant association between basic health insurance and in-hospital all-cause mortality (adjusted OR: 1.41; 95% CI: 0.97–2.05; p = 0.07), basic health insurance and MACCE (ad-

justed OR: 1.27; 95% CI: 0.94–1.72; p = 0.11), or basic health insurance and 1-year all-cause mortality after discharge (adjusted OR: 1.53; 95% CI: 0.85–2.76; p = 0.15) (table 4). Finally, insurance type did not impact length of in-hospital stay (b = 0.01, p = 0.44).

Table 4: Effect of basic insurance on different outcomes after STEMI assessed via multivariable logistic/generalised linear mixed-effects regression[1].

Characteristic	OR/Beta	95% CI	p-value
In-hospital all-cause mortality	1.41	0.97–2.05	0.07
MACCE	1.27	0.94–1.72	0.12
Length of stay in days	0.01	-0.02–0.04	0.44
1-year all-cause mortality after discharge	1.53	0.85–2.76	0.15

[1] Model for in-hospital all-cause mortality: n = 8651; model for MACCE: n = 8630; model for length of stay: n = 8647; model for 1-year all-cause mortality after discharge: n = 3499.
[2] Adjusted for fixed effects (age, sex, obesity, Killip class >2, history of previous AMI, dyslipidaemia, arterial hypertension, diabetes, cancer, current smoking, maximum in-hospital creatine kinase, glycaemia, impaired left ventricular ejection fraction, multivessel disease, immediate/discharge full guideline-recommended treatment) and random effects (hospital).
Abbreviations: CI: confidence interval; MACCE: major adverse cardiac and cerebrovascular events; OR: odds ratio; STEMI: ST-elevation myocardial infarction.

Temporal trends for all individual immediate guideline-recommended drugs and for PCI stratified according to insurance status are shown in figure 1. Temporal trends for immediate full guideline-recommended treatment stratified by insurance type are shown in figure 2.

Figure 1: Temporal trends in the application of immediate individual guideline-recommended drugs and PCI after ST-elevation myocardial infarction according to insurance type. P-values were established by linear-by-linear association. Abbreviations: ACEI: angiotensin-converting enzyme inhibitor; ARB: angiotensin II receptor blocker; PCI: percutaneous coronary intervention.

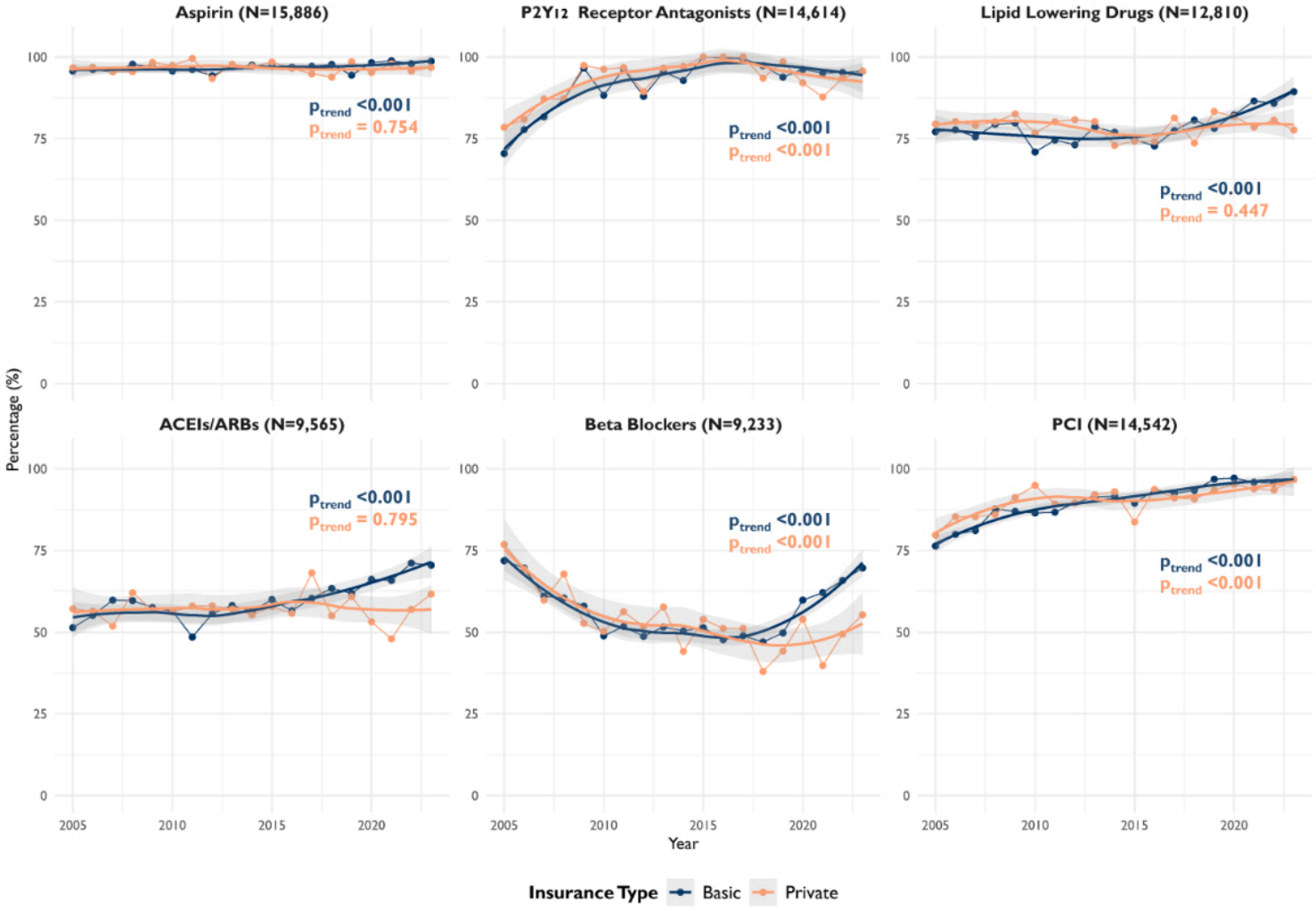
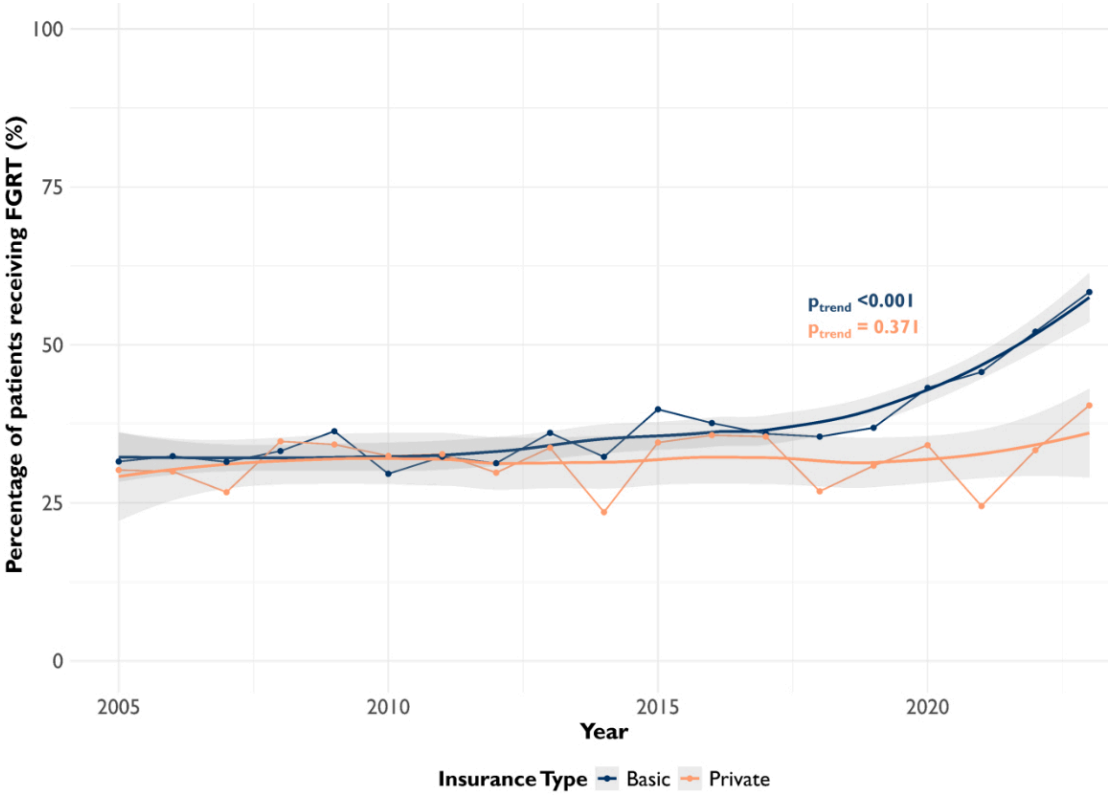


Figure 2: Temporal trends of immediate full guideline-recommended treatment (optimal medical therapy plus percutaneous coronary intervention) in ST-elevation myocardial infarction patients according to insurance type. P-values were established by linear-by-linear association. Abbreviations: FGRT: full guideline-recommended treatment.



Discussion

The main finding of this study is that we observed no significant impact of health insurance status on the administration of immediate optimal medical therapy or full guideline-recommended treatment, or on in-hospital all-cause mortality, MACCE, length of hospital stay or 1-year all-cause mortality after discharge of STEMI patients in Switzerland. These findings suggest a high level of equity in acute cardiac care in the country.

Accordingly, while unadjusted analyses suggested that patients with basic health insurance alone more often received optimal medical therapy and full guideline-recommended treatment than patients with additional supplementary private health insurance, after adjusting for confounders in the multivariable analyses, no significant association between insurance status and optimal medical therapy or full guideline-recommended treatment was observed. This is in contrast to numerous previous publications, which highlighted disparities in treatments among STEMI patients according to insurance type across several countries [20–23]. In the USA, multiple studies have reported that STEMI patients with supplementary private health insurance were more likely to undergo PCI than those with other insurance plans [20–22]. One of these studies reported that patients with basic Medicaid insurance had 15% lower odds of receiving PCI than their propensity score-matched counterparts with supplementary private health insurance [21]. Finally, two American studies documented higher rates of coronary angiography [21] and CABG [22] in STEMI patients with supplementary private health insurance compared to other types of insurance. With respect to pharmacological treatment after STEMI, one American study documented higher rates of aspirin and beta-blocker prescription at discharge in coronary artery disease patients with supplementary private health insurance compared to other insurance plans [24]. Similar findings from the same country were reported for the prescription of aspirin, beta-blockers, heparin, clopidogrel and glycoprotein IIb/IIIa inhibitors in a non-ST-elevation acute coronary syndrome population [25]. The reasons for the discrepant findings observed in the current study are probably multifactorial. Socioeconomic factors such as education and income are known to affect in-hospital care [25–28]. As

an example, due to financial concerns, less wealthy patients may refuse to receive expensive guideline-recommended treatments if they are not reimbursed by the insurance scheme [25]. In Switzerland, socioeconomic disparities – with insurance status being a reflection thereof – may be levelled out by existing premium subsidies for people with low incomes. It also appears that in Switzerland the effect of insurance type on cardiac treatment is context-dependent. Struja et al. reported significantly higher rates of non-emergent cardiovascular procedures including PCI in supplementary private health insurance patients who were hospitalised for any medical reason, which may reflect the financial incentive for physicians and hospitals to treat patients with supplementary private health insurance [29]. Alternatively, it was also suggested that in Switzerland supplementary private health insurance patients, who spend more on health coverage, may attempt to receive medical care more intensively to maximise their return [29]. We hypothesise, however, that these financially driven aspects may not hold true in life-threatening conditions such as STEMI. On another note, as shown in table 1, the crude prevalences of immediate optimal medical therapy and full guideline-recommended treatment were rather low (optimal medical therapy: 37.2%; full guideline-recommended treatment: 35.5%). We hypothesise that these low numbers likely reflect the absence of uniform guideline recommendations for all patients, particularly for the immediate administration of beta-blockers and ACEIs/ARBs [17]. In contrast, optimal medical therapy and full guideline-recommended treatment prevalences at discharge were substantially higher, suggesting that in-hospital medical care in Switzerland remains at a high standard. Overall, the lack of impact of insurance status on in-hospital treatment suggests an excellent equity of emergency cardiac care in Switzerland.

While the unadjusted in-hospital mortality and MACCE rates were higher in the basic health insurance group than in supplementary private health insurance patients, in the multivariable analyses, the association was lost for both outcomes. In addition, there was no significant association between insurance status and 1-year mortality after discharge. These findings are in great contrast to previous analyses conducted in various countries, which reported a significant effect of insurance status on mortality [20, 21, 26]. One study from the USA observed a higher 30-day and 1-year mortality in AMI patients with public Medicaid insurance compared to patients with private insurance [20]. Similar results for in-hospital mortality were later described in a propensity score-matched STEMI cohort by Patel et al., who reported 35% higher odds for Medicaid beneficiaries to die during the hospitalisation compared to privately insured patients [21]. A more recent work from Australia supported this notion, stating that AMI patients undergoing PCI with private health insurance had 41% lower odds of dying in hospital than those with public insurance plans [26]. Reportedly, the difference in mortality was primarily influenced by STEMI patients and those living in major cities [26]. Apart from in-hospital treatment differences discussed above, a plethora of potential reasons for differential in-hospital mortality according to insurance status have been mentioned. Most notably, socioeconomic factors, access to (PCI-capable) emergency department and greater delay to cardiac treatment have been pointed out [3, 26, 30, 31]. While this study does not allow any investigation of socioeconomic factors, access to and presentation in a Swiss hospital with a catheterisation laboratory is, owing to the country's small geographic size, almost invariably guaranteed. Accordingly, in our study, overall patient delay, i.e. the time elapsed from symptom onset to arrival at hospital, was acceptable at 140 min and no difference between the groups. Somewhat surprisingly, system delay, i.e. the time from arrival at the hospital to the moment of PCI, was significantly shorter for patients with basic health insurance. This is in contrast to the previous assumption that patients with basic health insurance coverage have marginally longer system delays and may also have contributed to the more balanced in-hospital mortality observed in the present study [32].

Median length of hospital stay was not impacted by insurance status. This result aligns with numerous studies that did not identify insurance type as an independent predictor of the length of hospital stay [21, 23, 26, 33].

In the present cohort, approximately 21% of patients had supplementary private health insurance, a proportion consistent with data from the Federal Office of Health, supporting the notion that the study population mirrored the overall insurance status in Switzerland [7]. The patient profile of individuals with basic health insurance and supplementary private health insurance differed. In accordance with previous reports, supplementary private health insurance patients appear to be older than those with basic health insurance, emphasising the notion that younger generations may be less willing to purchase supplementary private health insurance due to the increasing financial burden [21, 26, 29]. Then, the proportion of supplementary private health insurance was higher among women than among men in this study. This finding does not necessarily correspond

to previous works, where sex distributions differed depending on the study [21, 26, 29]. In our study, patients with basic health insurance exhibited higher rates of obesity, smoking and diabetes than patients with supplementary private health insurance, a finding in alignment with previous publications showing a greater prevalence of cardiovascular risk factors in basic health insurance patients [8, 20, 21].

To our knowledge, although different studies have investigated temporal trends on different drugs and PCI in the AMI and STEMI setting, no studies have yet taken insurance status into account [34–36]. As expected, the analysis of temporal trends revealed a significant increase in PCI procedures over time for both insurance groups, cementing its role as the most important in-hospital intervention after STEMI. The administration of $P2Y_{12}$ receptor blockers in both insurance types showed a significant increase from the beginning of the study period, reaching its peak around the year 2017. In the last few years, however, it appears that the rates of $P2Y_{12}$ receptor blocker administration have been on a slight decline. This may be a finding that needs to be investigated more thoroughly in the future. Figure 1 shows that for ACEIs/ARBs, beta-blockers and lipid-lowering drugs, disparities between the two insurance types appear to have emerged in the last few years. The reasons – especially the contribution of the recent COVID-19 pandemic – for these disparities have yet to be established. It may be wise, however, to closely monitor future trends for these medications.

Strengths and limitations

The study's strengths lie in the large patient sample covering the whole of Switzerland, the prospective nature of the registry and the extended 18-year observation period. Additionally, the comprehensive data collection enabled us to account for numerous potential confounders.

The AMIS Plus registry has some weaknesses inherent to all observational studies, especially those conducted over decades. Participation and data entry by hospitals in the registry is voluntary and the number of participating hospitals at specific times may fluctuate. In addition, the potential impact of unmeasured or unknown confounders, especially socioeconomic factors including education or income, cannot be ruled out [30, 31, 37, 38]. Also, there may be complex factors including specific treatment decisions such as delayed treatment that may have influenced certain covariates or outcomes of interest. We also acknowledge that excluding transferred patients and those with in-hospital symptom onset may have influenced the composition of the study cohort and the outcomes assessed. Regarding the administration of the analysed drugs, we are reliant on the information provided by the hospitals and have no data on dosage or contraindications which may have impacted optimal medical therapy or full guideline-recommended treatment. Regarding 1-year mortality, there are no data on post-discharge therapy and health, which may have influenced this outcome.

Conclusion

This study provides evidence that, in Switzerland, insurance status does not influence in-hospital treatment or outcomes in STEMI patients, including guideline-recommended therapies, or in-hospital and 1-year mortality. This suggests that Swiss hospitals maintain a high level of equity in emergency cardiac care.

Data availability

Individual data used for the construction of the AMIS Plus registry are the property of the hospitals participating in the AMIS Plus registry and may only be made available by each hospital's Principal Investigator and the AMIS Plus Steering Committee. Due to data protection regulations related to the different hospitals involved in this study, the authors do not have authorisation to provide unrestricted data access. However, analysis files may be provided to other researchers subject to approval by the AMIS Plus Steering Committee and subsequent negotiation of an individual AMIS Plus module contract with the AMIS Plus Steering Committee. Requests must be submitted to Prof. Dr Hans Rickli, President of the AMIS Plus Steering Committee (hans.rickli[at]kssg.ch) and Dr Dragana Radovanovic, Head of the AMIS Plus Data Centre (dragana.radovanovic[at]uzh.ch).

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Potential competing interests

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Appendix

Table S1: Results from multivariable logistic mixed effects regression analyses for OMT and FGRT at discharge (n = 8,462).

Characteristic	Optimal medical therapy			Full guideline-recommended treatment		
	OR	95% CI	p-value	OR	95% CI	p-value
(Intercept)	2.18	1.41, 3.37	<0.001	2.04	1.32, 3.13	0.001
Insurance type (basic)	1.03	0.91, 1.17	0.68	1.00	0.88, 1.13	>0.99
Age (years)	0.99	0.99, 1.0	<0.001	0.99	0.99, 1.0	<0.001
Male sex	1.17	1.03, 1.31	0.012	1.17	1.04, 1.31	0.010
BMI >30 (obesity)	1.14	1.00, 1.29	0.052	1.14	1.01, 1.30	0.040
Killip classes >2	1.04	0.83, 1.32	0.73	1.01	0.80, 1.27	0.93
Impaired LVEF	1.10	0.90, 1.36	0.35	1.05	0.86, 1.29	0.61
Multivessel disease	1.16	1.05, 1.29	0.005	1.15	1.04, 1.27	0.008
Previous AMI	0.86	0.74, 1.01	0.065	0.86	0.74, 1.00	0.051
Diabetes	1.07	0.92, 1.25	0.38	1.01	0.87, 1.17	0.93
Cancer	0.76	0.60, 0.96	0.022	0.76	0.60, 0.96	0.021
Current smoker	0.85	0.76, 0.95	0.004	0.87	0.78, 0.97	0.013
Dyslipidemia	1.02	0.92, 1.14	0.68	1.05	0.94, 1.17	0.43
Arterial hypertension	1.48	1.32, 1.65	<0.001	1.42	1.27, 1.58	<0.001
Maximum CK (max. level during hospitalisation, IU/l)	1.00	1.00, 1.00	<0.001	1.00	1.00, 1.00	<0.001
Glycemia (on admission, mmol/l)	1.01	0.99, 1.02	0.47	1.01	0.99, 1.02	0.32

Abbreviations: AMI, acute myocardial infarction; BMI, body mass index; CI, confidence interval; CK, creatine kinase; FGRT, full guideline-recommended treatment; LVEF, left ventricular ejection fraction; OMT, optimal medical therapy; OR, odds ratio.