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Does health insurance status influence surgical complications? An analysis of abdominal, thoracic and vascular interventions in a Swiss tertiary referral centre

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Summary

STUDY AIMS: In Switzerland, basic health insurance is compulsory. Supplementary or private health insurance may be arranged, providing advantages such as hospital comfort and a free choice of doctors. Since there is limited data on whether insurance status influences the outcome of surgery, this study aimed to investigate the influence of supplementary insurance status on the overall complication occurrence in a group of abdominal, thoracic and vascular surgeries.

METHODS: This study is based on surgical patient data prospectively collected between September 2016 and March 2018 from one participating Swiss tertiary referral hospital of the StOP?-trial (NCT02428179), which investigated the effect of structured intraoperative briefings on patient outcomes. First, additional data, including insurance status, demographic and surgical parameters within 30 days was collected. Second, due to endogeneity concerns in the sample driven by selective access to a supplementary insurance, propensity-score matching (PSM) was used to balance samples for the treatment variable (insurance status) by demographic parameters and surgical complexity. The primary outcome was the estimated treatment effect of a supplementary insurance on the occurrence of surgical complications, categorised by the Clavien-Dindo classification (CDC). Finally, multiple logistic regression was used to detect further conditional associations of demographic and surgical variables with the occurrence of complications.

RESULTS: Of all 3173 procedures, 64.3% were elective, 48.2% had a higher surgical complexity (excluding appendectomies, cholecystectomies, hernia surgery and lymph node excision) and 18.6% of all patients had supplementary insurance. The occurrence of complications, including surgical site infection and postoperative complications, was 30.4%. After matching 591 patients with basic insurance to 591 patients with a supplementary insurance, no significant association between insurance status and complications could be found (crude odds ratio [OR] [95% CI]: 0.97 [0.77–1.23]). In contrast to insurance status, multiple logistic regression identified that variables such as surgical complexity (adjusted OR [95% CI]: 1.80 [1.27–2.56]), contamination (adjusted OR [95% CI]: 1.90 [1.41–2.56]) and duration of surgery (adjusted OR [95% CI]: 1.008 [1.006–1.009]) were associated with the occurrence of complications.

CONCLUSION: Despite the different cost-liable insurance levels, there were no significant differences and, therefore, no disadvantages for basic insured patients regarding the complication rate in this Swiss cohort undergoing abdominal, thoracic or vascular surgery.

Introduction

In Switzerland, basic health insurance is compulsory by law. The goal of this compulsory insurance system is that everyone receives the same quality of medicine [1], meeting the highest standards. This means that market-orientated healthcare insurance companies cover all standard treatment costs. Many different providers also offer various supplementary insurance models, which include, e.g. benefits in advanced hospitality and Swiss-wide choice of attending doctors [2].

Ethically, medical treatment and the implicated outcome should be independent of financial concerns. Still, studies of the US healthcare system found disadvantages for surgical outcomes, as measured by mortality and complication rates of different surgical procedures, between patients with no insurance or public insurance such as Medicare or Medicaid [3–5]. Similar findings were reported for surgical site infections [6]. These studies implicate a strong influence of insurance status on medical treatment outcomes. There is less knowledge about disparities in European healthcare systems. A Swiss retrospective study of 30,175 trauma patients suggests a positive effect of supplementary health insurance on surgical complications [7].

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On the contrary, smaller studies in general and abdominal surgery reflect no benefit on surgical complication [8] or surgical site infections [9]. Despite showing less importance of the insurance status in the Swiss health system, many factors are still indistinct. One main uncharted factor in the medical outcome is the experience of the lead surgeon. This consideration is of major importance, as many patients raise concerns about not having the option to choose the most experienced surgeon. The supplementary insurance often allows the treatment by a more experienced doctor in the clinic [10]. Abdominal, thoracic and vascular surgery may offer highly complex anatomical relations. Therefore, repetitive intraoperative decision-making to adjust the surgical procedure may occur. Intraoperative decision-making may be highly demanding and rely mainly on the lead surgeon's experience. Surgical experience could therefore have a strong impact on intra- and postoperative complications.

Given the lack of studies of comprehensive size in the field of abdominal, thoracic and vascular surgery, the present study aimed to investigate the estimated treatment effect of supplementary insurance on surgical complications for patients for this specialty in Switzerland. Furthermore, we wanted to evaluate the role of potential confounders on this relationship, including demographic and surgical variables (figure 1).

Methods

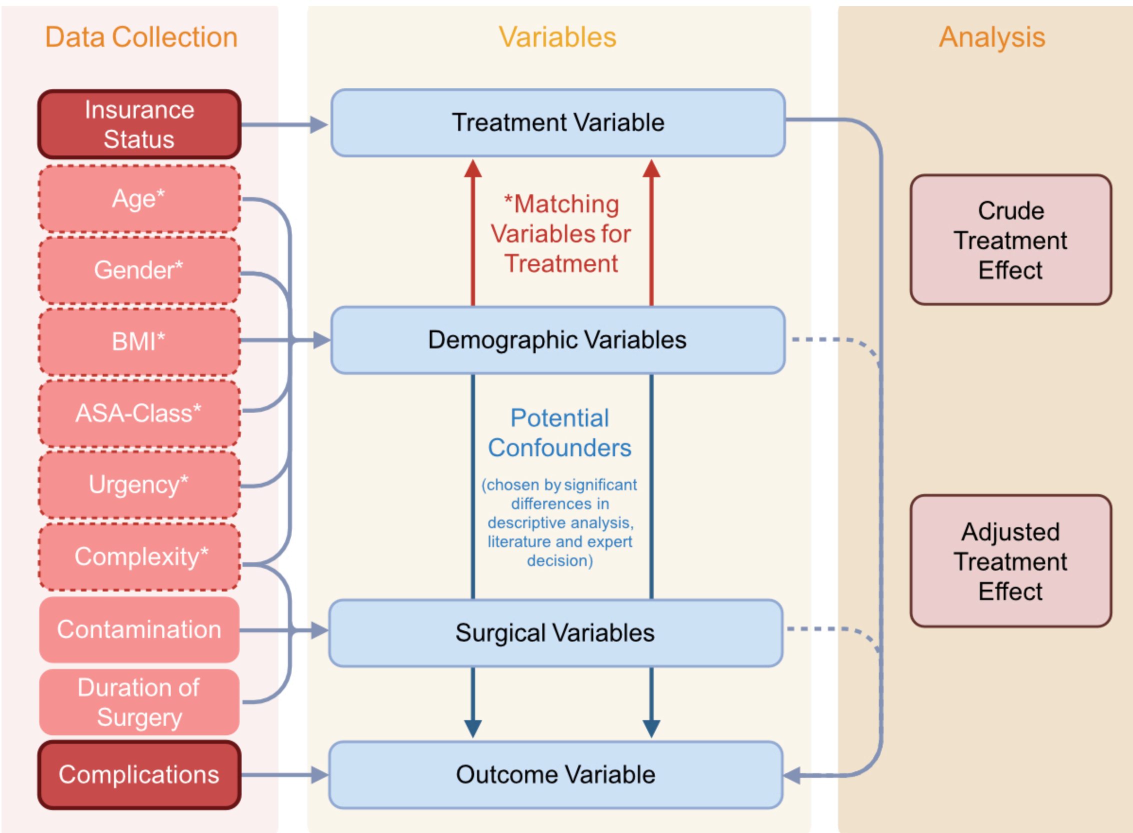
Patients

Data from consecutive patients undergoing surgical procedures at a tertiary referral hospital in Switzerland was collected prospectively between September 2016 and March 2018 as part of the StOP?-trial (NCT02428179) [11]. In the original multicentre trial, a protocol for structured pre-surgical communication was tested for influences on surgical parameters, however, without significant effect for surgical site infection. For the present study, data of one participating centre (Triemli Hospital, Switzerland) was used with a focus on patients' insurance status. Further information about included patients (demographic and surgical parameters) was obtained from the clinic-internal digital patient file system. The study was approved by the local ethics committee before initiation (ID 2020-00265), and general consent was required for the analysis. The study size depended on the collective of the StOP?-trial of one centre (Triemli hospital).

Inclusion and exclusion criteria

Patients aged over 16 years undergoing surgery (elective or emergency) in the abdominal, thoracic or vascular surgical department were included in this study from the StOP?-trial (appendix table S1). This included patients with a highly unfavourable prognosis at the time of admission

Figure 1: Summary of assessed variables, included confounders and matching variables. Assessed variables from the StOP-trial and internal medical records. Matching treatment (insurance) by simulation of a selection process for insurance along with categories of demographics (age, sex), patient status (body mass index [BMI], American Society of Anesthesiologists (ASA) score ≥III) and surgical relevance (urgency, surgical complexity), which could be potentially influenced by the insurance status. Inclusion of variables was determined by expected influence for insurance status and occurrence of complications through the literature, significant differences in first descriptive analysis and expert decision (SW, SG, MB). Created with BioRender.com.



(multiorgan failure in septic conditions, life-threatening abdominal complications after complex cardiac surgery, aortic aneurysm rupture, mesenteric ischaemia or other life-threatening thromboembolic conditions) despite their imminent risk of death within 72 hours, however without procedures of deliberate termination. Excluded were low-complexity surgeries, like the opening of a subcutaneous abscess as well as endovascular interventions and thyroid surgeries, due to their very low degree of surgical site infection. Additional reasons for exclusion were (b) withdrawal of general consent, (c) repeated procedures, (d) errors in clinical documentation as well as (e) missing essential data, such as age, body mass index (BMI) or duration.

Data collection

A summary of included variables is shown in figure 1. Even though the StOP?-trial concentrated on surgical site infection as the primary outcome [11], all complications were documented according to the Clavien-Dindo classification (CDC) as well as other available parameters (e.g. contamination of the surgical field) used in this analysis. Following the protocol of the StOP?-trial, all included parameters were collected within 30 days post-surgery by study nurses and validated independently. Collection of missing values and additional demographic parameters (insurance status, age, BMI, American Society of Anesthesiologists [ASA] classification, urgency and duration of surgery) was completed at time of admission from internal electronic medical records.

Classification of surgical and demographic variables

All patients were separated by their insurance status into basic insurance (mandatory, public) and additional supplementary insurance (private) based on their system records. We categorised the surgical procedures into six groups by their anatomical region or similar surgical protocol: (a) upper gastrointestinal, (b) hepatic/biliary/pancreatic/splenic, (c) colorectal, (d) hernia, (e) thoracic and vascular and (f) Other, which included non-defined exploratory laparotomies or laparoscopies, nephrectomies or endocrine surgery and lymph node excisions. Furthermore, surgeries were classified as either “intermediate” or of “major complexity” according to the classification scheme used by the National Institute for Health and Care Excellence (NICE) [12]. The group of “intermediate complexity” surgeries was represented by appendectomies, cholecystectomies, hernia surgeries and lymph node excisions. All other surgeries were classified as surgeries of “major complexity”. Complications were assessed by study nurses within 30 days post-surgery using the Clavien-Dindo classification [13]. All procedures were classified into six categories: free of complications (0), complications without required treatment (I), complications with required pharmacological treatment (II), complications with requirement of an intensified intervention (radiological, endoscopic or surgical) (III), life-threatening complications (IV) and death (V). Additional assessed parameters of the intervention were patient age in years, sex, BMI in kg/m^2, urgency (elective vs emergency) and duration of surgery in minutes. The ASA classification was used as a surrogate parameter to assess the patient’s morbidity, categorising all patients with a few pre-existing diseases as low morbidity (ASA I–II) and those with major pre-existing diseases as high morbidity (ASA III–V). The grade of surgical wound contamination was classified according to swissnoso (I to IV, clean to dirty-infected), corresponding to the CDC’s surgical wound classification grades [14].

Outcomes

The primary outcome of this analysis was the estimated treatment effect of supplementary insurance on the occurrence of complications (outcome variable) in a comparable population. Furthermore, the association of potential confounders on the occurrence of complications including surgical parameters such as complexity, contamination and duration of surgery was assessed (figure 1).

Statistical analysis

Standard descriptive statistics were performed for analysis of characteristics such as absolute and relative frequencies for categorical variables and median with a 95% confidence interval (95% CI) for continuous variables. For comparisons between basic and supplementary insured patients, Fisher’s exact tests were used for nominal data and Mann-Whitney tests for continuous data. Two-sided p-values <0.05 were considered statistically significant.

Since the limited access to a supplementary insurance as well as many different demographic and surgical variables can have a profound influence on the occurrence of complications, two different approaches were used to obtain the estimated treatment effect as well as the adjusted association of several variables (figure 1).

First, given that the endogenous diversity in our sample of basic and supplementary insured can be attributed, in part, to the selected access to a supplementary insurance, we used propensity score matching to balance the probability of being in either insurance group [15]. The matching variables were chosen according to their potential use in a randomisation protocol of a clinical trial and as criteria relevant for the insurance selection process from the perspective of an applicant from an insurance company [16]. Demographic variables (age, sex, BMI, comorbidities in the form of the ASA classification, and urgency) were therefore included for matching. Besides these variables, surgical complexity was used in addition to demographic variables as it could be shown to be a helpful variable to balance patient characteristics of different included surgeries (table S2) and therefore allowing a reduction of their heterogeneity for the estimated treatment effect after matching (appendix figure S1). Furthermore, the complexity also influences the choice of insurance status, e.g. through the aim of freely choosing a certain doctor, making it even more important as a matching variable. With these matching variables, a propensity score was calculated by logistic regression, estimating the probability of each patient being in either the treatment or the control group based on the observed covariates.

We used the R package *matchit* [15] with the implemented “1:1 matching” and “nearest” approach for the necessary calculations. Using 1:1 matching, our model aimed for a straightforward interpretation and increased comparability. Standardised mean differences (SMD) were used as a balance measure indicating the success of balancing in matched with a value of <0.1 (table 1) [17]. However, 1:1 matching led to a substantial reduction in number of patients with basic insurance, creating potential concerns about reduced generalisability and robustness. The chosen matching approach was therefore compared to a weighted “full matching” approach as well as a propensity score-based sensitivity analysis in a regression model with the treatment variable and propensity score as an independent variable. For the “full matching”, all procedures were matched with the implemented function in the *matchit* package by creating different weights from the observed matching covariates. Without dropping procedures through 1:1 or k:1 matching, full matching allows compensation of disadvantages and can achieve balance without dropping procedures [18]. We used standardised mean differences as well as estimations of the treatment effect on outcome and surgical variables for comparing the described matching approaches (table S3 and figure S2). The reduction of standardised mean difference <0.1 was assumed as a sufficient balancing of either approach [17]. Comparable estimations of the treatment effect for outcome and surgical variables between propensity score-based sensitivity analysis, 1:1 and full matching approaches suggest a robustness of the results despite a loss of numbers in the 1:1 matching (table S3). Based on these results, 1:1 matching was chosen for the implantation in our main analysis owing to its advantages in interpretation.

Second, multiple logistic regression was performed to assess associations of the insurance status, demographic and surgical variables with the occurrence of complications as shown in figure 1. The pre-defined inclusion as potential confounders was based on their significant differences in descriptive analysis, literature research of previous studies [7, 9, 11] or expert decision (SW, SG, MB). Crude and adjusted odds ratios (OR) as well as their 95% CI were reported for both, unmatched and 1:1 matched samples (figure 3). The multiple regression model of the matched samples included matching variables in order to account for differences remaining after matching [19].

The statistical environment R (version 4.1.2) / R Studio (version 2024.12.1+563) (session information in supplementary information) and PRISM (version 10.4.1) were used for statistical and graphical analyses.

Ethics

All procedures performed in studies involving human participants complied with ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study was approved before its initiation by the local ethics committee (ID 2020-00265).

Informed consent was obtained from all individual participants included in the study, where appropriate.

Results

Analyses of demographic and surgical parameters before and after matching

A total of 3397 surgeries meeting the inclusion criteria were identified (figure 2). Of these 3397 surgeries, 224 were excluded, giving a final number of 3173 interventions included in the study. Of these, 2645 (83.3%) were abdominal (8.5% upper gastrointestinal, 19.9% hepatic/biliary/ pancreatic/ splenic, 20.9% colorectal, 25.3% hernia surgeries) and 528 (16.6%) were thoracic or vascular surgeries (table S1).

In the unmatched population, 2582 (81.4%) had basic insurance and 591 (18.6%) had supplementary insurance (table 1). Overall, the median age was 61 years (IQR: 44–73); 1830 were male (57.7%) and 1343 were female (42.3%). The median BMI for all patients was 25 (IQR: 22–29). The surgeries were approximately evenly divided between those of “major complexity” (48.2%; n = 1530) and “intermediate complexity” (51.8%; n = 1643). Two-thirds of surgeries (64.3%; n = 2039) were electively planned and 1134 (35.7%) were emergency procedures. One-third (34.0%; n = 1080) of all patients had major pre-existing diseases with high morbidity (ASA score ≥3). Interestingly, a significantly higher number of patients with supplementary insurance had a pre-existing high morbidity (40.0% vs 32.6%). Patients with supplementary insurance were older: 69 years (IQR: 56–76) vs 59 years (IQR: 42–72). The median BMI was lower in patients with supplementary insurance: 25.0 (IQR: 23–29) vs 24 (IQR: 22–28). There was an increased rate of “major complexity” surgeries in patients with supplementary insurance (45.8% vs 58.7%). There were no sex differences between the basic and supplementary groups. The differences in standardised mean difference were shown before and after matching by the matching variables. After 1:1 matching, 591 procedures of each insurance status were compared with improved balance, suggested by the standardised mean difference <0.1 (table 1).

Surgery complication rate, duration and contamination by insurance status

In total, postsurgical complications occurred in 964 (30.4%) of all interventions without PS-matching (table 2). Patients with supplementary insurance had an increased rate of overall postsurgical complications compared to patients with basic insurance (29.2% vs 35.5%, p = 0.003). The most relevant difference between basic and supplementary insurance was detectable in the CDC II group (5.3% vs 8.3%) with a minor difference in mortality (1.8% vs 2.9%).

In the matched sample, there was no significant difference in occurrence of complications (35.5% vs 36.2%, p = 0.86). We did not detect a relevant difference in mortality in the matched sample neither (3.2% vs 2.9%). As shown in table 2, surgeries of patients with supplementary insurance were shorter compared to their matched procedures (95 min [IQR: 62–172] vs 90 min [IQR: 50–165]; p = 0.005). The number of surgeries with increased contamination was not significantly different between basic and supplementary insured patients.

Figure 2: Flowchart of study design. Shown is a summary of included and excluded procedures. After exclusion, 3173 procedures were analysed, including 2582 with basic health insurance and 591 with supplementary health insurance. Created with BioRender.com.

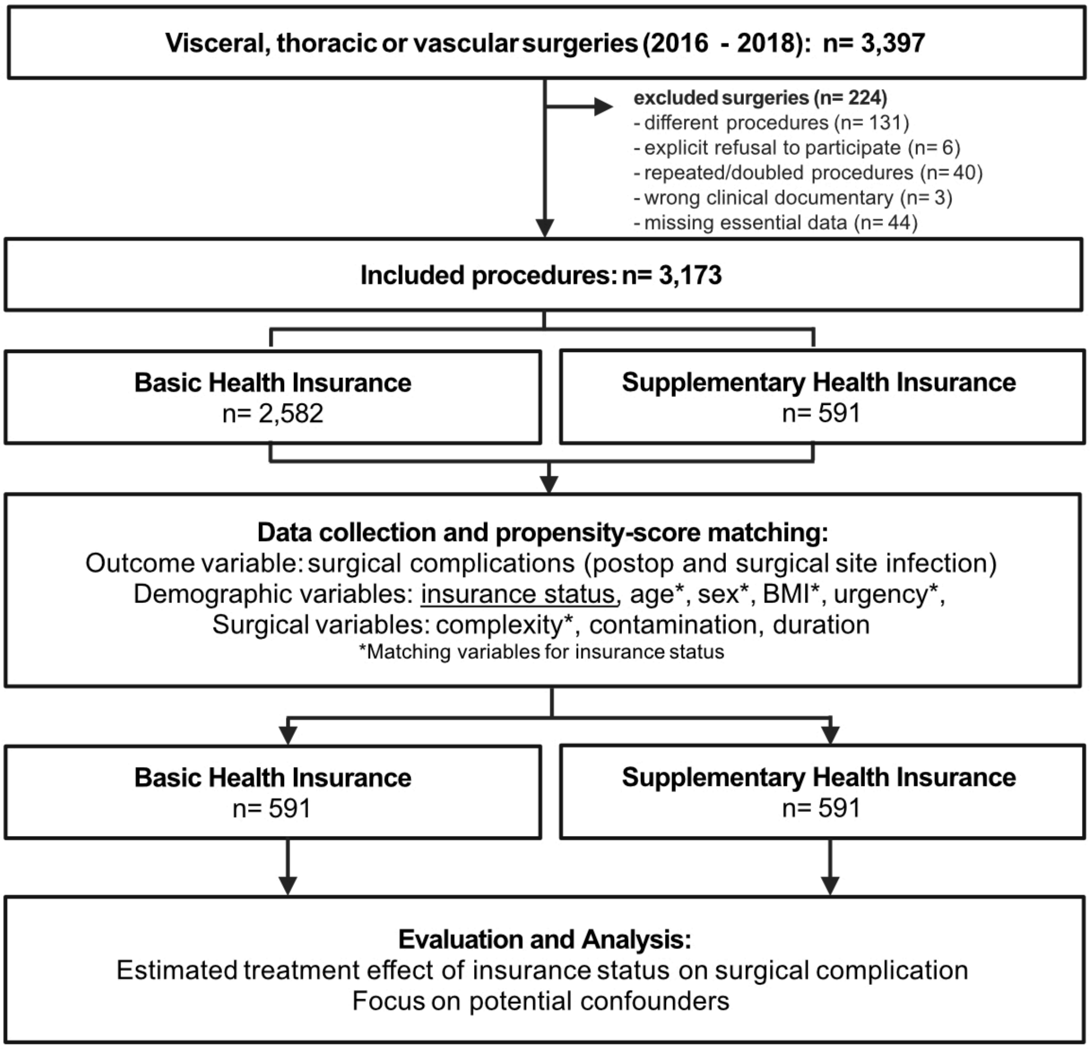


Table 1:
Demographic and surgical parameters before and after propensity-score matching. Age and BMI are shown as median with IQR (interquartile range); all other categories are shown as counts and %.

			Unmatched sample			Matched sample *		
			Basic	**Supplementary**	**Standardised mean difference (SMD)**	**Basic**	**Supplementary**	**Standardised mean difference (SMD)**
Independent variable	Health insurance		2582 (81.4)	591 (18.6)		591 (50.0)	591 (50.0)	
Matching variables	*Age in years		59 (42–72)	69 (56–76)	0.477	67 (55–78)	69 (56–76)	0.004
	*Sex: male		1498 (58.0)	332 (56.2)	0.037	341 (57.7)	332 (56.2)	0.031
	*BMI in kg/m^2		25 (23–29)	24 (22–28)	0.219	25 (22–28)	24 (22–27)	0.026
	*Elective cases		1637 (63.4)	402 (68.0)	0.099	399 (67.5)	402 (68.0)	0.011
	*ASA-score ≥III		843 (32.6)	237 (32.6)	0.152	237 (40.1)	237 (40.1)	0.000
		ASA I+II	1739 (67.4)	354 (59.9)		354 (59.9)	354 (59.9)	
		ASA III	784 (30.4)	226 (8.2)		220 (37.2)	226 (38.2)	
		ASA IV	55 (2.1)	9 (1.5)		14 (2.4)	9 (1.5)	
		ASA V	4 (0.1)	2 (0.3)		3 (0.5)	2 (0.3)	
	*Surgical complexity: major		1183 (45.8)	347 (58.7)	0.262	355 (60.1)	347 (58.7)	0.028

ASA: American Society of Anaesthesiology.

* Matching by “nearest” algorithm including 1:1 matching of 591 supplementary insured patients by matching variables and surgical complexity. Standardised mean differences were calculated as a balance measure between basic and supplementary groups within unmatched and matched samples.

Surgical complications, contamination and duration separated by insurance status and surgical complexity

In the matched population, the surgical complexity was evenly distributed in both insurance groups. In total, 480 (40.6%) interventions were of intermediate complexity, while 702 (59.4%) were of major complexity. Based on the higher frequency of major complexity surgeries, we analysed both groups of surgical complexity separately (table 2). Of all 424 complications, 81 (19.1%) appeared in surgeries of intermediate complexity and 343 (80.9%) in those of major complexity. Separated by their surgical complexity and insurance status, there was a substantial but non-significant trend of reduced occurrence of complications for patients with supplementary insurance with surgeries of intermediate complexity (intermediate basic: 45 [19.1%] vs supplementary: 36 [14.8%], p = 0.22). There was no significant difference in occurrence of complications in the group with major complexity (major basic: 169 [47.6%] vs supplementary 174 [50.1%], p = 0.54). There were no relevant differences within the grades of complications or between low- and high-risk complications (CDC I–II vs CDC III–V). The observed difference in duration of surgery in combined complexity was even more pronounced in the matched intermediate complexity group (basic: 65 min [IQR: 50–94] vs supplementary: 55 min [IQR: 40–75], p <0.001) without statistical significance in procedures of major complexity. There was no difference in surgical contamination, either if separated by the surgical complexity nor in the overall group.

Estimated treatment effect of insurance status on complication rate and other variables

To determine the estimated treatment effect of insurance status, we compared odds ratios between unmatched and

Table 2:
Analysis of surgical complications, contamination and duration separated by complexity. Complications, assessed by the Clavien-Dindo classification (CDC), and contamination, assessed by degree (I–IV), are shown as counts and %, while duration is shown as medians with IQR (interquartile range).

			Unmatched sample			Matched sample*		
			Basic	Supplementary insurance	p-value**	Basic	Supplementary insurance	p-value**
All complexities***	No complications		1828 (70.8)	381 (64.5)	0.003	377 (63.8)	381 (64.5)	0.86
	All complications		754 (29.2)	210 (35.5)		214 (36.2)	210 (35.5)	
		CDC I	341 (13.2)	85 (14.4)		92 (15.6)	85 (14.6)	
		CDC II	138 (5.3)	49 (8.3)		39 (6.6)	49 (8.3)	
		CDC III	184 (7.1)	52 (8.8)		47 (8.0)	52 (8.8)	
		CDC IV	45 (1.7)	7 (1.2)		17 (2.9)	7 (1.2)	
		CDC V (death)	46 (1.8)	17 (2.9)		19 (3.2)	17 (2.9)	
		CDC low (I–II)	479 (63.5)	134 (63.8)	0.99	131 (61.2)	134 (63.8)	0.62
		CDC high (III–V)	275 (36.5)	76 (36.2)		83 (38.8)	76 (36.2)	
	Duration in min		85 (55–144)	90 (50–165)	0.78	95 (62–172)	90 (50–165)	0.005
	Contamination (II–IV)		1509 (58.5)	341 (57.7)	0.75	341 (57.7)	341 (57.7)	0.99
Intermediate complexity***	No complications		1190 (85.1)	208 (85.2)	0.99	191 (80.9)	208 (85.2)	0.22
	All complications		209 (14.9)	36 (14.8)		45 (19.1)	36 (14.8)	
		CDC I	118 (8.4)	19 (7.8)		21 (8.9)	19 (7.8)	
		CDC II	24 (1.7)	6 (2.5)		4 (1.7)	6 (2.5)	
		CDC III	53 (3.8)	9 (3.7)		13 (5.5)	9 (3.7)	
		CDC IV	8 (0.6)	0 (0.0)		5 (2.1)	0 (0.0)	
		CDC V (death)	6 (0.4)	2 (0.8)		2 (0.8)	2 (0.8)	
		CDC low (I–II)	142 (67.9)	25 (69.4)	0.99	25 (55.6)	25 (69.4)	0.25
		CDC high (III–V)	67 (32.1)	11 (30.6)		20 (44.4)	11 (30.6)	
	Duration in minutes		65 (50–95)	55 (40–75)	<0.001	65 (50–94)	55 (40–75)	<0.001
	Contamination (II–IV)		736 (52.6)	118 (48.4)	0.24	112 (47.5)	118 (48.4)	0.86
Major complexity***	No complication		638 (55.3)	173 (50.9)	0.15	186 (52.4)	173 (49.9)	0.54
	All complications		515 (44.7)	167 (49.1)		169 (47.6)	174 (50.1)	
		CDC I	223 (19.3)	66 (19.4)		71 (19.4)	66 (19.0)	
		CDC II	114 (9.9)	43 (12.7)		35 (10.3)	43 (12.4)	
		CDC III	131 (11.4)	43 (12.7)		34 (12.6)	43 (12.4)	
		CDC IV	7 (0.6)	0 (0.0)		12 (4.4)	7 (2.0)	
		CDC V (death)	40 (3.5)	15 (4.4)		17 (3.8)	15 (4.3)	
		CDC low (I–II)	337 (61.8)	65 (62.6)	0.86	106 (62.7)	109 (62.6)	0.99
		CDC high (III–V)	208 (38.2)	66 (37.4)		63 (37.3)	65 (37.4)	
	Duration in minutes		136 (80–225)	140 (80–222)	0.88	146 (90–235)	140 (80–222)	0.33
	Contamination (II–IV)		773 (65.4)	223 (64.3)	0.75	229 (64.5)	223 (64.3)	0.99

CDC: Clavien-Dindo classification.

* Matching by “nearest” algorithm including 1:1 matching of 591 supplementary insured patients by matching variables and surgical complexity.

** p-values calculated by Fisher’s exact test for categorical variables and Mann-Whitney test for continuous variables with significance set at p <0.05.

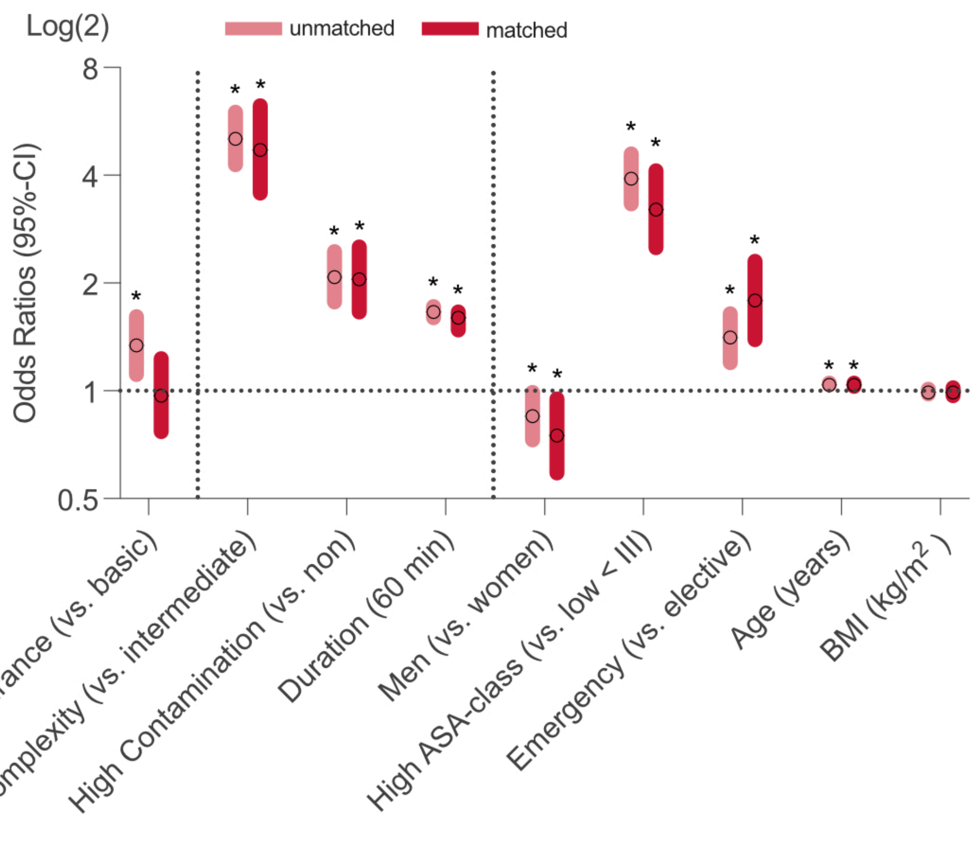
*** Intermediate complexity included appendectomies, cholecystectomies, hernia surgeries and lymph node excisions. Major complexity included all other procedures matched samples of the occurrence of complications (outcome variable) including treatment, surgical and demographic variables (figure 3). It was possible to show a change from a significant estimated treatment effect of insurance status (crude OR [95% CI]: 1.34 [1.11–1.61], p = 0.003) to no significance by matching (crude OR [95% CI]: 0.97 [0.77–1.23], p = 0.81). There was no relevant influence of matching on the odds ratios of other variables. The most pronounced associations with the occurrence of complications were major surgical complexity (crude OR [95% CI]: 5.06 [4.28–6.00], p <0.001), an increased ASA classification (crude OR [95% CI]: 3.91 [3.33–4.59], p <0.001) and increased contamination (crude OR [95% CI]: 2.08 [1.77–2.45], p <0.001).

Association of insurance status, demographic and surgical variables with occurrence of complications

Based on the potential confounding of included variables on the occurrence of complications, multiple logistic regression analyses were performed on unmatched and matched samples, adjusting for treatment, surgical and demographic variables (table 3). Similar to the matching, adjustment for confounding showed no remaining association of insurance status in the unmatched and matched samples. The following descriptions focus on associations from the matched sample as both the unmatched and matched samples showed similar trends after adjustment.

After adjustment, surgical variables such as major surgical complexity (adjusted OR [95% CI]: 1.80 [1.27–2.56], p <0.001), high surgical contamination (adjusted OR [95% CI]: 1.90 [1.41–2.56], p <0.001) and surgical duration (adjusted OR [95% CI]: 1.008 [1.006–1.009], p <0.001) remained significantly associated with the occurrence of surgical complication. Adjustment for demographic variables showed that a high (≥III) ASA classification (OR [95% CI]: 1.57 [1.15–2.13], p = 0.004), an emergency (OR [95% CI]: 2.14 [1.59–2.19], p <0.001) and higher age (OR [95% CI]: 1.03 [1.02–1.04], p <0.001) were positively associated with the occurrence of complications. Urgency is the only variable whose association increased after adjustment (crude OR: 1.79 vs adjusted OR: 2.14). Male sex had a significant association with a reduced occurrence of complications in the univariate analysis (OR [95% CI]: 0.75 [0.59–0.95], p = 0.02) without significant association after adjustment (OR [95% CI]: 0.82 [0.62–1.08], p = 0.16). There was no association between the BMI and occurrence of complication throughout the analyses.

Figure 3: Influence of the treatment (supplementary insurance) and other variables on the occurrence of complications in unmatched and matched samples. Shown are associations in odds ratios and 95% confidence interval (CI) of treatment (insurance status), surgical variables (complexity, contamination, duration) and demographic variables (sex, American Society of Anaesthesiology [ASA] classification, urgency, age and body mass index [BMI]) on the occurrence of complications in unmatched (pink) and matched (red) samples. Statistical significance was set at p <0.05 and is indicated with an asterisk (*). Analysed variables were included by their expected significance in first descriptive analysis and expert decision. Binary variables were compared to a reference level as indicated beside the group.



Discussion

This study provides data concerning overall complications of surgical patients undergoing abdominal, thoracic and vascular surgical interventions in relation to the patient's insurance status. We were able to investigate a large cohort of patients acquired prospectively for 18 months. The cohort represents an average patient population and interventions of a large Swiss hospital.

We found no evidence for an association between supplementary insurance and reduced surgical complications. In the analysis of the unmatched sample, patients with basic insurance had even fewer overall complications than those with supplementary insurance. To investigate this initial finding, we used propensity-score matching (PSM) to balance an endogenous diversity of demographic parameters as we expected a selective access to supplementary imbalances and searched for other possible confounders of the found association. We showed no significant estimated treatment effect of a supplementary insurance in a balanced sample with a comparable patient population. However, demographic parameters, as well as contamination of the surgical wound according to the standards of swissnoso [14], complexity of the performed surgeries adapted to the National Institute for Health and Care Excellence (NICE) classification [12] and duration of surgery were found to be significantly associated with the occurrence of surgical complications. We conclude therefore that the statement of comparable standards in healthcare quality in general surgical patients, regardless of the insurance status, remains valid.

Contextualisation of the study results within the Swiss healthcare system

Intuitively, benefits regarding complication rates from a supplementary insurance status in the Swiss healthcare system were expected, while no such benefits were statistically measurable in this study. A potential explanation could be that the Swiss healthcare system meets high quality standards for all general surgical patients. Furthermore, intensive supervision of surgical residents is standard to provide this quality, and if treatment exceeds the resident's experience, the threshold for attending doctors to intervene is low. Therefore, the expected benefit of supplementary insurance is mainly the direct care by an experienced attending doctor, which is eliminated by the described intensive supervision.

In this study, it was impossible to measure the impact of surgical experience in a statistically reliable manner, and reasoning would remain hypothetical. However, adjusted to the surgical complexity and influences such as the emergency status, our results showed no association between surgical complications and insurance status. Therefore, we can agree with the conclusions made by Schneider et al. and Duggan et al., which focused on the correlation between surgical site infection or medical outcomes of oncological surgical procedures and insurance status in the Swiss healthcare system [8–9]. In their studies, no negative impact of basic insurance could be found either. In comparison to their studies, our analyses showed results for a larger spectrum of complications and surgeries, better representing the real-world situation. Funke et al. showed a significant increase in surgical complications among trauma

Table 3:
Logistic regression analyses of complications of unmatched and propensity-matched surgeries for potential confounding.

		Unmatched sample*				1:1 Matched sample*			
		Unadjusted**		Adjusted***		Unadjusted**		Adjusted***	
		Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Treatment variable	Supplementary insurance (vs basic)	1.34 (1.11–1.61)	0.003	1.02 (0.81–1.27)	0.88	0.97 (0.77–1.23)	0.81	1.04 (0.79–1.38)	0.77
Surgical variables	Major surgical complexity (vs intermediate)	5.06 (4.28–6.00)	<0.001	2.05 (1.66–2.52)	<0.001	4.71 (3.57–6.26)	<0.001	1.80 (1.27–2.56)	0.001
	Increased contamination (vs non)	2.08 (1.77–2.45)	<0.001	1.56 (1.28–1.90)	<0.001	2.50 (1.95–3.24)	<0.001	1.90 (1.41–2.56)	<0.001
	Duration in minutes	1.011 (1.01–1.012)	<0.001	1.008 (1.007–1.009)	<0.001	1.01 (1.008–1.011)	<0.001	1.008 (1.006–1.009)	<0.001
Matching variables	Men (vs women)	0.85 (0.73–0.99)	0.04	0.89 (0.75–1.07)	0.22	0.75 (0.59–0.95)	0.02	0.82 (0.62–1.08)	0.16
	High ASA score (vs low <III)	3.91 (3.33–4.59)	<0.001	1.56 (1.27–1.91)	<0.001	3.21 (2.51–4.12)	<0.001	1.57 (1.15–2.13)	0.004
	Emergency (vs elective procedure)	1.41 (1.20–1.64)	<0.001	1.87 (1.54–2.28)	<0.001	1.79 (1.39–2.30)	<0.001	2.14 (1.59–2.91)	<0.001
	Age in years	1.04 (1.04–1.05)	<0.001	1.03 (1.02–1.03)	<0.001	1.04 (1.03–1.05)	<0.001	1.03 (1.02–1.04)	<0.001
	BMI in kg/m^2	0.99 (0.98–1.01)	0.66	0.99 (0.97–1.01)	0.30	0.99 (0.97–1.02)	0.56	0.99 (0.96–1.02)	0.48

* Matching by "nearest" algorithm including 1:1 matching of 591 supplementary insured patients by matching variables and surgical complexity. Variables were chosen by their potential association to insurance status and re-included in a logistic regression for additional adjustment for their conditional effects. Estimated treatment effects can be anticipated within univariate analysis of matched population and comparing unmatched and matched sample.

Represented are odds ratios (OR) with their 95% confidence interval (CI) for ** binary logistic regression (crude) between the occurrence of a complication and the indicated exposure variables and *** multiple logistic regression (adjusted) including treatment, surgical and matching variables to determine the adjusted association of insurance status. The reference variable is shown in brackets. Included variables were selected by their significant influence on insurance and complications in preliminary descriptive analysis, known influence literature research or experts' decision. Statistical significance was set at $p < 0.05$.

patients with basic insurance [7]. However, a direct comparison of trauma and abdominal surgery remains speculative and can differ in terms of complexity and variety of surgical procedures. Furthermore, as major surgeries in the abdominal, thoracic or vascular field require a high level of interdisciplinary cooperation, for example with intensive care medicine and complex post-operative management, the number of complications could be less reliant on the experience of the surgeon alone. Similar to our study, Funke et al. did not find a difference in mortality associated with health insurance status [7].

Association of included variables interfering with the insurance status

Our results emphasise the importance of recognising external influences when investigating insurance status. Matching our sample by the probability to have access to a supplementary insurance through balanced co-variables influenced the estimated treatment effect substantially. We found that age especially was a relevant factor for the probability of being supplementary insured – which has also been shown by Altwicker-Hamori [16]. Age is of special importance, as older patients can be for example more likely to have a supplementary insurance and have higher rate of ASA-associated physical status, associated with an increased occurrence of complications. Those results are similar to Funke et al [7]. Another example could be that supplementarily insured patients also had more surgeries with major complexity, which was then associated with a higher occurrence of complications. However, it is also likely that patients with planned major surgery rely on supplementary insurance for the free choice of doctors or hospital. In our perspective, it is therefore necessary to acknowledge both influences, the selected access to health insurances as well as the potential confounding of different demographic and surgical variables. For future studies, we support considering other relevant demographic parameters such as education or income. Another important association that should be considered for future studies was the significant time reduction of surgeries for patients with supplementary insurance similar to Schneider et al. and Duggan et al. [8–9]. This time reduction was especially present within surgeries of intermediate complexity. Whether this result was a simple expression of a more subtle difference of complexity in surgery with an intermediate profile or that the surgery performed by a senior surgeon just took less time was not evident in our analysis. Our analyses support that a prolonged duration of surgery, as a surrogate of a more challenging surgery, was associated with an increased occurrence of complications. However, we could not detect a significant reduction of complications along with the time reduction of patients with supplementary insurance.

Generalisability of the study results

The patients themselves might expect a more beneficial outcome for the additional cost of supplementary insurance. Several studies in the US healthcare system show an evident difference with private/supplementary healthcare plans [3–4]. The American system risks creating different classes in medical treatment. But in contrast to the Swiss healthcare system and our study, most US studies focus on patients with private health insurance and those without insurance at all [20]. Especially in Switzerland, fundamental treatment is covered by compulsory basic healthcare, and the increment to the therapy within a supplementary healthcare plan is marginal regarding the medical quality [2]. Therefore, a significant difference in medical treatment and outcome may be expected in the American healthcare system but not in the universal coverage system of Switzerland. However, political debates regarding the Swiss health insurance system are omnipresent in Swiss politics. The fear of a two-tier medical system is a recurring argument in such debates. At this point, our study indicates no evidence for a two-tier medical system in Switzerland regarding surgical treatment.

There is also the probability that benefits offered by supplementary insurances in Switzerland might influence the intended medical outcome without being reflected by the complication rate. Complications of surgical patients can only be a surrogate marker for treatment quality but are not the same as the intended medical outcome, for example the overall survival in cancer patients. There might be many connections between complications and medical outcomes without absolute certainty that overcoming complications may affect the medical outcome. Furthermore, the quality of the management of surgical complications may outweigh the original impact of the complication.

Limitations

This study is limited in its conclusion as there is no general definition of medical outcome, and investigations require the assessment of different surrogate parameters, such as surgical site infection or postsurgical complications. Thus, making final statements about causality can be challenging after all and requires comprehensive future guidance to improve robust definitions which can be summarised in research, such as meta-analyses.

There are different possibilities of selection biases inherent through the study design. First, this study is limited to the data of the initial StOP?-trial, which was not randomised, and accumulates a further selection bias through the focus on one centre and higher complexity surgery. However, similar to the StOP?-trial, our study tried to increase the generalisability by a broad inclusion and restricted exclusion. While the inclusion of many different surgery types can lead to heterogeneity, we tried to minimise it through categorisation into intermediate and high complexity, matching and statistical adjustment, with the purpose of reducing the influences of heterogeneity on the outcome variable (figure S1). Including surgeries typical for a department of abdominal, thoracic and vascular surgery, we hope to allow increased generalisability and comparison to a typical Swiss tertiary referral centre. However, it is important to encourage further studies to focus on a comparison within separate surgery types. Second, we experienced a high endogenic heterogeneity of patients with basic and supplementary insurance. We tried to reduce this imbalance and increase plausibility through the use of propensity-score matching. As already stated in the methods, 1:1 matching can lead to a selection bias by dropping important residues during the matching process. In our study, the experienced bias was limited as we could show robustness of our matching through sensitivity analysis (figure S2 and table S3). However, there will always be a risk for residual and unmeasured confounding, as the matching uses a retrospective approach based on observed variables. Third, patients were excluded when data was missing to simplify the analysis, creating a potential for selection bias and unknown confounding. It is therefore important to point out that our results aim not for causality but to reflect associations of treatment on the outcome translatable to a comparable cohort. Propensity-score matching cannot substitute for prospective randomisation and a multicentric view to allow casual conclusions and increased generalisability.

As our study data was limited by the framework of the StOP?-trial, we want also to address the need for further investigations of important parameters such as Comprehensive Complication Index (CCI) or surgical experience, which could not be assessed in this study.

Conclusion

We demonstrated evidence that insurance status is not associated with surgical complications of abdominal, thoracic and vascular surgeries within the Swiss healthcare system. The duration of surgery of intermediate complexity did differ significantly in favour of patients with supplementary insurance. Nevertheless, basic insurance status did not increase significantly the occurrence of surgical complications in a comparable cohort.

Data sharing statement

Upon reasonable request, individual data or codes that support results can be shared with necessary adjustments for deidentification, ending after 48 months following publication. Requests must be approved by the corresponding author as well as an independent committee for measures of ethical approval.

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Author contributions: Study conception and design: SW, LB, SG. – Acquisition of data: MB, SW, SG, LB, CZ. – Analysis and interpretation of data: MB, SW, SG. – Drafting of manuscript: MB. – Critical revision of manuscript: All mentioned authors.

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Appendix

Information to Table S1:

Shown are all procedures in numbers and percentages, classified into different subcategories and separated into their insurance status (basic, supplementary) and 1:1 matching

Table S1: Distribution of Surgeries

	Total	Basic	Supp.	Matched Total [a]	Matched Basic [a]	Matched Supp. [a]
	n= 3173 (100.0)	n= 2582 (81.4)	n= 591 (18.6)	n= 1182 (100.0)	n= 591 (50.0)	n= 591 (50.0)
a) Upper gastrointestinal surgery, no. (%)	**271 (8.5)**	**225 (8.7)**	**46 (7.8)**	**106 (9.0)**	**60 (10.2)**	**46 (9.3)**
Bariatric Surgery	102 (37.6)	92 (43.6)	10 (22.2)	23 (21.7)	13 (21.7)	10 (21.7)
Upper gastrointestinal surgery	66 (24.4)	52 (22.0)	14 (31.1)	31 (29.2)	17 (28.3)	14 (30.4)
Small intestine	103 (38.0)	81 (34.4)	22 (46.7)	52 (49.1)	30 (50.0)	22 (47.8)
b) Abdominal surgery, no. (%)	**630 (19.9)**	**513 (19.9)**	**117 (19.8)**	**225 (19.0)**	**108 (18.3)**	**117 (19.8)**
Hepatic Surgery	57 (9.1)	41 (7.7)	16 (13.6)	36 (16.0)	20 (18.5)	16 (13.7)
Surgery of biliary tract	2 (0.3)	1 (0.2)	1 (0.9)	1 (0.4)	0 (0.0)	1 (0.9)
Cholecystectomy	491 (78.0)	415 (82.7)	76 (67.3)	141 (62.7)	65 (60.2)	76 (65.0)
Pancreatic Surgery	75 (12.0)	53 (8.9)	22 (16.4)	42 (18.7)	20 (18.5)	22 (18.8)
Spleen Surgery	5 (0.8)	3 (0.5)	2 (1.8)	5 (2.2)	3 (2.8)	2 (1.7)
c) Colorectal Surgery, no. (%)	**664 (20.9)**	**545 (21.1)**	**119 (20.1)**	**229 (19.4)**	**110 (18.6)**	**119 (20.1)**
Colectomy	251 (37.8)	190 (33.3)	61 (50.0)	114 (49.8)	53 (48.2)	61 (51.3)
Appendectomy	341 (51.4)	300 (56.8)	41 (35.7)	80 (34.9)	39 (35.5)	41 (34.5)
Rectum	72 (10.8)	55 (9.9)	17 (14.3)	35 (15.3)	18 (16.4)	17 (14.3)
d) Hernia, no. (%)	**802 (25.3)**	**677 (26.2)**	**125 (21.2)**	**257 (21.7)**	**132 (22.3)**	**125 (21.2)**
Femoral / Inguinal / Umbilical / Hiatus	742 (92.5)	625 (92.0)	117 (93.5)	240 (93.4)	123 (93.2)	117 (93.6)
Incisional Hernia	60 (7.5)	52 (8.0)	8 (6.5)	17 (6.6)	9 (6.8)	8 (6.4)
e) Thoracic and Vascular Surgery, no. (%)	**528 (16.6)**	**404 (15.7)**	**124 (21.0)**	**251 (21.2)**	**127 (21.5)**	**124 (21.0)**
Wedge Resection	30 (5.7)	26 (6.6)	4 (3.5)	13 (5.2)	9 (7.1)	4 (3.2)
Aortic Surgery	56 (10.6)	41 (9.2)	15 (12.2)	31 (12.4)	16 (12.6)	15 (12.1)
Peripheral Vessel Surgery	200 (37.9)	154 (38.4)	46 (38.3)	94 (37.5)	48 (37.8)	46 (37.1)
Thoracoscopic Surgery	205 (38.8)	151 (37.7)	54 (41.7)	99 (39.4)	45 (35.4)	54 (43.5)
Thoracotomy	37 (7.0)	32 (8.1)	5 (4.3)	14 (5.6)	9 (7.1)	5 (4.0)
f) Others, no. (%)	**278 (8.8)**	**218 (8.4)**	**60 (10.2)**	**114 (9.6)**	**54 (9.1)**	**60 (10.2)**
A) Intermediate, no. (%)	**1643 (51.8)**	**1399 (54.2)**	**244 (41.3)**	**480 (40.6)**	**236 (39.9)**	**244 (41.3)**
B) Major, no. (%)	**1530 (48.2)**	**1183 (45.8)**	**347 (58.7)**	**702 (59.4)**	**355 (60.1)**	**347 (58.7)**

[a] Matching by "nearest" algorithm including 1:1 matching of 591 supplementary insured patients by matching variables.
Abbreviations: Supp. (supplementary insurance), no (number)

Information to Table S2:

Shown are patient characteristics of all procedures in numbers and percentages or median and 95%-CI, classified into different surgery groups and complexity in the unmatched sample. Categorization into complexity leads to a significant separation of surgeries, allowing a comparability in the comparison of insurance status after matching or adjustment.

Table S2: Demographic and surgical attributes compared for different surgical complexity (according to NICE categorization) and surgery subgroups

	A) Intermediate Complexity [a] 1643 (51.8)	B) Major Complexity 1530 (48.2)	p-value *	a) Upper GI-surgery 271 (9.0)	b) Abdominal surgery 630 (19.0)	c) Colorectal Surgery 664 (19.4)	d) Hernia 802 (21.7)	e) Thoracic and Vascular Surgery 528 (21.2)	f) Others 278 (9.6)
Insurance (supp.)	244 (14.9)	347 (22.9)	< .001	46 (17.0)	117 (18.6)	119 (17.9)	125 (15.6)	124 (23.5)	60 (21.6)
Age [y]	53 (37-68)	67 (55-76)	< .001	62 (48-75)	60 (44-73)	53 (34-70)	59 (43-71)	64 (49-76)	64 (49-76)
Gender (Men)	991 (60.3)	839 (54.8)	.002	126 (46.5)	285 (45.2)	360 (54.2)	583 (72.7)	336 (63.6)	140 (50.4)
BMI [(kg/m²)]	25 (23-28)	25 (22-29)	.98	26 (23-35)	26 (23-30)	25 (22-28)	25 (23-28)	25 (22-28)	25 (22-28)
Elective Cases	985 (60.0)	1054 (68.9)	< .001	195 (72.0)	345 (54.8)	248 (37.3)	740 (92.3)	384 (72.9)	126 (45.3)
ASA-classification > III	270 (16.4)	810 (52.9)	< .001	126 (46.5)	168 (26.7)	162 (24.4)	137 (17.7)	347 (65.7)	140 (50.4)
All complications	245 (14.9)	719 (47.0)	< .001	119 (43.9)	194 (30.8)	209 (31.5)	114 (14.2)	210 (39.8)	118 (42.4)
CDC I	137 (8.3)	289 (18.9)		49 (18.1)	85 (13.5)	94 (14.2)	64 (8.0)	86 (16.3)	48 (17.3)
CDC II	30 (1.8)	157 (10.3)		27 (10.0)	44 (7.0)	46 (6.9)	17 (2.1)	35 (6.6)	18 (6.5)
CDC III	62 (3.8)	174 (11.4)		23 (8.5)	49 (7.8)	46 (6.9)	27 (3.4)	59 (11.2)	32 (11.5)
CDC IV	8 (0.5)	44 (2.9)		13 (4.8)	9 (1.4)	8 (1.2)	2 (0.2)	15 (2.8)	5 (1.8)
CDC V (death)	8 (0.5)	55 (3.6)		7 (2.6)	7 (1.1)	15 (2.3)	4 (0.5)	15 (2.8)	15 (5.4)
Duration [min]	65 (46-90)	138 (80-225)	< .001	105 (70-155)	90 (64-135)	90 (55-18165)	60 (43-87)	160 (81-250)	80 (50-125)
Contamination (II-IV)	854 (52.0)	996 (65.1)	< .001	216 (79.7)	599 (95.1)	649 (97.7)	31 (3.9)	230 (43.6)	125 (45.0)

Complications assessed by Clavien-Dindo-Classification (CDC) and contamination (in grades I-IV) are shown as numbers with %, and duration as median with IQR (interquartile range). Abbreviations: Supp. (supplementary insurance). GI (gastrointestinal). * p-values calculated by Fishers-Exact-test for categorical and Mann-Whitney test for non-parametrical continues variables with significant assumption if p-value <0.05. [a)] Intermediate complexity included appendectomies, cholecystectomies, hernia surgeries, and lymph node excisions, major complexity all other procedures

Information to Figure S1

Shown is the graphical comparison of the estimated treatment effect for the unmatched, 1:1 matching and full matching sample within different subgroups (including surgery groups) to visualize potential heterogeneity. Small differences between estimated effects were not relevant after either matching approach.

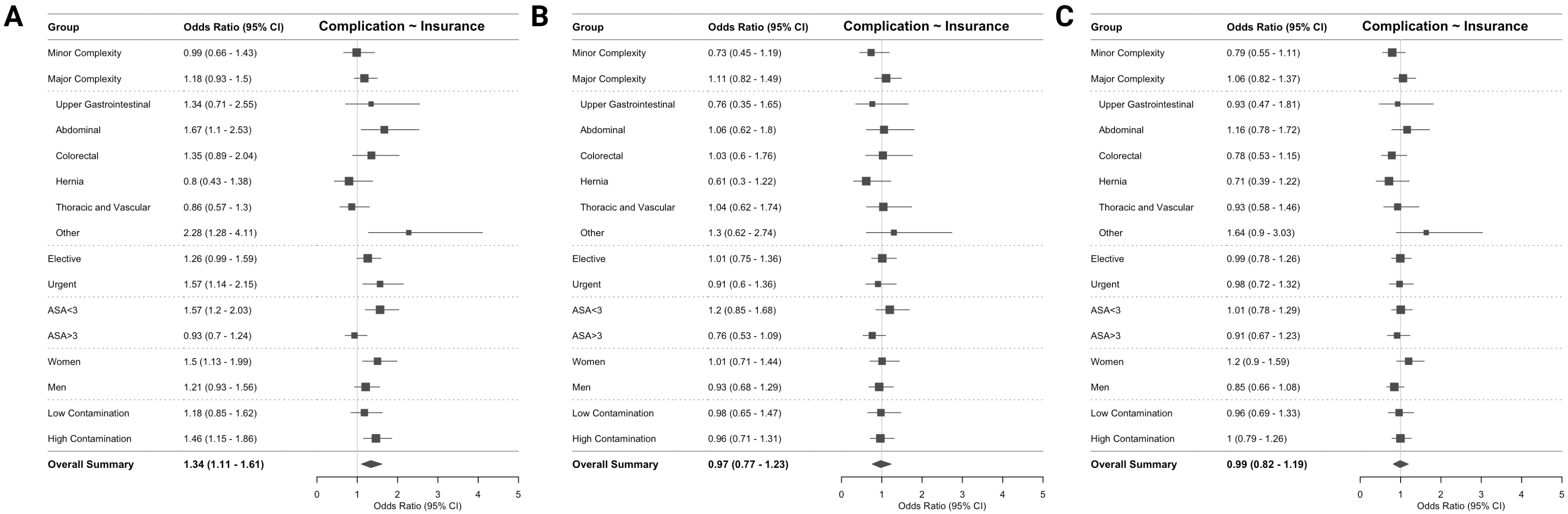

Figure S1: Association of a supplementary insurance with the occurrence of complications within different subgroups. Shown are odds ratios of the insurance status of (A) unmatched (B) 1:1 matched and (C) full matched samples with 95%-confidence intervals (CI) for relevant subgroups including different groups of procedures and their overall effect using logistic regression. For full matched analysis, weights were included in an adjusted logistic regression.

Information to Figure S2 and Table S3

Shown is a graphical comparison of balance measures (standardized mean difference) for the unmatched, 1:1 matching and full matching approach with the aim of SMD < 0.1 for matching variables. Table S3 shows the results of a sensitivity analysis summarizing differences on the estimated treatment effect on outcome and surgical variable by logistic regression on unmatched, adjusted to the propensity score, 1:1 matching and full-matching.

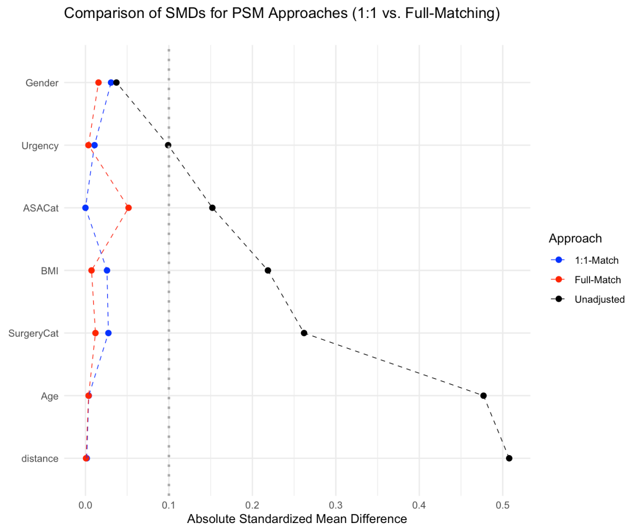

Figure S2: Comparison between standardized mean differences of unmatched population, 1:1 matching and full matching. Shown are standardized mean differences (SMD) as a balance measure for the different approaches (black = unmatched, red = full matching, blue 1:1 matching). Balance was expected with SMD < 0.1. Included were matching variables based on their influence for access to the treatment group (supplementary insurance) between surgeries of patients with basic and supplementary insurance.

Table S3: Comparison of approaches using adjustment for propensity score, 1:1 and full matching

	Unmatched sample				Matched sample *			
Variable	Unadjusted	p-value	Adjusted to PS [a]	p-value	1:1 matching [b]	p-value	Full matching [c]	p-value
Suppl. Insurance (vs, basic)	1.34 (1.11, 1.61)	.003	0.96 (0.78, 1.17)	.68	0.97 (0.77-1.23)	.81	0.99 (0.82-1.19)	.91
Major Complexity (vs. intermediate)	5.06 (4.28, 6.00)	< .001	3.43 (2.84, 4.15)	< .001	4.71 (3.57-6.26)	< .001	4.57 (3.86-5.42)	< .001
Increased Contamination (vs. non)	2.08 (1.77, 2.45)	< .001	2.39 (2.01, 2.83))	< .001	2.50 (1.95-3.24)	< .001	2.42 (2.07-2.83)	< .001
Duration (min)	1.01 (1.011, 1.012)	< .001	1.01 (1.009, 1.011)	< .001	1.01 (1.008-1.011)	< .001	1.01 (1.01-1.012)	< .001

Represented are odds ratios (OR) with their 95%-confidence interval (CI) for logistic regression (crude) between the occurrence of complications and the indicated exposure variables. The reference levels of binary variables are shown in brackets as well as the unit for continuous variables. Statistical significance was anticipated with p-value < 0.05 (two-sided). Abbreviations: suppl. (supplementary), PS (propensity score). [a] Logistic regression with treatment variable and propensity score. [b] Matching by “nearest” algorithm including 1:1 matching of 591 supplementary insured patients by matching variables and surgical complexity. [c] Matching by “full” approach included all patients matched by different weights given through observation of matching variables. * Matching variables were chosen by their potential association determining the access to an insurance status.

Session Info R-Studio

R version 4.1.2 (2021-11-01)
Platform: x86_64-apple-darwin17.0 (64-bit)
Running under: macOS 15.1.1

Matrix products: default
LAPACK: /Library/Frameworks/R.framework/Versions/4.1/Resources/lib/libRlapack.dylib

locale:
[1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8

attached base packages:
[1] grid stats graphics grDevices utils datasets methods base

other attached packages:
[1] forestplot_3.1.6 abind_1.4-8 checkmate_2.3.2 purrr_1.0.4 broom_1.0.7 tidyr_1.3.1
[7] ggplot2_3.5.1 dplyr_1.1.4 MatchIt_4.5.0 data.table_1.16.4 writexl_1.5.1 readxl_1.4.3

loaded via a namespace (and not attached):
[1] Rcpp_1.0.9 rstudioapi_0.13 magrittr_2.0.1 tidyselect_1.2.0 munsell_0.5.0 colorspace_2.0-2 R6_2.5.1
[8] rlang_1.1.5 tools_4.1.2 gtable_0.3.0 cli_3.6.4 withr_3.0.2 tibble_3.2.1 lifecycle_1.0.3
[15] vctrs_0.6.5 glue_1.8.0 compiler_4.1.2 pillar_1.10.1 cellranger_1.1.0 generics_0.1.3 scales_1.3.0
[22] backports_1.4.1 pkgconfig_2.0.3

