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**Working Paper**

## Swiss hospital financing with DRGs: Are there treatments/-combinations that are associated with profitability?

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**Swiss hospital financing with DRGs: Are there treatments/-combinations that are associated with profitability?**

**Jonas Subelack**



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# **Swiss hospital financing with DRGs: Are there treatments/-combinations that are associated with profitability?**

**Keywords:** Hospital financing, hospital profitability, hospital reimbursement, DRG, Switzerland

**JEL Classification:** H51, I11, I15, I18, L51

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Jonas Subelack; University of St.Gallen, School of Medicine

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## **Declarations**

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## **Conflict of interest**

None.

## **Ethics approval and consent to participate**

Not applicable.

## **Data availability**

The first dataset (“Kennzahlen der Schweizer Spitäler”) is publicly available on the website of the Swiss Federal Office of Public Health. The second dataset (“Medizinische Statistik der Krankenhäuser”) is available upon reasonable request from the Swiss Federal Statistical Office.

## Abstract

**Objective:** This study aims to investigate whether specific treatments or combinations of treatments are significantly associated with the profitability of Swiss acute-care hospitals under the current diagnosis-related group (S-DRG) reimbursement system, while accounting for differences between public and private institutions.

**Methods:** A comprehensive panel dataset of 142 Swiss acute-care hospitals, spanning from 2015 to 2022, was utilized, combining detailed financial and clinical case-level data. Profitability was assessed through hospital-level net financial results excluding deficit-covering payments. All cases were assigned uniquely to a medically homogeneous service group or area, as determined by Swiss hospital capacity planning. Fixed-effects panel regression models analyzed the associations between service areas and profitability, while an Apriori association rule mining algorithm identified service group combinations associated with profitability.

**Results:** From 2015 to 2022, overall hospital profitability margins declined continuously, with public hospitals consistently reporting lower profitability than private hospitals (net profitability margin: 0.75% vs. 1.61%), despite receiving substantial subsidies (CHF 67.1 million vs. CHF 4.1 million). The primary panel regression revealed that three service areas are significantly associated with hospital profitability: Ear, nose and throat (16,778 CHF;  $p < 0.05$ ), gynecology (27,456 CHF;  $p < 0.01$ ), and heart (10,725 CHF;  $p < 0.01$ ). The Apriori algorithm identified that the combination of the following service groups is most strongly linked to profitability: AUG1.2 (orbit, eyelids, tear ducts), BEW10 (plexus surgery), and GEF2 (interventional and endovascular vascular medicine; support: 0.051, confidence: 0.935, lift: 1.615).

**Conclusion:** The analysis of hospital profitability based on the treatments and combinations of treatments performed indicates that the S-DRG reimbursement system is relatively fair. However, across all analyses, the heart service area is primarily associated with profitability, while the serious injury service area is mainly associated with losses. Therefore, minor adjustments to the S-DRG cost weights should be made to reduce this imbalance.

## Abbreviations

CHF	Swiss franc
CHOP	Swiss classification of surgical interventions
CMI	Case mix index
DRG	Diagnosis related groups
EBITDA	Earnings before interest, taxes, depreciation and amortization
FTE	Full-time equivalent
GDP	Gross domestic product
H+	Association of Swiss hospitals
ICD	International statistical classification of diseases and related health problems
p.a.	Per year ( <i>per annum</i> )
S-DRG	Swiss diagnosis related groups
SPLB	Hospital planning service areas ( <i>DE: Spitalplanungs-Leistungsbereiche</i> )
SPLG	Hospital planning service groups ( <i>DE: Spitalplanungs-Leistungsgruppen</i> )
VIF	Variance inflation factor

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## Introduction

Swiss healthcare costs rose continuously over the last decades, from 7.3% of the GDP in 1990 to 9.1% in 2000 and to 11.7% in 2022 (1). Hospitals are the largest cost factor in the Swiss healthcare system, accounting for 35.7% of all costs in 2022 (2). Already in 2007, the Swiss government agreed on several initiatives to contain further cost increases through economic incentives, of which most were rolled out in 2012 (3). The key measures included the implementation of Swiss diagnosis-related group reimbursements (S-DRG) for hospitals, hospital capacity planning, dual financing of hospitals from insurances and cantons (federal states), and Swiss-wide free hospital selection for patients (4). The absolute reimbursement for an inpatient case in a Swiss hospital is generally based on a uniform cost weight per S-DRG, multiplied by the base rate of the individual hospital (and insurance company) (5, 6). The cost weight of the S-DRG reflects the average resource consumption of a case, calculated based on historical data from all Swiss hospitals (7). The base weight varies greatly between hospitals, ranging from CHF 8,426 at Diaconis Palliative Care Hospital (cost weight 1.0) to CHF 15,360 at Hochgebirgsklinik Davos in 2023 (8).

Today, a growing number of Swiss hospitals are in financial distress, and 90% of Swiss hospitals are operating considerably below the target EBITDA margin of 10%, which is considered sustainable, allowing hospitals to finance long-term investments (9-12). In 2023, the median EBITDA margin of (acute-care) hospitals was 2.5% (6.2% in 2021), and 25% of the Swiss hospitals reported an EBITDA margin of less than 0.1% (12). On the one hand, H+ (the association of Swiss hospitals) argues that the Swiss hospital system is generally underfunded, so the current reimbursement system does not accurately reflect the actual cost increases (9). On the other hand, the question arises as to why some hospitals manage to operate profitably on an ongoing basis, such as Klinik Hirslanden AG, with average net profits of CHF 30,599,045 p.a. from 2015 to 2022 (13). In general, hospitals that operate more efficiently should make a profit within the S-DRG system, but several voices from medical doctors to hospital managers point out that some treatments are more financially lucrative than others (10, 14-17). For example, hospital treatments for children were described as unprofitable (16), while orthopedic treatments were described as quite profitable (14, 15). If this is true and some treatments generally generate higher margins than others, hospitals would achieve unequal

financial results, even if they work with similar efficiency, which is contrary to the fundamental S-DRG philosophy (18-21).

Therefore, this study analyses whether there are specific treatments or treatment combinations that are associated with profitability. Switzerland implemented a systematic classification model as part of hospital capacity planning, whereby all cases are uniquely assigned to a hospital capacity planning service group (SPLG: Spitalplanungs-Leistungsgruppe), primarily based on diagnosis (i.e., ICD) and treatment codes (i.e., CHOP: Swiss classification of surgical interventions), which bundles medically homogeneous cases (22-24). In 2022, the canton of Zurich, which developed and introduced this classification model, counted 134 SPLGs (e.g., BEW7.1 First hip prosthesis), where multiple SPLGs are grouped into one of the 24 higher-level hospital planning service areas (SPLB: Spitalplanungs-Leistungsbereiche; e.g., surgical musculoskeletal system) (25). The research questions are:

- 1) Are there SPLBs that are significantly positively or negatively associated with profitability?
- 2) Are there SPLG combinations that are significantly positively or negatively associated with profitability?

By investigating these research questions and assessing the differences between public and private hospitals in the Swiss healthcare system, this study aims to determine whether differences in hospital profitability can be attributed to the service groups/ areas offered. Therefore, this research makes both a practical and conceptual contribution. In practice, efficient and hence affordable healthcare is essential for all Swiss citizens. Additionally, a fair reimbursement system is crucial for hospitals to maintain their operations and for the Swiss government, which regularly has to bail out system-relevant but loss-making hospitals (26-28). Thus, this research provides scientific insights for a more financially sustainable and fairer hospital reimbursement system, one that rewards efficiency without favoring or disfavoring certain treatments. Theoretically, this study introduces a novel approach to assessing hospital profitability. Previously, some analyses of diagnosis-related group (DRG) reimbursements' profitability have employed an inductive methodology (e.g., Deckungsbeitragsrechnung), where cost accounting is performed at the DRG level to determine whether reimbursements exceed the anticipated hospital-specific costs (29-33). This inductive approach relies on granular cost data and typically focuses on individual DRGs in isolation. In contrast, this paper

adopts a holistic hospital-level (deductive) perspective, where the hospital's overall financial outcome is evaluated based on the service areas/ service group combinations treated. This approach captures the cumulative effect of cross-subsidizations, fixed-cost allocations, and operational interactions that a bottom-up analysis might miss. To my knowledge, neither such a holistic profitability analysis with clustered treatments as explanatory variables has been performed yet, nor have the interaction effects of different treatments been investigated with an Apriori algorithm. Thus, this research provides a novel perspective on how a hospital's service portfolio affects its financial situation and contributes to the broader health economics literature on hospital reimbursement systems.

## Methods

### Data

Two comprehensive datasets have been used for this research. The first dataset ("Kennzahlen der Schweizer Spitäler") from the Swiss Federal Office of Public Health is the annual compendium of key figures of the Swiss hospitals. It provides hospital-level information on structure (e.g., hospital legal form), activity (e.g., number of discharges), and finances per year (e.g., net profit) (13, 34, 35). Here, the hospital details (e.g., name and location) are disclosed transparently. The second dataset ("Medizinische Statistik der Krankenhäuser") is the national hospital discharge database, containing anonymized case-level data for all inpatient stays in Switzerland (36). It includes each patient's diagnoses (i.e., ICD codes), procedures (i.e., CHOP codes), the assigned S-DRG for every hospital stay, along with other details like length of stay, admission type, canton of hospital, and hospital type. In Switzerland, there are 13 different hospital types defined. For example, there is the general hospital center care level 1, which includes university hospitals (K111) (37). In this second dataset, no specific hospitals are named; instead, an anonymous hospital ID is used, which remains stable within a year. Additionally, to assign each case from the second dataset to a SPLG, the SPLG-Grouper software from the canton Zurich department of health has been utilized, with definitions per respective year (38).

To generate a comprehensive dataset that includes the financial data per hospital and year, as well as the number of cases per SPLG, the two datasets had to be merged. As direct hospital name-based matching was not possible, a derived hospital identifier was created by combining

information available in both datasets, specifically the year, canton, and hospital type (Year\_Canton\_Type). Thus, half of all hospitals could already be uniquely assigned. For the other half, where there were multiple hospitals within a canton with the same typology, the hospitals were ranked from top to bottom according to the number of discharges. Some cantons (e.g., Zurich) transparently publish the number of SPLG cases per hospital (39). This information has been used to verify the matching by discharge numbers. Hospital profitability (or loss) is the primary outcome of interest. In the first dataset, this metric is reported as “FiErg (Jahresergebnis)”, which represents the hospital’s overall annual result after all revenues and expenditures (net profitability), excluding any deficit coverage payments. This is particularly important in the Swiss context, as some public hospitals receive substantial payments to cover deficits (26-28). By excluding those, FiErg reflects the actual financial performance of the hospital under normal circumstances within the S-DRG reimbursement system (35). Absolute profitability is reported in Swiss Francs (CHF) and relative profitability as profit margin (FiErg / total revenues). The first dataset differentiates between four legal forms (i.e., R1: Private organization; R2: Association/ foundation; R3: Sole proprietorship; R4: Public organization) (35).

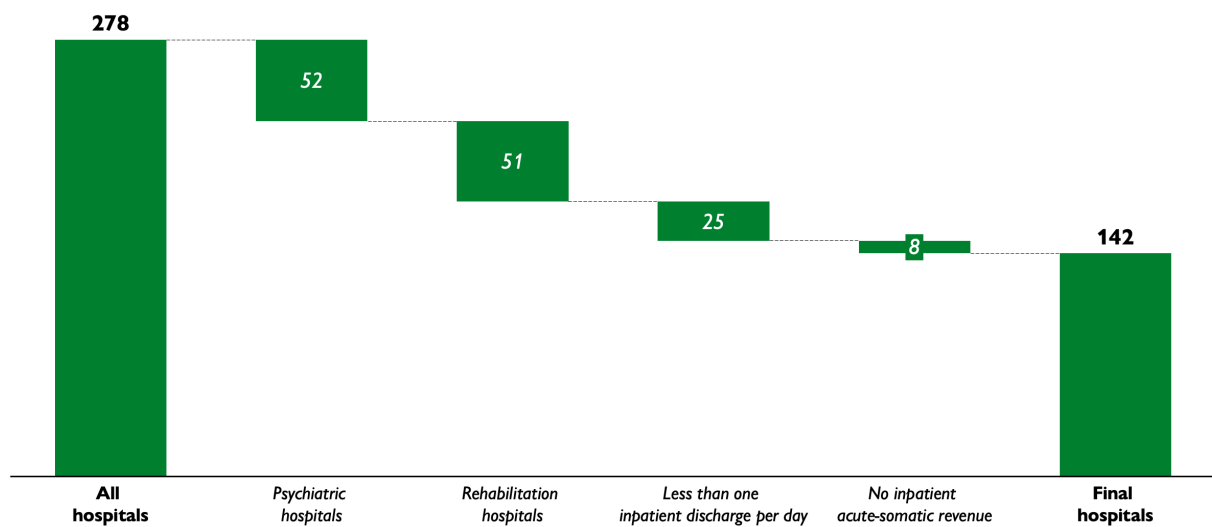
#### Hospital selection

278 hospitals are included in the first dataset for the year 2022 (13). This also includes institutions that are primarily focused on psychiatric or rehabilitation patients. In line with the Swiss SpitalBenchmark, which captures the finances of Swiss acute-care hospitals, psychiatric and rehabilitation institutions were excluded based on their hospital typology (i.e., K211, K212, K221) (12). Also, in line with previous studies, very small institutions were excluded from the sample, specifically those hospitals that reported fewer than one inpatient discharge per day, because extremely low-volume facilities would not provide a stable basis for the profitability analyses (40). Finally, institutions were removed that did not report any inpatient acute-care reimbursements (i.e., ErlKVGStatA or ErlZvOKPStatA).

Thus, the final sample includes 142 hospitals for the year 2022 (see Figure 1). Data were used from 2015 (three years after the implementation of the new S-DRG reimbursement system) to 2022 (4, 13). Stratifications by ownership focus on private (R1) and public hospitals (R4), which account for 88.8% (49.1% private, 39.7% public) of cases in the initial sample and 89.4% (47.1% private, 42.3% public) in the final sample (see Figure 5). If the absolute number of cases per SPLG is not considered for analysis, but a binary indication is required to classify whether a

hospital treats a relevant number of cases in a SPLG, the classification developed by Kuklinski et al. is applied (41). Here, in principle, a volume-based inclusion criterion is used, where hospitals accounting for the first 97.5% of total cases in that SPLG are deemed relevant providers for that SPLG. This captures most of the volume while excluding only the very smallest institutions. Additionally, hospitals were included that treated ten or more patients in a year in a SPLG, even if they fell in the lower 2.5%.

**Figure 1:** Hospital selection for analyses



Source: Own illustration; Note: Exemplary for the year 2022

### Statistical Analyses

A descriptive table outlines general hospital information (e.g., number of beds, total staff, hospital type), key financial metrics (e.g., net profit, subsidies, costs), and case distribution per SPLB. All details are stratified by public and private hospital ownership and analyzed for differences between these two subgroups via Wilcoxon rank-sum test and the Chi-squared test. Furthermore, boxplot diagrams illustrate the profitability margin trend from 2015 to 2022 and highlight the variance between hospitals. These are also stratified by public and private hospital ownership. A fixed-effects ( $\alpha_i$ ) panel regression with cluster-robust standard errors is used to answer research question one and analyze whether cases in a SPLB are significantly positively or negatively associated with profitability. Here, the dependent variable is the absolute net profit (Profit) per hospital (i) and year (t) in CHF. The key independent variables in focus are the absolute number of cases performed within each SPLB ( $\sum_{k=1}^K \gamma_k \text{SPLB}_{kit}$ ). Additionally, the following four relevant time-variable confounders are accounted for: year ( $\delta$ ), bed occupancy rate (BedOccupancyRate), share of private patients (SharePrivatePatients),

and share of inpatient revenue (ShareInpatient). The analysis is repeated with the binary specification of whether a hospital treated a SPLB as the independent variable. Thereby, it can be evaluated whether the complete opening or closing of the respective SPLB unit influences hospital profitability. Moreover, the analysis is repeated with hospital profitability margin as the dependent variable to check for robustness of the results.

$$\text{Profit}_{it} = \beta_0 + \beta_1 \text{BedOccupancyRate}_{it} + \beta_2 \text{SharePrivatePatients}_{it} + \beta_3 \text{ShareInpatient}_{it} + \sum_{k=1}^K \gamma_k \text{SPLB}_{kit} + \delta_t + \alpha_i + \epsilon_{it}$$

An Apriori algorithm (association rule mining) is used to analyze research question two and identify SPLG combinations associated with profitability or losses. As this analysis requires binary inputs for the dependent and independent variables, profitability was defined as “1” if the hospital’s absolute net profit (FiErg; excluding deficit coverage) was equal to or greater than 0 CHF. A SPLG was considered as addressed if it was classified as a relevant provider as previously defined via the 97.5% approach. First, the Apriori algorithm identified general connections between SPLGs within a hospital, resulting in a SPLG network diagram that put the 100 most relevant links in relation to each other and a list of the most strongly linked SPLGs. Specifically, per identified rule, the support (frequency of itemset), confidence (probability of itemset B occurring given itemset A), and lift are reported (strength of association compared to random chance) (42). The parameters were defined as follows: support  $\geq 0.25$ , confidence  $\geq 0.95$ , min length = 2, and max length = 3. Second, the Apriori algorithm has been used to identify SPLG combinations that are associated with hospital profitability or hospital losses. Here, the parameter requirements were defined as follows: support  $\geq 0.05$ , confidence  $\geq 0.70$ , min length = 2, and max length = 5 (lowered as no rules with the previous requirements were found). Results are considered significant at the 95% confidence level. Stata 18.5 was used for all analyses, except for the Apriori algorithm, which was run in R 4.4.3 (“arules” library).

## Results

The final sample comprises a panel dataset of 142 hospitals from 2015 to 2022, with 1,127 annual data points, including financial information and the number of cases treated per SPLG. Of these, 671 are from private hospitals and 246 are from public hospitals (see Table 1). Public hospitals treated on average significantly more patients than private ones (18,446 vs. 6,683

**Table 1:** Descriptive Swiss hospital statistics from 2015 to 2022

Variables	All hospitals		Private hospitals		Public hospitals		Test for differences <sup>a</sup>
	n	Mean/ Proportion	n	Mean/ Proportion	n	Mean/ Proportion	
General hospital information							
Number of beds	1,127	159.8	671	112.8	246	340.2	p<0.05 <sup>b</sup>
Bed occupancy rate	1,121	73.8%	669	70.1%	246	80.9%	p<0.05 <sup>b</sup>
Number of discharges	1,127	9,132.7	671	6,692.8	246	18,445.7	p<0.05 <sup>b</sup>
Average stay length	1,126	5.2	671	4.7	246	5.6	p<0.05 <sup>b</sup>
Number of care days	1,127	55,833.1	671	35,193.8	246	130,429.7	p<0.05 <sup>b</sup>
Privately insured	1,127	3.6%	671	4.2%	246	2.3%	p<0.05 <sup>b</sup>
Case Mix Index (CMI)	781	0.968	449	0.956	186	0.974	p=0.92 <sup>b,c</sup>
Total staff (FTE)	1,127	1,009.2	671	600.1	246	2,455.2	p<0.05 <sup>b</sup>
Doctors	1,025	170.1	584	91.8	246	416.2	p<0.05 <sup>b</sup>
Nurses	1,127	415.1	671	257.4	246	976.7	p<0.05 <sup>b</sup>
Other staff	1,117	135.1	661	83.6	246	319.3	p<0.05 <sup>b</sup>
Teaching hospital	1,127	72.5%	671	61.0%	246	94.3%	p<0.05 <sup>b</sup>
Emergency department	1,127	70.5%	671	60.5%	246	98.8%	p<0.05 <sup>b</sup>
Hospital type							p<0.05 <sup>d</sup>
K111	40	3.5%	7	1.0%	32	13.0%	
K112	309	27.4%	146	21.8%	120	48.8%	
K121	124	11.0%	65	9.7%	41	16.7%	
K122	204	18.1%	130	19.4%	33	13.4%	
K123	104	9.2%	51	7.6%	9	3.7%	
K231	227	20.1%	203	30.3%	0	0%	
K232	4	0.4%	4	0.6%	0	0%	
K233	24	2.1%	0	0%	8	3.3%	
K234	16	1.4%	9	1.3%	3	1.2%	
K235	75	6.7%	56	8.3%	0	0.0%	
Key financials (CHF)							
Net profit <sup>e</sup>	1,127	47,832	671	649,936	246	-2,284,343	p<0.05 <sup>b</sup>
Net profit margin	1,127	-0.06%	671	0.35%	246	-1.47%	p<0.05 <sup>b</sup>
Revenues	1,127	191,836,654	671	122,585,694	246	446,404,061	p<0.05 <sup>b</sup>
Deficit coverage	1,127	1,093,817	671	750,076	246	2,651,318	p=0.23 <sup>b</sup>
Subsidy	1,127	18,291,133	671	4,103,927	246	67,055,126	p<0.05 <sup>b</sup>
Other revenues	1,127	11,772,507	671	7,640,630	246	26,559,373	p<0.05 <sup>b</sup>
Inpatient revenues (vs. outpatient revenues)	1,127	74.4%	671	76.1%	246	70.1%	p<0.05 <sup>b</sup>
Inpatient revenues (vs. all revenues)	1,127	55.2%	671	58.3%	246	50.9%	p<0.05 <sup>b</sup>
Costs	1,127	191,741,993	671	121,386,431	246	448,255,228	p<0.05 <sup>b</sup>
Educational costs	1,127	1,223,792	671	330,826	246	4,370,070	p<0.05 <sup>b</sup>
Advanced training costs	1,127	2,155,851	671	731,327	246	7,233,998	p<0.05 <sup>b</sup>
Research costs	1,127	164,034,004	671	108,636,320	246	377,590,003	p<0.05 <sup>b</sup>
Case distribution per SPLB							
	10,431,365	100%	4,535,153	100%	4,618,386	100%	p<0.05 <sup>d</sup>
Basic package	5,103,605	48.9%	2,004,323	44.2%	2,464,722	48.9%	
Dermatology	37,065	0.4%	12,962	0.3%	20,185	0.4%	
Ear, nose and throat	319,648	3.1%	145,250	3.2%	145,616	3.1%	
Endocrinology	57,670	0.6%	22,220	0.5%	29,852	0.6%	
Gastroenterology	278,988	2.7%	120,764	2.7%	136,261	2.7%	
Gynecology	300,121	2.9%	161,924	3.6%	105,722	2.9%	
Heart	439,494	4.2%	196,515	4.3%	206,542	4.2%	
Hematology	122,730	1.2%	42,975	0.9%	68,368	1.2%	
Nephrology	42,728	0.4%	15,360	0.3%	23,604	0.4%	
Neurology	56,256	0.5%	20,127	0.4%	32,470	0.5%	
Neurosurgery	168,201	1.6%	66,769	1.5%	85,986	1.6%	
Obstetrics	764,968	7.3%	316,055	7.0%	344,633	7.3%	
Ophthalmology	90,457	0.9%	35,663	0.8%	48,286	0.9%	
Pneumology	176,990	1.7%	61,106	1.3%	100,463	1.7%	
Radio oncology	97,031	0.9%	39,597	0.9%	51,028	0.9%	

Rheumatology	33,276	0.3%	13,276	0.3%	16,246	0.3%
Severe injuries	22,629	0.2%	7,461	0.2%	12,636	0.2%
Surgical musculoskeletal system	1,478,664	14.2%	854,397	18.8%	371,177	14.2%
Thoracic surgery	22,725	0.2%	7,942	0.2%	13,566	0.2%
Transplants	4,463	0.0%	685	0.0%	3,648	0.0%
Urology	477,075	4.6%	235,846	5.2%	181,976	4.6%
Vascular	155,265	1.5%	65,877	1.5%	77,688	1.5%
Visceral surgery	181,316	1.7%	88,059	1.9%	77,711	1.7%

**Notes:** All hospitals are the sum of private (R1) and public (R2) hospitals as well as hospitals operated by associations/ foundations (R2) or as sole proprietorships (R3); a) Test for differences performed for year 2022 as latest year with data and most datapoints across years, b) Wilcoxon rank-sum test performed, since neither normal distribution (Shapiro-Wilk-Test) nor variance homogeneity (robust Levene's test) are given, c) Test for differences performed for year 2020 as latest year with data, d) Chi-squared test, e) Excluding deficit coverage

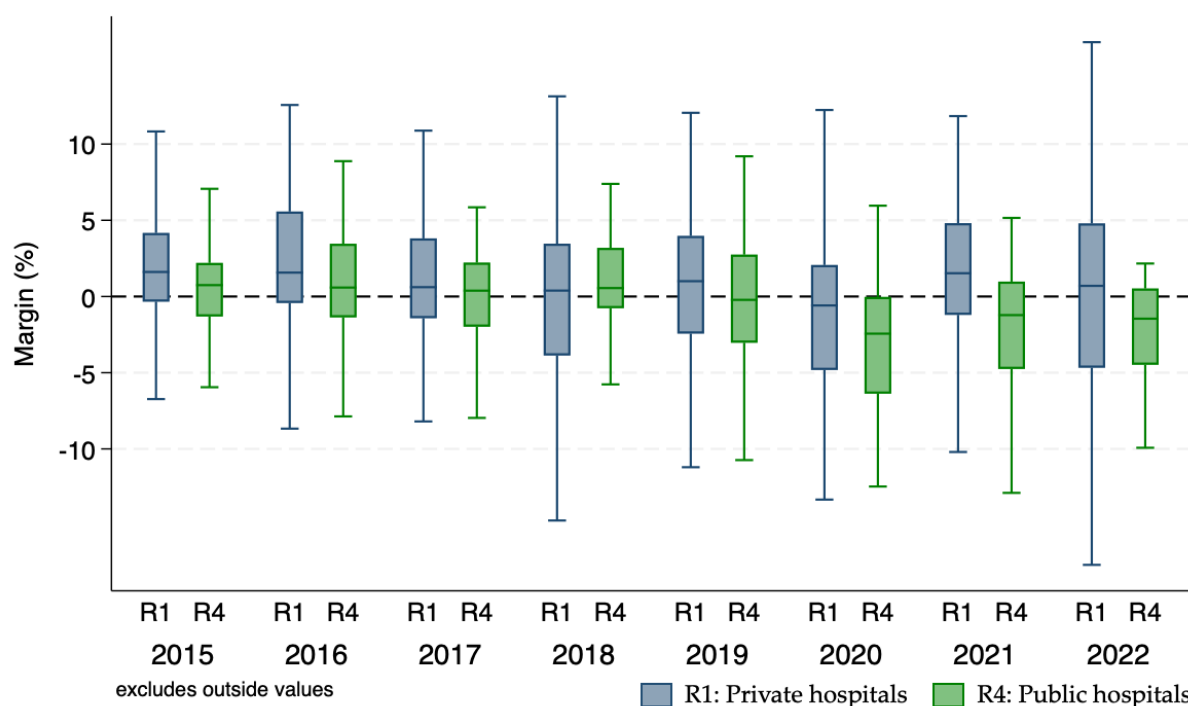
departures p.a.;  $p < 0.05$ ), had a significantly higher bed occupation rate (80.9% vs. 70.1%;  $p < 0.05$ ), included significantly more often an emergency department (98.8% vs. 60.5%;  $p < 0.05$ ) and are significantly more often a teaching hospital (94.3% vs. 61.0%;  $p < 0.05$ ). The mean resource consumption per patient, as indicated by the CMI, is quite similar (0.974 vs. 0.956;  $p = 0.92$ ). Public and private hospitals significantly deviate in terms of hospital type ( $p < 0.05$ ) with most public hospitals (48.8%) being general hospitals center care level 2 (K112), and most private hospitals (30.3%) being special clinics for surgery (K231). Public as well as private hospitals primarily treated patients from the SPLB basic package (all hospitals average: 48.9%), from surgical musculoskeletal system (14.2%), and obstetrics (7.3%). Financially, private hospitals on average reported profits (649,936 CHF) compared to public hospitals, which on average reported significant losses (-2,282,343 CHF;  $p < 0.05$ ). Public hospitals received significantly higher subsidies than private hospitals (67,055,126 CHF vs. 4,103,927 CHF;  $p < 0.05$ ). All hospitals generated the majority of revenues from inpatient treatments (55.2% of all hospitals' revenues; 74.4% compared to outpatient treatments). Public hospitals relied significantly less on inpatient revenues than private hospitals ( $p < 0.05$ ).

In 2015, the median hospital profitability margin was 1.19%, indicating that most hospitals were profitable; however, there was also a great variance, and some hospitals reported substantial losses (see Figure 6). Until 2022, the median hospital profitability margin had consistently decreased to 0.24%, with a dip in 2020, where most hospitals reported losses (median profitability margin: -0.96%). The variance in hospital profitability margins increased from 2015 to 2022. When stratifying hospital profitability margins by public and private hospitals, it is evident that private hospitals continuously reported higher profitability margins (2015: public: 0.75% vs. private: 1.61%; see Figure 2). Both public and private hospitals reported declining profitability margins. Since 2019, public hospitals have reported a negative



median hospital profitability margin, whereas private hospitals reported a negative median hospital profitability margin only once in 2020. The variance in the hospital profitability margins is greater for private than for public hospitals.

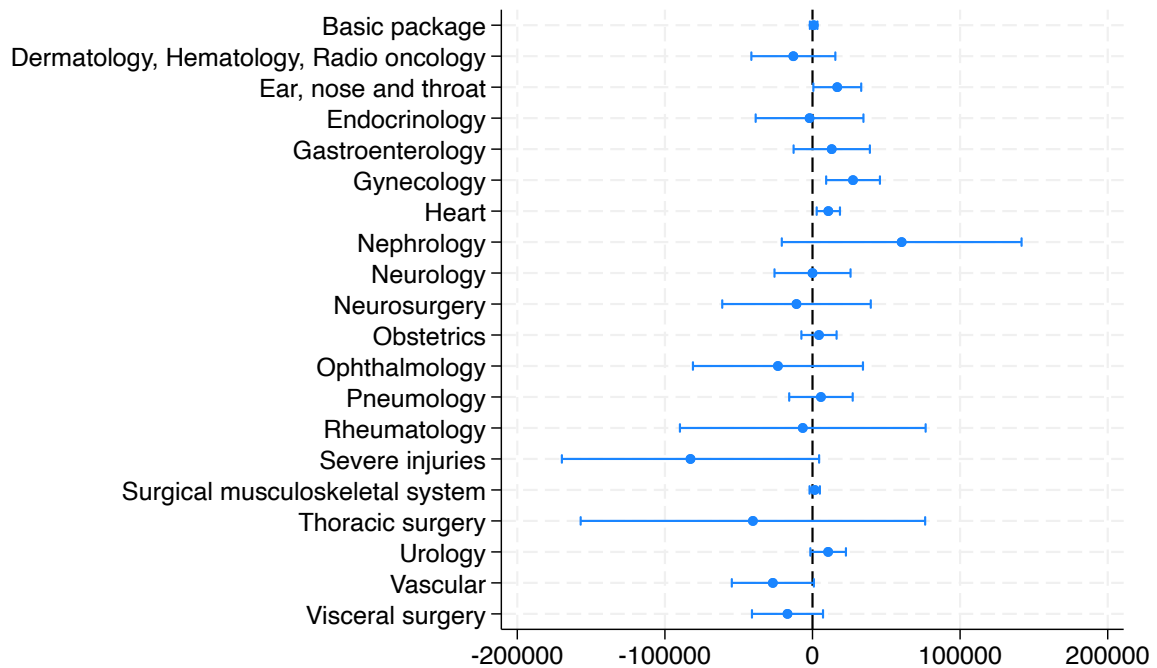
**Figure 2:** Hospital net profitability margin from 2015 to 2022, stratified by public/ private hospital



**Note:** Margin (%) referring to net profit margin(excluding deficit coverage) divided by hospital revenue; The whiskers in the boxplots represent values within 1.5 times the interquartile range (IQR), extending from the first quartile (Q1) to the third quartile (Q3). Values outside this range (potential outliers) are excluded from the visualization.

Table 2 and Figure 3 present the results of the fixed-effects panel regression analysis with cluster-robust standard errors. When focusing on all hospitals and the absolute number of cases treated per SPLB, three significant SPLBs are identified, all of which are positively associated with hospital profitability: Ear, nose and throat (16,778 CHF;  $p < 0.05$ ), gynecology (27,456 CHF;  $p < 0.01$ ), and heart (10,725 CHF;  $p < 0.01$ ). Correspondingly, it can be inferred that an additional patient treated in the SPLB heart is associated with an average increase in annual hospital profit of around 10,725 CHF, *ceteris paribus*. The largest coefficients, albeit not significant, are nephrology (60,419 CHF) on the positive side and transplants (-182,811 CHF) on the opposing side. For private and public hospitals, the SPLB heart is also significantly positively associated in both subgroups (private: 3,775 CHF,  $p < 0.05$ ; public: 18,379 CHF,  $p < 0.05$ ). Gynecology is only significantly positively associated at public hospitals (43,541 CHF;  $p < 0.01$ ). Ear, nose and throat is not significant in any of the subgroups. Private hospitals also report three significantly negative associated SPLBs with hospital profitability: neurosurgery (-43,505 CHF;  $p < 0.05$ ), severe injuries (-106,727 CHF;  $p < 0.05$ ), and transplants (-542,132 CHF;  $p < 0.01$ ).

**Figure 3:** Fixed effects panel regression coefficients



**Note:** Values indicate coefficient in CHF per additional case, with positive values indicating increasing profitability; excluding SPLB transplants because of extraordinarily high variance. Figure 7 includes all SPLB coefficients, including transplants.

When examining all hospitals and analyzing the binary indication of whether a SPLB was treated, three SPLBs were significantly associated with profitability: opening an SPLB unit in surgical musculoskeletal system (-2,626,690 CHF;  $p < 0.05$ ) or transplants (-5,194,664 CHF;  $p < 0.01$ ) resulted in a significant loss. Opening an SPLB unit in visceral surgery (1,798,277 CHF;  $p < 0.05$ ) led to a significant increase in profitability. Surgical musculoskeletal system (-2,097,084 CHF;  $p < 0.05$ ) and visceral surgery (1,891,208 CHF;  $p < 0.01$ ) were similarly significantly associated in private hospitals. Transplants could not be analyzed for any subgroup due to collinearity. Additionally, ear, nose, and throat (-14,700,000 CHF;  $p < 0.01$ ), endocrinology (5,545,300 CHF;  $p < 0.05$ ), and gynecology (-11,300,000 CHF;  $p < 0.05$ ) received statistically significant results for public hospitals. A robustness check with a similar regression, using profitability margin as the dependent variable instead of absolute profit, yielded directionally similar results (see Table 6). Specifically, heart, ear, nose and throat, gynecology, and visceral surgery are also partially significantly associated with the hospital's profitability margin.

The Apriori-based network analysis revealed distinct patterns of associations among the SPLGs. The SPLG BP (basic package surgery and internal medicine) emerged as a central and interconnected hub, frequently co-occurring with numerous other SPLGs (see Figure 4).

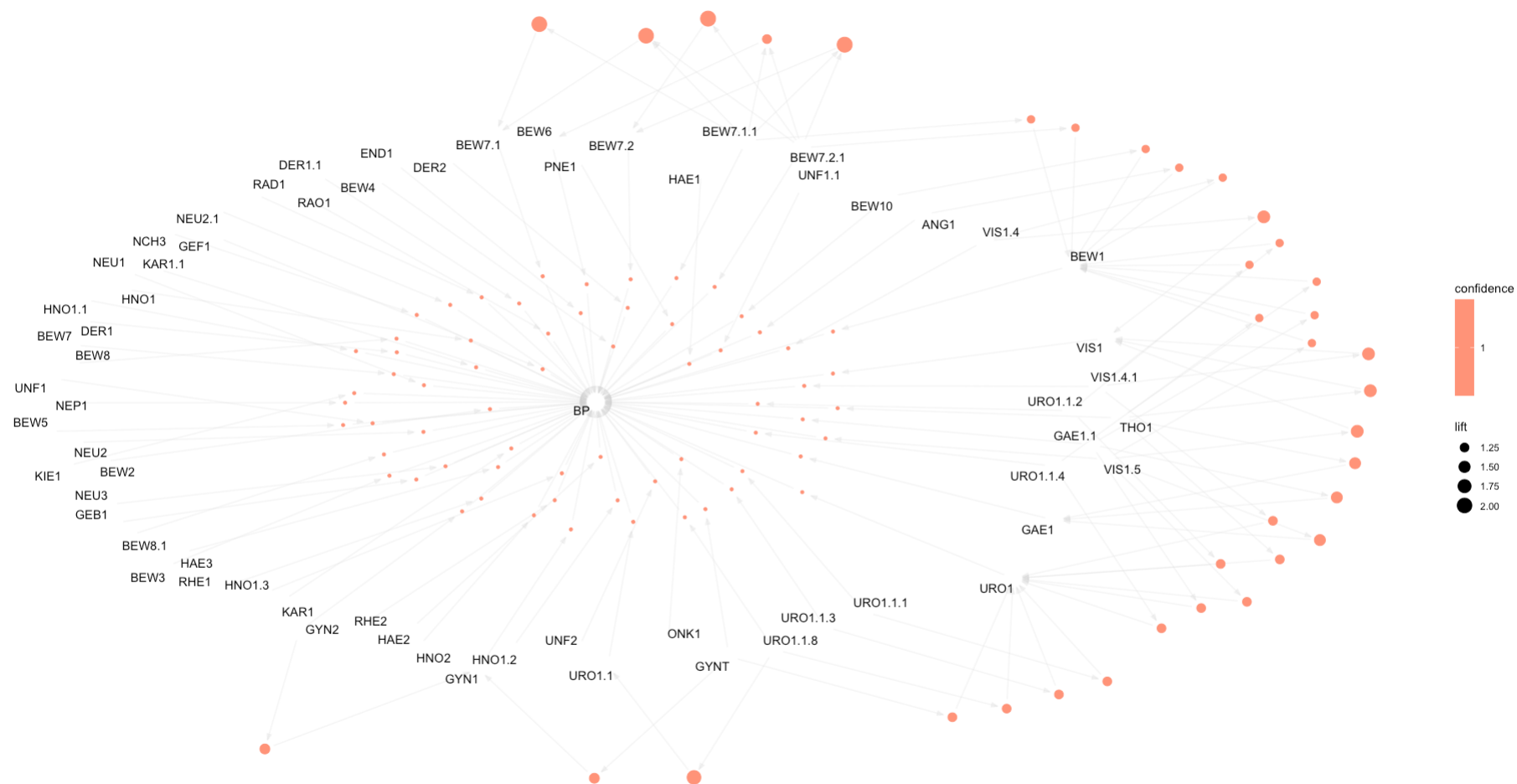
**Table 2:** Fixed-effects panel regression analysis of absolute hospital profitability (CHF) with cluster-robust standard errors

Independent variables:	All hospitals		Private hospitals		Public hospitals	
	Absolute SPLB case numbers	SPLB offered by hospital <sup>b</sup>	Absolute SPLB case numbers	SPLB offered by hospital <sup>b</sup>	Absolute SPLB case numbers	SPLB offered by hospital <sup>b</sup>
	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)	Coefficient (Standard Error)
	P-value	P-value	P-value	P-value	P-value	P-value
<b>SPLB</b>						
Basic package	788 (1,294)	n.a. <sup>c</sup>	2,104 (1,168) *	n.a. <sup>c</sup>	-1,094 (2,825)	n.a. <sup>c</sup>
Dermatology/ Hematology/ Radio oncology <sup>a</sup>	-12,980 (14,425)	-748,615 (510,610)	-2,582 (7,830)	-933,174 (538,342) *	-12,748 (25,811)	16,300,000 (10,300,000)
Ear, nose and throat	16,778 (8,218) **	-1,548,084 (1,026,655)	4,835 (2,954)	-234,887 (764,646)	49,512 (25,091) *	-14,700,000 (3,211,939) ***
Endocrinology	-1,997 (18,515)	318,924 (425,556)	-1,902 (27,201)	-91,198 (651,719)	-13,369 (28,427)	5,535,300 (2,586,260) **
Gastroenterology	13,030 (13,103)	-985,998 (940,816)	4,352 (12,457)	1,108,777 (902,719)	10,114 (26,507)	-12,100,000 (9,493,829)
Gynecology	27,456 (9,234) ***	-1,363,788 (703,839) *	13,745 (9,981)	-767,032 (689,799)	43,541 (14,305) ***	-11,300,000 (5,189,834) **
Heart	10,725 (3,990) ***	1,057,310 (918,382)	3,775 (1,616) **	664,512 (1,110,258)	18,379 (7,411) **	6,591,464 (5,691,931)
Nephrology	60,419 (41,184)	-612,451 (998,626)	57,625 (59,098)	-142,286 (912,539)	71,539 (58,649)	-144,040 (2,118,296)
Neurology	15 (13,060)	174,037 (493,022)	9,972 (15,996)	-30,954 (489,105)	-2,833 (21,268)	8,014,518 (14,500,000)
Neurosurgery	-10,838 (25,518)	55,838 (638,017)	-43,505 (19,935) **	720,206 (688,105)	82,888 (72,053)	-2,135,011 (2,727,181)
Obstetrics	4,382 (6,046)	-107,049 (2,681,923)	347 (5,705)	1,430,144 (3,019,629)	14,517 (23,306)	n.a. <sup>c</sup>
Ophthalmology	-23,418 (29,204)	260,918 (646,473)	-617 (10,036)	-906,898 (825,231)	-67,780 (76,814)	808,042 (1,888,360)
Pneumology	5,725 (10,899)	-632,549 (631,180)	7,864 (6,335)	155,823 (612,505)	-13,049 (23,948)	-2,320,190 (5,290,946)
Rheumatology	-6,576 (42,203)	12,993 (522,067)	4,009 (39,187)	248,123 (615,220)	-13,642 (112,442)	-2,560,479 (8,677,581)
Severe injuries	-82,661 (44,188) *	59,808 (516,380)	-106,727 (51,298) **	-15,608 (630,606)	-88,934 (148,476)	-4,475,578 (2,905,232)
Surgical musculoskeletal system	1,503 (1,769)	-2,626,690 (1,112,054) **	3,944 (2,070) *	-2,097,084 (978,876) **	-5,453 (6,074)	n.a. <sup>c</sup>
Thoracic surgery	-40,366 (59,168)	1,356,002 (863,067)	40,532 (36,045)	1,898,662 (1,099,069) *	-118,473 (119,616)	5,551,185 (2,829,515) *
Transplants	-182,811 (153,026)	-5,194,664 (1,175,394) ***	-542,132 (92,453) ***	n.a. <sup>c</sup>	-125,061 (170,870)	n.a. <sup>c</sup>
Urology	10,601 (6,113) *	314,817 (1,331,917)	2,288 (5,601)	-24,311 (961,959)	13,596 (14,624)	n.a. <sup>c</sup>
Vascular	-26,870 (14,092) *	-484,036 (926,321)	-17,713 (8,955) *	-1,329,890 (968,516)	-35,692 (30,204)	1,570,279 (2,757,239)
Visceral surgery	-16,942 (12,206)	1,798,277 (748,464) **	-13,064 (13,223)	1,891,208 (714,574) ***	-26,518 (18,771)	7,894,242 (7,576,948)

**Confounders:** Year, bed occupancy rate, share of private patients, share of inpatient revenue\*\*\*)  $p < 0.01$ ; \*\*)  $p < 0.05$ ; \*)  $p < 0.1$ 

**Note:** a) The SPLBs Dermatology, Hematology, and Radio oncology were merged into the combined category Dermatology/Hematology/Radio oncology. This was necessary because the three SPLBs exhibited very high correlations, leading to problematic multicollinearity (Variance Inflation Factor:  $VIF > 10$ ). By merging the most strongly correlated SPLBs, the multicollinearity was reduced to acceptable levels ( $VIF < 10$ ), fulfilling the statistical requirements for the analysis. b) The independent variables are binary, with “1” indicating that a hospital is relevant within the SPLG and “0” indicating not relevant. A hospital was classified as relevant if it was among the providers that collectively treated at least 97.5% of all cases within each SPLG, excluding providers with only minimal caseloads. If one SPLG was classified as relevant, the SPLB was considered relevant. c) „n.a.“ referring to independent variables that STATA has omitted because of collinearity. Hausman tests were performed to justify the selection of fixed-effects models over random-effects models, indicating significant unobserved heterogeneity at the hospital level. Additionally, modified Wald tests for groupwise heteroscedasticity, Wooldridge tests for autocorrelation, and Pesaran’s tests for cross-sectional dependence were conducted. Due to evidence of heteroscedasticity, autocorrelation, and potential cross-sectional dependence, fixed-effects panel regressions with cluster-robust standard errors at the hospital level were applied to ensure robust and unbiased estimates.

**Figure 4: SPLG network diagram**



**Note:** SPLG network diagram based on the top 100 rules with the highest lift.

Despite its central position and numerous connections, the strength of these associations (lift) is low to moderate. In contrast, the peripheral nodes formed several specialized and closely connected clusters, especially around the SPLGs BEW.x (SPLB: Surgical musculoskeletal system), VIS.x (SPLB: Visceral surgery), and URO.x (SPLB: Urology). Table 3 notes the fundamental rules. Here, the rule with the greatest lift (2.907) had the two SPLGs URO1.1 (urology with specialization in 'operative urology') and VIS1.4.1 (complex bariatric surgery) as antecedents for VIS1.4 (bariatric surgery) as consequent. The rule with the greatest lift (2.266) and two antecedents from different SPLGs than the consequent is GEB1 (basic obstetrics care) and URO1.1.4 (isolated adrenalectomy) as antecedents for HNO2 (thyroid and parathyroid surgery) as consequent. When examining the network analysis for the private hospitals (see Figure 8 and Table 7), the SPLG BP also appears as a central and highly connected networked hub with low to moderate lifts. A very dominant cluster with strong confidence and lifts of the BEW.x SPLGs is evident. Further, a more interconnected cluster with GAE.x (SPLB: Gastroenterology) and VIS.x SPLGs is visible. The rule with the greatest lift (2.488) had the two SPLGs KAR1 (cardiology including pacemaker) and NEU1 (neurology) as antecedents for GAE1.1 (specialized gastroenterology) as consequent. When examining the network analysis for public hospitals (see Figure 9, Table 8), it reveals a distinct structure without a clear center. One strong cluster is visible around HAE1.1 (highly aggressive lymphomas and acute leukemias), and several other, more interconnected clusters are visible around BEW7.2.1 (knee prosthesis replacement operations) and URO1.1.7 (implantation of an artificial urinary bladder sphincter). The rule with the greatest lift (3.280) had the two SPLGs AUG1.4 (cataract) and VIS1.2 (liver resection) as antecedents for AUG1.5 (vitreous humor/retinal problems) as consequent. The rule with the greatest lift (3.114) and two antecedents from different SPLGs than the consequent is NCH1.1 (specialized neurosurgery) and GYNT (gynecological tumors) as antecedents for GEFA (interventions and vascular surgery intra-abdominal vessels) as consequent.

Further, the Apriori algorithm identified SPLG combinations that are linked with profitability. For all hospitals, the SPLGs that are most strongly linked with profitability (support: 0.051, confidence: 0.935, lift: 1.615) are AUG1.2 (orbit, eyelids, tear ducts), BEW10 (plexus surgery), and GEF2 (interventional and endovascular vascular medicine) (see Table 4). On an aggregated level, diverse combinations of the SPLGs AUG1.2 and BEW10 or AUG1.2 and VIS1.2 or BEW10 and HNO1.3 (middle ear surgery) are associated with profitability (see Figure 10).

**Table 3: Typical SPLG combinations**

Antecedents	Consequent	Support	Confidence	Lift
URO1.1, VIS1.4.1	VIS1.4	0.255	0.993	2.907
GAE1, VIS1.4.1	VIS1.4	0.259	0.986	2.888
PNE1, VIS1.4.1	VIS1.4	0.252	0.986	2.887
GYN1, VIS1.4.1	VIS1.4	0.258	0.983	2.878
DER1, VIS1.4.1	VIS1.4	0.256	0.983	2.877
VIS1.4.1	VIS1.4	0.264	0.980	2.869
VIS1, VIS1.4.1	VIS1.4	0.264	0.980	2.869
URO1, VIS1.4.1	VIS1.4	0.264	0.980	2.869
BEW1, VIS1.4.1	VIS1.4	0.264	0.980	2.869
BP, VIS1.4.1	VIS1.4	0.264	0.980	2.869
BEW5, VIS1.4.1	VIS1.4	0.256	0.980	2.868
BEW2, VIS1.4.1	VIS1.4	0.256	0.980	2.868
BEW6, VIS1.4.1	VIS1.4	0.250	0.979	2.866
GEF1, HNO2	ANG1	0.253	0.979	2.830
GEF1, RAD1	ANG1	0.256	0.976	2.821
GEF1, HNO1.1	ANG1	0.254	0.966	2.792
GAE1.1, GEF1	ANG1	0.261	0.961	2.776
GEB1, GEF1	ANG1	0.273	0.957	2.764
GEF1, GYN2	ANG1	0.270	0.950	2.745
GEF1, HAE3	ANG1	0.270	0.950	2.745
GEB1, URO1.1.4	HNO2	0.254	0.963	2.266
KAR1, URO1.1.4	HNO2	0.250	0.962	2.264
RAD1, VIS1.5	HNO2	0.256	0.960	2.259
GYN2, URO1.1.4	HNO2	0.257	0.957	2.252
KAR1.1, VIS1.5	HNO2	0.257	0.957	2.252
GAE1.1, URO1.1.4	HNO2	0.256	0.957	2.252
KAR1, VIS1.5	HNO2	0.283	0.955	2.247
KAR1.1, VIS1.5	KAR1	0.262	0.974	2.235
KAR1.1, VIS1.4	KAR1	0.258	0.964	2.212
NEU2.1, VIS1.5	KAR1	0.256	0.957	2.196
RAD1, VIS1.5	KAR1	0.255	0.953	2.189
GEF1, NEU1	NEP1	0.256	0.966	2.187
KAR1.1, RAD1	KAR1	0.279	0.952	2.184
HNO2, UNF1	KAR1	0.278	0.951	2.184
HAE1, VIS1.5	KAR1	0.276	0.951	2.183
NEU3, VIS1.5	NEP1	0.282	0.955	2.161
GEF1, NEU3	NEP1	0.256	0.954	2.158
ANG1, NEU1	NEP1	0.274	0.954	2.158
NEU2.1, VIS1.5	NEP1	0.255	0.953	2.158
HNO2, UNF1	NEP1	0.278	0.951	2.153
RHE2, VIS1.5	ONK1	0.259	0.954	2.113
RAD1, VIS1.5	ONK1	0.255	0.953	2.111
BEW1, RAO1	ONK1	0.253	0.953	2.110
RAO1, VIS1	ONK1	0.252	0.953	2.110
HAE3, RAO1	ONK1	0.250	0.953	2.109
BEW7.2.1	BEW7.2	0.297	1.000	2.064
BEW7.1.1, BEW7.2.1	BEW7.2	0.258	1.000	2.064
BEW7.1, BEW7.2.1	BEW7.2	0.295	1.000	2.064
BEW6, BEW7.2.1	BEW7.2	0.296	1.000	2.064
BEW5, BEW7.2.1	BEW7.2	0.295	1.000	2.064

**Note:** Top 50 rules listed as per defined parameters (see methodology), sorted top down by lift; 16,445 rules identified

**Table 4: SPLG combinations linked with profitability**

Antecedents	Consequent	Support	Confidence	Lift
AUG1.2, BEW10, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, BEW7, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, GEF2, HNO1.2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, BEW3, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, GEF2, VIS1	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, GAE1, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, DER1, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, GEF2, GYN1	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, BEW6, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, GEF2, URO1	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, BEW5, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, BEW2, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW1, BEW10, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, BP, GEF2	Profitability	0.051	0.935	1.615
AUG1.2, BEW10, GEF2, GYN1.3	Profitability	0.051	0.934	1.613
AUG1.2, BEW10, GEF2, HNO1.1	Profitability	0.051	0.934	1.613
AUG1.2, BEW10, GEF2, URO1.1	Profitability	0.051	0.934	1.613
AUG1.2, BEW10, GYN1.4, HNO1.2	Profitability	0.054	0.924	1.595
AUG1.2, BEW10, DER1, GYN1.4	Profitability	0.052	0.922	1.591
AUG1.2, BEW10, BEW8.1, GYN1.4	Profitability	0.051	0.919	1.587
AUG1.2, BEW10, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, BEW7, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, BEW3, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, GYN1, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, BEW6, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, BEW5, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, BEW2, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW1, BEW10, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, BP, GYN1.4	Profitability	0.055	0.912	1.574
AUG1.2, BEW10, GYN1.4, GYN2	Profitability	0.054	0.910	1.571
AUG1.2, BEW10, GYN1.4, URO1	Profitability	0.054	0.910	1.571
AUG1.2, BEW10, GYN1.3, GYN1.4	Profitability	0.053	0.909	1.569
AUG1.2, BEW10, GYN1.4, HNO1	Profitability	0.053	0.909	1.569
AUG1.2, BEW10, GYN1.4, HNO1.1	Profitability	0.052	0.908	1.567
AUG1.2, BEW10, GYN1.4, URO1.1	Profitability	0.052	0.908	1.567
AUG1.2, BEW10, GAE1, GYN1.4	Profitability	0.052	0.908	1.567
AUG1.2, BEW10, BEW8, GYN1.4	Profitability	0.051	0.906	1.564
AUG1.2, BEW10, GEB1, GYN1.4	Profitability	0.051	0.906	1.564
AUG1.2, BEW10, GYN1.4, VIS1	Profitability	0.051	0.906	1.564
AUG1.2, BEW10, BEW8.1, GYN1.3	Profitability	0.051	0.906	1.564
AUG1.2, BEW10, BEW3, GYN1.3	Profitability	0.057	0.901	1.556
AUG1.2, BEW10, GYN1.3, HNO1.2	Profitability	0.056	0.900	1.553
AUG1.2, BEW10, GYN1.3, URO1.1	Profitability	0.055	0.899	1.551
AUG1.2, BEW10, GYN1.3, HNO1.1	Profitability	0.054	0.897	1.548
AUG1.2, BEW10, GYN1.3, PNE1	Profitability	0.051	0.892	1.540
GEF2, HNO1.2, KAR1.1, VIS1.2	Profitability	0.051	0.891	1.537
GEF2, HAE1, HNO1.2, VIS1.2	Profitability	0.051	0.891	1.537
AUG1.2, BEW10, BEW2, GYN1.3	Profitability	0.057	0.889	1.534
AUG1.2, BEW10, DER1, GYN1.3	Profitability	0.055	0.886	1.529
GEF2, HNO1.2, VIS1.2	Profitability	0.052	0.881	1.520

**Note:** Top 50 rules listed as per defined parameters (see methodology), sorted top down by lift; 187,463 rules identified

For private hospitals, the SPLGs that are most strongly linked with profitability (support: 0.052, confidence: 1.0, lift: 1.617) are AUG1.2 and GEF2 (see Table 9). On an aggregated level, diverse combinations with the SPLGs ANG2 (intra-abdominal vascular interventions) and GYN1.2 (malignant neoplasms of the cervix), or ANG2 and GEF2, or GYN1.4 (malignant neoplasms of the ovary) and GEF2 are associated with profitability for this subgroup (see Figure 11). For public hospitals, the SPLGs that are most strongly linked with profitability (support: 0.053, confidence: 1.0, lift: 2.050) were AUG1.3 (specialized anterior segment surgery), HER1.1.3 (surgery and interventions on the thoracic aorta), and URO1.1.6 (plastic reconstruction of the urethra) (see Table 10). On an aggregated level, diverse combinations with the SPLGs HER1.1.3 and AUG1.3 or AUG1.3 and NCH1 (cranial neurosurgery) or AUG1.3 and HAE1.1 are associated with profitability for this subgroup (see Figure 12). Additionally, the Apriori algorithm identified SPLG combinations that are linked with losses. For all hospitals, the SPLGs that are most strongly linked with losses (support: 0.054, confidence: 0.701, lift: 1.667) are UNF1 (trauma surgery polytrauma), UNF2 (severe burns), GEFA, and BEW7.1.1 (hip prosthesis replacement operations) (see Table 11).

**Table 5:** SPLG combinations linked with losses

Antecedents	Consequent	Support	Confidence	Lift
UNF1, UNF2, GEFA, BEW7.1.1	Losses	0.054	0.701	1.667
UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, GEFA, GYNT, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, BEW7.1, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
HAE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
NEU3, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
NEU2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GYN2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
HAE3, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GEB1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
RHE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
HAE2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
PNE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, VIS1, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GAE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
DER1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GYN1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW6, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, URO1, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW5, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BP, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664

**Note:** Top rules listed as per defined parameters (see methodology), sorted top down by lift; 23 rules identified



On an aggregated level, combinations of the two SPLGs UNF1 and UNF2, or UNF2 and GEFA, are associated with losses (see Figure 13). For private hospitals, no rule has been identified that links SPLGs with losses at the pre-defined thresholds. For public hospitals, the SPLGs that are most strongly linked with losses (support: 0.053, confidence: 0.929, lift: 1.813) are AUG1.1 (strabology), VIS1.3 (esophageal resection), and BEW7.1.1 (see Table 12). On an aggregated level, diverse combinations of the SPLGs AUG1.1 and VIS1.3, or VIS1.3 and VIS1.4, or VIS1.3 and BEW10, are associated with losses (see Figure 14).

## Discussion

This study aims to investigate whether there is a systematic imbalance in the reimbursement of inpatient hospital cases, specifically between profitable and unprofitable service groups/areas. In general, the hospital profitability results highlight a worsening situation, as the net profitability of Swiss hospitals declined continuously from 2015 to 2022, with many hospitals reporting losses. While the profitability dip in 2020 can be attributed to the COVID-19 pandemic, the general downward trend is unambiguous (43). Accordingly, the hospital profitability results are in line with the widely discussed deteriorating financial situation of Swiss hospitals (10, 11, 17). Private hospitals, which exhibit distinct structures and are primarily specialty hospitals for surgery, constantly reported higher net profitability margins than public hospitals. Specifically, half of these hospitals still reported a small positive net profit in 2022, while almost 75% of public hospitals reported a loss, despite receiving on average 67,055,126 CHF in subsidies (e.g., for teaching) in addition to the S-DRG reimbursements, which are reflected in the net profitability. The finding that public hospitals are financially in a worse situation than private hospitals is also in line with the public debate (15, 44).

Regarding research question one, whether there are significant positive or negative associations between SPLBs and profitability, some SPLBs have been identified with significant associations, although the results differ in part depending on the sub-analysis. The primary causal fixed effects panel regression identified the following SPLBs as significantly positively associated with hospital profitability: heart, gynecology, and ear, nose, and throat. Across the various subgroup analyses, the SPLB heart and visceral surgery were predominantly associated with hospital profitability, and the SPLB gynecology and ear, nose

and throat were associated multiple times. On the opposite side, the SPLB transplants and surgical musculoskeletal system were multiple times associated with hospital losses. The scientific evidence regarding the profitability of certain Swiss hospital cases is very limited, partly because the system should not create such cases. One previous study focused on hernia procedures (SPLB: visceral surgery) and concluded that 68% of these cases were unprofitable, with an average loss of -624 CHF per patient (45). Another study focused on orthopedic surgery patients, where 80% of these cases were profitable, with a mean net result of 2,147 CHF (46). While these two specific findings are contrary to this study's results, the study by Rohrer et al. also reveals that profitability can vary greatly within an area (i.e., primary hip and knee surgery were primarily profitable, whereas spine and revision knee surgery resulted in losses more often (46).

Regarding research question two, whether there are SPLG combinations that are significantly positively or negatively associated with profitability, some significantly associated SPLG combinations have been identified. For all hospitals, the SPLG combinations most strongly associated with profitability are AUG1.2, BEW10, VIS1.2, and HNO1.3, and the combinations most strongly linked to losses are UNF1, UNF2, and GEFA. Swiss hospital capacity planning requires for mandating certain SPLGs that other SPLGs are offered locally in the hospital. However, there is no requirement for the aforementioned SPLG combinations to be linked to other SPLGs, as per the definitions from the canton of Zurich (47). Across the most relevant SPLG combinations predominantly associated with profitability were the SPLBs heart, gynecology, neurosurgery, hematology, and ear, nose and throat. The SPLB severe injuries was only identified in SPLG combinations associated with hospital losses. Additionally, the network analysis reveals a dominant cluster centered around the surgical musculoskeletal system for private hospitals, emphasizing significant activity. In line with this study's previous regression analyses, the SPLB heart remains significantly positively associated with hospital profitability. On the negatively associated side, the SPLB severe injuries stands out. This finding is in line with a previous Swiss study that focused on severely injured patients, concluding that two-thirds of these patients were not reimbursed enough to cover their costs, resulting in a loss (mean: -3,493 CHF) for the hospital (48).

While the study results indicate that some service offerings are statistically significantly associated with hospital profitability under the S-DRG reimbursement system, previous

research also noted other relevant factors associated with hospital profitability. For example, Havranek et al. found that hospital size, complexity, teaching intensity, and patient mix, among other factors, are significantly associated with costs (49). These factors have been accounted for as far as possible, but factors such as hospital size, which is strongly correlated with the number of cases in basic packages, had to be excluded. Additionally, a better patient experience has been associated with higher revenues and lower costs (50). Mehra et al. examined the profitability of individual cases in a Swiss hospital and found that a psychiatric diagnosis, admission as an emergency case, and admission from an external healthcare provider were significantly associated with losses (51). Furthermore, Fischer et al. evaluated the relevance of patient mix by using case-level cost data to investigate whether these were highly profitable or highly unprofitable, and stratified the distributions by hospital type (i.e., university hospital, centrum hospital, regional hospital, specialized hospital) (52). Here, they noted that across all hospitals, 6.4% of cases were highly profitable (mean: 7,456 CHF) compared to 3.0% of highly unprofitable cases (mean: -18,683 CHF). While university hospitals had a higher proportion of unprofitable cases (5.9% vs. 5.2%), regional hospitals had more highly profitable cases (7.6% vs. 2.1%). In general, previous research on the Swiss hospital reimbursement system has shown that the introduction of the S-DRG in 2012 had a significant impact on hospital operations, including a shortened length of stay (53).

## **Limitations**

Regarding the data and methodology employed, several limitations are considered, which might impact the interpretation of the results. As the anonymized hospital cases do not contain any age information, no cases could be assigned to the SPLB newborns. In addition, hospital matching between the two data sets had to be performed, whereby half of the cases could be matched directly. The other half of the cases were matched based on the hospital's discharge numbers, with quality checks validating the correct matching. Further, the net profitability (margin) of the overall hospital was analyzed. Since the acute inpatient cases were used to explain profitability, it would also be valuable to evaluate acute inpatient profitability independently of outpatient profitability, general subsidies et cetera. Also, differences between private and public hospitals were evaluated based on their legal form as indicated by the Swiss Federal Office of Public Health. In practice, some hospitals are operated as a public-

private partnership with mixed ownership, for example, the Hôpital du Jura bernois SA, where the Swiss Medical Network owns 52% and the canton of Bern 48% (54). Data bias is limited, as all Swiss hospitals are legally required to report all their case and financial information (5).

Regarding the methodology, three SPLBs had to be aggregated in the fixed effects panel regression to meet the requirements and achieve low to moderate multicollinearity, as indicated by a variance inflation factor of less than 10 (55, 56). Further, the Apriori algorithm could not utilize the absolute net profitability or the relative profitability margin of the hospital, but only a binary variable: (0) loss, (1) profit (57). Similarly, the number of treated cases in a SPLG was not specified, but only whether a SPLG was treated (1) or not (0), which was classified by the previously defined 97.5% rule. Thus, future research should focus on the profit from acute inpatient care and build on an expanded database, including patient age, to account for the SPLB newborns. Furthermore, the analyses should be repeated with the latest data (focused on inpatient profitability only) and supplemented with an alternative methodological approach to distinguish the effects of the three aggregated SPLBs.

## **Conclusion**

Overall, the Swiss hospital landscape is facing major financial challenges. While private hospitals are in a better financial position than public hospitals, with the majority reporting losses, all Swiss hospitals are facing a downward trend in profitability. The analyses of the SPLBs and SPLG combinations associated with profitability demonstrate that the S-DRG reimbursement system is relatively fair. However, there are a few significant divergences, such that the SPLB heart is primarily associated with profitability, while the SPLB severe injuries is associated mainly with losses. Thus, minor S-DRG adjustments should be made to increase cost weights for cases with severe injuries, potentially financed by slightly reduced cost weights for heart cases. Additionally, it should be noted that the slightly better financial situation of private hospitals is not only due to the service specialization. Specifically, private hospitals have a strong cluster in the SPLB surgical musculoskeletal system, among other things, although this service group is not significantly associated with profitability in the analyses. Finally, the healthcare system stakeholders should examine how Swiss hospitals can be reimbursed in a financially sustainable manner without relying on regular deficit compensations.

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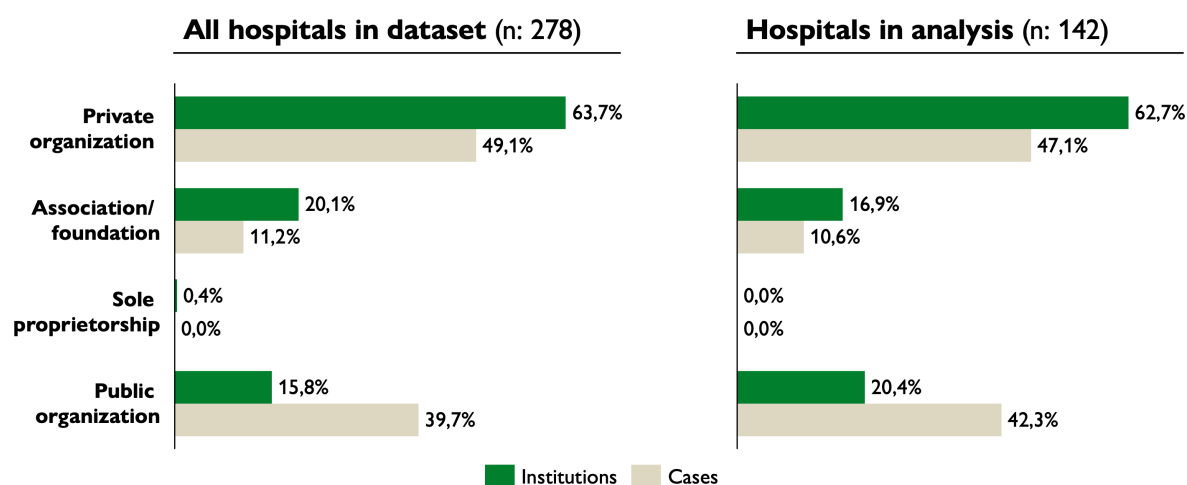
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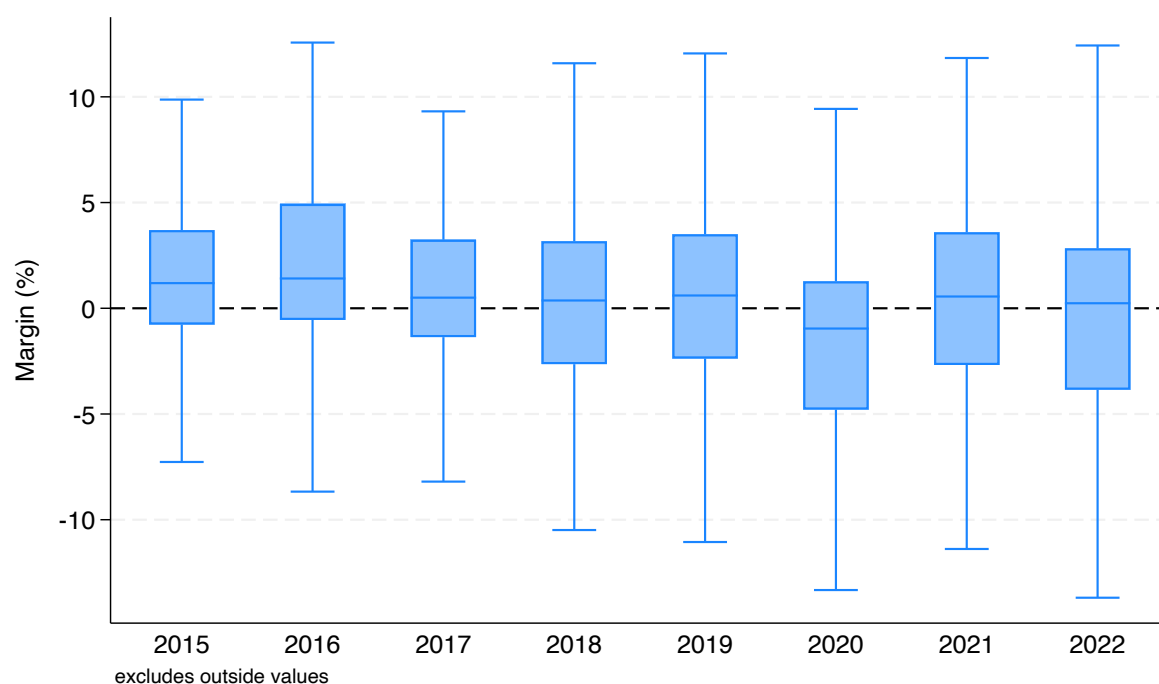
## Appendix

**Figure 5:** Distribution of institutions and cases per legal entity form



**Note:** Exemplary for the year 2022; Definitions from Swiss Federal Office of Public Health: Private organization (R1), Association/foundation (R2), Sole proprietorship (R3), Public organization (R4).

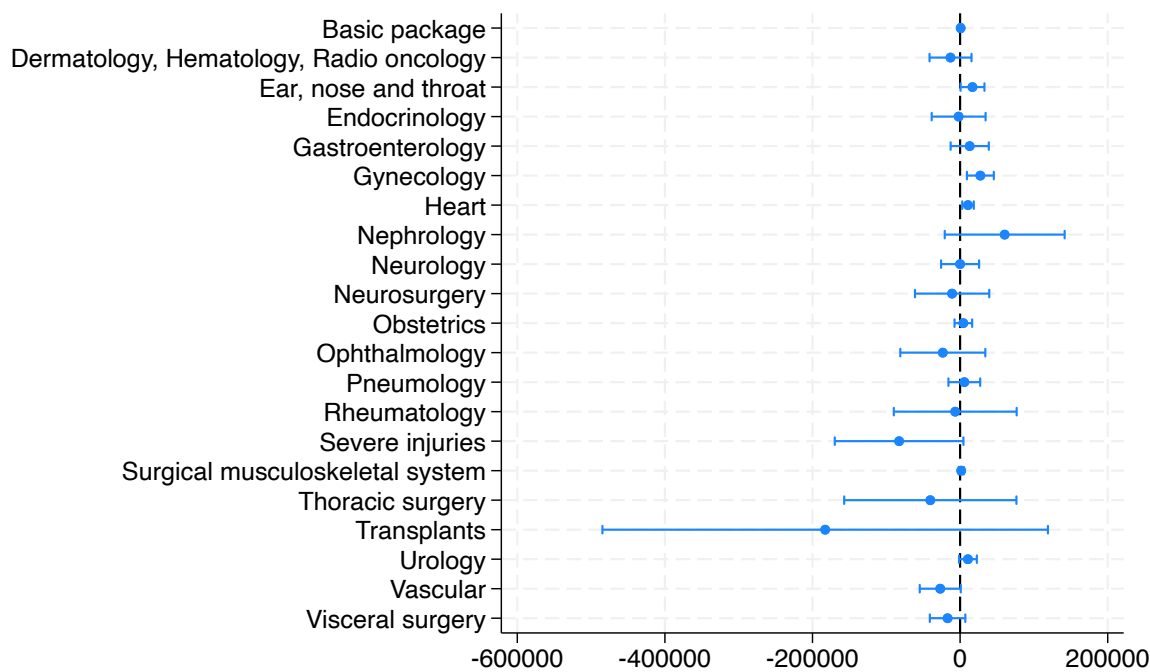
**Figure 6:** Hospital net profitability margin from 2015 to 2022



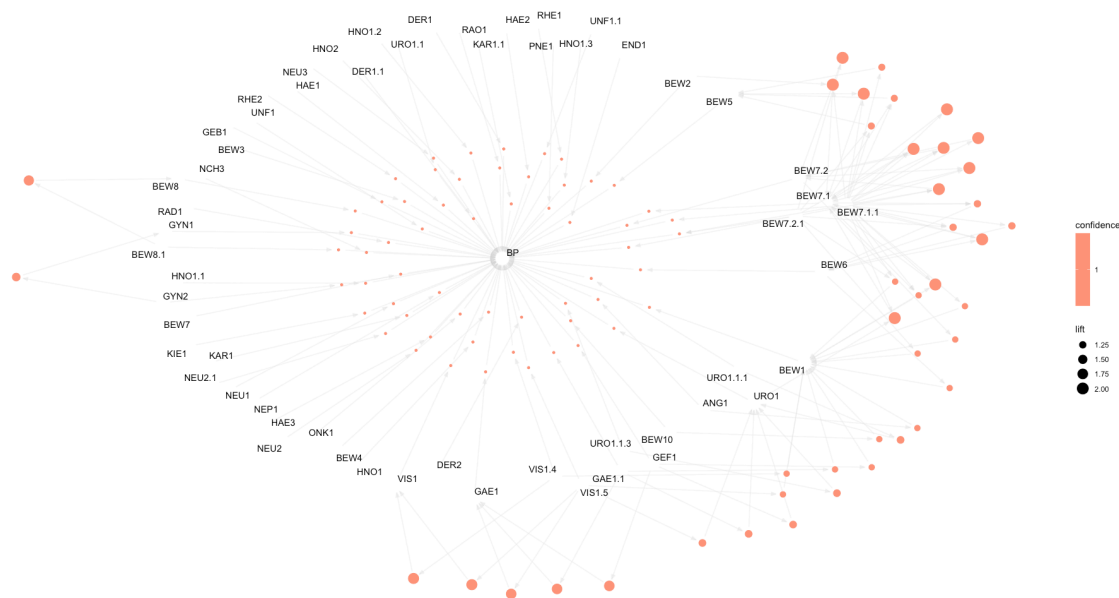
**Note:** Margin (%) referring to net profit margin(excluding deficit coverage) divided by hospital revenue; The whiskers in the boxplots represent values within 1.5 times the interquartile range (IQR), extending from the first quartile (Q1) to the third quartile (Q3). Values outside this range (potential outliers) are excluded from the visualization.



**Figure 7:** Fixed effects panel regression coefficients (incl. transplants)

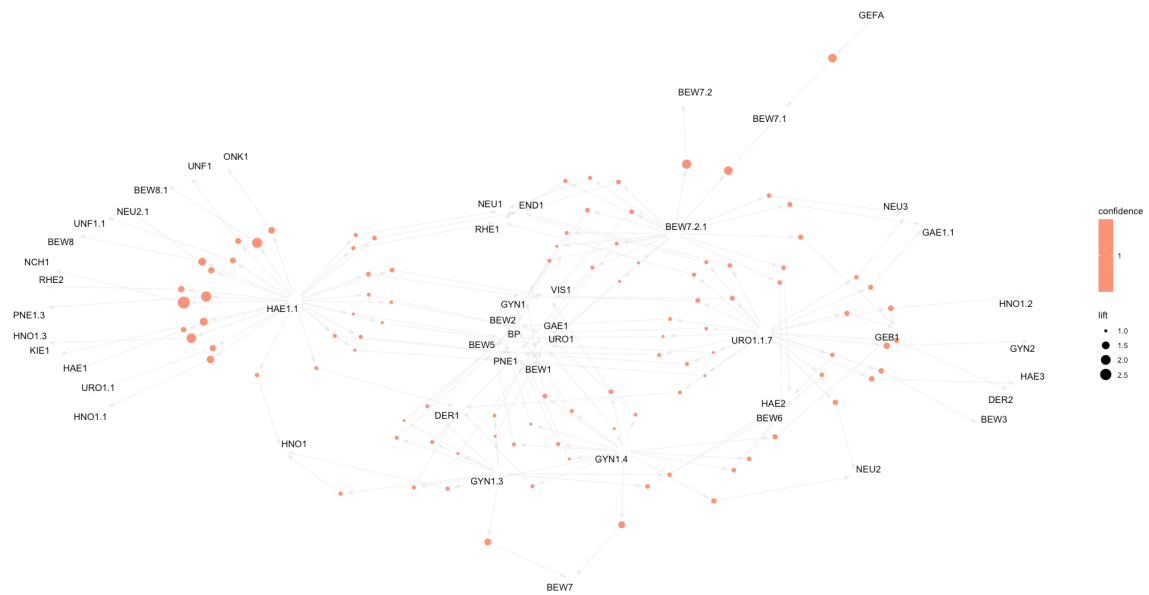


**Figure 8:** SPLG network diagram for private hospitals



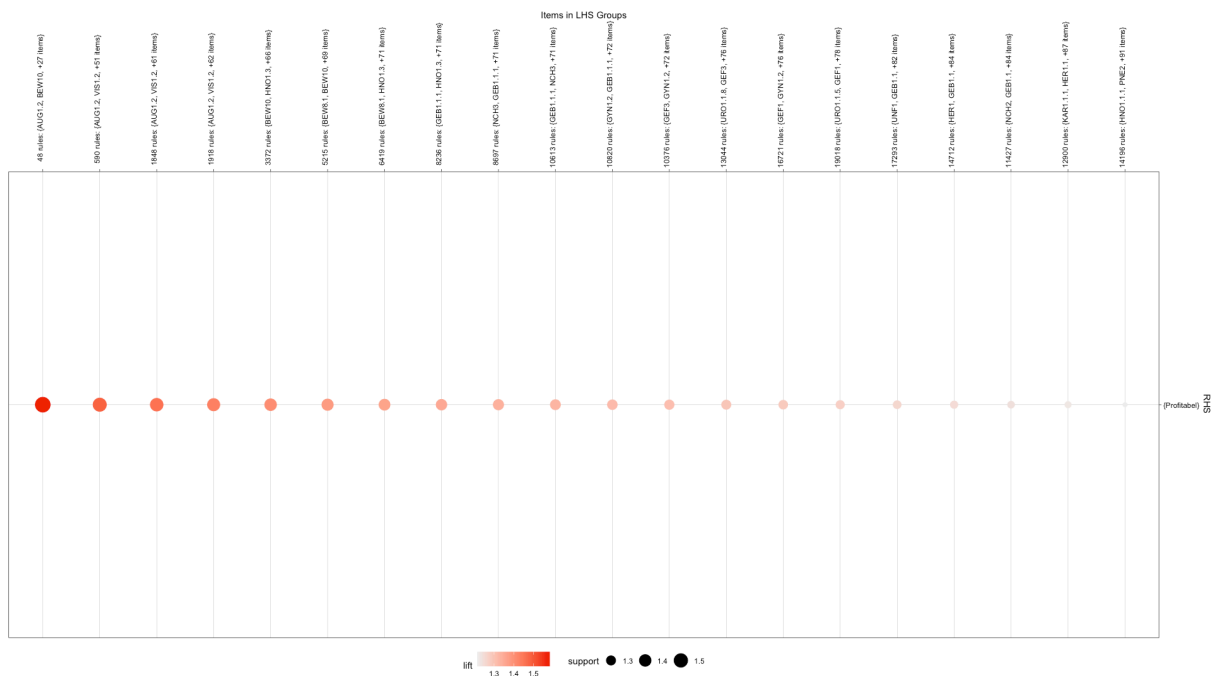
**Note:** SPLG network diagram based on top 100 rules based on highest lift.

**Figure 9: SPLG network diagram for public hospitals**

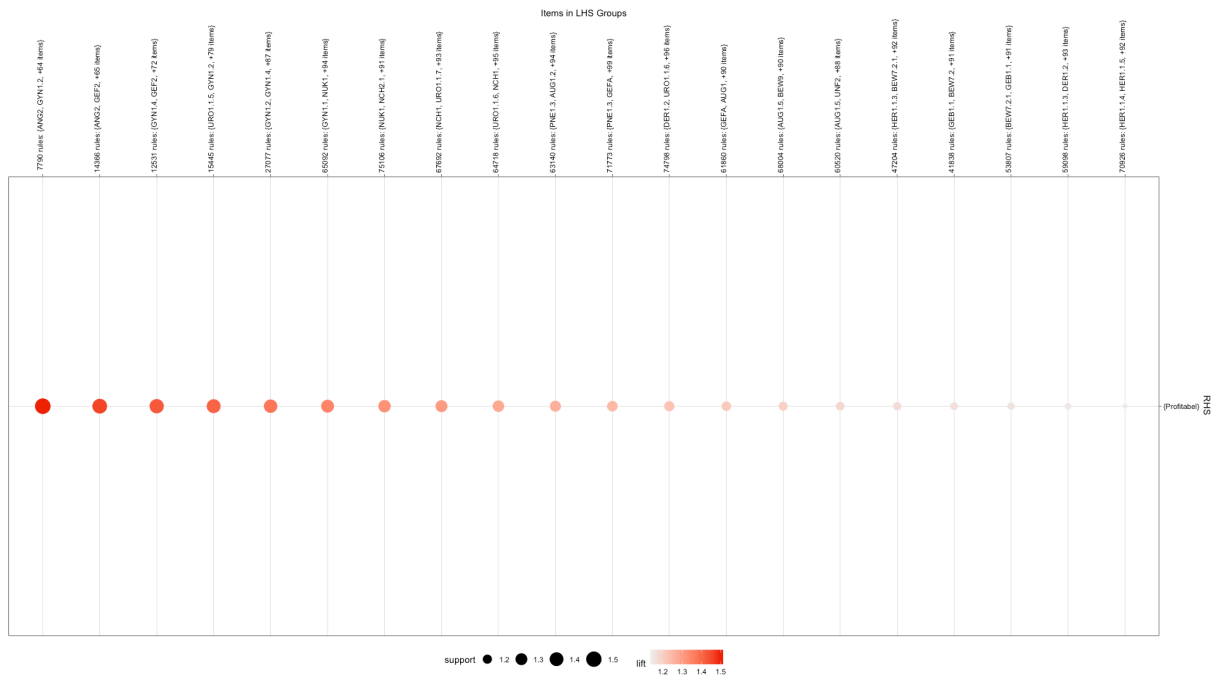


**Note:** SPLG network diagram based on top 100 rules based on highest lift.

**Figure 10: SPLG combinations linked with profitability**



**Figure 11: SPLG combinations linked with profitability for private hospitals**



**Figure 12: SPLG combinations linked with profitability for public hospitals**

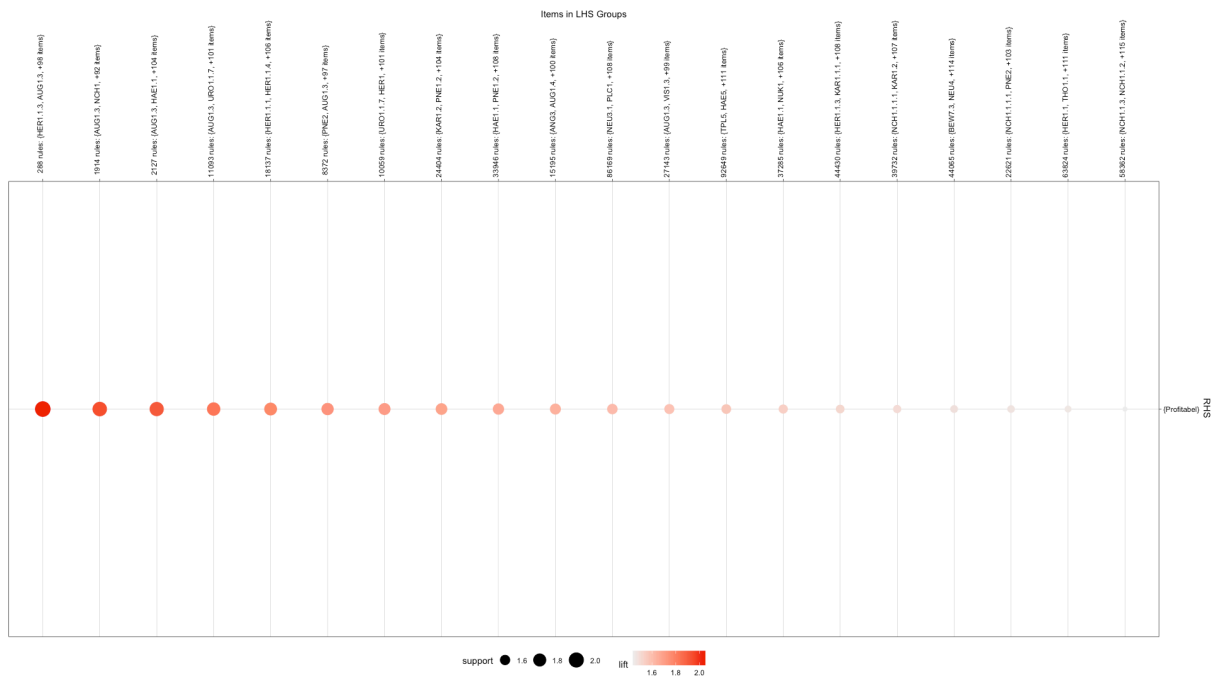


Figure 13: SPLG combinations linked with losses

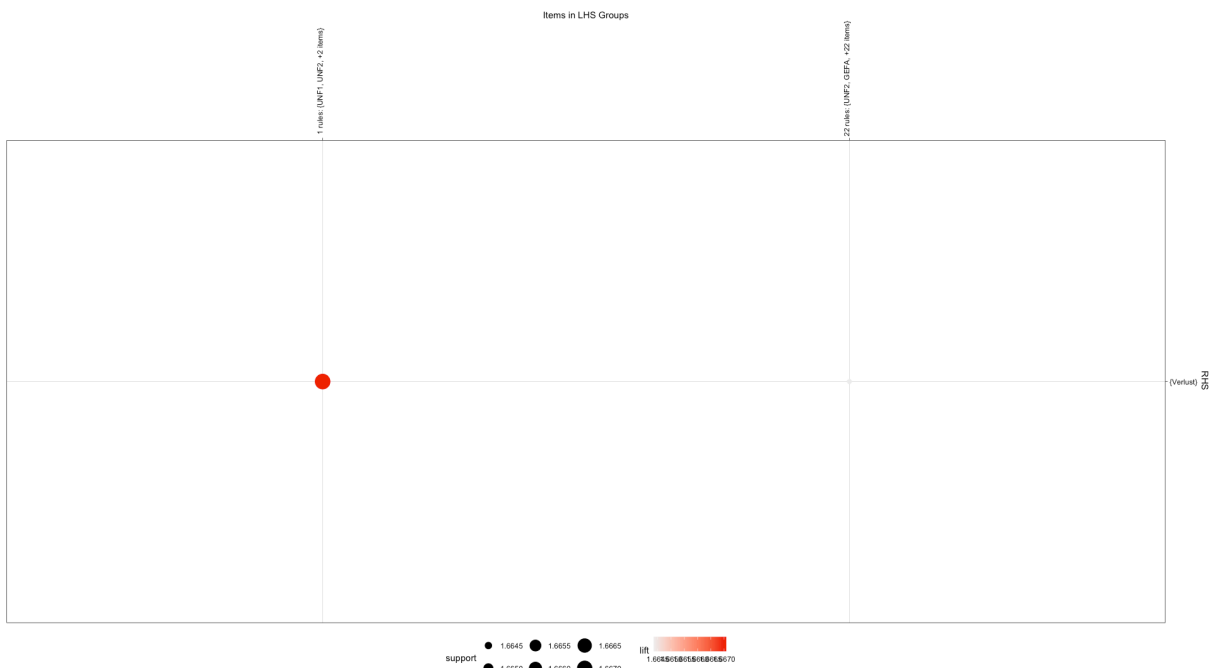
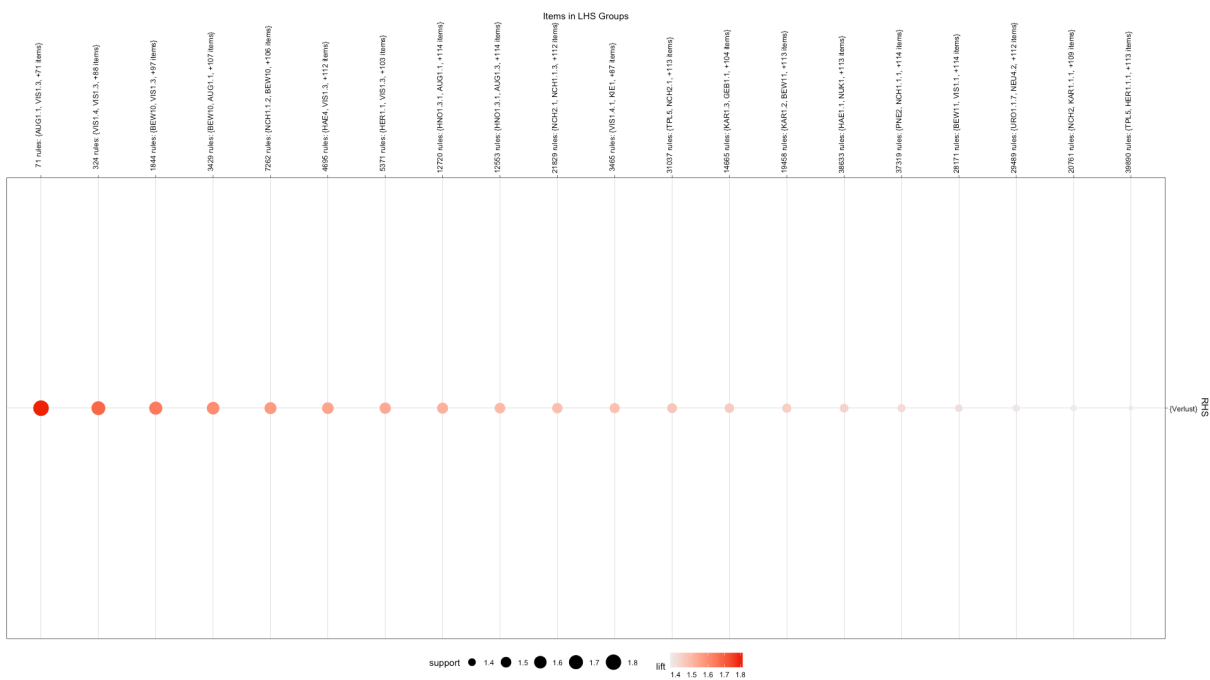


Figure 14: SPLG combinations linked with losses for public hospitals



**Table 6:** Fixed-effects panel regression analysis of relative hospital profitability margin with cluster-robust standard errors

	All hospitals		Private hospitals		Public hospitals	
	Absolute SPLB case numbers	SPLB offered by hospital <sup>b</sup>	Absolute SPLB case numbers	SPLB offered by hospital <sup>b</sup>	Absolute SPLB case numbers	SPLB offered by hospital <sup>b</sup>
<b>SPLB</b>	Coefficient (Standard Error) P-value	Coefficient (Standard Error) P-value	Coefficient (Standard Error) P-value	Coefficient (Standard Error) P-value	Coefficient (Standard Error) P-value	Coefficient (Standard Error) P-value
Basic package	0.001 (0.000)	n.a. <sup>c</sup>	0.001 (0.001)	n.a. <sup>c</sup>	0.000 (0.001)	n.a. <sup>c</sup>
Dermatology/ Hematology/ Radio oncology <sup>a</sup>	-0.001 (0.003)	-2.493 (1.091) **	-0.001 (0.004)	-2.926 (1.333) **	0.001 (0.006)	7.184 (4.611)
Ear, nose and throat	0.004 (0.001) ***	-0.186 (0.932)	0.003 (0.002) **	0.841 (0.941)	0.009 (0.006)	-7.499 (4.268) *
Endocrinology	0.005 (0.005)	0.482 (0.632)	-0.002 (0.008)	-0.827 (0.972)	0.004 (0.010)	0.768 (1.444)
Gastroenterology	0.004 (0.004)	1.305 (0.732) *	-0.004 (0.004)	2.025 (1.061) *	0.005 (0.006)	-8.321 (3.911) **
Gynecology	0.004 (0.002) *	-0.597 (0.776)	0.006 (0.005)	-0.244 (1.161)	0.010 (0.005) **	-2.841 (1.402) *
Heart	0.001 (0.001) **	0.739 (0.658)	0.001 (0.001)	0.239 (0.882)	0.001 (0.001)	1.015 (1.818)
Nephrology	-0.009 (0.009)	-0.152 (1.389)	0.006 (0.018)	0.419 (0.855)	-0.019 (0.017)	-1.819 (5.096)
Neurology	0.000 (0.003)	0.060 (0.737)	0.006 (0.006)	-0.204 (1.129)	-0.004 (0.004)	31.886 (9.087) ***
Neurosurgery	0.002 (0.006)	0.305 (0.343)	-0.003 (0.008)	0.563 (0.459)	0.018 (0.015)	0.788 (1.479)
Obstetrics	0.001 (0.002)	-1.565 (1.747)	0.000 (0.003)	-1.212 (2.174)	0.003 (0.006)	n.a. <sup>c</sup>
Ophthalmology	-0.001 (0.006)	0.391 (0.545)	0.001 (0.007)	-0.469 (0.911)	-0.009 (0.013)	0.953 (0.884)
Pneumology	-0.004 (0.003)	0.402 (0.769)	0.000 (0.002)	0.808 (1.157)	-0.015 (0.009)	-5.929 (1.943) ***
Rheumatology	0.000 (0.011)	-0.235 (0.754)	0.001 (0.014)	0.656 (1.068)	-0.012 (0.025)	-16.103 (4.675) ***
Severe injuries	-0.008 (0.010)	0.360 (0.555)	-0.024 (0.016)	0.666 (0.745)	0.010 (0.024)	-2.151 (1.384)
Surgical musculoskeletal system	0.001 (0.001)	-0.610 (0.966)	0.001 (0.001)	-0.743 (1.624)	0.003 (0.003)	n.a. <sup>c</sup>
Thoracic surgery	0.000 (0.010)	0.562 (0.579)	0.005 (0.016)	1.159 (0.743)	-0.005 (0.021)	1.014 (1.052)
Transplants	-0.030 (0.020)	-1.249 (0.999)	-0.060 (0.052)	n.a. <sup>c</sup>	-0.041 (0.051)	n.a. <sup>c</sup>
Urology	0.000 (0.002)	2.316 (1.932)	0.000 (0.004)	2.278 (1.923)	-0.002 (0.003)	n.a. <sup>c</sup>
Vascular	-0.003 (0.003)	0.189 (0.796)	-0.008 (0.004) **	-0.760 (0.834)	0.004 (0.010)	3.668 (2.228)
Visceral surgery	-0.006 (0.005)	2.291 (1.548)	0.002 (0.006)	3.588 (2.105) *	-0.008 (0.010)	6.857 (3.229) **

**Confounders:** Year, bed occupancy rate, share of private patients, share of inpatient revenue

\*\*\*)  $p < 0.01$ ; \*\*)  $p < 0.05$ ; \*)  $p < 0.1$

**Note:** Coefficient provided in percentage points; a) The SPLBs Dermatology, Hematology, and Radio oncology were merged into the combined category Dermatology/Hematology/Radio oncology. This was necessary because the three SPLBs exhibited very high correlations, leading to problematic multicollinearity ( $VIF > 10$ ). By merging the most strongly correlated SPLBs, the multicollinearity was reduced to acceptable levels ( $VIF < 10$ ), fulfilling the statistical requirements for the analysis. b) The independent variables are binary, with “1” indicating that a hospital is relevant within the SPLG and “0” indicating not relevant. A hospital was classified as relevant if it was among the providers that collectively treated at least 97.5% of all cases within each SPLG, excluding providers with only minimal caseloads. If one SPLG was classified as relevant, the SPLB was considered relevant. c) „n.a.“ referring to independent variables that STATA has omitted because of collinearity.

**Table 7:** Typical SPLG combinations for private hospitals

Antecedents	Consequent	Support	Confidence	Lift
KAR1, NEU1	GAE1.1	0.280	0.964	2.488
KAR1, NEU3	GAE1.1	0.279	0.959	2.475
KAR1, NEU2.1	GAE1.1	0.253	0.955	2.465
DER1, VIS1.5	GAE1.1	0.259	0.951	2.454
KAR1.1, NEU1	NEU3	0.268	0.989	2.141
KAR1, NEU1	NEU3	0.286	0.985	2.131
NEU1, UNF1	NEU3	0.258	0.983	2.128
HNO1, URO1.1.3	URO1.1	0.253	0.988	2.119
KAR1, NEU2.1	NEU3	0.259	0.978	2.116
NEU3, UNF1	NEU1	0.258	0.994	2.111
NEU1, UNF1.1	NEU3	0.286	0.975	2.110
URO1.1.3, VIS1	URO1.1	0.265	0.983	2.108
GAE1, URO1.1.3	URO1.1	0.264	0.983	2.108
DER1, URO1.1.3	URO1.1	0.261	0.983	2.108
NEU2, UNF1.1	NEU3	0.271	0.973	2.107
HNO1.1, NEU1	NEU3	0.271	0.973	2.107
HAE2, URO1.1.3	URO1.1	0.253	0.983	2.107
URO1.1.1, URO1.1.3	URO1.1	0.252	0.983	2.106
UNF1.1, VIS1	NEU3	0.264	0.973	2.105
NEU2.1, UNF1.1	NEU3	0.259	0.972	2.104
GYN1, UNF1	NEU3	0.253	0.971	2.103
URO1.1.1, VIS1	URO1.1	0.286	0.980	2.100
GAE1.1, NEU2.1	NEU3	0.288	0.970	2.099
DER1, URO1.1.1	URO1.1	0.277	0.979	2.099
GAE1, URO1.1.1	URO1.1	0.277	0.979	2.099
GAE1.1, UNF1.1	NEU1	0.250	0.988	2.098
HAE2, URO1.1.1	URO1.1	0.271	0.978	2.098
PNE1, URO1.1.1	URO1.1	0.264	0.978	2.096
BEW3, URO1.1.1	URO1.1	0.261	0.978	2.096
GEB1, URO1.1.1	URO1.1	0.259	0.978	2.096
NEU1, ONK1	NEU3	0.270	0.968	2.095
END1, URO1.1.1	URO1.1	0.256	0.977	2.095
HAE3, URO1.1.1	URO1.1	0.255	0.977	2.095
GAE1.1, URO1.1.1	URO1.1	0.252	0.977	2.094
KAR1.1, RHE1	NEU3	0.262	0.967	2.093
END1, UNF1	NEU3	0.256	0.966	2.092
KAR1, NEU3	NEU1	0.286	0.985	2.091
GEB1, UNF1.1	NEU3	0.253	0.966	2.091
NEP1, NEU2.1	NEU3	0.252	0.966	2.090
HNO2, NEU3	NEU1	0.282	0.984	2.090
KAR1.1, NEU3	NEU1	0.268	0.984	2.089
URO1.1.3	URO1.1	0.276	0.974	2.087
URO1, URO1.1.3	URO1.1	0.276	0.974	2.087
BP, URO1.1.3	URO1.1	0.276	0.974	2.087
HNO2, NEU1	NEU3	0.282	0.964	2.087
GAE1.1, NEU1	NEU3	0.322	0.964	2.087
BEW1, URO1.1.3	URO1.1	0.274	0.974	2.087
GYN1, UNF1	NEU1	0.256	0.983	2.087
GEB1, UNF1	NEU1	0.250	0.982	2.086
GYN1, URO1.1.3	URO1.1	0.270	0.973	2.086

**Note:** Top 50 rules listed as per defined parameters (see methodology), sorted top down by lift; 8,416 rules identified.

**Table 8:** Typical SPLG combinations for public hospitals

Antecedents	Consequent	Support	Confidence	Lift
AUG1.4, VIS1.2	AUG1.5	0.276	1.000	3.280
AUG1.4, VIS1.1	AUG1.5	0.276	0.986	3.232
ANG3, AUG1.4	AUG1.5	0.264	0.985	3.230
AUG1.2, AUG1.4	AUG1.5	0.256	0.984	3.229
ANG3, KAR1.1.1	KAR1.2	0.264	0.970	3.225
ANG3, KAR1.3	KAR1.2	0.264	0.970	3.225
AUG1.4, THO1.1	AUG1.5	0.272	0.971	3.185
AUG1, AUG1.4	AUG1.5	0.260	0.970	3.181
AUG1.4, THO1.2	AUG1.5	0.276	0.958	3.141
AUG1.4, THO1	AUG1.5	0.276	0.958	3.141
AUG1.4, URO1.1.1	AUG1.5	0.276	0.958	3.141
AUG1.4, BEW8	AUG1.5	0.276	0.958	3.141
AUG1.4, RAO1	AUG1.5	0.272	0.957	3.139
AUG1.4, URO1.1.4	AUG1.5	0.272	0.957	3.139
AUG1.4, RHE2	AUG1.5	0.272	0.957	3.139
AUG1.4, UNF1	AUG1.5	0.272	0.957	3.139
AUG1.4, URO1.1.2	AUG1.5	0.268	0.957	3.137
AUG1.4, URO1.1.8	AUG1.5	0.268	0.957	3.137
AUG1.4, DER1.1	AUG1.5	0.268	0.957	3.137
AUG1.4, HER1	AUG1.5	0.264	0.956	3.135
AUG1.4, KIE1	AUG1.5	0.260	0.955	3.133
AUG1.4, NUK1	AUG1.5	0.252	0.954	3.129
AUG1.4, NCH1.1	AUG1.5	0.252	0.954	3.129
AUG1.4, GEB1.1	AUG1.5	0.252	0.954	3.129
AUG1.4, UNF2	AUG1.5	0.252	0.954	3.129
NCH1.1, GYNT	GEFA	0.252	1.000	3.114
HNO1.1.1, GYNT	GEFA	0.252	1.000	3.114
THO1.2, GYNT	GEFA	0.264	1.000	3.114
NCH1.1, BEW7.1	GEFA	0.252	1.000	3.114
THO1.2, BEW7.1	GEFA	0.264	1.000	3.114
AUG1.5, VIS1.2	AUG1.4	0.276	0.958	3.100
AUG1.5, URO1.1.2	AUG1.4	0.268	0.957	3.096
ANG3, AUG1.5	AUG1.4	0.264	0.956	3.094
AUG1, AUG1.4	ANG3	0.264	0.985	3.067
DER1.1, GYNT	GEFA	0.268	0.971	3.022
AUG1.4, NUK1	ANG3	0.256	0.969	3.018
AUG1.4, GEB1.1	ANG3	0.256	0.969	3.018
GEB1.1, GYNT	GEFA	0.252	0.969	3.017
AUG1.2, AUG1.4	ANG3	0.252	0.969	3.017
URO1.1.1, VIS1.3	ANG3	0.252	0.969	3.017
VIS1.1, VIS1.2	ANG3	0.305	0.962	2.994
AUG1, VIS1.2	ANG3	0.297	0.961	2.991
AUG1.2, VIS1.1	ANG3	0.297	0.961	2.991
AUG1.2, VIS1.2	ANG3	0.293	0.960	2.989
NUK1, VIS1.2	ANG3	0.285	0.959	2.986
GEB1.1, VIS1.2	ANG3	0.285	0.959	2.986
VIS1.2, VIS1.4	ANG3	0.272	0.957	2.980
DER1.1, BEW7.1	GEFA	0.268	0.957	2.979
AUG1.4, THO1.1	ANG3	0.268	0.957	2.979
AUG1.4, AUG1.5	ANG3	0.264	0.956	2.977

**Note:** Top 50 rules listed as per defined parameters (see methodology), sorted top down by lift; 151,372 rules identified.

**Table 9:** SPLG combinations linked with profitability for private hospitals

Antecedents	Consequent	Support	Confidence	Lift
AUG1.2, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, HNO1.1	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, URO1.1	Profitability	0.051	1.000	1.617
AUG1.2, BEW7, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, GEF2, VIS1	Profitability	0.052	1.000	1.617
AUG1.2, BEW3, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, GEF2, HNO1.2	Profitability	0.052	1.000	1.617
AUG1.2, DER1, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, GAE1, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, GEF2, GYN1	Profitability	0.052	1.000	1.617
AUG1.2, BEW6, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, GEF2, URO1	Profitability	0.052	1.000	1.617
AUG1.2, BEW5, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, BEW2, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, BEW1, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, BP, GEF2	Profitability	0.052	1.000	1.617
AUG1.2, GEF1, GYN1.3	Profitability	0.052	1.000	1.617
AUG1.2, BEW7, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, GYN1.3, VIS1	Profitability	0.051	1.000	1.617
AUG1.2, BEW3, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, GYN1.3, HNO1.2	Profitability	0.051	1.000	1.617
AUG1.2, DER1, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, GAE1, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, GYN1, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, BEW6, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, GYN1.3, URO1	Profitability	0.051	1.000	1.617
AUG1.2, BEW5, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, BEW2, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, BEW1, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, BP, GEF2, GYN1.3	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, BEW7, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, GEF2, VIS1	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, BEW3, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, GEF2, HNO1.2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, DER1, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, GAE1, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, GEF2, GYN1	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, BEW6, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, GEF2, URO1	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, BEW5, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, BEW2, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW1, BEW10, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, BEW10, BP, GEF2	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, HNO1.1, URO1.1	Profitability	0.051	1.000	1.617
AUG1.2, BEW7, GEF2, HNO1.1	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, HNO1.1, VIS1	Profitability	0.051	1.000	1.617
AUG1.2, BEW3, GEF2, HNO1.1	Profitability	0.051	1.000	1.617
AUG1.2, GEF2, HNO1.1, HNO1.2	Profitability	0.051	1.000	1.617

**Note:** Top 50 rules listed as per defined parameters (see methodology), sorted top down by lift; more than 1 million rules identified.



**Table 10:** SPLG combinations linked with profitability for public hospitals

Antecedents	Consequent	Support	Confidence	Lift
AUG1.3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GYN1.2, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GYN1.1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
ANG2, AUG1.3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.5, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GEF2, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GYN1.4, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GYN1.3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HAE1.1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, BEW11, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, AUG1.4, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, AUG1.5, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, KAR1.2, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, BEW9, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.6, VIS1.3	Profitability	0.053	1.000	2.050
ANG3, AUG1.3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.6, VIS1.2	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, KAR1.1.1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, NCH1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, BEW10, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.6, VIS1.4.1	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.6, VIS1.1	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, KAR1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, NUK1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1, AUG1.3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, NCH1.1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.2, AUG1.3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, THO1.1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, HNO1.1.1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, PNE1.1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.2, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, THO1.2, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GEB1.1.1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, PNE1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GEB1.1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, BEW8.1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.6, URO1.1.8	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, NCH3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, HNO1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, RAO1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, DER1.1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, THO1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GEF3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.6, VIS1.4	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.4, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, HER1.1.3, URO1.1.1, URO1.1.6	Profitability	0.053	1.000	2.050
AUG1.3, GEF1, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050
ANG1, AUG1.3, HER1.1.3, URO1.1.6	Profitability	0.053	1.000	2.050

**Note:** Top 50 rules listed as per defined parameters (see methodology), sorted top down by lift; 641,815 rules identified.

**Table 11:** SPLG combinations linked with losses

Antecedents	Consequent	Support	Confidence	Lift
UNF1, UNF2, GEFA, BEW7.1.1	Losses	0.054	0.701	1.667
UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, GEFA, GYNT, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, BEW7.1, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
HAE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
NEU3, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
NEU2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GYN2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
HAE3, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GEB1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
RHE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
HAE2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
PNE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, VIS1, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GAE1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
DER1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
GYN1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW6, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
UNF2, URO1, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW5, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW2, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BEW1, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664
BP, UNF2, GEFA, BEW7.1.1	Losses	0.056	0.700	1.664

**Note:** Top 23 rules listed as per defined parameters (see methodology), sorted top down by lift; 23 rules identified.

**Table 12:** SPLG combinations linked with losses for public hospitals

Antecedents	Consequent	Support	Confidence	Lift
AUG1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, AUG1.3, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, VIS1.3, GEFA, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, AUG1.4, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, AUG1.5, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, KAR1.2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, VIS1.3, GYNT, BEW7.1.1	Losses	0.053	0.929	1.813
ANG3, AUG1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, HER1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, VIS1.2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, KAR1.1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, VIS1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, KAR1.3, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1, AUG1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, NCH1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, VIS1.3, BEW7.1, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, HER1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, AUG1.2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, THO1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, URO1.1.2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, THO1.2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, GEB1.1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, GEB1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, URO1.1.8, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, RAO1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, THO1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, GEF3, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, VIS1.3, VIS1.4, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, URO1.1.4, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, URO1.1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, GEF1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
ANG1, AUG1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, VIS1.3, VIS1.5, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, URO1.1.3, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, HNO2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, RAD1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, BEW8, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, KAR1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, KAR1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, ONK1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, RHE2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, NEP1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, GYN2, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, NEU2.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, URO1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, UNF1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, UNF1.1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, HAE3, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, HAE1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813
AUG1.1, GEB1, VIS1.3, BEW7.1.1	Losses	0.053	0.929	1.813

**Note:** Top 50 rules listed as per defined parameters (see methodology), sorted top down by lift; 332,986 rules identified.