Predictors for shorter and longer length of hospital stay outliers: a retrospective case-control study of 8247 patients at a university hospital trauma department

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Abstract: BACKGROUND Providing efficient healthcare is important for hospitals. Shorter and longer length of hospital stay (LOS) outliers influence financial results and reimbursement. The objective of this study was to identify independent diagnosis related group (DRG)-related risk factors for shorter and longer LOS outlier status. METHODS A retrospective case-control study was conducted at a Swiss level 1 trauma centre between January 2012 and December 2014. The study included all patients with available information on LOS based on DRG. Many predictor variables were tested. The outcome variable was the DRG-based LOS. Logistic regression models were fitted for shorter and longer LOS outliers, with a significance level of <1%. RESULTS A total of 8247 patients were analysed, of whom inliers were more frequent than shorter and longer LOS outliers (n = 5838 [70.8%] vs n = 1996 [24.2%] vs n = 413 [5.0%]). Predictors for shorter LOS outliers were death (odds ratio [OR] 4.89, 95% confidence interval [CI] 3.27-7.31), concussion (OR 4.87, 95% CI 4.20-5.63) and psychiatric disease (OR 1.85, 95% CI 1.46-2.34). Predictors for longer LOS outliers were age 65 years (OR 1.74, 95% CI 1.31-2.30), number of diagnoses 5 (OR 2.07, 95% CI 1.52-2.81), comorbidity (OR 1.75, 95% CI 1.28-2.40), number of surgical procedures (OR 1.76, 95% CI 1.36-2.28), complication perioperatively (OR 1.69, 95% CI 1.24-2.30), infection (OR 2.66, 95% CI 1.57-4.49]), concussion (OR 1.52, 95% CI 1.14-2.01) and urinary tract infection (OR 2.34, 95% CI 1.61-3.41). CONCLUSION This large study showed that LOS outliers, especially shorter LOS outliers, are relatively common. Patients who died, or had concussion or psychiatric disease were more commonly discharged early. Patients weremore often discharged late if they were aged 65 years, had more diagnoses, were comorbid, had more surgical procedures, complications perioperatively, infection, concussion and urinary tract infection. For hospitals, this can help raise awareness and lead to better management of specific diagnoses in order to avoid monetary deficits. For the public health sector, this information may be considered in future revisions of the DRG.

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Predictors for shorter and longer length of hospital stay outliers: a retrospective case-control study of 8247 patients at a university hospital trauma department

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Summary

BACKGROUND: Providing efficient healthcare is important for hospitals. Shorter and longer length of hospital stay (LOS) outliers influence financial results and reimbursement. The objective of this study was to identify independent diagnosis related group (DRG)-related risk factors for shorter and longer LOS outlier status.

METHODS: A retrospective case-control study was conducted at a Swiss level 1 trauma centre between January 2012 and December 2014. The study included all patients with available information on LOS based on DRG. Many predictor variables were tested. The outcome variable was the DRG-based LOS. Logistic regression models were fitted for shorter and longer LOS outliers, with a significance level of <1%.

RESULTS: A total of 8247 patients were analysed, of whom inliers were more frequent than shorter and longer LOS outliers (n = 5838 [70.8%] vs n = 1996 [24.2%] vs n = 413 [5.0%]). Predictors for shorter LOS outliers were death (odds ratio [OR] 4.89, 95% confidence interval [CI] 3.27–7.31), concussion (OR 4.87, 95% CI 4.20–5.63) and psychiatric disease (OR 1.85, 95% CI 1.46–2.34). Predictors for longer LOS outliers were age ≥65 years (OR 1.74, 95% CI 1.31–2.30), number of diagnoses ≥5 (OR 2.07, 95% CI 1.52–2.81), comorbidity (OR 1.75, 95% CI 1.28–2.40), number of surgical procedures (OR 1.76, 95% CI 1.36–2.28), complication perioperatively (OR 1.69, 95% CI 1.24–2.30), infection (OR 2.66, 95% CI 1.57–4.49]), concussion (OR 1.52, 95% CI 1.14–2.01) and urinary tract infection (OR 2.34, 95% CI 1.61–3.41).

CONCLUSION: This large study showed that LOS outliers, especially shorter LOS outliers, are relatively common. Patients who died, or had concussion or psychiatric disease were more commonly discharged early. Patients weremore often discharged late if they were aged ≥65 years, had more diagnoses, were comorbid, had more surgical procedures, complications perioperatively, infection, concussion and urinary tract infection. For hospitals, this can help raise awareness and lead to better management of specific diagnoses in order to avoid monetary deficits. For the public health sector, this information may be considered in future revisions of the DRG.

Keywords: *length of stay (LOS) at the hospital, diagnosis related groups (DRG), outlier, inlier, trauma, fractures, complications*

Introduction

The increase in healthcare costs can be more rapid than the rise in the inflation rate, which may occur despite any improvements in quality [1]. Therefore, efficient healthcare is important for hospitals. In the diagnosis related group (DRG) system, fixed prices, irrespective of actual costs, require hospitals and physicians to economise on treatment costs [2]. In Switzerland in 2012, the DRG system replaced a cost-based reimbursement system that depended on the length of hospital stay (LOS) [3]. In the United States, such a system was first introduced in New Jersey in 1980 [4]. The DRG system classifies patients into around 500 groups of diseases according to the International Classification of Diseases (ICD) and other patient characteristics.

LOS is one of the crucial points for cost containment, because inpatients who stay for a shorter (shorter LOS outlier) or longer (longer LOS outlier) period than that predicted from their respective DRG lead to less financial reimbursement. Shorter LOS outliers directly decrease financial reimbursement, whereas longer LOS outliers receive extra payments that are usually not cost-effective. This is particularly important for patients who develop in-hospital complications because they usually stay substantially longer [5]. LOS is also associated with patient outcomes. Patient satisfaction is associated with shorter LOS, and complications are linked to longer LOS [6]. However, there is a lack of information on risk factors for shorter and longer LOS outlier status in Switzerland.

Author contributions
TJ: statistical analysis and interpretation of data, drafting the manuscript; BS: statistical analysis; VN: ethics approval, acquisition and interpretation of data, drafting the manuscript RMM: acquisition and interpretation of data; all: revision of the manuscript, final approval of the version to be published.

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The objective of this study was to identify independent DRG-related risk factors for shorter and longer LOS outlier status.

Materials and methods

Study design

Between January 2012 and December 2014, 8534 inpatients were treated and discharged (inclusion criteria) at the authors' trauma department. Overall, 287 patients without information on LOS based on DRG were excluded, resulting in an analytical sample size of 8247 patients. All data were acquired through a search of the hospital's routine database for billing purposes, including the disease codes of the World Health Organization. The International Statistical Classification of Diseases and Related Health Problems, 10th Revision, German Modification, Version 2010 (ICD-10) was used [7]. Prior to the start of the study, ethical approval was obtained from the local ethics committee (Kantonale Ethikkommission Zürich, KEK-ZH-Nr: 2011-0382).

Predictor variables

The main predictor variable was age. Many secondary predictor variables (and, if applicable, their ICD-10 codes) were investigated. All available data for billing purposes were included in order to provide the most comprehensive review of potential risk factors since there is very little evidence about this subject. Several, often rare, subcategories (e.g., lung contusion, hepatitis, pseudarthrosis) that would probably not add more information, but instead crowd the analysis, were excluded. By including many variables, we hoped to address various specialties and provide the basis for future studies. The included variables were gender, comorbidities, injury severity score (ISS), normalised ISS (NISS), number of surgical procedures, in-house mortality, and the presence of the following medical conditions / diagnoses described by specific ICD-10 codes as stated: perioperative complications (distinct Y-codes), number of traumatic diagnoses (all S*-Codes), number of secondary medical diagnoses, wound infection (T81.4), head concussion (S06.0), viscerocranial fracture (S02), epidural haematoma (S06.4), subdural haematoma (S06.5), subarachnoid haematoma (S06.6), multiple rib fractures (S22.4, S22.5), pneumothorax (S27.0, S27.2), liver rupture (S36.12, S36.13, S36.14, S36.15), splenic rupture (S36.02, S36.03, S36.04, S36.08), and fractures of the cervical spine (S12, S18), thoracic spine (S22.0, S22.1), lumbar spine (S32.0, S32.82), pelvic ring (S32.3, S32.5, S32.7, S32.81, S32.83, S32.89), clavicle (S42.0, S42.7), scapula (S42.1, S42.7), humerus (S42.2 – S42.4), radius (S52.1, S52.3, S52.4, S52.5, S52.6, S52.7), ulna (S52.0, S52.2), hand (S62), femoral neck (S72.0), femoral pertrochanter (S72.1, S72.2), femoral diaphysis and lower end (S72.3, S72.4), patella (S82.0), tibia (S82.1, S82.2, S82.3, S82.7), fibula (S82.11, S82.21, S82.31, S82.4, S82.6, S82.7, S82.81, S82.82), malleolus (S82.5, S82.6), foot (S92) and calcaneus (S92.0), as well as any psychiatric disease (F*), depression (F32, F31.3, F31.4, F31.5, F33.0, F33.1, F33.2, F33.3, F33.8, F33.9, F34.1), dementia (F00 - F03), coronary heart syndrome (I20 – I25), arterial hypertension (I10 – I15), arrhythmia (I47 – I49), peripheral vascular disease (I70, I79), chronic lung disease (J40-J47), thyroid disease (E00 – E07), diabetes mellitus (E10 – E14), osteoporosis (M80 – M82), malignant tumour (C*), and urinary tract infection (N30, N39.0) [8].

Outcome variables

The outcome variable was the LOS status at the hospital, based on SwissDRG. Patients were classified into three groups as shorter LOS outliers, inliers, and longer LOS outliers. Technically, every case was assigned a DRG for billing purposes, and as long as the length of stay (LOS) of the case was within the low and high margins of the DRG (inlier definition), a case was classified as LOS inlier. If the LOS was below the low trim point of the DRG, the case was defined as a shorter LOS outlier. If LOS exceeded the high trim point, the case was accordingly defined as a longer LOS outlier [9].

Statistics

Categorical values are presented as absolute number (%), and continuous values as median (interquartile range [IQR]). For differences in patient characteristics (general characteristics, truncal injuries, extremity fractures and concomitant diseases) between shorter LOS outliers, inliers, and longer LOS outliers, categorical variables were analysed with chi-squared tests and continuous variables with the Kruskal-Wallis test. In order to identify independent DRG-related risk factors for shorter and longer LOS outlier status, two multivariable logistic regression models were fitted; one with shorter LOS outliers vs inliers and another with longer LOS outliers vs inliers as the dependent variable. Confounding was assumed for gender *a priori*. The Wald test was used to detect differences in odds and the significance level was set at 1% owing to multiple testing. Power calculation revealed that at least 1294 patients were needed to detect differences of 5% between out- and inliers at a power of 80% and a significance level of 1%. SPSS (version 21.0, IBM Corp, Armonk, NY, USA) and Stata (version 13.1; StataCorp LLC, College Station, TX, USA) were used.

Results

General patient characteristics by LOS group

A total of 8247 patients (39.8% females; median age 49.0 years, IQR 32.0–67.0) were included in the study. All general patient characteristics differed significantly between the three LOS groups except for ISS, NISS and in-house mortality. Inliers (n = 5838, 70.8%) were more frequent than shorter LOS outliers (n = 1996, 24.2%) and longer LOS outliers (n = 413, 5.0%) (table 1).

Although males were more frequent in all three LOS groups, the proportion of males was higher among shorter LOS outliers than among inliers and longer LOS outliers (64.4 vs 59.1 vs 55.7%, p <0.001). The median age was higher in longer LOS outliers than in inliers and shorter LOS outliers (64.0 vs 50.0 vs 40.0 years, p <0.001). The same was observed for the number of diagnoses (8.0 vs 5.0 vs 4.0%, p <0.001), secondary diagnoses (7.0 vs 4.0 vs 3.0%, p <0.001) and number of surgical procedures (10.0 vs 5.0 vs 4.0, p <0.001). The proportion with patients with complications perioperatively and with wound infections was higher in longer LOS outliers than inliers and shorter

LOS outliers (24.0 vs 10.1 vs 3.8%, p <0.001 and 7.5 vs 1.4 vs 0.3, p<0.001, respectively).

Truncal injuries by LOS groups

The proportion of patients with a concussion was higher in shorter LOS outliers than in longer LOS outliers and inliers (52.3 vs 23.7 vs 14.6%, p <0.001) (table 2). The proportion of patients with fractures of the viscerocranium was higher in longer LOS outliers than in shorter LOS outliers and inliers (14.5 vs 13.7 vs 13.7%, p <0.001). The proportion of patients with an intracranial haematoma was higher in inliers than longer LOS and shorter LOS outliers (2.1 vs 1.0 vs 0.1%, p <0.001 for epidural; 7.9 vs 4.8 vs 1.7%, p <0.001 for subdural; and 6.6 vs 4.6 vs 2.0%, p <0.001 for subarachnoid). The proportion of patients with multiple rib fractures and pneumothorax was higher in longer LOS outliers than inliers and shorter LOS outliers (9.0 vs 7.7 vs 2.7%, p <0.001 and 4.8 vs 3.9 vs 1.0%, p <0.001). The same was observed for liver and splenic ruptures (1.9 vs 0.7 vs 0.2%, p <0.001 and 2.2 vs 0.8 vs 0.2%, p <0.001, respectively). The proportions of patients with cervical and thoracic spine fractures was higher in inliers than longer and shorter LOS outliers (3.8 vs 2.9 vs 1.1%, p <0.001 and 5.3 vs 5.1 vs 1.4%, p <0.001). Lumbar spine fractures were more frequently observed in longer LOS outliers than inliers and shorter LOS outliers (7.5 vs 5.6 vs 1.4%, p <0.001). The same was true for pelvic ring fractures (6.8 vs 4.0 vs 0.5%, p <0.001).

Extremity fractures by LOS groups

The proportions of patients with clavicle and scapula fractures were higher in inliers than longer and shorter LOS outliers (5.7 vs 3.9 vs 1.4%, p <0.001 and 1.9 vs 1.9 vs 0.7%, p = 0.001, respectively) (table 3). The proportion of patients with humeral fractures was higher in longer LOS outliers than inliers and shorter LOS outliers (6.8 vs 5.5 vs 1.1%, p <0.001). The proportion of patients with a radius fracture was higher in inliers than longer and shorter LOS outliers (10.0 vs 8.0 vs 3.9%, p <0.001). The proportions of ulna and hand fractures were higher in longer LOS outliers than inliers and shorter LOS outliers (4.1 vs 3.2 vs 1.5, p <0.001 and 4.6 vs 2.0 vs 1.0%, p <0.001). The proportions of patients with fractures of the femoral neck and diaphysis were higher in in longer LOS outliers than inliers and shorter LOS outliers (2.7 vs 2.2 vs 0.3%, p <0.001 and 7.0 vs 6.7 vs 1.3%, p <0.001). The proportion of patients with pertrochanteric fractures was higher in inliers than longer and shorter LOS outliers (2.0 vs 1.0 vs 0.7%, p <0.001). The proportion of patients with fractures around the knee, ankle and foot was higher in longer LOS outliers than inliers and shorter LOS outliers (2.2 vs 1.0 vs 0.1%, p <0.001 for the patella; 9.0 vs 4.7 vs 1.7, p <0.001 for the tibia; 11.9 vs 8.3 vs 3.0%, p <0.001 for the fibula; 7.0 vs 6.3 vs 2.6%, p <0.001 for the malleolus; 8.5 vs 3.5 vs 1.7%, p <0.001 for the foot; and 4.8 vs 1.4 vs 0.5%, p <0.001 for the calcaneus).

Concomitant diseases by LOS groups

Regarding concomitant diseases (table 4), the proportion of patients with any psychiatric disease, depression, and dementia was higher in longer LOS outliers than inliers and shorter LOS outliers (30.5 vs 15.7 vs 15.5%, p <0.001 for any psychiatric disease; 8.2 vs 3.3 vs 2.0%, p <0.001 for depression; and 3.9 vs 1.4 vs 1.6%, p = 0.001 for dementia). The proportion of patients with a coronary heart syndrome was higher in inliers than longer and shorter LOS outliers (2.3 vs 2.2 vs 1.0%, p = 0.001). The proportion of patients with arterial hypertension, arrhythmia, pe-

Table 1: General patient characteristics according to the length of hospital stay (LOS), based on diagnosis related group (DRG) (n = 8247).

Variable	Category	LOS based on DRG	p-value†					
		Shorter LOS outlier (n = 1996)		Inlier (n = 5838)		Longer LOS outlier (n = 413)		
		n or median*		(% or IQR*)	n or median*	(% or IQR*)	n or median*	(% or IQR*)
Age (y)		40.0	(27.0–59.0)	50.0	(34.0–69.0)	64.0	(47.0–77.0)	<0.001
Gender	Female	710	(35.6)	2388	(40.9)	183	(44.3)	<0.001
	Male	1286	(64.4)	3450	(59.1)	230	(55.7)	
Number of diagnoses		4.0	(3.0–6.0)	5.0	(3.0–8.0)	8.0	(5.0–12.0)	<0.001
Number of secondary diagnoses		3.0	(2.0–5.0)	4.0	(2.0–7.0)	7.0	(4.0–11.0)	<0.001
Comorbidity	No	1384	(69.3)	3065	(52.5)	108	(26.2)	<0.001
	Yes	612	(30.7)	2773	(47.5)	305	(73.8)	
ISS‡		25.0	(17.0–75.0)	24.0	(16.0–34.0)	20.0	(14.0–29.0)	0.09
NISS‡		33.0	(22.0–75.0)	29.0	(20.0–43.0)	27.0	(17.0–38.0)	0.048
Number of surgical procedures		4.0	(2.0–6.0)	5.0	(2.0–12.0)	10.0	(5.0–28.0)	<0.001
Complication perioperatively	No	1921	(96.2)	5250	(89.9)	314	(76.0)	<0.001
	Yes	75	(3.8)	588	(10.1)	99	(24.0)	
Infection	No	1990	(99.7)	5758	(98.6)	382	(92.5)	<0.001
	Yes	6	(0.3)	80	(1.4)	31	(7.5)	
Death	No	1941	(97.2)	5653	(96.8)	408	(98.8)	0.06
	Yes	55	(2.8)	185	(3.2)	5	(1.2)	

LOS = length of hospital stay; DRG = diagnosis related group; IQR = interquartile range; ISS = injury severity score; NISS = normalised injury severity score; ICU = intensive care unit * The absolute number (%) is given for categorical data and the median (IQR) is provided for continuous data † Chi-squared test for categorical data and Kruskal-Wallis test for continuous data ‡ There were many missing data for ISS and NISS in all three groups. The number of available patients was n = 35 for shorter LOS outliers, n = 427 for inliers, and n = 43 for longer LOS outliers.

ripheral vascular disease, chronic lung disease, thyroid disease, diabetes mellitus, osteoporosis, a malignant tumour, or urinary tract infection was higher in longer LOS outliers than inliers and shorter LOS outliers (34.6 vs 18.1 vs 8.9%, p <0.001; 13.1 vs 6.4 vs 2.9, p <0.001; 2.4 vs 1.3 vs 0.6%, p = 0.002; 4.6 vs 3.1 vs 1.0%, p <0.001; 3.4 vs 2.7 vs 1.1%, p <0.001; 9.4 vs 5.5 vs 3.3%, p <0.001; 6.5 vs 4.2 vs 0.8%, p <0.001; 4.6 vs 2.8 vs 1.7%, p = 0.001; 11.4 vs 3.5 vs 0.6%, p <0.001).

Independent risk factors for shorter LOS outliers

There were 17 independent protective factors for shorter LOS outliers regarding LOS (table 5): comorbidity (odds ratio [OR] 0.46, 95% confidence interval [CI] 0.38–0.56; p <0.001), number of surgical procedures (OR 0.55, 95% CI 0.48–0.62; p <0.001), complication perioperatively (OR 0.58, 95% CI 0.44–0.76; p <0.001), epidural haematoma (OR 0.10, 95% CI 0.02–0.43; p = 0.002), subdural haematoma (OR 0.29, 95% CI 0.18–0.45; p <0.001), cervical spine fracture (OR 0.34, 95% CI 0.20–0.56; p <0.001), thoracic spine fracture (OR 0.46, 95% CI 0.30–0.71; p <0.001), lumbar spine fracture (OR 0.35, 95% CI 0.23–0.54, p <0.001), pelvic ring fracture (OR 0.20, 95% CI 0.10–0.39; p <0.001), clavicle fracture (OR 0.20, 95% CI 0.13–0.31; p <0.001), humerus fracture (OR 0.20, 95% CI 0.13–0.32; p <0.001), radius fracture (OR 0.35, 95% CI 0.27–0.46; p <0.001), diaphyseal femur fracture (OR 0.21, 95% CI 0.09–0.45; p <0.001), patella fracture (OR 0.11, 95% CI 0.03–0.47; p = 0.003), tibial fracture (OR 0.49, 95% CI 0.31–0.76; p = 0.002), osteoporosis (OR 0.42, 95% CI 0.24–0.74; p = 0.003) and urinary tract infection (OR 0.31, 95% CI 0.16–0.61; p = 0.001).

Three independent risk factors were identified for shorter LOS outliers regarding LOS: death (OR 4.89, 95% CI 3.27–7.31; p <0.001), concussion (OR 4.87, 95% CI 4.20–5.63; p <0.001) and psychiatric disease (OR 1.85, 95% CI 1.46–2.34; p <0.001).

Independent risk factors for longer LOS outliers

There were two independent protective factors for longer LOS outliers regarding LOS (table 6): subdural haematoma (OR 0.47, 95% CI 0.27–0.80; p = 0.006) and cervical spine fracture (OR 0.42, 95% CI 0.22–0.79; p = 0.007).

Eight independent risk factors were identified for longer LOS outliers regarding LOS: age ≥65 years (OR 1.74, 95% CI 1.31–2.30; p <0.001), number of diagnoses ≥5 (OR

Table 2: Truncal injuries according to the length of hospital stay (LOS) based on diagnosis related group (DRG) (n = 8247).

Variable	Category	LOS based on DRG	p-value*					
		Shorter LOS outlier (n = 1996)		Inlier (n = 5838)		Longer LOS outlier (n = 413)		
		n		(%)	n	(%)	n	(%)
Head injury								
Concussion	No	952	(47.7)	4987	(85.4)	315	(76.3)	<0.001
	Yes	1044	(52.3)	851	(14.6)	98	(23.7)	
Fracture	No	1723	(86.3)	5038	(86.3)	353	(85.5)	<0.001
	Yes	273	(13.7)	800	(13.7)	60	(14.5)	
Epidural haematoma	No	1994	(99.9)	5718	(97.9)	409	(99.0)	<0.001
	Yes	2	(0.1)	120	(2.1)	4	(1.0)	
Subdural haematoma	No	1963	(98.3)	5379	(92.1)	393	(95.2)	<0.001
	Yes	33	(1.7)	459	(7.9)	20	(4.8)	
Subarachnoid haematoma	No	1956	(98)	5455	(93.4)	394	(95.4)	<0.001
	Yes	40	(2.0)	383	(6.6)	19	(4.6)	
Thoracic injury								
Multiple rib fractures	No	1942	(97.3)	5390	(92.3)	376	(91.0)	<0.001
	Yes	54	(2.7)	448	(7.7)	37	(9.0)	
Pneumothorax	No	1976	(99.0)	5608	(96.1)	393	(95.2)	<0.001
	Yes	20	(1.0)	230	(3.9)	20	(4.8)	
Abdominal injury								
Liver rupture	No	1993	(99.8)	5800	(99.3)	405	(98.1)	<0.001
	Yes	3	(0.2)	38	(0.7)	8	(1.9)	
Splenic rupture	No	1993	(99.8)	5789	(99.2)	404	(97.8)	<0.001
	Yes	3	(0.2)	49	(0.8)	9	(2.2)	
Spine fracture								
Cervical	No	1975	(98.9)	5616	(96.2)	401	(97.1)	<0.001
	Yes	21	(1.1)	222	(3.8)	12	(2.9)	
Thoracic	No	1968	(98.6)	5526	(94.7)	392	(94.9)	<0.001
	Yes	28	(1.4)	312	(5.3)	21	(5.1)	
Lumbar	No	1969	(98.6)	5510	(94.4)	382	(92.5)	<0.001
	Yes	27	(1.4)	328	(5.6)	31	(7.5)	
Pelvic ring fracture								
Overall	No	1987	(99.5)	5606	(96.0)	385	(93.2)	<0.001
	Yes	9	(0.5)	232	(4.0)	28	(6.8)	

* Chi-squared test for categorical data

2.07, 95% CI 1.52–2.81; p <0.001), comorbidity (OR 1.75, 95% CI 1.28–2.40; p = 0.001), number of surgical procedures (OR 1.76, 95% CI 1.36–2.28; p <0.001), complication perioperatively (OR 1.69, 95% CI 1.24–2.30; p = 0.001), infection (OR 2.66, 95% CI 1.57–4.49; p <0.001), concussion (OR 1.52, 95% CI 1.14–2.01; p = 0.004) and urinary tract infection (OR 2.34, 95% CI 1.61–3.41; p <0.001).

Discussion

Although some reports [4, 9–13] have focused on risk factors for monetary deficits according to DRGs from diverse departments in hospitals, very little is known about independent risk factors for shorter LOS and longer LOS outliers according to SwissDRG in a trauma department. The present study showed that outliers are relatively common in trauma patients. In our study, shorter LOS outliers were more frequent than longer LOS outliers (24.2 vs 5.0%). However, we identified three independent risk factors (death, concussion, and psychiatric disease) for shorter LOS outliers. On the other hand, there were eight independent risk factors (age ≥65 years, number of diagnoses ≥5, comorbidity, number of surgical procedures, complication perioperatively, infection, concussion and urinary tract infection) for longer LOS outliers.

A previous Portuguese study of 9,253,087 patients from diverse hospital departments found the proportion of longer LOS outliers to be 3.9%, and reported age, type of admission and hospital type to be significantly associated with longer LOS [10]. Our slightly higher proportion of 5.0% in a trauma department is, therefore, probably influenced by our teaching University Hospital status and cohort demographics [11].

In terms of costs, a previous study of 28,893 cases discharged from diverse departments of our hospital found psychiatric disease, admission as an emergency case and

Table 3: Extremity fractures according to the length of hospital stay (LOS) based on diagnosis related group (DRG) (n = 8247).

Variable	Category	LOS based on DRG	p-value*					
		Shorter LOS outlier (n = 1996)		Inlier (n = 5838)		Longer LOS outlier (n = 413)		
		n		(%)	n	(%)	n	(%)
Shoulder fracture								
Clavicle	No	1968	(98.6)	5508	(94.3)	397	(96.1)	<0.001
	Yes	28	(1.4)	330	(5.7)	16	(3.9)	
Scapula	No	1983	(99.3)	5727	(98.1)	405	(98.1)	0.001
	Yes	13	(0.7)	111	(1.9)	8	(1.9)	
Humerus	No	1974	(98.9)	5517	(94.5)	385	(93.2)	<0.001
	Yes	22	(1.1)	321	(5.5)	28	(6.8)	
Forearm fracture								
Radius	No	1919	(96.1)	5255	(90.0)	380	(92.0)	<0.001
	Yes	77	(3.9)	583	(10.0)	33	(8.0)	
Ulna	No	1966	(98.5)	5651	(96.8)	396	(95.9)	<0.001
	Yes	30	(1.5)	187	(3.2)	17	(4.1)	
Hand fracture								
Overall	No	1976	(99.0)	5721	(98.0)	394	(95.4)	<0.001
	Yes	20	(1.0)	117	(2.0)	19	(4.6)	
Femur fracture								
Neck	No	1991	(99.7)	5709	(97.8)	402	(97.3)	<0.001
	Yes	5	(0.3)	129	(2.2)	11	(2.7)	
Pertrochanteric	No	1982	(99.3)	5721	(98.0)	409	(99.0)	<0.001
	Yes	14	(0.7)	117	(2.0)	4	(1.0)	
Diaphysis	No	1970	(98.7)	5447	(93.3)	384	(93.0)	<0.001
	Yes	26	(1.3)	391	(6.7)	29	(7.0)	
Knee fracture								
Patella	No	1994	(99.9)	5780	(99.0)	404	(97.8)	<0.001
	Yes	2	(0.1)	58	(1.0)	9	(2.2)	
Tibia overall	No	1963	(98.3)	5566	(95.3)	376	(91.0)	<0.001
	Yes	33	(1.7)	272	(4.7)	37	(9.0)	
Fibula overall	No	1936	(97.0)	5355	(91.7)	364	(88.1)	<0.001
	Yes	60	(3.0)	483	(8.3)	49	(11.9)	
Ankle fracture								
Malleolus	No	1945	(97.4)	5470	(93.7)	384	(93.0)	<0.001
	Yes	51	(2.6)	368	(6.3)	29	(7.0)	
Foot fracture								
Overall	No	1963	(98.3)	5631	(96.5)	378	(91.5)	<0.001
	Yes	33	(1.7)	207	(3.5)	35	(8.5)	
Calcaneus	No	1987	(99.5)	5759	(98.6)	393	(95.2)	<0.001
	Yes	9	(0.5)	79	(1.4)	20	(4.8)	

* Chi-squared test for categorical data

admission from an external healthcare provider to be significant predictors for higher monetary deficits [12]. Regarding LOS, our study suggests that these results for monetary deficits may be in line with discharges from our trauma department, where psychiatric disease was an independent risk factor for shorter LOS outlier status [14]. A potential explanation is that these patients may have been transferred to a specialised psychiatric unit. However, since we used data from a routine database without opening individual patient charts, this cannot be answered for sure. Another study of 23,098 patients in the American College of Surgeon's National Surgical Quality Improvement Program (ACS NSQIP) found that the median LOS was 16.1 days in patients with complications compared with 5 days in patients without complications [1]. These results are backed up by our results, where complications perioperatively were an independent risk factor for longer LOS outlier status. Furthermore, concussion was not only a risk factor for shorter, but also for longer LOS. This may be explained by the fact that patients with mild concussions may have been discharged early, whereas those with severe concussion (or even additional diagnoses) may have been discharged late.

Aside from its retrospective nature, a limitation of our study is that the data for the identification of independent DRG-related risk factors were exclusively obtained from ICD codes instead of chart review. This may have occasionally led to misclassification of certain variables. However, coding is always done with care, not only because financial reimbursement relies on obtaining the most accurate information. The information about the lack of differences for ISS and NISS must be interpreted with caution. Both variables included many missing data and the number of patients analysed was low. This study included many variables as potential risk factors. Correlations between variables may exist. However, the goal of this study was to provide a first insight into the topic, and, by fitting regression models, ORs are always given in the reference category of all other variables. Future studies will be able to focus on fewer variables in more detail and/or further subcategories as well.

The introduction of DRGs and the modification from retro- to prospective payments has led to a shift in risks of monetary loss from insurers to healthcare providers, who are now forced to economise on treatment costs [2]. Shorter LOS outliers are usually accepted by hospitals as they are

Table 4: Concomitant diseases according to the length of hospital stay (LOS) based on diagnosis related group (DRG) (n = 8247).

Variable	Category	LOS based on DRG	p-value*					
		Shorter LOS outlier(n = 1996)		Inlier (n = 5838)		Longer LOS outlier (n = 413)		
		n		(%)	n	(%)	n	(%)
Psychiatric								
Overall	No	1687	(84.5)	4921	(84.3)	287	(69.5)	<0.001
	Yes	309	(15.5)	917	(15.7)	126	(30.5)	
Depression	No	1956	(98.0)	5647	(96.7)	379	(91.8)	<0.001
	Yes	40	(2.0)	191	(3.3)	34	(8.2)	
Dementia	No	1964	(98.4)	5754	(98.6)	397	(96.1)	0.001
	Yes	32	(1.6)	84	(1.4)	16	(3.9)	
Heart and vessels								
Coronary heart syndrome	No	1977	(99.0)	5706	(97.7)	404	(97.8)	0.001
	Yes	19	(1.0)	132	(2.3)	9	(2.2)	
Arterial hypertension	No	1819	(91.1)	4783	(81.9)	270	(65.4)	<0.001
	Yes	177	(8.9)	1055	(18.1)	143	(34.6)	
Arrhythmia	No	1938	(97.1)	5467	(93.6)	359	(86.9)	<0.001
	Yes	58	(2.9)	371	(6.4)	54	(13.1)	
Peripheral vascular disease	No	1985	(99.4)	5763	(98.7)	403	(97.6)	0.002
	Yes	11	(0.6)	75	(1.3)	10	(2.4)	
Lung								
Chronic lung disease	No	1976	(99.0)	5655	(96.9)	394	(95.4)	<0.001
	Yes	20	(1.0)	183	(3.1)	19	(4.6)	
Endocrine								
Thyroid disease	No	1974	(98.9)	5678	(97.3)	399	(96.6)	<0.001
	Yes	22	(1.1)	160	(2.7)	14	(3.4)	
Diabetes mellitus	No	1931	(96.7)	5515	(94.5)	374	(90.6)	<0.001
	Yes	65	(3.3)	323	(5.5)	39	(9.4)	
Osteoporosis	No	1981	(99.2)	5593	(95.8)	386	(96.5)	<0.001
	Yes	15	(0.8)	245	(4.2)	27	(6.5)	
Tumour								
Malignant	No	1963	(98.3)	5674	(97.2)	394	(95.4)	0.001
	Yes	33	(1.7)	164	(2.8)	19	(4.6)	
Infection								
Urinary tract	No	1985	(99.4)	5633	(96.5)	366	(88.6)	<0.001
	Yes	11	(0.6)	205	(3.5)	47	(11.4)	

*Chi-squared test for categorical data

still cost-covering, whereas longer LOS outliers are only reimbursed with a smaller than 50% rebate on average daily costs and usually lead to a financial deficit [2]. The results of our study could be helpful to hospitals and physicians since patients with risk factors for outlier status can be counselled and managed appropriately (of course, keeping in mind that providing the best patient care for each patient independent of monetary considerations is of utmost importance for each physician). Although physicians are aware that there are out- and inliers, the recommended LOS times are usually unknown. It seems important that regular training is implemented in the routine schedule of physicians to optimise costs for healthcare providers. An additional option is to integrate the optimal LOS in electronic chart systems in order to keep treating physicians up-to-date. Since LOS can be influenced by hospitals and patients alike, this may ultimately reduce costs for hospitals, insurers and patients. Future revisions of the DRG may also take this knowledge into consideration.

Table 5: Logistic regression model for factors associated with shorter LOS outliers regarding length of hospital stay (LOS) (n = 6250).

Variable	Adjusted OR*	(Adjusted 95% CI*)	p-value†
Age ≥65 years	0.87	(0.73–1.03)	0.113
Female gender	1.10	(0.97–1.25)	0.154
Number of diagnoses ≥5	0.87	(0.75–1.02)	0.093
Comorbidity	0.46	(0.38–0.56)	<0.001
Number of surgical procedures	0.55	(0.48–0.62)	<0.001
Complication perioperatively	0.58	(0.44–0.76)	<0.001
Infection	0.67	(0.27–1.63)	0.376
Death	4.89	(3.27–7.31)	<0.001
Concussion	4.87	(4.20–5.63)	<0.001
Fracture	0.86	(0.70–1.06)	0.148
Epidural haematoma	0.10	(0.02–0.43)	0.002
Subdural haematoma	0.29	(0.18–0.45)	<0.001
Subarachnoid haematoma	0.78	(0.51–1.18)	0.234
Multiple rib fractures	0.66	(0.46–0.94)	0.020
Pneumothorax	0.59	(0.34–1.02)	0.057
Liver rupture	0.65	(0.17–2.53)	0.535
Splenic rupture	0.50	(0.14–1.74)	0.275
Cervical spine fracture	0.34	(0.20–0.56)	<0.001
Thoracic spine fracture	0.46	(0.30–0.71)	<0.001
Lumbar spine fracture	0.35	(0.23–0.54)	<0.001
Pelvic ring fracture overall	0.20	(0.10–0.39)	<0.001
Clavicle fracture	0.20	(0.13–0.31)	<0.001
Scapula fracture	0.90	(0.43–1.87)	0.779
Humerus fracture	0.20	(0.13–0.32)	<0.001
Radius fracture	0.35	(0.27–0.46)	<0.001
Ulna fracture	0.69	(0.45–1.05)	0.084
Hand fracture overall	0.54	(0.31–0.95)	0.032
Femoral neck fracture	0.72	(0.22–2.41)	0.599
Pertrochanteric fracture	1.69	(0.63–4.52)	0.294
Diaphyseal femur fracture	0.21	(0.09–0.45)	<0.001
Patella fracture	0.11	(0.03–0.47)	0.003
Tibial fracture overall	0.49	(0.31–0.76)	0.002
Fibula fracture overall	0.62	(0.35–1.08)	0.091
Malleolar fracture	0.54	(0.30–0.97)	0.041
Foot fracture overall	0.56	(0.35–0.89)	0.014
Calcaneal fracture	0.89	(0.37–2.11)	0.790
Psychiatric disease overall	1.85	(1.46–2.34)	<0.001
Depression	0.62	(0.41–0.95)	0.027
Dementia	1.54	(0.91–2.60)	0.106
Coronary heart syndrome	0.96	(0.55–1.67)	0.879
Arterial hypertension	0.96	(0.75–1.22)	0.727
Arrhythmia	1.03	(0.72–1.46)	0.887
Peripheral vascular disease	1.22	(0.59–2.54)	0.596
Chronic lung disease	0.73	(0.43–1.24)	0.243
Thyroid disease	0.73	(0.44–1.21)	0.217
Diabetes mellitus	1.24	(0.90–1.73)	0.194
Osteoporosis	0.42	(0.24–0.74)	0.003
Malignant tumour	1.28	(0.84–1.95)	0.245
Urinary tract infection	0.31	(0.16–0.61)	0.001

OR = odds ratio; CI = confidence interval * Adjusted for all variables shown in the table given in the reference category of all other variables † Wald test

Conclusion

Our study showed that outliers, especially shorter LOS outliers, are relatively common. There were several predictors for outliers. Patients who died, or had concussion or psychiatric disease were more commonly discharged early. Patients were more often discharged latedischarged late if they were aged ≥65 years, had more diagnoses, were comorbid, had more surgical procedures, complications perioperatively, infection, concussion and urinary tract infection. For hospitals, this can help raise awareness and lead to better management of specific diagnoses in order to avoid monetary deficits. For the public health sector, this information may be considered in future revisions of the DRG.

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Table 6: Logistic regression model for factors associated with longer LOS outliers regarding length of hospital stay (LOS) (n = 6250).

Variable	Adjusted OR*	(Adjusted 95% CI*)	p-value†
Age ≥65 years	1.74	(1.31–2.30)	<0.001
Female gender	1.08	(0.85–1.37)	0.516
Number of diagnoses ≥5	2.07	(1.52–2.81)	<0.001
Comorbidity	1.75	(1.28–2.40)	0.001
Number of surgical procedures	1.76	(1.36–2.28)	<0.001
Complication perioperatively	1.69	(1.24–2.30)	0.001
Infection	2.66	(1.57–4.49)	<0.001
Death	0.32	(0.12–0.82)	0.017
Concussion	1.52	(1.14–2.01)	0.004
Fracture	1.04	(0.73–1.47)	0.837
Epidural haematoma	0.61	(0.21–1.75)	0.358
Subdural haematoma	0.47	(0.27–0.80)	0.006
Subarachnoid haematoma	0.66	(0.37–1.17)	0.157
Multiple rib fractures	0.72	(0.46–1.14)	0.161
Pneumothorax	1.00	(0.55–1.82)	0.988
Liver rupture	1.81	(0.70–4.68)	0.223
Splenic rupture	1.51	(0.64–3.51)	0.344
Cervical spine fracture	0.42	(0.22–0.79)	0.007
Thoracic spine fracture	0.76	(0.46–1.25)	0.278
Lumbar spine fracture	0.86	(0.54–1.35)	0.505
Pelvic ring fracture overall	1.15	(0.73–1.81)	0.539
Clavicle fracture	1.05	(0.60–1.84)	0.871
Scapula fracture	0.92	(0.40–2.11)	0.847
Humeral fracture	0.94	(0.60–1.45)	0.767
Radius fracture	0.88	(0.58–1.33)	0.542
Ulna fracture	1.29	(0.72–2.33)	0.391
Hand fracture overall	1.91	(1.11–3.31)	0.020
Femoral neck fracture	1.06	(0.44–2.59)	0.894
Pertrochanteric fracture	0.39	(0.12–1.32)	0.130
Diaphyseal femur fracture	0.64	(0.34–1.19)	0.156
Patella fracture	1.83	(0.82–4.09)	0.138
Tibial fracture overall	1.79	(1.05–3.05)	0.033
Fibula fracture overall	1.10	(0.60–2.03)	0.757
Malleolar fracture	1.24	(0.63–2.43)	0.532
Foot fracture overall	1.84	(0.98–3.44)	0.057
Calcaneal fracture	1.66	(0.74–3.72)	0.218
Psychiatric disease overall	1.11	(0.80–1.52)	0.533
Depression	1.55	(0.98–2.46)	0.062
Dementia	1.37	(0.73–2.58)	0.327
Coronary heart syndrome	0.53	(0.26–1.09)	0.085
Arterial hypertension	1.21	(0.91–1.60)	0.187
Arrhythmia	1.08	(0.76–1.53)	0.685
Peripheral vascular disease	0.98	(0.47–2.03)	0.960
Chronic lung disease	0.83	(0.49–1.40)	0.486
Thyroid disease	0.75	(0.42–1.35)	0.336
Diabetes mellitus	0.96	(0.65–1.41)	0.836
Osteoporosis	0.84	(0.54–1.32)	0.448
Malignant tumour	0.93	(0.55–1.56)	0.782
Urinary tract infection	2.34	(1.61–3.41)	<0.001

OR = odds ratio; CI = confidence interval * Adjusted for all variables shown in the table given in the reference category of all other variables † Wald test

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