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Effects of the Austrian performance-oriented inpatient reimbursement system on treatment patterns: illustrated on cases with knee-joint problems

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Abstract This paper analyzes changes in the treatment patterns of inpatients due to the effects of the new Austrian performance-oriented inpatient payment system (LKF-system) introduced in 1997. The primary variables of interest are the inpatients' length of stay (LOS) and the associated reimbursement points (LKF-points). We applied regression models to investigate treatment patterns of inpatients with knee-joint problems in Austria between 2002 and 2006. For both non-surgical and surgical groups, the number of cases increased. We revealed the Federal State-specific reimbursement features together with Federal State-specific Big Ticket technologies such as magnetic resonance imaging (MRI) and the age of the inpatients as the main influencing factors on average LOS and average LKF-points. The average LOS decreased for surgical groups and also resulted in a decline in the average LKF-points from 2002 to 2006, while for the non-surgical group both average LOS and average LKF-points slightly decreased from 2003 to 2006.

Keywords Austria · Regression models · Hospital · Knee-joint problems · Performance-oriented reimbursement system for inpatients

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1 Introduction and literature review

Since the 1980s, the conjunction of demographic, technological, and financial pressures led to a worldwide increase in hospital costs and public financial shortages (cf. Saltman and Figueras 1998). The inevitable health care reforms concentrate on cost reduction and cost containment (cf. European Commission 2008; Klauber et al. 2008; Leidl 1998). Further governmental ambitions aim at greater efficiency and effectiveness in hospital performance with consistent health care quality by enforcing rationalization, application of new technologies, and appropriate management activities (cf. Wolf-Ostermann et al. 2002; Greiling 2000).

Originally developed in the US (cf. Fetter 1991), case-based reimbursement systems on basis of Diagnosis-Related Groups (DRGs) have been regarded the most successful allocation approach and have become the prevailing payment strategy for non-private inpatients (cf. European Commission 2008; Klauber et al. 2008; Leidl 1998; Schwartz et al. 1996). Hereby, hospitals are refunded on a per-case basis depending on diagnoses and treatments to enforce cost awareness and subsequently an economical use of financial means.

For hospitals, however, such performance-oriented reimbursement systems still imply some counterproductive incentives to avoid saving targets and to exploit maximization loop holes (cf. Schaffhauser-Linzatti and Rauner 2008; Hofmarcher et al. 2005; Leonard et al. 2003; Sommersguter-Reichmann and Stepan 1999). Such incentives are characterized by principal-agent relations (cf. Smith et al. 1997) and have been proven by numerous studies (cf. Fuloria and Zenios 2001; Feldstein 1993; Zakoworotny 1993; Donaldson and Magnussen 1992; Fetter 1991; Neubauer and Demmler 1991).

Only knowledge and understanding of these incentives can help develop appropriate control and steering mechanisms (cf. Eichhorn et al. 2000) to precociously counteract adverse hospitals' optimizing strategies (cf. Obst 2005; Röder et al. 2001; Palley and Conger 1995; Walker 1994; Neubauer et al. 1987) and may further help investigate the effects of the Austrian reimbursement system on inpatient treatment. Such optimization strategies comprise (1) bureaucratic systems, (2) performance, (3) quantity, and (4) time structure which are closely related and cannot be separately examined (cf. Schaffhauser-Linzatti and Rauner 2008).

1. Bureaucratic, i.e., system-inherent optimization strategies first subsume DRG-creep via up-coding (cf. Vaul 1998; Hsia et al. 1992). Hereby, hospitals increase their incomes by allocating inpatients to more expensive than the adequate cheaper case groups and consequently change the income-effective case-mix of inpatients (cf. Rauner 2007). A further documentation practice comprises DRG-point gathering by conducting additionally funded, but medically unconditional performances, exploiting specific extra-paid regulations such as for intensive care units; but also down-coding and non-coding (cf. Röder et al. 2003). Possibilities to reveal such optimizing strategies are the application of anti-optimizing software to at least neutralize the hospitals' optimization software (cf. Diemer 2006; Güntert 2005; Finkenzeller 2004; Nüßle and Damian 2004; Rauner and Schaffhauser-Linzatti 2002; Latta and Helbing 1991) or the employment of specially trained staff for quality assurance (cf. Hielscher 2006; Röder et al. 2004).

2. Performance optimization strategies induce hospitals to reposition their range of services such as treatments, surgeries, or technical equipments, mainly by a change in case mix, staff, and work load (cf. Fleßa 2007; Kuntz et al. 2007; Seelos 2007; Beck 2006; Selbmann 2005; Stepan 1985). Among others, the maximization of the contribution margin leads to cream-skimming or patient-dumping, i.e., to a concentration on profitable groups of inpatients. Hospitals that conduct unbundling shift expensive treatments which could be performed in house to other health care institutions (cf. Feldstein 1993). These strategies lead to concerns that health care quality might deteriorate, however, they are difficult to detect (cf. Breyer et al. 2005; Knüppel 2003; Schmelzer and Klask 1996). Counter strategies of policy makers include a comprehensive, however, medically restricting standardization of treatment patterns and single treatments by DRGs to support process orientation of hospitals (cf. Kuntz and Vera 2007; Ernst et al. 2004).
3. Quantity optimization strategies tightly follow performance-related optimization strategies by reducing or enlarging the number of inpatient cases and hospitals' capacities. Such reductions indeed cut costs for single hospitals in the short run, however, displace them to other health care institutions, mainly to the extramural sector. This downsizing strategy requires accompanying measures which may not be provided sufficiently and which do not necessarily lead to a reduction of the total costs within the overall health care system (cf. Knorr and Krämer 2006; Kuntz and Scholtes 2000; Asmuth et al. 1997). Corresponding enlargements target income increases. A popular, but empirically not often analyzed strategy (cf. Engelke and Fricke 2003; Rauner et al. 2003; Wray et al. 1999) is the revolving-door effect by which inpatients are prematurely discharged and readmitted in order to account for them again.
4. Time structure optimization strategies directly refer to the length of stay (LOS) of inpatients. When performance-oriented reimbursement financing models are introduced, multiple studies prove that the LOS is reduced (cf. Rauner 2007; Theurl and Winner 2005) in order to optimize income according to the incentives implied in the allocation schemes. This one-time effect, however, faces higher admission and readmission rates (cf. Rauner and Schaffhauser-Linzatti 2002; Westphal 1996; Knüppel 2003; Menke et al. 1998) and does not necessarily induce cost reductions (cf. Krusch et al. 2006; Ashby et al. 2000; Taheri et al. 2000). Further, shorter LOS need not increase the quality of treatment. They tend to reduce complications (cf. Thomas et al. 1997), however, enforce problems of after treatment, mainly for elderly and multimorbid inpatients, increase the severity of inpatients and the burden of the staff (cf. Selbmann 2005; Knüppel 2003; Crane 2001). The discussion can be summarized as follows: "LOS [Lenght Of Stay] … seems as just one piece of a large pie (cf. Lippman 2000: 38)."

In 1997, Austria introduced a performance-oriented inpatient payment system (Leistungsorientierte Krankenhausfinanzierung, LKF). Literature prove (cf. Rauner and Schaffhauser-Linzatti 2001, 2002) that Austrian hospitals have already exploited the incentives implied under the new regime and indeed, the cost increase could be reduced from 10 to 2–4% each year (cf. Federal Ministry of Health, Women, and

Youth 2006) and the LOS steadily decreased from about 10 days in 1996 to 7.5 days in 2003 (cf. Theurl and Winner 2005).

For example, Sommersguter-Reichmann (2003) found that the hospital's pure technical efficiency did not really enhance for their sample of 22 hospitals in on particular Federal State in the early period from 1997 to 1999 after the introduction of the LKF-system. They used data envelopment analysis (DEA) over time applying the Malmquist productivity index (MPI). However, a positive technology shift could be found between 1996 and 1998 (cf. Sommersguter-Reichmann 2000).

Hofmarcher et al. (2005) analyzed 42 low-profile acute care hospitals from 1997 to 2000 using DEA techniques. They disclosed an increase in LKF-points (about 2%), patient-days, and number cases (about 10%) along with a decrease in average LOS per case (from 7.3 to 6.7 days). In 2000, the efficiency scores for the outputs ranged from 80 to 90%, indicating that in both settings 10–20% of the inputs could be saved, respectively.

Rauner et al. (2005) showed that fixed budgets outperformed variables budgets for optimal allocation of both budgets and inpatients with different treatments among hospitals within a geographic region such as Vienna. The objective was to maximize the overall quality of treatment provided by the regional hospitals. They found that one hospital could be merged to a nearby hospital and the other could be closed which was planned to be transformed to a nursing home.

Two studies in the past investigated the effect of the LKF-system on the LOS of Austrian inpatients with data from 1998. First, Leonard et al. (2003) compared LOS differences in Austria compared to Canada due to the inpatient reimbursement system. For all six clinical categories analyzed, they revealed that a case-based system was highly associated with a longer LOS compared to a global budgeting approach such as in Canada. Discharge day patterns were also found to be different in the two countries. Using generalized linear models for major diagnoses, Rauner et al. (2003) proved significant interdependencies among day and month of admission as well as types of admission and discharges on the LOS. They disclosed "unbundling" and "patient splitting" effects.

Although the effects of the reimbursement system on the LOS have been studied in Austria in past, only a limited number of independent variables was incorporated. We add to the literature by considering the following independent variables: *years* (2002–2006), *infrastructure*, *patient characteristics* (e.g., age, gender), *patient treatment* (e.g., Federal State), *reimbursement* (e.g., surgical versus non-surgical groups), and *number of cases* (e.g., number of cases, proportion of inpatients treated from other Federal States, proportion of foreign inpatients). We also investigate the influence of these independent variables on LOS and the average reimbursement per case, i.e., average LKF-points per inpatient. Especially the incorporation of the Federal State as well as different surgical and non-surgical groups for one diagnosis is unique in our longitudinal study. In the past, it was only stated that due to the slightly different reimbursement variants in the Federal States, there might be different treatment patterns and LOS in the Federal States (cf. Rauner and Schaffhauser-Linzatti 1999; Hofmarcher and Riedel 2001), but this was not illustrated on an example in the literature. We have chosen knee-joint problems as illustrative example for our study due to high demographic, technological, and financial pressures on the related treatment patterns.

Mechanical knee symptoms are caused by primary traumatic damages and chronic, non-traumatic, degenerative lesions each (cf. Özalay et al. 2005). While traumatic knee lesions such as menisci, ligamenta, and cartilage were mostly found for younger inpatients after sport accidents (e.g., ski, snowboard, soccer, or inlineskating), chronic knee symptoms are often caused by bone deficits (e.g., osteoporosis, reduction of cartilage, old tear of meniscus or ligamentum tear of elderly inpatients which steadily increase in number due to increased life expectancy). This is why, we analyze the age-effect in our regression models.

The treatment (e.g., diagnostic methods, management and therapeutic techniques) underwent a paradigm shift (cf. Solomon et al. 2003). Non-invasive diagnosis methods changed from conventional X-Ray over Computer Tomography (CT), spiral CT to musculoskeletal Magnetic Resonance Imaging (MRI); invasive diagnostic techniques and surgery such as spiral-CT arthrography (CTA) or MRI-arthrography or arthroscopy have become standard worldwide (cf. Gold et al. 2007; Makdissi et al. 2006; Vande Berg et al. 2002; Aubel et al. 1992). They have significantly reduced LOS or can even be performed on an outpatient basis nowadays. Therefore, both treatment and diffusion effects of diagnostic techniques have to be investigated too.

The paper is structured as follows. Section 2 sketches the Austrian performance-oriented reimbursement system for inpatients. The knowledge of its underlying national framework as well as its specifications in each of the nine Federal States is a precondition to understand the design of the study and the applied statistical modeling methodology in Sect. 3. The results of the quantitative analysis and their consequences are illustrated in the following Sect. 4. The paper concludes with providing health care decision makers with generalized policy implications that are derived from the experience with knee-joint problems. We finally refer to issues for further research.

2 The Austrian performance-oriented reimbursement system for inpatients

As one of the wealthiest countries worldwide, Austria's excellent health care and social system comprises about 98% of all citizens (cf. Hofmacher and Rack 2006) and is based on compulsory insurance, self-administration, and public co-financing.

Although three quarters of the Austrians appreciate the public health care system compared to 54% within the European Commission (EC), systems changes are indispensable as health care costs increase more rapidly than total economy (cf. Probst 2000). Further, Austria does not only expend more than other EC countries for its health care system, it also has one of the highest inpatient care bed densities in the EC due to internationally high admission rates and LOS (cf. European Commission 2008; Czypionka et al. 2007; Hofmacher et al. 2005; Narath 1994). About 75% of the bed capacity and 85% of all hospital employees are provided by publicly funded hospitals (cf. Hofmarcher et al. 2002). The following presentation refers to fund hospitals financed by the LKF-system including public hospitals and non-profit private hospitals.

Under the former payment strategy without financial limits of the overall budget, the hospitals were funded a performance-independent, fixed lump sum per inpatient per day (cf. Neubauer and Demmler 1991) which resulted in increased LOS, capacity enlargements, and finally in increasing cost structures. This strategy was replaced by the LKF-System (cf. Federal Ministry of Health, Women, and Youth 2006) which introduced a performance-oriented reimbursement based on diagnoses and treatments. It hereby standardizes and documents treatment patterns and performance catalogues for all inpatients to keep Austria's high level of health care quality. The incentives targeted by the LKF-system comprise a reduction of inpatient admissions in favor of day hospital and outpatient treatment, inpatients' LOS, intensive care beds, and cost increases as well as enhancement of internal efficiency and effectiveness improvements. They have proven to step to the desired direction since its introduction in 1997 (cf. Leonard et al. 2003; Rauner et al. 2003; Rauner and Schaffhauser-Linzatti 1999, 2001, 2002). Notwithstanding, the always demanded, accompanying requirements such as the inclusion of ambulances and the extramural sector including after treatment have not been fully realized to balance the multiple demands (cf. Fried 2006; Güntert et al. 2005; Österle and Zechmeister 2004).

The fund hospitals are mainly regulated by federal law and executed provincially. Its dualistic funding is provided on the one hand publicly by the state (about 18%), the nine Federal States (about 4%), and municipalities (about 2%), on the other hand by private, non-profit organizations such as orders (about 4%) and mainly by the social insurance agencies (about 72%) which again are remunerated by dues of the employees and employers (cf. European Commission 2008; Federal Ministry of Health, Women, and Youth 2006). According to fixed shares the financial means are distributed to specialized funds of each Federal State and further to the hospitals in each Federal State. The majority of the means is spent for LKF-related rewards (about 86%) but also for structural achievements and investment grants (about 5%) and for other legally defined expenditures (about 9%) (cf. European Commission 2008; Federal Ministry of Health, Women, and Youth 2006; Hofmacher and Rack 2006; Walter 2005; Zechmeister et al. 2002; Probst 2000). The LKF-related payments are based on standardized LDF-points which were calculated on basis of 20 reference hospitals using regression tree methodologies and underlie regular revisions; substantial changes were introduced in 2002, mainly by implementing the day clinics model (cf. Schaffhauser-Linzatti and Rauner 2008; Rauner 2007). The LDF-points are determined by the so-called (1) core part and (2) regulation part of the LKF-system and are allocated to the performing hospital per diagnosis and treatment. The monetary value per point depends on the overall limited budget for a Federal State, on the total number of points gathered within the core part, and on the specific determinations of the regulation part.

2.1 The core part of the LKF-system

The core part is uniformly regulated for all hospitals. Within the core part, nearly all inpatients (exceptions include, f.e., asylum cases, semi-stationary patients, stroke, or child and youth neuropsychiatry) are allocated to cost-homogenous diagnosis-related Leistungsorientierten Diagnose-Fallgruppen (LDF-groups) which consist of either Hauptdiagnose-Gruppen (HDG groups) according to the International Classification of Diseases (ICD) Codes or Medizinische Einzelleistungs-Gruppen (MEL-groups) including single medical treatments. They may be again split into subgroups, such as according to age or gender. Each LDF-group is granted LKF-points which are compound of a treatment component reflecting direct medical treatment, and a day component depending on the length of stay, and indirect medical costs such as care. Specific regulations referring to 0-day patients and intensive care patients have not been introduced from the very beginning of the LKF-implementation and are now particular subject to hospitals' strategic considerations to maximize LDF-points (cf. Schaffhauser-Linzatti and Rauner 2008; Rauner 2007; Rauner and Schaffhauser-Linzatti 1999, 2001; Rauner et al. 2003).

2.2 The regulation part of the LKF-system

The regulation part of the LKF-system is individually designed by each Federal State and permits the recognition of region-specific supply side factors as well as of the structural quality of the hospital expressed by type of hospital, equipment, utilization, structure of the buildings, personnel, and/or hotel component. The regulation part underlies marginal adaptations each year (cf. Schaffhauser-Linzatti and Rauner 2008; Rauner 2007; Hofmacher and Rack 2006; Hofmarcher and Riedel 2001; Rauner and Schaffhauser-Linzatti 1999; Dienesch and Heitzenberger 1998). In the Federal States of Burgenland and Tyrol, the core part of the LKF-system is weighted by 70% and the regulation part by 30% of the total means, in Salzburg by 63.5 and 36.5%, respectively, in Upper Austria the core part accounts for 100%. Lower Austria assigns 2.7% of the total budget by a declining ratio of the collected maximum points. Carinthia, Vorarlberg, Styria, and Vienna do not separate the core and the regulation parts, but calculate different mixed-coefficient multipliers for each LDF-point (cf. Rauner 2007). For example, Vienna incorporates both the number of beds and staff. Additional to the LKF-based payments, all hospital owners can contribute further means for investment and deficit coverage (cf. Schaffhauser-Linzatti and Rauner 2008; Rauner 2007; Rauner et al. 2003).

These inconsistent regulations lead to nine different reimbursement structures among the Federal States. Consequently, one and the same medical treatment performed in Austria within the uniform LKF-system is charged differently which induces different incentives for profit maximization strategies in each Federal State (cf. Schaffhauser-Linzatti and Rauner 2008; Rauner 2007; Rauner et al. 2003).

3 Methodology

The main research questions of this paper investigate whether inpatients' LOS and the corresponding LKF-points depend on inpatients' characteristics, hospitals' infrastructure, and inherent LKF-system structures. We structure the following key variables that drive hospitals' reimbursement within six main categories: (1) year of observation, (2) infrastructure, (3) patient characteristics, (4) patient treatment, (5) reimbursement, (6) cases; the data were provided by the Federal Ministry of Health, Family, and Youth.

3.1 Year of observation (variable *year*)

To analyze longitudinal effects, the sample comprises five years from 2002 until 2006. The inpatients' documentation before the introduction of the LKF-system was not detailed enough for any comparison to years before 1997. Structural changes in 2002 do not allow for tracing inpatients' cases back either, as in this year the LKF-model was fundamentally revised due to new regression tree allocations of inpatients' groups and corresponding LDF-point assignments, the implementation of the ICD 10 instead of the ICD 9 classification, and the currency conversion from Austrian Schillings to Euro.

3.2 Infrastructure

The average number of MRIs per case per year in each Federal State represents the most influencing infrastructural instrument for knee diagnosis (variable *mri*).

3.3 Patient characteristics

All inpatients are characterized by gender (variable *gender*) and group of age (variable *age*) which is split into the subgroups 0–14, 15–29, 30–44, 45–59, 60–74, and 75+ years.

3.4 Patient treatment

First, the Federal State in which the performing hospital is located and which need not be identical with the residence of the patient enters into the model. The variable *federal state* represents the hospitals in the nine Federal States of *Burgenland, Carinthia, Lower Austria, Salzburg*, *Styria, Tyrol, Upper Austria, Vienna,* and *Vorarlberg*. Second, the LOS of each inpatient (variable *los*) is included.

3.5 Reimbursement

The reimbursement of each hospital is traced by the LOS (variable *los*) and the total LKF-points reimbursed per patient (variable *lkf*). As we analyze the comprehensive clinical pattern of knee-joint problems, the non-surgical HDG-group 15.05 and all surgical MEL-groups are regarded. These groups comprise all subgroups MEL14.09, MEL14.10, and all knee-joint related subgroups of HDG15.05, and all knee-joint related subgroups of MEL14.12, MEL14.13, MEL14.14, MEL14.16, MEL14.20, MEL14.21, and MEL14.26. As some of these subgroups are rather small and in order to obtain reliable results, we only consider those groups with at least 1,000 cases, i.e., HDG15.05, MEL14.14 (traditional surgeries), and MEL14.21 (arthroscopic surgeries) into the calculations.

3.6 Cases

The total number of cases (variable *cases*) is split into the proportion of Austrian inpatients who are treated in a different Federal State than their residences (variable *non-federal state patients*) and the proportion of non-Austrian inpatients (variable *foreign patients*). The primary variables of interest are the (expected) LOS and the associated reimbursed LKF-points per inpatient. To gain more detailed insight into the factors driving these variables, we consider data not only stratified by *year* and case structure (*foreign patients* and *non-federal state patients*), but additionally by *gender, age*, *federal state, and mri*. For modeling LOS (variable $tlos_i$), a semi-logarithmic linear regression model is employed:

$$tlos_i = \log\left(\frac{los_i}{cases_i} + 0.5\right) = x_i^T \beta + \varepsilon_i, \tag{1}$$

where T denotes transposition and the regressor x_i comprises all available covariates: auxiliary variables for *federal state* (reference group: Vienna), *age* (reference group: 0–14), and *gender* (reference group: male), as well as the numeric variables *years* (reference group: 2002), *foreign patients*, *non-federal state patients*, and *mri*. A continuity correction is applied in the log-transformation of the response because some observations i have an observed average LOS of zero. Separate models are fitted to the three LDF-groups (one HDG-group and two MEL-groups), estimating the vector of regression coefficients β via weighted least squares (WLS) because the variance of the disturbance term ε_i is proportional to $1/cases_i$.

For understanding the relationship between LOS and LKF-points, a very similar approach is employed. A linear regression model, again estimated by WLS, is fitted to the logarithm of the average LKF-points (variable $tlkf_i$):

$$tlkf_i = \log\left(\frac{lkf_i}{cases_i}\right). \tag{2}$$

All regressors from the LOS model above are also used for modeling $tlkf_i$, and they are complemented by log-transformed average $tlos_i$. To account for heterogeneity in the reimbursement for different Federal States, different slopes with respect to $tlos_i$ are fitted in the linear regression models.

All computations have been carried out in the R system for statistical computing, version 2.8.0 (cf. R Development Core Team 2008), using packages sandwich and lmtest (cf. Kleiber and Zeileis 2008).

4 Results

The paper reveals whether inpatients' LOS and reimbursed LKF-points are influenced by main independent variables defined within the following six categories discussed before: (1) year of observation, (2) infrastructure, (3) patient characteristics, (4) patient treatment, (5) reimbursement, and (6) cases.

First, Table 1 displays the general results of the descriptive statistics including number of cases, average LOS, and average LKF-points. For both non-surgical group HDG15.05 and surgical groups MEL14.14 and MEL14.21, the number of cases increased. The average LOS increased for HDG15.05 and also resulted in an increase in the average LKF-points from 2002 to 2006 (however, both LOS and LKF-points slightly decreased from 2003 to 2006), while for MEL14.14 and MEL14.21 both average LOS and average LKF-points slightly decreased over the years. The number of arthroscopic surgeries (MEL14.21) rose about 2.7 percent points more compared to traditional surgeries (MEL14.14), whereas traditional surgeries were performed about 21 times more compared to arthroscopic surgeries. This effect might be explained by the replacement of traditional by arthroscopic surgeries in the last years.

Table 1 Descriptive statistics for Austrian knee-joint inpatients from 2002 to 2006

Non-surgical/surgical group	Outcome	Years				
		2002	2003	2004	2005	2006
HDG15.05	Number of cases	1,456	1,457	1,498	1,435	1,568
	Average LOS	5.71	7.37	6.98	6.95	7.22
	Average LKF-points	840.91	993.02	961.8	972.44	957.78
MEL14.14	Number of cases	1,548	1,652	1,575	1,704	1,670
	Average LOS	5.51	5.17	5.02	4.83	4.77
	Average LKF-points	3,408.14	3,375.46	3,373.22	3,302.29	3,281.74
MEL14.21	Number of cases	21,687	23,459	24,004	24,032	23,975
	Average LOS	3.08	2.95	2.83	2.75	2.67
	Average LKF-points	1,619.23	1,613.81	1,601.06	1,587.23	1,583.13

Next, we investigate in detail the dependence of LOS and LKF-points on the independent explanatory variables for the non-surgical group and the two surgical groups during the period of 2002 to 2006. Table 2 reports the main results of our semi-logistic regression models along with sandwich standard errors (in brackets) to account for potential cross-sectional heterogeneity. It is structured according to the calculations of *tlos*, which has been defined as the log of average LOS with continuity correction, and *tlkf*, which has been defined as the log of average LKF-points per case as described in SubSect. 3.3. Also, the R^2 is provided for each regression, i.e., the proportion of the variance explained by the model (0.56–0.97). One, two, or three stars convey significance of the coefficients at 0.05, 0.01, and 0.001 levels, respectively.

We revealed the Federal State-specific reimbursement features and the age of the patients as the main influencing factors on average LOS and average LKF-points. One might disclose some indirect effect of Big Ticket technologies such as MRI in the rate of non-Federal State patients for the non-surgical group HDG15.05 (0.001 significance level). However, for the arthroscopic surgical group MEL14.21 with nearly 24,000 cases in 2006, we found minor direct effect (0.05 significance level).

In the following, we explain in more detail the differences among the non-surgical HDG-group and the two surgical MEL-groups.

4.1 HDG15.05

The regression results in Table 2 show that most of the variation in LOS (i.e., variable *tlos*) was explained by differences with respect to *age* of the inpatients and *federal state*

Table 2 Results of the regression models investigating the effect on the expected LOS (*tlos*) and on expected LKF-points (*tlkf*) for Austrian knee-joint inpatients from 2002 to 2006

	Dependent variable: *tlos*			Dependent variable: *tlkf*		
	HDG15.05	MEL14.14	MEL14.21	HDG15.05	MEL14.14	MEL14.21
(Intercept)	−0.714 (0.453)	1.753*** (0.161)	1.100*** (0.084)	5.664*** (0.121)	7.822*** (0.074)	7.063*** (0.032)
Years	0.005 (0.013)	−0.029*** (0.004)	−0.032*** (0.002)	−0.007 (0.004)	−0.006*** (0.001)	0.000 (0.001)
Gender (female)	0.067 (0.035)	−0.011 (0.011)	0.085*** (0.005)	0.024* (0.010)	−0.003 (0.003)	−0.004** (0.001)
Age (15–19)	0.713*** (0.124)	0.027 (0.035)	−0.022 (0.031)	−0.123*** (0.033)	−0.036 (0.024)	0.002 (0.009)
Age (30–44)	1.041*** (0.122)	0.032 (0.035)	−0.059 (0.030)	−0.152*** (0.034)	−0.031 (0.024)	0.004 (0.009)
Age (45–59)	1.039*** (0.120)	0.002 (0.039)	0.023 (0.030)	−0.144*** (0.034)	−0.021 (0.025)	0.005 (0.009)
Age (60–74)	1.079*** (0.120)	−0.127* (0.053)	0.119*** (0.030)	0.161*** (0.037)	0.013 (0.025)	0.005 (0.009)
Age (75+)	1.393*** (0.129)	−0.140 (0.108)	0.342*** (0.032)	0.663*** (0.035)	0.026 (0.029)	0.003 (0.010)
Federal state (Burgenland)	0.433* (0.208)	0.357*** (0.062)	0.074* (0.030)	−0.033 (0.076)	0.145 (0.081)	0.066 (0.039)
Federal state (Carinthia)	1.044*** (0.169)	0.348*** (0.068)	0.261*** (0.034)	−0.048 (0.063)	−0.013 (0.134)	−0.057 (0.038)
Federal state (Lower Austria)	0.918*** (0.138)	0.075 (0.048)	−0.093*** (0.025)	−0.172* (0.076)	0.056 (0.076)	0.048* (0.024)
Federal state (Upper Austria)	1.347*** (0.225)	0.022 (0.082)	0.076 (0.042)	−0.218* (0.106)	0.099 (0.066)	0.073** (0.025)
Federal state (Salzburg)	1.037*** (0.255)	0.080 (0.089)	0.085 (0.044)	−0.025 (0.099)	0.051 (0.081)	−0.018 (0.025)
Federal state (Styria)	1.143*** (0.064)	0.210*** (0.024)	0.261*** (0.021)	−0.127* (0.063)	0.159 (0.109)	0.043 (0.030)
Federal state (Tyrol)	0.587** (0.206)	0.002 (0.069)	−0.109** (0.035)	0.179** (0.068)	0.104 (0.077)	0.096*** (0.024)
Federal state (Vorarlberg)	0.688*** (0.200)	0.107 (0.072)	−0.145*** (0.038)	0.132 (0.081)	0.013 (0.087)	0.031 (0.024)
Foreign patients (%)	−0.009 (0.005)	−0.001 (0.001)	0.002 (0.003)	0.002 (0.001)	−0.001* (0.000)	0.000 (0.001)
Non-federal state patients (%)	0.018*** (0.002)	−0.001 (0.001)	0.000 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
mri per case (×1,000)	0.108 (0.222)	−0.050 (0.078)	0.016 (0.037)	0.029 (0.056)	0.017 (0.021)	0.019* (0.009)
tlos				0.579*** (0.031)	0.165*** (0.032)	0.257*** (0.018)

Table 2 Continued

	Dependent variable: *tlos*			Dependent variable: *tlkf*		
	HDG15.05	MEL14.14	MEL14.21	HDG15.05	MEL14.14	MEL14.21
Federal state (Burgenland):tlos				0.003 (0.044)	−0.082 (0.045)	−0.092** (0.032)
Federal state (Carinthia):tlos				0.040 (0.041)	0.029 (0.070)	0.013 (0.028)
Federal state (Lower Austria):tlos				0.058 (0.045)	−0.022 (0.044)	−0.074***(0.019)
Federal state (Upper Austria):tlos				0.104* (0.046)	−0.027 (0.037)	−0.086***(0.018)
Federal state (Salzburg):tlos				0.033 (0.047)	−0.008 (0.046)	−0.027 (0.017)
Federal state (Styria):tlos				0.038 (0.043)	−0.057 (0.062)	−0.062** (0.023)
Federal state (Tyrol):tlos				−0.094* (0.043)	−0.042 (0.044)	−0.107***(0.018)
Federal state (Vorarlberg):tlos				−0.033 (0.057)	0.002 (0.049)	−0.048** (0.018)
R^2	0.697	0.558	0.920	0.965	0.616	0.933

of the hospital where the inpatients have been treated. Their influence in the regression can also be brought out by marginal visualizations as in Figs. 1 and 2, respectively. The remaining variables had only little (and mostly non-significant) influence: There was a tiny increase in expected LOS by about 0.5% per year and the expected LOS for female patients is about 6.7% higher than for male patients.

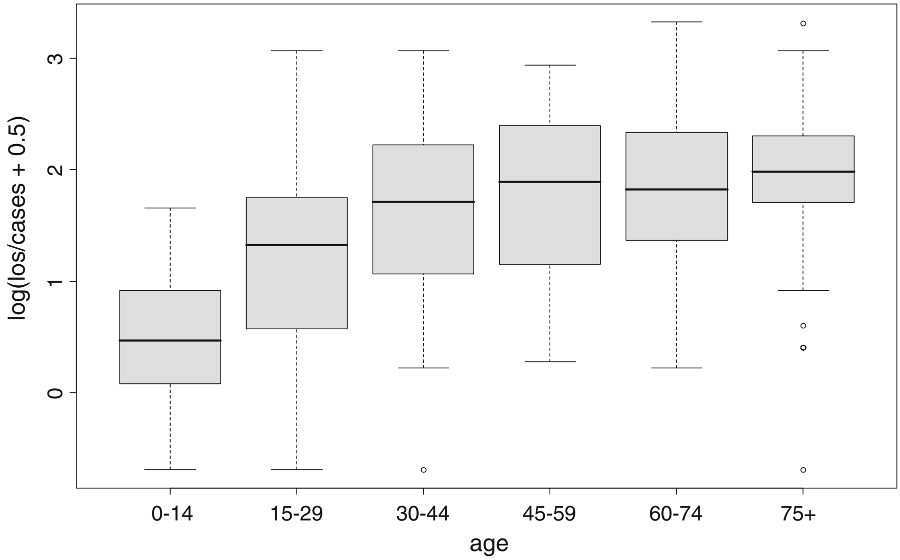

Fig. 1 The influence of age on the average LOS (*tlos*) for HDG15.05

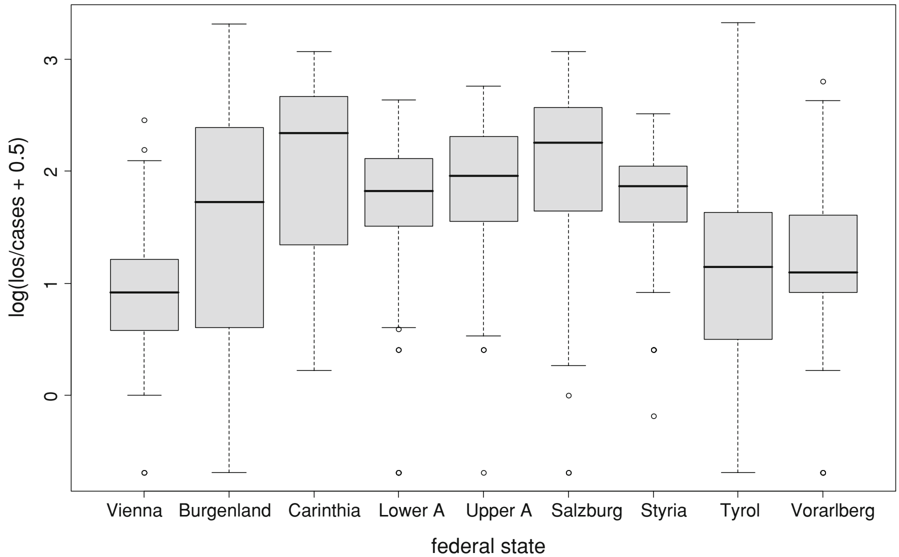

Fig. 2 The influence of the Federal State on the average LOS (*tlos*) for HDG15.05

Figure 1 and Table 2 convey that *tlos* varies significantly (at 0.1% level) across *age* groups. For example, the expected LOS for inpatients older than 75 years was about 303% higher ($3.03 = \exp(1.393) - 1$) than for the reference group of inpatients younger than 15 years. This LOS development clearly corresponds with the characteristics of HDG15.05 treatment which relates to age-related attritions described in the introduction.

As also expected, the variable *federal state* in which the inpatient was treated highly influenced *tlos*. For HDG15.05, inpatients in all Federal States significantly stayed longer in hospital compared to the reference Federal State of Vienna (0.001 significance level). For example, the expected LOS in Burgenland was about 54% higher than in Vienna. Foreign inpatients were non-significantly kept a bit shorter in hospital compared to inhabitants, while inpatients who lived in another Federal State than the hospital were treated about 1.8% longer compared to inpatients that were treated in their home Federal State hospital (0.001 significance level).

To understand what drives the changes in the reimbursement (i.e., the LKF-points) for the HDG15.05 inpatients, the regression model for *tlkf* in the fourth column of Table 2 and Fig. 3 are used. Unsurprisingly, this shows that changes in LKF-points were largely explained by changes in LOS (variable *tlos*), e.g., a 1% increase in LOS resulted in a 0.579% increase in the reimbursed LKF-points for the inpatients in Vienna. The second strongest influence was the *age* effect, in particular for the inpatients in the 75+ years group for which 94.1% ($0.941 = \exp(0.663) - 1$) more LKF-points were reimbursed (given the same LOS). The impact of all remaining variables is comparatively low: For female inpatients reimbursements were 2.4% higher. Finally, intercept and slope of the regression varied somewhat with the Federal State, e.g., the association between *tlos* and *tlkf* was slightly stronger for Upper Austria ($0.683 = 0.579 + 0.104$) but slightly lower for Tyrol ($0.485 = 0.579 - 0.094$).

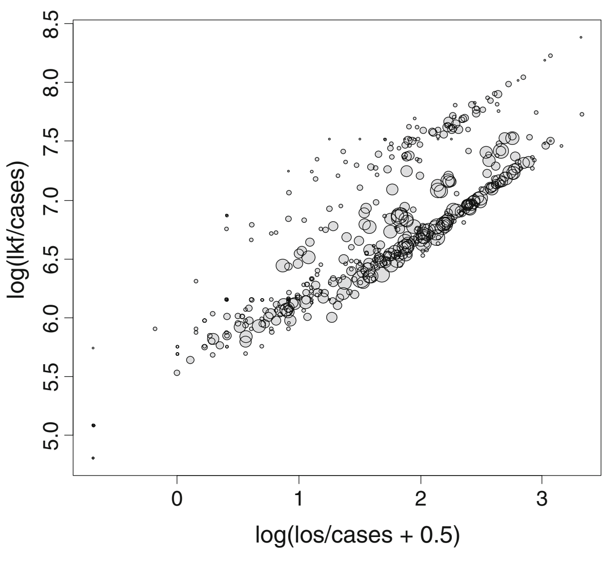

Fig. 3 The influence of the average LKF-points (*tlkf*) on the average LOS (*tlos*) for HDG15.05

4.2 MEL14.14

Table 2 proves a substantial variation of LOS for traditional surgeries (MEL14.14) with respect to decrease over *years* and *federal state*. We disclosed a highly significant decrease of about 3% per year in expected LOS (conforming with the aggregated statistics in Table 1). In the Federal States of Burgenland, Carinthia, and Styria inpatients with knee-joint problems staid significantly longer in the hospital compared to other Federal States as illustrated in Fig. 4 (0.001 significance level). Burgenland had an about 43% longer expected LOS compared to Vienna, which could be explained by Burgenland's few and only lower-technology hospitals compared to Vienna together with the difference in the regulation part of the LKF-system.

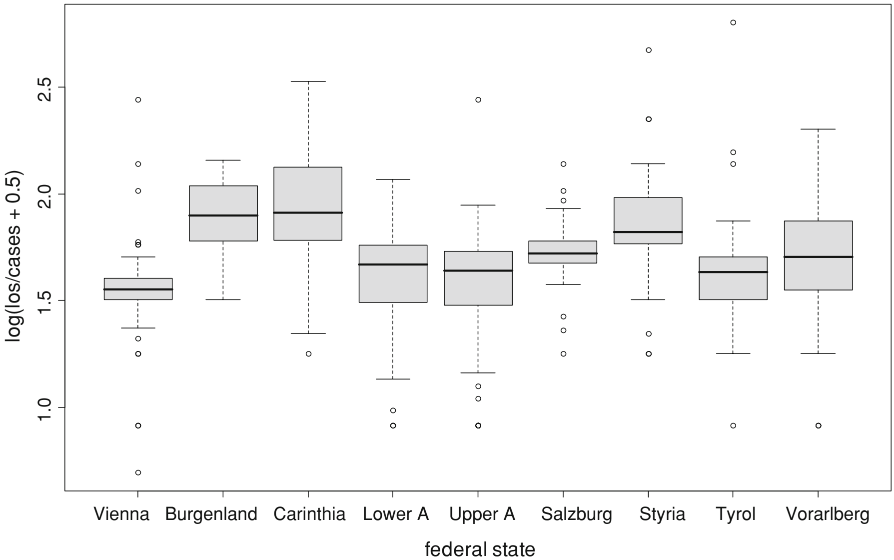

Fig. 4 The influence of the Federal State on the average LOS (*tlos*) for MEL14.14

Figure 5 shows that *age* and *gender* had a much smaller influence on the expected LOS compared to the non-surgical group HDG15.05. According to the results only inpatients aged 60–74 years staid about 14% shorter in hospital compared to inpatients aged 0–14 years (0.05 significance level) which, however, might be due to the standardization of age groups in this paper which does not correspond to the age-specific LKF-boundaries in this case.

Again, the LKF-points mainly depend on the variable *tlos* (0.001 significance level) with a lower slope compared to HDG15.05 and MEL14.21. R^2 amounted to only 0.616 for MEL14.14 compared to 0.965 for HDG15.05 and 0.933 for MEL14.21. However, there was a minor decrease with respect to time, the variable *year* (0.001 significance level). None of the variables *gender*, *age*, and *federal state* had any statistically significant influence on the reimbursement, only *foreign patients* were slightly allocated less LKF-points (0.05 significance level).

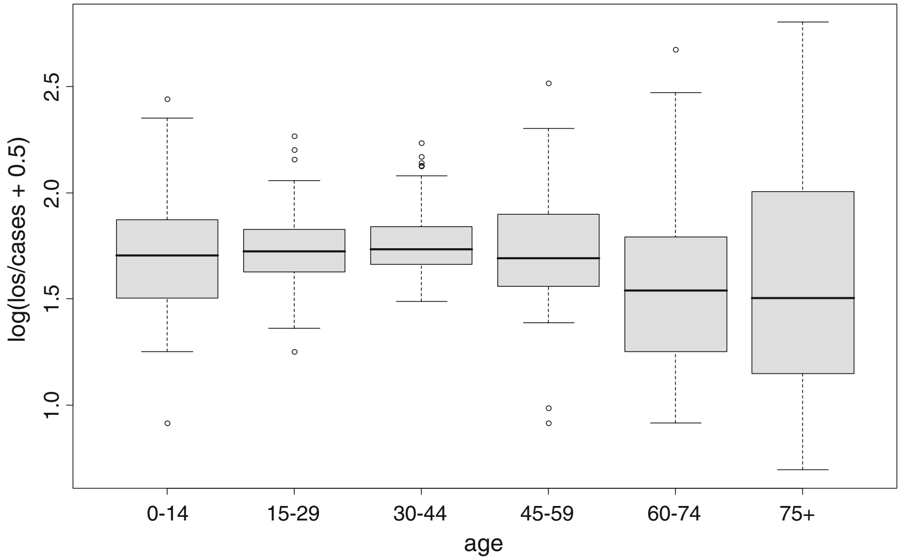

Fig. 5 The influence of age on the average LOS (*tlos*) for MEL14.14

4.3 MEL14.21

Table 2 highlights that the most substantial part of the variation in LOS is again explained by the variables *age* (cf. Fig. 6) and *federal state* (cf. Fig. 7). The older the inpatients were, the longer they staid in hospital (0.001 significance level). For

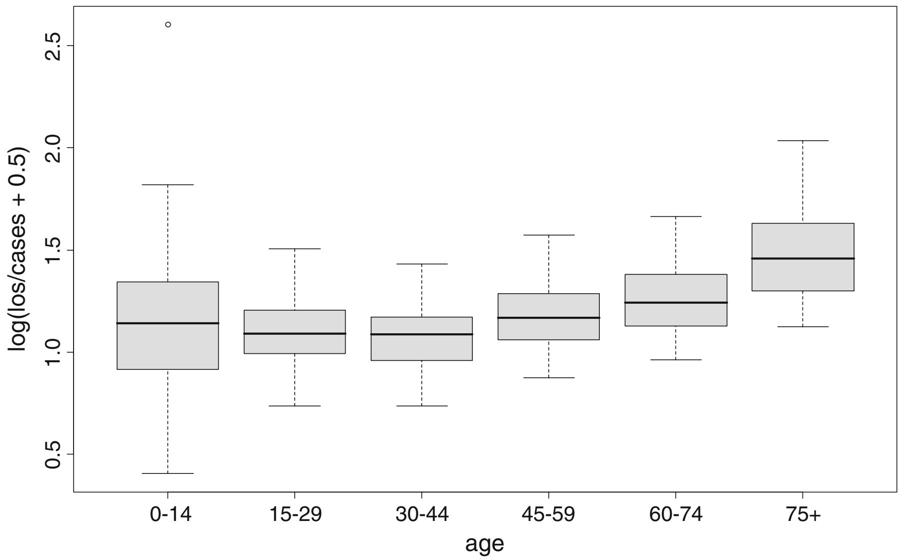

Fig. 6 The influence of age on the average LOS (*tlos*) for MEL14.21

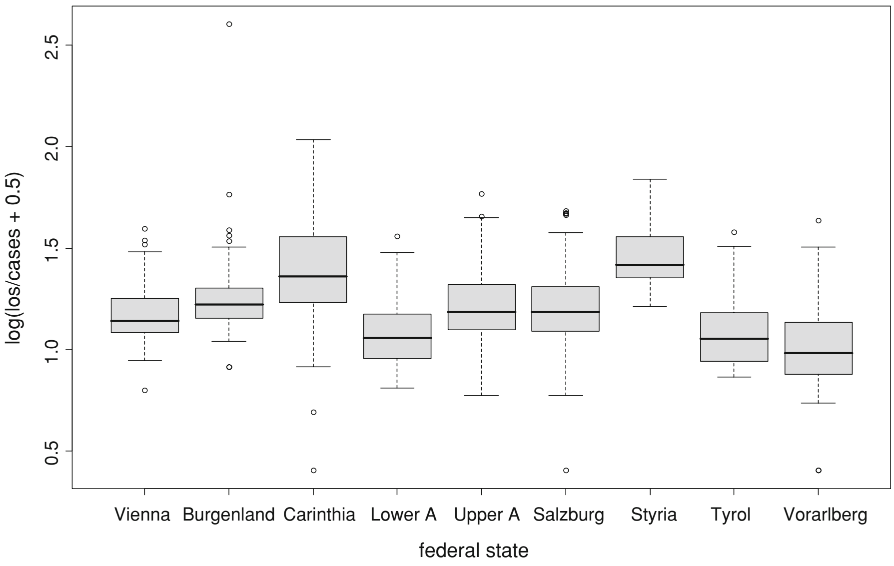

Fig. 7 The influence of the Federal State on the average LOS (*tlos*) for MEL14.21

example, inpatients aged 75+ years had an about 41% longer expected LOS compared to inpatients aged 0–14 years (cf. Fig. 6). Compared to the traditional surgical group MEL14.14 this effect was more significant for the arthroscopic surgical group MEL14.21.

Also significantly longer expected LOS (cf. Fig. 7) were found for the Federal States of Burgenland (0.05 significance level), Tyrol (0.01 significance level), as well as Carinthia, Styria, and Vorarlberg (0.001 significance level), while inpatients in Lower Austria (0.001 significance level) were discharged earlier with an about 9% lower expected LOS compared to Vienna.

For the first time, the results showed a gender gap insofar as female inpatients staid significantly longer (about 9%) in hospital than male ones (0.001 significance level).

With regards to LKF-points, female patients were reimbursed significantly lower than male ones (0.01 significance level), but just about 0.4%. For inpatients in the Federal State Tyrol hospitals were paid about 10% more LKF-points compared to Vienna. It can be seen that the MRI diffusion had a positive effect on reimbursement (0.05 significance level). In general, the number of LKF-points significantly depended on LOS.

4.4 Overall results

The main results clearly prove that LOS can be expected to be the main driver for LKF-points. Columns 4 to 6 in Table 2 show for row *tlos* that the increase in *tlkf* was highly significant for all HDG- and MEL-groups in Vienna. The expected LKF-points due to *tlos* in all Federal States were comparable to Vienna for the traditional surgical group MEL14.14 in all Federal States and for HDG15.05 in all Federal States except for Upper Austria and Tyrol, but significantly differed for the arthroscopic surgical group MEL14.21 except in Salzburg and Carinthia. For example, if the LOS of a MEL14.21 inpatient treated in Vienna was increased by 1%, the hospital would be reimbursed 0.257% more LKF-points. However, if the same inpatient with the same LOS was treated in Burgenland, then an increase of 1% in LOS would have resulted in just 0.165% more LKF-points ($0.165 = 0.257 - 0.092$).

The overall results give evidence that the LKF-points allocated to inpatients significantly depended on *tlos* for all groups of treatment. However, *tlos* and LKF-points of the non-surgical HDG-group 15.05 were subject to strong influences, while *tlos* and LKF-points of the surgical MEL-groups 14.14 and 14.21 were not affected to such an extent. Mostly, *tlos* was impacted by the Federal States in which the hospitals were located whereas no specific pattern in regard to the specific characteristics of the corresponding regulation parts can be revealed by the data.

Further, *tlos* and *tlkf* partially related to the age of the inpatients. The older the inpatients, the longer the expected LOS and the more LKF-points which mostly applied to HDG15.05, not always to the MEL-groups. The interpretation of this outcome is obvious as attritions concern elderly people and are mostly treated non-surgically, while surgically treated accidents may happen to people of all ages. Most astonishingly, the number of MRIs did neither influence inpatients' LOS nor LKF-points. We only found some minor effect for the arthroscopic surgical group MEL14.21 (0.05 significance level) on *tlkf*. Due to the fact that we had aggregated inpatient data for each Federal State and that the number of MRI was rather stable, the variable *mri* might have been an inadequate proxy for the technological change. However, technological differences were indirectly captured by the variable *federal state*.

All of the results above are robust to alternative specifications of the influence for the variable *mri* (as well as for the other numeric variables), such as partially linear models. As before, the explanation for this is that most of the technological differences seem to be captured in the indicator variables pertaining to federal state. Note, however, that a flexible specification of the dependence on age is crucial for all models. For our data, this is naturally incorporated by the indicator variables for the different age groups (see Figs. 1, 5, and 6). However, if the age (rather than an age group only) had been available, a partially linear model or generalized additive model (GAM) would have been conceivable for assessing changes in LOS and LKF, respectively.

5 Conclusion

This paper investigates multiple influences on the LOS and on inpatients' reimbursement by LKF-points within the Austrian hospital financing system. To do so, it adds to the literature by considering independent variables in the categories year, infrastructure, patient characteristics, patient treatment, reimbursement, and cases for the first time. We hereby develop semi-logarithmic linear regression models for longitudinal observations from 2002 to 2006 of knee-joint inpatients for both surgical and non-surgical groups.

The findings prove that the individual regulations of the LKF-system within the nine Federal States lead to nine different specifications which again result in nine different LOS and LKF-point reimbursements for identical diagnoses and treatments.

Also, the age of the inpatients should not be disregarded in budgetary considerations, whereas older inpatients mostly applied to non-surgical diagnoses and staid longer than younger patients with mainly surgical treatments. The commonly known correlation of LOS and LKF-points was confirmed. However, the expected influence of modern technology was not compelling, presumably due to the fact that first, the number of MRIs did not increase significantly except in 2003, and second, the data base targeted more on the revelation of overall Federal State effects evoked by the regulation part of the LKF-system to prove the hospitals' incentives of DRG-creep.

Consequently, further research could be targeted to analyze inpatient data on individual basis. For example, diagnoses such as stroke and delivery might be good illustrative examples to disclose effects such as patient shifting, revolving-door strategies, end-of-the-week discharges, and technology shifts.

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