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Christoph Schwierz, Boris Augurzky, and Jürgen Wasem*

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Abstract

This paper investigates the relationship between health outcomes and variations in staffing levels as approximated by admissions on weekdays versus admissions on weekends. Because days of admission are potentially endogenous, we instrument on emergency admissions only, which are reasonably exogenous to the time of admission. Further, we introduce a direct measure for within-diagnosis variation in severity across days of admission to control for the unobservable selection of patients. We find that after controlling for patient heterogeneity and endogeneity of the day of admission there is still a significant variation in mortality rates between weekend and weekday admissions. Patients admitted during the weekend exhibit higher in-hospital mortality rates. We also find signs of premature discharge, as patients with short lengths of stay tend to exhibit higher probability to be readmitted as emergency cases.

JEL Classification: I12, I18

Keywords: Hospital quality, weekend effect, inpatient outcomes

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1. Introduction

The first objective of this paper is to consider variations in the quality of hospital treatment by the day of admission and discharge of in-patients in German acute-care hospitals. Hospital resources are not evenly distributed over the week. Usually, staffing and medical services are restricted during the weekend as compared to the regular workday. Diagnoses may be delayed, physicians might find less time for patients, or physicians working on irregular workdays might be less experienced. As such, the outcome quality of service during those periods may be lower and patients may experience a higher rate of adverse health outcomes.

The second objective of this paper is to explore the existence and consequences of premature discharge. Discharges can be the result of a trade-off between the patients' need of further hospitalization on the one hand and higher turnover of patients on the other hand. Cost pressures on hospitals have contributed to a steep decrease in the average length of stay (LOS) of patients. Increasingly, scarce resources are distributed among a higher number of patients. Reimbursement based on prospective-payment systems (PPS) such as the recently introduced Diagnosis Related Groups (DRG) in Germany further enforces this tendency. In PPS payment is not anymore based on the actual but on an average LOS (among other factors) of a patient within a DRG. This generates incentives to dismiss patients earlier and to increase patients' turnover.

Several studies have analyzed variations in the quality of care by days of the week. Using patient data from a German insurance company Kaiser et al. (2006) find higher readmission rates for discharges on Fridays and higher out-of-hospital mortality rates for discharges during the weekend. Bell and Redelmeider (2001) find higher readmission and in-hospital mortality rates in the UK for patients admitted during the weekend. Goldfrad and Rowan (2000) observe that discharges from intensive care units at night have higher mortality rates than those discharged during the day. Using data from a paediatric intensive care unit Arias et al. (2004) detect no association between the day of admission and mortality rates, but a positive association between evening admissions and mortality rates. Heggestad (2002) finds that admission to a hospital with a relatively short average LOS increases the rate of unplanned readmission and that more staff has a compensatory effect on this adverse outcome.

These studies demonstrate that there are significant variations in the quality of care by days of the week. However, many studies fail to control sufficiently for the varying patient mix. Patients admitted during the weekend or night might be frailer than those admitted during the weekdays or day, such that differences in quality outcomes may reflect differences in the patient-mix rather than varying quality of treatment.

One way to attenuate the problem of selection is focusing on the sample of emergency admissions which are largely exogenous to the day of admission (Dobkin 2003). Unlike elective admissions emergency admissions are unplanned. In Germany every acute care hospital is required by law to admit every emergency case, unless it reaches its capacity limit. However, even emergency admissions could be selected in the way that less urgent cases are triaged to Mondays by the hospital staff or that patients themselves postpone their admission in order to be able to stay at home during the weekend. This would shift the risk-burden of weekend admission upwards even within the pool of emergency admissions. Dobkin (2003) corrects for this selection problem. He argues that without selection illnesses should be randomly distributed throughout the days of the week. This means that for each diagnosis on weekdays we should observe 5/7 of all admissions and 2/7 of all admission on weekends. Deviations from these proportions suggest a selection of patients which he finds to be associated positively with higher risk admissions on weekends. In his study, Dobkin finds a positive correlation between mortality and weekend admissions when ignoring the above described unobservable selection. Once the selection index is added to the regression, the higher mortality for patients admitted on the weekend disappears. With his approach he refutes the prominent results of Bell and Redelmeier (2001). We use Dobkin's approach to test for the importance of unobservable selection within our data.

The paper is organized as follows. Section 2 describes the data and presents first descriptive results. Section 3 introduces the econometric model. Results are discussed in section 4. Section 5 concludes.

2. The data and descriptive results

2.1 The data

The data are composed of administrative patient-level data of 72 German hospitals for the year 2004. They are a full sample of all patients treated by these hospitals. The data are standardized and provided by hospitals to health insurance companies for billing purposes. In sum, they comprise the following variables: patient's age, sex, the hospital and department of admission, length of stay, discharge status, and several indicators of illness severity: the relative DRG weight, the patient clinical complexity level (PCCL), whether there was an operative DRG, the number of secondary diagnoses and the hours of artificial ventilation. The relative DRG weight determines the hospital's revenue for each case. High weights mean high reimbursement but also high costs due to time consuming and complex procedures. PCCL measures four levels of complexity with higher levels indicating more complex cases. Furthermore, cases of patients undergoing operative – in contrast to non-operative – DRGs, those experiencing more secondary diagnoses and artificial ventilation should have a higher level of illness severity. Moreover, we have information about the main diagnosis of the patient. In the sample there are 601 different DRGs in 18 major diagnostic groups (MDC).

We use two different quality indicators: (i) unplanned readmissions as well as (ii) in-hospital mortality (Vivian and Hamilton 2000, Cutler 1995).[2] Studies have shown a positive link between readmission rates and the medical care process during hospital stay (Weissman et al. 1999). We look at readmissions up to 15 days after hospitalization. For this short spell the link between hospital treatment quality and the probability of readmission is strengthened relative to longer spells (Ashton and Wray 1997; Sibritt 1995). In-hospital mortality is a standard measure of outcome quality (Bell and Redelmeier 2001, Evans and Kim 2006, Vivian and Hamilton 2000, Cutler 1995). We use one-day mortality rates to study the immediate "weekend effect" as well as total mortality rates for longer term effects.

We exclude observations if the reason for admission is neither coded as *normal* nor as *emergency* (e.g. removal of an organ or birth), if the discharge reason was other than *regularly ended* or *death,* or if there are missing values or wrongly coded variables of interest. This also excludes patients who leave the hospital prematurely against the advice of the doctor. In our sample this accounts for 1.5 % of all observations. Because we are interested in measures of health outcome up to 30 days after admission, we restrict the sample to admissions up to 30 days before the end of each year, in order to observe the outcomes for all patients from the sample. Additionally, we remove observations that fall into a major diagnostic group or a hospital department where in-hospital mortality or emergency readmissions did not occur. This leaves us with 692 548 observations in our sample.

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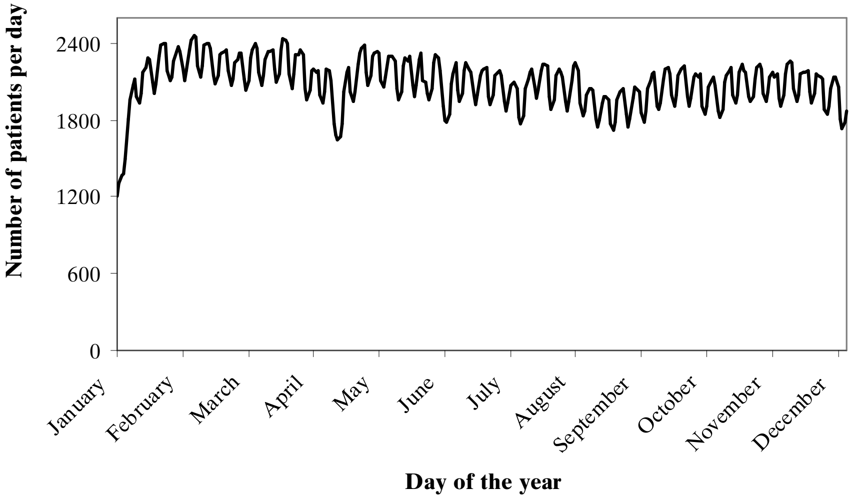
[2] We look at emergency readmissions and not at planned, elective readmissions. Planned readmissions cannot be interpreted as a sign of low quality of patients' treatment. Patients with planned readmission, e.g. those with regular dialysis treatment, might be discharged more often on a specific day of the week and readmitted on a weekly basis.

2 2 Descriptive analysis

There is a recurrent pattern of admissions and discharges throughout the days of the year (Figure 1). The number of patients rises on Mondays to reach a peak on Wednesdays to drop sharply before each weekend.

Figure 1

Numbers of in-hospital patients throughout the year



Accordingly, the number of admissions is highest on Mondays and is declining with the days of the week (Figure 2). This pattern is accentuated for electively admitted patients, but there is also a surge in emergency admissions on Mondays. On average 17.7 percent of all emergency admissions occur on Mondays, which is 23.8 percent over the expected 1/7 of admissions in case of a uniform distribution of admissions over the days of the week. As far as discharges are concerned, they rise from Sundays to Fridays and decline thereafter (Figure 3). The pattern of discharges for emergency cases is far less uniform than what could be expected from the pattern of emergency admissions: there is a steep surge in discharges before the weekend. Two explanations can account for this phenomenon. First, the causes for emergency admissions are unequally distributed across the days of the week and they differ in the expected length of stay. Second, patients are dismissed before the weekend because staffing on weekends is reduced, too.

Figure 2

The distribution of elective and emergency admissions by day of the week

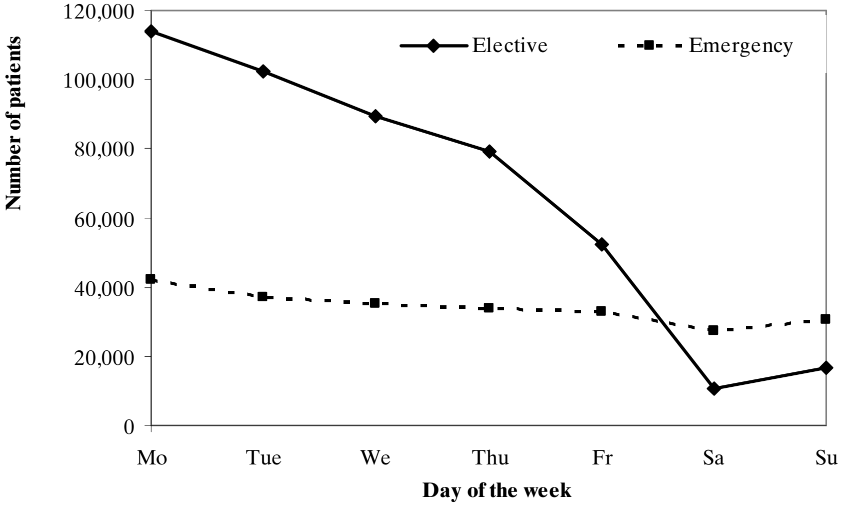
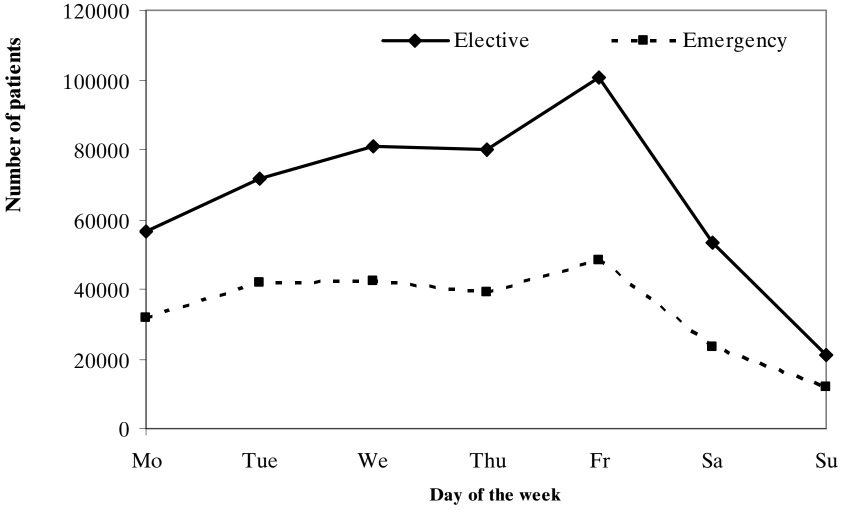


Figure 3

The distribution of elective and emergency discharges by day of the week



A rough test of the abovementioned explanations is considering the mean length of stay (LOS) of patients in dependence of the day of admission and discharge. Reducing the number of patients before the weekend may lead to relatively low LOS for those discharged shortly before the onset of the weekend. Further, if medical treatment is more restricted during the weekend, we would expect those patients staying over the weekend to have relatively high LOS due to postponements in medical treatment. However, daily variations in LOS may also reflect pure differences in the case-mix of patients. In this case, it may be misleading to compare the average LOS across the days of the week. To approximate the problem in a univariate analysis we thus consider a patient's adjusted LOS ΔL_{ij}, which is constructed as the percentage difference of a patient's i actual LOS in diagnosis j (L_{ij}) to the hospital's average LOS in the same diagnosis $\overline{L}_j$:

$$\Delta L_{ij} = \frac{L_{ij} - \overline{L}_j}{\overline{L}_j}.$$

Positive (negative) percentages show that, on average, a patient stayed longer (shorter) in hospital than the average patient in this diagnosis.

Basically, for both elective and emergency patients admitted on Mondays and Tuesdays the adjusted LOS is negative and increasingly positive until Saturdays for emergency and until Sundays for elective admissions (Figure 4). The picture reverses for discharges (Figure 5). Patients discharged from Mondays to Wednesdays have above average LOS, whereas patients discharged thereafter have either average or lower than average LOS. These patterns suggest that even after the adjustment for the diagnosis patients tend to be either discharged before Saturday if admitted at the beginning of the week or that they stay during the weekend when admitted closer to the end of the week. Whether this discharge policy is due to lower staffing on weekends or only due to medical causes will be disclosed later in a multivariate regression framework, where we take account for the full set of individual risk-factors.

Figure 4
Mean adjusted length of stay for elective and emergency admissions by day of the week

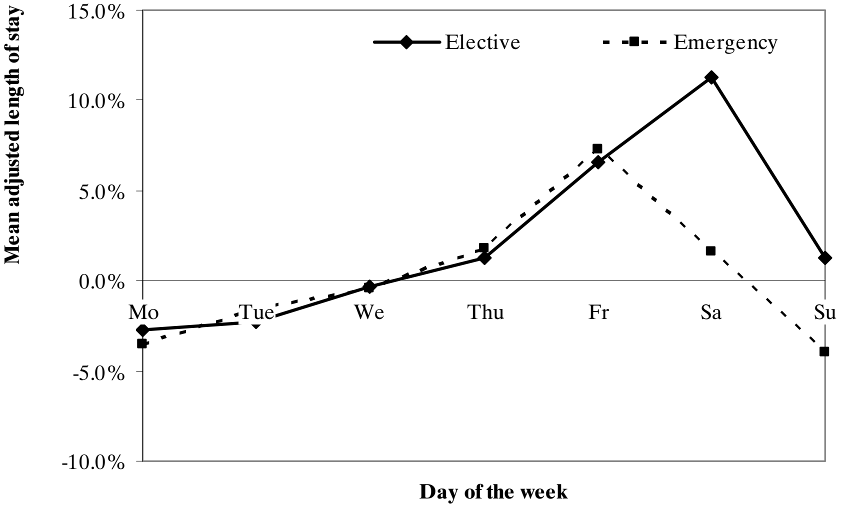


Figure 5
Mean adjusted length of stay for elective and emergency discharges by day of the week

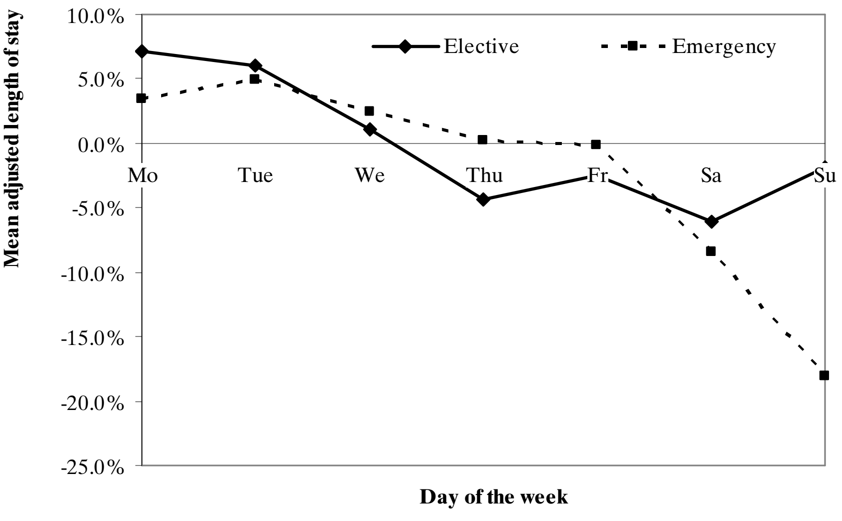


Table 1
Descriptive statistics

	Elective admissions			
	Monday-Friday		Saturday-Sunday	
	Mean	SD[1]	Mean	SD
Age	55.17	14.95	52.20	16.77
Clinical complexity level	1.32	1.55	1.33	1.59
Relative diagnosis weight	1.15	1.43	1.29	1.70
Share of men	0.49	0.50	0.45	0.50
Ventilation in min.	2.49	44.36	4.47	48.06
Share of operative cases	0.42	0.49	0.42	0.49
Excess length of stay[2]	-0.003	0.718	0.052	0.679
Death within 1 day after admission	0.001	0.031	0.003	0.057
Death within hospital	0.011	0.105	0.018	0.134
Emergency readmission[3]	0.007	0.084	0.006	0.075
Observations	437376		27402	
	Emergency admissions			
	Monday-Friday		**Saturday-Sunday**	
	Mean	**SD**	**Mean**	**SD**
Age	52.17	16.52	50.39	17.22
Clinical complexity level	1.65	1.61	1.53	1.58
Relative diagnosis weight	1.25	1.91	1.14	1.77
Share of men	0.52	0.50	0.50	0.50
Ventilation in min.	6.49	72.45	5.87	73.12
Share of operative cases	0.29	0.45	0.23	0.42
Excess length of stay[2]	0.004	0.720	-0.013	0.682
Death within 1 day after admission	0.006	0.078	0.008	0.091
Death within hospital	0.026	0.159	0.029	0.169
Emergency readmission[3]	0.020	0.140	0.013	0.113
Observations	181048		57729	

Notes: [1] Standard deviation; [2] Adjusted length of stay as deviation of the individual from the average length of stay by diagnosis and hospital; Standard deviations in parentheses; [3] Up to 15 days after discharge.

In Table 1 we present descriptive results of the characteristics and health outcomes of elective and emergency patients' by weekday and weekend admissions. Patients admitted during the weekend are more often women and are on average younger than those admitted during the weekdays. Considering differences in the levels of the severity of illness for weekday versus weekend admissions, it seems that admissions during the weekend are of higher-risk, as the average relative diagnosis weight and minutes of artificial ventilation are higher for weekend admissions. For emergency patients this is similar, although the differences are smaller. LOS clearly differs by day of admission. Elective patients admitted on weekends have longer adjusted LOS than the other subsamples. Weekend admissions also have on average higher mortality rates. However, rates of emergency readmissions seem independent of the day of admission for elective patients and are lower for emergency admissions on weekends.

3. Models and estimation methods

The aim of our models is to single out the impact of the day of admission and selection on unobservables on the length of stay and the probability of occurrence of adverse health outcomes. We first use our measure of adjusted length of stay as the outcome variable. For patient *i* with illness *j* admitted to department *d* in hospital *h* let L_{ijdh} be the diagnosis-adjusted length of stay. In the basic specification we assume that:

$$L_{ijdh} = \gamma D_i + \beta X_i + u_h + v_d + w_{ijdh}. \tag{1}$$

The main vector of interest D_i is a vector of dummies denoting the days of the week. In a first model D_i is the day of admission. In a second model it is the day of discharge. We use D_i and not a weekend dummy, because we are interested in the gradient of increasing length of stay if admitted later than on a Monday and of decreasing length of stay if discharged later than on a Monday. X_i are patients' characteristics: Sex, dummies for patients aged 30 to 39, 40 to 49, 50 to 59, 60 to 69 and 70 to 75 and interactions between sex and age groups, the relative DRG weight, dummies for patient clinical complexity level, whether a DRG was operative, the number of secondary diagnoses, the minutes of artificial ventilation, the month (January to November) of admission, and whether admission took place on a public holiday. Finally, u_h is a hospital fixed-effect, v_d is a department fixed-effect, and w_{ijdh} is a random error.

We then use the outcome of emergency readmissions R_{ijdh} in the following model:

$$R_{ijdh} = \gamma W_i + \eta L_{ijdh} + \beta X_i + u_h + v_d + w_{ijdh}. \tag{2}$$

Where W_i is 1 if patient *i* is admitted on a weekend and 0 otherwise. The inclusion of L_{ijdh} in equation (2) as an explanatory variable allows investigating whether the probability to be readmitted as an emergency depends on the past length of stay.[3] It thus allows approaching the issue of premature discharges.

Finally, we use in-hospital mortality M_{ijdh} as the outcome of interest:

$$M_{ijdh} = \gamma W_i + \beta X_i + u_h + v_d + w_{ijdh} \quad (3)$$

We do not include L_{ijdh} as a determinant in equation (3), because it is clearly endogenous to in-hospital mortality.

Patients' risk profiles are, probably only partially measured by observables. It is for instance possible that patients are heterogeneous with respect to unobservable risk factors, such as the immediacy of the need of treatment. In order to control for the potential unobservable heterogeneity in patients characteristics we build upon Dobkin's (2003) approach. Dobkin assumes that, regardless of the day of the week, the same number of patients should be admitted in each illness if patients are not selected by severity. To test this hypothesis he constructs a selection index. This index is measured as the difference between the number of admissions on each day of the week and an evenly distributed number of admissions throughout the week. We use the same identification strategy.

For each illness we measure how much higher or lower the admissions during weekends than we would expect if all patients were admitted at random. This variable is supposed to measure the bias introduced by the selection of patients. If the excess patients with a given illness who come in during weekdays do not differ systematically in their illnesses then this variable will not have an impact on the difference between days of the week. However, if patients admitted during weekends are systematically of higher-risk then the

[3] We have also estimated a recursive multivariate probit model. Multivariate probit models allow testing for endogeneity of independent variables and for correlations between the unobservables in a system of equations (Greene 2003; Maddala 1983). They are more efficient than univariate models in case of significant cross-equation correlations. The model was based on two equations. Adjusted LOS was the dependent variable in the first equation. It then entered the second equation as an explanatory variable to explain the occurrence of emergency readmissions. Thus, we tested for the endogeneity of LOS to emergency readmissions. The methods are more complicated, but the results were very close to those presented in the univariate model framework. For simplicity we therefore do not present them here.

variable will reduce the bias in the estimate of the weekend effect on adverse health outcomes. Thus, the variable estimates the amount of selection that is introduced by unobservable heterogeneity in the severity of illness of patients.[4] In order to measure the impact of unobservable selection we include the selection index s_{jdh} in a second specification of models (1) to (3).

The estimation strategy is as follows. We estimate equation (1) with ordinary least squares and robust standard errors. Equations (2) to (3) are estimated with univariate probit models, as the dependent variables are binary. We exclude all patients who die in a hospital when using emergency readmissions as the outcome. For all models we provide "raw estimates", where only the effect of the time of admission is measured. Estimations are done separately for the samples of elective and emergency admissions.

4. Results

We first turn to the discussion of the determinants of the adjusted length of stay as modelled in equation (1). We do not depict the results of the other covariates in order to save space.[5] Most of the coefficients of the day dummies are highly significant and have the expected signs. For elective admissions the raw estimates show that the adjusted LOS for admissions is higher from Tuesday to Saturday admission as compared to the base line of Monday admissions (Table 2). Elective patients admitted on Sundays have also on average higher adjusted lengths of stay than patients admitted on Mondays. The inclusion of patients' characteristics as further explanatory variables does not lower these effects to a large extent. Additionally, the admission ratio does not impact significantly on this outcome. Thus, deviations from average length of stay can be explained by patients' characteristics and selection index only to a minor extent. This picture is basically very similar for emergency admissions. This may be surprising, as the distribution of the admissions for these patients across the days of the week is close to uniform.

[4] For a detailed description of the selection index see Dobkin (2003).

[5] Overall we find that patients who are male, older, have more minutes of artificial ventilation, a higher clinical complexity level, a lower relative diagnosis weight and those not treated operatively have significantly higher excess length of stay and higher probabilities of in-hospital death or being readmitted as an emergency. Moreover, we find significant differences across individual diagnoses, departments, hospitals and days and month of admission. Results are available from the authors upon request.

Table 2
Association between the days of admission and adjusted length of stay[1]

	Elective admissions			Emergency admissions		
	Raw	**Without selection[2]**	**With selection**	**Raw**	**Without selection**	**With selection**
Tuesday	0.0047	0.0021	0.0021	0.0198***	0.0123**	0.0122**
	(0.0030)	(0.0029)	(0.0029)	(0.0051)	(0.0049)	(0.0049)
Wed.	0.0239***	0.0184***	0.0183***	0.0315***	0.0236***	0.0235***
	(0.0031)	(0.0031)	(0.0031)	(0.0052)	(0.0051)	(0.0051)
Thursday	0.0400***	0.0377***	0.0376***	0.0540***	0.0466***	0.0463***
	(0.0033)	(0.0032)	(0.0032)	(0.0053)	(0.0051)	(0.0051)
Friday	0.0934***	0.0775***	0.0771***	0.1086***	0.0929***	0.0922***
	(0.0041)	(0.0039)	(0.0039)	(0.0054)	(0.0052)	(0.0052)
Saturday	0.1411***	0.1106***	0.0729***	0.0519***	0.0499***	0.0481***
	(0.0074)	(0.0073)	(0.0075)	(0.0055)	(0.0053)	(0.0053)
Sunday	0.0405***	0.0317***	0.0076	0.0038	0.0038	0.0015
	(0.0054)	(0.0054)	(0.0062)	(0.0052)	(0.0050)	(0.0050)
Selection index			0.0223			0.0841
			(0.0195)			(0.0705)
Obs.		458293			234255	

Notes:
1 Percentage deviation of individual from the average length of stay in a hospital by 3-digit diagnosis; OLS estimation results, standard deviations in parentheses;
2 Model without or with admission ratio as a control for unobservable selection of patients by day of admissions;
On patient level independent variables include age in the age categories 30-39, 40-49, 50-59, 60-69, 70-75, sex, interactions between age and sex, minutes of artificial ventilation, the clinical complexity level, average diagnosis weight, dummy for an operation and three-digit main diagnosis. Moreover, we control for hospital and departmental fixed-effects and the month of admission; ***, **, * significant at 1%, 5% and 10% level respectively.

When we look at the days of discharge, we find that the adjusted LOS is lower for all days relative to Monday discharges (Table 3). This is true in all specifications of our model and for both subsamples. The combined evidence on the LOS by days of admission and discharge clearly indicates that there is a steering of patients' LOS according to the days of week above of what may be explained by (to us) observable personal and medical characteristics of the patients.

Table 3
Association between the days of discharge and adjusted length of stay

	Elective			Emergency		
	Raw	**Without selection**	**With selection**	**Raw**	**Without selection**	**With selection**
Tuesday	-0.0105***	-0.0197***	-0.0194***	0.0150***	0.0047	0.0048
	(-0.0040)	(-0.0039)	(-0.0039)	(0.0055)	(0.0053)	(0.0053)
Wednesday	-0.0606***	-0.0703***	-0.0694**	-0.0098*	-0.0215***	-0.0214***
	(-0.0040)	(-0.0039)	(-0.0039)	(-0.0055)	(-0.0053)	(-0.0053)
Thursday	-0.1148***	-0.1191***	-0.1179***	-0.0327***	-0.0446***	-0.0445***
	(-0.0039)	(-0.0038)	(-0.0038)	(-0.0055)	(-0.0054)	(-0.0054)
Friday	-0.0962***	-0.1052***	-0.1040***	-0.0360***	-0.0494***	-0.0494***
	(-0.0038)	(-0.0037)	(-0.0037)	(-0.0053)	(-0.0051)	(-0.0051)
Saturday	-0.1316***	-0.1267***	-0.1272**	-0.1191***	-0.1047***	-0.1048***
	(-0.0041)	(-0.0039)	(-0.0039)	(-0.0059)	(-0.006)	(-0.0058)
Sunday	-0.0899***	-0.0743***	-0.0766***	-0.2159***	-0.1705***	-0.1701***
	(-0.0057)	(-0.0056)	(-0.0056)	(-0.0075)	(-0.0072)	(-0.0073)
Selection index			0.0204			0.0848
			(0.0209)			(0.0705)
R^2						
Obs.		458293			234255	

Notes: See notes to Table 2.

In the following we present results for the probability to be readmitted as an emergency (Table 4). The raw effect of a weekend admission on this outcome is negative and highly statistically significant within both subsamples. However, the effect vanishes, once we account for the patients' characteristics in the estimation framework. The admission index does not affect the probability of emergency readmissions on conventional statistical levels. There is a negative and statistically significant effect of the adjusted length of stay on the probability of an emergency readmission such that below average LOSs seem to increase the risk of future emergency readmissions. This is an indication of premature discharges. In quantitative terms for an elective patient with mean characteristics and an adjusted LOS of minus 20 percent a simulated increase in his adjusted LOS by 20 percentage points (i.e. to the average expected LOS) reduces the risk of readmission by 0.059 percent (95 percent confidence interval: -0.00065; -0.00054).[6] As the mean

[6] The estimation is based on simulation results. To this end, we set the desired change in the value of the explanatory variable and, using simulated parameters values, we generate the mean expected value of the patient outcome as well as the 95 percent confidence interval. We then draw 1,000 simulations of the estimated model parameters from their asymptotic sampling distribution. To generate the expected outcomes all other explanatory variables are set at their

expected emergency readmission rate is 0.7 percent, this effect amounts to an 8 percent reduction in the emergency readmission rate. The effect is nearly the same within the sample of emergency patients. A simulated increase of the adjusted LOS by 20 percentage points up to the average expected LOS reduces the risk of readmission by 0.41 percent (95 percent confidence interval: -0.004352 -0.003859) and the average emergency readmission rate by roughly 9 percent.

Table 4
Marginal effects for the probability of an emergency readmission

	Elective admissions			Emergency admissions		
	Raw	**Without selection**	**With selection**	**Raw**	**Without selection**	**With selection**
Weekend	-0.0015***	-0.0001	0.0001	-0.0069***	-0.0003	-0.0002
	(-0.0005)	(-0.0001)	(-0.0002)	(-0.0006)	(-0.0002)	(-0.0002)
Adjusted LOS		-0.0014***	-0.0014***		-0.0044***	-0.0045***
		(-0.0004)	(-0.0004)		(-0.0011)	(-0.0011)
Selection index			-0.0038			-0.0030
			(-0.0031)			(-0.0039)
Observations		458293			234255	

Notes: Marginal effects from probit models, t-values in parentheses; Patients who died in hospital are excluded from these models; See also notes Table 2.

Considering the probability of in-hospital mortality within one day of admission, there is a positive and statistically significant association with weekend admissions (Table 5). However, within the sample of elective admissions this effect becomes statistically insignificant after inclusion of the remaining explanatory variables. Emergency patients admitted on weekends remain with a higher in-hospital mortality risk, which is however quantitatively small. For a hypothetical emergency patient with mean characteristics being admitted on a weekend increases his risk to die in hospital by 0.005 percent (95 percent confidence interval: 0.000029; 0.000091). This is roughly a one percent increase in his average risk to die.

The effect of a weekend admission is positive and highly statistically significant on the probability of in-hospital mortality within the whole hospital stay. This suggests a higher probability of dying within the hospital for those admitted during weekends. The effect is lower but still significant, when the full set of individual patient characteristics is employed. Simulation results show that for elective admissions the mean weekend effect on mortality is 0.09 percent (95 percent confidence interval: 0.00042; 0.00151). This effect is

mean values. We use CLARIFY, a STATA add-on, for this purpose (Tomz et al. (2001), King et al. (2001)).

0.20 percent (95 percent confidence interval: 0.00141; 0.00266) for emergency admissions. This implies for both elective and emergency patients an increase in the mean risk of dying of roughly 8 percent if admitted during the weekend. For elective patients this is an equivalent of 417 expected deaths on the weekend (95 percent confidence interval: 192; 692) and 474 deaths for emergency patients (95 percent confidence interval: 331; 626). Overall and in contrast to Dobkin's (2003) findings, the inclusion of the selection index does not alter the weekend effects. Thus, selection on unobservables does not seem to play a significant role in our sample.

Table 5
Marginal effects for the probability of in-hospital mortality

	Elective			**Emergency**		
	Raw	**Without selection**	**With selection**	**Raw**	**Without selection**	**With selection**
			One day in-hospital mortality[1]			
Weekend	0.0015***	5.8 E-6	2.2 E-5	0.0016***	7.8 E-6***	7.7 E-6***
	(2.8 E-4)	(2.4 E-6)	(1.5 E-5)	(3.3 E-4)	(2.3 E-6)	(1.6 E-6)
Selection index	-	-	-1.9 E-6	-	-	-2.1 E-5**
	-	-	(-1.4 E-6)	-	-	(-7.7 E-6)
Observations		458293			234255	
			Total in-hospital mortality[2]			
Weekend	0.0066***	4.7 E-4***	5.5 E-4***	0.0029***	0.0015***	0.001571***
	(8.0 E-4)	(9.2 E-5)	(1.5 E-4)	(7.5 E-4)	(2.9 E-4)	(2.9 E-4)
Selection index	-	-	-1.3 E-4	-	-	-0.0027
	-	-	(-1.8 E-4)	-	-	(-0.0019)
Observations		458293			234255	

Notes: [1] If died in hospital within 1 day after admission, 0 otherwise; [2] If died in hospital, 0 otherwise; See also notes to Table 2.

5. Conclusion

Health outcomes in a hospital may, among other things, depend on the admission and discharge policy. Especially, they may vary with the days of the week. We have investigated this hypothesis based on patients' data of 72 German hospitals and have proxied health outcomes by two quality measures: emergency readmissions and in-hospital mortality rates.

We have also addressed the question of premature discharge and find that patients are likely to be discharged before the weekend if admitted in the beginning of the week or that they stay during the weekend if admitted later in the week. This result is robust even after adjusting for observable patient characteristics. Further, we find that this pattern persists also not only for elective but also for emergency admissions, although the latter are relatively randomly distributed over the days of the week. Most probably the reduction in staff-levels over the weekend is a causal factor of this admission and discharge policy. Moreover, we find that patients with below average LOS have a significantly higher probability to be readmitted as emergency cases within 15 days after their last discharge. Thus, is it probable that some patients are discharged too early and therefore have to bear a higher risk of re-hospitalization.

In line with some previous studies, health outcomes in our data are worse for weekend than for weekday admissions. Elective patients admitted on weekends bare a higher risk of an emergency readmission than patients admitted during the week. Moreover, one day and total in-hospital mortality are higher for weekend admissions. The effects are quantitatively small for one day in-hospital mortality and substantial in terms of potentially amenable deaths for total in-hospital mortality. Therefore, it is possible that hospitals have a problem to provide adequate medical quality on weekends.

We tried to accommodate for the problem of unobservable heterogeneity of patients admitted on weekends as opposed to weekdays by focusing on outcomes of emergency admissions, which are relatively randomly distributed over the days of the week. Further, we have introduced an admission ratio into the model framework as proposed by Dobkin (2003). The intuition may be that on weekends only patients most needy of the immediate treatment are admitted to the hospitals. Those, who can wait, are probably triaged to days when capacities are freed up. Thus, not low-staff levels may be the reason for worse outcomes on weekends but the high-risk profile of patients. Our results do not confirm this intuition, as the admission ratio is not statistically significant. This contrast to Dobkin's finding that patients admitted on weekend have on average a higher-risk profile.

Concluding, we find some evidence that quality of outcome varies by days of the week. As there are significant differences between weekdays and the weekend, where staffing changes are typically pronounced, we suppose that different staffing policies between the weekdays and the weekend could partly explain differences in outcome quality. Generally during the weekends there are fewer personnel and patients might have to wait longer for their medical treatment. Unfortunately, due to the lack of data we are not able to test this hypothesis directly. We suggest that hospitals extend their working week and define Saturday as a typical day of the week. This may not only reduce the problem of lower outcome quality at the weekend but also increase economic efficiency by increasing utilization of bed capacities. However, we cannot completely exclude the possibility that unobserved differences in patient characteristics may also account for those differences in health outcomes.

Further research should take into account (i) out-of-hospital mortality as a better indicator of health outcome that in-hospital mortality and (ii) staffing variations during the days of the week. Both variables depend on the availability of adequate data which until now is not given in Germany.

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