European Spine Journal
https://doi.org/10.1007/s00586-019-06209-5

ORIGINAL ARTICLE

Non-medical factors significantly influence the length of hospital stay after surgery for degenerative spine disorders

D. Mai[1,2] · C. Brand[2] · D. Haschtmann[1] · T. Pirvu[1] · T. F. Fekete[1] · A. F. Mannion[1]

Received: 26 July 2019 / Accepted: 7 November 2019

Abstract

Background Unnecessarily long hospital stays are costly and inefficient. Studies have shown that the length of hospital stay (LOS) for spine surgical procedures is influenced by various disease-related or medical factors, but few have examined the role of socio-demographic/socio-economic (SDE) factors.

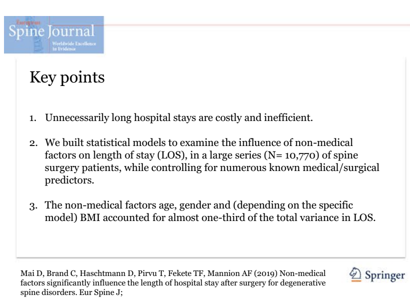
Methods This was a retrospective analysis of data from 10,770 patients (5056 men, 5714 women; 62 ± 15 years) with degenerative spinal disorders, collected prospectively in an in-house database within the framework of EUROSPINE's Spine Tango Registry. Surgeons completed the Tango surgery form (clinical history, demographics, surgical measures, complications), and patients, a baseline Core Outcome Measures Index. Stepwise linear regression analyses examined SDE predictors of LOS, controlling for potential medical/biological factors.

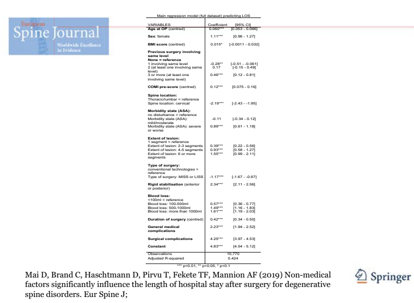
Results The mean LOS was 7.9 ± 5.2 days. The final model accounted for 42% of variance in LOS, with SDE variables explaining 13% variance and medical/surgical predictors, 29%. In the final model, the SDE factors age and being female were significant independent predictors of LOS, whereas others were either non-significant (insurance status, being of Swiss nationality, being a smoker) or reached only borderline significance ($p < 0.1$) (BMI). Controlling for all other SDE and medical/surgical confounders, being female was associated with 1.11-day longer LOS (95% CI 0.96–1.27; $p < 0.0001$).

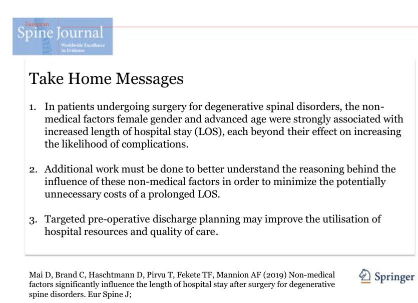
Conclusions Patients of advanced age and female gender are at increased risk of longer hospital stay after surgery for degenerative spinal disorders. Further studies should seek to understand the reasoning behind the gender disparity, in order to minimise potentially unnecessary costs of prolonged LOS. Targeted preoperative discharge planning may improve the utilisation of hospital resources.

Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.







Keywords Length of stay · Spine surgery · Degenerative disorders of the cervical and thoracic/lumbar spine · Non-medical predictors

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00586-019-06209-5) contains supplementary material, which is available to authorized users.

Extended author information available on the last page of the article

Introduction

Inpatient stays after orthopaedic surgery can be very costly, with the use of hospital resources such as equipment, staffing and bed capacity all being related to the LOS. The LOS is a metric that is commonly used to plan resource utilisation and to monitor the quality of care. Generally, LOSs have decreased steadily over the years as a result of surgical innovations and improvements in perioperative management [1, 2]. Shorter LOSs are also being promoted in systematic developments such as the introduction of prospective payment systems and diagnosis-related groups for hospital reimbursements [3], which ensure payment of a given amount for a procedure regardless of the hospitalisation episode. However, hospitals are constantly under clinical and financial pressure to become more cost efficient and LOS is a common target for cost-containing initiatives. Intuitively, the decision to discharge a patient after surgery should be a medical one. The type and extent of surgery, as well as various intraoperative variables, will play a role in how a patient feels after the operation and how long their hospital stay will be. A longer, more complex surgery, with a greater level of surgical invasiveness [4] can be expected to result in a longer stay than would a shorter, more straightforward surgery. However, surgical variables are likely not the only factors governing the LOS; for any given procedure, with its given degree of complexity, various non-surgical and even non-medical factors can also be expected to play a role and partially account for inter-individual differences in LOS.

Only few data are available on non-medical or socio-demographic/socio-economic (SDE) predictors of LOS in relation to spine surgery. In addition, some of the existing data are inconsistent. Previous studies retrospectively reviewing factors related to prolonged LOS have identified increased age as an important factor, explained by the fact that aged tissue takes physiologically longer to heal and older patients may be less able to function independently at home upon discharge. Other non-medical factors such as insurance status, race/ethnicity or geographic location were found to be significant predictors of prolonged LOS in anterior cervical spine procedures [5]. Female gender has been found to be a significant predictor of LOS in some studies [6, 7] whilst other reports have found no relationship between gender and LOS [8]. Often, the identification of a given variable as a risk factor (or not) is influenced by the inclusion, in the model, of other closely related or "proxy" measures of that variable. Furthermore, some of the prior LOS studies in the spine literature have substantial limitations such as small sample sizes with inadequate statistical power, examination of just one specific pathology, or a study design in which important medical confounders of LOS were not included in the predictor models [7, 9].

Against this background, the present study sought to determine the influence of non-medical factors on LOS after surgery for degenerative spine disorders. It involved the data from a large consecutive series of patients, collected over 13 years, and made use of multivariable regression models to account for a high quality set of potential confounders such as the invasiveness of surgery, surgical complications and other intraoperative factors.

Patients and methods

The study was a retrospective analysis of data that had been collected prospectively from consecutive patients operated in our Spine Centre, part of a tertiary care orthopaedic hospital in Switzerland. The data were collected in our local spine outcomes database between 2005 and 2017 using the framework of the EUROSPINE Spine Tango Registry (https://www.eurospine.org/spine-tango.htm) and were supplemented with additional data (insurance status, nationality, etc.) systematically imported into the database from the clinic information system. The use of this routinely collected data, given with the patients' informed consent, was approved by the Ethics Committee (KEK-ZH-Nr 2014-0418).

We identified 13,368 consecutive patients who were documented as having undergone spine surgery for degenerative diseases of the spine, with either a primary intervention or revision surgery. The cervical interventions primarily included anterior or posterior fusion (± instrumentation) procedures. Thoracic/lumbar interventions included posterior decompression and/or spondylodesis with rigid stabilisation either with posterior and/or interbody fusion (open or mini-open/MISS), as well as complex deformity corrections. Overall, 10,770 of 13,368 patients were retained in complete case analyses (19% lost due to missing data, i.e. "listwise deletion"; Fig. 1). Their characteristics are described in Table 1.

Of the variables documented in the local database, predictors of LOS (i.e. number of days from surgery to discharge) were chosen based on the available literature, and were categorised into blocks representing particular stages of the clinical pathway: (1) non-medical patient characteristics; (2) preoperative medical patient characteristics; (3) surgical details; (4) perioperative outcomes. The patient demographics and variables considered in the analysis are illustrated in Table 1. Non-medical patient characteristics comprised age, sex, BMI, smoking status, nationality and insurance status. Preoperative medical characteristics included the Core Outcome Measures Index (COMI) [10] preoperative score (measure of symptoms/disease burden/reduced quality of life before surgery), region operated (cervical vs. thoracic/lumbar spine), morbidity state (American Society

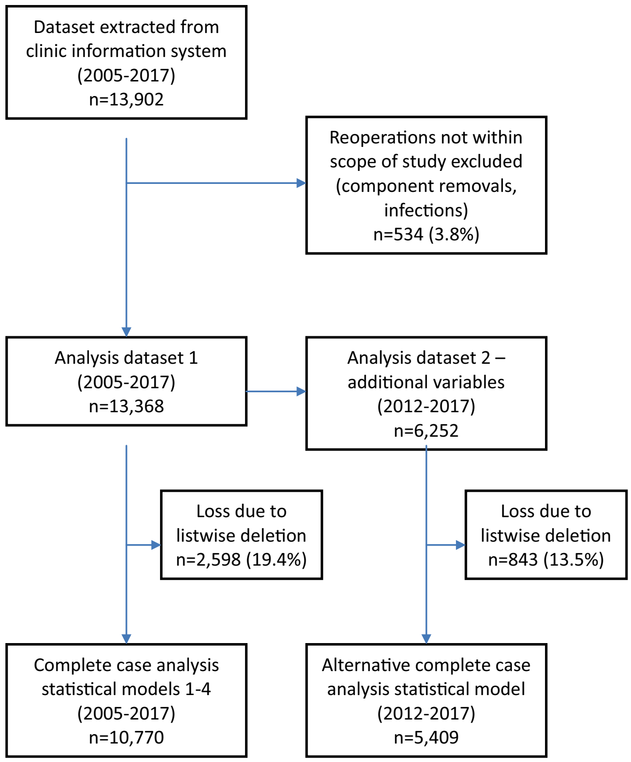


Fig. 1 Data flow diagram

of Anesthesiologists (ASA) class [11]), number of affected segments, and previous surgery involving the same spine level. It must be noted that there was an unknown degree of uncertainty around the spinal level of the repeat surgical procedures included in the analysis because this item is not specifically measured in Spine Tango for each recorded instance of repeat surgery (only "number of previous surgeries" and whether "any previous surgery done on the same level"). An assumption was therefore made that cases of multiple repeat procedures were likely to involve the same level repeatedly, and the predictor was constructed accordingly. It is shown in the models with the caveat "at least one previous surgery involving same level". As the predictor derived this way exhibited qualities suggesting a degree of ordinality in the initial statistical models, it was retained despite the limitation. Surgical procedures were characterised by whether instrumented fusion was used or not and whether the surgery was conventional or minimally/less invasive (MISS/LISS). In a subset of data collected using a later iteration of the Spine Tango form, introduced in 2012 (Fig. 1), more detailed surgical information was available, allowing calculation of a surgical invasiveness index score for each case (based on the formulae of Mirza et al. [4]). This represented a composite score, given by the number of levels operated and whether anterior and/or posterior decompression, fusion and/or stabilisation procedures had been carried out. The rich set of potential predictors was completed by the perioperative outcome variables blood loss, duration of surgery, general medical complications and surgical complications arising during surgery and before discharge, as documented on the Spine Tango form.

The local registry data represented a nearly complete record (99% coverage) of all relevant surgical procedures in the target period and the missing 1% were not expected to bias the results in either direction. The 19% cases excluded from the analysis by listwise deletion of those without a full complement of predictor variables appeared to be a random sub-sample of all potential participants, based on observable characteristics.

The data set was analysed through a series of stepwise linear regression models. We entered the aforementioned blocks of variables sequentially, retaining or dropping variables after each step. Predictors were retained in models if they showed at least borderline statistical significance ($p < 0.1$) and if they proved generally robust in the context of a growing number of covariates. The distributional properties of the outcome variable made it suitable for standard linear regression (Gaussian distributional assumption/identity link function), resulting in model residuals following an approximately normal distribution. Alternative GLM specifications were initially considered but deemed unnecessary. Continuous predictors were entered as centred variables, where this was deemed useful in order to facilitate model interpretation. This allowed interpretation of the constant as the predicted length of stay for an "average" patient with reference values of the categorical predictors. All analyses were done in Stata 15.1.

Results

The mean (± SD) LOS was 7.9 ± 5.2 days. The main regression models are shown in Table 2. Model 1 includes the non-medical patient characteristics age, sex and BMI. The latter accounted for 13% of variance. We also tested for effects of smoking status, nationality (Swiss vs. other nationality) and type of health insurance, each of which was statistically insignificant. Preoperative medical patient characteristics were added in model 2, and showed that LOS was associated strongly and positively with previous surgeries, COMI score, morbidity and the number of affected spinal segments. The model's predictive power improved to explain nearly 23% of variance. Key surgical details were added in model 3. The number of cases in which MISS/LISS procedures were used was very small (see Table 1), but minimally invasive procedures were nonetheless associated with reduced LOS (− 1.5 days), whilst the use of rigid stabilisation was associated with a pronounced increase of LOS (+ 3.8 days). The final model included a set of perioperative outcomes:

Table 1 Predictor variables as used in the statistical models ($n = 10{,}770$)

Continuous	Mean (SD)	Median (min–max)
Age at OP	62.3 (14.5)	64 (6–94)
BMI score	26.4 (4.7)	26 (13–56)
COMI pre-score (0 (best) to 10 (worst) status)[a]	7.5 (1.9)	7.9 (0–10)[b]
Duration of surgery (h)	2.7 (1.7)	2.5 (0.5–10)
Invasiveness Index based on using Spine Tango formula (relevant data available from 2011; $n = 5409$)	7.9 (8.9)	6.0 (0–84)
Categorical	***n***	**%**
Sex		
Male	5056	47.0
Female	5714	53.0
Smoker[b]		
No	7540	74.7
Yes	2550	25.3
Nationality[b]		
Swiss	9429	87.5
Other	1341	12.5
Insurance status[b]		
Privately insured	3184	29.6
Semi-privately insured	2890	26.8
General public insurance scheme	4696	43.6
Previous surgery involving same level		
None	8034	74.6
1 involving same level	1495	13.9
2 (at least one involving same level)	678	6.3
3 or more (at least one involving same level)	563	5.2
Spine location		
Cervical	1663	15.4
Thoracic or lumbar	9107	84.6
Morbidity state (ASA)		
No disturbance	2142	19.9
Mild/moderate	5490	51.0
Severe or worse	3138	29.1
Type of surgery		
Conventional techniques	10,515	97.6
MISS or LISS	255	2.4
Extent of lesion (number of affected levels)		
1 segment	5202	48.3
2–3 segments	4705	43.7
4–5 segments	640	5.9
6 or more segments	223	2.1
Rigid stabilisation (anterior or posterior)		
No	5323	49.4
Yes	5447	50.6
Blood loss		
< 100 ml	2593	24.1
100–500 ml	6090	56.6
500–1000 ml	1295	12.0
More than 1000 ml	792	7.4

Table 1 (continued)

Categorical	*n*	%
Any general medical complication[c]		
No	9956	92.4
Yes	814	7.6
Any surgical complication[d]		
No	9885	91.8
Yes	885	8.2

[a]0.19% of patients reported a baseline COMI score of 0, and 0.56% of ≤ 1. These scores may seem unlikely, but we have no reason to assume that the responses are invalid. COMI is a self-report measure and thus contains subjective elements. Moreover, most of these patients had conditions that are not typically very symptomatic in terms of pain and disability but are at risk of serious progression if not treated, e.g. early cervical myelopathy

[b]These covariates were not retained in the final models due to statistical insignificance and instability likely caused by multi-collinearity (smoking status and insurance status correlate with age)

[c]General medical complications documented on the Spine Tango form included: anaesthesiological, cardiovascular, pulmonary, cerebral, kidney/urinary, liver/GI, death, other

[d]Surgical complications included: wrong level, vascular, neurological, implant malposition, dural tear, wound infection, implant failure, other. An alternative statistical model in which we specifically included the detailed complication information (i.e. the different complication types) did not change the overall findings regarding the significant predictors

in addition to the amount of blood loss and the duration of surgery, we observed particularly strong effects for the presence of a general medical complication (+ 2.2 days) and of a surgical complication (+ 4.3 days). Predictive power peaked at nearly 43% of variance, and the predictors included in previous steps generally retained their effect directions, although they naturally revealed gradually reducing effect sizes. Notably, female patients, even after controlling for a large set of covariates that were strong determinants of LOS, had a systematically longer LOS than male patients (+ 1.1 days). Further, interaction analysis of model 4 (details not shown) revealed that the influence of sex on LOS varied somewhat by age group. Table 2 shows the average effect over the entire age distribution, and, whilst an effect was present in all age groups, it was shown to increase with age: in the age group under 45 years, women stayed 0.86 days longer than men; in the age group 45–64 years, 1.02 days longer; and in the age group 65+ years, 1.29 days longer.

The "average patient" in model 4 (a male recipient of back surgery of average age and BMI with a low risk profile, e.g. no complications or previous surgery, low blood loss and an uncomplicated standard surgical approach) was predicted to spend 4.8 days in hospital (model constant).

An alternative model specification relying on the more parsimonious invasiveness index (replacing the individual variables MISS, rigid stabilisation, number of affected levels, blood loss and duration of surgery)[1] showed the same significant predictors as the full model, but previous surgery had a higher degree of stability in the model, the effect of BMI achieved statistical significance, and gender still showed approximately the same effect size, with females having + 1.2 days longer LOS than males (Table 3).

Finally, given the long observation period (2005–2017), additional tests were carried out for possible effects of time. However, whilst mean LOS varied from year to year there was no clear trend towards either lower or higher LOS and no effect could be detected in the statistical models (controlling for individual years or pooled time periods).

Discussion

This study was designed to determine the influence of non-medical factors on LOS after surgery for degenerative spinal disorders whilst controlling for known medical and surgical determinants of LOS. Female gender and age, in particular, and (depending on the model in question) BMI were each found to be significantly and independently associated with a longer LOS, whilst insurance status, being of Swiss nationality, and being a smoker were non-significant. The non-medical factors accounted for almost one-third of the total variance in LOS explained by the model.

We intentionally included all relevant medical/surgical factors in our predictor models in order to ascertain the unique influence of the socio-demographic/socio-economic factors. The effect of age was not simply a reflection of greater comorbidity or a higher incidence of complications, since these factors were controlled for in the models by inclusion of the ASA grade [12] and the presence of

[1] Calculation of this score was only possible for the data collected since 2012 (see earlier), and therefore the model is based on a smaller, more recent sub-sample of patients ($n = 5{,}409$) (Fig. 1).

Table 2 Main regression models (full data set)

Variables	Model (1)		Model (2)		Model (3)		Model (4)	
	Coefficient [95% CI]		Coefficient [95% CI]		Coefficient [95% CI]		Coefficient [95% CI]	
Age at OP (centred)	0.10***	[0.098–0.11]	0.058***	[0.050–0.065]	0.064***	[0.057–0.071]	0.060***	[0.053–0.066]
Sex: female	1.91***	[1.73–2.10]	1.70***	[1.52–1.88]	1.12***	[0.95–1.28]	1.11***	[0.96–1.27]
BMI score (centred)	0.096***	[0.077–0.12]	0.036***	[0.017–0.055]	0.038***	[0.020–0.056]	0.015*	[−0.0011 to 0.032]
Previous surgery involving same level								
None = reference								
1 involving same level			0.67***	[0.41–0.92]	−0.017	[−0.26 to 0.22]	−0.28**	[−0.51 to −0.061]
2 (at least one involving same level)			1.68***	[1.32–2.05]	0.55***	[0.21–0.89]	0.17	[−0.15 to 0.49]
3 or more (at least one involving same level)			1.96***	[1.56–2.35]	0.83***	[0.46–1.21]	0.46***	[0.12–0.81]
COMI pre-score (centred)			0.18***	[0.13–0.22]	0.15***	[0.11–0.20]	0.12***	[0.075–0.16]
Spine location								
Thoracic/lumbar = reference								
Spine location: cervical			−1.49***	[−1.74 to −1.24]	−3.01***	[−3.26 to −2.77]	−2.19***	[−2.43 to −1.95]
Morbidity state (ASA)								
No disturbance = reference								
Morbidity state (ASA): mild/moderate			0.78***	[0.52–1.05]	0.017	[−0.23 to 0.26]	−0.11	[−0.34 to 0.12]
Morbidity state (ASA): severe or worse			2.24***	[1.92–2.57]	1.41***	[1.11–1.72]	0.89***	[0.61–1.18]
Extent of lesion								
1 segment = reference								
Extent of lesion: 2–3 segments			1.19***	[1.00–1.38]	0.88***	[0.70–1.05]	0.39***	[0.22–0.56]
Extent of lesion: 4–5 segments			2.71***	[2.33–3.09]	2.36***	[2.01–2.72]	0.93***	[0.58–1.27]
Extent of lesion: 6 or more segments			4.53***	[3.90–5.15]	3.49***	[2.91–4.07]	1.55***	[0.99–2.11]
Type of surgery: conventional technologies = reference								
Type of surgery: MISS or LISS					−1.46***	[−1.99 to −0.93]	−1.17***	[−1.67 to −0.67]
Rigid stabilisation (anterior or posterior)					3.79***	[3.61–3.97]	2.34***	[2.11–2.56]
Blood loss								
< 100 ml = reference								
Blood loss: 100–500 ml							0.57***	[0.36–0.77]
Blood loss: 500–1000 ml							1.49***	[1.16–1.83]
Blood loss: more than 1000 ml							1.61***	[1.19–2.03]
Duration of surgery (centred)							0.42***	[0.34–0.50]
Any general medical complication[a]							2.23***	[1.94–2.52]

Table 2 (continued)

Variables	Model (1)		Model (2)		Model (3)		Model (4)	
	Coefficient [95% CI]		Coefficient [95% CI]		Coefficient [95% CI]		Coefficient [95% CI]	
Any surgical complication[a]							4.25***	[3.97–4.53]
Constant	6.81***	[6.67–6.94]	5.03***	[4.77–5.29]	4.72***	[4.48–4.97]	4.83***	[4.54–5.12]
Observations	10,770		10,770		10,770		10,770	
Adjusted R-squared	0.131		0.226		0.333		0.424	

[a] An alternative statistical model in which we specifically included the more detailed complication information (i.e. the different complication types) did not change the overall findings regarding the significance of the other variables explaining LOS

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

medical/surgical complications as documented on the Spine Tango form. Instead, it is likely that the finding is explained by older people recovering more slowly from surgery and anaesthesia (as well as from any associated complications), with older tissue taking longer to heal. The effect of age may also reflect a sociological component, in that older patients may be considered less able to function independently at home upon discharge. Our findings regarding age as a predictor of LOS are in line with almost all previous studies [7, 8, 13–15]. Age, of course, is not a modifiable risk factor, and hence there are few practical implications that can emerge from this finding; nonetheless, knowledge of the independent influence of age on LOS could allow for better discharge planning and the consideration of less costly alternatives for postoperative care.

A significant finding from our study was that gender seemed to play a relevant role in governing LOS. The effect was consistent across different age groups, although more marked in older patients. All else being equal, LOS was just over one day longer for women undergoing spine surgery than for men. A similar gender difference in LOS has been reported before, in two small studies in the spine literature [7, 9] and also in studies of patients undergoing shoulder [16], knee or hip surgery [17], although it has not been a consistent finding in all [5, 18] and few studies have demonstrated an effect beyond that mediated by an increase in complications in women. A very recent analysis of the NSQIP database by Heyer et al. [19] also reported that female patients stayed significantly longer in hospital. The authors hypothesised that this may have been due to the greater need for blood transfusion, higher incidence of urinary tract infections (UTIs), or more dependent preoperative status of women necessitating subsequent discharge to nursing or rehabilitation facilities; however, despite having measured these explanatory variables, they did not go on to include them in a multivariable model to test their hypothesis with respect to LOS [19]. In our study, complications as well as preoperative status were included in the multivariable model in which female gender still exerted an independent effect on LOS, and hence these factors are unlikely to account for our findings. We were unable to account for the severity of complications, and, if women had suffered more severe complications than men, this could possibly have explained their longer LOS; however, at least based on the types of complications recorded, there was no evidence to suggest that this was the case. Another possible explanation for why women stay longer in hospital after surgery is that more elderly women than men tend to live alone, since men have a shorter life expectancy. A lack of family support has been shown to be associated with a prolonged LOS [20]. A further possible explanation is that women typically experience slightly higher pain levels than men after surgery and for some degenerative disorders may be less satisfied with the

Table 3 Alternative regression model using invasiveness index (calculable in data collected after 2012)

Variables	Coefficient [95% CI]	
Age at OP (centred)	0.055***	[0.044–0.065]
Sex: female	1.15***	[0.91–1.40]
BMI score (centred)	0.059***	[0.034–0.085]
Previous surgery involving same level		
None = reference		
1 involving same level	− 0.0064	[− 0.35 to 0.34]
2 (at least one involving same level)	0.86***	[0.38–1.35]
3 or more (at least one involving same level)	0.86***	[0.34–1.39]
COMI pre-score (centred)	0.12***	[0.052–0.18]
Spine location: thoracic/lumbar = reference		
Spine location: cervical	− 1.34***	[− 1.68 to − 1.01]
Morbidity state (ASA): no disturbance = reference		
Morbidity state (ASA): mild/moderate	0.34	[− 0.072 to 0.75]
Morbidity state (ASA): severe or worse	1.18***	[0.69–1.67]
Any general medical complication	2.46***	[1.96–2.95]
Any surgical complication	5.83***	[5.42–6.25]
Invasiveness index[a]	0.22***	[0.21–0.24]
Constant	4.27***	[3.87–4.66]
Observations	5409	
Adjusted R-squared	0.393	

[a]Based on the formulae of Mirza et al. [4] but calculated on the basis of the fields completed on the Spine Tango Surgery form

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

surgical result [21], leading the medical team to err on the side of caution, delaying discharge to allow longer for recovery. In the past, women were considered to be the weaker sex and this idea might still prevail in the minds of either patients or doctors, biasing their appraisal of readiness for discharge. Interestingly, a previous study showed that spine surgeons tend to over-rate the 12-month outcome in men more so than in women, in comparison with the patient's own ratings [22]. Whether or not this is also the case in the early stages after surgery remains to be known. A previous study showed that a lack of paid employment was significantly associated with a longer hospital stay after spine surgery [23]; although the findings were not specifically related to gender, women are still less likely to be in paid employment than men. It is also conceivable that the "working man" wishes to get back to his comfortable home environment more readily than does the "home-maker" wife, for whom a return to home effectively constitutes a return to work. Policy makers may wish to clarify the possible explanations for the gender difference and evaluate whether less costly social (rather than medical) care could be used to assist with earlier discharge in women. Discharge planning prior to admission with a focus on a clear endpoint in the patient's care could ensure that all the support processes are in place to help the discharge happen in a timely fashion [24].

In the present study, BMI had a slight (but in most models statistically significant) influence on LOS. The impact of a higher BMI or obesity on LOS is controversial, and may depend on the other variables included in the given predictor models. Obesity may increase the risk of postoperative complications, exerting its effect through greater comorbidity or by simply making access to the surgical site more difficult. In the present study, these covariates were controlled for in our model, perhaps minimising any effect of BMI per se. Kalanithi et al. [25] showed that spinal fusion patients who were morbidly obese were at significantly increased risk of a longer hospital stay, generating greater hospital charges. Possibly, in this respect, preoperative weight loss programmes or lifestyle modification counselling may prove cost-effective and at the same time allow patients to benefit from improved postoperative outcomes. However, in the very obese, the necessary weight loss may be difficult to achieve, and if it requires closely supervised programmes and/or other medical interventions, then this may offset any potential savings in terms of LOS.

Factors such as smoking status, nationality and health insurance were not significantly associated with LOS in our study. The literature is inconsistent regarding the influence of smoking status on LOS. Using adjusted analysis, Seican et al. [26] reported that prior smokers undergoing elective spine surgery were significantly more likely to have prolonged hospitalisation and major complications compared with never smokers. It is unclear why smoking showed no significant effect in the present study. We documented current smoking habit rather than a history of smoking, and it was based on self-declaration at the time of surgery; possibly, social desirability bias or the adoption of a period of smoking cessation just prior to surgery may have influenced the accuracy of the responses. That nationality and health insurance had no significant effect on LOS was encouraging, and suggested equitable hospital policy was in place with regard to this aspect of care.

Despite including a large sample of data, collected systematically on a prospective basis over many years, our study has certain limitations that require mention. First, it is based on a secondary analysis of registry data supplemented with other routinely collected clinical data and, as such, data items were not specifically provided and designed to answer the research question. Additional important confounders may have been omitted by virtue of the study design. Also, it involved the data from just one orthopaedic hospital in Switzerland. The results should ideally be confirmed in a multicentre study. This could be done using data collected with the same documentation forms from other reliable centres in the EUROSPINE Spine Tango registry, and employing the exact same approach to the statistical models. Whilst the extent of surgery and predominant surgical technique (instrumented fusion or not; use of MISS) were controlled for in the model, the degenerative disorders were only grouped as either cervical or thoracic/lumbar, without further differentiation or comparison between diagnoses or specific operative procedures. This will be addressed in our future studies, to create more detailed surgical models. Although standardised forms were used for data collection, there may have been inconsistencies in documentation between the different surgeons. And finally, a variable that was not included in the present study but that has been shown to be relevant in relation to LOS is the discharge destination [27]. In terms of achieving a more complete understanding of how non-medical factors affect LOS, the postoperative circumstances the patient has to face, such as going into a rehabilitation program or going home to live alone, should be known.

Compliance with ethical standard

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Pumberger M, Chiu Y-L, Ma Y et al (2012) National in-hospital morbidity and mortality trends after lumbar fusion surgery between 1998 and 2008. J Bone Joint Surg Br 94-B:359–364. https://doi.org/10.1302/0301-620x.94b3.27825
2. Sivasubramaniam V, Patel HC, Ozdemir BA, Papadopoulos MC (2015) Trends in hospital admissions and surgical procedures for degenerative lumbar spine disease in England: a 15-year time-series study. BMJ Open 5:1–7. https://doi.org/10.1136/bmjopen-2015-009011
3. MedlinePlus Medical Encyclopedia (2013) Health care financing trends. Health Care Financ Rev 9:127–132
4. Mirza SK, Deyo RA, Heagerty PJ et al (2008) Development of an index to characterize the "invasiveness" of spine surgery. Spine (Phila Pa 1976) 33:2651–2661. https://doi.org/10.1097/brs.0b013e31818dad07
5. Alosh H, Li D, Riley LH, Skolasky RL (2015) Health care burden of anterior cervical spine surgery. J Spinal Disord Tech 28:5–11. https://doi.org/10.1097/bsd.0000000000000001
6. Saltzman BM, Basques B, Leroux T et al (2018) The influence of gender on early adverse events, hospital charges and length of stay after shoulder arthroplasty. Int Orthop 42:149–155. https://doi.org/10.1007/s00264-017-3547-6
7. Arnold M, Rice LR, Anderson KK et al (2011) Factors affecting hospital length of stay following anterior cervical discectomy and fusion. Evid Based Spine-Care J 2:11–18
8. Basques BA, Fu MC, Buerba RA et al (2014) Using the ACS-NSQIP to identify factors affecting hospital length of stay after elective posterior lumbar fusion. Spine (Phila Pa 1976) 39:497–502. https://doi.org/10.1097/BRS.0000000000000184
9. Sultan AA, Berger RJ, Cantrell WA et al (2019) Predictors of extended length of hospital stay in adolescent idiopathic scoliosis patients undergoing posterior segmental instrumented fusion. Spine (Phila Pa 1976) 44:715–722. https://doi.org/10.1097/BRS.0000000000002919
10. Mannion AF, Porchet F, Kleinstück FS et al (2009) The quality of spine surgery from the patient's perspective. Part 1: the core outcome measures index in clinical practice. Eur Spine J 18:367–373. https://doi.org/10.1007/s00586-009-0942-8
11. De Cassai A, Boscolo A, Tonetti T et al (2019) Assignment of ASA-physical status relates to anesthesiologists' experience: a survey-based national-study. Korean J Anesthesiol 72:53–59. https://doi.org/10.4097/kja.d.18.00224
12. Bjorgul K, Novicoff WM, Saleh KJ (2010) American society of anesthesiologist physical status score may be used as a comorbidity index in hip fracture surgery. J Arthroplasty 25:134–137. https://doi.org/10.1016/j.arth.2010.04.010
13. Nie H, Hao J, Peng C, Ou Y (2013) Clinical outcomes of discectomy in octogenarian patients with lumbar disc herniation. Clin Spine Surg 26:74–78
14. Zheng F, Cammisa FP, Sandhu HS et al (2002) Factors predicting hospital stay, operative time, blood loss, and transfusion in patients undergoing revision posterior lumbar spine decompression, fusion, and segmental instrumentation. Spine (Phila Pa 1976) 27:818–824
15. Gruskay JA, Fu M, Basques BA et al (2016) Factors affecting length of stay and complications after elective anterior cervical discectomy and fusion national surgical quality improvement project database (ACS NSQIP). J Spinal Disord Tech 29:34–42
16. Dunn JC, Lanzi J, Kusnezov N et al (2015) Predictors of length of stay after elective total shoulder arthroplasty in the United States. J Shoulder Elb Surg 24:754–759. https://doi.org/10.1016/j.jse.2014.11.042
17. Husted H, Holm G, Jacobsen S (2008) Predictors of length of stay and patient satisfaction after hip and knee replacement surgery: fast-track experience in 712 patients. Acta Orthop 79:168–173. https://doi.org/10.1080/17453670710014941
18. Herren C, Aghayev E, Kaulhausen T et al (2014) Einflussfaktoren auf die Verweildauer in der WirbelsäulenchirurgieInfluencing

factors on the length of stay in lumbar spine surgery. Orthopade 43:1043–1051. https://doi.org/10.1007/s00132-014-3033-4
19. Heyer JH, Cao N, Amdur RL, Rao RR (2019) Postoperative complications following orthopedic spine surgery: Is there a difference between men and women? Int J Spine Surg 13:6017. https://doi.org/10.14444/6017
20. Shelton W, Moore CD, Socaris S et al (2010) The effect of a family support intervention on family satisfaction, length-of-stay, and cost of care in the intensive care unit. Crit Care Med 38:1315–1320. https://doi.org/10.1097/CCM.0b013e3181d9d9fe
21. Pochon L, Kleinstück FS, Porchet F, Mannion AF (2016) Influence of gender on patient-oriented outcomes in spine surgery. Eur Spine J 25:235–246. https://doi.org/10.1007/s00586-015-4062-3
22. Porchet F, Lattig F, Grob D et al (2010) Comparison of patient and surgeon ratings of outcome 12 months after spine surgery. J Neurosurg Spine 12:447–455. https://doi.org/10.3171/2009.11.spine09526
23. Walid MS, Robinson ECM, Robinson JS (2011) Higher comorbidity rates in unemployed patients may significantly impact the cost of spine surgery. J Clin Neurosci 18:640–644. https://doi.org/10.1016/j.jocn.2010.08.029
24. Gonçalves-Bradley DC, Lannin NA, Clemson LM et al (2016) Discharge planning from hospital (review) summary of findings for the main comparison. Cochrane Database Syst Rev. https://doi.org/10.1002/14651858.CD000313.pub5.www.cochranelibrary.com
25. Kalanithi PA, Arrigo R, Boakye M (2012) Morbid obesity increases cost and complication rates in spinal arthrodesis. Spine (Phila Pa 1976) 37:982–988. https://doi.org/10.1097/BRS.0b013e31823bbeef
26. Seicean A, Seicean S, Alan N et al (2013) Effect of smoking on the perioperative outcomes of patients who undergo elective spine surgery. Spine (Phila Pa 1976) 38:1294–1302. https://doi.org/10.1097/BRS.0b013e31828e2747
27. Kulinskaya E, Kornbrot D, Gao H (2005) Length of stay as a performance indicator: robust statistical methodology. IMA J Manag Math 16:369–381. https://doi.org/10.1093/imaman/dpi015

Affiliations

D. Mai[1,2] · C. Brand[2] · D. Haschtmann[1] · T. Pirvu[1] · T. F. Fekete[1] · A. F. Mannion[1]

✉ A. F. Mannion
anne@annefmannion.com

[1] Spine Center, Schulthess Clinic, Lengghalde 2, 8008 Zurich, Switzerland

[2] SwissRDL, Institute of Social and Preventive Medicine (ISPM), University of Berne, Mittelstrasse 43, 3012 Bern, Switzerland