

EUROPEAN REGIONAL DIFFERENCES IN ALL-CAUSE MORTALITY AND LENGTH OF STAY FOR PATIENTS WITH HIP FRACTURE

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SUMMARY

The objective of this study was to compare healthcare performance for the surgical treatment of hip fractures across and within Finland, Hungary, Italy, the Netherlands, Norway, Scotland, and Sweden. Differences in age-adjusted and sex-adjusted 30-day and one-year all-cause mortality rates following hip fracture, as well as the length of stay of the first hospital episode in acute care and during a follow up of 365 days, were investigated, and associations between selected country-level and regional-level factors with mortality and length of stay were assessed.

Hungary showed the highest one-year mortality rate (mean 39.7%) and the lowest length of stay in one year (12.7 days), whereas Italy had the lowest one-year mortality rate (mean 19.1 %) and the highest length of stay (23.3 days). The observed variations were largely explained by country-specific effects rather than by regional-level factors. The results show that there should still be room for efficiency gains in the acute treatment of hip fracture, and clinicians, healthcare managers, and politicians should learn from best practices. This study demonstrates that an international comparison of acute hospital care is possible using pooled individual-level administrative data. Copyright © 2015 John Wiley & Sons, Ltd.

KEY WORDS: hip fracture; length of stay; mortality; regional differences; europe

1. INTRODUCTION

In this international healthcare performance study a disease-focused approach assessing the treatment of hip fracture was used with the advantage of having a consensus around what outcome measures, i.e. mortality, to compare (Häkkinen and Joumard, 2007). Hip fractures are a significant cause of morbidity and mortality worldwide. Hip fractures account for 63–72% of all hospital admissions for fractures in patients aged over 50 years (Ström *et al.*, 2005) and even after the initial hospitalisation, hip fractures continue to generate significant costs throughout the first year after hip fracture (Haentjens *et al.*, 2005). Patients with hip fracture have an excess fivefold to almost eightfold increased risk of all-cause mortality during the first three months after the fracture (Haentjens *et al.*, 2005).

In Medin and colleagues (Medin *et al.*, 2015) it was demonstrated how the European Union 7th Framework Programme European Health Care Outcomes, Performance, and Efficiency (EuroHOPE) patient database can be used to describe similarities and differences in patient characteristics, all-cause mortality rates, and length of stay (LoS) among patients surgically treated for hip fractures, across seven European countries: Finland,

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Hungary, Italy,¹ the Netherlands, Norway, Scotland, and Sweden. The results showed marked differences in mortality and in LoS at the national level as well as at the regional level. In the current study the objectives were to assess associations between selected national-level and regional-level factors and age-adjusted and sex-adjusted 30-day mortality rate, one-year mortality rate, LoS of the first hospital episode in acute care as well as after 365 days following hip fracture surgery in the same seven countries. The paper will start with a presentation of underlying hypotheses for national and regional effects on these measures. Thereafter, the data will be thoroughly described and the data analyses conducted presented. The paper will end with the study results and a discussion.

2. HYPOTHESES

2.1. Country-level effects

2.1.1. Type of funding. Social insurance models and tax-based models have basic ideas such as universal coverage and third-party payments in common but they typically differ along several dimensions such as redistributive efforts, level of integration between payers and providers, and reimbursement methods (Mossialos and Dixon, 2002a; Street *et al.*, 2011). Reimbursement systems are usually described along two dimensions (Jegers *et al.*, 2002): whether the system is prospective or retrospective and whether the funding is activity-based or fixed. During the studied time period all seven countries included in the current study applied prospective payment systems, but some with elements of cost compensation (e.g. in Finland price adjustments from the regions to the municipalities may appear during the fiscal year). Activity-based funding (ABF) systems were used by Hungary, Italy, the Netherlands, and Norway. The Netherlands used diagnosis-related group (DRG)-based funding, while the Norwegian and the Italian models combined ABF based on the DRG system with risk-adjusted capitation. In Sweden, the reimbursement system differed among the counties with a dominance of DRG-based funding. In Finland and Scotland fixed funding systems, i.e. global budgets, were used. We hypothesised that ABF would lead to shorter LoS than fixed-payment systems where the incentives for discharging a patient are absent (Street *et al.*, 2011).

2.1.2. National clinical guidelines. There are no internationally accepted clinical guidelines for how to treat hip fractures. However, Finland, the Netherlands, Norway, Scotland, and Sweden all published national clinical guidelines in the 2000s (Micheleson *et al.*, 2005; van Vugt 2008; Frihagen *et al.*, 2010, Scottish Intercollegiate Guidelines Network, 2009, Socialstyrelsen 2003). Most recommendations focus on the maximum waiting time for surgical treatment (24 h) and on what surgical procedure to use, both of which are believed to be associated with better surgical outcome. The hypothesis is that in countries where clinical guidelines are developed and available, better performance in terms of lower mortality rates and shorter LoS should be presented.

2.2. Regional-level effects

2.1.3. Socio-economic status. Socio-economic status is a well-established factor influencing health outcomes of patients. More specifically there seem to be an association between social deprivation and hip fracture mortality (Quah *et al.*, 2011). Therefore, regions in countries with higher GDP per capita and small socio-economic differences such as Norway, the Netherlands, and Sweden are expected to be associated with lower mortality rate and shorter LoS compared with the other countries.

2.1.4. Distance to hospital. The greater the population density, the higher the probability for short distances to the hospital, shorter preoperative waiting time, and hence lower mortality rates. Also, LoS is assumed to be shorter as patients are assumed to be discharged earlier if they live close to the hospital.

¹Italian data cover the inhabitants of City of Turin and of the provinces in the Lazio region (Frosinone, Latina, Rieti, Roma, and Viterbo).

2.1.4. Practice-makes-perfect. If the practice-makes-perfect theory (Halm *et al.*, 2002) is valid for hip-fracture care, a higher population density, a higher number of hip fracture cases per capita, and a more concentrated healthcare delivery system measured by a higher Herfindahl–Hirschman Index (HHI) for concentration of hip fracture care should have a positive effect on mortality rates and on healthcare resource utilisation. In a study of American patients with hip fracture, it was found that individuals undergoing surgery at hospitals performing a relatively large number of hip fracture surgeries had both shorter LoS and lower probabilities of in-hospital mortality rate than patients at low-volume hospitals (Hughes *et al.*, 1988). However, in Sund and colleagues no clear relationship was found between hospital volume and the effectiveness of hip fracture treatment, but an association between the rehabilitation unit volume and effectiveness was detected (Sund, 2010).

2.1.5. Sex. Finally, as the ratio of women to men suffering from hip fracture has been 3:1 (Thorngren, 1995) and as excess mortality associated with hip fracture is higher in men than in women regardless of age (Haentjens *et al.*, 2005), a variable representing the share of males per region was included. It is assumed that a larger share of males would have a negative effect on mortality.

To summarise, in the regression models it is assumed that the values for mortality and LoS were functions of the following exogenous country-level variables: (i) funding type and (ii) availability of national clinical guidelines as well as of the following regional exogenous variables: (i) GDP per capita; (ii) population density; (iii) HHI; (iv) number of hip fracture cases above 50 years per 100 000 inhabitants; and (v) share of males in the region.

3. METHODS

3.1. Data

Patients were included in the national EuroHOPE comparison databases if they were older than 50 years, had been admitted to hospital inpatient care because of hip fracture and undergone a surgical procedure related to hip fracture surgery between 1 January and 31 December 2007.² Hip fracture was defined using any of the following International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) diagnosis: femoral neck fracture (ICD-9 code 820.00-10 or ICD-10 code S72.0), pertrochanteric fracture (ICD-9 code 820.20-21, 820.30-31, or ICD-10 code S72.1), or subtrochanteric fracture (ICD-9 code 820.22, 820.32, or ICD-10 code S72.2). The surgical procedures included were total or partial prosthetic replacement, internal fixation, or external fixation of the hip joint. The development of the national comparison databases was conducted by using a common protocol and by linking data from the discharge registers to data from other national routinely collected data covering drug utilization and deaths (Häkkinen *et al.*, 2013; Moger and Peltola, 2014). Because it was not possible to pool individual data due to national data regulations, aggregate regional-level measures calculated from the national comparison databases were used. The dependent variables were regional-level age and sex-adjusted mortality rates and LoS, based on the ratio between observed and predicted mortality and LoS in the region. The predicted mortality rates and LoS was acquired with coefficients from a negative binomial regression model (logistic regression), estimated with pooled individual-level data from Finland, Hungary, Italy, and Sweden. LoS was measured as the time from acute care index admission until death or up to 365 days, and it included hospital transfers. Acute hospital care was defined as treatment given in the hospital's intensive care unit, in a medical or a surgical ward. For a full description of the episode approach developed for the EuroHOPE-project, see Häkkinen, Iversen *et al.*, 2013. The following patients were excluded: patients with a LoS involving continuous hospital treatment longer than the 99th percentile, patients younger than 50 years of age, tourists, visitors, and other residents with incomplete personal identity numbers.³

²For Norway data from 1 January to 31 December 2009 were used.

³In Italy, residents of either the Lazio or Piedmont regions with their index admission outside of their regions were excluded.

Data on the national and regional level factors were acquired from the statistical database of the Organisation for Economic Co-Operation and Development and from the national statistics bureaus in each country. The region was defined on the basis of the patient's residence, not of the location of the hospital where the patient was treated. Regions in Finland (17), Italy (6), Norway (18), the Netherlands (10), Scotland (11), and Sweden (20) refer to local authorities responsible for health care, whereas in Hungary (20) region is based on a regional governmental division where public authorities have limited responsibility for healthcare provision, but not funding. For Italy, data from only one region (Lazio, population 5.5 million) and one town (Turin, population 0.9 million) were available. Six regions with less than 100 hip fractures in 2007 were excluded as well as four additional regions from Scotland where data were incomplete.

3.2. Analysis

Regional-level analyses were carried out with pooled regional-level data and risk-adjusted indicators for all countries. Four different responses at the regional level were studied: age and sex adjusted 30-day mortality rate, one-year mortality rate, and age-adjusted and sex-adjusted LoS for first hospital stay in acute care and in one year. First a one-way random-effect analysis of variance (ANOVA) model was used to determine the portion of variance that was because of cross-country differences as opposed to regional differences. Then, the estimations for each of the four dependent variables were performed with a random-intercept model (mixed-effects maximum likelihood regression), using the explanatory variables mentioned previously (M2). If the random intercept model did not show evidence of variation in the intercepts according to the Hausman test, a fixed-effect regression model was used (M1). In addition the country-level fixed effects were replaced with fixed-effects variables describing the funding type as well as the availability of clinical guidelines in a separate model (M3).

4. RESULTS

4.1. Descriptive statistics

Our database covered 59 605 patients with hip fracture from the period 2007,⁴ residing in 102 regions in seven European countries. Figure 1 present the age-standardised and sex-standardised national and regional mortality rates and LoS. At the national level, Hungary showed the highest one-year mortality rate, and at the same time, the shortest LoS in one year whereas Italy had the lowest one-year mortality rate and the longest LoS during the first acute stay as well as in one year. The same pattern was observed for 30-day mortality rate.

The regional-level indicators and regional averages are presented in Table I. The average GDP per capita per region was almost three times higher in Norway than in Hungary where the within country variation was also greatest. There were marked differences in the average population density per region, where the highest value was found in Italy and the lowest in Sweden. The average HHI was highest in Finland and lowest in the Netherlands, whereas Italy had the highest share of patients with hip fracture per region and Finland the lowest share. The situation was the complete opposite when it comes to share of males per region, which was the lowest in Italy and the highest in Finland.

4.2. Country-level and regional-level analysis

The one-way random effects ANOVA indicated that 73% of the variation in age-adjusted and sex-adjusted 30-day mortality rate was between the countries whereas only 27% of the variation was attributable to regional differences. Variation in one-year mortality rate were to 88% attributable to the country level whereas 57% of the variation in risk-adjusted LoS for the first hospital admission and during the first year were attributable to

⁴For Norway data from 1 January to 31 December 2009 were used.

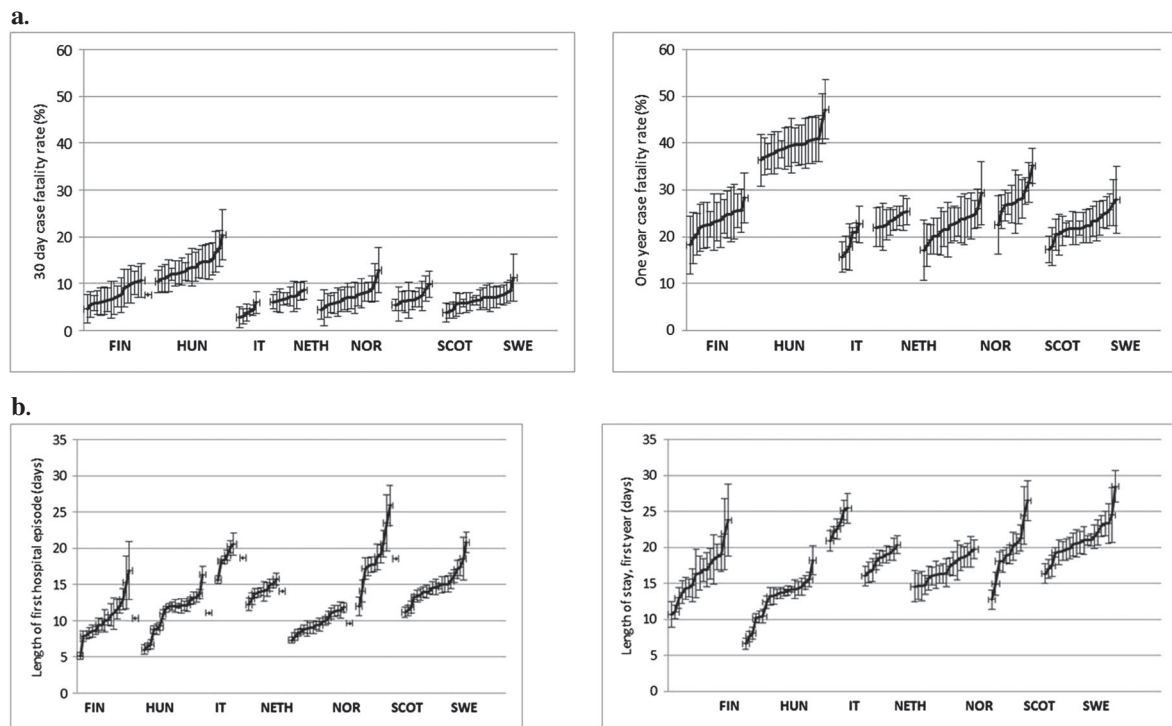


Figure 1. a: National and regional variation in 30-day and one-year mortality rate (%), age-standardised and sex-standardised mortality rates. b: National and regional variation in length of first hospital episode and during one-year (days), age-standardised and sex-standardised rates.

the country level. The Hausman test suggested fixed effect models for the estimations of 30-day mortality rate and the LoS measures and random effects model for the one-year mortality rates.

Fixed budgets did not have any significant effect on mortality or LoS at the national level (Tables II and III). Availability of national clinical guidelines was associated with lower mortality rates and longer LoS in one year, which was according to the expectations. There were significant differences between countries in both mortality and LoS where 30-day mortality rate was 5.4% points higher in Hungary than in Finland (which was included in the reference category). In Italy 30-day mortality rate was 4.6% points lower than Finland and in Sweden 1.3% points lower. The result of the random effect model for one-year mortality rates showed the same trend with the addition of Scotland having a higher rate than the average. The first LoS was 8.5 days longer in Italy compared with in Finland, 7.5 days longer in Scotland, 4 days longer in Sweden, and 3 days longer in the Netherlands. Total LoS in one year was 7 days longer in Italy and 4 days longer in Sweden. In Hungary the total LoS in one year was almost three days shorter compared with Finland. At the regional level a larger share of males was associated with higher 30-day mortality rate in M3. The regional variables did not further explain variances in a statistically significant way.

5. DISCUSSION

The EuroHOPE hip fracture project compared healthcare performance for the treatment of hip fractures across and within seven European countries, i.e. Finland, Hungary, Italy, the Netherlands, Norway, Scotland, and Sweden based on pooled administrative patient-level data, taking into account differences in patient characteristics.

At the national level, comparisons of healthcare units has become increasingly common and in many countries disease-specific quality registers are maintained with the objective of comparing outcomes of medical

Table I. Regional indicators and their regional averages and coefficient of variations of non-adjusted and age-adjusted and sex adjusted mortality rate, and length of stay

	Finland			Hungary			Italy		
	Avg	SD	CV	Avg	SD	CV	Avg	SD	CV
Number of regions (N)	17	–	–	20	–	–	6	–	–
Regional indicators									
GDP per capita (EUR)	29 816.5	5225.4	17.5	14 562.6	6372.3	43.8	27 262.6	3860.9	14.2
Population density	64.4	169.1	262.8	248.2	703.8	283.5	1379.5	2758.7	200.0
Herfindahl–Hirschman index	0.7	0.2	33.3	0.4	0.1	33.2	0.3	0.2	86.9
Hip fracture/100 000*	306.7	1785	58.2	641.1	500.4	78.1	1268.8	1780.9	140.4
Share of males (%)	30.5	3.2	10.5	30.2	1.9	6.2	23.1	1.4	6.2
Regional averages									
30-day mortality rate (%)	7.6	2.0	26.5	11.7	2.0	17.5	4.1	1.2	29.2
30-day mortality rate (%), age-and sex adjusted	7.5	1.9	25.8	13.7	2.5	17.9	4.0	1.1	28.6
One-year mortality rate (%)	23.6	2.9	12.2	34.8	2.1	6.1	19.7	3.1	15.7
One-year mortality rate (%), age-and sex adjusted	23.3	2.4	10.5	39.7	2.6	6.5	19.1	2.8	14.5
LOS (days)	10.4	2.8	27.5	10.9	2.6	23.9	18.9	1.7	9.2
LOS (days), age-and sex adjusted	10.3	2.8	27.5	11.1	2.6	23.9	18.7	1.8	9.4
LOS 365 (days)	16.4	3.5	21.3	12.6	2.9	23.0	23.4	1.7	7.5
LOS 365 (days), age-and sex adjusted	16.4	3.5	21.3	12.7	2.9	23.0	23.3	1.8	7.6

Avg = average, SD = standard deviation, GDP = gross domestic product, EUR = euro, CV = coefficient of variation.

*Above 50 years of age.

Table I. (Continued)

	Netherlands			Norway		
	Avg	SD	CV	Avg	SD	CV
Number of regions (N)	10	–	–	18	–	–
Regional indicators						
GDP per capita (EUR)	35 273.0	5267.9	14.9	43 060.7	10 680.2	24.8
Population density	548.7	356.7	65.0	103.6	312.9	302.1
Herfindahl–Hirschman index	0.2	0.1	43.9	0.5	0.3	54.3
Hip fracture/100 000*	713.6	405.6	56.8	314.3	151.9	48.3
Share of males (%)	26.8	1.9	7.3	28.9	2.0	6.8
Regional averages						
30-day mortality rate (%)	7.3	0.7	9.8	8.4	2.5	30.2
30-day mortality rate (%), age-and sex adjusted	7.1	0.8	11.9	7.2	2.0	28.3
One-year mortality rate (%)	24.0	1.4	5.8	25.3	3.8	15.2
One-year mortality rate (%), age-and sex adjusted	23.5	1.3	5.4	22.4	2.9	13.1
LOS (days)	14.2	1.0	7.3	9.8	1.4	13.9
LOS (days), age-and sex adjusted	14.1	1.0	7.3	9.6	1.3	13.8
LOS 365 (days)	18.3	1.4	7.8	17.0	1.7	10.2
LOS 365 (days), age-and sex adjusted	18.3	1.4	7.8	16.9	1.7	10.2

treatments and interventions in healthcare, especially for large and resource-consuming groups as patients with hip fractures. However, national datasets may not be sufficient for discovering new approaches that cost less and are more effective. International studies comparing outcomes across countries or across regions in different countries have been less common, and to our knowledge this is the first multi-national population-level study on hip fracture where register data have been linked and assessed at the individual level and where explanations to differences are addressed. Among the few international studies available there is one where patients with hip fracture were followed in Sweden and in the Netherlands (Berglund-Röden *et al.*, 1994). The results showed that the functional outcome after four months was consistent between the centres studied, but a difference in

Table I. (Continued)

	Scotland			Sweden		
	Avg	SD	CV	Avg	SD	CV
Number of regions (N)	11	–	–	20	–	–
Regional indicators						
GDP per capita (EUR)	31 075.9	9011.4	29.0	31 556.3	4248.1	13.5
Population density	219.4	304.5	138.8	45.6	64.3	141.2
Herfindahl–Hirschman index	0.6	0.3	43.4	0.5	0.2	46.5
Hip fracture/100 000*	524.4	351.7	67.1	703.4	732.8	99.8
Share of males (%)	23.7	2.5	10.6	29.9	2.1	6.9
Regional averages						
30-day mortality rate (%)	7.0	1.5	21.0	7.2	1.4	19.4
30-day mortality rate (%), age-and sex adjusted	6.9	1.4	20.0	6.3	1.2	19.4
One-year mortality rate (%)	28.5	2.8	10.0	24.5	2.8	11.6
One-year mortality rate (%), age-and sex adjusted	28.1	3.3	11.7	22.3	2.4	10.9
LOS (days)	18.7	3.9	20.8	14.8	2.2	14.9
LOS (days), age-and sex adjusted	18.6	3.9	20.9	14.6	2.2	14.9
LOS 365 (days)	19.5	3.8	19.6	20.9	2.7	12.7
LOS 365 (days), age-and sex adjusted	19.5	3.9	19.8	20.7	2.6	12.7

mortality within the first postoperative months was found, which seemed attributable to the operation procedure. In a study from 2002 patients with hip fracture in Budapest (Hungary) were compared with those in Sundsvall and Lund (Sweden) with regards to surgical treatment procedure, rehabilitation, and outcomes (Cserháti *et al.*, 2002). The results showed that less intracapsular and more trochanteric fractures were observed in Budapest and that a larger share of Hungarian patients returned to their homes instead of to a nursing home at discharge. However, the Hungarian mortality rate six months later significantly exceeded that of the Swedish centres (24% versus 15 and 13%). In the current study the differences in mortality between Hungary and Sweden were even higher (39.7% versus 13.3% in six-month mortality rate).

The results of the current study showed that there were remarkable variations in mortality and LoS, across countries and within countries, even after accounting for patient characteristics such as age and sex. One could argue that additional case-mix factors such as pre-fracture mobility and pre-surgery American Society of Anesthesiologists Physical Status would have reduced patient characteristics confounding the results. The variations in mortality rate seemed to be associated with country-level factors such as funding-type, socio-economic status, availability of clinical guidelines, and country-specific effects that remain unexplainable, rather than regional-level factors available for the study. The direction of the effects was the expected for Hungary with higher mortality rate and shorter LoS than in Finland and higher within country variation especially for LoS. Italy had surprisingly lower mortality rates and somewhat longer LoS than expected (please note that the regions included are rich areas). However, there were a number of national-level and regional-level factors that are believed to be associated with lower mortality rate, which unfortunately was not included in the study. For example, there is a belief that a focus on care maps to improve timely surgical intervention, movement toward replacement arthroplasty, a push for earlier weight bearing exercise, better use of prophylactic antibiotics, aggressive medical management, and increased rates of discharge to non-acute healthcare settings (rather than home) may contribute to improvements in mortality (Brauer *et al.*, 2009). However, none of these aspects could be followed in the current study. The causes for differences in LoS across the countries types were most likely because of the different surgical methods and rehabilitation practices for the different fracture types (Sund *et al.*, 2009). Difference in LoS could also arise because of death of the patient (shortens the LoS). In addition, although we attempted to make the content of care given in hospitals comparable between the countries the differences may be related to the fact that patients in some countries were transferred very soon to hospitals not included in our data (i.e. health centres or rehabilitation institutions), whereas in other countries the care in the acute phase may also include rehabilitation and care services.

Table II. Regression results, fixed effects, and random effects models for 30-day and one-year mortality rates (standard errors in brackets)

	Standardised 30-day mortality rate			Standardised one-year mortality rate		
	M1	M2	M3	M1	M2	M3
Intercept	12.578*** (3.113)	11.000*** (2.841)	7.841** (2.811)	24.046*** (17.583,28.179)	26.042*** (4.456)	30.804*** (5.546)
GDP per capita (EUR 1000)	-0.003 (0.003)	-0.004 (0.003)	-0.005 (0.004)	-0.004 (0.005)	-0.005 (0.004)	-0.014 (0.007)
Population density	-0.002 (0.028)	0.003 (0.030)	-0.029 (0.040)	0.035 (0.040)	0.037 (0.041)	-0.048 (0.078)
Herfindahl-Hirschman index	-1.159 (0.979)	-1.071 (1.001)	-1.320 (1.286)	-1.171 (1.400)	-1.175 (1.426)	-3.175 (2.537)
Hip fracture/100 000	-0.039 (0.038)	-0.035 (0.039)	-0.073 (0.050)	-0.004 (0.054)	0.002 (0.055)	-0.059 (0.099)
Share males	-0.103 (0.086)	-0.046 (0.085)	0.201* (0.086)	0.038 (0.124)	0.054 (0.125)	0.298 (0.171)
Dummy for fixed budget			0.610 (0.723)			2.680 (1.427)
Dummy clinical guidelines			-3.936*** (1.002)			-9.914*** (1.978)
Country indicators ^a						
Sweden	-1.308* (0.636)	-0.914* (0.444)		-1.165 (0.911)	-3.106 (2.459)	
Hungary	5.400*** (0.870)	5.553*** (0.895)		15.470*** (1.244)	13.235*** (1.064)	
Italy	-4.572*** (1.215)	-3.798*** (1.009)		-4.938** (1.738)	-6.744** (2.374)	
Netherlands	-1.090 (0.916)	-0.574 (0.482)		-0.238 (1.311)	-2.112 (11.634)	
Norway	-0.433 (0.838)	0.058 (-0.112)		-0.933 (1.199)	-2.718 (3.493)	
Scotland	-1.225 (0.944)	-0.664 (0.512)		5.364*** (1.351)	3.402*** (0.857)	
Finland		0.0339 (0.895)			-1.957 (1.064)	
Adjusted R-squared	0.7208	0.0204	0.4249	0.8794	0.0287	0.5276
F statistics	23.53***	1.00	11.13***	64.65***	0.24	16.32***
Hausman test, chi squared		28.318***			0.511	

GDP = gross national product, EUR = euro, M1 = Fixed effect model, M2 = random effect model, M3 = dummies for tax-based funding, M4 = Dummies for systems with clinical guidelines.

The reference categories in the fixed-effect model are Finland, ABF, and the absence of national clinical guidelines.

^aDummy variables in M1 (reference Finland), random effects in M2.

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

Table III. Regression results, fixed effects and random effects models for length of stay (standard errors in brackets)

	Standardised first LoS			Standardised LoS in one year		
	M1	M2	M3	M1	M2	M3
Intercept	10.225* (4.220)	23.532*** (3.639)	29.761*** (3.585)	15.127** (4.830)	21.631*** (4.016)	23.990*** (3.900)
GDP per capita (EUR 1000)	0.004 (0.004)	-0.000 (0.004)	-0.007 (0.005)	0.005 (0.005)	0.007 (0.004)	0.000 (0.005)
Population density	-0.005 (0.038)	0.009 (0.042)	0.018 (0.050)	-0.017 (0.044)	-0.012 (0.046)	0.020 (0.055)
Herfindahl-Hirschman index	-0.609 (1.326)	-1.428 (1.431)	-1.813 (1.640)	-0.427 (1.518)	-0.704 (1.578)	0.208 (1.784)
Hip fracture/100 000	-0.043 (0.051)	-0.012 (0.056)	0.050 (0.064)	-0.019 (0.059)	-0.004 (0.062)	0.077 (0.070)
Share males	-0.020 (0.117)	-0.325** (0.113)	-0.542*** (0.110)	0.000 (0.134)	-0.194 (0.124)	-0.342** (0.120)
Dummy for fixed budget			-0.283 (0.922)			-1.898 (1.003)
Dummy clinical guidelines			2.092 (1.278)			4.207** (1.390)
Dummy clinical guidelines						
Country indicators ^a						
Sweden	4.232*** (0.863)	1.013*** (0.207)		4.279*** (0.987)	2.534*** (0.584)	
Hungary	1.353 (1.179)	-2.019 (-1.759)		-2.920* (1.349)	-4.373* (2.020)	
Italy	8.507*** (1.646)	4.316*** (0.835)		7.270*** (1.885)	4.508*** (1.169)	
Netherlands	3.350** (1.241)	-0.054** (-0.020)		1.595 (1.421)	-0.258 (-0.230)	
Norway	-1.142 (1.136)	-4.026 (4.005)		0.090 (1.300)	-1.497 (-21.623)	
Scotland	7.539*** (1.279)	3.782*** (0.642)		2.606 (1.464)	0.569 (0.320)	
Finland		-3.012** (-1.759)			-1.482 (2.020)	
Adjusted R-squared	0.5723	0.3194	0.2194	0.5286	0.3145	0.2234
F statistics	12.68***	8.90798***	4.856***	10.79***	8.68***	4.95***
Hausman test, chi squared		52.3425 ***			13.0431 **	

GDP = gross national product, EUR = euro, M1 = fixed effect model, M2 = random effect model, M3 = dummies for DRG systems and existence of national clinical guidelines.

The reference category in the fixed-effect model includes Finland, ABF, and the absence of national clinical guidelines.

^aDummy variables in M1 (reference Finland), random effects in M2.

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

There seemed to be no relationship between GDP and LoS, although there is a wealth of evidence showing that healthcare spending is usually highly correlated with GDP per capita. Higher share of males in the region had a small positive association with higher 30-day mortality rate (in model M3). There was no clear association between GDP per capita, HHI, population density, or number of hip fracture cases per region and mortality rate or LoS. Previous studies on hospital volume and hip fracture outcome have indeed been inconsistent (Luft *et al.*, 1987; Shervin *et al.*, 2007), but one aspect that is known to be of importance for mortality in patients with hip fracture is pre-operative waiting time. Several studies have demonstrated that a delay in surgery increases morbidity and mortality in these patients (Sorbie, 2003; Szita *et al.*, 2002; Sund and Liski, 2005), and it is generally recommended that patients with a hip fracture undergo surgery within 24 h after admission (Royal College of Physicians, 1989). There is also evidence that pre-operative waiting time has an effect on LoS (Olsson *et al.*, 2006; Siegmeth *et al.*, 2005). In addition, researchers have suggested that fast-track treatment for patients with hip fracture, including earlier transfers from the emergency room, would benefit outcomes and contribute to better continuity of care (Larsson and Holgers, 2011; Turesson *et al.*, 2003). Unfortunately, data on lead-times were not available in our dataset.

The use of register data is both a strength and limitation of the study. A major strength of our data is that we were able to combine all hospital discharges of a patient and to extract the acute hospital care of the episodes for the analysis and that all transfers of patients between hospitals and between clinical wards were included. Coding practices and the availability of uniformly defined data affect and constrain any register-based study. One weakness in the register data was the lack of information on aspects known to affect mortality and LoS, such as additional measures at the patient level for case-mix, pre-operative waiting time, post-operative complications (Hommel *et al.*, 2003), and surgical procedure type. Finally, as patients with hip fracture are elderly and in many cases in need of rehabilitation, it would have been useful to include LoS in nursing homes and their related costs.

Despite of many research, the reasons for regional variations in health care are not clearly understood (Skinner, 2011). It is important that doctors, healthcare managers, and politicians are informed of differences in mortality rates and LoS observed within and between countries, and this study can be considered a step towards routine international register-based comparisons of health systems in the treatment of hip fractures.

CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest.

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