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Effects of competition and bundled payment on the performance of hip replacement surgery in Stockholm, Sweden: results from a quasi-experimental study

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ABSTRACT

Objective To evaluate the effects of competition and a bundled payment model on the performance of hip replacement surgery.

Design A quasi-experimental study where a difference-in-differences analytical framework is applied to analyse routinely collected patient-level data from multiple registers.

Setting Hospitals providing hip replacement surgery in Sweden.

Participants The study included patients who underwent elective primary total hip replacement due to osteoarthritis from 2005 to 2012. The final study sample consisted of 85 275 hip replacement surgeries, where the exposure group consisted of 14 570 surgeries (n=6380 prereform and n=8190 postreform) and the control group consisted of 70 705 surgeries (n=32 799 prereform and n=37 906 postreform).

Intervention A reform involving patient choice, free entry of new providers and a bundled payment model for hip replacement surgery, which came into force in 2009 in Region Stockholm, Sweden.

Outcome measures Performance is measured as length of stay of the surgical admission, adverse event rate within 90 days following surgery and patient satisfaction 1 year postsurgery.

Results The reform successfully improved the adverse event rate (1.6 percentage reduction, p<0.05). Length of stay decreased less in the more competitive market than in the control group (0.7 days lower, p<0.01). These effects were mainly driven by university and central hospitals. No effects of the reform on patient satisfaction were found (no significance).

Conclusions The study concludes that the incentives of the reform focusing on avoidance of adverse events have a predictable impact. Since the payment for providers is fixed per case, the impact on resource use is limited. Our findings contribute to the general knowledge about the effects of financial incentives and market-oriented reforms.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study is based on linked patient-level data from several national patient registers covering all orthopaedic departments in Sweden over 8 years.
⇒ Patient-level data were analysed through a quasi-experimental research design where a difference-in-differences analytical framework was applied to estimate the causal effects of a reform involving competition and bundled payment.
⇒ Although we are not aware of such policies during the study period, the results may be biased if an unrelated policy was initiated during or after the reform and affected the performance differently in the regions.
⇒ Until 2008, when information on American Society of Anesthesiologists grade (severity) became available, it was not possible to distinguish clearly between patients who were included in the reform and those who were not.
⇒ We were not able to disentangle whether the effects were driven by increased competition or the introduction of the bundled payment or a combination.

INTRODUCTION

To improve healthcare system performance, many countries have introduced market-oriented reforms focusing on strengthening patient choice and promoting competition between healthcare providers.[1–3] Economic incentives for providers are further important to drive efficiency and improve quality. As a result, healthcare systems have increasingly reformed payment systems to better meet specific health policy objectives.[4]

The evidence on the effects of market-oriented reforms is inconsistent and varies with patient group. For example, recent studies considering the competition-induced reforms in the English National Health Service and their effects on planned care found that competition increased efficiency for hip and knee replacements[5] and had no or negative effects on quality for coronary

artery bypass grafts and hip and knee replacements.[6–8] Similar discrepancies have also been found in the US Medicare system.[9]

It is also important to note that reforms encouraging competition have been introduced with different payment systems and incentives. Effects of innovative payment systems such as add-on payments, bundled payments and population-based payments have been explored in a report from the Organisation for Economic Co-operation and Development (OECD).[4] It was found that several of these payments achieved the intended policy objectives. For example, bundled payments for bypass surgeries and hip and knee replacements in the USA and Sweden improved readmission, mortality and complication rates. Cost savings were also observed for these conditions, mainly achieved by a shorter length of stay (LOS) and fewer readmissions.

With this study, we contribute to the knowledge about the effects of these types of reforms. We consider a 'patient choice reform' for hip and knee replacement surgery, which came into force in 2009 in Region Stockholm, Sweden. Prior to the reform, the system relied mainly on planning mechanisms with limited choice for patients and less competition between providers. Patient selection was mainly based on catchment areas. The payment system was a Diagnosis Related Group (DRG) payment for the hospital resources with no economic consequences for the posthospital period after discharge.

The reform consists of three central elements: free choice of provider for patients, free entry of new providers and bundled payment where the providers receive a package price for the entire cycle of care. A non-price competition with a fixed payment per patient was introduced on the market through the reform, aiming to increase the performance of the providers.[10] The paper aims to assess the effects of this reform on the performance of elective total hip replacement surgery. We make use of indicators capturing aspects of resource use (LOS of surgical admission) and quality (adverse events (AE) within 90 days following the surgery and patient satisfaction measured 1 year postsurgery) to measure performance. We also examine whether the reform had heterogeneous effects across different hospital types.

The effects of this choice reform have previously been examined by Wohlin *et al*.[11] Findings from their study show that waiting times had disappeared and complications rates, resource use as well as costs had declined significantly. Patient-reported outcome measures, such as pain and quality of life postsurgery, however, had remained unchanged. Moreover, providers had made comprehensive changes in the care process, such as reduced the LOS and increased the number of operations per room, team and day. However, as most of their analyses were based on before-and-after comparisons of the outcomes (except for the analysis of complication rates), the causal link was not able to be captured. Our study adds to this existing knowledge by using a nationwide data set covering a longer study period and methods to estimate the causal effects of the reform on all included performance indicators. In addition, we examine the heterogeneity of the effects by hospital type. In contrast to Wohlin *et al*,[11] we analyse the effects on hip replacement surgeries only. Furthermore, in a previous study, using causal analysis, we found no effects of the same reform on the quality of hip replacement surgery as captured by postsurgery patient-reported outcome measures of health gain, pain reduction and patient satisfaction,[12] which is also in line with the findings by Wohlin *et al*.[11]

Setting

The Swedish healthcare system is decentralised and mainly financed through regional income taxes. The responsibility for care delivery lies with the 21 regions. Specialised somatic care is mainly provided by hospitals owned and run by the regions, but also by privately owned hospitals which are publicly financed and regulated.

There are roughly 75 orthopaedic providers performing hip replacement surgery. These providers can be divided into university (n≈9), central (n≈23) and local hospitals (n≈33) as well as private specialised centres (n≈9). There are more than 16 000 primary hip replacement surgeries performed per year and most of these patients suffer from osteoarthritis.[13] The surgery can be considered a standard procedure; however, it does require experience and technical expertise of the orthopaedic surgeon.

Most of the operations are performed at region-owned hospitals; however, the number of operations at private specialised centres is increasing as it is becoming more common to move some of the elective surgery from acute hospitals to specialised centres. In general, orthopaedic providers are reimbursed through the DRG model, either as activity-based funding or as the basis for a budget.

The patient choice reform in Region Stockholm

In Sweden, patient choice policies have in general been limited to primary care, but Stockholm has in addition introduced more than 30 choice models in specialised care. In January 2009, Stockholm introduced patient choice for elective total hip and knee replacement surgery. The reform was targeted to improve quality and efficiency through competition, reduce waiting times, increase patient choice and access, as well as separate low-risk and high-risk patients.[10]

In addition to the freedom of choice of provider for patients, the reform also involves free entry of new providers who fulfil certain criteria. These criteria include, inter alia, that the operating surgeon performs at least 50 operations per year and that the operating room meets certain requirements for air quality and requirements for reporting data on quality indicators. Accredited providers are not limited in production volume.[10] In 2009, there were two university, two central and three local hospitals as well as five private specialised centres in Stockholm.

Only patients with American Society of Anesthesiologists (ASA) grades 1–2 (ie, low-risk patients without other comorbidity causing functional limitations) are given the

opportunity to choose provider. High-risk patients are mainly still operated at central and university hospitals on a separate contract.[10]

Stockholm used a DRG-based reimbursement scheme prior to 2009; however, in connection to the introduction of choice of caregiver, bundled payment was implemented as reimbursement scheme. Hence, the role for the Stockholm region as a public single payer implies non-price competition since clinics compete for patients, with a fixed payment per patient. The bundled payment involves a lump sum payment per patient to providers to cover their cost for a defined care chain, including diagnostics, surgery, postoperative care and follow-up, as well as implant costs. Neither primary care visits, including assessment and referrals, nor postoperative rehabilitation is included in the care chain. Through a complication guarantee, providers are also financially responsible for any AEs occurring within 2 years following the surgery. Conditioning on some performance targets, a few percentages of the bundled payment are retained and providers are only remunerated if they are successful in reaching those targets. The providers are monitored by the region using data on the performance indicators collected from the national quality registries and the local patient administrative system.[10]

MATERIALS AND METHODS

Data

We collected patient-level data from multiple national registers, which were linked through personal identification numbers and thereafter pseudonymised. We identified patients who underwent elective primary total hip replacement due to osteoarthritis from 2005 to 2012 through the Swedish Hip Arthroplasty Register (SHAR). SHAR is one of the oldest national quality registers and have been collecting patient-level data from all orthopaedic departments (including private departments) performing hip replacements in Sweden since 1979. The data collected in the register include information about, for example, patient characteristics (such as age, sex and diagnosis), the prosthesis (eg, type of implant) and reoperations, as well as different patient-reported outcome measures. The register started collecting patient-reported variables from a few departments in the beginning of 2000s, and since 2010 all departments report on this. Before the surgery, patients are asked to respond voluntarily to a questionnaire covering the EQ-5D index, which measures health-related quality of life, a visual analogue scale for health and pain estimation, and questions on, among others, walking ability to determine musculoskeletal joint disease according to the Charnley classification, smoking habits, and whether the patient participated in osteoarthritis school. The patient receives another questionnaire after 1, 6 and 10 years covering the same patient-reported outcome measure items, as well as a supplementary question on satisfaction with the surgery according to the visual analogue scale. For this study, we retrieved information about the surgery, the patient and patient satisfaction from SHAR. Administrative data on patients' hospital inpatient care episodes related to the surgery as well as previous use of inpatient care within 1 year prior to surgery to determine the comorbidity were collected from the patient register. Furthermore, dates of deaths were collected from the Cause of Death Register and information on patients' education and civil status was collected from the Swedish Longitudinal Integrated Database for Health Insurance and Labour Market Studies.

Patients under 18 years of age (n=16), patients who underwent bilateral hip replacement (n=1268) or had a prior hip replacement within 90 days of the surgery (n=570), as well as patients who underwent surgery in a different region from their registered residential region (n=5936) were excluded from the study. Furthermore, patients at a private specialised centre in Stockholm which mainly performs surgery on privately insured patients (n=467) were excluded as they are not affected by the reform. In addition, patients with missing information on any of the covariates (n=571) were also excluded. The final study sample consisted of 85 275 hip replacement surgeries.

Performance indicators

Performance was measured by three indicators to capture aspects of resource use and quality. As a measure describing resource use, we use LOS of the surgical admission (*OP_LOS*), which was calculated as discharge date − admission date + 1, and is based on data from the patient register.

As measures of quality, we defined two binary indicators. The first is based on medical outcomes and indicates whether the patient suffered an AE within 90 days following the surgery (*AE_90D*). The AEs include death, further surgery of the hip and the following complications if they resulted in hospitalisation: pneumonia, ulcers, and cardiovascular, cerebrovascular and thromboembolic complications. This indicator is based on data from SHAR, the patient register and the Cause of Death Register. The second quality indicator is based on patient-reported outcome and indicates whether the patient was satisfied with the outcome of the surgery (*SATISF*). The indicator, collected from SHAR, is measured 1 year postsurgery where a value between 0 and 40 on a visual analogue scale (ranging from 0 to 100) indicates a satisfied patient. The definitions of both quality indicators follow those used by SHAR.[13] While patient-reported outcomes, and the visual analogue scale in particular, have some limitations due to response spreading and visual or cognitive ability, the use in a binary variable based on a cut-off should reduce these concerns. The data on LOS and AEs were available for the whole study period; however, the information on patient satisfaction was only available since 2007. There are other long-term measures available for measuring the quality of elective hip replacement surgery such as health gain, pain reduction and patient satisfaction 1 and 6 years

after the surgery. We decided not to include such long-term quality indicators in this study since an analysis in a previous study by the researcher team showed no effects following the reform for short-term and long-term indicators.[12] Furthermore, a major reason for choosing effects for 90 days (AEs) and 1 year (patient satisfaction) is the nature of the reimbursement principle for the reform. The payment only considers events within 1 year, which has been based on clinical experience.

Analytical approach

As the choice reform was implemented in Region Stockholm only, leaving the other 20 regions in Sweden unaffected, we have a typical set-up for difference-in-difference (DiD) analysis. DiD analysis is a quasi-experimental research design and has become a commonly used method in health settings to estimate causal effects of healthcare policies.[14–18] The method compares changes in an outcome before and after an intervention in the exposed group versus a control group. Confounders that vary across groups are assumed to be time-invariant and confounders that vary over time are assumed to be group-invariant. The parallel trend assumption states that the groups have the same trends in outcomes before the intervention, and in the absence of the intervention the groups would have experienced the same development in outcomes.

To estimate the causal effects of the choice reform on the performance, we constructed repeated cross-sections and performed the DiD analyses using regression modelling. Patients who underwent surgery at hospitals located in Stockholm formed the exposure group and patients at hospitals located in the other regions in Sweden were combined into a control group. As ASA grade was not available from all hospitals prior to 2008, we could not distinguish between patients who were included in the reform and those who were not until 2008. In the main analysis, all patients (low-risk and high-risk) were included. For each performance indicator, we estimated the effects with and without covariates. Included covariates were age group, sex, level of comorbidity as indicated by Elixhauser Comorbidity Index, civil status and educational level.

To validate the parallel trend assumption, we plotted the mean outcomes per group and year.[14–18] We also performed a simple statistical test of the assumption by evaluating the significance of the interaction between time and group in the preintervention period in linear trend models.[14 17 19]

As we have two dichotomous performance indicators (*AE_90D* and *SATISF*) and one indicator based on count data (*OP_LOS*), we normally would apply non-linear models to avoid the problematic features that come with outcome variables with bounded support. However, Lechner[16] concludes that it is problematic to estimate DiD models within the non-linear case as it often leads to inconsistent estimates of the effect. Consequently, as proposed by Lechner,[16] and following Häkkinen *et al*,[20] we used a linear specification in our DiD analyses. Generalised estimating equations were used to solve the linear regression models, while accounting for clustering of patients within hospitals. We collapsed the data into two periods, prereform (2005–2008) and postreform (2009–2012), to avoid problems of serially correlated outcomes.[21]

To examine whether the reform had heterogeneous effects across different hospital types with different patient case-mixes, we also estimated the DiD models stratified by hospital type. Three private specialised centres located within larger acute hospitals with access to intensive care were coded as local hospitals. All statistical analyses were performed in the SAS V.9.4 software.[22]

Sensitivity analyses

First, we limited the analysis to low-risk profile patients as these were the only ones covered by the reform. We considered a subsample consisting of standard, low-risk profile patients who were comprised by the reform (standard patient sample). The sample included patients with ASA grade 1 or 2, age between 55 and 84 years and body mass index (BMI) between 18.5 and 29.9, which is often used as a reference population in SHAR's annual reports to allow for fair comparisons between orthopaedic providers. As information on ASA grade was not available until 2008, we were not able to validate the parallel trend assumption for the standard patient sample. For this reason, we also created a subsample consisting of a proxy of the standard patients (proxy sample). The proxy sample, available from 2005, included patients aged 55–84 years and with no registered comorbidity.

Second, we defined another control group based on patients from two of the other regions in Sweden: Halland and Västra Götaland. These two regions were selected as they had a similar hospital structure, including private specialised centres, as Stockholm before the reform.

Patient and public involvement

Patients and the public were not involved in the design and performance of the study. The study is based on routinely collected patient-level data from multiple registers, and as the results are presented at an aggregated level the patients included in the registers should not be affected by any type of discomfort or integrity infringement.

RESULTS

Trends and descriptive statistics

Descriptive statistics are presented in table 1, and annual and group-specific means of the performance indicators as well as the corresponding estimated counterfactual (ie, what the Stockholm outcomes would have been had they developed over time as the control group did) are presented in figure 1A–C. The level of resource use (*OP_LOS*) declined over time in both groups, overall and by hospital type. Stockholm had a shorter LOS than the other regions, both prereform and postreform, although

Table 1 Descriptive statistics, prereform and postreform, by treatment group

	Region Stockholm				Other regions			
	2005–2008		2009–2012		2005–2008		2009–2012	
Performance indicators	**Mean/%**	**n**	**Mean/%**	**n**	**Mean/%**	**n**	**Mean/%**	**n**
Resource use, mean								
OP_LOS	5.8	6380	5.1	8190	7.4	32 799	6.1	37 906
Resource use by hospital type, mean								
OP_LOS								
University	6.7	859	6.7	918	8.8	2379	7.2	2483
Central	5.6	2272	5.1	1948	7.5	11 853	6.0	14 130
Local	7.0	1644	5.7	2050	7.3	18 249	6.1	20 537
Private specialised	4.4	1605	4.3	3274	4.9	318	4.7	756
Quality, %								
AE_90D	6.3	6380	4.4	8190	4.2	32 799	4.1	37 906
SATISF*	86.9	2581	86.6	7512	88.6	14 235	89.1	34 686
Quality by hospital type								
AE_90D, %								
University	5.7	859	3.5	918	4.5	2379	4.0	2483
Central	8.5	2272	6.2	1948	4.3	11 853	4.8	14 130
Local	5.6	1644	5.2	2050	4.1	18 249	3.7	20 537
Private specialised	4.4	1605	3.0	3274	3.5	318	2.6	756
SATISF*, %								
University	88.7	238	83.6	834	86.5	1004	89.9	2138
Central	87.0	1108	87.4	1737	89.1	5203	89.2	12 888
Local	84.8	650	84.0	1857	88.7	7853	89.2	18 947
Private specialised	88.4	585	88.7	3084	83.4	175	90.3	713
Covariates								
Sex, %								
Female	63.1	4028	62.7	5137	56.9	18 653	57.0	21 594
Male	36.9	2352	37.3	3053	43.1	14 146	43.0	16 312
Age, %								
18–54	8.8	561	9.4	768	8.3	2735	8.8	3319
55–64	26.1	1663	23.0	1887	24.0	7884	22.8	8641
65–74	34.2	2181	38.2	3125	36.0	11 804	38.2	14 496
75–84	26.0	1656	25.0	2051	27.6	9038	26.0	9851
85+	5.0	319	4.4	359	4.1	1338	4.2	1599
Elixhauser Comorbidity Index, %								
0	66.2	4222	69.0	5649	62.4	20 482	53.1	20 120
1	20.0	1274	17.5	1432	22.7	7439	26.6	10 086
2	8.2	526	8.5	695	9.9	3246	13.0	4945
3+	5.6	358	5.1	414	5.0	1632	7.3	2755
BMI†, mean	26.7	1589	26.8	8045	27.4	7027	27.6	35 781
ASA grade†, %								
1	23.5	391	21.9	1790	25.0	1844	24.8	8997
2	58.3	971	56.7	4634	59.8	4416	60.5	21 998
3	17.7	295	20.5	1671	14.9	1100	14.5	5252
4	0.5	9	0.9	75	0.3	24	0.3	96

Continued

Table 1 Continued

	Region Stockholm				Other regions			
	2005–2008		2009–2012		2005–2008		2009–2012	
Performance indicators	Mean/%	n	Mean/%	n	Mean/%	n	Mean/%	n
5	0.0	0	0.0	0	0.0	1	0.0	2
Civil status, %								
Unmarried	11.2	712	12.6	1032	9.4	3081	10.7	4073
Married	50.9	3245	50.4	4128	57.4	18 812	57.1	21 657
Divorced	20.8	1325	21.7	1774	14.9	4897	16.1	6087
Widowed	17.2	1098	15.3	1256	18.3	6009	16.1	6089
Education, %								
Low	29.2	1862	24.1	1975	44.8	14 708	37.7	14 274
Middle	40.9	2610	41.3	3382	37.5	12 305	40.8	15 484
High	29.9	1908	34.6	2833	17.6	5786	21.5	8148
Hospital type, %								
University	13.5	859	11.2	918	7.3	2379	6.6	2483
Central	35.6	2272	23.8	1948	36.1	11 853	37.3	14 130
Local	25.8	1644	25.0	2050	55.6	18 249	54.2	20 537
Private specialised	25.2	1605	40.0	3274	1.0	318	2.0	756

OP_LOS: length of surgical admission; AE_90D: indicator for whether the patient suffered an adverse event within 90 days following the surgery; SATISF: indicator for whether the patient was satisfied with the outcome of the surgery.
*Indicates data available from 2007.
†Indicates data available from 2008.
ASA, American Society of Anesthesiologists; BMI, body mass index; LOS, length of stay.

the other regions seemed to approach Stockholm's level over time. With regard to the quality indicator based on medical outcomes (*AE_90D*), the other regions had a lower rate than Stockholm, overall and by hospital type, at least before the reform. The overall AE rate decreased marginally in the other regions, whereas Stockholm experienced a rather sharp decline (specifically at university and central hospitals) after the reform and thus caught up with the other regions. The share of satisfied patients (*SATISF*) remained quite stable over time, both overall and by hospital type. Stockholm had a slightly lower share of satisfied patients compared with the other regions.

In the comparison of patient characteristics between the two groups (table 1), we observe that patients in Stockholm had a lower level of comorbidity, slightly lower BMI and higher level of education. Stockholm also had a higher share of female patients and patients with ASA grade 3, and a lower share of married patients. The patients had a similar age structure across the groups. The differences and similarities in patient characteristics remained over time.

The hospital structure differed quite a lot between the groups (table 1). The share of patients in Stockholm who underwent surgery at private specialised centres increased from 25% prereform to 40% postreform. In contrast, more than half of the patients in the other regions underwent surgery at a local hospital, both prereform and postreform. Moreover, the share of patients treated at university hospitals was higher in Stockholm.

To shed light on the validity of the parallel trend assumption, we visually inspect the graphs provided in figure 1A–C. The group-specific lines seem to be approximately parallel for all three indicators, despite differences in patient characteristics. However, since information on patient satisfaction is only available from 2 years before the reform, it is rather difficult to say something about the trend. Thus, results regarding patient satisfaction should be interpreted with caution. The statistical tests of the assumption did not find any signs of differential prereform trends.

DiD analyses

Results from the DiD analyses are summarised in table 2. Relative to the control group, the reform increased resource use in Stockholm. However, as table 1 and figure 1A show, the level of resource use still decreased slightly after the introduction of the reform. The adjusted DiD estimate indicates that the decrease in *OP_LOS* was 0.7 days lower (baseline LOS of 5.8 days) in Stockholm in comparison with the other regions. The effect was statistically significant. The results furthermore show an improvement in quality based on AEs within 90 days of the surgery. The DiD estimates indicate a significant reduction in the AE rate by 1.6 percentage points (adjusted)

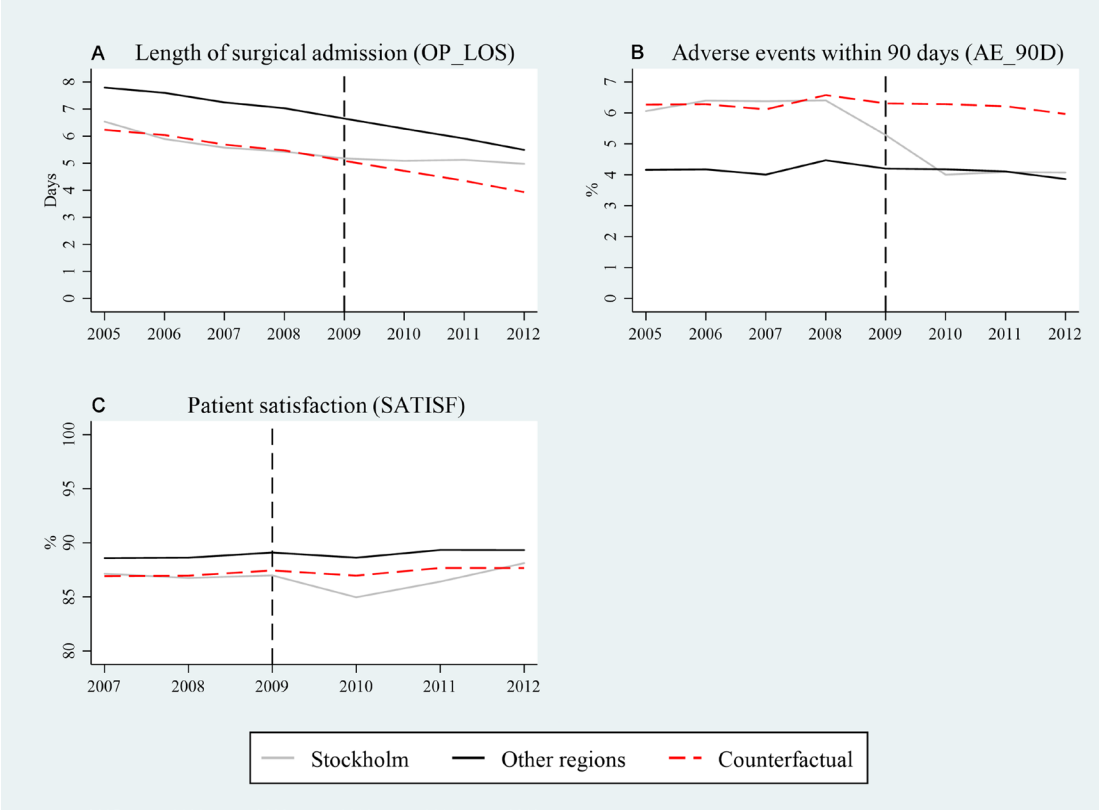

Figure 1 (A–C) Performance indicators per group over time and the corresponding counterfactuals. The vertical reference line indicates the introduction of the reform. Not corrected for covariates.

and 1.8 percentage points (unadjusted), compared with the baseline rate of 6.3%. Hence, after the reform came into force in 2009, the AE rate in Stockholm was approximately the same as in the other regions in Sweden. There were no effects of the reform on patient satisfaction (table 2).

Results from the DiD analyses stratified by hospital type are summarised in figure 2A–C. In relation to the control group, LOS of the surgical admission significantly decreased by almost 1.5 days less at university hospitals, compared with the baseline LOS of 6.7 days, as an effect of the reform (figure 2A). Similarly, LOS significantly decreased by approximately 1 day less at central hospitals, compared with the baseline LOS of 5.6 days. We found no effect on LOS at local and private specialised centres. Moreover, there was a significant difference in the effect between university and local and private specialised centres. As figure 2B indicates, there was a significant decrease in AE rates at university and central hospitals in Stockholm after the reform. The effect was larger at central hospitals (nearly 3 percentage points, compared with the baseline value of 8.5%) than at university hospitals (almost 2 percentage points, compared with the baseline value of 5.7%). There were no statistically significant differences in the effects between hospital types. Figure 2C shows that the share of satisfied patients decreased at private specialised centres after the reform; however, the decrease was not statistically significant in the adjusted model.

Table 2 Results from the difference-in-difference analyses

Performance indicators	Unadjusted		Adjusted	
	DiD estimate	SE	DiD estimate	SE
Resource use				
OP_LOS	0.594**	0.271	0.669***	0.258
Quality				
AE_90D	−0.018***	0.006	−0.016**	0.007
SATISF_D	−0.008	0.016	−0.010	0.017

OP_LOS: length of surgical admission; AE_90D: indicator for whether the patient suffered an adverse event within 90 days following the surgery; SATISF: indicator for whether the patient was satisfied with the outcome of the surgery.
*P<0.1, **P<0.05, ***P<0.01.
DiD, difference-in-difference analysis.

Sensitivity analyses

Descriptive statistics for the standard patient and proxy sample are presented in online supplemental tables 1 and 2. Note that there are a few patients with ASA grade 3 in the proxy sample, and similarly a few patients with comorbidities in the standard patient sample. The overlap of patients between the two samples is around 50%. Online supplemental figure 1 shows the annual and group-specific means of the performance indicators. Graphs and tests of linear time trends support the parallel

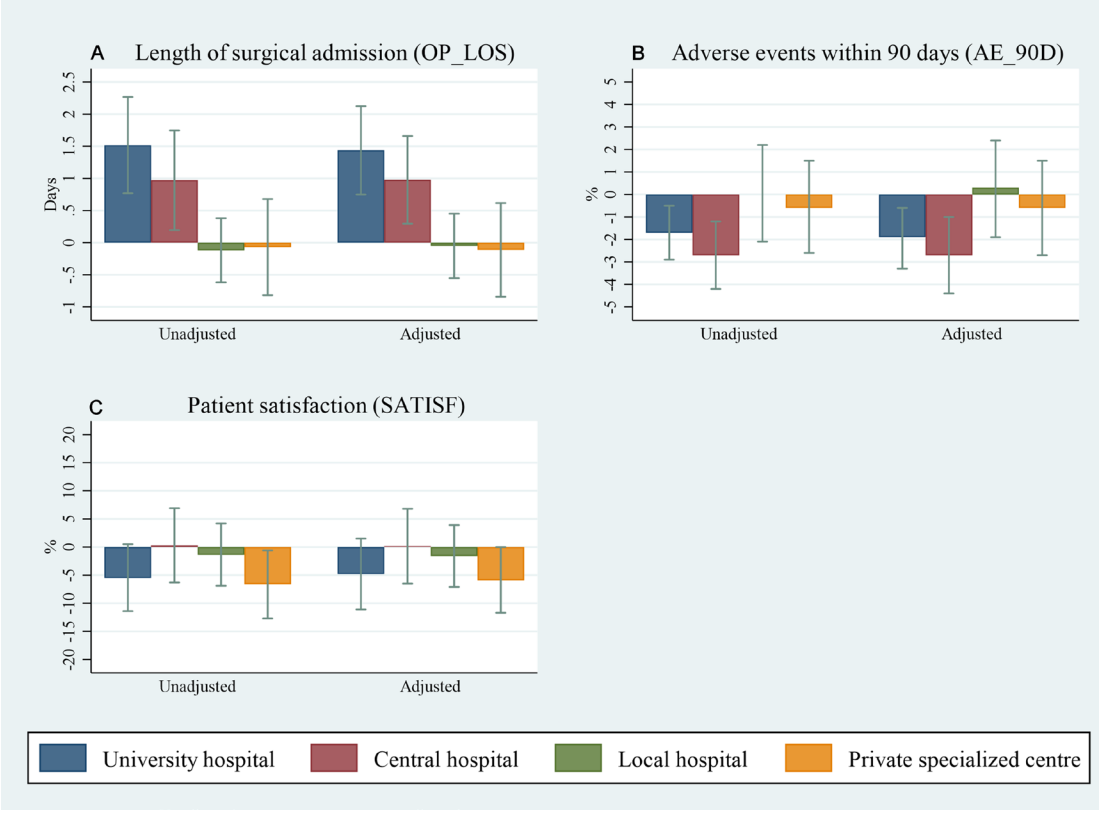

Figure 2 (A–C) Unadjusted and adjusted difference-in-difference estimates stratified by hospital type. The vertical bars indicate 95% CI.

trend assumption for the proxy sample. Columns 1 and 2 of online supplemental table 3 present the results from the DiD analyses based on these samples. The results of a lower decrease in LOS of the surgical admission, decreased AE rates and no effect on patient satisfaction remain. Online supplemental figure 2 summarises the results from the DiD analyses stratified by hospital type, per sample. Note, however, that in the standard patient sample, there are only 34 patients treated at university hospitals in Stockholm and 18 patients treated at private specialised centres in the control group (online supplemental table 1). Due to the small sample sizes, the results for these two strata and sample should be interpreted with caution. As in the main analysis, although with somewhat different magnitudes, LOS decreased less quickly at university and central hospitals in both samples (online supplemental figure 2A). Again, there was no effect on LOS at local hospitals and private specialised centres. In the proxy sample, we also found a significant decrease in the AE rate of over 3 percentage points at both university and central hospitals (online supplemental figure 2B). Although interpreted with caution, the share of satisfied patients decreased with more than 30 percentage points at private specialised centres in the standard patient sample (online supplemental figure 2C). In the proxy sample, we also see a significant decrease in patient satisfaction at university hospitals.

Descriptive statistics as well as annual and group-specific means of the performance indicators for the control group consisting of patients from the regions Halland and Västra Götaland are presented in online supplemental table 4 and figure 3, respectively. The parallel trend assumption is supported by the graphs and tests of linear time trends. The results from the DiD analyses using this control group are similar to those in the main analysis (column 3 of online supplemental table 3). According to the results from the DiD analyses stratified by hospital type, LOS statistically significantly decreased by 2 days less at university hospitals (online supplemental figure 4A), compared with the control group. However, in contrast to the main analysis, there was no statistically significant effect on LOS at central hospitals, nor at local hospitals or private specialised centres. Moreover, we found a similar decrease in AE rates at university and central hospitals as in the main analysis (online supplemental figure 4B). Regarding patient satisfaction, the results were similar to those from the main analysis. The share of satisfied patients decreased at private specialised centres; however, the effect was not statistically significant (online supplemental figure 4C).

DISCUSSION

Key findings

We found that the combined introduction of patient choice, free entry of new providers and bundled payment for hip replacements in Stockholm led to a significant decrease in the AE rate, which led to Stockholm being

on par with the rest of Sweden. However, we also found that LOS decreased less quickly in the more competitive market than in the control group. We found no effects of the reform on patient satisfaction.

Our findings are to some extent in contrast to the findings in the existing literature on the effects of competition for hip and knee replacements. In opposite to our finding of improved quality in terms of a lower AE rate, several studies have found a negative or no relationship between competition and quality.[6 8 9] However, Feng *et al*[7] found no association between competition and patient-reported health gains, nor did we in our previous study on the effects of the same reform on postsurgery patient-reported outcome measures,[12] which is similar to our present finding regarding patient satisfaction. As competition-inducing reforms are introduced with different payment systems and incentives, differences in the results may be explained by this. The report from the OECD on the effects of bundled payments[4] refers to a small number of studies that show similar results for quality improvement as our study.

Moreover, our findings are in line with the previous study by Wohlin *et al*,[11] who also found that the choice reform in Stockholm successfully reduced the AE rate. Furthermore, they showed that LOS decreased over time, which was also apparent in our study; however, we showed that, as an effect of the reform, LOS did not decrease as quickly. Qualitative studies have shown that the reform led to a separation of low-risk and high-risk patients where the acute hospitals increasingly treated high-risk and complex patients and the private specialised centres took care of the low-risk patients.[11 23] In our analysis of the heterogeneity of the effects, we show that the effect on LOS derives from the fact that LOS did not decrease as much at university and central hospitals in Stockholm as in the other regions, which is likely to be an effect of the altered case-mix. This is also in line with the findings by Cooper *et al*,[5] who studied the effects of the entry of private surgical centres to compete against English National Health Service hospitals and found that competition improved efficiency, although the hospitals were left to treat sicker patients. Furthermore, we found that the decrease in the AE rate specifically derived from improved rates at university and central hospitals.

Implications

The objectives of the reform were many. These included improvements in quality and efficiency, reduced waiting times, increased patient choice and access, as well as a separation of low-risk and high-risk patients. We have shown that the reform was successful in improving the AE rate; however, LOS did not decrease as much postreform and there was no change in patient satisfaction.

A limitation with most payment principles used in non-price competitive healthcare markets is that only a limited episode of care is covered and thus postoperative activities, such as complications, are not included. With the principle of bundled payments, providers receive a package price for a defined care chain, including postoperative care. Hence, the incentive to focus on quality is most likely strengthening and providers might give priority to avoid negative quality effects at the expense of higher resource use. This could explain the lower decrease in LOS in Stockholm.

The lower decrease in LOS may also be related to an increase in case-mix between different hospitals—an effect that has previously been shown to have negative consequences for the working environment and training for healthcare personnel.[11 23] The total effects of this reform—intended and unintended consequences—should be taken into consideration in the future planning of healthcare reforms.

It is furthermore important to consider whether the patients are making a choice and how. Theory suggests that non-price competition and choice may stimulate providers to improve quality. However, for this to be effective, patients should be sensitive to differences in quality when making their choice of healthcare provider.[24] Studies examining the relationship between hospital choice and quality for elective hip replacements have found that, in addition to distance, hospital quality does affect the choice of hospital.[24–26] Further studies exploring how hospital demand is driven by quality in the setting of Stockholm would be helpful to further understand the impact of the reform.

Limitations

The first limitation of our study relates to the DiD analytical framework which accounts for time-invariant differences between Stockholm and the other regions. Should a policy unrelated to the patient choice reform be initiated during or after the choice reform and affect the groups and their performance differently, the results may be biased. We are however unaware of such policies during our study period. Second, we are not able to disentangle whether the effects are driven by increased competition or the introduction of the bundled payment or a combination. Third, we could not clearly distinguish between patients who were included in the reform and those who were not until 2008, as we did not have information on ASA grade. Nevertheless, by including all patients in the analysis, we gained an understanding of the effects on the patient group as a whole. Furthermore, the sensitivity analyses using various patient samples (including a sample only with patients comprised by the reform) showed similar results as for the main analysis.

CONCLUSION

The combined introduction of patient choice, free entry of new providers and a bundled payment model for elective total hip and knee replacement surgery in Stockholm aimed to improve quality and efficiency, shorten waiting times, as well as increase patient choice and access. Our evaluation of the reform on hip replacements shows that the AE rate was successfully improved;

however, LOS of the surgical admission decreased less in the more competitive market than in the control group. These effects were mainly driven by university and central hospitals. No effects of the reform on patient satisfaction were found. Our findings contribute to the general knowledge about the effects of financial incentives and market-oriented reforms. The total effects of this reform—intended and unintended consequences—should be taken into consideration in the future planning of healthcare reforms.

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Contributors FG, SK, MP and CR designed the study. FG, GG and HM were involved with data collection. FG performed the data analysis and drafted the manuscript. All authors contributed to the interpretation of the findings and revised and approved the final manuscript. FG acts as guarantor.

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Competing interests FG is employed by a research and development unit at Region Stockholm, and CR is partly contracted by the same organisation. Region Stockholm initiated the reform being analysed, but had no part in the design, execution, results or conclusions of the study.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval The study was approved by the regional ethical review board in Gothenburg, Sweden (reference numbers 271-14, T695-14 and 2020-00072).

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Data availability statement Data may be obtained from a third party and are not publicly available. The data used in this study are available from the Swedish Hip Arthroplasty Register, the National Board of Health and Welfare, and Statistics Sweden, but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available.

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REFERENCES

1 Cooper Z, Gibbons S, Jones S, *et al*. Does Hospital competition save lives? Evidence from the English NHS patient choice reforms. *Econ J* 2011;121:F228–60.
2 OECD. Competition in hospital services. OECD policy Roundtables, Directorate for financial and enterprise Affairs competition Committee 2012.
3 Vrangbaek K, Robertson R, Winblad U, *et al*. Choice policies in northern European health systems. *Health Econ Policy Law* 2012;7:47–71.
4 OECD. *Better ways to pay for health care*. Paris: OECD Publishing, 2016.
5 Cooper Z, Gibbons S, Skellern M. Does competition from private surgical centres improve public hospitals' performance? Evidence from the English National Health Service. *J Public Econ* 2018;166:63–80.
6 Skellern M. *The effect of hospital competition on value-added indicators of elective surgery quality*. London: Centre for Economic Performance, 2019.
7 Feng Y, Pistollato M, Charlesworth A, *et al*. Association between market concentration of hospitals and patient health gain following hip replacement surgery. *J Health Serv Res Policy* 2015;20:11–17.
8 Moscelli G, Gravelle HSE, Siciliani L. *Effects of market structure and patient choice on hospital quality for planned patients*. York, UK: York, 2019.
9 Colla C, Bynum J, Austin A. Hospital competition, quality, and expenditures in the U.S. Medicare population. National Bureau of economic research working paper series 2016;22826.
10 SLL. Regelbok för höft- och knäprotesoperationer, 2011. [Rulebook for hip and knee replacement operations, 2011]. *Region Stockholm* 2011.
11 Wohlin J, Stalberg H, Ström O, *et al*. *Införande av värdebaserad ersättningsmodell och vårdval för höft- och knäprotesoperationer i Stockholm Läns Landsting. [Introduction of value-based remuneration model and care choice for hip and knee replacements in Region Stockholm*. Stockholm: Karolinska Institutet, 2016.
12 Goude F, Kittelsen SAC, Malchau H, *et al*. The effects of competition and bundled payment on patient reported outcome measures after hip replacement surgery. *BMC Health Serv Res* 2021;21:387.
13 Swedish hip arthroplasty register. annual report 2013. *Swedish Hip Arthroplasty Register* 2014.
14 Dimick JB, Ryan AM. Methods for evaluating changes in health care policy: the difference-in-differences approach. *JAMA* 2014;312:2401–2.
15 Wing C, Simon K, Bello-Gomez RA. Designing difference in difference studies: best practices for public health policy research. *Annu Rev Public Health* 2018;39:453–69.
16 Lechner M. The estimation of causal effects by Difference-in-Difference methods. *Foundations and Trends® in Econometrics* 2011;4:165–224.
17 Fredriksson A, Oliveira GMde. Impact evaluation using Difference-in-Differences. *RAUSP Manage J* 2019;54:519–32.
18 Angrist JD, Pischke J-S. *Mostly harmless econometrics: an empiricist's companion*. Princeton: NJ: Princeton University Press, 2009.
19 Ryan AM. Effects of the premier Hospital quality incentive demonstration on Medicare patient mortality and cost. *Health Serv Res* 2009;44:821–42.
20 Häkkinen U, Hagen TP, Moger TA. Performance comparison of hip fracture pathways in two capital cities: associations with level and change of integration. *Nordic J Health Eco* 2019;6:80–98.
21 Bertrand M, Duflo E, Mullainathan S. How much should we trust Differences-In-Differences estimates? *Q J Econ* 2004;119:249–75.
22 SAS. version 9.4 2003.
23 Korlén S, Amer-Wåhlin I, Lindgren P, *et al*. Professionals' perspectives on a market-inspired policy reform: a guiding light to the blind spots of measurement. *Health Serv Manage Res* 2017;30:148–55.
24 Beukers PDC, Kemp RGM, Varkevisser M. Patient Hospital choice for hip replacement: empirical evidence from the Netherlands. *Eur J Health Econ* 2014;15:927–36.
25 Beckert W, Christensen M, Collyer K. Choice of NHS-Funded hospital services in England. *Econ J* 2012;122:400–17.
26 Gutacker N, Siciliani L, Moscelli G, *et al*. Choice of hospital: which type of quality matters? *J Health Econ* 2016;50:230–46.

Supplemental Table 1. Descriptive statistics, pre- and post-reform, standard patient sample, by treatment group.

	Region Stockholm				Other regions			
	2008		2009–2012		2008		2009–2012	
Performance indicators	**Mean / %**	**N**	**Mean / %**	**N**	**Mean / %**	**N**	**Mean / %**	**N**
Resource use								
OP_LOS	5.2	923	4.8	4,504	6.8	3,872	5.8	19,710
Resource use by hospital type								
OP_LOS								
University	6.5	34	6.5	270	7.7	232	6.8	972
Central	5.2	322	4.9	890	6.5	1,328	5.6	7,176
Local	6.4	225	5.6	1,011	6.9	2,294	5.9	11,233
Private specialized	4.2	342	4.3	2,333	5.7	18	5.1	342
Quality								
AE_90D	6.1%	923	3.6%	4,504	3.4%	3,872	3.2%	19,710
SATISF	86.4%	852	87.3%	4,223	89.4%	3,542	89.5%	18,465
Quality by hospital type								
AE_90D								
University	5.9%	34	1.9%	2,710	2.6%	232	2.6%	972
Central	7.5%	322	5.6%	890	3.2%	1,328	3.6%	7,176
Local	7.1%	225	4.1%	1,011	3.5%	2,294	3.0%	11,233
Private specialized	4.1%	342	2.9%	2,333	11.1%	18	1.8%	342
SATISF*								
University	83.9%	31	85.9%	255	89.8%	212	87.9%	883
Central	85.3%	286	88.3%	817	89.8%	1,208	89.7%	6,693
Local	87.6%	210	84.1%	932	89.7%	2,106	89.5%	10,570
Private specialized	86.8%	325	88.4%	2,219	56.3%	16	91.2%	319
Covariates								
Sex								
Female	64.6%	596	64.1%	2,885	56.9%	2,205	57.5%	11,333
Male	35.4%	327	35.9%	1,619	43.1%	1,667	42.5%	8,377
Age								
18–54	0.0%	0	0.0%	0	0.0%	0	0.0%	0
55–64	28.7%	265	27.9%	1,256	28.8%	1,117	26.7%	5,262
65–74	43.8%	404	45.7%	2,057	41.6%	1,609	44.1%	8,696
75–84	27.5%	254	26.4%	1,191	29.6%	1,146	29.2%	5,752
85+	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Elixhauser Comorbiditity Index								
0	73.7%	680	78.6%	3,539	61.3%	2,372	58.6%	11,555
1	18.7%	173	15.5%	697	26.2%	1,015	27.5%	5,418
2	5.3%	49	4.8%	218	9.3%	359	10.3%	2,022
3+	2.3%	21	1.1%	50	3.3%	126	3.6%	715
BMI	25.1	923	25.1	4,504	25.4	3,872	25.6	19,710
ASA-grade								
1	29.5%	272	27.6%	1,243	30.0%	1,161	29.6%	5,833
2	70.5%	651	72.4%	3,261	70.0%	2,711	70.4%	13,877
3	0.0%	0	0.0%	0	0.0%	0	0.0%	0
4	0.0%	0	0.0%	0	0.0%	0	0.0%	0
5	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Civil status								
Unmarried	8.1%	75	10.3%	464	7.8%	301	8.7%	1,717
Married	53.7%	496	53.2%	2,395	60.2%	2,332	59.9%	11,802
Divorced	22.0%	203	22.8%	1,026	15.3%	592	16.2%	3,185
Widowed	16.1%	149	13.7%	619	16.7%	647	15.3%	3,006
Education								
Low	27.3%	252	22.8%	1,028	41.4%	1,602	36.3%	7,164
Middle	40.2%	371	39.6%	1,784	37.4%	1,449	39.8%	7,843
High	32.5%	300	37.6%	1,692	21.2%	821	23.9%	4,703
Hospital type								
University	3.7%	34	6.0%	270	6.0%	232	4.9%	972
Central	34.9%	322	19.8%	890	34.3%	1,328	36.4%	7,176
Local	24.4%	225	22.4%	1,011	59.2%	2,294	57.0%	11,233
Private specialized	37.1%	342	51.8%	2,333	0.5%	18	1.7%	329

Notes: This sample is only available from 2008. OP_LOS, length of surgical admission; AE_90D, indicator for whether the patient suffered an adverse event within 90 days following the surgery; SATISF, indicator for whether the patient was satisfied with the outcome of the surgery.

Supplemental Table 2. Descriptive statistics, pre- and post-reform, proxy sample, by treatment group.

	Region Stockholm				Other regions			
	2005–2008		2009–2012		2005–2008		2009–2012	
Performance indicators	**Mean / %**	**N**	**Mean / %**	**N**	**Mean / %**	**N**	**Mean / %**	**N**
Resource use								
OP_LOS	5.4	3,618	4.7	4,859	7.1	17,695	5.6	17,050
Resource use by hospital type								
OP_LOS								
University	6.5	384	6.5	272	8.2	944	6.6	743
Central	5.2	1,202	4.8	1,055	7.1	5,645	5.4	6,549
Local	6.8	826	5.4	1,046	7.1	10,877	5.7	9,256
Private specialized	4.4	1,206	4.2	2,486	4.8	229	4.5	502
Quality								
AE_90D	6.0%	3,618	3.7%	4,859	3.5%	17,695	3.1%	17,050
SATISF*	88.6%	1,434	87.6%	4,529	89.0%	7,095	89.6%	15,895
Quality by hospital type								
AE_90D								
University	5.5%	384	1.8%	272	2.9%	944	2.7%	743
Central	9.1%	1,202	5.8%	1,055	3.5%	5,645	3.6%	6,549
Local	5.1%	826	3.7%	1,046	3.6%	10,877	2.8%	9,256
Private specialized	3.7%	1,206	3.1%	2,486	3.1%	229	2.8%	502
SATISF*								
University	90.3%	103	83.9%	254	86.6%	343	89.6%	651
Central	87.8%	582	88.5%	964	89.9%	2,426	89.7%	6,090
Local	88.2%	321	84.9%	959	88.9%	4,196	89.6%	8,673
Private specialized	89.5%	428	88.8%	2,352	84.6%	130	89.8%	481
Covariates								
Sex								
Female	65.5%	2,368	65.5%	3,181	57.9%	10,239	58.3%	9,944
Male	34.5%	1,250	34.5%	1,678	42.1%	7,456	41.7%	7,106
Age								
18–54	0.0%	0	0.0%	0	0.0%	0	0.0%	0
55–64	34.0%	1,231	29.5%	1,435	31.2%	5,526	31.9%	5,434
65–74	39.6%	1,433	44.8%	2,179	41.1%	7,269	44.0%	7,496
75–84	26.4%	954	25.6%	1,245	27.7%	4,900	24.2%	4,120
85+	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Elixhauser Comorbiditity Index								
0	100.0%	3,618	100.0%	4,859	100.0%	17,695	100.0%	17,050
1	0.0%	0	0.0%	0	0.0%	0	0.0%	0
2	0.0%	0	0.0%	0	0.0%	0	0.0%	0
3+	0.0%	0	0.0%	0	0.0%	0	0.0%	0
*BMI***	26.5	899	26.5	4,767	26.9	3,334	27.2	16,092
*ASA-grade***								
1	31.2%	292	27.4%	1,331	37.5%	1,292	37.7%	6,176
2	59.9%	561	61.8%	2,997	54.8%	1,888	54.9%	8,998
3	8.8%	82	10.5%	510	7.5%	259	7.3%	1,200
4	0.2%	2	0.2%	12	0.1%	5	0.1%	11
5	0.0%	0	0.0%	0	0.0%	0	0.0%	1
Civil status								
Unmarried	9.2%	333	10.7%	520	7.7%	1,360	9.2%	1,569
Married	53.3%	1,928	52.9%	2,569	60.1%	10,634	60.2%	10,259
Divorced	22.1%	799	22.2%	1,080	15.2%	2,697	16.9%	2,885
Widowed	15.4%	558	14.2%	690	17.0%	3,004	13.7%	2,337
Education								
Low	27.4%	990	22.5%	1,091	45.0%	7,965	36.2%	6,176
Middle	41.1%	1,487	40.3%	1,957	36.8%	6,511	40.6%	6,915
High	31.5%	1,141	37.3%	1,811	18.2%	3,219	23.2%	3,959
Hospital type								
University	10.6%	384	5.6%	272	5.3%	944	4.4%	743
Central	33.2%	1,202	21.7%	1,055	31.9%	5,645	38.4%	6,549
Local	22.8%	826	21.5%	1,046	61.5%	10,877	54.3%	9,256
Private specialized	33.3%	1,206	51.2%	2,486	1.3%	229	2.9%	502

Notes: * indicates data is available from 2007, ** indicates data is available from 2008. OP_LOS, length of surgical admission; AE_90D, indicator for whether the patient suffered an adverse event within 90 days following the surgery; SATISF, indicator for whether the patient was satisfied with the outcome of the surgery.

Supplemental Table 3. Results from the difference-in-difference analyses.

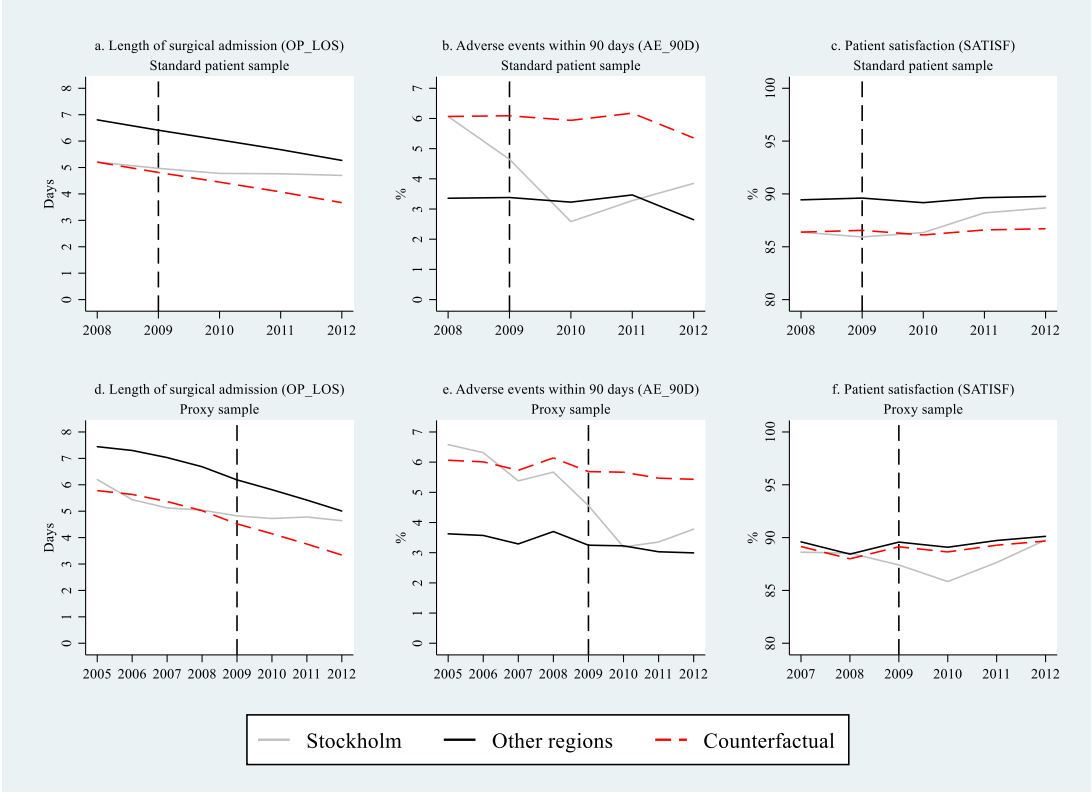
Performance indicators	Standard patient sample		Proxy sample		Full sample – Halland and Västra Götaland	
	Unadjusted DiD (Std. err.)	**Adjusted DiD (Std. err.)**	**Unadjusted DiD (Std. err.)**	**Adjusted DiD (Std. err.)**	**Unadjusted DiD (Std. err.)**	**Adjusted DiD (Std. err.)**
Resource use						
OP_LOS	0.557**	0.606***	0.840***	0.800***	0.782**	0.820**
	(0.223)	(0.211)	(0.271)	(0.274)	(0.350)	(0.332)
Quality						
AE_90D	-0.023**	-0.022**	-0.018**	-0.019**	-0.022***	-0.021***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.006)	(0.007)
SATISF_D	0.008	0.005	-0.015	-0.016	-0.003	-0.006
	(0.017)	(0.017)	(0.020)	(0.020)	(0.017)	(0.018)

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. DiD, difference-in-difference analysis; Std. err., standard error; OP_LOS, length of surgical admission; AE_90D, indicator for whether the patient suffered an adverse event within 90 days following the surgery; SATISF, indicator for whether the patient was satisfied with the outcome of the surgery.

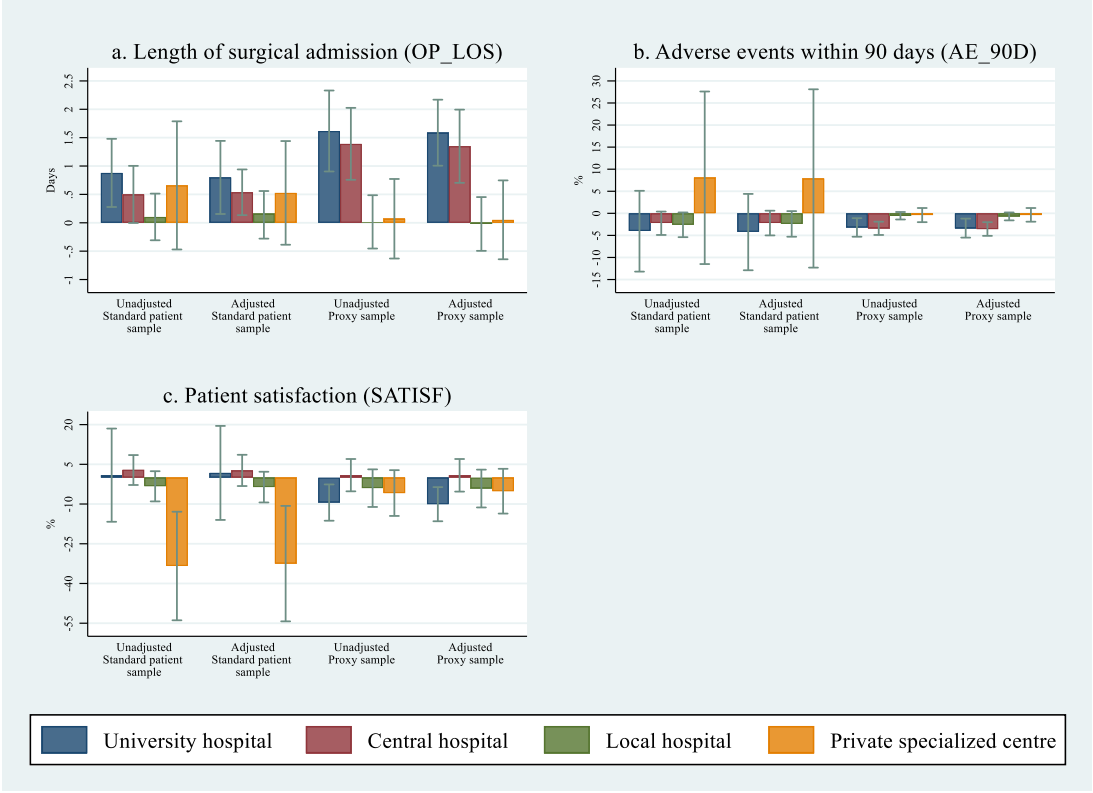
Supplemental Table 4. Descriptive statistics, pre- and post-reform, by treatment group.

	Region Stockholm				Region Västra Götaland and Halland			
	2005–2008		2009–2012		2005–2008		2009–2012	
Performance indicators	**Mean / %**	**N**	**Mean / %**	**N**	**Mean / %**	**N**	**Mean / %**	**N**
Resource use								
OP_LOS	5.8	6,380	5.1	8,190	8.3	7,348	6.7	7,653
Resource use by hospital type								
OP_LOS								
University	6.7	859	6.7	918	10.0	894	7.9	949
Central	5.6	2,272	5.1	1,948	8.2	3,116	6.8	3,418
Local	7.0	1,644	5.7	2,050	8.2	3,020	6.8	2,654
Private specialized	4.4	1,605	4.3	3,274	4.9	318	4.7	632
Quality								
AE_90D	6.3%	6,380	4.4%	8,190	3.4%	7,348	3.6%	7,653
SATISF*	86.9%	2,581	86.6%	7,512	86.6%	3,400	86.6%	7,000
Quality by hospital type								
AE_90D								
University	5.7%	859	3.5%	918	3.4%	894	2.8%	949
Central	8.5%	2,272	6.2%	1,948	3.5%	3,116	4.1%	3,418
Local	5.6%	1,644	5.2%	2,050	3.2%	3,020	3.4%	2,654
Private specialized	4.4%	1,605	3.0%	3,274	3.5%	318	2.7%	632
SATISF*								
University	88.7%	238	83.6%	834	82.7%	410	82.8%	830
Central	87.0%	1,108	87.4%	1,737	87.0%	1,388	87.0%	3,077
Local	84.8%	650	84.0%	1,857	87.7%	1,427	86.7%	2,501
Private specialized	88.4%	585	88.7%	3,084	83.4%	175	89.9%	592
Covariates								
Sex								
Female	63.1%	4,028	62.7%	5,137	56.4%	4,142	57.8%	4,421
Male	36.9%	2,352	37.3%	3,053	43.6%	3,206	42.2%	3,232
Age								
18–54	8.8%	561	9.4%	768	8.6%	635	9.3%	714
55–64	26.1%	1,663	23.0%	1,887	24.4%	1,794	22.4%	1,713
65–74	34.2%	2,181	38.2%	3,125	35.0%	2,571	36.2%	2,774
75–84	26.0%	1,656	25.0%	2,051	28.0%	2,054	27.0%	2,067
85+	5.0%	319	4.4%	359	4.0%	294	5.0%	385
Elixhauser Comorbiditity Index								
0	66.2%	4,222	69.0%	5,649	57.8%	4,247	56.4%	4,319
1	20.0%	1,274	17.5%	1,432	25.2%	1,850	25.2%	1,926
2	8.2%	526	8.5%	695	11.8%	864	12.1%	925
3+	5.6%	358	5.1%	414	5.3%	387	6.3%	483
*BMI***	26.7	1,589	26.8	8,045	27.1	1,558	27.4	7,025
*ASA grade***								
1	23.5%	391	21.9%	1,790	27.3%	440	28.0%	2,067
2	58.3%	971	56.7%	4,634	60.5%	976	59.8%	4,405
3	17.7%	295	20.5%	1,671	12.3%	198	11.9%	878
4	0.5%	9	0.9%	75	0.0%	0	0.3%	21
5	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Civil status								
Unmarried	11.2%	712	12.6%	1,032	9.1%	667	9.8%	748
Married	50.9%	3,245	50.4%	4,128	58.0%	4,263	58.2%	4,457
Divorced	20.8%	1,325	21.7%	1,774	14.9%	1,098	16.3%	1,246
Widowed	17.2%	1,098	15.3%	1,256	18.0%	1,320	15.7%	1,202
Education								
Low	29.2%	1,862	24.1%	1,975	46.4%	3,409	39.4%	3,013
Middle	40.9%	2,610	41.3%	3,382	35.9%	2,636	39.2%	2,999
High	29.9%	1,908	34.6%	2,833	17.7%	1,303	21.4%	1,641
Hospital type								
University	13.5%	859	11.2%	918	12.2%	894	12.4%	949
Central	35.6%	2,272	23.8%	1,948	42.4%	3,116	44.7%	3,418
Local	25.8%	1,644	25.0%	2,050	41.1%	3,020	34.7%	2,654
Private specialized	25.2%	1,605	40.0%	3,274	4.3%	318	8.3%	632

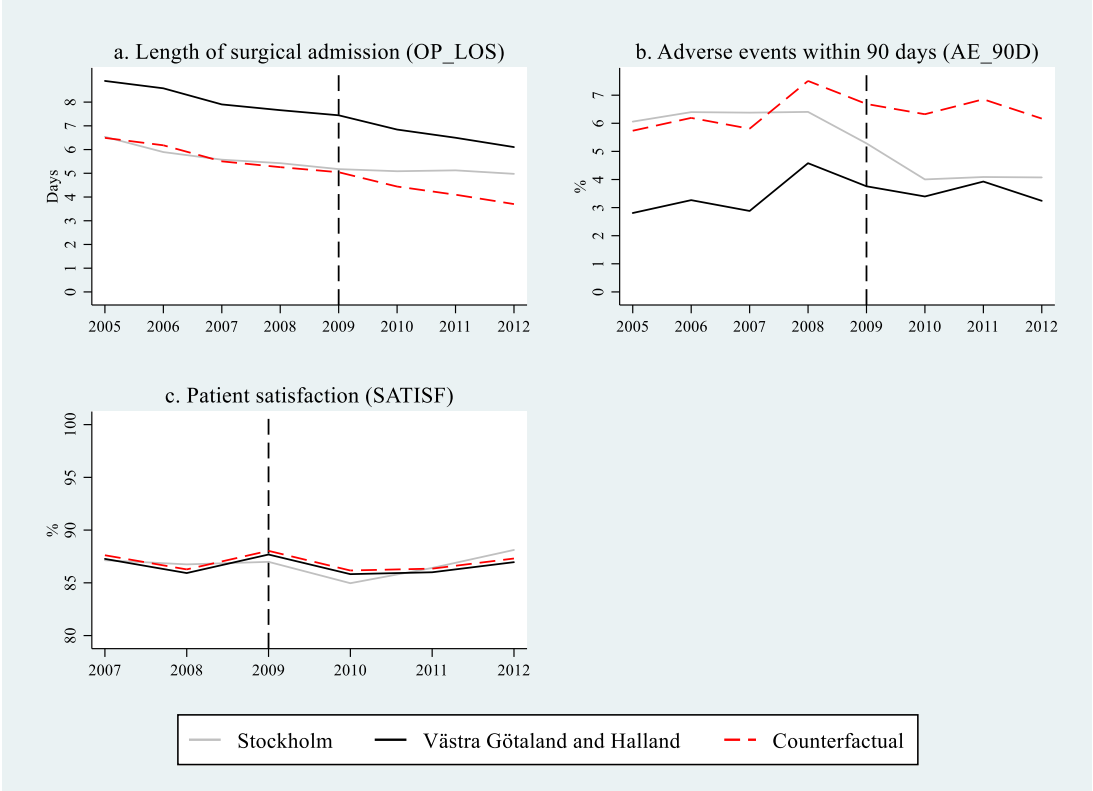
Notes: * indicates data is available from 2007, ** indicates data is available from 2008. OP_LOS, length of surgical admission; AE_90D, indicator for whether the patient suffered an adverse event within 90 days following the surgery; SATISF, indicator for whether the patient was satisfied with the outcome of the surgery.



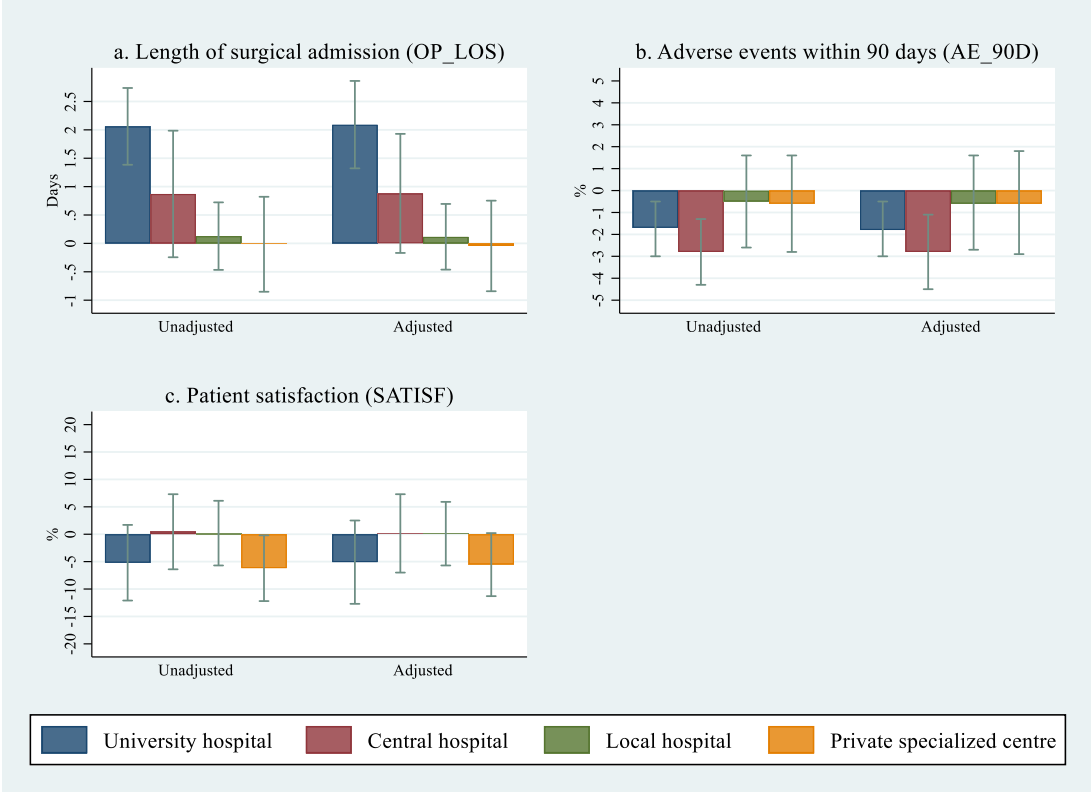
Supplemental Figure 1a-f. Performance indicators per group over time and corresponding counterfactuals, per sample. The vertical reference line indicates the introduction of the reform. Not corrected for covariates.



Supplemental Figure 2a-c. Unadjusted and adjusted difference-in-difference estimates stratified by hospital type, per sample. The vertical bars indicate 95% confidence intervals.



Supplemental Figure 3a-c. Performance indicators per group over time and corresponding counterfactuals. The vertical reference line indicates the introduction of the reform. Not corrected for covariates.



Supplemental Figure 4a-c. Unadjusted and adjusted difference-in-difference estimates stratified by hospital type. The vertical bars indicate 95 % confidence intervals. Control group consists of patients from Halland and Västra Götaland.