Effects of introducing bundled payment and patients' choice of provider for elective hip and knee replacements in Stockholm county

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Foreword By Professor Michael E. Porter

As countries around the world grapple with unsustainable costs and erratic quality of health care systems, a central theme is emerging. The only real solution is to substantially improve the value of care, where value is the patient health outcomes achieved relative to money spent. There is an urgent need for bold steps to move from volume-based health care delivery to value-based health care delivery. As introduced in my 2006 book with Elizabeth Teisberg, "Redefining Health Care," this will require a shift to multidisciplinary, team-based care organized around patients' medical conditions, to measuring the patient outcomes that matter for each condition, and the overall costs of delivering those outcomes. Over the last several years, health care providers globally have begun to embrace these principles in numerous medical fields.

In moving to a value-based system, a key enabler is shifting to bundled reimbursement, or reimbursement that covers the full cycle of care for the patient's medical condition. Fee for service rewards volume of services, not value. Global capitation, or a single payment covering any medical need that arises, exposes providers to risks that they cannot control, has been prone to encourage limitation of services only, and lacks accountability for specific outcomes. Bundled reimbursement aligns payment with value in delivering care for the patient's particular medical need, and aligns payment with the outcomes the provider team can control. Coupled with rigorous outcome measurement, then, bundled reimbursement encourages and rewards relentless value improvement.

The benefits of bundled reimbursement are now becoming widely recognized, but implementation has proceeded slowly. Bundled reimbursement compensates the entire care team rather than today's siloed reimbursement for individual services. It also requires understanding the true costs of delivering care over the care cycle, something providers today rarely understand. Bundled reimbursement also works best when combined with rigorous outcome measurement, which is still in its infancy in most countries. There is a rapidly growing number of bundled pricing pilots and initiatives, but large-scale implementation is still in the early stage.

One of pioneer examples is the "Vårdval höft-och knäprotesoperationer" (Choice of Care in Hip and Knee Replacements) in the County of Stockholm, Sweden. Since January 2009, all non-complex hip and knee replacements in the county of 2 million people have been reimbursed with a bundled payment, covering over 4,000 procedures per year. The bundle includes all services from pre-operative evaluation to outpatient follow-up, and incorporates care guarantees covering infection and revision surgery. In partnership with the well-established Swedish Hip Arthroplasty Register, reporting of outcomes is mandatory.

The results of this pathbreaking new reimbursement model have been striking, as this report demonstrates. Not only has the new reimbursement model encouraged providers to make numerous improvements in care, but complications have dropped substantially and waiting time has disappeared. The County Council is refining the reimbursement model and has extended it to other conditions.

This case illustrates that bundled reimbursement is not only feasible, but value enhancing. Stockholm's leadership provides an important benchmark to guide the design and implementation of bundled reimbursement globally.

Sincerely,

Michael E. Porter, PhD, MBA
Bishop William Lawrence University Professor
Director, Institute for Strategy and Competitiveness
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Executive summary

BACKGROUND

Previous research has shown that transparency around health outcomes and changes to reimbursement influence how healthcare is delivered. It has been suggested that bundled payment, where providers receive a package price for the entire cycle of care, and where financial risk for complications is transferred to the provider, enables providers to work differently – with potentially positive effects on outcomes and cost.

In 2009, the Stockholm County Council (SLL) introduced bundled payment for primary hip and knee replacements and also allowed citizens to choose freely among accredited providers ("Patient choice program"). Compared to other countries, Sweden performed well even before the reform in terms of complications and prosthesis survival. However, waiting times were unacceptably long and many patients had to wait for more than one year for surgery.

In 2010, the Karolinska Institutet was commissioned by the SLL to analyze the effects of the reform from a patient value perspective. The study has been performed in collaboration with the Institute for Strategy and Competitiveness at Harvard Business School, and the Swedish Hip Arthroplasty Registry.

RESULTS

The combined introduction of bundled payment and adoption of patients' choice of provider resulted in higher production capacity and reduced waiting times. There were, however, no signs of patients being operated on earlier in the progression of the disease than what was medically justified or that patients would undergo surgery on other indications than previously.

A number of providers implemented changes in order to reduce the cost of treatment as well as the risk of complications. Changes included standardization of the treatment process, development of manuals and checklists for staff, certification of personnel, introduction of financial incentives for staff (tied to low rates of complications), and the introduction of additional follow-up visits to identify complications at an early stage. Private providers

implemented changes to a greater extent than public providers. Providers reported an overall level of satisfaction with the new model.

Quantitative analysis shows that the risk of reoperation after primary hip/knee replacement in Stockholm dropped by 26 percent after the introduction of bundled payment and patient choice of provider (2010 compared to 2007–2008). This risk reduction can be partially explained by a general reduction in risk among healthcare providers who treated Stockholm patients before, and partially by a shift in volume to providers with lower risk.

A difference-in-difference analysis was carried out to investigate whether these results were in fact associated with introducing the new model, or whether they seemed to depend on secular trends applicable to regions outside of Stockholm (new surgical methods, quality initiatives, more resources, quality registry monitoring etc.). Results from the analysis showed that improvement in complication rates observed in SLL was not caused by trends present in the seven comparison regions. If anything, the interaction model indicates that the SLL results were even more favorable than what was found when studying SLL alone.

Private providers reduced their risk of complications more than public providers. This is consistent with the results from the interview-based analysis in which private providers reported taking greater action to improve the treatment process than public providers.

No change was observed in patient-reported outcome measures (PROM).

Analysis of cost at provider level showed a reduction in costs over the full cycle of care of approximately SEK 11,300 per patient (14 percent). At the payer level, reduced prices and risk transfer led to a cost reduction per treated patient of SEK 16,500 (20 percent) for SLL, corresponding to a total of SEK 60 million per year. For the county, the total cost of primary hip and knee replacement surgery fell by 3 percent, even though total volumes increased by 21 percent.

Sick leave during the year before and the year after primary surgery declined in total by 17 percent (38 net days of sick leave). A corresponding reduction was observed across the rest of the country, and the change observed in SLL was probably due to a combination of reduced queues and political reforms.

CONCLUSION AND RECOMMENDATIONS

After the reform, waiting times for primary hip/knee replacements decreased, and costs over the full cycle of care, as well as the risk of complications, were significantly reduced. Providers were also generally satisfied with the bundled payment model.

Several recommendations have been set out at the end of this report. Amongst these recommendations, the most important ones are to secure financing for education and to expand the scope of the reform to also include ASA 3 patients (currently ASA 1-2).

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Introduction

1.1. BACKGROUND

The overall goal of each and every healthcare system is to create as much good health as possible for its population, with the limited available resources. Within healthcare, however, variation in methodology as well as results, in terms of quality and cost, between countries, regions and producers is larger than in the majority of other sectors. At the same time, in many countries, healthcare costs have increased faster than GDP, which is not a development that is sustainable in the long term [i].

It has been suggested that one possible reason for this variation and unsustainable cost increases, in addition to new ways of working and an aging population, is that healthcare providers, in accordance with tradition, are organized according to medical specialties and not according to diseases and treatment. Additionally, healthcare management and governance (such as monitoring and reimbursement) are often focused on the individual activities that healthcare professionals perform instead of the treatment results they achieve. This way of organizing healthcare has created difficulties for healthcare providers in coordinating and continuously developing their treatment process to achieve the best possible health outcomes with as few resources as possible [ii].

Bundled payment. In both literature and in practice a new type of reimbursement model is being developed that has been theoretically well placed to contribute to the developments outlined above. Within this model, healthcare providers are reimbursed with a package price for the whole or the greater part of the continuum of care. This type of compensation is known internationally as "bundled payment". Principles underlying bundled payment can be divided into three main components: package price, performance compensation and individual adjustment.

- **Package price.** The basic principle is that the provider receives a package price for an entire chain of care instead of being reimbursed for each individual activity. The package price may also include compensation for expected costs related to potentially avoidable complication and thus include a warranty reimbursement, which results in the provider

bearing financial responsibility for these predefined complications. By compensating providers with a package price, parts of the financial risk shifts from the payer to the provider, which means that the provider is given both more freedom and more responsibility to ensure effective and high-quality patient flows.

- **Performance compensation.** Considering that parts of the reimbursement are based on agreed upon performance indicators (health outcomes or other key figures), which are relevant to the specific patient group, the provider can invest in activities that are expected to improve their performance.

- **Individual adjustment.** Some bundled payment systems are designed in such a way that the package price and performance compensation are adjusted according to treated patients' individual conditions (disease-specific factors, comorbidities, demographics, etc.). This means that patients with different conditions can be treated under the same reimbursement model.

Research has previously shown that healthcare management and governance have an impact on how care is delivered [iii, iv]. Hypotheses suggest that, by increasing the degree of freedom and responsibility shifted from payers to providers, bundled payment can enable and encourage healthcare providers to be innovative and change their practices in order to improve quality and reduce resource utilization [4, v, vi].

1.2. THE NEW MODEL AND HIP/KNEE REPLACEMENT SURGERY IN STOCKHOLM

In January 2009, the healthcare administration at Stockholm County Council (SLL) introduced, in accordance with the Act on System of Choice (LOV), a so-called patient choice for primary elective hip and knee replacement surgery, and at the same time introduced a bundled payment model for the patients covered by the patient choice. The new model required healthcare providers who wished to perform these operations to undergo an authorization. Patients were free to select among authorized providers, which were not limited in production capacity. Authorization criteria included, among other requirements, reporting of quality data, that the operating surgeon had to perform at least 50 operations per year, and that the operating room had to meet certain air quality requirements.

The new model was only available for patients without comorbidities that caused functional limitations (ASA 1-2), totaling approximately 78 percent of all hip and knee replacement patients with total replacement in 2009. Fractures, as well as fracture repair failures, were not covered by the new model.

The bundled payment model was introduced with the following design:

- **Package price:** Healthcare providers received a package price of SEK 56,300 for the continuum of care, including diagnostics, surgery with follow-up care, prosthetic costs,

and the necessary pre-surgical and post-surgical visits. To ensure that the initial diagnosis took place in primary care (and that the cost of the medical work-up was born by the primary care unit), compensation for the initial visit was reduced by 50 percent along with the introduction of a fine for providers who had more than 35 percent of initial visits that did not lead to surgery. Moreover, there was no specific remuneration for radiological examinations. Providers also had to assume the responsibility for any complications and became financially responsible for potentially avoidable adverse events (PAAE) that were related to the primary surgery and which occurred up to two years after the primary surgery (five years in cases where infection treated with antibiotics occurred during the first two years).

- **Performance compensation.** In respect of compensation, 3.2 percent was withheld and paid out as performance compensation if providers reached certain predetermined targets (mostly process measures).

- **Individual adjustment.** Whereas the patient group included in the new model was considered to be homogeneous, individual adjustment was not deemed to be necessary.

Providers' treatment outcomes would be followed by SLL's patient administrative system as well as through the national quality register. Patient satisfaction with the treatment process was measured using a specially designed questionnaire that the patient received after completing treatment. Previously, the majority of these operations were performed in emergency hospitals and reimbursed according to the NordDRG model. Additionally, specific volumes were procured under the Public Procurement Act (LOU) by SLL and sometimes by public healthcare providers who used private healthcare providers as subcontractors. In comparison with other countries, Sweden performed favorably, with as good or better prosthetic survival rates for hip replacements [vii, viii]. Still, a large proportion of patients in the SLL had to wait more than 90 days for surgery [ix].

1.3. PURPOSE, LIMITATIONS AND OUTLINE

In 2010, the Stockholm County Council initiated a joint study together with the Karolinska Institute, which was expanded to include collaboration with the Harvard Business School and the Swedish Hip Replacement Register. The aim was to study how the adoption of the new model affected healthcare providers professionally and whether it had value-creating effects for the health system in terms of improved medical outcomes and/or lower costs. In addition, recommendations would be given for further development.

It is important to note that the introduction of the new model included two components, each of which, according to different logics, may have influenced the added value for the healthcare system: firstly, the patients' choice of provider, and secondly, the bundled payment model.

On March 2, 2012, a preliminary report was published by the SLL, describing the early findings, conclusions and subsequent recommendations. In 2012 and 2013, the majority of the research project's quantitative analysis was conducted, which serves as the basis for this expanded report. In 2015, an additional analysis was carried out to investigate changes in complication rates in SLL in comparison with other counties. The report includes an appendix that contains in-depth information pertaining to the results and methods of analysis, including comparability with quality register data on complications.

2

Data and methods

This report is based on interviews as well as an analysis of patient-level and aggregate-level register data. Both the analysis plan and the data collection plan have been approved by Stockholm's regional ethical review board (2011/5:6).

In addition, the Sveus research database was utilized for in-depth analysis of the trends in complication rates in SLL compared to other counties affiliated with Sveus (www.sveus.se) [x]. This took place under a separate research approval from Stockholm's regional ethical review board (2011/759-31 and supplement 2013/1050-32).

The qualitative analysis is based on interviews with representatives from 10 healthcare providers. All interviews were recorded and conducted using a semi-structured approach, that is, by initially posing broad questions about the new model, which were later complemented by specific questions on predefined topics. The material was transcribed and subject to content analysis. Representatives of SLL were interviewed during the spring of 2010 and an ongoing dialogue has taken place between SLL and the research team throughout the project period. The interviews with SLL have not been subject to content analysis.

The quantitative analysis is based on linking information from SLL's administrative health database (GVR/VAL), Swedish Hip Replacement Register (SHPR), Prescribed Drug Register (PDR), sickness absence data from the National Social Insurance Agency (FK), and socioeconomic and demographic variables from Statistics Sweden (SCB).

Additionally, an incomplete database was obtained from the healthcare providers' surgery planning system with the ASA classification during the period 2007–2008. Aggregated data on waiting times and surgical volumes was obtained from the SLL, Swedish Hip Replacement Register (SHPR) and the Swedish Knee Arthroplasty Register (SKAR).

The research database includes 16,177 patients, registered as residents of Stockholm County, who underwent primary hip or knee replacement surgery during 2007–2010 within the SLL. Patients who had surgery for tumors or fractures were excluded. All analyzed surgeries had at least 12 months' follow-up time, and 81 percent had 24 months of follow-up. The primary hip or knee replacement surgery that was analyzed for each individual is designated in this report as the index operation.

To understand the impact of the new model on the patient group as a whole to the greatest extent possible, all patients who underwent surgery during the period were included, comprising both patients covered by the new model and those covered by DRG reimbursement. Wherever possible, statistical analyses were adjusted to account for differences in patient characteristics, between groups and over time, hereinafter referred to as the *case mix*. Analyses were adjusted for age, gender, somatic comorbidity, depression diagnosis, educational level, country of birth, disposable income, prior primary joint replacement in another joint, and type of prosthesis (see overview in tables A1–A4). Statistically significant differences were assessed at the 5 percent level, in accordance with scientific practice. The results are reported in the body of the report, with associated figures and tables located in the Appendix.

The surgeries included in the material under study were carried out by 10 different healthcare providers, of which five were owned by SLL ("public providers") and five were privately run ("private providers"). This report also utilizes a division into *specialist centers* and *emergency hospitals*. In this report, a specialist center is a unit that performs hip and knee replacement surgery, and which is not an emergency hospital. Capio St. Göran's Hospital is the only emergency hospital that is run privately. The remaining four of five private providers were considered specialist centers.

Below is a description of the method for identifying complications or potentially avoidable adverse events (PAAE):

Orthopedic complications or PAAE were defined by at least one diagnostic code for complications (Table A6) or procedure code for reoperation (Table A7) recorded in connection with an episode of inpatient care within two years of the primary surgery. The codes were based on the coding guide for complication diagnoses from the Swedish Orthopedic Association. Since multiple inpatient care episodes, sometimes with different diagnoses/procedures, could often have one single, original cause, repeated complications diagnoses/procedures were counted as only one complication. Complication codes were also identified during the inpatient stay during which the primary surgery was performed. Identified orthopedic complications were handled hierarchically, with prosthetic removal/replacement being counted prior to reoperation, and reoperation prior to inpatient stay with a sole diagnosis of orthopedic complication. For example, a patient who first had an inpatient visit for an infection that had been treated with debridement, but who subsequently underwent a prosthetic removal/replacement, would only be defined as a prosthetic removal/replacement in this analysis. Orthopedic complications were estimated through survival analysis, taking into account that patients may have different lengths of follow-up following primary surgery. Follow-up time of an individual patient ended if the patient suffered a complication, had a new primary operation in another joint, died, or moved to another county.

Cardiovascular events (myocardial infarction, deep vein thrombosis, and pulmonary embolism) were identified by relevant diagnosis codes (Table A7) registered during inpatient visits commencing within 30 days of the primary surgery.

3

Results

This section describes the results emerging from effects observed across six dimensions: production and accessibility (3.1), healthcare providers' practices and care process (3.2), health outcomes (3.3), resource utilization and cost (3.4), patients' experience of care (3.5), and the providers' views on the new model and its effects (3.6).

3.1. EFFECTS ON PRODUCTION AND ACCESSIBILITY

A principal reason for introducing the patients' choice of provider was to reduce the long queues by increasing accessibility. At the same time, concerns existed within SLL that the patients' choice of provider would lead to patients undergoing surgery earlier during the course of the disease than medically motivated, or to patients having surgery on the basis of other indications than before. There was also a concern that sicker patients who were not included in the new model (ASA 3-4 patients) would have poorer access to healthcare. These aspects are analyzed in this section.

Temporarily increased volumes. When the new model was introduced in 2009, the total volumes of elective hip and knee replacement surgery in Stockholm increased by 20 percent (care choice and DRG-funded), which then decreased by a total of 4 percent until 2012. The decrease was driven by the patient-choice funded portion of the surgeries, which decreased by 12 percent during the same period. The DRG-reimbursed surgeries, however, increased by 20 percent during the period (Table A10).

No queues for patients covered by the new model. The overall proportion of patients who waited more than 90 days for primary hip or knee replacement surgery (the new model and DRG-reimbursed) fell between 2008 and 2010 by 23 percentage points (Figure 1). Since healthcare providers reported that no queues existed for patients covered by the new model, it is likely that those patients who were reported as having waited more than 90 days after the introduction of the new model (including for medical reasons and self-selected waiting) consisted primarily of patients waiting for DRG-reimbursed surgeries.

Two providers reported that they have successfully begun to allow patients to book their own surgery time during the appointment for therapy decisions.

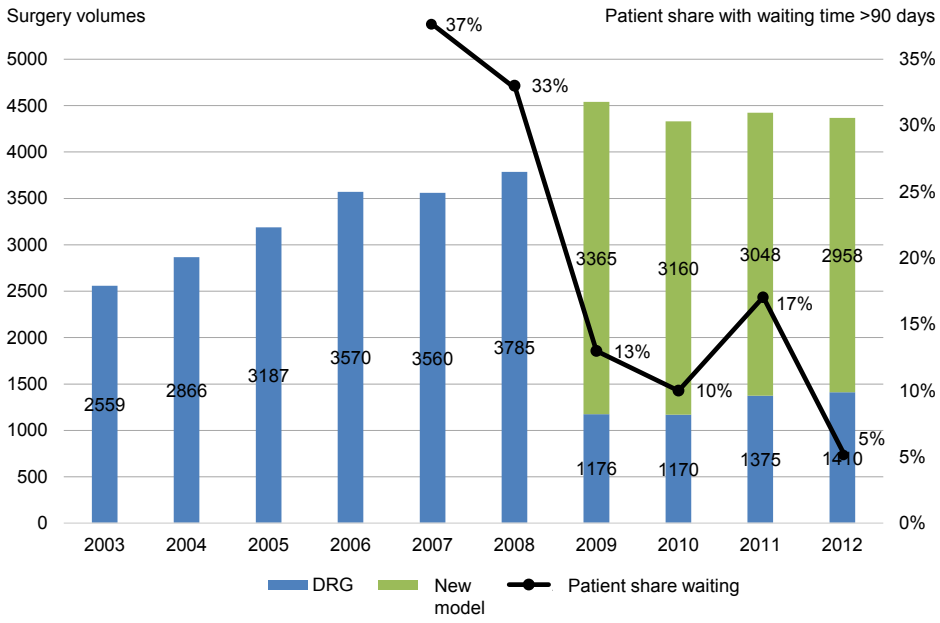

Figure 1. Production volumes and proportion of patients with waiting times for surgery >90 days. Includes all primary elective hip/knee replacements in Stockholm 2003–2012. Proportion of patients with waiting times >90 days include both medically justified waiting and self-selected waiting.

Increased equal access to care. To understand whether introducing the new model affected access to care for specific groups, changes in sociodemographic variables among patients undergoing surgery were studied (educational level, marital status, country of origin and disposable income). In addition, preoperative pain level has been analyzed for different groups. The analysis shows that the increase in accessibility occurred alongside an equal rise in volumes for all groups. Detailed examination showed that patients born outside the EU-27 reported a higher preoperative level of pain ($p<0.05$) than patients born in Sweden. Such a disparity can possibly be explained by cultural differences in the way pain is perceived and presented [xi, xii]. The difference between patients born outside the EU-27 and the other groups increased slightly after the introduction of the new model, however not statistically significant ($p=0.23$).

More surgeries took place at specialist centers and fewer at emergency hospitals. All eight healthcare providers who previously operated on publicly financed Stockholm patients as well as two additional private specialist centers were authorized during the introduction of patients' choice of provider. From 2008 to 2009, shifts took place in production from public

providers (-18 percent) to private providers (+107 percent), and from emergency hospitals (-13 percent) to smaller specialist centers (+218 percent) (Figure 2).

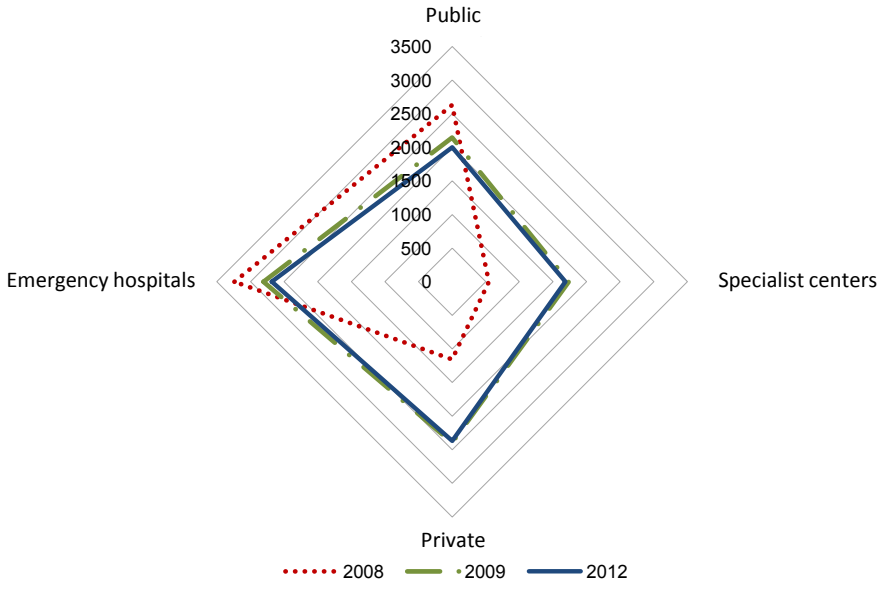

Figure 2. Production volumes 2008, 2009, 2012. Includes all primary elective hip/knee replacements in Stockholm during 2008, 2009 and 2012.

Emergency hospitals increasingly took care of patients with high comorbidity. When analyzing the Charlson Comorbidity Index (CCI), a well-established comorbidity index [xiii], it was found that emergency hospitals increasingly cared for patients with high comorbidity, while specialist centers took care of patients with less comorbidity ($p<0.05$). On average, CCI increased from 0.619 to 0.705 (+14%) for emergency hospitals, and decreased from 0.298 to 0.252 (-15%) for specialist centers.

The new model does not appear to have led to operating based on other indications. As the adoption of the new model meant that past constraints on volume production were removed, and since the volume also initially increased, it is relevant to study whether patients with less discomfort underwent surgery. Calculations of average CCI showed a total reduction of approximately 7% after introduction of the new model. One possible reason for this could be that those patients who, prior to the adoption of the new model, were in line and therefore had not been prioritized for surgery, had, on average, slightly lower comorbidity than those who had undergone surgery. It was found that the adoption of the new model had

not prompted any change in the mean age at time of surgery. Quantitative analysis shows that preoperative pain levels and patient-reported quality of life for patients who underwent hip replacement surgery remained unchanged or deteriorated slightly. All in all, this indicates that patients did not appear to have received surgery earlier in the course of the disease than what was medically justified. This finding is consistent with that of SLL from an audit that was performed and which included extensive review of medical documentation. Thus, initial volume increase was probably related to a need that had accumulated during the time preceding the introduction of the new model.

3.2. EFFECTS ON PROVIDERS' WAYS OF WORKING AND CARE PROCESS

The design of the reimbursement system aims to enable and stimulate healthcare providers to be innovative and to provide healthcare in a way that accomplishes the best possible health outcomes at the lowest possible cost. This section analyzes the impact on healthcare providers' work based on interviews with organizational representatives in combination with quantitative analysis of register data.

Fundamental changes in the care process. Five of the nine providers who performed these surgeries prior to the adoption of the new model stated that the new model design resulted in them making changes to the treatment process or their way of working in order to enhance productivity and/or to reduce the risk of complications. Three of these providers, all private, reported that they implemented major change projects such as study visits to other providers in Sweden and abroad, process mapping, development of manuals and checklists, development of information for patients, staff training and certification.

Three providers reported that they introduced additional follow-up visits with the purpose of having trained nurses remove surgical stitches and at the same time identify any infections at an early stage. Previously, the stiches were removed within primary care.

> ***"And then one should not hide the fact that this warranty also brings forward an awareness. One feels that it costs to have complications. I must say, it increases quality."***
>
> – Healthcare provider during an interview

Increased number of surgeries per room, team and day. Three healthcare providers reported that they increased the number of surgeries per room, team and day from three to between four and five, as a consequence of the adoption of the new model. All three providers accomplished this by reducing switching time and in no cases should this have resulted in longer working hours for staff. In addition, a redistribution of surgical volumes took place to the benefit of providers with higher productivity in the operating room. An estimate of resource utilization based on interviews with healthcare providers – in combination with the observed changes in the distribution of operation volumes presented in Figure 2 – shows

that the average number of surgeries per room, team and day increased from approximately 3.1 to 3.6 from 2008 to 2011. This corresponds to an increase in the utilization rate of fixed surgical resources by approximately 16 percent. For patients covered by the new model, approximately 3.7 surgeries were performed per room, team and day during 2011.

"We have also increased productivity in the operating room by thirty-three to fifty percent."

– Healthcare provider during an interview

Reduced length of inpatient stay after surgery, but with major differences between healthcare providers. Duration of hospital stay in surgical departments in connection with the surgery has, as similar to the rest of the country, continuously decreased during the last decade. When adjusting for trends over time, gender and type of surgery, a significant reduction in length of inpatient stay after introduction of the new model was noticed. By contrast, after 2010 the continuous reduction that was observed during the period before the adoption of the new model ceased, and the length of stay stabilized at around four days during 2011–2012. The absolute reduction in length of stay was even greater when postoperative stay at geriatric and/or rehabilitation department was included in the analysis. The reduction then amounted to a about one day (crude values): from approximately 6.7 days in 2008 to 5.8 days in 2009 (Figure 3). A large part of the reduction appeared to be due to the shift of surgical volumes from emergency hospitals with longer average inpatient stay to specialist centers with shorter average inpatient stay.

The qualitative analysis was consistent with the quantitative regarding the reduction in length of stay: four providers reported that they reduced treatment time by an average of one day and that increasingly patients were admitted the same day as the surgery was performed instead of the day before the procedure. After the adoption of the new model, providers were also responsible for rehabilitation costs incurred at external rehabilitation units. A number of providers reported that they had therefore actively stopped sending patients to external rehabilitation units following the adoption of the new model, as they argued that patients sometimes remained for unjustifiably long periods of time in these units, which the providers did not want to pay for. In the quantitative analysis, it appeared that the use of external geriatric and rehabilitation units decreased (crude values) from 1.42 days in 2008 to 1.10 in 2009 and 0.92 in 2010.

Initial analysis of treatment time led on to an in-depth analysis of differences between healthcare providers. Figure 4 and Figure 5 show the unadjusted average length of stay per provider and Figure 6 shows the relative differences in length of stay between providers after adjusting for patient characteristics available in the data. There were significant differences between different healthcare providers with a clear line of division between emergency hospitals and specialist centers.

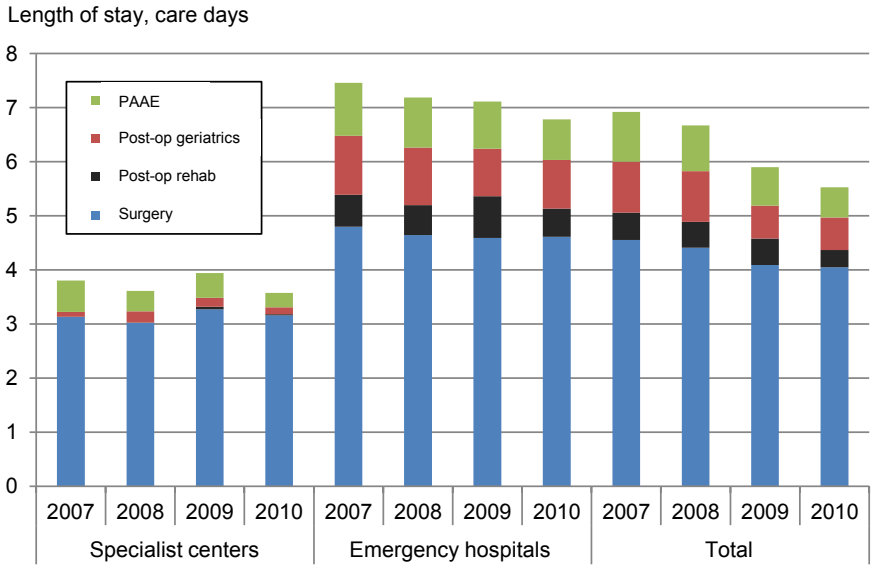

Figure 3. Average length of stay per year. All primary elective hip/knee replacements 2007–2010. Inpatient stay for potentially avoidable adverse events (e.g. infection or reoperation) related to the primary surgery is separated from inpatient stay related to the surgery, geriatric care and rehabilitation. Length of stay split by specialist center and emergency hospital, respectively.

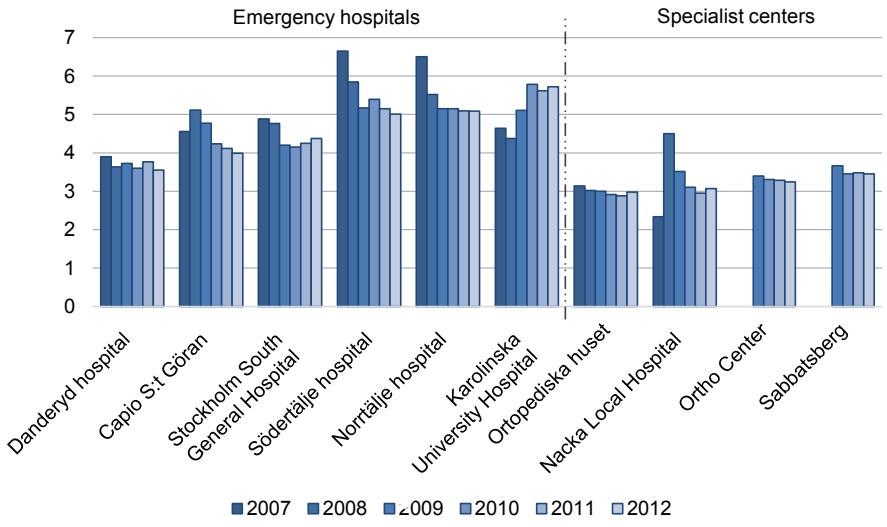

Figure 4. Average length of stay per provider. All primary elective hip/knee replacements 2007–2012.

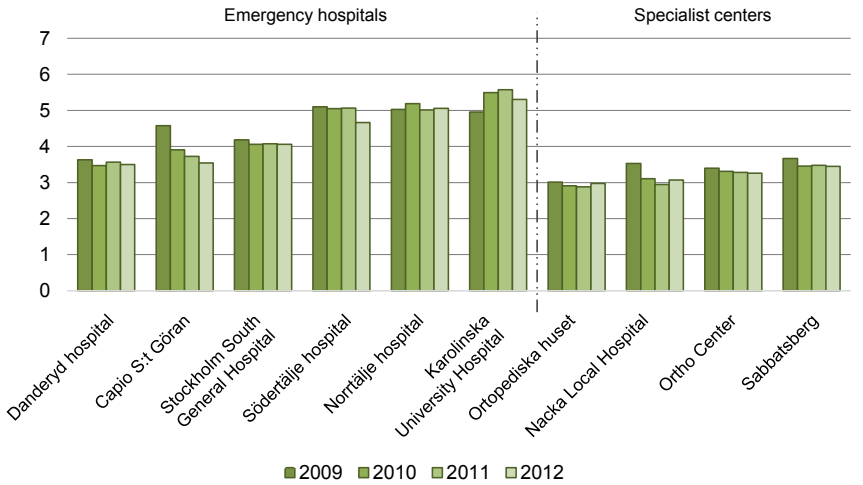

Figure 5. Average length of stay per provider for patients covered by the new model. Primary elective hip/knee replacements under the new model 2009–2012.

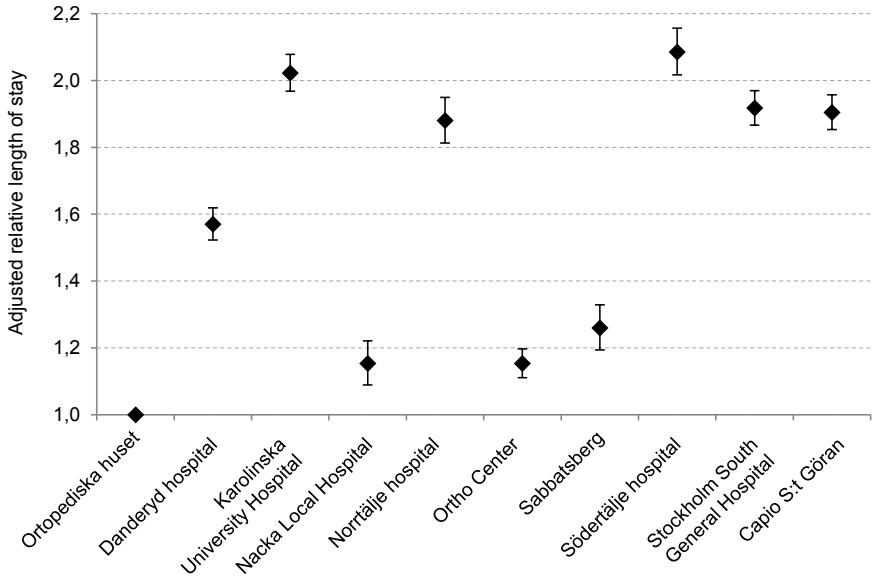

Figure 6. Adjusted relative length of stay for all patients, with confidence intervals (95%). Relationship between providers' length of stay (including geriatric care and rehabilitation) for all patients, adjusted for age, gender, depression diagnosis, education level, country of birth, disposable income, prior primary joint prosthesis, co-morbidity and prosthesis type. Ortopediska huset = 1.0; value of 2.0 corresponds to 100% longer average length of stay compared to Ortopediska huset, adjusted for patient characteristics as mentioned above.

No significant changes in surgical method or choice of prostheses. No healthcare providers suggest that they have changed surgical technique or type of prosthesis as a consequence of introducing the new model. Quantitative analysis shows that the hips that were operated on without cement and with hybrid technology increased during the observation period (after 2007), but that there have been no significant changes following the adoption of the new model. There are however differences in the choice of hip prosthetic between providers (see Table A14).

A private healthcare provider reported having negotiated prices down for special prosthetics by about 30 percent after the adoption of the new model. No other providers reported changes in prosthetic prices and no providers reported changes in prosthetic supplier resulting from the adoption of the new model.

Reduced prescriptions of opioids and antibiotics. Analysis of data from the Prescribed Drug Register shows that the prescription of opioids decreased by 21 percent. The prescription of other analgesics increased by 7 percent and the prescription of antibiotics declined by 8 percent after the adoption of the new model (see Table A15).

Minor changes in facilities/equipment. One specialist center reported investing in improved air quality (laminar flow) in the operating room resulting from the requirements within the new model. No other changes to facilities or equipment were reported.

Private providers introduced financial incentives for staff. One private provider reported that a small incentive for staff based on volume was introduced, but that it has not resulted in any positive effects. Two additional private providers planned to introduce their own respective financial incentives for staff: one based on patient satisfaction and short-term results and the other based on cost savings related to avoided complications and the complications warranty. Public providers expressed that it was not possible for them to introduce financial incentives for staff.

Marketing through the improvement of websites and information for other healthcare providers. Four private providers and one public provider reported that they actively worked with patient recruitment. Their methods included improved websites, letters to general practitioners, as well as information meetings for general practitioners and physiotherapists. No providers reported marketing their services directly to patients, aside from providing improved information to those patients who sought out their services on their own. Providers reported that an overwhelming majority of patients chose the provider that their general practitioner had recommended.

Improved service through increased accessibility and a better structured care process. Five providers were of the opinion that the level of service provided to patients increased after the adoption of the new model. Increased accessibility over the phone, improved structure of the continuum of care, and better patient information, as well as the ability to select date for surgery at the time of therapy decision were cited as primary reasons.

> ***"One cannot (or should not) expect to benefit without making some effort, rather we actually have to work for it. We must create a good reputation around town. It is essential for us to continue to have our jobs and being able to do these things."***
>
> – Healthcare provider in an interview

3.3. EFFECTS ON HEALTH OUTCOMES

The analyses in this section aimed to investigate whether the health outcomes, i.e. the treatment result, changed after the adoption of the new model. In this report, health outcomes are divided into complications or PAAE registered in SLL's administrative healthcare database (GVR/VAL), and patient-reported health outcomes (PROM) reported to the Swedish Hip Replacement Register (SHPR) for patients who underwent hip replacement surgery. Section 5 presents the analysis of sick leave, which can also be seen as a health outcome.

Reduced risk of complications. Four categories of complications or PAAE have been analyzed (definitions are presented in Tables A6-A7):

- Inpatient care episodes with complications diagnosed, within two years of primary surgery
- Inpatient reoperation within two years of primary surgery
- Inpatient prosthetic removal/replacement within two years of primary surgery
- Cardiovascular event within 30 days of primary surgery

The risk of complications decreased across all categories following the adoption of the new model (Table 1). The degree of orthopedic complications further decreased when comparing surgeries carried out in 2010 with the 2007/2008 population.

Table 1. Complications demanding inpatient stay after primary hip/knee replacement. Results adjusted for simultaneous changes in patient characteristics (age, gender, depression diagnosis, educational level, country of birth, disposable income, prior primary joint prosthesis, comorbidity and prosthesis type).

Complications	Risk 2007/2008	Change 2009/2010	Statistical significance of change	Change 2010	Statistical significance of change
Orthopedic complication within 2 years	6%	-18%	p=0.00	-26%	p=0.00
Reoperation within 2 years	5%	-23%	p=0.00	-36%	p=0.00
Revision/removal within 2 years	2%	-19%	p=0.09	-34%	p=0.01
Cardiovascular event within 30 days	1%	-44%	p=0.01		

According to the analysis performed, there were no significant differences in the risk of complications between hospitals and specialist centers prior to the adoption of the new model. However, private providers decreased their risk of complications more than public providers after the adoption of the new model. The total risk reduction can partly be explained by a general risk reduction among healthcare providers who treated SLL patients prior to the adoption of the new model, and partly by volume shifts to providers with a lower level of risk. This is consistent with the results of the qualitative, interview-based analysis, in which

private providers reported to a greater extent than public providers that they implemented changes to the care process with the aim of reducing the risk of complications[1].

The analysis also shows that the patients' sociodemographic and medical conditions prior to the surgery had a significant effect on the risk of complications. Patients with a disposable family income in the fourth quartile (second highest) were at a 23 percent lower risk compared to those who were in the first quartile (lowest family income). Similar effects could be identified for other categories of complications (see Tables A2-A5).

It should be noted that the follow-up time in this analysis was limited to two years and that analysis of the change over a longer period was not possible within the scope of this study. However, in the future, this analysis should be supplemented with analyses of complications occurring within 5–10 years. It should also be noted that the method used in this report to detect complications is not directly comparable to the numbers presented in the annual reports of the Swedish Hip and Knee Replacement Registers; for a full description of the differences see the summary in the Appendix.

Significant reduction in the frequency of orthopedic complications persisted when compared with trends in other counties. Difference-in-differences analyses were carried out to investigate whether the reduction in orthopedic complications was actually associated with introduction of the new model, or whether it seemed to depend on secular trends applicable to regions outside of Stockholm (new surgical methods, quality initiatives, more resources, quality register monitoring etc.). Results from the analysis showed that improvement in complication rates observed in SLL was not caused by trends present in the six comparison regions. If anything, the interaction model indicates that the SLL results were even more favorable than what was found when studying SLL alone. Difference-in-differences analyses were conducted using the Sveus research database (see section 1.2). Changes in the rate of inpatient reoperations are presented in Figure 7.

[1] The risk for complications was significantly lower in private providers compared to public providers. In a report from the The Swedish Agency for Health and Care Services Analysis (MYVA) differences were highlighted between various types of hospitals [1]. However, this analysis had somewhat other prerequisites: i) results in this report are based on analyses of patient administrative data directly from the healthcare providers' medical records whereas the MYVA results are based on quality registry data, manually filled out and separately reported by the provider ii) somewhat differing definitions of outcomes, for details see Appendix iii) within this report results were adjusted for simultaneous changes in case mix factors stated above whereas the MYVA report included adjustments only for age, gender, BMI and ASA iv) MYVA's comparison treated Sweden as a whole v) differences in time horizons of the analysis vi) additionally, the reimbursement models within the different counties' adoptions of patients' choice of provider differed, especially for SLL.

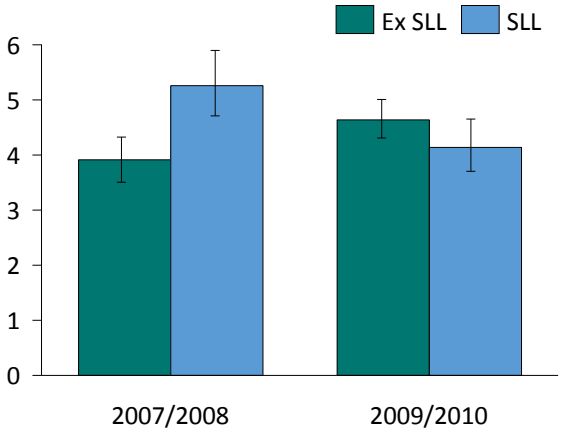

Figure 7. Proportion of patients undergoing reoperation within two years after primary hip/knee replacement. Stockholm county compared to six other Swedish county councils (Region Jämtland Härjedalen, Region Östergötland, Landstinget Dalarna, Landstinget i Uppsala län, Region Skåne and Västra Götalandsregionen), during the period before and after introduction of the new model.

The Sveus study population was not identical to the population studied within this report; the Sveus study population comprised patients with two years of complete follow-up, and adjustments carried out for the results of the Sveus study population were based solely on the variables available in the administrative patient system. Detailed information on the regression analysis is provided in Table A13.

Patient-reported pain and quality of life after surgery was unchanged. The treatment effect on patient-reported quality of life (EQ-5D), patient-reported pain reduction (pain according to the visual analog scale, VAS) and satisfaction with surgical results were analyzed for patients who underwent hip replacements. Only marginal changes were noted. Differences existed between specialist centers and emergency hospitals, where emergency hospital patients had somewhat greater pain prior to surgery as well as somewhat less relative improvement. The observed differences are very small and have not been analyzed in detail.

These patient-reported measures have been analyzed based on the number of points, unlike the measure used by SHPR in its annual reports, which presents changes in terms of percentage change. PROM data is missing for knee replacement patients as it was not being systematically collected by the Swedish Knee Arthroplasty Register (SKAR) at the time of this study. However, a pilot introduction of such measures has since then been performed [xiv].

3.4. EFFECTS ON RESOURCE CONSUMPTION AND COSTS

Analyses in this section are intended to investigate whether the cost of illness and treatment changed after the adoption of the new model. Costs related to sick leave (indirect costs) and resource utilization within the healthcare system (direct costs) have been analyzed. In addition, payer cost has been analyzed, i.e. what Stockholm county healthcare administration paid for healthcare.

Sick leave decreased in Stockholm and in the rest of the country. The average number of sick days for the patient group decreased both before and after surgery in Stockholm and in the rest of the country (Figure 8). The total reduction in Stockholm was 17 percent (38 net days of sick leave) during the period of one year before and one year after surgery. It is not possible to determine what these reductions were due to, but it is likely a combination of reduced waiting times and an overall reduction in sick leave throughout the country during the period 2007–2010 as a result of political reforms [xv].

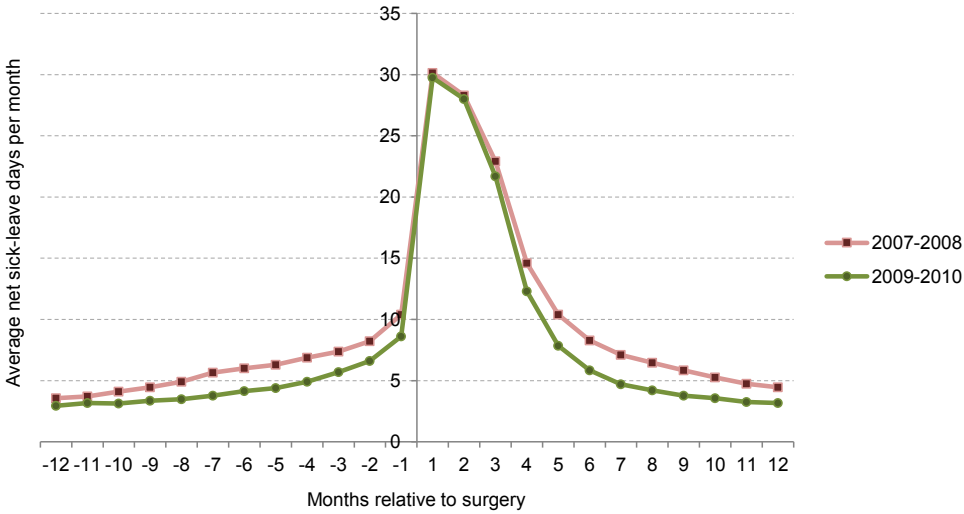

Figure 8. Sick-leave patterns for Stockholm patients with at least one net day of sick leave the first year after primary surgery.

Table 2. Average number of net sick-leave days one year before and after primary surgery, in Stockholm and the rest of Sweden. Adapted from Banefeldt et al. [xvi]

	Average net sick-leave days 12 months before surgery	Average net sick-leave days 12 months after surgery	Total
Stockholm			
2007/2008	71.5	148.5	220.0
2009/2010	54.2	128.1	182.3
Difference	**-17.3**	**-20.4**	**-37.7**
%	-24 %	-14 %	-17 %
Rest of Sweden			
2007/2008	80.1	159.2	239.3
2009/2010	55.2	130.8	186.0
Difference	**-24.8**	**-28.4**	**-53.3**
%	- 31 %	-18 %	-22 %

Resource utilization per treatment decreased. Resource utilization has been analyzed based on the number of doctor visits during 12 months before and 12 months after the index operation, as well as based on the length of stay related to the surgery and any complications. Pharmaceutical prescriptions were analyzed in section 3.2 above, but in relation to other resources the costs of pharmaceuticals are low and therefore were not included in the cost analysis.

Table 3. Resource utilization before and after introduction of the new model.

	2007/2008[i]	2009/2010[i]	Difference[ii]	%[iii]	Aggregated difference/ year[iv]
Doctor visits (12 months before surgery)[v]	2.36	2.23	-0.14	-6%	-787
Doctor visits (12 months after surgery)[v]	1.93	1.78	-0.16	-8%	-657
Doctor visits in total	**4.29**	**4.01**	**-0.28**	**-7%**	**-1,444**
Number of inpatient care episodes with PAAE	0.111	0.085	0.026	-23%	112
Care days, surgery	4.48	4.07	-0.41	-9%	-1,778
Care days, rehab[vi]	0.49	0.41	-0.08	-17%	-350
Care days, geriatrics[vi]	0.94	0.60	-0.34	-36%	-1,464
Care days due to complications[ii]	0.88	0.64	-0.24	-27%	-1,048
Care days in total	**6.79**	**5.72**	**-1.07**	**-16%**	**-4,640**

[i] Average per patient
[ii] Difference in average resource utilization, after versus before introduction of the new model
[iii] Percentage change in average resource utilization
[iv] Aggregated difference based on 2010 surgery volumes
[v] Visits to orthopedic clinic, at any of the 10 clinics participating in the new model
[vi] Inpatient care episodes starting within 30 days after discharge
[vii] Based on all inpatient care episodes with registered PAAE diagnosis (see table A6-A7)

The number of physician visits per surgery decreased by 7 percent and the number of inpatient days of care decreased by 16 percent after the adoption of the new model. In total, 1,444 doctor visits and 4,640 bed days per year were freed-up for additional patients annually, based on 2010 surgical volumes (Table 3). As described in Section 3.2, the decrease in length of stay was mainly due to the shift in care that occurred from emergency hospitals to specialist centers which had shorter average length of stay. Both specialist centers and emergency hospitals reduced the number of doctor visits, from 4.3 to 3.7 (specialist centers) and 4.2 (emergency hospitals). Visits to professional groups other than doctors (e.g. nurses) have not been analyzed.

Using the average 2010 unit costs taken from the SKL database of cost per patient (CPP), calculations show that avoided costs amount to approximately SEK 11,300 per patient (14 percent), which corresponds to a total of SEK 49 million per year, based on the 2010 surgical volumes.

Payer costs were reduced by 20 percent per patient. The risk of cost increase was a key concern for SLL when introducing the new model, since the abolishment of volume restrictions could mean volume increases with associated potential cost increases.

In this analysis, SLL's cost for the care episode was calculated as a function of unit and price volume. The costs taken into account include the primary treatment, treatment of complications, geriatrics and rehabilitation, as well as pre-operative and post-operative visits. Patients covered by the new model have a fixed unit price, while the unit price for DRG-reimbursed patients was based on DRG weight and healthcare providers' DRG point price. The analysis was adjusted to compensate for changes in the management of economic contributions to education-heavy providers during the period. Figure 9 and Figure 10 illustrate the total volume-related and cost-related effects.

When comparing the periods 2007–2008 and 2009–2010 it can be noted that the average reimbursement per patient decreased by 20 percent. In terms of 2010 volumes, this means a saving of approximately SEK 56 million per year. The volume increased by 21 percent and hence total costs fell by 3 percent.

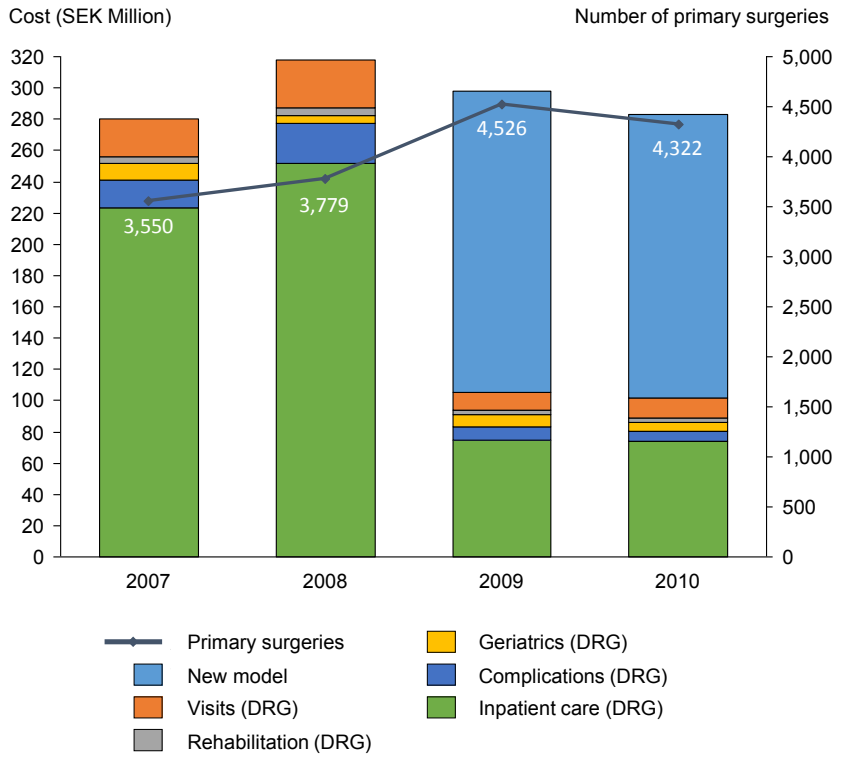

Figure 9. Production volume and total payer cost. Costs were computed from a payer perspective (Stockholm county) with 2010 as price index year and include inpatient stay after surgery, inpatient geriatric care and rehabilitation initiated within 30 days of discharge, inpatient care for complications up to two years after surgery, as well as pre-operative and post-operative visits.

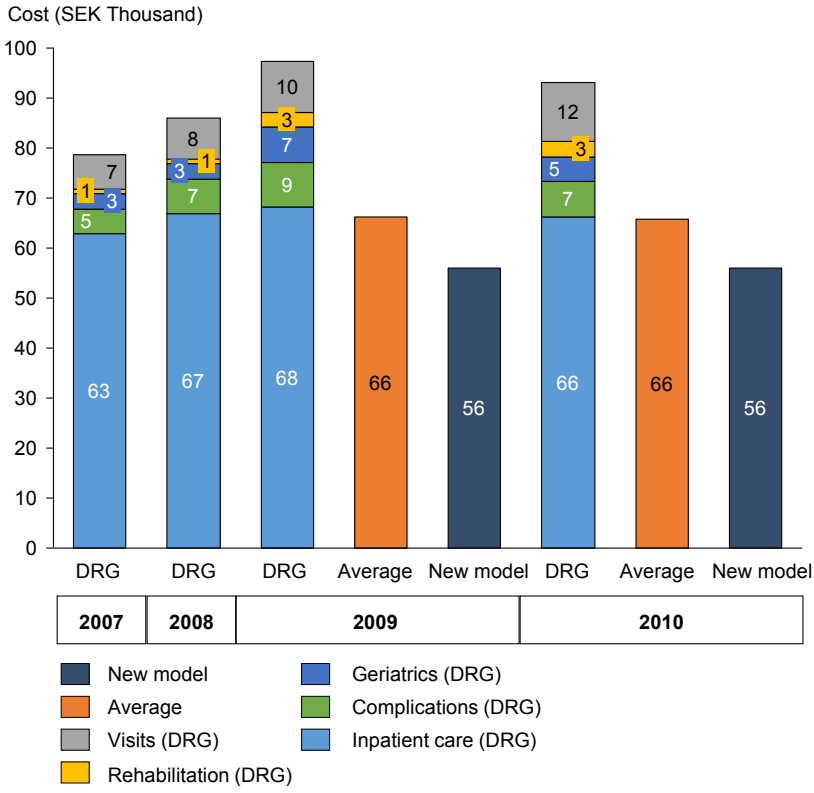

Figure 10. Payer cost per patient. Costs were computed from a payer perspective (Stockholm county) with 2010 as price index year and include inpatient stay after surgery, inpatient geriatric care and rehabilitation initiated within 30 days of discharge, inpatient care for complications up to two years after surgery, as well as pre-operative and post-operative visits.

3.5. EFFECTS ON THE PATIENTS' EXPERIENCE OF CARE

Section 3.3 presents the results of patient-reported outcome measures (PROMs), which can be seen as health outcomes. This section analyzes the patient-reported experience of treatment (Patient Reported Experience Measures, PREM). It should be noted that PREM is not classified as a health outcome measure, rather as a process measure.

PREM data was collected for the study population through a patient questionnaire in 2010 and is only available for the time after the adoption of the new model. A comparative analysis over time was not possible, and instead healthcare providers who increased their production volume were compared to those who reduced (or remained at the same level of) their production volume following the introduction of the new model.

Healthcare providers who increased their production volume after adoption of the new model had better results on 37 of the 40 questions in the patient survey, of which 30 were significantly better. Since measurements of the patients' experience of care were not performed prior to the adoption of the new model, it is not possible to determine whether the changes occurred over time. In this context, it is worth noting that the volume shift of patients occurred toward providers with a higher level of satisfied patients, which may have contributed to increasing the average patient satisfaction.

"...we have very actively informed [our staff] in connection with making the decision to join under this new model. Now it is a market economy and not a planned economy anymore and now we must work for it."

– Healthcare provider during an interview

3.6. HEALTHCARE PROVIDERS' VIEW ON THE NEW MODEL AND ITS EFFECTS

Representatives of providers were generally positive. A majority of healthcare providers were generally supportive of the new model. Healthcare providers described the new reimbursement model as patient-friendly and patient-centered.

The price level was perceived as low. Most healthcare providers expressed that the price was too low. Private providers reported that they were forced to supplement it with patients from insurance companies and patients from other county councils to achieve what they considered to be a reasonable margin.

Need for differential pricing based on patient characteristics. Healthcare providers stated that the bundled payment should vary based on the patient's conditions, so-called individual adjustment (see Section 1.1). One example that was mentioned in this context was related to patients who do not speak Swedish; for these patients, providers received reimbursement for an interpreter but not for the additional consumption of healthcare that could be expected due to communication challenges. Elderly patients needing extra inpatient care constituted another group that healthcare providers felt should entail extra compensation.

The complication warranty needs to be more clearly defined and case management needs to be more efficient. Most healthcare providers were positive towards the complications warranty, but stated that the complications covered by the warranty should be more clearly defined. Furthermore, they stated that an upper limit on the healthcare provider's liability for costs should be introduced, in order to prevent the costs of a single complication becoming disproportionately large in relation to the provider's finances.

A number of healthcare providers stated that the handling of warranty cases on SLL's side needed to be streamlined.

Management of monitoring and performance-based reimbursement needs to be streamlined. Six healthcare providers expressed that the handling of performance-based reimbursement needed to be streamlined. Providers stated that neither sending out patient surveys nor settling performance-based reimbursements were done in accordance with the rule book.

Ensuring primary care's investigative responsibility should not be placed on the orthopedic clinic. Eight healthcare providers expressed that it was wrong to place the responsibility on them for ensuring that primary care handles arthrosis investigations and submits accurate referrals. Their argument was that healthcare providers do not have the capacity to train representatives of the large number of primary care units that referred patients and that general practitioners often switch primary care unit affiliation. Furthermore, some of the healthcare providers stated that general practitioners could not be expected to possess the expertise to assess which patients required surgery and that patients would suffer if referrals were sent back as it would delay treatment. Finally, several providers expressed concern about losing patients to other healthcare providers if they sent back incomplete referrals.

One suggestion proposed by healthcare providers was to remove the fine and instead give primary care providers a financial incentive to submit complete referrals.

The new model has entailed increased administration. Four healthcare providers expressed that the new model resulted in an increased administrative load due to greater reporting requirements. Two of these providers had changed their IT systems to facilitate the reporting process.

Training of resident physicians needs to be ensured. The new model causing problems for emergency hospitals in meeting their educational responsibilities when their volumes decreased, seemed to be the question that engaged healthcare providers the most. The general perception among providers was that training should also take place at specialist centers and that a separate reimbursement model should be developed for this purpose.

Positive effects on other patient groups but concern regarding inaccurate prioritizations. Four of the five public emergency hospitals reported that the capacity for more complex procedures, sicker patients and emergency care increased after the adoption of the new model. This was generally perceived to be a positive change as they felt that the emergency hospital resources were utilized better when focused on more difficult patients. Three emergency hospitals expressed difficulties in using the freed capacity to increase DRG-related production, since DRG production that surpassed the set target levels was reimbursed at a discounted price.

Two healthcare providers who implemented improvement projects after introduction of the new model reported that lessons learned from this process could also be used in other treatment areas.

Two healthcare providers expressed a concern that patients covered by the new model were prioritized or could be prioritized before other patient groups for financial reasons.

Good transparency around results but doubts around initiating rankings. Healthcare providers were generally supportive of the publication of patient satisfaction and health outcomes through the agency Healthcare guide 1177, but several stressed the importance of not ranking healthcare providers against each other if there are no significant differences when adjusting for differences in case mix.

Patients choose healthcare providers based on recommendations from general practitioners and proximity to residential area. All healthcare providers reported experience that a clear majority of patients chose healthcare providers based on the general practitioners' recommendation and without seeking out information themselves. Healthcare providers believed that the general practitioners' choice of provider was mainly related to the proximity to the patient's home and the historical relationship between the provider and the general practitioner.

Unclear whether the new model affected healthcare personnel's work environment. Two private providers expressed the opinion that the changes that were implemented led to staff being more satisfied with their work situation. Two public providers reported that staff had more demanding work and that they expressed dissatisfaction. None of these healthcare providers could confirm these findings with employee survey results.

4

Conclusions and discussion

The analysis suggests that the introduction of the new model resulted in the desired effects, i.e. improved coordination of the care process, lower costs through improved utilization of resources and that the reimbursement model allows healthcare providers to focus more on good health outcomes and avoid complications. Additionally, the patients' freedom of choice increased and patients no longer had to wait for surgery. Furthermore, both the risk of complications during the first two years after primary surgery decreased and the cost for SLL decreased, despite increased volumes. For all of the above reasons, the results may be deemed satisfactory from a payer perspective.

The results of the register studies in combination with the results of the interview-based study suggest that the introduction of patients' choice of provider in conjunction with the adoption of the bundled payment model contributed to the observed effects.

Private healthcare providers have, to a greater extent than public providers, changed their practices as a consequence of the adoption of the new model, which also seems to have had positive effects on the risk of complications as well as on cost. Possible reasons may include that private providers perceive themselves as being more exposed to fluctuations in revenue and financial risk and/or that they have better insight into their cost base for this specific patient group. Another possible explanation could be that private providers are organized in a way that makes it easier for them to change their ways of working.

The analyses show that patients' medical and sociodemographic background affect both the expected results and expected resource utilization. Adjustment algorithms should therefore be developed to enable comparative and accurate monitoring of healthcare providers and to customize package prices that better match expected costs based on patient characteristics (see individual adjustment in Section 1.1).

It is important to note when interpreting the quantitative analyses that have been reported that it has not been possible to isolate the observed effects resulting from the adoption of the bundled payment model from the introduction of patients' choice of provider. When interpreting the quantitative analyses, it should also be noted that the data is based on codes recorded by the healthcare providers, and are therefore dependent on care contacts being properly recorded. It

should also be noted that analyses at the system level are particularly complex as it is difficult to isolate the impact of specific reforms from other changes in the healthcare system. The trends in complication rates after surgery were compared to the extent possible with other counties, and the observed effect in the SLL after the adoption of the new model remained statistically significant. In this context, it should also be mentioned that a national project was initiated in 2008 to pursue continuous improvement with decreased complication rates (Prosthesis-Related Infections Should be Stopped, PRISS) [xvii].

In the interpretation of the cost analysis, it should be noted that during interviews the healthcare providers stated that the shift in care from emergency hospitals to specialist centers has resulted in reduced training efforts. Potential indirect cost increases related to that have not been considered in the analysis. Furthermore, aggregated CPP data for emergency hospitals indicate that costs have increased for three emergency hospitals and decreased for one emergency hospital. Whether this is due to emergency hospitals operating on more difficult patients, reduced productivity, reduced surgery volumes, altered calculation model for the CPP or if it is dependent on other factors cannot be determined without a deeper analysis of hospital CPP data in collaboration with hospitals, which was outside the scope of this study. We recommend that such an analysis is carried out.

In summary, the results suggest that the introduction of the bundled payment model for hip and knee replacement surgery has had positive effects for SLL's healthcare system, but that some components should be analyzed further and certain aspects of the model should be further developed. The section below includes the authors' recommendations.

5

Authors' recommendations

Below are the authors' proposed improvements in the existing reimbursement scheme in SLL and further analysis of hip and knee replacement surgery:

1. Develop methods, processes and systems to enable effective management of bundled payment reimbursement models
2. Let the opinions of healthcare providers form the basis of future updates to and development of the reimbursement model, and involve them in the continued development
3. Ensure training for resident physicians as well as collaboration around and conditions for research, regardless of the reimbursement model design. Resident physician medical training may, for example, be replaced by a separate education grant.
4. Adjust the package price according to differences in patient characteristics and explore possibilities of also including patients with more severe comorbidity (ASA 3-4) in the reimbursement model
5. Focus SLL's follow-up on health outcomes and cost on patient level and explore the possibility of basing performance-based payments on health outcomes to a greater extent and process indicators to a lesser extent
6. Define the provider's responsibility for complications more clearly and improve its case management
7. Analyze whether the division of responsibilities and financial means of control related to pre-operative investigations are optimally designed
8. Examine the possibility of including sickness absence and return to work in healthcare management and governance
9. Evaluate how the hospitals' other reimbursements should be adjusted with the adoption of bundled payment models and other parallel reimbursement models
10. Examine possibilities of allowing bundled payments to cover the entire care process (e.g. physiotherapy after surgery and patient-education on arthrosis prior to primary surgery)
11. Ensure expertise around value-based reimbursement within the payer organization, e.g. through the establishment of a working group specialized in the development, implementation and monitoring of value-based reimbursement models

12. Enable and stimulate knowledge transfer around value-based reimbursement between the payer's various departments to take advantage of lessons learned from previous work and possible synergies with other reimbursement models
13. Introduce increased reporting of patient-reported outcomes for knee replacement surgery based on the pilot project already initiated by the quality register SKAR
14. Work actively to ensure that healthcare providers harmonize their respective reporting and coding practices with national initiatives (based on quality registries and the Swedish Orthopedic Association coding guide), e.g. reporting of side of surgery (laterality) which could also be included as a variable in SLL's administrative database
15. At a later time, perform an analysis similar to this study with a longer time horizon, i.e. 5–10 years follow-up time, to provide further clarity in the long-term changes as well as changes over time

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References

[i] Przywara, B., Projecting future health care expenditure at European level: drivers, methodology and results, in Economic Papers 417, European Economy. 2010, European Commission.

[ii] Porter, M.E., What is value in health care? N Engl J Med, 2010. 363(26): p. 2477-81.

[iii] Berwick, D.M., B. James, and M.J. Coye, Connections between quality measurement and improvement. Med Care, 2003. 41(1 Suppl): p. I30-8.

[iv] Hussey, P.E. et al., Bundled Payment: Effects on Health Care Spending and Quality, RAND Evidence-based Practice Center (Agency for Healthcare Research and Quality at U.S. Department of Health and Human Services), AHRQ Publication No. 12-E007-EF, August 2012

[v] Casale A et al., "ProvenCareSM": A Provider-Driven Pay-for-Performance Program for Acute Episodic Cardiac Surgical Care, Annals of Surgery, Vol. 246, No. 4, October 2007, pp. 613–621.

[vi] Porter, M.E., A strategy for health care reform--toward a value-based system. N Engl J Med, 2009. 361(2): p. 109-12

[vii] Sadoghi, P., et al., Application and survival curve of total hip arthroplasties: a systematic comparative analysis using worldwide hip arthroplasty registers. Int Orthop, 2012. 36(11): p. 2197-203.

[viii] Robertsson, O., et al., Knee arthroplasty in Denmark, Norway and Sweden. A pilot study from the Nordic Arthroplasty Register Association. Acta orthopaedica, 2010, Feb;81(1):82-9.

[ix] Hälso- och Sjukvårdsförvaltningen, Stockholms läns landsting

[x] Sveus, Värdebaserad uppföljning av vården för planerad kirurgi vid ledsjukdom – analys från framtagande av uppföljningssystem, 2015. (ISBN: 6 978-91-982603-5-9)

[xi] Cassisi, J.E., et al., Patterns of pain descriptor usage in African Americans and European Americans with chronic pain. Cultur Divers Ethnic Minor Psychol, 2004. 10(1): p. 81-9.

[xii] Krupic, F., et al., Influence of ethnicity and socioeconomic factors on outcome after total hip replacement. Scand J Caring Sci, 2013. 27(1): p. 139-46.

[xiii] Quan, H., et al., Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care, 2005. 43(11): p. 1130-9.
[xiv] Svenska knäprotesregistret, Årsrapport 2014 (2015).
[xv] Försäkringskassans uppföljning av sjukförsäkringsreformen, Delredovisning – juni 2012.
[xvi] Banefelt et al., Characterizing Work Productivity Loss In Incident Rheumatoid Arthritis In Sweden. Value In Health, 2014. 7(17): p. A383
[xvii] Gustafson, P. et al., PRISS – Protesrelaterade Infektioner Skall Stoppas, LÖF 2014 (ISBN 978-91-637-4746-5)

7

Appendix

7.1. DIFFERENCES IN ANALYSES COMPARED TO THE SWEDISH HIP REPLACEMENT REGISTER – A SUMMARY

- Unlike SHPR, GVR (Stockholm's administrative healthcare database) captures non-surgically treated infections and dislocations as long as they have been registered during a hospital admission. This means that the GVR complications analysis will identify certain diagnoses that are not considered as complications, as reported by SHPR.
- SHPR publishes complications following hip arthroplasties as reported to the registry of healthcare providers. This means that the frequency of "false positive" complications in the SHPR database can be expected to be very low. Conversely, SHPR reported in its 2011 annual report that some underreporting of infection-related complications ("false negative") took place between 2005-2008.
- The analysis of complications of hip and knee arthroplasty is based on diagnostic codes and procedure codes registered in the GVR up to two years after the index operation, and therefore identifies hospital admissions in a way that captures even less serious complications than those reported to SHPR (e.g. a dislocation corrected by non-surgical re-position). On the other hand, the risk of under-reporting is very small since hospital admissions related to complications will most likely already be registered in the GVR.
- SHPR reports all surgeries performed by healthcare providers regardless of the patient's place of residence. Only patients registered as living in Stockholm county are included in the analysis of this report.
- SHPR reports which side (right/left) the surgery was performed on, which means that the analyses in the register's annual report of hip surgeries can ensure that any secondary surgery/removal was performed on the same side as the index operation. The side operated on is rarely reported (6%) for surgeries registered in the GVR, which means that subsequent operations could theoretically represent a secondary surgery on the opposite leg. Yet, this is statistically unlikely, and in the event this occurs it would impact all analyzed fiscal years in the same way. The same reasoning can be applied to the risk for prosthetic-related hospitalization without surgical intervention.

7.2. DEFINITIONS AND ADDITIONAL RESULTS

Table A1. Study population patient characteristics (primary hip/knee replacement surgeries 2007-2010).

	Knee arthroplasty (n=7,534)				Hip arthroplasty (n=8,643)			
	Specialist clinic (n=2,158)		Hospital (n=5,376)		Specialist clinic (n=2,327)		Hospital (n=6,316)	
	Mean	**min-max**	**Mean**	**min-max**	**Mean**	**min-max**	**Mean**	**min-max**
Age (years)*	67.4	30–91	68.5	11–95	68.0	37–97	67.8	13–100
Male (%)*	37	0–1	37	0–1	33	0–1	38	0–1
Prior hip prosthetic (%)[1]*	2	0–1	2	0–1	10	0–1	9	0–1
Prior knee prosthetic (%)[1]*	12	0–1	13	0–1	2	0–1	2	0–1
Depression (%)[2]*	14	0–1	14	0–1	12	0–1	14	0–1
Charlson Comorbidity Index[3]*	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
0	1,782	83	3,477	65	2,033	87	4,275	68
1	326	15.1	1,568	29.2	259	11.1	1,603	25.4
2+	50	2.3	331	6.2	35	1.5	438	6.9
Country of origin[4]*	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Sweden	1,748	81	4,215	78	2,013	87	5,305	84
Nordic countries excluding Sweden	170	7.9	472	8.8	162	7.0	469	7.4
EU27 excluding Nordic	96	4.5	249	4.6	110	4.7	333	5.23
Other	144	6.7	440	8.2	42	1.8	209	3.3
Education[4]*	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Primary school	548	25.39	1,545	28.74	566	24.32	1,651	26.14
High school	961	44.53	2,327	43.28	945	40.61	2,575	40.77
Higher education	649	30.07	1,504	27.98	816	35.07	2,090	33.09
Marital status[4]*	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Married	1,248	57.8	2,873	53.5	1,226	52.7	3,087	49.1
Single	193	8.94	566	10.5	264	11.4	828	13.2
Divorced	444	20.6	1,082	20.1	539	23.2	1,304	20.7
Widowed	273	12.7	851	15.8	298	12.8	1,075	17.1
Disposable family income[5]*								
1st quartile	124,986	-	125,876	-	125,367	-	124,998	-
2nd quartile	224,068	-	222,839	-	225,080	-	222,606	-
3rd quartile	350,918	-	349,320	-	351,244	-	350,665	-
4th quartile	777,175	-	807,318	-	887,749	-	834,003	-

* p-value less than <0.05 indicates a statistically significant difference between at least two of the four groups

[1] Code for the primary prosthetic within 2 years prior to surgery

[2] Diagnostic code for depression or prescription of anti-depressants (ATC N06) during 12 months prior to surgery

[3] Charlson Comorbidity Index is developed using diagnoses linked to increased mortality [4]. In this context, CCI is calculated using hospitalizations and outpatient diagnoses that were identified in VAL during the 2 years prior to the index operation.

[4] Classification from Statistics Sweden

[5] Swedish crowns after tax and negative transfers, reported as the mean value within the quartile

Table A2. Cox model on the risk of hospitalization due to prosthetic related complications diagnosed within 2 years of the index operation.

Variable	HR	P-value	CI_lower	CI_upper
After 2008 (yes/no)	0.82	0.00	0.71	0.94
Male (yes/no)	1.49	0.00	1.28	1.72
Age (by year)	1.00	0.51	0.99	1.01
Depression (yes/no)*	1.69	0.00	1.42	2.01
Prior hip prosthetic (2 years)	1.04	0.80	0.77	1.39
Prior knee prosthetic (2 years)	1.29	0.04	1.01	1.65
Charlson index (0=1.0)				
Charlson index 1	1.42	0.00	1.21	1.66
Charlson index 2+	1.81	0.00	1.41	2.32
Country (Sweden=1.0)				
Nordic countries excluding Sweden	0.77	0.07	0.58	1.02
Europe excluding EU27 and Nordic	0.96	0.79	0.69	1.32
Other	0.91	0.56	0.65	1.26
Education (Primary school=1.0)				
High school	0.95	0.57	0.81	1.13
Higher education	0.86	0.13	0.71	1.04
Marital status (Married=1.0)				
Single	0.82	0.15	0.63	1.07
Divorced	1.04	0.72	0.85	1.27
Widowed	0.87	0.27	0.69	1.11
Disposable family income (1st quartile=1.0)				
2nd quartile	0.92	0.40	0.75	1.12
3rd quartile	0.81	0.08	0.64	1.02
4th quartile	0.77	0.05	0.59	0.99

* Diagnostic code for depression or prescription of anti-depressants (ATC N06) during 12 months prior to surgery

Table A3. Cox model on the risk of hospitalization with prosthetic related reoperations within 2 years of the index operation.

Variable	HR	P-value	CI_lower	CI_upper
After 2008 (yes/no)	0.77	0.00	0.66	0.89
Male (yes/no)	1.25	0.01	1.06	1.46
Age (by year)	0.98	0.00	0.97	0.99
Depression (yes/no)*	1.40	0.00	1.15	1.70
Prior hip prosthetic (2 years)	0.90	0.54	0.65	1.26
Prior knee prosthetic (2 years)	1.12	0.42	0.85	1.49
Charlson index (0=1.0)				
Charlson index 1	1.24	0.02	1.04	1.48
Charlson index 2+	1.35	0.06	0.99	1.83
Country (Sweden=1.0)				
Nordic countries excluding Sweden	0.74	0.06	0.54	1.01
Europe excluding EU27 and Nordic	0.85	0.39	0.58	1.24
Other	1.31	0.08	0.97	1.77
Education (Primary school=1.0)				
High school	1.11	0.26	0.92	1.34
Higher education	0.95	0.61	0.77	1.17
Marital status (Married=1.0)				
Single	0.78	0.08	0.59	1.03
Divorced	1.00	0.98	0.80	1.24
Widowed	0.85	0.23	0.65	1.11
Disposable family income (1st quartile=1.0)				
2nd quartile	0.97	0.82	0.78	1.21
3rd quartile	0.82	0.12	0.63	1.05
4rd quartile	0.80	0.12	0.61	1.06

* Diagnostic code for depression or prescription of anti-depressants (ATC N06) during 12 months prior to surgery

Table A4. Cox model on the risk of prosthetic replacement surgery within 2 years of the index operation.

Variable	HR	P-value	CI_lower	CI_upper
After 2008 (yes/no)	0.81	0.09	0.63	1.03
Male (yes/no)	1.72	0.00	1.33	2.23
Age (by year)	0.99	0.18	0.98	1.00
Depression (yes/no)*	1.87	0.00	1.38	2.53
Prior hip prosthetic (2 years)	1.56	0.04	1.02	2.40
Prior knee prosthetic (2 years)	1.69	0.01	1.15	2.49
Charlson index (0=1.0)				
Charlson index 1	1.20	0.20	0.91	1.59
Charlson index 2+	0.95	0.87	0.55	1.65
Country (Sweden=1.0)				
Nordic countries excluding Sweden	0.68	0.17	0.39	1.17
Europe excluding EU27 and Nordic	1.40	0.17	0.86	2.27
Other	1.19	0.50	0.71	2.00
Education (Primary school=1.0)				
High school	1.45	0.02	1.06	1.99
Higher education	1.15	0.43	0.81	1.66
Marital status (Married=1.0)				
Single	0.66	0.08	0.41	1.06
Divorced	0.85	0.37	0.59	1.22
Widowed	0.78	0.28	0.50	1.22
Disposable family income (1st quartile=1.0)				
2nd quartile	0.62	0.01	0.43	0.89
3rd quartile	0.59	0.01	0.39	0.89
4rd quartile	0.65	0.05	0.42	1.00

* Diagnostic code for depression or prescription of anti-depressants (ATC N06) during 12 months prior to surgery

Table A5. Logistic mixed-effects model on the risk of hospitalization due to cardiovascular events within 30 days of the index operation.

Variable	OR	P-value	CI_lower	CI_upper
After 2008 (yes/no)	0.58	0.01	0.39	0.86
Male (yes/no)	1.24	0.31	0.82	1.86
Age (by year)	1.02	0.14	0.99	1.04
Depression (yes/no)*	0.55	0.08	0.28	1.08
Prior hip prosthetic (2 years)	0.62	0.35	0.23	1.69
Prior knee prosthetic (2 years)	0.81	0.62	0.35	1.86
Care time (by day)	1.08	0.01	1.02	1.15
Charlson index (0=1.0)				
Charlson index 1	1.63	0.02	1.04	1.48
Charlson index 2+	1.77	0.06	0.99	1.83
Country (Sweden=1.0)				
Nordic countries excluding Sweden	0.75	0.51	0.32	1.75
Europe excluding EU27 and Nordic	2.80	0.00	1.57	4.99
Other	1.41	0.41	0.63	3.17
Education (Primary school=1.0)				
High school	0.88	0.59	0.55	1.40
Higher education	1.09	0.73	0.66	1.81
Marital status (Married=1.0)				
Single	0.60	0.24	0.25	1.41
Divorced	1.04	0.89	0.59	1.83
Widowed	0.97	0.91	0.54	1.74
Disposable family income (1st quartile=1.0)				
2nd quartile	1.23	0.45	0.72	2.10
3rd quartile	0.80	0.51	0.41	1.55
4th quartile	0.72	0.39	0.34	1.52

Note: Each healthcare provider was estimated to have its own "intercept" for the risk of a cardiovascular event and their own coefficient for the variable Care time.

* Diagnostic code for depression or prescription of anti-depressants (ATC N06) during 12 months prior to surgery

Table A6. Number of patients with at least one hospitalization due to prosthetic-related potentially avoidable adverse events within 2 years (2007-2010).

Complication	ICD-10	Number	%
Ectopic bone generation	M614	1	0.12
	M895	2	0.24
Fracture adjacent to the prosthetic	M966	3	0.37
	M966F	27	3.29
	M966G	3	0.37
Infection after surgical/medical procedure	T814	174	21.22
Dislocation	T840	115	14.02
	T840F	195	23.78
	T840G	102	12.44
Prosthetic infection	T845	45	5.49
	T845F	70	8.54
	T845G	83	10.12
		820	**100**

Table A7. Procedure codes used to identify reoperations (including revision/removal) and cardiovascular events.

Revision/removal	Early reoperation	Other reoperations	Cardiovascular events
events	NGW49	NGA12	I26
NGC19	NGW59	NGH22	I21
NGC29	NGW69	NGL49	I22
NGC39	NGW79	NGS19	I24
NGC49	NGW89	NGS49	I80
NGC53	NGW99	NGT19	J819
NGC59	NFW49	NFC59	J15
NGC99	NFW59	NFA12	J18
NGU03	NFW69	NFH22	J13
NGU09	NFW79	NFL49	R33
NGU19	NFW89	NFS19	
NFC20	NFW99	NFS49	
NFC21		NFT19	
NFC22			
NFC23	**Re-position**		
NFC29	NGH20		
NFC30	NFH20		
NFC31			
NFC32			
NFC33			
NFC39			
NFC40			
NFC41			
NFC42			
NFC43			
NFC49			
NFC99			
NFU19			

Table A8. Number of patients with reoperations (2007-2010).

	Knee	Hip	All
Replacement/removal	128	135	263
Early reoperation	235	41	276
Re-position	2	113	115
Other reoperations	24	18	42
Total	**389**	**307**	**696**

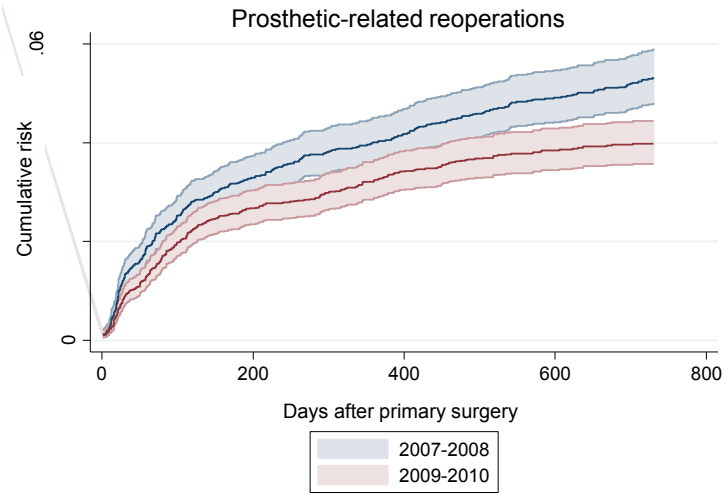

Figure A11. Cumulative unadjusted risk for reoperation prior to and following the reform (95 % confidence interval).

Table A9. Number of patients with replacement or removal.

Revision code	Joint	Number	Incidence %
Secondary prosthetic	Hip	115	44%
	Knee	102	39%
Removal of implant	Hip	20	8%
	Knee	26	10%
		263	**100%**

Table A10. Total number of primary hip/knee replacement surgeries 2007-2012.

	2007	2008	2009	2010	2011	2012
DRG-reimbursed	3560	3785	1176	1170	1375	1410
Change 2009 ->				-1%	17%	20%
Reimbursed with bundle	NA	NA	3365	3160	3048	2958
Change 2009 ->				-6%	-9%	-12%
Total	3560	3785	4541	4330	4423	4368
Change 2007 ->		6%	28%	22%	24%	23%
Change 2008 ->			20%	14%	17%	15%
Change 2009 ->				**-5%**	**-3%**	**-4%**
Change 2010 ->					2%	1%
Change 2011 ->						-1%

Table A11. Total production of primary hip/knee replacement surgeries in 2008 vs. 2009 and in 2008 vs. 2012.

	Number of surgeries				% of total production		
	2008	2009	Change		2008	2009	Change
DRG	3785	1176	-2609	-69%	100%	26%	-74 %-points
Bundle	0	3365	3365	-	0%	74%	74 %-points
Emergency hospital	3240	2808	-432	-13%	86%	62%	-24 %-points
Specialist clinic	545	1733	1188	218%	14%	38%	24 %-points
Private	1157	2397	1240	107%	31%	53%	22 %-points
Public	2628	2144	-484	-18%	69%	47%	-22 %-points
Total	3785	4541	756	20%			

	Number of surgeries				% of total production		
	2008	2012	Change		2008	2012	Change
DRG	3785	1410	-2375	-63%	**100%**	32%	-68 %-points
Bundle	0	2958	2958	-	**0%**	68%	68 %-points
Emergency hospital	3240	2682	-558	-17%	**86%**	61%	-24 %-points
Specialist clinic	545	1686	1141	209%	**14%**	39%	24 %-points
Private	1157	2369	1212	105%	**31%**	54%	24 %-points
Public	2628	1999	-629	-24%	**69%**	46%	-24 %-points
Total	3785	4368	583	15%			

Table A12. Total production of primary hip/knee replacement surgeries under the new model in 2009 and 2012.

	Number of patient choice surgeries				% of total production		
	2008	**2012**	**Differens**		**2008**	**2012**	**Differens**
Emergency hospital	1655	1283	-372	-22%	**49%**	43%	-6 %-points
Specialist clinic	1710	1675	-35	-2%	**51%**	57%	6%-points
Private	2110	2022	-88	-4%	**63%**	68%	6 %-points
Public	1255	936	-319	-25%	**37%**	32%	-6 %-points
Total	3365	2958	-407	-12%			

Table A13. The effect of various factors on the risk of reoperation within 2 years of the index operation. Multivariate logistic regression analysis performed on data from Sveus Research Database. All regression analyses of complication frequencies were adjusted for the variables presented below.

Variable	OR	P-value	CI_lower	CI_upper
After 2008 (yes/no)	1.17	0.03	1.02	1.35
Male (yes/no)	1.15	0.01	1.04	1.28
Age (by year)	0.99	0.00	0.98	0.99
Comorbidity according to Elixhauser	1.09	0.00	1.04	1.13
Hip prosthetic (yes/no)	0.64	0.00	0.57	0.71
Bilateral arthroplasty during the same surgery (yes/no)	0.78	0.17	0.55	1.11
Non-primary arthrosis (yes/no)	1.15	0.09	0.98	1.36
Stockholm	1.37	0.00	1.17	1.62
Stockholm after 2008	0.66	0.00	0.53	0.82

Table A14. Use of cement-free prosthetic or hybrid technology among various age groups under the new model during 2009-2010 (only hip replacement)

	<50	50–54	55–59	60–64	65–69	70+
Danderyd	100%	100%	100%	98%	98%	69%
KS	91%	93%	85%	71%	56%	40%
Nacka	100%	33%	46%	16%	8%	0%
Norrtälje	100%	80%	56%	27%	45%	34%
Ortopediska huset	100%	83%	76%	34%	6%	0%
Orthocenter	95%	96%	84%	53%	22%	2%
Sabbatsberg	100%	100%	96%	90%	94%	56%
Södertälje	100%	78%	50%	10%	11%	1%
Södersjukhuset	100%	96%	86%	67%	37%	4%
St: Göran	95%	93%	94%	62%	55%	7%

Table A15. Pharmaceutical use per patient and on aggregate level.

	2007/2008[1]	2009/2010[1]	Change[2]	%[3]	Aggregate change/year[4]
Opioids (DDD 0-12 months post surgery)[5]	41.9	33.2	-8.69	-21%	-37,567
Other analgesics (DDD 0-12 months post surgery)[6]	74.0	78.9	+4.92	+7%	+21,266
Antibiotics (DDD 0-12 months post surgery)	0.46	0.43	-0.04	-8%	-162
Antibiotics (DDD 12-24 months post surgery)	0.38	0.33	-0.04	-11%	-175

[1] Average by patient
[2] Change in average use prior to and following the reform
[3] Percentage change in average resource use prior to and following the reform
[4] Aggregate change based on the number of surgeries in 2010
[5] Defined daily doses ATC N02A.x
[6] Defined daily doses ATC N02B.x

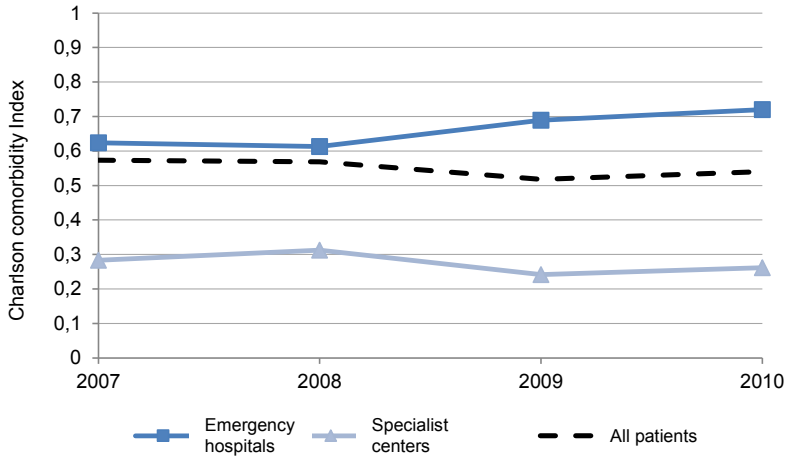

Figure A12. Charlson comorbidity index by type of healthcare provider.

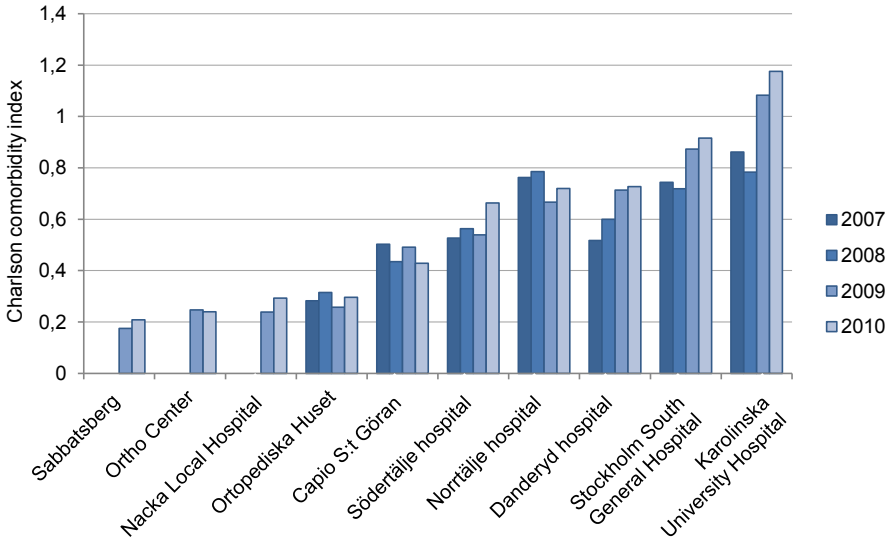

Figure A13. Charlson comorbidity index by healthcare provider (2007-2010).