Ten-year epidemiological study in an orthopaedic and trauma surgery centre: Are there risks involved in increasing scheduled arthroplasty volume without increasing resources?

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Original article

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Roger Erivan[a,*], Thibault Chaput[b], Guillaume Villatte[a], Matthieu Ollivier[c,d], Stéphane Descamps[a], Stéphane Boisgard[a]

[a] *SIGMA Clermont, ICCF, université Clermont Auvergne, CHU Clermont-Ferrand, CNRS, 63000 Clermont-Ferrand, France*
[b] *Service de chirurgie orthopédique, CHU Clermont-Ferrand, 63000 Clermont-Ferrand, France*
[c] *ISM UMR 7287, Aix-Marseille université, CNRS, 13288 Marseille cedex 09, France*
[d] *Department of Orthopaedics and Traumatology, Institute for locomotion, St. Marguerite Hospital, 270, boulevard Sainte-Marguerite, BP 29, 13274 Marseille, France*

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Background: Current trends in patient management include decreasing hospital stay lengths and reductions in available material and human resources. A shortening of hospital stays in university hospitals has been documented over the last decade. However, to our knowledge, no study has assessed possible relationships linking shorter stays to staffing levels or complication rates. The objectives of this study were: 1) to assess changes in case volume in a university orthopaedics and trauma surgery department between 2006 and 2016, 2) and to look for correlations linking these changes to staffing levels and the rates of significant complications, including the number of hip dislocations after total hip arthroplasty (THA) and the number of infections and complications resulting in malpractice litigation after hip, knee, or shoulder arthroplasty.

Hypothesis: The case volume increased during the study period, whereas resources remained unchanged or decreased.

Material and methods: A retrospective study was performed using the electronic database of an orthopaedics and trauma surgery department. Data collected between 2006 and 2016 were analysed. Mean hospital stay length, patient age, and surgical volume were recorded, and changes over time in case volume for trauma surgery and scheduled arthroplasties were evaluated. Changes in staffing levels and rates of complications (dislocation after THA and infections and complications resulting in malpractice litigation) between 2006 and 2016 were assessed. Only arthroplasty procedures performed in the department were considered for the study of complications and litigation.

Results: Between 2006 and 2016, mean hospital stay decreased from 8.7 ± 10.8 days (range, 0–141 days) in to 7.0 ± 9.4 days (range, 0–150 days). Mean patient age increased from 54.4 ± 21.2 years (range, 11.7–100.9 years) in 2006 to 59.3 ± 20.9 years (range, 13.2–103.1 years) in 2016. The total number of procedures rose from 2158 in 2006 to 3100 in 2016 (+43.6%). The number of THAs increased by 16.2% and the number of total knee arthroplasties by 96.7%. The number of operations for trauma increased from 725 in 2006 to 1135 in 2016 (+56.0%). During the study period, the number of hospital beds declined from 70 to 55. No increase was seen in the frequencies of dislocation after THA (3/284 [1.4%] in 2006 and 4/330 [1.2%] in 2016) or prosthetic joint infection (5/439 [1.1%] in 2006 and 6/657 [0.9%] in 2016). In contrast, malpractice suits filed by patients after arthroplasty increased from 1/439 (0.2%) in 2006 to 8/657 (1.2%) in 2016.

Conclusion: Over the last decade, trauma and arthroplasty surgical volumes increased substantially, whereas staffing levels remained unchanged and number of beds diminished. The frequency of significant complications such as dislocation after THA did not increase. In contrast, a marked rise was seen in malpractice litigation. However, the increased volume with unchanged resources found in this study should be interpreted in the light of the marked increase in patient dependency and of our role as a referral centre managing patients with complications after surgery performed at other institutions.

Level of evidence: IV, retrospective observational study.

1. Introduction

Changes in medical management over time are resulting in ever shorter hospital stays. In addition, the population is ageing and life expectancy is increasing both at birth and at 65 years of age [1]. However, disease-free life expectancy is shorter (62.6 years in males and 64.4 years in females) and, consequently, many patients have multiple co-morbidities that produce an increasingly heavy management burden [2].

Our university orthopaedic and trauma surgery department performs scheduled orthopaedic procedures and also manages a large proportion of the trauma patients in the district and of patients with complex trauma-related conditions in the region. The district has a population of 638,092 and the region a population of 1,359,000. The emergency department of our hospital has 51,697 visits per year, of which 15,768 resulted in hospital admission in 2016. The steadily increasing volume of trauma surgery is resulting in overcrowding and in an excessive number of emergency operations. As a result, scheduled surgical procedures have increasingly long waiting times that have a potential for leading to litigation by the patients [3].

A shortening of hospital stays in university hospitals has been documented over the last decade. However, to our knowledge, no study has assessed possible relationships linking shorter stays to staffing level or complication rate. The objectives of this study were

- to assess changes in case volume in a university orthopaedics and trauma surgery department between 2006 and 2016;
- and to look for correlations linking these changes to staffing levels and the rates of significant complications, including the number of hip dislocations after total hip arthroplasty (THA) and the number of infections and complications resulting in malpractice litigation after hip, knee, or shoulder arthroplasty. Only arthroplasty procedures performed in the department were considered for this part of the study. The working hypothesis was that the case volume increased during the study period, whereas resources remained unchanged or decreased.

2. Materials and methods

2.1. Data collection

Our orthopaedics and trauma surgery department performs scheduled orthopaedic surgical procedures, chiefly at the hip and knee and less often at the foot. Upper limb surgery is under development. No spinal surgery or emergency hand surgery is performed. For this study, we searched the hospital database for the codes for healthcare interventions performed at our department in 2006 and 2016. We compiled a list of all codes of healthcare interventions performed and of primary and secondary diagnoses in the inpatient surgery ward, outpatient surgery unit, and operating rooms. We also collected the human and material resources available for the healthcare interventions performed. Data on infections were retrieved from the infection-control department and data on malpractice litigation from the legal department. For the analysis of complications, including infections, and of malpractice suits, only arthroplasty procedures performed at our department were considered. We recorded infections after hip, knee, or shoulder arthroplasty; dislocations after THA; and malpractice complaints about hip, knee, or shoulder arthroplasty procedures (which included requests for out-of-court settlement submitted to the hospital, complaints submitted to the arbitration and compensation commission (*Commission de conciliation et d'indemnisation*), and complaints filed with the administrative tribunal of our city (Clermont-Ferrand).

2.2. Classification of healthcare interventions and adverse events

Healthcare interventions were categorised as scheduled or performed on an emergency basis. Subgroups were then created within each category to distinguish the upper limb from the lower limb then to separate individual joints. The number of dislocations after THA and the number of infections after hip, knee, or shoulder arthroplasties were collected. We also collected the number of complaints related to arthroplasty procedures.

2.3. Statistical analyses

Quantitative variables are described as mean ± standard deviation (range) and compared between 2006 and 2016 using Student's *t* test. The statistical analyses were performed using Excel™ (Microsoft, Redmond, WA, USA). There were no missing data, and all healthcare interventions were analysed.

3. Results

3.1. Overall time trends

Table 1 reports the results. Mean hospital stay duration per patient was 8.7 ± 10.8 days (range, 0–141) in 2006 and 7 ± 9.4 days (range, 0–150 days) in 2016 ($p = 1.5\ 10^{-10}$) (Fig. 1). Mean age increased from 54.4 ± 21.2 years (range, 11.7–100.9 years) in 2006 to 59.3 ± 20.9 years (range, 13.6–103.1 years) in 2016 ($p = 4.69 \cdot 10^{-18}$). Case volume increased in the department between 2006 and 2016 (Fig. 2). Thus, the total number of healthcare interventions increased from 2158 to 3100 per year, an overall 43.6% increase for orthopaedic surgery and trauma surgery pooled.

3.2. Time trends for scheduled surgery

The number of scheduled orthopaedic surgery procedures increased by 21.8%, from 1447 in 2006 to 1763 in 2016. Our department predominantly performed lower limb arthroplasty procedures. The number of THA procedures per year rose by 16.2%, from 284 in 2006 to 330 in 2016, whereas the number of bipolar hemiarthroplasties of the hip decreased from 80 to 55 (−31.2%). The number of THA revisions per year increased from 46 to 67 (+45.6%) (Fig. 3). The annual number of total knee arthroplasties (TKAs) increased from 155 to 305 (+96.8%) and the annual number of unicompartmental knee arthroplasties from 14 to 40 (+185%). The annual number of TKA revisions rose from 14 to 16 (+14.3%) (Fig. 4). Ligament reconstruction procedures at the knee diminished from 97 to 83 (−14.4%) and procedures for meniscal lesions from 125 to 104 (−14.9%). The number of total ankle arthroplasties remained unchanged at 3 per year, whereas the number of ankle arthrodesis procedures increased from 12 to 17 (+41.7%). Finally, surgical procedures for hallux valgus decreased from 70 to 54 (−22.8%).

Our upper limb surgical activity grew significantly during the study period. As a result, the annual number of shoulder arthroplasties increased from 0 in 2006 to 22 in 2016. Similarly, procedures to treat shoulder instability increased from 2 to 14 per year (+600%) and procedures for rotator cuff abnormalities from 10 to 25 (+150%) (Table 1).

The annual number of procedures for hardware removal at any site increased from 312 to 408 (+30.8%) between 2006 and 2016. In tandem with the increase in arthroplasty volume, when both patients who underwent arthroplasty in our department and those referred to us from other institutions were considered, the number of arthroplasty complications increased. Thus, the annual number of dislocations after THA increased from 8 to 14 (+75%) and

Table 1
Changes in surgical volume between 2006 and 2016.

		2006	2016	Change (%)
Overall data				
	Mean hospital stay length, days*	8.78	7.04	−19.80
	Mean age, years**	54.4	59.3	9.00
	Number of scheduled orthopaedic procedures	1447	1763	21.80
	Number of procedures for trauma	711	1135	59.60
	Number of patients	2273	2807	23.50
	Total number of procedures	2158	3100	43.70
	Number of outpatient procedures (1-day admission)	266	817	243.8
Lower limb trauma				
Pelvis	Symphysis	6	10	66.70
	Acetabulum	6	6	0.00
Femur	Distal	15	10	−33.30
	Proximal	81	164	102.50
	Shaft	49	84	71.40
	Bipolar hemi-arthroplasty	80	55	−31.30
Patella	Fracture	10	7	−30.00
Tibia	Tibial plateau	23	31	34.80
	Shaft	10	5	−50.00
	Distal	43	52	20.90
	Medial malleolus only	2	6	200.00
Fibula	Isolated	7	13	85.70
Bimalleolar fractures	Or equivalent	31	112	261.30
Foot	Fractures	18	16	−11.10
Amputation		18	20	11.10
Flaps		14	15	7.10
Autologous skin graft		14	13	−7.10
Soft tissue irrigation		38	33	−13.20
Wound care	Soft tissues only	46	140	204.30
	Tendon repair by suturing	15	36	140.00
Scheduled lower limb procedures				
Hip	Total arthroplasty	284	330	16.20
	Bipolar hemi-arthroplasty	80	55	−31.30
	Hip arthroplasty revision	46	67	45.70
	Acetabular augmentation	6	1	−83.30
	Proximal femoral osteotomy	7	0	−100.0
Knee	Total arthroplasty	155	305	96.80
	Knee arthroplasty revision	14	16	14.30
	Unicompartmental knee arthroplasty	14	40	185.70
	Valgus tibial osteotomy	39	9	−76.90
	Ligament reconstruction	97	83	−14.40
	Meniscus	125	104	−16.80
	Synovectomy	12	4	−66.70
	Other arthroscopic procedure	8	4	−50.00
	Medial patello-femoral ligament reconstruction	8	8	0.00
	Anterior tibial tuberosity transfer	5	3	−40.00
	Manipulation under general anaesthesia	6	14	133.30
Foot/Ankle	Total arthroplasty	3	3	0.00
	Hallux valgus	70	54	−22.90
	Ankle arthrodesis	12	17	41.70
	Claw toe deformity	21	8	−61.90
	Joint release	3	2	−33.30
	Non-union	3	8	166.70
Removal of fixation material		312	408	30.80
Complications of arthroplasty	THA dislocation	8	14	75.00
	TKA lavage	13	39	200.00
	Knee lavage	30	46	53.30
	Lavage of other joints	4	4	0.00
Upper limb trauma				
Internal fixation of clavicle fracture		1	18	1700.0
Internal fixation of humeral fracture	Proximal humerus	17	52	205.90
	Distal humerus	19	15	−21.10
	Plate fixation of shaft fracture	8	8	0.00
	Nailing of shaft fracture	14	43	207.10
Internal fixation of forearm fracture	Proximal	8	20	150.00
	Shaft	19	19	0.00
	Distal	59	79	33.90
Shoulder/elbow	Closed reduction of shoulder	40	15	−62.50
	Reverse shoulder arthroplasty	2	18	800.00
	Closed reduction of elbow	12	6	−50.00
Scheduled upper limb procedures				
Shoulder	Cuff	10	25	150.00
	Total arthroplasty	0	22	
	Bone block	2	14	600.00
	Bankart	3	9	200.00
Hand	Carpal tunnel	11	58	427.30
	Synovial cyst at the wrist	7	7	0.00
	Trigger finger	19	30	57.90

THA: total hip arthroplasty; TKA: total knee arthroplasty.

* $p = 1.50E-10$.

** $p = 4.69E-18$.

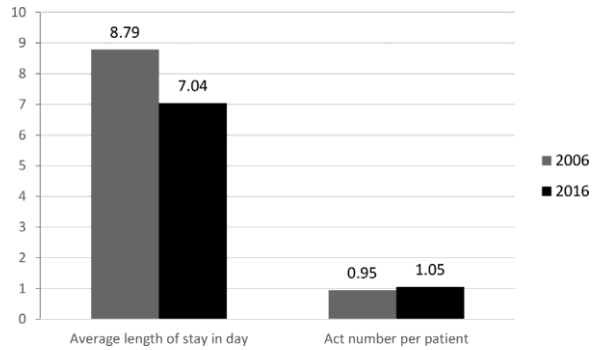

Fig. 1. Changes in mean hospital stay length and number of healthcare interventions per patient.

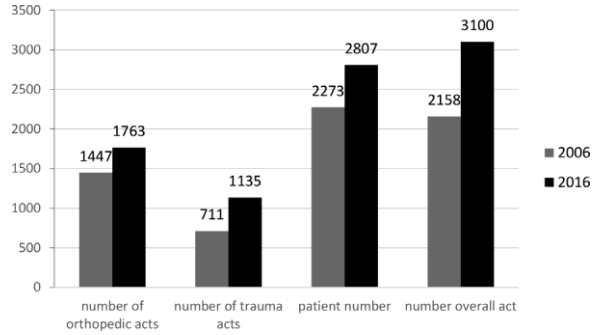

Fig. 2. Changes in numbers of the main healthcare procedures; total numbers and numbers for scheduled orthopaedic surgery and trauma surgery are shown.

the number of prosthetic joint infections from 13 to 39 (+200%) at the hip and from 30 to 46 (+53.3%) at the knee. In contrast, when only patients who underwent arthroplasty procedures at our department were considered, the changes were small: the number of dislocations after THA (3/284 [1.4%] in 2006 and 4/330 [1.2%] in 2016) and of prosthetic joint infections (5/439 [1.1%] in 2006 and 6/657 [0.9%] in 2016) remained the same. However, during the study period, the number of complaints made by patients after arthroplasty increased, from 1/439 (0.2%) in 2006 to 8/657 (1.2%) in 2016 (Table 2).

3.3. *Time trends for trauma surgery*

Overall, the annual number of surgical procedures for trauma increased from 711 in 2006 to 1135 in 2016 (+59.6%). Among traumatic fractures of the lower limb (Fig. 5), most involved the femur in 2006, with a total of 225 and the following distribution by site: proximal femur (other than the femoral neck), $n = 81$; femoral neck, $n = 80$; femoral shaft, $n = 49$; and distal femur, $n = 15$. In 2016, there were 313 femoral fractures, a 39.1% increase versus 2006. Femoral fractures were distributed as follows in 2016: proximal femur (other than the femoral neck), $n = 164$ (+102.4%), femoral neck, $n = 55$ (−31.2%); femoral shaft, $n = 84$ (+71.4%), and distal femur, $n = 10$ (−50%).

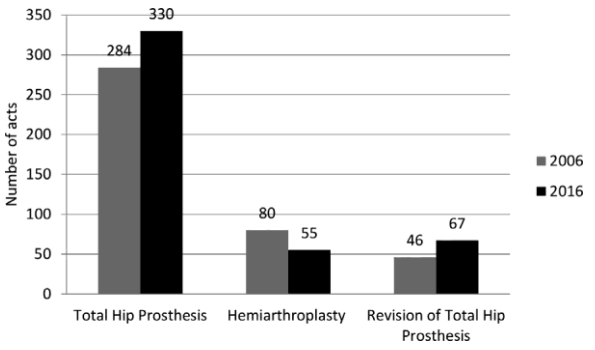

Fig. 3. Change in the number of hip arthroplasties.

In 2006, there were 116 fractures of the tibia and ankle. In this group, the most common fractures involved the tibial pilon ($n = 43$). In 2016, the number of tibial fractures was 219 (+88.8%), including 52 tibial pilon fractures (+20.9%). Bimalleolar and similar fractures increased from 31 in 2006 to 112 in 2016 (+261.3%). Overall, fractures of the foot remained unchanged (18 in 2006 and 16 in 2016, −11.1%). The number of pelvic fractures managed by internal fixation remained low and stable (6 to 10 symphyseal fractures, +66.7%) and the number of acetabular fractures managed by internal fixation was 6 in both 2006 and 2016.

At the upper limb (Fig. 6), the same analysis showed that the number of clavicular fractures managed by internal fixation increased from 1 in 2006 to 18 in 2016. Closed gleno-humeral joint reduction under general anaesthesia decreased from 40 to 15 (−62.5%). Humeral fractures increased from 58 to 118 (+103.4%) overall. Fractures of the distal humerus, which predominated in 2006, decreased from 19 to 15 (−21%), whereas fractures of the proximal humerus increased from 17 to 52 (+205.9%). Plate fixation of humeral shaft fractures was performed in 8 patients in both 2006 and 2016. Intra-medullary nailing of the humerus increased over the decade from 14 to 43 (+207.1%). Finally, fractures of the forearm also increased, from 86 to 118 (+37.2%). Fractures of the distal radius increased from 59 to 79 (+33.9%), whereas radial shaft fractures remained stable at 19 during both 2006 and 2016. Finally, proximal fractures of the radius or ulna managed by internal fixation increased from 8 to 20 (+122.2%).

The number of wounds requiring treatment in the operating theatre increased from 46 to 140 (+204.3%). Tendon repair by suturing in the operating theatre increased from 15 to 36 (+140%).

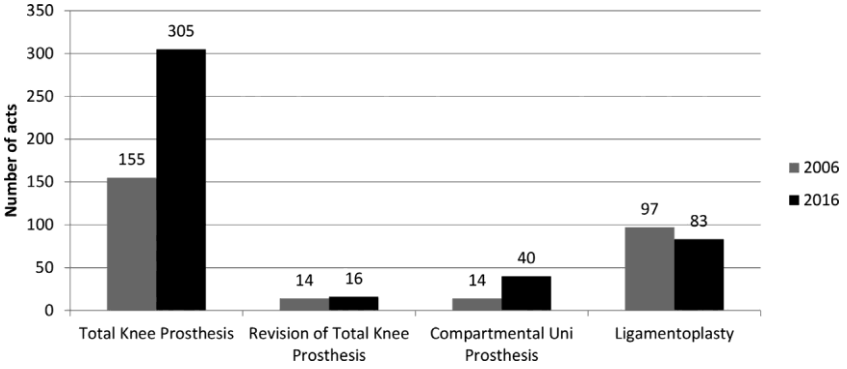

Fig. 4. Change in the number of scheduled procedures on the knee.

Table 2
Changes in complication rates in patients who underwent scheduled arthroplasty procedures.

	Year					
	2006			2016		
Procedure	THA	TKA	TSA	THA	TKA	TSA
Number of patients	284	155	0	330	305	22
Total number of infections treated	13	30	0	39	46	1
Number of infections after arthroplasty in our department	4	1	0	3	2	1
Infection rate for arthroplasty at our department	1.41%	0.65%		0.91%	0.66%	4.55%
Total number of dislocations	8			14		
Number of dislocations after arthroplasty in our department	3			4		
Number of patients who complained after being managed at our department	1			8		

THA: total hip arthroplasty; TKA: total knee arthroplasty; TSA: total shoulder arthroplasty.

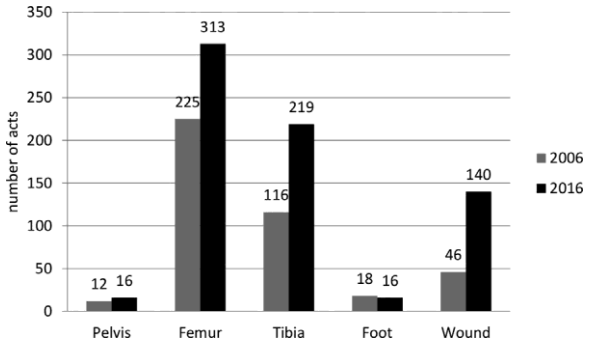

Fig. 5. Change in lower limb trauma surgery.

As our department does not provide emergency care to hand trauma patients, most wounds either involved the lower limb or involved the hand but occurred concomitantly with more serious injuries and in polytrauma patients.

3.4. Outpatient surgery

In 2006, our department had no dedicated outpatient surgical unit. However, some patients were admitted only for 1 day for procedures performed according to an outpatient care pathway. Thus, in 2006, 266 patients had a hospital stay length of a single day (266/2158, 12.3%). An outpatient surgical unit was opened in March 2016. In 2016, i.e., during the first year, 466 patients were managed in this unit. In addition, in 2016, 351 patients were admitted to the conventional ward but had a hospital stay length of a single day, yielding a total of 817 patients managed on a day-care basis. These 817 patients represented 26.4% of the 3100 patients managed in 2016. Thus, over the decade, the number of day-care procedures increased by 243.8%.

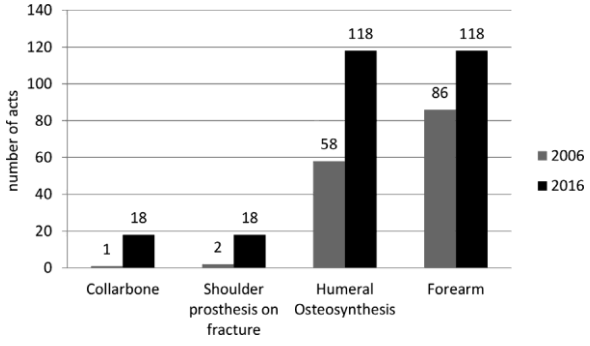

Fig. 6. Change in upper limb trauma surgery.

3.5. Changes in resources over time

The healthcare staff comprised 7 surgeons, 4 anaesthesiologists, and 8.4 operating theatre nurses. During the day, three operating theatres were available, including two for 8 hours each and one for 12 hours. For night-time trauma surgery, we had access to two operating theatres, which were shared among various specialities (orthopaedics, vascular surgery, visceral surgery, neurosurgery, ENT surgery, and ophthalmological surgery). These resources remained unchanged between 2006 and 2016. In contrast, in the wards, the number of beds available for conventional hospital admission decreased from 70 in 2006 to 55 in 2016; a ward nurse and a nursing assistant were lost. On the other hand, an outpatient surgical unit was created.

4. Discussion

The study results confirm our working hypothesis. Overall, the surgical volume increased substantially over a decade in our department. Further increases can be expected as the population continues to age. Furthermore, our trauma volume is likely to increase, as private community hospitals in our district are becoming less involved with trauma surgery. Among large hospital centres, our university hospital is the only one in the district where orthopaedic surgeons are on call around the clock and manage all trauma emergencies. Among the community hospitals in the district, one manages only hand injuries and the other only simple traumatic injuries (the patients are triaged and no operating theatre is available outside standard working hours).

According to the French national institute for demographic data (*Institut national d'études démographiques* [INED]), life expectancy at birth increased between 2006 and 2016 from 76.9 to 79.4 years in males and from 84 to 85.4 years in females. A corollary of this increased life expectancy is growth in the numbers of traumatic injuries in elderly individuals and of traumatic and infectious complications of arthroplasty related both to normal ageing and to older age at the time of arthroplasty [2]. Our data illustrate this fact. Complications related to arthroplasty procedures performed at our department did not increase. However, there was an increase in the number of patients managed for complications, which was due to the fact that other centres in our district did not always provide emergency care for complications in their patients. The number of complaints made by patients who underwent arthroplasty at our centre increased substantially, from 1 in 2006 to 8 in 2016. In general, most complaints are motivated by infection or by deterioration of the patient–surgeon relationship [3]. Infections were not a major source of complaints in our study. Consequently, closer scrutiny of patient–surgeon rapport and, more specifically, of the information supplied by surgeons to patients in our department is warranted.

A Swedish study estimated that the number of TKAs per 10,000 population will increase from 330 in 2020 to 382 in 2030 [4]. Similar estimates have been made for the US and Germany [5–7]. Our results support these estimates. French health authorities are encouraging surgeons to discharge patients as early as possible, as hospital stay length is a key factor in patient management and cost-effectiveness of surgery departments. Thus, hospital stay length has become a highly controversial issue, and healthcare staff are being asked to shorten stays as much as possible. This policy should be viewed within the framework of the medical information system introduced in France in 1991 (*Programme de médicalisation du système d'information*), which requires healthcare facilities to supply the authorities and statutory health insurance system with information on their caseloads. This information is supplied using a coding system that assigns standardised codes to healthcare interventions and defines homogeneous groups of patients [8,9]. The authorities use this information to determine costs to the healthcare facility and, therefore the amount of funds they assign to each healthcare facility. Thus, funding is based on case volume during the past year. However, costs per code or patient group are considered fixed over time, whereas in reality they increase. Consequently, healthcare facilities must increase their case volume to remain economically viable. An obstacle to decreasing hospital stay durations is the dearth of beds in rehabilitation and convalescence facilities, which increases bed occupancy in surgical wards. This situation constitutes an incentive to the development of outpatient surgery. In our department, a dedicated outpatient surgical outpatient unit was created in March 2016, with the objective of managing 50% of all healthcare interventions performed in the operating theatre on an outpatient basis. In 2016, 15.03% of operations were in outpatient surgical unit patients.

Importantly, global data rather than individual data should be the main focus of attention. Individual data are often influenced by local factors such as the activity of the various practitioners and centres in the area. Globally, surgical volume is increasing. Thus, healthcare staff are working more (managing a higher number of patients) but also perhaps better (due to advances in techniques and practices and to the institution of rest periods after night and weekend duties) and more rationally (informatisation, management of down times in the operating theatre, elimination of unnecessary procedures, and enhanced recovery). It is extremely difficult to prove, using reliable indicators, that the workload has increased commensurately with the surgical volume. Our centre became a referral centre for complex osteo-articular infections during the study period, and we therefore now admit more patients with severe infections. This fact explains the substantial increase in infection case volume. On the other hand, the decrease in femoral neck fractures over time is ascribable to the creation of a geriatric trauma surgery unit in a nearby hospital in our district. In France, healthcare available in public centres has changed, and private centres now focus chiefly on profitable activities such as scheduled surgery, simple emergencies, and hand injuries. A scheduled THA is more profitable than internal fixation of an acetabular fracture, although both procedures are considered by the French authorities to have similar costs. This selection of activities by private facilities is possible due both to technical advances and to the increase in scheduled orthopaedic procedures associated with ageing of the population. Selection is an adverse effect of funding based on prior case volume in a setting where case volume is increasing. At the same time, patients requiring less profitable procedures are increasingly numerous and are usually managed in public hospital centres. Providing patients with appropriate information remains of the utmost importance [10]. During the study period, the numbers of complaints and of medical errors increased in orthopaedic and trauma surgery [11]. Consequently, care is in order to ensure that the increase in case volume does not result in poorer patient information or patient–surgeon rapport.

This study has several limitations. First, coding errors may have occurred. A given healthcare intervention or diagnosis can be coded in several ways. However, the predominance of healthcare interventions used for the most common problems probably limited the risk of bias due to faulty coding. Second, failure to code some interventions or diagnoses may have occurred. It should be noted, however, that the use and quality of coding have been optimised in recent years. This fact may explain the dramatic increase in some diagnoses. Third, we compared only 2006 and 2016. Nonetheless, this comparison allowed us to objectively document changes without having to report a large amount of numerical data. We believe that the 10-year interval between the two measurement periods provides a fairly reliable picture.

5. Conclusion

This study demonstrated an overall increase in case volume in an orthopaedics and trauma surgery department over a decade. During the study, the human and material resources remained unchanged or decreased. The same applies to many healthcare facilities in France. Optimisation of the patient care pathway is therefore a key issue. It is unclear to what extent case volume will be able to continue to increase. Furthermore, the increase in case volume impacts both research and teaching activities in teaching hospitals, with human resources being increasingly used for patient care. Hospital authorities prefer to emphasise patient care, as a means of remaining financially viable. However, university hospitals must retain sufficient human resources for research and teaching if they are to meet their goals of providing high quality care, training future physicians, conducting clinical research to improve practices, and conducting basic research to improve treatments. Any imbalance among these activities will adversely affect hospital departments — which may therefore lose their university status — and the population they serve.

Disclosure of interest

The authors declare that they have no competing interest. A single author has financial relationships unrelated to this study: SB is a consultant for Zimmer-Biomet. The other authors have no financial relationships unrelated to this study to declare.

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None.

Author contributions

Roger Erivan: designed the study, wrote the article, handled the statistical analyses, validated the final version of the article, and performed surgical procedures.

Thibault Chaput: designed the study, wrote the article, and validated the final version of the article.

Guillaume Villlate: designed the study, wrote the article, validated the final version of the article, and performed surgical procedures.

Matthieu Ollivier: handled the statistical analyses and validated the final version of the article.

Stéphane Descamps: designed the study, validated the final version of the article, and performed surgical procedures.

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