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Original article

Progression and projection for hip surgery in France, 2008-2070: Epidemiologic study with trend and projection analysis

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ABSTRACT

Introduction: Hip replacement was declared "operation of the century" in tribute to the functional improvement it provides. Frequency is increasing, but it is difficult to estimate the actual number of procedures performed and the expected progression, because of changes in indications and lengthening life-expectancy, and also, in France, because there is no registry. As data are lacking in France, we conducted an investigation 1) to update the number of hip surgeries in France, and 2) to forecast progression over the coming decades, considering extreme scenarios.
Hypothesis: The number of hip procedures can be expected to increase considerably over the coming 50 years.
Material and method: A study was conducted to analyze national coding data for the number of hip surgeries performed in France. Two scenarios were defined: one taking account of population progression and age structure, the other also extrapolating trends observed over recent years. Current hip surgery activity in France was measured, and progression estimated according to population changes.
Results: In 2018 in France, 183,139 procedures were coded as principally concerning the hip. There was a clear predominance of reconstruction procedures, with 148,965 primary hip replacements, 124,251 of which were total. There were 19,304 hip replacement revision procedures. There were strong regional differences in revision according to the type of center performing surgery ($p < 0.0001$). Between 2018 and 2050, primary hip replacement could be expected to increase by 41.9% or 114.3% and hip surgery overall by 42.0% or 98.3%, depending on the scenario.
Discussion: The present results are subject to future technological breakthroughs and medical discoveries, but forecast a major increase in hip surgery requirements. These results extend the present state of medical knowledge.
Level of evidence: IV, descriptive epidemiological study.

1. Introduction

The number of orthopedic surgery procedures has been constantly increasing worldwide over recent decades [1–3], for multiple reasons: improvement in biomaterials and in surgical techniques, contribution of imaging, optimization of perioperative care, and patients' demand to be able to age in good health with minimal functional disability [3,4]. One of the most important developments has been in total hip arthroplasty (THA), which has now been consecrated "operation of the century" by some authors [5] because of the clear functional improvement achieved, and especially definitive abolition of pain, although risks remain [6–8]. Increasing numbers of patients are having resort to orthopedic surgery, as the population in France ages and constantly grows [9].

Estimating the number of procedures and their progression is made difficult by changes in indications and by the extension of life-expectancy. Scandinavian countries have registries [10–12], while other countries, such as France, uses codes for surgical procedures that enable the total number of operations related to hip surgery to

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be quantified. Numerous parameters, such as technical innovations [13], population changes, and health-system funding changes, hinder attempts to forecast and plan for future rates of hip surgery [5,11].

To the best of our knowledge, such data are not available for France, and we therefore conducted a study:

- to update the number of hip surgeries in France:
- to forecast progression over the coming decades, considering the extreme scenarios.

The study hypothesis was that the number of hip surgeries can be expected to increase over the next 50 years.

2. Material and method

2.1. Material

Data for numbers and types of hip surgery were obtained from the DIAMANT data-base of the French PMSI medical information program on hospital admissions in medical, surgical, obstetric and odontologic (MCO) departments according to principal intervention as coded on the CCAM medical acts classification system. Data were collected by collating the standardized discharge reports, containing administrative, demographic, medical and therapeutic information, with the CCAM codes. Registration numbers for legal entities on the FINESS national health-care and social establishments file were taken from the DRESS research, studies, assessment and statistics directorate. The PMSI data-base provided patient gender and age-group. The anonymized discharge reports provided the dates (years) of the procedure in question. On the basis of these data, patients were age-grouped as 0–14, 15–29, 30–44, 45–59, 60–74, 75–89 and $\geq$ 90 years of age. Legal entity and FINESS data were used to classify health-care structures as public, private non-profit, or for-profit.

The study analyzed French national data. Statistical data were obtained from the National Institute of Statistics and Economic Studies (INSEE), for population demographics and progression over the coming years based on the present French birth-rate of 1.96. This kind of study uses low, medium and high estimates according to various parameters: life-expectancy, fecundity and migration. The present study used the medium scenario: i.e., mean values for the various parameters. It also took account of INSEE's predicted variations per age-group to calculate a progression factor according to patient-age per procedure [9].

The coding information search was started in March 2019, so as to have complete data for 2018. The DIAMANT data-base uses the following procedure: each center sent its full 2018 data set at the beginning of February 2019; then the hospital admissions information agency (ATIH) extracts all information in the data-bank on the 20th of each month and makes it available on a secure server on the 21st, and the data is then integrated into the DIAMANT base within 5 working days.

3. Methods

Data were categorized for simplified analysis: surgical or non-surgical hip dysplasia, primary hip arthroplasty (total or partial), hip implant dislocation, hip implant removal, hip implant revision, hip arthroscopy, and tumor surgery. Table 1 shows codes per category.

Two scenarios were applied for each category, based on the DRESS method [14]:

3.1. Scenario 1: Constant characteristics

This scenario simply carries forward the parameters as measured on the PMSI data-base for the last full year (2018), treating them as unchanging over time. Thus, it takes account only of changes in population and age structure. It serves as a kind of baseline, with 2018 values adjusted for expected population change. The model was adjusted for each procedure according to changes in age-groups predicted by the INSEE data. For example, numbers for procedures mainly performed on younger patients increase less than for procedures performed on more elderly patients, as the population tends to age year on year. Thus, for each procedure and each decade, we calculated a procedure-weighting factor based on age distribution per procedure and INSEE data. Table 2 shows a few examples.

3.2. Scenario 2: Extrapolated progression

This scenario carries forward trends observed over the period 2012–2018, adjusted for population change as in scenario 1. For each procedure, we estimated the progression in the number of procedures, using a linear regression model based on the data for recent years, extrapolated into the future.

Geographic descriptions were based on raw data, averaging the number of procedures over the period 2012-2018, with regionally based calculation according to the type of health-care structure. We also calculated the total number of procedures and number per head of the population.

3.3. Statistics

Statistical calculations were made on Excel™ (Microsoft, Redmond, WA) and XLSTAT™ software (Addinsoft, New York, NY). The global projections per procedure were made by summing the individual projections for each age-group, weighted according to the INSEE data. Independent models were thus constructed for each procedure according to its target population and relevant age-groups. Results for quantitative variables were reported as numbers or mean $\pm$ standard deviation and range, with 95% confidence intervals for estimates and first-order risk set at 5%. Variations in number of procedures were reported as numbers, without statistical calculations as these were real numbers rather than estimates, and the observed differences were by definition exact. There were no missing data; all data were analyzed.

4. Results

4.1. Data for 2018

In 2018, which was the last analyzable year, 183,139 procedures in France were coded as principally involving hip surgery. Distribution per category is shown in Table 3.

There was clear predominance of reconstruction surgery, with 150,060 primary hip arthroplasties, including 125,227 THAs. There were 19,457 revision procedures, amounting to 11.5% of implant surgeries. There were in all 180,180 procedures for primary hip arthroplasty, revision and associated complications, amounting to 98.3% of hip surgeries.

4.2. Progression 2012-2018

For the period 2012-2018, a mean 177,355 $\pm$ 5,075 procedures [range, 169,741–183,139] were performed per year, with an increase of 7.9% over the period (Fig. 1).

At national level, taking all procedures together, 76,349 (43.0%) were performed in a public-sector hospital, 12,767 (7.2%) in a

Table 1
Procedure codes.

Class	Sub-class	PMSI - CCAM Procedure
Dysplasia	Non-surgical	NEEP001–Scheduled traction reduction of non-traumatic unstable hip, age > 12 months
		NEEP003 - Scheduled traction reduction of non-traumatic unstable hip, age < 12 months
		NEEP006 - Scheduled harness traction reduction of non-traumatic unstable hip, age > 12 months
	Surgical	NEEA004–Arthrotomy reduction of non-traumatic unstable hip
		NEMA003–Supra-acetabular hip bone block + extra-articular proximal femoral osteotomy
		NEMA017 - Supra-acetabular hip bone block osteoplasty + greater trochanter osteotomy
		NEMA018–Hip arthroplasty femoral cup
		NEMA020 - Acetabuloplasty + femoral osteotomy
		NEMA021 - Supra-acetabular hip bone block osteoplasty/acetabuloplasty
Primary hip arthroplasty	THA	NEKA010 - THA + metallic acetabular reinforcement + femoral graft reconstruction
		NEKA012 - THA + acetabular reconstruction and/or femoral graft reconstruction
		NEKA013 - THA after hip fusion
		NEKA014 - THA + metallic acetabular reinforcement
		NEKA015 - THA after internal fixation osteotomy and/or femoral cervicocephalic implant
		NEKA016 - THA + femoral shaft osteotomy
		NEKA017 - THA + femoral head lowering in acetabulum
		NEKA019 - THA after hip fusion + metallic acetabular reinforcement
		NEKA020 - THA
		NEKA021 - THA + femoral head lowering in acetabulum +realignment osteotomy/femoral alignment
	PHA	NEKA018 - Cervicocephalic implant
		NEKA011 - Cervicocephalic implant + mobile cup
THA dislocation	Non-surgical	NEEP002 - Reduction of hip implant dislocation
		NEEP004 - Reduction of hip dislocation + rigid full-leg splint
		NEEP005 - Reduction of hip dislocation + femoral head fracture
		NEEP007 - Reduction of hip dislocation + continuous traction
	Surgical	NEEA001 - Reduction of hip dislocation by arthrotomy
		NEEA002 - Reduction of hip implant dislocation by arthrotomy
		NEEA003 - Reduction of hip dislocation + femoral head fracture fixation with arthrotomy
		NEDA002–Inert block + lowering of greater trochanter with or without THA head/neck exchange
Implant revision		NEKA001–THA acetabular + femoral exchange + compacted graft without internal fixation
		NEKA002 - THA acetabular and/or femoral exchange + acetabular and/or femoral bone reconstruction
		NEKA003 - THA acetabular + femoral exchange without bone reconstruction
		NEKA004–THA acetabular insert exchange
		NEKA005 - THA acetabular and/or femoral exchange + acetabular and/or femoral internal fixation
		NEKA006 - THA acetabular + femoral exchange + reconstruction + acetabular and/or femoral internal fixation
		NEKA007 - THA acetabular and/or femoral exchange + compacted graft reconstruction without internal fixation
		NEKA008 - THA acetabular + femoral exchange + reconstruction and/or acetabular and/or femoral internal fixation
		NEKA009 - THA acetabular and/or femoral exchange without bone reconstruction
		NEKA022–THA femoral cervicocephalic implant exchange
		NELA001–THA reimplantation + bone reconstruction
		NELA002 - THA reimplantation without bone reconstruction
		NELA003–Acetabular component implantation in ipsilateral femoral cervicocephalic implant bearer
	Implant ablation	NEGA001–THA ablation + acetabular and/or femoral bone reconstruction
		NEGA002 - THA ablation
		NEGA003 - THA ablation + trochanteroiliac coaptation
		NEGA004 - Ablation of PTA insert + acetabular component implantation
		NEGA005 - Ablation of femoral cervicocephalic implant
Tumoral		NEMA011–Massive and/or made-top-measure hip implant for segmental and/or hip bone defect
		NEMA019–Sacroiliac arthroplasty with segmental bone defect + direct fusion
		NEMA013–Hip arthroplasty after en-bloc resection + femur/hip fixation
Arthroscopy		NEJC001–Arthroscopic hip debridement
		NEFC001 - Arthroscopic hip synovectomy
		NEQC001 - Arthroscopic hip exploration

THA: total hip arthroplasty; PHA: partial hip arthroplasty; PMSI: *Programme de médicalisation du système d'informations* medical information system; CCAM: Classification Commune des Actes médicaux medical acts classification.

Table 2
Examples of weighting factors pert procedure according to population change per relevant age-group.

Procedure–principal only	2020	2025	2030	2035	2040	2050	2060	2070
NEEA004–Non-traumatic unstable hip reduction by arthrotomy	1.004	1.009	1.010	1.017	1.028	1.045	1.054	1.067
NEEP001–Scheduled non-traumatic unstable hip reduction by traction age > 12 months	1.010	1.034	1.056	1.077	1.093	1.124	1.150	1.173
NEGA002 - Ablation of THA	1.031	1.119	1.216	1.284	1.317	1.393	1.477	1.532
NEKA004–THA acetabular Insert exchange	1.034	1.132	1.242	1.318	1.353	1.443	1.544	1.607
NEKA005–THA acetabular and/or femoral component exchange + acetabular and/or femoral internal fixation	1.038	1.149	1.272	1.357	1.396	1.501	1.622	1.697
NEKA011–Cervicocephalic implant + mobile cup	1.056	1.226	1.418	1.547	1.601	1.827	2.106	2.263
NEKA020 - THA	1.027	1.106	1.191	1.252	1.282	1.339	1.397	1.438
NEMA017–Supra-acetabular hip-bone block osteoplasty + greater trochanter osteotomy	1.002	0.999	0.991	0.992	1.002	1.008	1.004	1.011

THA: total hip arthroplasty.

Table 3
Number of hip surgeries in 2018.

Class	Sub-class	Number in 2018
Dysplasia	Total	1.565
	Non-surgical	382
	Surgical	1.183
Arthroscopy		1.251
Primary implant	Total	150.060
	THA	125.227
	PHA	24.833
THA dislocation	Total	10.663
	Non-surgical	10.199
	Surgical	464
Revision		19.457
Tumoral		143

THA: total hip arthroplasty; PHA: partial hip arthroplasty.

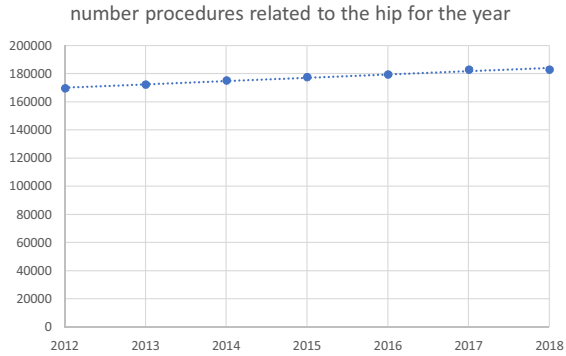

Fig. 1. Progression in annual number of procedures related to the hip, 2012–2018; p= 2.0E-18.

non-profit private structure, and 88,239 (49.8%) in a for-profit structure. Between 2012 and 2018, there was an increase of 10.4%, from 71,899 to 79,387, in the public sector, 14.2%, from 11,927 to 13,616, in the private non-profit sector, and 4.9%, from 85,915 to 90,136 in the for-profit sector. Over the period as a whole, 59.6% of procedures concerned female patients (105,614 procedures), with an increase of 7.6%, from 99,208 to 106,776, and an increase of 8.7% in males, from 66,509 to 72,325 procedures.

Fig. 2 maps the geographic distribution of primary THA according to the 2012-2018 averages, and Fig. 3 maps implant revision. There were marked regional differences for primary, revision and complications surgery. Primary THA ranged from a mean 16.0 procedures per 1,000 persons per year between 2012 and 2018 in Corsica to 26.4 in Brittany; revision ranged from 1.5 procedures per 1,000 persons per year in Corsica to 3.7 in Bourgogne Franche-Comté. Primary THA rates in public, non-profit and profit structures varied non-significantly between regions (p = 0,965), while revision rates varied significantly (p < 0.0001), with numerous disparities, as shown in Table 4.

4.3. Foreseeable progression over coming decades according to data for recent years

Foreseeable progression over coming years was estimated on the 2 scenarios described above (see Methods): scenario 1, taking account only of age, with constant activity compared to 2018; and scenario 2, further taking account progression per procedure over recent years to forecast coming progression.

4.3.1. Dysplasia

The number of procedures for hip dysplasia decreased by 4.3% between 2012 and 2018, from 1,636 to 1,565 (Fig. 4). Procedures concerned female patients in a mean 60.9% of cases (976/1,603). For the period 2018-2050, scenario 1 predicted a 5.5% increase, and scenario 2 a 12.6% increase (p = 0.201).

4.3.2. Arthroscopy

Hip arthroscopy procedures increased by 58.6% between 2012 and 2018, from 789 to 1,251. Fig. 5 shows the projections. Procedures concerned female patients in a mean 44.7% of cases (425/950). For the period 2018-2050, scenario 1 predicted a 5.6% increase, and scenario 2 a 189.9% increase (p = 0.003).

4.3.3. Primary THA

Primary THA is the most frequent hip procedure, and increased by 10.5% between 2012 and 2018, from 135,746 to 150,060 (Fig. 6). Procedures concerned female patients in a mean 60% of cases (86,254/143,679). For the period 2018-2050, scenario 1 predicted a 41.9% increase, and scenario 2 a 114.3% increase (p = 0.0001).

4.3.4. Revision

Hip implant revision decreased slightly between 2012 and 2018, by 0.4%, from 19,533 to 19,457 procedures (Fig. 7). Procedures concerned female patients in a mean 56.1% of cases (10,936/19,499). For the period 2018-2050, scenario 1 predicted a 43.8% increase, and scenario 2 a 43.5% increase (p = 0.642). In this instance, the two scenarios were virtually equivalent, as levels were more or less constant between 2012 and 2018, and the only relevant factor was numbers per age-group.

4.3.5. Hip dislocation

Hip dislocation rates decreased over the years in the elderly, while increasing in the overall French population. The decrease between 2012 and 2018 was 10.7%, from 11,947 to 10,663 procedures. The 2 scenarios diverged (Fig. 8). Procedures concerned female patients in a mean 61.1% of cases (6,915/11,312). For the period 2018-2050, scenario 1 predicted a 51.0% increase, and scenario 2 a 39.2% decrease (p < 0.0001).

4.3.6. Overall activity

Overall, the number of hip procedures increased yearly between 2012 and 2018, by 7.9%, from 169,741 to 183,139 (Fig. 9). For the period 2018-2050, scenario 1 predicted a 42.0% increase, and scenario 2 a 98.3% increase (p = 0.001).

5. Discussion

The present study provided precise figures for hip surgery in France and for foreseeable progression over coming years. At national level, there were disparities between procedures and between public/private sectors, notably for revision surgeries. Hip surgery was principally arthroplastic. Overall progression in hip surgery up to 2050 can be expected to be either 42.0% or 98.3% depending on the scenario; the study hypothesis was thus confirmed: overall hip surgery activity can be expected to increase in coming decades.

The study showed hip surgery to be an important part of orthopedic surgery in France, with numerous procedures performed. These data are comparable to those for other countries and to previous analyses of French data on both primary arthroplasty [3,10,15] and revision [4]. Arthroplasty and the management of arthroplasty complications account for most hip surgery procedures. In 2007 in the USA, Kurtz et al. [1] reported results similar to the present, but on a single scenario using a Poisson model with non-linear regression, more appropriate to knee arthroplasty. Ferguson et al. [16], in 2018, reported that rates of THA in developed countries were increasing by 30-40% every 10 years, comparable to the present estimates and lying between the 2 present scenarios.

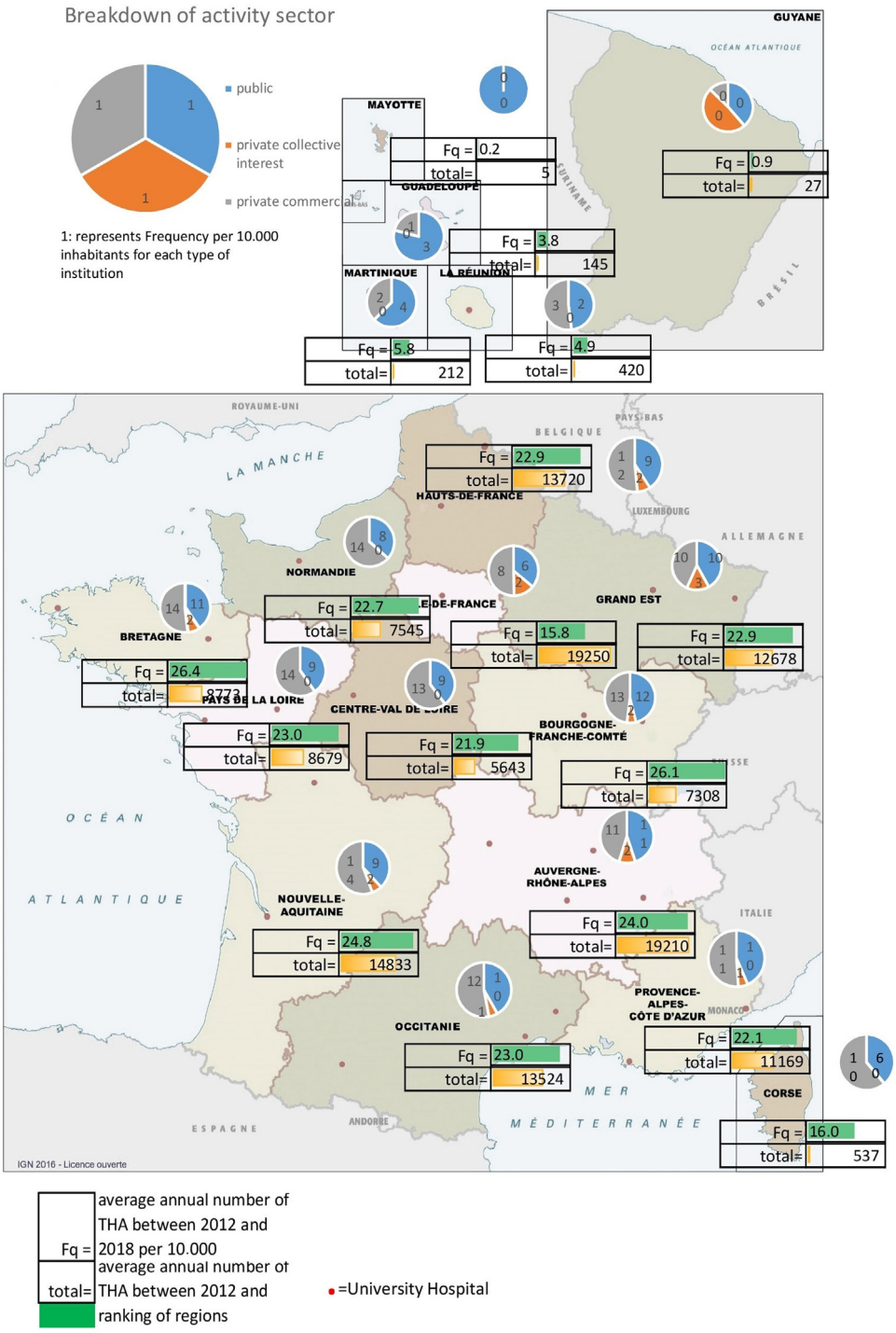

Fig. 2. Map of French national distribution of primary THA: means for 2012–2018 (THA: total hip arthroplasty).

In regard to our secondary objective, hip surgery activity can be expected to grow in the coming years and decades. Scenario 1 is to be seen as a baseline, with no change in the frequency of procedures, whereas scenario 2 takes additional account of trends in recent years. The data are obviously only estimates, and it seems reasonable to imagine that the real figures for each procedure will generally lie somewhere between the two scenarios. The regional distributions show considerable disparities, due to the local health-care offer (centers specializing in certain types of surgery, to patient demographics), and to medical demographics. The probable increase in activity may be slowed by national-level capacity to undertake these procedures, as a constant mean increase, although possible, is in reality liable to be curbed [17]. Regarding hip dislocation, our data did not allow us to take account of the impact of dual mobility designs [13]. It would seem reasonable to expect an overall increase of 10% per decade in France, although with some variations: primary THA and hip arthroscopy are likely to increase more than revision and dysplasia surgeries due to improved prevention and the ever younger age of the patients in question.

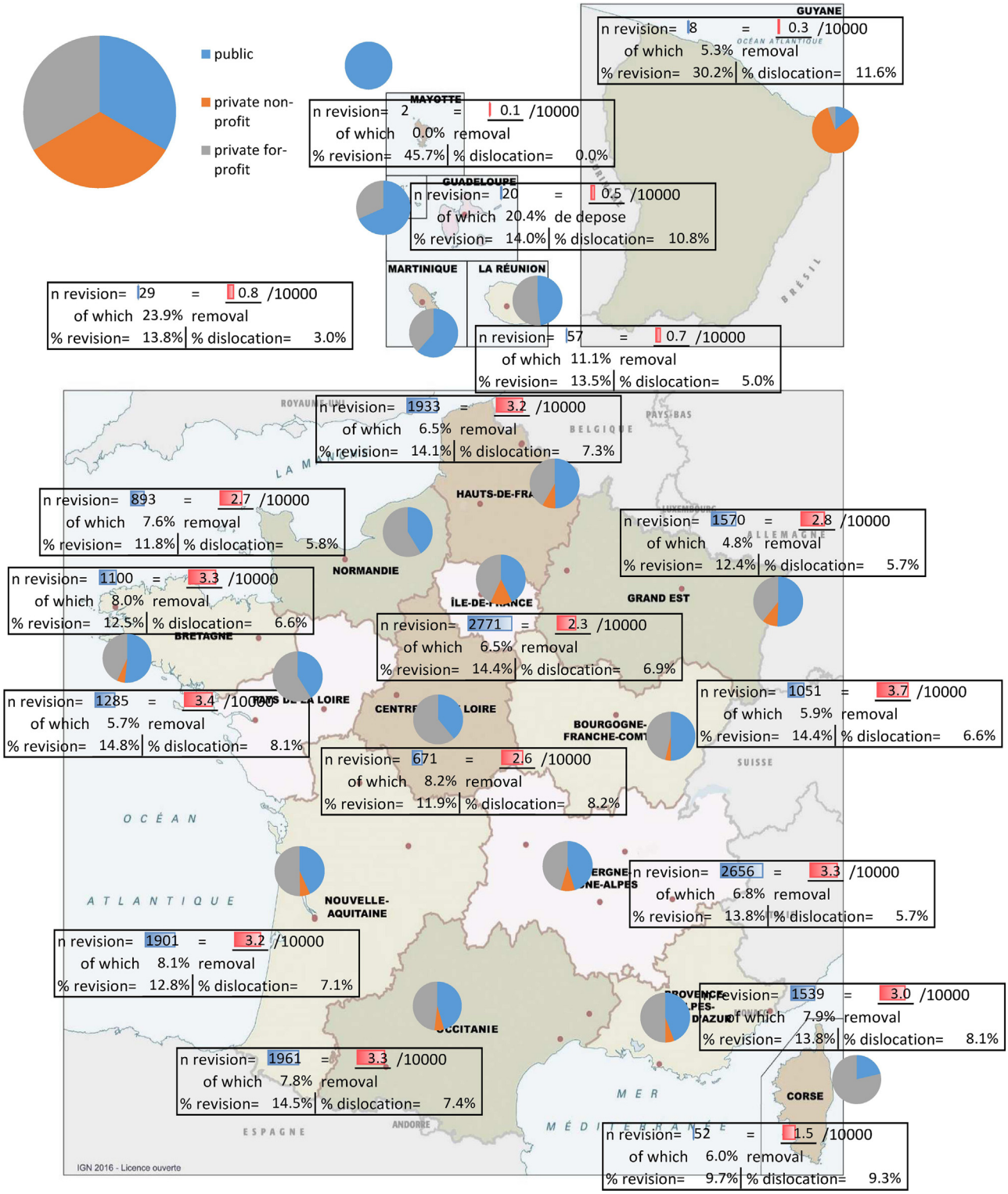

Fig. 3. Map of French national distribution of THA revision and complications surgery: means for 2012–2018 (THA: total hip arthroplasty).

The study involved several limitations:

- there may be a bias related to lack of coding and non-exhaustive inventorying of procedures. There may also be classification bias related to the coding system: we simply trusted the system, without checking each file–which would not have been feasible. Nevertheless, in the French health system surgery is budgeted in terms of coded procedures, and most procedures are therefore doubtless coded, especially since the "activity-based tarification" system was introduced;
- although we sought to be exhaustive, some procedures, and particularly the less frequent ones, may have been overlooked. We took account only of principal codings, and may therefore have underestimated certain procedures: the procedure coded

Table 4
Disparities in hip implant revision surgeries according to region and type of health-care structure. Values in bold are significant at $p = 0.05$; the further from zero, the greater the significance; positive values show a greater number of procedures in this type of center, negative values a smaller number.

Residues (Adjusted)	Public sector	Private non-profit	Private for-profit
Alsace-Champagne-Ardenne-Lorraine	4.297	4.579	−6.652
Aquitaine-Limousin-Poitou-Charentes	−2.041	−1.025	2.566
Auvergne-Rhône-Alpes	−0.061	4.091	−2.054
Bourgogne-Franche-Comté	3.096	−4.442	−0.791
Bretagne	4.184	−2.652	−2.801
Centre	−3.411	−7.331	7.191
Corse	−3.497	−2.010	4.526
Guadeloupe	2.069	−1.253	−1.415
Guyane	−1.801	8.131	−2.407
Île-de-France	−3.169	15.169	−4.681
Languedoc-Roussillon-Midi-Pyrénées	0.015	−1.255	0.634
Martinique	1.742	−1.506	−0.959
Mayotte	1.656	−0.420	−1.435
Nord-Pas-de-Calais-Picardie	3.913	2.507	−5.198
Normandie	−2.524	−8.504	6.912
Pays de la Loire	−3.177	−10.313	8.499
Provence–Alpes-Côte d'Azur	−1.084	−2.120	2.177
Réunion	0.383	−2.094	0.701

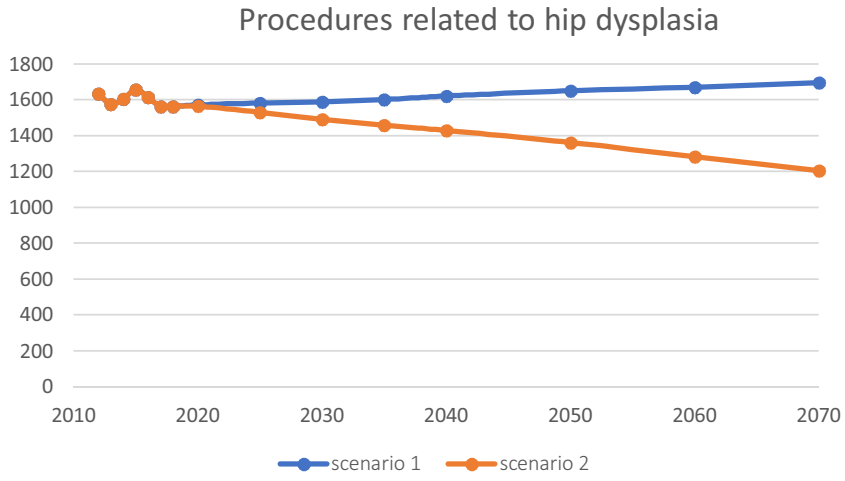

Fig. 4. Progression in number of procedures related to hip dysplasia for 2012–2018 and trends up to 2070 according to scenarios 1 and 2 ($p = 0.201$).

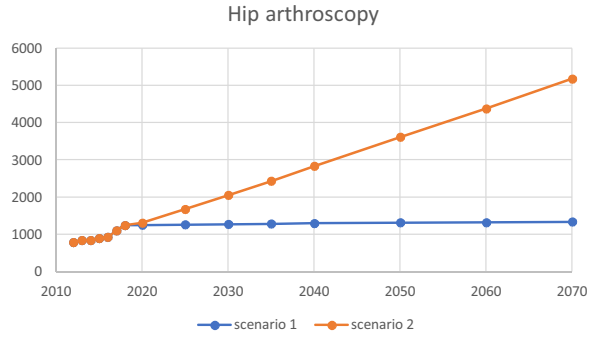

Fig. 5. Progression in number of procedures with hip arthroscopy for 2012-2018 and trends up to 2070 according to scenarios 1 and 2 ($p = 0.003$).

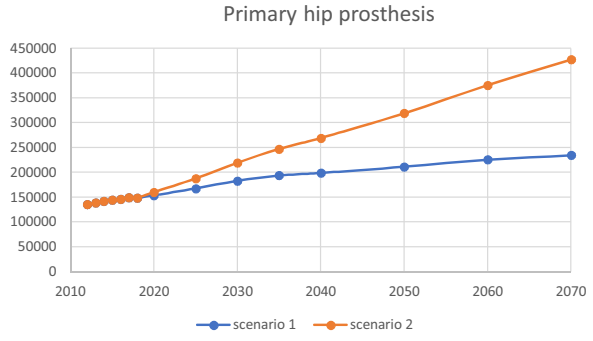

Fig. 6. Progression in number of primary arthroplasties for 2012-2018 and trends up to 2070 according to scenarios 1 and 2 ($p = 0.0001$).

as "principal" is the one bringing in the largest budget, but is not necessarily the one that actually motivated the surgery. However, this applies mainly in traumatology;

- another limitation is that population growth is not homogeneous but shows geographic variations. We did not take this into account, as the analysis would have been too complicated. As stated in the Methods section, we used the medium scenario for the INSEE data, which introduces uncertainty and may falsify the population growth estimates. Likewise, for progression under scenario 2, we applied linear regression, whereas exponential or logarithmic progression would be equally conceivable;
- we did not take account of change in medical demographics, and notably of changes in the number of orthopedic surgeons or the increasing proportion of female practitioners, both of which are liable to vary over time and can impact the relation between supply and demand;

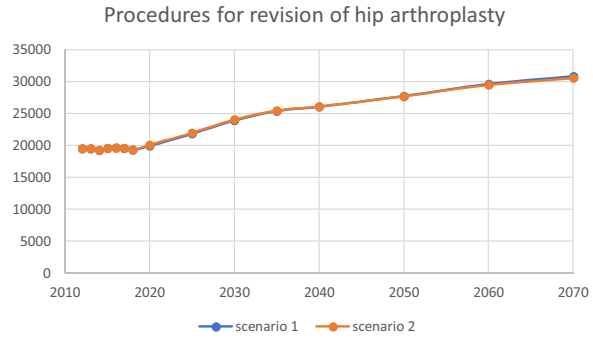

Fig. 7. Progression in number of hip arthroplasty revision procedures for 2012-2018 and trends up to 2070 according to scenarios 1 and 2 ($p = 0.642$).

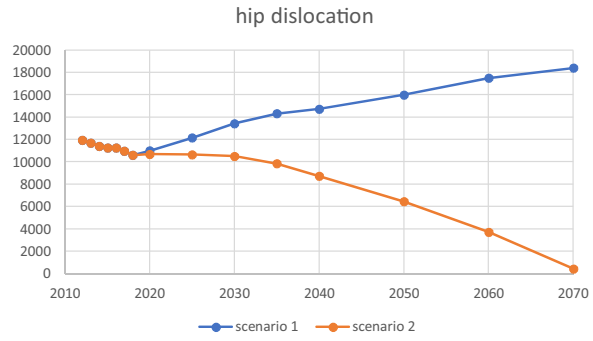

Fig. 8. Progression in number of procedures for hip dislocation for 2012-2018 and trends up to 2070 according to scenarios 1 and 2 ($p < 0.0001$).

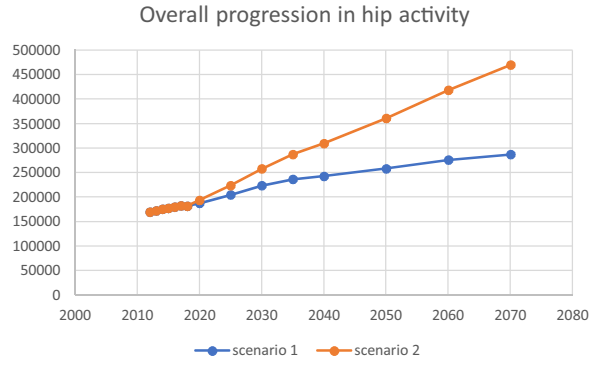

Fig. 9. Overall progression in number of hip surgeries for 2012-2018 and trends up to 2070 according to scenarios 1 and 2 ($p = 0.001$).

- the use of linear regression may be particularly questionable in the case of hip arthroscopy, which is a new field, with strong growth potential; a comparable study in a few years' time could show whether the expected slow-down has occurred;
- finally, estimates were based on the present state of medicine: if a cure were to be found for osteoarthritis, that would indeed be a game-changer; however, nothing of the sort presently exists.

Likewise, some new technology or developments in materials and implants might revolutionize the scenarios–but the present results can only be founded on the present state of medical knowledge.

6. Conclusion

Hip surgery is one of the oldest branches of orthopedics, and hip arthroplasty has, over the years, become a major procedure in France, due to the functional benefit and improved quality of life it ensures. The number of procedures has been incessantly increasing for more than 10 years and, according to forecasts, can be expected to continue to increase over the coming decades. Projections for 2050, taking account of population aging, suggest increases of 41.9–114.3% for THA and 42.0–98.3% for hip surgery as a whole. These estimates are subject to technological breakthroughs and medical discoveries, but describe a perspective of major increase in orthopedic surgery requirements.

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Author contributions

RE: project design, data study, article writing and correction. GV: project design and article writing. JD and NR: re-editing and correction. SD: project supervision and article writing. SB: project supervision.

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