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ORIGINAL STUDY

Trends in the utilisation rates and acute hospital capacity needs for total hip replacements: results of an analysis of administrative data

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Total hip replacement surgery is the mainstay of treatment for end-stage hip arthritis. In 2014, there were 28227 procedures (incidence rate 252/100000 population). Using administrative data, we projected the future volume of total hip replacement procedures and incidence rates using two models.

The constant rate model fixes utilisation rates at 2014 levels and adjusts for demographic changes. Projections indicate 32248 admissions by 2025 or an annual growth of 1.22% (incidence rate 273).

The time trend model additionally projects the evolution in age-specific utilisation rates. 34895 admissions are projected by 2025 or an annual growth of 1.95% (incidence rate 296). The projections show a shift in performing procedures at younger age.

Forecasts of length of stay indicate a substantial shortening. By 2025, the required number of hospital beds will be halved. Despite more procedures, capacity can be reduced, leading to organisational change (e.g. elective orthopaedic clinics) and more labour intensive stays.

Conflicts of interest : none

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Keywords : Elective surgery ; Arthroplasty ; Replacement ; Hip ; Incidence rate ; Forecasting ; Hospital Bed Capacity.

INTRODUCTION

Hip joint replacement surgery is the mainstay of treatment for end-stage arthritis of the hip, and has demonstrated to provide long-lasting pain relief, improved functioning and quality of life *(34)*. It is one of the most common elective surgical procedures performed worldwide. Yet, despite its major role in the treatment of end-stage osteoarthritis, different indication criteria for hip joint replacement seem to be applied resulting in varying utilisation rates within and between countries *(23,26)*. Belgium is with 255 hip replacements per 100 000 population ranked fourth among the OECD countries, only preceded by Switzerland (308/100 000), Germany

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(299/100 000) and Austria (271/100 000) *(26)*. Belgian national cost data are not available but the average reimbursed amount for a hospital admission in 2014 was 9 746.96 Euro: 5 199.56 Euro on average to finance the hospital stay; 202.81 Euro for pharmaceutical products; 2 475.9 Euro for fees of healthcare professionals and 1 868.69 Euro for medical devices. The future number of hip replacements is expected to increase with the ageing population. Nevertheless, during the last decade also an increase in utilisation rates in the population aged 64 years and under was found *(28)*. Therefore, it is important that a reliable projection of future hip replacement rates is made, taking into account changes in demography and practice, to inform policymakers and healthcare insurers (e.g. budget impact, organisational and payment reforms). Publications exist where projections of incidence rates are made based on historical utilisation rates and population forecasts for countries such as Germany *(31)*, the US *(19,20)*, the UK *(7,12,29)*, New Zealand *(14)*, Sweden *(24)*, Denmark *(30)*, Australia *(18)*, and the Netherlands *(27)*.

Not only projections of incidence rates are important to inform decision makers, it is also important to estimate the hospital use for these patients. After all, several evolutions such as advancements in surgery and anaesthesia, optimized organisation of the care process (e.g. by clinical pathways), new clinical insights (e.g. early rehabilitation) and changing societal evolutions and expectations (e.g. preferring community care above hospital care) have resulted in substantial decreases in hospital length of stay (LOS) *(3,5,10,16,22,37)*. Moreover, changing practices also include shifts from inpatient towards same-day care *(13,32)*.

The primary objective of this study was to estimate the incidence rate of total hip replacements (THR) in Belgium by 2025. We hypothesise that this will, due to changing demographics and enlarged indications, increase substantially. The secondary objective was to estimate the required hospital capacity to accommodate this patient population, taking into account changing trends in practice such as a decreased length of stay and shifts between inpatient and same-day care.

MATERIALS AND METHODS

We used nationwide administrative data from the Belgian Hospital Discharge Dataset (B-HDDS). The B-HDDS comprises information on all inpatient and same-day admissions in acute hospitals, summarized in a single episode record. The data include patient characteristics such as age, sex and residence; length of stay (defined as the number of inpatient days – excluding rehabilitation care – between admission and discharge); diagnostic and procedural information. The latter is used to assign each hospital admission to an APR-DRG-SOI (All Patient Refined-Diagnosis Related Group-Severity of Illness). Each APR-DRG is subdivided in 4 SOI-subclasses: 1 (minor), 2 (moderate), 3 (major) and 4 (extreme).

We identified all patients with an APR-DRG code for THR (APR-DRG 301) from 2003 until 2014 inclusive.

Data concerning the historic (2003-2016) and projected (2017-2061) evolution of the Belgian population were obtained from the Federal Planning Bureau (36). Population data were provided annually and subdivided by age group (0-19, 20-39, 40-59, 60-74, 75-84, 85+), sex and the three Belgian regions (Flanders, Wallonia and Brussels). Population projections accounted for international migration, domestic relocation, and the future evolution in fertility and mortality.

Annual projections up to 2025 were made for the volume (number of admissions) and incidence (admissions per 100 000 population) of THR, the LOS and the hospital capacity needs for Belgium. Although the focus of this article is on THR, the analysis was part of a larger study on the required hospital bed capacity in Belgium *(35)*.

Two different projection methods were used to obtain estimates of future volume of THR procedures. Both methods start from the observed number of procedures in 2014 and adjust for changes in population size and composition, specified by age-sex-region specific groups. The first method keeps THR incidence rates constant at 2014 levels. The second method estimates the time trend of THR incidence rates stratified by age group and SOI. Based on a similar historic evolution in incidence rates, three age group were retained: 0-59, 60-84 and 85+, representing 18.7%, 67.6% and 13.7% of THR procedures in 2014. SOI-levels 3 and 4 were combined given the smaller number of procedures in each subcategory, accounting for 10.7% and 1.7% of THR procedures in 2014.

Our trend estimation strategy differs from those in previous THR projection studies. They relied on models with linear trend *(12,27)*, exponential trend (despite evident system constraints) *(7,14,19, 20,24,29,31)*, (rather restrictive) asymptotic growth trend *(18,24,25)* or constant trend (despite significant historic evolutions) *(7,12,14,19,20,27,31)* and model selection based on historic fit. We implemented a wide range of potential specifications and a two-step evaluation procedure that not only assesses the model's ability to fit historic patterns but also its potential to produce accurate outcomes.

In a first step, the B-HDDS was used to generate a quarterly series of incidence rates for each subgroup. A time trend was estimated using deterministic – exponential, logarithmic, linear and power – and ARIMA (auto-regressive integrated moving average) models. The latter are a general class of stochastic time series models – the random walk model and exponential smoothing models are well-known special cases – without pre-determined functional form *(11,17,21)*. As in Nemes et al. *(24,25)*, each specification is evaluated using the Akaike Information Criterion for small samples (AICc) to assess goodness of fit to historical data and the level of complexity *(2,15)*. We preserved the best model as well as competing models whose AICc value is only marginally different (difference less than 5 units) *(4)*.

In a second step, selected models were re-estimated on a subpart of the data (2003-2011) and predictions were generated for the remaining part (2012-2014). The prediction's accuracy was assessed using the Mean Absolute Error (MAE). We calculated the mean and standard deviation of the MAE over all remaining models. The final selection consists of models with a MAE below the mean value augmented with 1 standard deviation.

The projection outcome was calculated as the average of the remaining estimates. The creation of a combination forecast is a popular strategy in time series analysis to improve accuracy and reduce the influence of occasional extreme projections *(6,21,24,25)*. Moreover, through the use of ARIMA models and a validation period, our methodology gives more weight to recent observations.

The number of projected admissions was transformed into projected inpatient days and beds to estimate the capacity needs. We projected the future evolution in LOS by SOI-level up to 2025. The same estimation strategy was followed as for the computation of the time trend in incidence rates (see above). Projected inpatient days were calculated as the product of projected admissions and LOS. An occupancy rate of 80% – applicable in the Belgian hospital payment system for surgical, medical and intensive care beds – was used to infer the future bed need.

All analyses were performed with SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Between 2003 and 2014, THR procedures in Belgium increased at an average annual growth rate of 2.23%, from 22 143 cases (IR 213) to 28 227 cases (IR 252) (Table I). In 2014 the proportion of women undergoing THR was 60.8 and the average age at replacement was 70.7, in line with results from Culliford et al. *(7)* for the UK.

The age distribution is visualized in Figure 1. In 2014, less than 2% of the patients was younger than 40 years; the age groups 40-59, 60-74, 75-84 and 85+ represented a share of 17.0%, 37.7%, 29.9%, and 13.7% respectively. Age-specific incidence rates are given in Table I. They significantly increase by age. Hence population ageing will impact on the number of THR procedures. In 2014, 18.1% of the Belgian population was aged 65+ and supplementary Figure 6 indicates that population ageing will accelerate as the baby-boom cohort (1946-1964) ages.

Figure 2 presents the population incidence rate. It is projected to increase to 273 under the constant rate projection method (red line) and 296 [95% CI : 288-303] under the trend projection method (blue line). The coloured areas represent the effect on the incidence rate of population ageing (orange) and the evolution of age-specific incidence rates (blue).

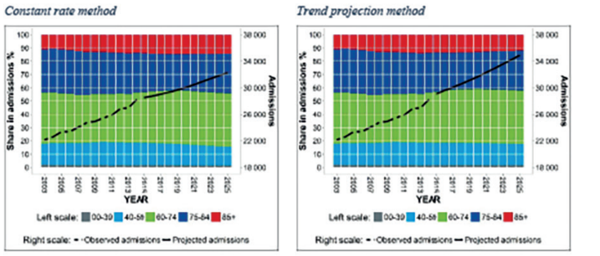


Figure 1. — Observed and projected proportion of admissions by age and total admissions.

Both are important and explain about half of the projected increase in population incidence rate (see also Table I).

Under the constant rate projection method, the total number of admissions is forecasted to grow to 32 248 by 2025, or an annual growth of 1.22%. The share of admissions by age is quite stable, and reflects demographic changes. The share of patients in age groups 60-74 and 85+ grows relatively more importantly at the expense of patients aged below 60 (see Figure 1).

Under the trend projection method, the increase in THR procedures is more important. Admissions are forecasted to rise to 34 895 by 2025 [95% CI: 34 047 – 35 743], or an annual growth of 1.95% [95% CI: 1.72 – 2.17]. Table I clearly reveals the effect of the trend projections on the incidence rates.

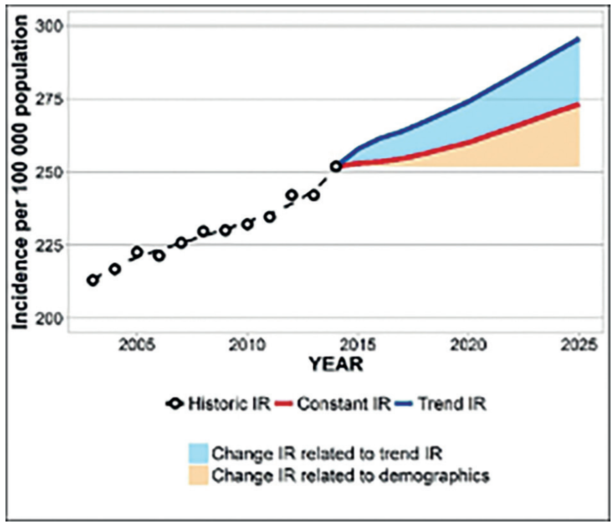


Figure 2. — Observed and projected population incidence rate (IR) (per 100 000 population) under the constant rate and trend projection methods.

Table I. — Overview observed and projected incidence rate, admissions, inpatient days and beds by age group for 2003, 2014, 2020 and 2025.

			Projection: demographic change, incidence rates constant, trend LOS				Projection: demographic change, trend incidence rates, trend LOS			
Year	Age group	Population	IR (per 100 000)	Cases	Days	Beds	IR (per 100 000)	Cases	Days	Beds
2003	0-59	8 128 130	48.5	3 941	43 610	149	*(same figures)*			
	60-84	2 106 834	746.6	15 730	257 397	881				
	85+	161 457	1 531.1	2 472	57 133	196				
	ALL	**10 396 421**	**213.0**	**22 143**	**358 140**	**1 227**				
2014	0-59	8 515 530	62.1	5 290	33 322	114	*(same figures)*			
	60-84	2 405 099	793.1	19 076	174 630	598				
	85+	288 415	1 338.7	3 861	59 220	203				
	ALL	**11 209 044**	**251.8**	**28 227**	**267 172**	**915**				
2020	0-59	8 582 177	60.5	5 195	20 924	72	67.8	5 821	23 220	80
	60-84	2 643 216	774.2	20 463	122 575	420	820.6	21 690	127 578	437
	85+	332 949	1 323.3	4 406	46 369	159	1 251.8	4 168	43 994	151
	ALL	**11 558 342**	**260.1**	**30 064**	**189 868**	**650**	**274.1**	**31 679**	**194 792**	**667**
2025	0-59	8 567 772	58.8	5 038	11 455	39	72.0	6 167	13 655	47
	60-84	2 884 776	782.7	22 579	83 975	288	850.4	24 532	87 629	300
	85+	352 630	1 313.3	4 631	31 614	108	1 189.9	4 196	28 906	99
	ALL	**11 805 178**	**273.2**	**32 248**	**127 044**	**435**	**295.6**	**34 895**	**130 190**	**446**

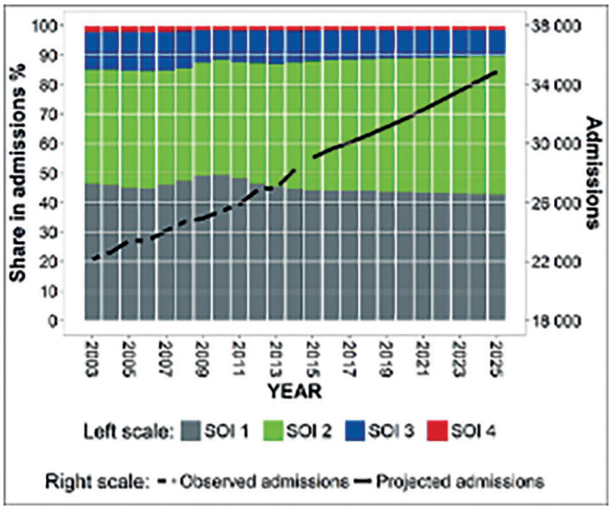


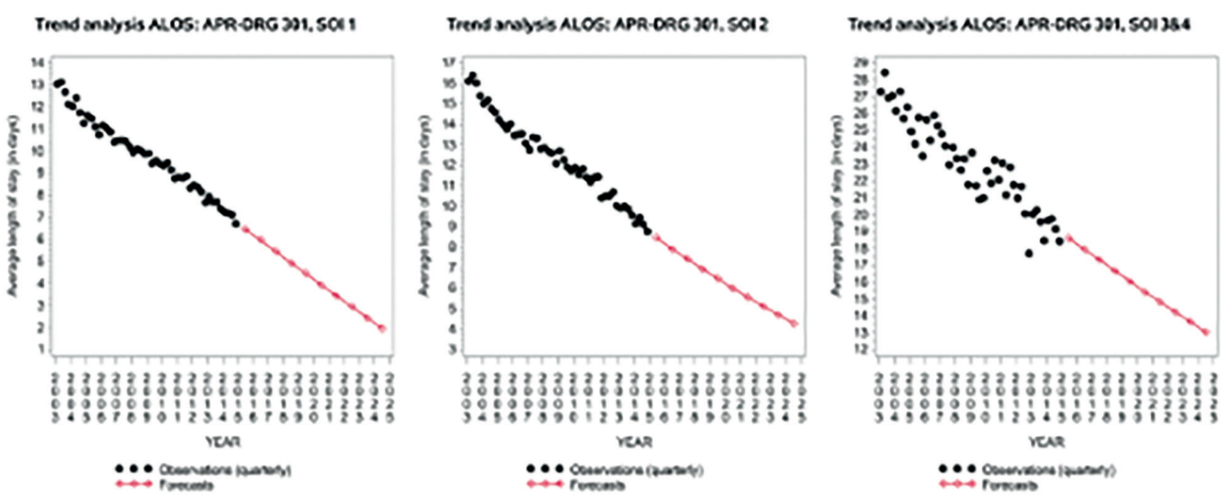
Figure 3. — Observed and projected proportion of admissions by severity of illness (SOI) and total admissions.

In comparison with the constant rate projection, the age-specific incidence rates in 2025 change by +22.4% [95% CI: 22.1% – 22.7%], +8.6% [95% CI: 6.0% – 11.2%] and -9.4% [95% CI: 14.6% – 4.4%] for age groups 0-59, 60-84 and 85+, respectively. The trend projections reveal a shift in performing THR procedures at relatively younger age. As can be seen in Figure 1, the changing age-specific incidence rates affects the age composition of future patients. For example, patients aged 85 or more make up 12% of the patient population in 2025 under the trend projection method compared to 14.6% under the constant rate method and 13.7% observed in 2014.

SOI is an indicator of complications and additional procedures patients may have during THR. It is a major determinant of LOS and hospital capacity requirements. Figure 3 shows the proportion of admissions coloured by SOI under the trend projection method. Admissions with low SOI (SOI 1 and 2) are relatively more common with a combined share of 87.5% in 2014 increasing to 89.7% in 2025.

The estimated evolution of LOS by SOI is visualized in Figure 4. During the period 2003-2014, substantial reductions in LOS were realized from 12.7 to 7.1 days in SOI 1, from 16.0 days to 9.1 days in SOI 2 and from 27.5 to 19.3 days in SOI 3-4. Similarly, Burn et al. (5) observed a reduction in LOS for primary THR in the UK from 14.4 to 5.6 days between 1997 and 2014. Despite the increasing number of THR, the systematic reduction in LOS led to a decrease in inpatient days and hospital beds between 2003 and 2014 by 90 968 days and 312 beds (see Table I)

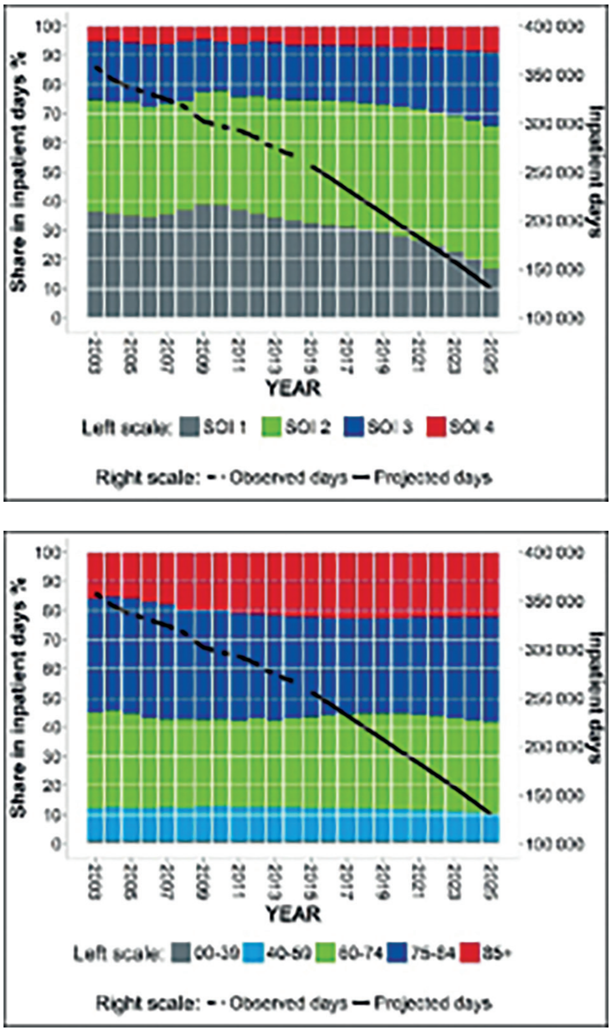
Our projections show a continued shortening of LOS and reduction in inpatient days (see Figure 4



Note: APR-DRG = all patient refined – diagnosis related group; ALOS = average length of stay; SOI = severity of illness.

Figure 4. — Observed and projected evolution in ALOS for APR-DRG 301 "Total Hip Replacement" by SOI group.

and Figure 5). By 2025 LOS is predicted to be 1.5 [95% CI: 0.8 – 2.2], 3.9 [95% CI: 3.2 – 4.7] and 12.5 [95% CI: 11.4 – 13.5] days in SOI 1, 2 and 3-4, respectively, i.e. an (average) annual reduction by 13.31% [95% CI: -18.0 – 10.1], 7.48% [95% CI: -9.1 – 5.8] and 3.88% [95% CI: -4.7 – 3.2]. The important future reduction in LOS for SOI 1 may be somewhat smaller in case of substitution from inpatient to same-day treatment. In 2014, THR in Belgium was only marginally performed as same-day surgery (with 5 registered cases). Given shorter LOS, corresponding inpatient days and beds are projected to halve by 2025, i.e. a reduction of 136 982 days, 469 beds or an average annual decrease by 6.33%. A substantial part of hospital capacity is taken up by older patients with higher SOI-levels (see Figure 5).



Note: SOI = severity of illness.

Figure 5. — Observed and projected proportion of inpatient days by age and by severity of illness (SOI) and total inpatient days under the trend projection method.

DISCUSSION

With this population-level study we have investigated the future projected volume and incidence rate of THR in Belgium up to the year 2025, as well as the impact on the required hospital capacity. Given projected population changes in age and sex, the number of THR performed in Belgium in 2025 was estimated to grow to 32 248, or an annual growth of 1.22%. Allowing a trend in THR incidence rates, the expected annual growth is even larger (1.95%). The estimated incidence rate was projected to rise from 252 per 100 000 Belgian inhabitants in 2014 to 273 (constant rate model) or to 296 (trend projection model) in 2025.

Although similar studies use different models (e.g. using a linear or exponential trend model (see also section 2.2.1), using more/fewer/other age groups, further subdividing the population by BMI-level to make explicit the changing prevalence in obesity *(7)*, or applying the incidence rates observed in other countries) projections are in line with overall results of these studies for other countries, showing an increase in past decades as well as forecasting an increase in THR in the future. However, the (current) incidence rate of THR varies considerably between countries. A direct comparison with other countries should be made with caution for several reasons. First, as incidence rates increase with age, demographic differences between countries lead to divergent total incidence rates. Therefore, incidence rates by age groups should be compared. For example, Pabinger and Geissler (2014) found a 7-fold higher growth rate between 2005 and 2011 in patients aged 64 years and younger as compared to older patients in 27 OECD countries. Second, the organisation of the healthcare system and the hospital payment system, including the coding system of diagnoses or procedures, provide a second explanatory factor for different rates across countries *(28)*. Of course, differences in incidence rates can also point to practice variation between countries.

Similarly, the projected future hip replacement volume and incidence rate largely depend on the assumptions underlying the modelling method that was used. However, contrary to most other studies where a specific choice of technique was used (see section 2.2.1), we implemented a wide range of potential specifications and a two-step evaluation procedure that assesses the model's ability to produce accurate outcomes. Also the choice of projection model is important. In our study, the difference in incidence rate between the constant rate (273/100 000 population) versus the (more realistic) trend projection model (296/100 000 population) hides the divergent trend for the age groups 60-84 and 85+ between both models.

The accuracy of projections is strongly determined by the period they cover. Since longer-term projections are more unreliable, we limited our projections to 2025. A major limitation of this short-term projection is that the real demographic peak in elderly that will appear from 2030 onwards, is not taken into account. Especially for long-term decision on required hospital capacity this might be shortcoming. Keeping the age-dependent incidence rates at the projected level for 2025, but adjusting the population to the demographic projections of 2034 and 2043, would lead to a forecasted population incidence of 317 and 329, respectively, or 38 696 and 41 286 procedures and 514 and 573 beds.

Independently of the statistical method applied, projections are based on trends inferred from historical data. The estimated time trends are assumed to capture epidemiological trends, medico-technical progress, development of community care, the ongoing development in medical practice and organization, the influence of financial incentives and other policy decisions, etc. Changes in LOS or admission rates that were not yet present in the data but appear suddenly, so-called disruptive events, are not taken into account. Trend analysis further assumes that the effect of this extensive range of influential factors remains constant in the future. However, the future will never be a smooth continuation of past patterns. For example, the trend projections reveal a shift in performing THR procedures at relatively younger age. The incidence rate for patients younger than 60 years of age has increased from 48.5 per 100 000 population in 2003 to 62.1 in 2014 and is projected to increase to 72.0 in 2025 in the trend projection model. However, this trend might speed up or slow-down in the future. The trend in incidence rate for younger patients not only has an impact on the number of primary THR, but also on the number of revisions. If the trend speeds up, the number of revisions can be expected to increase dramatically *(33)*.

Changes in lifestyle and longer life expectancy may increase the incidence of osteoarthritis and hence the demand for total replacement. Other studies accounted for body mass index (BMI) as a risk factor, in addition to age and sex, when projecting future THR incidence rates *(7)*. The association between BMI and knee osteoarthritis is, however, found to be stronger than for hip. Nevertheless, increasing BMI in the population might make the present estimates too conservative.

What this study adds is the combined impact of the future volume of THR procedures and LOS on hospital capacity requirements, in terms of inpatient days and beds. By 2025, the required number of beds will be halved, which has important implications for policymakers, hospital management and healthcare insurers. For example, an evaluation of the required number of qualified personnel will have to take place. Budgets will have to take into account that the remaining inpatient days for the shorter inpatient stays will become more labour intensive and more complex. Given that the average number of patients per nurse in Belgium is higher than in other European countries, measures are needed to prevent overload of hospital staff and to ensure the quality of care *(1)*. As such a simple budget calculation cannot be made as part of the budget for hospital stays will have to be shifted towards home care and the average nurse resource allocation per hospitalization day will increase. Yet, abstracting from hospitalization reimbursements and assuming that the reimbursed amounts – fixed per procedure and SOI – for medical devices, fees for healthcare professionals and pharmaceutical products will remain stable at the 2014 level, it is estimated that the increased incidence rates (trend method) of

THR will coincide with an increase in healthcare expenditure: from 128.4 million Euro in 2014 to 161.6 million Euro in 2025. In addition, it might result in changing organisational formats with a concentration of elective orthopaedic surgery in stand-alone elective orthopaedic clinics. Examples abroad illustrate that this might increase efficiency since there is no competition with unplanned care (i.e. care is not postponed because of interruptions by unplanned care). Yet, typically, these centres do not treat complex patients which might demand policy measure to avoid 'cream skimming' *(8,9)*. Moreover, the future required hospital capacity will also depend on the availability of alternatives of traditional hospital care, such as home care or outpatient rehabilitation care. The number of same-day surgeries for THR is negligible in the hospital data used (2003-2014). In December 2015 the first dedicated same-day THR surgery programme was launched in a Belgian hospital. In case of an expansion of same-day surgeries, implications for policymakers, hospital management and healthcare insurers are similar to those of a reduced LOS.

CONCLUSION AND FUTURE PERSPECTIVES

Our findings suggest a growth in the number of THR because of an ageing population. The projected incidence rates are age-dependent, with a projected increase for age groups 85- and a projected decrease for age group 85+, instead of a general increase in the operation frequency. The number of revision procedures is expected to grow as well because of the current trend to undergo hip replacement in ever younger patients. The increase in the number of procedures and decrease in the LOS will result in a downward pressure on the required hospital capacity, with two important caveats. First, the projection horizon should be extended to take the demographic peak from 2030 onwards into account. Second, hospital staffing standards should be adapted to prevent overload.

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