

Osteoarthritis and Cartilage



Utilization rates of hip arthroplasty in OECD countries revised

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ABSTRACT

Objective: In 2014, we reported rising hip arthroplasty utilization across Organization for Economic Co-operation and Development (OECD) countries, particularly among younger patients. Since then, healthcare systems have evolved, demographic shifts are continued, and procedures were impacted by the COVID-19 pandemic. This study aims to reassess these trends through 2022.

Methods: We analyzed hip arthroplasty data from the OECD Health Statistics, U.S. Nationwide Inpatient Sample, and World Bank for 27 countries (2005–2022). We compared relative (compound annual growth rates (CAGR)) and absolute (i.e., mean annual differences (MAD)) procedure numbers, stratified by age (≤ 64 vs. ≥ 65), and examined associations with GDP, health expenditure, and life expectancy. Sensitivity analyses were performed to account for uncertainty in U.S. data.

Results: Between 2011 and 2022, hip arthroplasty utilization grew more slowly than 2005–2011 (CAGR: 1.00% vs. 2.03%; MAD: 1.78 vs. 2.03). Growth from 2011 to 2022 was concentrated among patients aged ≤ 64 (CAGR 3.08%; MAD: 3.11), while utilization declined among those ≥ 65 (CAGR: -2.27%; MAD: -12.46). Country-level variation narrowed, with the highest-to-lowest ratio falling from 6.65 (2005) to 2.96 (2022). Despite a sharp drop in 2020 due to COVID-19, most countries recovered by 2022. Sensitivity analyses confirmed the robustness of observed OECD trends. BRIC nations showed faster growth, but data limitations hindered comparisons.

Conclusion: Hip arthroplasty utilization continues to increase among younger patients but has declined in older ones. Continued demographic pressure and recovery from COVID-19 disruptions are expected to drive further increases in procedure volume.

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Introduction

In 2014, we published a comparative analysis of hip arthroplasty utilization across Organization for Economic Co-operation and Development (OECD) countries from 2005 to 2011, revealing striking cross-country differences and important trends [1]. We observed roughly a 38-fold variation in annual hip replacement rates among OECD countries, with higher utilization correlating with gross domestic product (GDP) and health care expenditures. We noted that hip arthroplasty was rising in all age groups, but growth was seven times greater in patients ≤ 64 years. Based on these findings, we projected an exponential rise in future revision procedures,

reasoning that younger patients receiving implants would live longer with their prostheses and eventually require more frequent revision surgeries [2].

Given the decade that has elapsed since the 2005–2011 analysis, an updated assessment is warranted to determine whether those initial findings and expectations hold true. Health systems and patient demographics have continued to evolve: populations have grown older on average [3], surgical techniques and prosthesis of hip arthroplasty developed [4,5], healthcare spending levels changed [6], obesity prevalence increased [7]. Meanwhile, surgical procedures were temporarily disrupted due to COVID-19-related restrictions [8]. It is therefore crucial to reassess hip arthroplasty utilization with the most recent data to see if the wide international variability has persisted or narrowed and to evaluate if the anticipated surge in revision surgeries is beginning to materialize [1,2]. In short, a follow-up analysis can confirm whether our identified trends have continued the same trajectory or taken new directions over the past decade.

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The present study extends the original methodology and analysis through 2022, maintaining a comparable country scope and metrics to facilitate direct comparison with the earlier results. We compiled OECD health data on hip arthroplasty procedures up to the year 2022, using the same definitions of utilization rate. Growth rates were calculated for the period 2011–2022 and compared against those from the 2005–2011 period to examine changes in growth dynamics over time. As in the prior analysis, we stratified the data by patient age group (≤ 64 vs. ≥ 65 years cohorts) to assess whether younger patients have continued to drive a disproportionate increase in utilization. This methodological continuity ensures that any differences observed between the two periods reflect genuine temporal shifts rather than inconsistencies in data handling.

The current study addresses the following research questions:

- How have the utilization rates, compound annual growth rates (CAGR), and mean annual difference (MAD) of hip arthroplasty in OECD countries evolved between 2011–2022 compared to the previously observed period (2005–2011)?
- What new trends in hip arthroplasty utilization have emerged between 2011 and 2022, and what implications might these have for future growth?

Methods

Data extraction and validation

Building on the data framework established in our previous study, we extracted hip arthroplasty data for OECD countries from the *Health Statistics* dataset, covering the period 2005–2022 [9]. We replicated the previously used country set of 27 countries to ensure methodological consistency. Two key indicators were extracted: (i) total number of inpatient hip arthroplasty cases per 100,000 inhabitants, and (ii) number of procedures per 1000 inhabitants aged ≥ 65 . For Mexico and Australia, due to the unavailability of inpatient case data, we instead extracted the total number of procedures per 100,000 persons.

The hip arthroplasty data are based on procedures classified under the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM). Specifically, the data include total hip replacement (81.51), partial hip replacement (81.52), and revision of hip replacement (81.53).

We extracted data on hip arthroplasty procedures, health expenditure, population age groups, and life expectancy from the OECD (Health Statistics) database, and GDP per capita from the World Bank [10]. Hip arthroplasty data for the United States (U.S.) was extracted from the NIS database [11]. All data were retrieved in March 2025.

Incidence to utilization rate conversion

In line with our previous work, we continue to distinguish between “incidence” as reported by the OECD—defined as the number of inpatient cases per 100,000 total population—and “utilization rate”, a more specific metric introduced to address age-related differences in arthroplasty frequency. Incidence can be misleading when procedure rates differ significantly between age groups, as it uses the total population as the denominator regardless of the age-specific numerator. To allow for meaningful comparisons across age groups, we define “utilization rate” as the number of procedures within a given age group divided by the corresponding population of that group. This approach ensures internal consistency between numerator and denominator and provides a more accurate reflection of age-specific procedure prevalence.

Age dependent grouping

The total number of hip arthroplasty procedures was disaggregated into two age groups. Data for patients aged ≥ 65 were directly obtained from the OECD Health Statistics cohort. The number of procedures for patients ≤ 64 was calculated by subtracting the ≥ 65 cohort from the total number of recorded procedures. Available data did not allow for further age group differentiation.

Comparison of compound annual growth rates and mean annual differences

We used the CAGR as a key metric to compare the development of hip arthroplasty procedures over time. CAGR reflects the average annual growth rate between two time points, assuming a constant rate of increase, and is particularly useful for comparing countries with differing baseline volumes. The formula is:

$$\text{CAGR} = \left(\frac{\text{End value}}{\text{Start value}} \right)^{\frac{1}{n}} - 1$$

where n denotes the number of years between the start and end values. We applied CAGR to assess changes across two periods: 2005–2011, corresponding to our previously published analysis [1], and 2011–2022, reflecting the revised data set. Additionally, MAD are provided to show the absolute change in procedure volume. MAD was calculated by subtracting the start value from the end value, divided by n and will be reported in this paper as the mean difference in procedures per 100,000 inhabitants per year.

Handling of missing data and sensitivity analyses

Few data points for hip arthroplasty procedures (total and ≥ 65) were not reported by OECD data: Australia (2022), Belgium (2015), the Netherlands (2011 and 2022), Norway (2010, 2011, 2021, and 2022), and the U.S. (from 2010 onward). For missing values in 2021 and 2022, we extrapolated data using the four-year CAGR preceding the missing year (e.g., for Australia, the 2022 value was based on the CAGR from 2017 to 2021). For gaps within the time series, we estimated values by applying the CAGR between the adjacent available years (e.g., Belgium's 2015 value was derived from the CAGR between 2014 and 2016).

For the U.S., where the latest OECD data point was from 2010, we used the NIS, a national database covering $\sim 20\%$ of U.S. hospital discharges, as previously employed [12–14]. Like the OECD Health Statistics, the NIS includes primary, partial, and revision arthroplasty procedures. It is based on ICD-9-CM coding until 2015 and *International Classification of Diseases, 10th Revision, Procedure Coding System* (ICD-10-PCS) from 2015 onwards. Because the NIS is based on a 20% sample of U.S. discharges (excluding rehabilitation and long-term care facilities), weights are applied to produce nationally representative estimates. In 2012, the NIS sampling strategy was redesigned to improve accuracy. To mitigate the impact of this one-time distribution two weight types are applied: (i) trend weights (TRENDWT) for data before 2012 and (ii) standard discharge weights (DISCWT) from 2012 onwards. For our analysis, we extracted NIS data from the Healthcare Cost and Utilization Project's (HCUP) with respective weights already applied [11]. Where available, we compared the NIS data with other sources and found no difference of more than $\pm 4\%$. Due to missing age-specific data on hip arthroplasty volume in NIS data, we applied the OECD distribution for each year.

To assess the robustness of NIS data and our age distribution assumption, we performed two types of sensitivity analyses: (i) we varied the total procedure volume reported by the NIS in $\pm 2.5\%$ increments, up to $\pm 10\%$; and (ii) we applied five alternative age distribution scenarios for the share of procedures among patients aged ≥ 65 , based on the lowest, highest, and interquartile values observed

across OECD countries ([Supplementary Material 1](#)). Sensitivity analyses were conducted specifically for the U.S., as the country accounts for nearly one-third of all procedures in our dataset and is expected to have a strong influence on overall results.

We excluded countries with unexplained discrepancies in the data (e.g., enormous increase in incidence from one year to the next).

Statistical and correlation analysis

We conducted linear regressions and Pearson correlation analyses to assess the association between hip arthroplasty utilization rates and key country-level indicators: GDP per capita (in thousand USD), health expenditure per capita (in thousand USD), and life expectancy (years). Each predictor was analyzed separately using pooled country-year data from 2005 to 2022. Multivariable models were avoided due to the number of cases, some missing values, and our focus on descriptive associations. Scatterplots were used to visually assess linearity and detect outliers prior to analysis. Log-transformed versions of skewed predictors were tested to evaluate robustness of results

Results

General data description

We build on our previous country scope with 27 countries with available data from 2005 to 2022 ([Table 1](#)). Post data validation,

Korea, Israel, and Mexico were excluded due to data inconsistencies. Korea showed an increase in procedures from ~10,100 in 2013 to ~26,000 in 2014 due to revision in surgical procedure coding, while in Israel and Mexico, the number of procedures among those aged ≥65 exceeded total recorded procedures ([Supplementary Material 2](#)). These three countries were excluded from both the current and previous data periods (2005–2011) to ensure a like-for-like comparison. Minor deviations from previously reported figures reflect ongoing OECD datasets updates.

Unlike other countries, U.S. NIS data showed a steep decline in 2021 and 2022, with no post-COVID-19 recovery, likely due to reporting changes (i.e., 2020 removal of arthroplasty from the inpatient-only list) rather than actual volume [15]. Accordingly, we extrapolated 2020 data using average year-on-year growth across OECD countries.

Total number of hip arthroplasties

Between 2005 and 2022, hip arthroplasties across countries increased by 38.1% [sensitivity corridor based on NIS variation: 37.9%; 38.4%], from approximately 1.20 million [1.16; 1.23] to 1.65 million [1.60; 1.70] ([Fig. 1](#)). Relative and absolute growth was more pronounced between 2005 and 2011 (CAGR: +2.70% [2.69%; 2.72%] and MAD: +34,600 procedures [33,300; 35,800]) than between 2011 and 2022 (CAGR: +1.5% [1.47–1.52%] and MAD: +22,600 procedures [22,300; 22,900]). In 19 of 24 countries, incidence increased at a higher CAGR than population over the period.

	Population			Inpatient cases per 100,000 inhabitants																	Change inpatient cases					Health exp. \$[/capita]	GDP \$[/capita]	Obesity ¹ [% of population]
	CAGR '05 - '11 [%]	CAGR '11 - '22 [%]	Total in 2022 [Mio]	2005	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total implants in 2022	CAGR '05 - '11 [%]	CAGR '11 - '22 [%]	MAD '05 - '11	MAD '05 - '22							
Australia	1.7	1.4	26.0	150	171	170	179	184	192	195	195	196	171	198	186	184*	47,677	2.3	0.6	3.5	1.2	5,616	65,835	28.3				
Austria	0.3	0.7	9.1	252	274	272	276	279	271	273	286	299	295	263	287	302	27,331	1.4	0.9	3.7	2.5	5,519	70,676	* 16.6				
Belgium	0.8	0.5	11.6	237	238	247	248	255	260*	265	274	275	284	230	272	283	32,885	0.0	1.6	0.2	4.1	5,141	68,080	* 15.9				
Canada	1.1	1.1	38.9	117	131	136	141	145	148	154	159	165	165	135	135	153	59,524	1.8	1.5	2.3	2.0	5,432	62,708	26.2				
Denmark	0.5	0.5	5.9	207	225	225	228	233	233	242	242	240	249	244	224	271	16,041	1.5	1.7	3.0	4.2	5,070	77,335	* 18.7				
Estonia	-0.3	0.1	1.3	111	134	140	142	142	156	146	156	170	169	172	172	184	2,479	3.1	2.9	3.8	4.5	2,525	47,762	* 21.0				
Finland	0.4	0.3	5.6	211	225	237	242	244	248	263	269	274	275	252	279	242	13,446	1.0	0.7	2.3	1.5	4,426	61,293	21.5				
France	0.6	0.4	67.9	217	230	232	236	238	240	241	245	244	247	215	237	246	167,343	1.0	0.6	2.2	1.5	5,133	56,134	17.0				
Germany	-0.4	0.4	83.8	255	290	287	283	293	299	304	309	311	315	294	301	326	273,181	2.2	1.1	5.8	3.3	6,392	67,533	23.6				
Hungary	-0.2	-0.3	9.6	103	113	110	119	128	138	138	139	139	147	108	79	133	12,787	1.6	1.5	1.7	1.8	2,420	43,665	28.5				
Ireland	1.7	1.0	5.1	139	118	118	126	124	131	127	131	123	125	196	222	250	12,756	-2.6	7.1	-3.5	12.0	5,421	137,231	23.0				
Italy	0.5	-0.2	58.9	150	159	162	165	168	173	179	185	187	194	163	194	212	124,836	1.0	2.7	1.5	4.8	3,383	56,172	* 11.4				
Luxembourg	1.8	2.1	0.7	220	209	203	198	189	193	198	197	203	219	178	209	214	1,398	-0.9	0.2	-1.8	0.5	5,518	144,751	* 16.5				
Netherlands	0.4	0.5	17.7	191	221*	226	226	229	233	236	239	248	254	217	241	242*	42,789	2.4	0.8	5.0	1.9	5,348	77,087	* 14.6				
New Zealand	1.0	1.4	5.1	133	142	146	151	160	156	157	167	159	159	147	144*	139*	7,126	1.1	-0.2	1.5	-0.3	4,875	53,071	28.8				
Norway	1.2	0.9	5.5	203	247*	250	242	243	244	252	252	259	267	239	254	275	15,018	3.4	1.0	7.3	2.5	6,331	122,516	* 16.0				
Poland	0.2	-0.2	37.8	40	75	78	84	97	110	129	159	160	177	139	181	152	57,535	11.0	6.6	5.8	7.0	2,374	46,039	* 18.5				
Portugal	0.1	-0.1	10.4	83	94	99	101	98	103	102	98	98	102	86	108	114	11,896	1.9	1.8	1.8	1.8	3,401	44,520	* 15.9				
Slovenia	0.4	0.2	2.1	157	187	189	161	165	173	170	200	188	199	165	175	209	4,411	3.0	1.0	5.0	2.0	3,491	51,036	* 19.4				
Spain	1.1	0.2	47.6	89	99	101	106	111	112	112	120	126	128	109	129	138	65,518	1.9	3.0	1.7	3.5	3,442	50,454	* 14.9				
Sweden	0.8	1.0	10.5	211	233	237	235	231	234	236	245	245	248	203	215	258	27,077	1.7	0.9	3.7	2.3	5,292	66,320	* 16.1				
Switzerland	1.0	0.9	8.8	266	306	302	296	300	305	314	309	307	313	306	322	338	29,680	2.3	0.9	6.7	2.9	7,214	90,139	* 12.1				
U.K.	0.8	0.6	67.3	141	176	177	182	185	182	187	180	186	182	97	180	173	116,158	3.7	-0.2	5.8	-0.3	4,524	58,393	24.7				
U.S. ²	0.9	0.6	333.3	126	144	149	156	164	170*	176	183	185	189	122	138*	145†	483,037	3.1	0.7	3.0	0.1	10,635	78,035	35.3				
Total	0.7	0.5	870.5														1,651,930											
Incidence				151	170	173	178	184	188	194	199	202	205	160	181	190		2.0	1.0	3.2	1.8							
Mean utilization rate				151	170	173	178	184	188	194	199	202	205	160	181	190		2.0	1.0	3.2	1.8							

Bold figures show summary. Framed figures show an increase in the growth rate/MAD compared to the previous period. Figures are underlined if the population growth exceeds inpatient growth in the same period and vice versa. Shaded values reflect the time intervals used for CAGR/MAD comparison. ¹2012 measured rates if available. If no measured data was reported, self-reported obesity percentages (%) were used as the best alternative estimate. ²Based on National Inpatient Sample data which underwent change in re-sampling strategy in 2012 *Data extrapolated based on last four-year CAGR; † estimated values by applying the CAGR between the adjacent available years; ‡ previous year utilization rate extrapolated based on year-on-year growth rate of hip arthroplasty procedures across other OECD countries.

Table 1

Hip arthroplasty inpatient cases per 100,000 population from 2005–2022 (base case with NIS data as extracted).

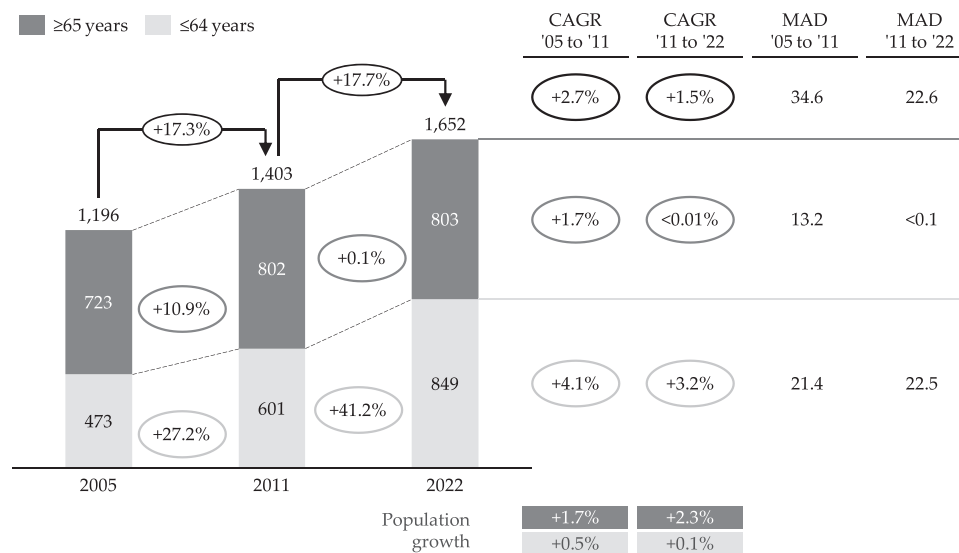


Fig. 1

Osteoarthritis and Cartilage

Total number of hip arthroplasties across selected OECD countries (in thousands). Note: Bars represent volumes for 2005, 2011, and 2022, divided by age group: darker grey for patients aged ≥ 65 years and lighter grey for patients aged ≤ 64 years. Numbers within bars indicate procedure volumes (in thousands). Percentages between bars show an absolute increase in hip arthroplasty volume for the respective period. MAD also reported in thousands.

The U.S. recorded the highest number of hip replacements in 2022 (~483,000 [434,700; 531,300]), followed by Germany (~273,000), while Luxembourg reported the lowest volume. In terms of incidence, Switzerland recorded the highest rate in 2022 at 338, 2.96 times higher than Portugal, which had the lowest incidence at 114. Disparities were greater in 2005 and 2011, when highest-to-lowest incidence ratio reached 6.65 and 4.14 respectively (Fig. 2).

Poland showed the strongest relative growth in 2005–2011 (CAGR: 11%), reflecting its low baseline. In the recent period, Ireland led relative (CAGR: 7.1%) and absolute growth (MAD: +5.7 per 100,000). Notably, New Zealand and the United Kingdom (U.K.) were the only countries with incidence decline from 2011–2022, whereas in the earlier period, declines were observed only in Luxembourg and Ireland.

Only three countries (i.e., Australia, Estonia, and Ireland) maintained growth during the COVID-19 peak in 2020, while others experienced declines (Supplementary Material 3). The U.K. recorded the steepest relative drop, with procedure falling nearly 50%. By 2022, most countries had returned to their pre-COVID-19 volumes, though 8 remained below.

Age related differences

Hip arthroplasty increased across both age groups between 2005 and 2022 (Table 2 and Table 3); however, the growth was substantially more pronounced among patients ≤ 64 years. In this group, procedure volumes increased by ~79% [sensitivity corridor based on age distribution scenarios: 100%; 78%] from ~472,600 [396,800; 491,500] in 2005 to 848,800 [791,700; 872,500] in 2022. In contrast, procedures among individuals aged ≥ 65 increased by only ~11% [8%; 11%], from 723,300 [704,400; 799,100] to 803,100 [779,500; 860,200].

Between 2011 and 2022, the older group's utilization rate declined in both relative (CAGR: -2.3% [-2.3%; -2.5%]) and absolute terms (MAD: -12.5 [-12.1; -15.1]). Conversely, in the younger group,

utilization continued to grow strongly, reflected by a CAGR of +3.1% [3.0%; 3.8%] and an MAD of +3.1 [3.1; 3.4]. As a result of these divergent trends, while the ≥ 65 segment accounted for around 60% [59%; 67%] of procedures in 2005, this proportion fell to 49% [47%; 52%] in 2022.

Overall, in the population aged ≥ 65 , the number of procedures grew more slowly than the population itself (CAGR: <0.1% [-0.2%; <0.1%] vs. 2.3%). In contrast, among individuals ≤ 64 years, procedure growth (CAGR: 3.2% [3.1%; 3.9%]) outpaced population growth (0.1%), reflecting increased relative utilization in this younger group. This observation was less prevalent in our previously observed period from 2005 to 2011.

Sensitivity analyses

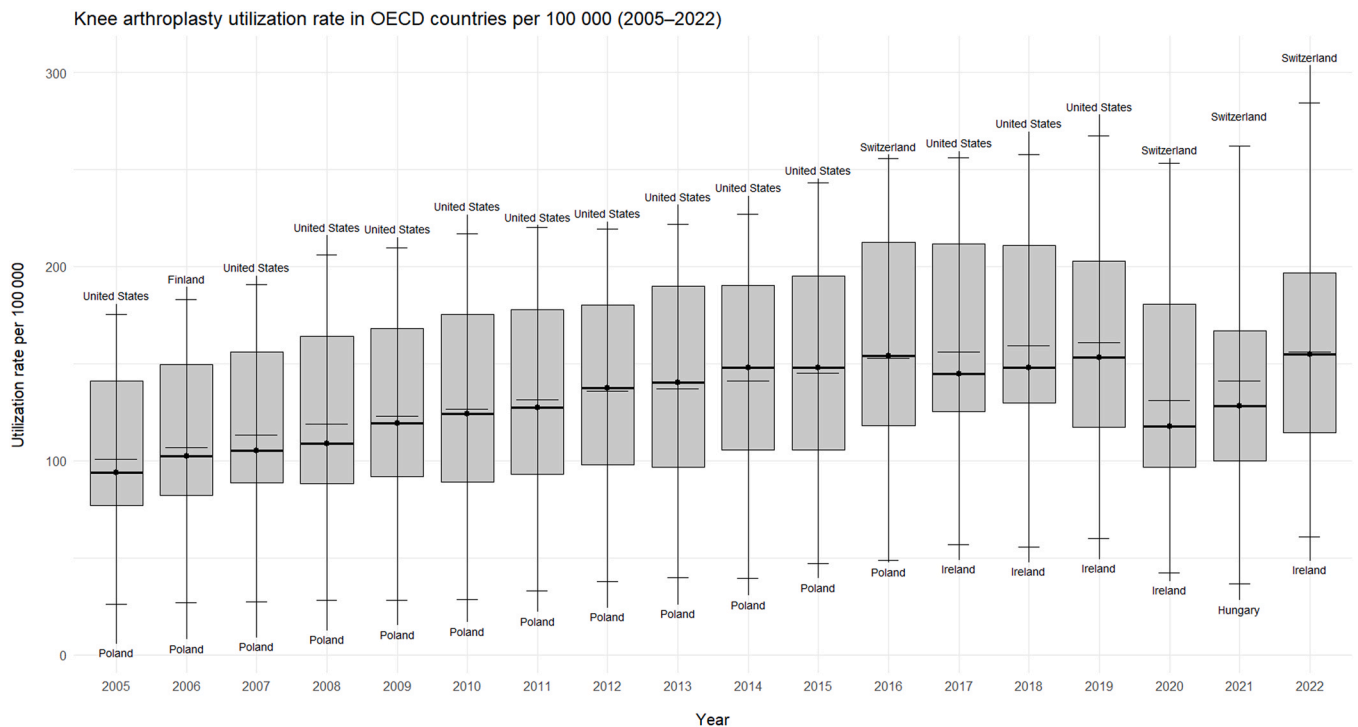
Sensitivity analyses using alternative utilization rate distributions between age groups in the U.S. produced largely consistent results for 2005–2011. Between 2011–2022, scenarios assuming higher utilization among patients aged ≥ 65 showed more pronounced declines in older adults and stronger relative increases in younger individuals (Fig. 3). In 2022, estimated U.S. procedure varied by ~80,000 between extreme scenarios and ~26,000 between moderate ones (Scenario 2 vs. 4) (Supplementary Material 4).

We also conducted a combined sensitivity analysis incorporating: (i) $\pm 10\%$ variations in NIS volume,

and (ii) alternative utilization rate distributions in the U.S. (as above). This resulted in a 6–7% variation in overall utilization estimates, with wider margins in age-stratified results due to the combined effects of volume and distribution assumptions (Supplementary Material 5 and Supplementary Material 6).

Regression and correlation results

Linear regressions and correlation results are summarized in Table 4 (corresponding scatterplots available in Supplementary

**Fig. 2**

Osteoarthritis and Cartilage

Hip arthroplasty utilization rate in OECD countries per 100,000 population (2005–2022). Note: Each box represents the 1.5 x interquartile range (IQR) of hip arthroplasty utilization rates across OECD countries for a given year (2005–2022). Vertical error bars at the top and end of the spectrum indicate the 95% confidence interval around the median. Thin black horizontal bars within the IQR mark the annual mean and black bold lines with dots indicate the median values. Country labels annotate the minimum and maximum observed values per year.

Material 7). Higher GDP, health expenditure, and life expectancy were positively associated with total utilization and age-specific utilization rates.

- GDP showed a stronger association with utilization in the ≥ 65 group ($\beta = 5.143$ [95% CI: 4.179; 6.106], $r = 0.451$ [0.373; 0.523]) compared to the ≤ 64 group ($\beta = 0.728$ [0.520; 0.935], $r = 0.315$ [0.228; 0.397]).
- Health expenditure had the highest explanatory strength for total utilization ($\beta = 19.322$ [95% CI: 16.139; 22.505], $r = 0.499$ [0.425; 0.566])
- Life expectancy was also positively associated with utilization across all models, with a β of 13.568 [11.132; 16.004] ($r = 0.499$ [0.425; 0.566]) for total utilization and stronger effect sizes in the ≥ 65 group ($\beta = 33.638$ [24.379; 42.896]; $r = 0.326$ [0.239; 0.407]).

In relative terms, a \$1000 increase in GDP per capita corresponded to a 1.1% increase in utilization for ≥ 65 and 0.6% for ≤ 64 . For health expenditure, relative increases were nearly identical: 7.0% (≥ 65 group) vs. 6.9% (≤ 64 group) per \$1000 increase. Results remained consistent in sensitivity analyses using log-transformed predictors (Supplementary Material 8).

Utilization versus incidence development

Among individuals aged ≥ 65 , trends differ depending on whether incidence or utilization is assessed. In our base case, incidence increased with a CAGR of 0.07% [0.06%; 0.08%] from 2005 to 2022, but

age-adjusted utilization declined (CAGR of -1.44% [-1.62%; -1.26%]), as procedure volumes failed to keep pace with population growth (Table 2, Supplementary Material 9).

This effect is also evident among patients aged ≤ 64 . While incidence growth declined from 3.41% [3.40%; 3.42%] (2005–2011) to 2.68% [2.66%; 2.71%] (2011–2022), utilization fell less strong from 3.60% [3.58%; 3.61%] to 3.08% [3.05%; 3.10%].

Between 2005 and 2011, utilization grew 36 times faster in younger versus older patients. Since 2011, utilization rates have declines in older adults but continued to rise in patient ≤ 64 years.

Discussion

Utilization rates instead of incidence

Understanding the distinction between incidence and utilization is not merely a technical issue—it carries implications for monitoring, resource planning, and policy development [13,16]. Incidence are commonly used to reflect procedure frequency across the general population [17]. However, its comparability depends on the denominator: in our case patients at risk for a hip prosthesis [18]. As our findings show, incidence can obscure trends when they fail to account for demographic shifts. In our study, incidence suggested a decline in growth across age groups, masking the high utilization growth among patients ≤ 64 . For stakeholders relying on such metrics this may cause misinterpretation, limiting the validity of cross-national comparisons or long-term trend analyses.

	Population			Inpatient cases per 100,000 inhabitants																		Change inpatient cases					Health exp. [\$/capita]	GDP [\$/capita]
	CAGR '05 – '11 [%]	CAGR '11 – '22 [%]	Total in 2022 [Mio]	2005	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total implants in 2022	CAGR '05 – '11 [%]	CAGR '11 – '22 [%]	MAD '05 – '11	MAD '05 – '22							
Australia	2.8	3.3	4.4	895	897	856	861	853	858	843	825	799	679	742	661	629*	27,882	0.0	-3.2	0.3	-24.4	5,616	65,835					
Austria	1.8	1.6	1.8	955	876	847	836	826	796	800	828	848	824	715	764	795	14,032	-1.4	-0.9	-13.2	-7.4	5,519	70,676					
Belgium	0.9	1.7	2.3	801	791	804	788	789	785*	782	790	775	782	618	714	732	16,763	-0.2	-0.7	-1.7	-5.4	5,141	68,080					
Canada	2.7	3.6	7.3	689	624	620	610	595	574	573	566	560	536	416	394	430	31,533	-1.6	-3.3	-10.8	-17.6	5,432	62,708					
Denmark	2.6	2.2	1.2	907	771	719	697	683	667	675	656	632	639	609	542	652	7,861	-2.7	-1.5	-22.7	-10.8	5,070	77,335					
Estonia	0.5	1.5	0.3	395	432	442	428	415	439	396	411	442	427	421	412	443	1,214	1.5	0.2	6.2	1.0	2,525	47,762					
Finland	2.3	2.7	1.3	828	707	694	666	631	609	614	601	588	567	498	533	449	5,778	-2.6	-4.0	-20.2	-23.5	4,426	61,293					
France	1.2	2.4	14.3	814	803	772	748	720	692	666	647	620	604	512	548	554	79,493	-0.2	-3.3	-1.8	-22.6	5,133	56,134					
Germany	1.0	1.0	18.5	708	677	671	653	668	675	681	681	675	670	613	616	664	123,183	-0.7	-0.2	-5.2	-1.2	6,392	67,533					
Hungary	0.9	1.6	2.0	414	399	376	398	406	420	406	394	381	382	264	186	311	6,172	-0.6	-2.2	-2.5	-8.0	2,420	43,665					
Ireland	2.5	3.4	0.8	1126	878	827	827	772	768	722	708	642	622	940	1013	1101	8,466	-4.1	2.1	-41.3	20.3	5,421	137,231					
Italy	1.3	1.2	14.1	387	373	367	366	360	359	359	364	360	364	299	346	367	51,868	-0.6	-0.1	-2.3	-0.5	3,383	56,172					
Luxembourg	1.6	2.7	0.1	1073	1005	967	934	863	866	885	868	885	935	749	872	878	849	-1.1	-1.2	-11.3	-11.5	5,518	144,751					
Netherlands	2.4	2.7	3.6	954	871†	829	772	746	717	704	685	684	678	565	608	593*	21,122	-1.5	-3.4	-13.8	-25.3	5,348	77,087					
New Zealand	2.6	3.4	0.8	924	809	782	759	780	736	729	755	707	681	604	569*	527*	4,427	-2.2	-3.8	-19.2	-25.6	4,875	53,071					
Norway	1.8	2.6	1.0	938	1063†	1037	970	942	922	920	894	890	880	761	780	818	8,186	2.1	-2.3	20.8	-22.3	6,331	122,516					
Poland	0.7	3.0	7.3	235	403	392	401	427	457	497	570	540	556	408	511	412	29,884	9.4	0.2	28.0	0.8	2,374	46,039					
Portugal	1.7	2.0	2.5	278	258	264	258	242	242	227	213	205	200	161	196	202	5,013	-1.2	-2.2	-3.3	-5.1	3,401	44,520					
Slovenia	1.6	2.5	0.4	653	680	655	538	532	523	487	548	488	499	396	402	460	2,067	0.7	-3.5	4.5	-20.0	3,491	51,036					
Spain	1.8	1.6	9.6	326	337	332	329	333	323	313	330	337	339	280	326	337	32,378	0.5	0.0	1.8	0.0	3,442	50,454					
Sweden	2.0	1.8	2.1	706	671	659	633	605	604	602	621	624	622	504	530	624	13,318	-0.9	-0.6	-5.8	-4.3	5,292	66,320					
Switzerland	2.2	2.0	1.7	1050	1057	1013	966	955	957	965	935	909	905	870	905	926	15,533	0.1	-1.2	1.2	-11.9	7,214	90,139					
U.K.	1.4	1.8	12.7	559	647	611	605	595	572	578	545	557	529	279	513	481	61,242	2.5	-2.7	14.7	-15.1	4,524	58,393					
U.S.	2.0	3.1	57.8	613†	619†	610†	612†	616†	612†	610†	609†	594†	581†	368†	403†	406†	234,831	0.1	-3.8	1.0	-19.4	10,635	78,035					
Total	1.7	2.3	168.0														803,095											
Incidence				91	97	97	98	100	101	102	104	104	104	80	89	92		1.1	-0.5	1.0	-0.5							
Mean utilization rate				612	615	601	594	592	586	585	584	573	561	426	471	478		0.1	-2.3	0.5	-12.5							

Bold figures show summary. Framed figures show an increase in the growth rate/MAD compared to the previous period. Figures are underlined if the population growth exceeds the inpatient growth in the same period and vice versa. Shaded values reflect the time intervals used for CAGR/MAD comparison. *Data extrapolated based on last four-year CAGR; † estimated values by applying the CAGR between the adjacent available years; ‡ OECD wide age split (i.e., ≥65 years versus ≤64 years) of total implants for respective year applied to National Inpatient Sample data.

Table 2

Osteoarthritis and Cartilage

Total utilization rate of hip arthroplasty procedures per 100,000 inhabitants aged 65 and older (≥65) from 2005 to 2022 (base case with NIS data as extracted).

Utilization rates remain on growth path

Next, we will outline how the shift in demography, longevity of hip replacements, and COVID-19 may have contributed to the historical and future development of procedures volume.

Young patients still dominating

Utilization among patients ≤64 continues to rise across countries, albeit slower. We see multiple factors fueling this trend: First, osteoarthritis, the leading cause of hip replacements in 90–95% of patients, increasingly affects middle-aged adults [19,20]. Over half of osteoarthritis cases now occur in individuals ≤64 years [21]. Second, advancements in implant technology and materials (e.g. highly cross-linked polyethylene liners, advanced ceramics) have made surgery more attractive for younger patients [22,23]. Over half of today's hip prostheses lasting 25+ years [24], reducing concerns about revision. Finally, younger adults are less willing to tolerate chronic pain or mobility loss and increasingly view increasingly pursue surgery to maintain active lifestyles [25,26]. As the first wave of the millennials (born 1981–1996) enters the common surgery age, we expect demographic pressure to further raise procedure volumes.

Across our OECD dataset, the share of individuals aged ≥80 increased from 3.86% in 2013 to 5.42% in 2022 – a +40% rise. While surgeons increasingly operate on patients in their 80s and 90s, supported by minimally invasive techniques and improved

postoperative recovery, individuals ≥80 remain less likely to undergo surgery [27]. Their growing share may lower overall rates and should be considered when interpreting results.

Increased longevity of replacements

In our previous research, we hypothesized that rising hip arthroplasty in younger patients would lead to more revisions and, consequently, higher utilization among older adults [1,2]. This assumption was not supported by our current findings. Instead, utilization among the ≥65 declined between 2011 and 2022. We attribute this partially to improvements in the longevity of primary implants. Supporting this, studies from Italy, Australia, and the UK report revision volumes beginning 2012 [28–30].

Technology advanced from basic designs to implants that prioritize biocompatibility (e.g., usage of antioxidant polyethylene), reduced stress shielding, and bone integration (e.g., cementless fixation) [31]. Concerns that younger recipients would outlive their prostheses appears less critical today. Recent U.S. data show only 1% of patients under 55 required revision within eight years [32].

Swedish data show stable revision rates. Aseptic loosening remains the leading cause of revision, although its incidence is declining. Meanwhile, periprosthetic joint infections and fractures have increased in occurrence and risen in relative importance over the past two decades [33].

	Population			Inpatient cases per 100,000 inhabitants																Change inpatient cases								
	CAGR '05-'11 [%]	CAGR '11-'22 [%]	Total in 2022 [Mio]	2005	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total implants in 2022	CAGR '05-'11 [%]	CAGR '11-'22 [%]	MAD '05-'11	MAD '05-'22							
																						Health exp. [\$/capita]	GDP [\$/capita]					
Australia	1.5	1.0	21.5	39	55	58	64	69	75	78	81	85	75	91	90	92*	19,795	6.0	4.8	2.7	3.4	5,616	65,835					
Austria	0.0	0.5	7.3	115	144	146	152	155	152	153	162	172	171	156	173	182	13,299	3.8	2.2	4.8	3.5	5,519	70,676					
Belgium	0.8	0.3	9.4	120	122	129	132	138	143†	149	156	159	166	137	165	172	16,122	0.3	3.2	0.3	4.5	5,141	68,080					
Canada	0.8	0.7	31.6	32	47	52	57	61	67	72	77	84	86	73	76	89	27,991	7.0	5.9	2.5	3.8	5,432	62,708					
Denmark	0.1	0.2	4.7	82	113	119	124	131	133	141	144	145	153	152	142	174	8,180	5.4	4.0	5.2	5.5	5,070	77,335					
Estonia	-0.5	-0.2	1.1	55	70	74	79	80	90	87	94	104	105	109	110	118	1,265	4.3	4.8	2.5	4.4	2,525	47,762					
Finland	0.1	-0.3	4.3	94	120	133	142	149	156	171	181	187	193	180	203	180	7,667	4.1	3.7	4.3	5.5	4,426	61,293					
France	0.4	-0.1	53.6	100	113	118	125	131	136	141	148	151	156	138	156	164	87,850	2.0	3.5	2.2	4.6	5,133	56,134					
Germany	-0.8	0.2	65.2	149	189	187	185	193	199	203	209	211	217	205	211	230	149,998	4.0	1.8	6.7	3.7	6,392	67,533					
Hungary	-0.4	-0.7	7.7	44	55	55	61	68	76	77	80	81	90	68	51	86	6,615	3.5	4.2	1.8	2.8	2,420	43,665					
Ireland	1.6	0.6	4.3	15	18	22	27	30	35	36	40	40	43	71	84	99	4,289	2.8	16.6	0.5	7.4	5,421	137,231					
Italy	0.3	-0.6	44.8	92	103	108	111	115	121	127	132	135	143	121	147	163	72,968	1.9	4.3	1.8	5.5	3,383	56,172					
Luxembourg	1.9	2.0	0.6	80	80	79	78	78	81	84	85	89	98	80	95	99	549	-0.1	1.9	0.0	1.7	5,518	144,751					
Netherlands	0.0	0.1	14.1	66	98†	106	113	119	126	131	137	145	152	132	150	153*	21,667	6.8	4.2	5.3	5.0	5,348	77,087					
New Zealand	0.7	1.1	4.3	25	40	45	52	57	58	58	64	62	65	62	63*	63*	2,699	8.1	4.2	2.5	2.1	4,875	53,071					
Norway	1.0	0.5	4.5	76	101†	105	106	109	112	120	122	129	138	126	138	153	6,832	4.8	3.9	4.2	4.7	6,331	122,516					
Poland	0.1	-0.8	30.6	11	24	26	31	38	47	59	76	81	95	78	105	90	27,652	13.9	13.0	2.2	6.0	2,374	46,039					
Portugal	-0.2	-0.7	8.0	43	55	60	62	62	67	68	67	68	74	63	81	86	6,883	4.3	4.2	2.0	2.8	3,401	44,520					
Slovenia	0.2	-0.3	1.7	66	89	94	82	86	95	97	118	115	124	106	115	141	2,345	5.0	4.3	3.8	4.7	3,491	51,036					
Spain	1.0	-0.2	38.0	41	50	52	57	61	64	65	70	75	77	67	80	87	33,140	3.2	5.2	1.5	3.4	3,442	50,454					
Sweden	0.5	0.8	8.4	108	133	139	140	141	143	145	152	151	155	127	136	165	13,759	3.6	2.0	4.2	2.9	5,292	66,320					
Switzerland	0.8	0.7	7.1	118	152	154	154	159	163	170	169	172	178	176	187	199	14,147	4.3	2.5	5.7	4.3	7,214	90,139					
U.K.	0.7	0.3	54.6	62	83	88	94	97	97	101	99	103	102	55	103	101	54,916	4.9	1.8	3.5	1.6	4,524	58,393					
U.S.	0.7	0.2	275.5	57†	71†	76†	81†	88†	93†	98†	104†	107†	112†	73†	84†	90†	248,206	3.8	2.2	2.3	1.7	10,635	78,035					
Total	0.5	0.1	702.63														848,835											
Incidence				60	73	76	79	84	88	91	95	98	101	80	92	97		3.4	2.7	2.2	2.2							
Mean rate				70	87	91	95	101	106	111	116	120	124	98	113	121		3.6	3.1	2.8	3.1							

Bold figures show summary. Framed figures show an increase in the growth rate/MAD compared to the previous period. Figures are underlined if the population growth exceeds the inpatient growth in the same period and vice versa. Shaded values reflect the time intervals used for CAGR/MAD comparison. *Data extrapolated based on last four-year CAGR; † estimated values by applying the CAGR between the adjacent available years; ‡ OECD wide age split (i.e., ≥65 years versus ≤64 years) of total implants for respective year applied to National Inpatient Sample data.

Table 3

Osteoarthritis and Cartilage

Total utilization rate of hip arthroplasty procedures per 100,000 inhabitants aged 64 and younger (≤64) from 2005 to 2022 (base case with NIS data as extracted).

The EU's Medical Device Regulation (MDR), supported by our group's past work, now mandates registry data for device approval. This has removed many inferior implants and fueled adoption of higher-quality ones, as national tenders begun to incorporate quality criteria [34–36].

COVID-19 effect

Our data show a drop in hip arthroplasty volumes across countries in 2020, often 10–30% below 2019 levels. Although urgent non-elective procedures (e.g., for fractures) were largely maintained, they represent only a minority of all arthroplasties [37]. Most are elective and were postponed during the pandemic [38].

By 2022, most countries returned to pre-pandemic arthroplasty volumes, though recovery varied: some experienced rapid, V-shaped rebounds, others followed slower, U-shaped recoveries. Despite rebounds, patient backlogs remain [38–40]. Many countries launched initiatives such as added funding, expanded operating hours, and/or outsourcing to boost throughput [41,42]. We hypothesize that these efforts further increase volumes beyond pre-pandemic levels in the next years.

BRIC countries

Beyond OECD countries, procedures have risen rapidly in Brazil (OECD candidate), Russia, India, and China. Brazil's public-sector

primary hip arthroplasty volume grew by ~26% between 2012–2019 [43]. China even tripled its volume between 2011–2019, thus outpacing any OECD country [44]. India has shown similarly rapid expansion, driven by improved affordability, broader insurance coverage, and a growing middle class [45]. Russia reported rising volumes pre-pandemic, though data remains limited [46]. Across all four countries, national joint replacement registries remain incomplete or absent. Strengthening data transparency and standardization will be critical for enabling reliable comparisons.

Implications for policy makers

To ensure health systems remain responsive to rising hip arthroplasty volumes, our findings point to implications on both the supply and demand sides.

Supply side implications: Younger patients now dominate arthroplasty volume, requiring a shift toward age-specific care models. Same-day discharge has gained traction among younger patients with low comorbidity burden, reducing hospital-related costs by up to 40% versus inpatient procedures [47]. In the U.S., this trend was accelerated by the removal of hip arthroplasty from the Medicare inpatient-only list in 2020. The NHS in England launched its SA-MEDAY strategy in 2024, aiming to expand same-day discharges [48]. Meanwhile, in Germany, patients remain in hospitals for 7–9 days post-surgery, followed by multiple weeks of rehabilitation [49].

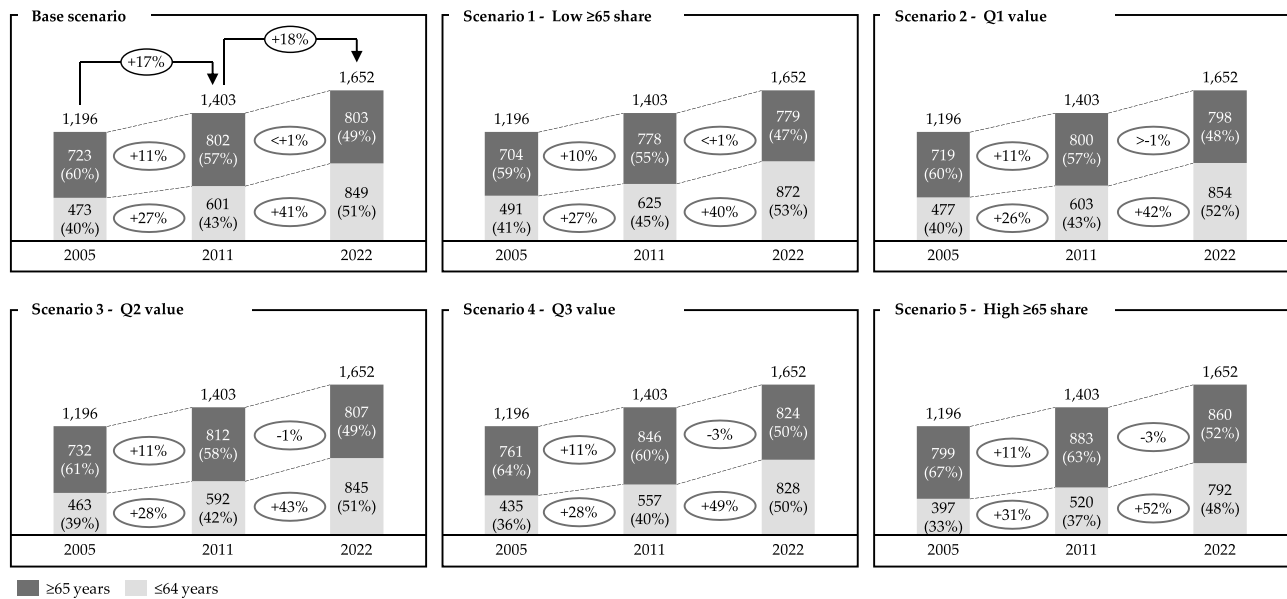


Fig. 3

Osteoarthritis and Cartilage

Sensitivity analysis of hip arthroplasty volumes under alternative assumptions for U.S. age group distributions. Note: The sensitivity analysis assesses the robustness of U.S. hip arthroplasty estimates under alternative assumptions about the distribution of hip arthroplasty procedures between age groups (≤ 64 vs. ≥ 65 years). The "base scenario" assumes the OECD-wide average age split. Alternative scenarios reflect the following country groupings: Scenario 1 ("Low ≥ 65 share")—five OECD countries with the lowest annual share of patients ≥ 65 years; Scenario 2—first quartile (Q1 value) of OECD countries by share of patients ≥ 65 ; Scenario 3—second quartile (Q2 value); Scenario 4—third quartile (Q3 value); Scenario 5 ("High ≥ 65 share")—five OECD countries with the highest annual share of patients ≥ 65 . Percentages in oval circles represent absolute growth; proportions in bars show age group distribution within total volume.

Predictor	Outcome	β (slope)	95% CI (β)	Pearson r	95% CI (r)
GDP per capita (in thousands)	Total utilization	1.407	[1.134; 1.679]	0.439	[0.360; 0.512]
	Utilization rate ≥ 65	5.143	[4.179; 6.106]	0.451	[0.373; 0.523]
	Utilization rate ≤ 64	0.728	[0.520; 0.935]	0.315	[0.228; 0.397]
Health expenditure per capita (in thousands)	Total utilization	19.322	[16.139; 22.505]	0.499	[0.425; 0.566]
	Utilization rate ≥ 65	60.368	[48.634; 72.102]	0.438	[0.359; 0.511]
	Utilization rate ≤ 64	11.225	[8.800; 13.649]	0.402	[0.320; 0.478]
Life expectancy	Total utilization	13.568	[11.132; 16.004]	0.467	[0.390; 0.537]
	Utilization rate ≥ 65	33.638	[24.379; 42.896]	0.326	[0.239; 0.407]
	Utilization rate ≤ 64	8.373	[6.553; 10.193]	0.400	[0.317; 0.476]

Note: β coefficients represent the change in hip arthroplasty utilization rate (procedures per 100,000 population) per one-unit increase in the predictor variable. Pearson correlation coefficients (r) indicate the strength and direction of association. All values are derived from linear regressions using pooled base case country-year data from 2005 to 2022. Confidence intervals are reported at the 95% level. Scatterplots can be investigated in [Supplementary Material 7](#). Results of log-transformed predictors (i.e., GDP and health expenditure) can be investigated in [Supplementary Material 8](#).

Table 4

Osteoarthritis and Cartilage

Linear regression results for hip arthroplasties and economic predictors across OECD countries.

Thus, promoting similar concepts could benefit the supply side of other systems as well.

In addition, surgical capacity must expand to address COVID-19-related backlogs and meet future demand. In response, NHS launched dedicated surgical hubs to deliver 2 million additional operations over three years [50]. Canada uses centralized referrals and public-private models to reduce waiting times. However, infrastructure alone remains insufficient. The orthopedic workforce has remained stable in many countries. Rullán et al [51]. estimate that

the average arthroplasty caseload per surgeon may need to double by 2050 in the U.S., underscoring the need for long-term workforce strategies.

Demand side implications: Part of the future burden may be reduced via risk factor management. Risk factors for osteoarthritis are well documented, including modifiable (e.g., joint injury, weight, muscle weakness) and non-modifiable ones (e.g., age, gender, genetic predisposition). Whittaker et al [52]. report a range of preventive measures along patients' lifespan ranging from monitoring

hip dysplasia in early childhood to preventing age related sarcopenia in elderly. Some of them are already introduced in selected countries of our sample and target obesity, diabetes, and smoking – but often too late [53]. Osteoarthritis prevention is a developing field with knowledge gaps. Beyond identifying high-risk groups and effective interventions, clear outcome measures are needed to assess preventive strategies [52].

Independent of supply and demand sides, registry infrastructure must be strengthened by improving harmonization, data access, and usability. Despite at least 24 arthroplasty registries in Europe, challenges such as inconsistent formats, limited accessibility, or missing data still limit interoperability and data analysis [54]. These gaps constrain benchmarking and policy efforts, even as post-market surveillance gains importance [35,36]. Successful harmonization efforts in other disease areas, such as multiple sclerosis registries applying the Maelstrom guidelines, offer a roadmap for joint arthroplasty registries [55]. Lastly, we encourage the OECD to consider increasing the granularity of age splits to enhance cross-country cohort comparison.

Limitations and outlook

Our analysis is limited by data quality variations across countries, including potential reporting errors and inconsistencies in records. U.S. data is based on a 20% discharge sample and use different weighting schemes before and after the 2012 redesign. As a result, trends spanning this period may reflect methodological artifacts impacting both validity and comparability of estimates, requiring cautious interpretation. Additionally, 2020–2021 U.S. data showed inconsistency and was extrapolated based on average growth trends in other OECD countries. In our base case, we assumed age split in hip arthroplasty of other OECD countries for the U.S., as we could not detect respective splits in NIS data. We conducted sensitivity analyses to account for those limitations.

Future research should explore more granular age-standardized analyses (e.g., 5-year age bands) to better isolate cohort effects, particularly in the growing ≥ 85 population. Forecasts for post-2030 arthroplasty volumes should be updated based on current utilization trends to validate or adjust earlier projections. Finally, long-term tracking of revision procedures and age-specific analyses of implant performance are needed to assess whether improved longevity continues to offset future revision burden, especially in younger patients.

Conclusions

Over the past decade, hip arthroplasty utilization has continued to grow across OECD countries, particularly among patients ≤ 64 years. While incidence-based trends suggest slowing growth, age-specific utilization reveals persistent increases in younger populations and a relative decline among older adults. Contrary to earlier projections, rates in the ≥ 65 group have not surged, likely due to improved implant longevity. As surgical volumes rebound post-COVID and demographic pressures rise ongoing monitoring will be essential to guide future planning and policy.

CRedit authorship contribution statement

Author 1: Conceptualization, Methodology, Formal analysis, Data curation, Interpretation, Writing – Original draft, Writing – Review & Editing, Visualization, Project administration. Author 2: Conceptualization, Interpretation, Writing – Review & Editing, Supervision. Author 3: Conceptualization, Interpretation, Writing – Review & Editing, Supervision. Author 4: Conceptualization, Project administration, Interpretation, Writing – Review & Editing, Supervision

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Conflict of Interest

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.joca.2025.09.012.

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