Rates of Total Joint Replacement in the United States: Future Projections to 2020–2040 Using the National Inpatient Sample

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ABSTRACT. ***Objective.*** To project future total hip and knee joint arthroplasty (THA, TKA) use in the United States to 2040.

Methods. We used the 2000–2014 US National Inpatient Sample (NIS) combined with Census Bureau data to develop projections for primary THA and TKA from 2020 to 2040 using polynomial regression to account for the nonlinearity and interactions between the variables, assuming the underlying distribution of the number of THA/TKA to be Poisson distributed. We performed sensitivity analyses using a negative binomial regression to account for overdispersion.

Results. Predicted total annual counts (95% prediction intervals) for THA in the United States by 2020, 2025, 2030, and 2040 are (in thousands): 498 (475, 523), 652 (610, 696), 850 (781, 925), and 1429 (1265, 1615), respectively. For primary TKA, predicted total annual counts for 2020, 2025, 2030, and 2040 are (in thousands): 1065 (937, 1211), 1272 (1200, 1710), 1921 (1530, 2410), and 3416 (2459, 4745), respectively. Compared to the available 2014 NIS numbers, the percent increases in projected total annual US use for primary THA and TKA in 2020, 2025, 2030, and 2040 are as follows: primary THA, by 34%, 75%, 129%, and 284%; and primary TKA, 56%, 110%, 182%, and 401%, respectively. Primary THA and TKA use is projected to increase for both females and males, in all age groups.

Conclusion. Significant increases in use of THA and TKA are expected in the United States in the future, if the current trend continues. The increased use is evident across age groups in both females and males. A policy change may be needed to meet increased demand. (J Rheumatol First Release April 15 2019; doi:10.3899/jrheum.170990)

Key Indexing Terms:
TOTAL HIP ARTHROPLASTY TOTAL KNEE ARTHROPLASTY HEALTHCARE DELIVERY

Total joint arthroplasty (TJA) is a successful elective procedure performed for the treatment of refractory pain and functional limitation associated with endstage arthritis. Significant gains in quality of life post-TJA[1], an aging population, and an obesity epidemic with increasing osteoarthritis (OA) incidence are the key reasons for the rapidly increasing implementation of this procedure[2,3]. In 2009, 438,000 hip and 686,000 knee arthroplasties were performed in the United States[4]. A recent US study projected that compared to 2010, annual use of primary knee and hip TJA (the 2 most common joints replaced) will increase by 210% (655K to 1375K) and 174% (293K to 512K) in 2020, respectively[5] (Table 1). However, policy makers need projections for longer periods, to plan future healthcare spending. Similar projections are available for other countries[6,7,8,9,10]. Two other studies provided US projections to 2050, but neither provided projections by sex or age[11,12] (Table 1). One projected primary total knee arthroplasty (TKA) rates and not primary total hip arthroplasty (THA)[11], and the other combined total joint replacement with partial joint replacement and primary with revision surgeries[12], which differ considerably surgically and in time trends and therefore should not be combined. The rapidly changing demographics of TJA recipients, with both rapid increases in much younger and older patients undergoing these procedures[13,14], female predominance in an aging population, and time trends in racial disparity in TJA use[15] make it important to study time

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Table 1. Summary of estimates from the key studies of TKA and THA projections in the United States in comparison with the current study.

Studies	2020 Projections (95% prediction interval)	2030 Projections (95% prediction interval)	2040 Projections (95% prediction interval)	Data Used: Reference for % Increase
Annual TKA projections, in thousands; % increase				
Inacio 2017[11]	Logistic: 882 (188, 934); 20	Logistic: 1163 (211, 1336); 13	Logistic: 1383 (234, 1774); 8	1993–2012 NIS (Ref: the last period 5 yrs prior)
	Poisson: 1071 (951, 1232); 35*	Poisson: 1950 (1695, 2400); 35*	Poisson: 3479 (2905, 4568); 33*	
Bashinskaya 2012[12]	Linear: 1783	Linear: 3008	Linear: 3657	1993–2009 NIS (Ref 2009: 680,839)
Kurtz 2007[17]	Poisson: 1520 (1362, 1700)	Poisson: 3481 (2948, 4136); 673	—	1990–2003 NIS (Ref 2003: 402,100)
Kurtz 2014[5]	Linear: 1375 (1193, 1558)	—	—	1990–2010 NIS (Ref 2009: 619,000)
Current study 2018	Polynomial/Poisson: 1065 (937, 1211); 56 Negative binomial: 1314 (960, 1800); 93	Polynomial/Poisson: 1921 (1530, 2410); 182 Negative binomial: 3041 (1839, 5029); 347	Polynomial/Poisson: 3416 (2459, 4745); 401 Negative binomial: 6594 (3279, 13,262); 868	2000–2014 NIS (Ref 2014: 680,886)
Annual THA projections, in thousands; % increase				
Inacio 2017[11]	—	—	—	—
Bashinskaya 2012[12]	Linear: 887	Linear: 1385	Linear: 1649	1993–2009 NIS (Ref: the last period 5 yrs prior)
Kurtz 2007[17]	Poisson: 384 (339, 435); 84	Poisson: 572 (481, 681); 174	—	1990–2003 NIS (Ref 2003: 202,500)
Kurtz 2014[5]	Linear: 512 (413, 611)	—	—	1990–2010 NIS (Ref 2009: 284,000)
Current study 2018	Polynomial/Poisson: 498 (475, 523); 34 Negative binomial: 513 (362, 728); 38	Polynomial/Poisson: 850 (781, 925); 129 Negative binomial: 1032 (590, 1806); 178	Polynomial/Poisson: 1429 (1265, 1615); 284 Negative binomial: 2004 (922, 4356); 439	2000–2014 NIS (Ref 2014: 371,605)

* Increase compared to the last period 5 years prior. "—" means data not provided. TKA: total knee arthroplasty; THA: total hip arthroplasty; NIS: US National Inpatient Sample.

trends in TJA use by these biological variables (sex, age). Therefore, the objective of our study was to use the existing national data to calculate projections for the absolute number of THA and TKA annually for 2020–2040, and to examine the projected increase in THA and TKA by sex and age.

MATERIALS AND METHODS

Data sources. The analysis presented in this paper used the US Nationwide Inpatient Sample (NIS). NIS is a national database of inpatient discharge data from about 8 million hospital stays each year. The NIS represents about a 20% stratified sample of US community hospitals, changed from a sample of hospitals to a sample of discharges in 2012. We used the 2000 to 2014 NIS data in combination with Census Bureau data to produce projections for primary THA and TKA from 2020 to 2040. Demographic data on the patients were obtained from the NIS. Primary THA and TKA are identified by the International Classification of Diseases, 9th revision, Clinical Modification codes 81.51 and 81.54, respectively. We used projected population statistics for the sex and age categories through 2040 as published by the Census Bureau in 2014[16]. These data are publicly available. The Institutional Review Board at University of Alabama at Birmingham approved the study (X1201207004).

Statistical analysis. The annual count of the THA and TKA (outcomes) was modeled using polynomial regression to account for the nonlinearity and interactions between the variables, assuming the underlying distribution to be Poisson, consistent with several previous studies[5,11], although other models have been used[11,12,17]. We assumed a continuous increase in THA/TKA use owing to the increase in OA incidence related to the obesity epidemic[3] and a rapidly growing population of adults ≥ 65 years in the United States that will increase from 34.4 million in 2000 to more than 70 million in 2030[18]. A large majority of the population that undergoes THA/TKA in the US is ≥ 65 years.

THA/TKA counts were regressed on the year as a second-degree polynomial to allow a flexible relationship. We ran a model for total THA/TKA use and separate models for age and sex to calculate THA or TKA among different population subgroups. To account for the differences in populations in each subgroup, the log of the corresponding population from the Census Bureau each year was included as offset in the model. Age was divided into 4 subgroups: < 45, 45–64, 65–84, and ≥ 85 years.

Independent models were used for each type, primary THA and primary TKA, respectively. The projected number of procedures was estimated from a single regression model per joint (primary THA, primary TKA) based on the projected population data for each subgroup. The projected national annual use was calculated by dividing the projected national total by the corresponding population from the Census Bureau[16]. Percent increase in primary THA/TKA use was calculated by comparing the future projected numbers to the actual 2014 US national estimates, which are in line with procedure volumes for all knee/hip arthroplasties[4]. The numbers were obtained from the Website of the Healthcare Cost and Utilization Project (a project of the Agency for Healthcare Research and Quality) for primary THA and TKA (371,605 and 680,886, respectively).

Sensitivity analyses were done using a negative binomial regression. Sex, age, race/ethnicity, and calendar year and all possible 2-way interaction terms with these 4 variables were included as covariates in the regression model to calculate the THA or TKA use among different population subgroups.

RESULTS

Overall projections to 2040. Compared to the 2014 NIS numbers, the total annual use is projected to increase for primary THA and TKA in the US in 2020, 2025, 2030, and 2040 as follows: primary THA by 34%, 75%, 129%, and 284%; primary TKA by 56%, 110%, 182%, and 401%, respectively (Figure 1).

Predicted total annual counts (95% prediction intervals) for primary THA/TKA use to 2020, 2025, 2030, and 2040 in the United States are as follows (in thousands): primary THA, 498 (475, 523), 652 (610, 696), 850 (781, 925), and 1429 (1265, 1615); primary TKA, 1065 (937, 1211), 1272 (1200, 1710), 1921 (1530, 2410), and 3416 (2459, 4745; Figure 1).

Sensitivity analysis using negative binomial regression resulted in higher projections for total primary THA/TKA compared to polynomial regression (in thousands): primary THA, 513 versus 498 for 2020, 1032 versus 850 for 2030, and 2004 versus 1429 for 2040; primary TKA, 1314 versus 1065 for 2020, 3041 versus 1921 for 2030, and 6594 versus 3416 for 2040 (Figure 2).

Projections for total annual TJA by sex and age. Total annual primary THA use is projected to increase for both females and males and in all age groups (Figure 3). The increase is slightly more for females (Figure 3A), and age groups 45–64 and 65–84 years (Figure 3B). Similar trends were noted for primary TKA (Figure 4).

DISCUSSION

Our study used the 2000–2014 US NIS data to make projections for the annual rate (incidence) of primary THA and TKA from 2020 to 2040. In their original study, Kurtz, *et al* used a Poisson model and NIS data up to 2005 and projected 572,000 primary THA and 3.5 million primary TKA by 2030[5], while Inacio, *et al* used 1993–2012 NIS data and predicted 2015 TKA volume of 733,021 and 794,211 in the logistic and the Poisson models, respectively (Table 1)[11]. We used polynomial regression with a Poisson distribution and our 2030 TKA estimates were 10–30% higher than those by Kurtz, *et al*[17] and 35% lower than those by Bashinskaya *et al*[12]. Our 2020 and 2025 TKA estimates are 20% and 40% higher than those by Inacio, *et al*[11], respectively (Table 1). All TKA projection studies used the NIS data[11,12,17]; however they differed in the years of NIS data and the models used (Poisson vs linear, vs logistic, vs polynomial), the type of arthroplasty (all projected TKA or THA except Bashinskaya, *et al,* who combined it with partial joint replacement[12]), and assumptions made (continued increase in all except Inacio, *et al*[11]).

Our THA estimates are lower than those by Bashinskaya, *et al*[12] and slightly higher than those from the original Kurtz, *et al* study[5]. Using the more recent data, our estimates to 2030 may be more accurate than those by Kurtz, *et al*, based on data up to 2005[5]. It is valuable to use different models and assumptions to predict future TKA/THA use, as we did in our study.

Our 2040 projections are likely less precise than the 2030 estimates. Our results provide guidance to healthcare policy makers to consider a future increase in healthcare resource allocation for the increasing THA/TKA need/demand. The number of arthroplasty surgeons needs to increase to meet the growing demand/need for THA/TKA.

As expected, the absolute increase in TJA was greater for TKA than THA and the slope of increase for TKA was significantly steeper than that for THA. These findings are consistent with previous studies of time trends[5,17].

The increase in use over time was slightly more for females, and for those 45–64 and 65–84 years old. We have identified groups that will likely be responsible for the greatest absolute increase in annual primary THA/TKA volume in the US in the future, and these groups would be excellent candidates for preventive strategies or alternate treatments.

Our data are not without limitations. Our predictions assumed a continuous increase in THA/TKA volume, which may plateau over time and be lower, either because of plateauing of OA incidence, breakthrough discovery of nonsurgical interventions for OA, or a reduced supply of surgeons. Our model did not account for any significant technological advances that will increase the survival of implants, or provide an alternative to TJA. We also did not account for change in healthcare policy with a change in the political climate in the US; the Affordable Care Act of 2010 may be replaced or repealed in the future. Our model also incorporates uncertainties of projections from the Census Bureau, which may vary over time. Our study's strengths are that we performed sensitivity analyses using a different model, and used the national TJA data from 2000–2014 and the Census Bureau estimates to make robust projections.

We conducted a study using national data and projected annual TJA use rates for primary THA, and primary TKA, up to 2040. These rates can help policy makers regarding allocation of resources, as well as help in future planning to ensure a steady supply of orthopedic surgeons who can perform these procedures and meet the increasing demand for these procedures.

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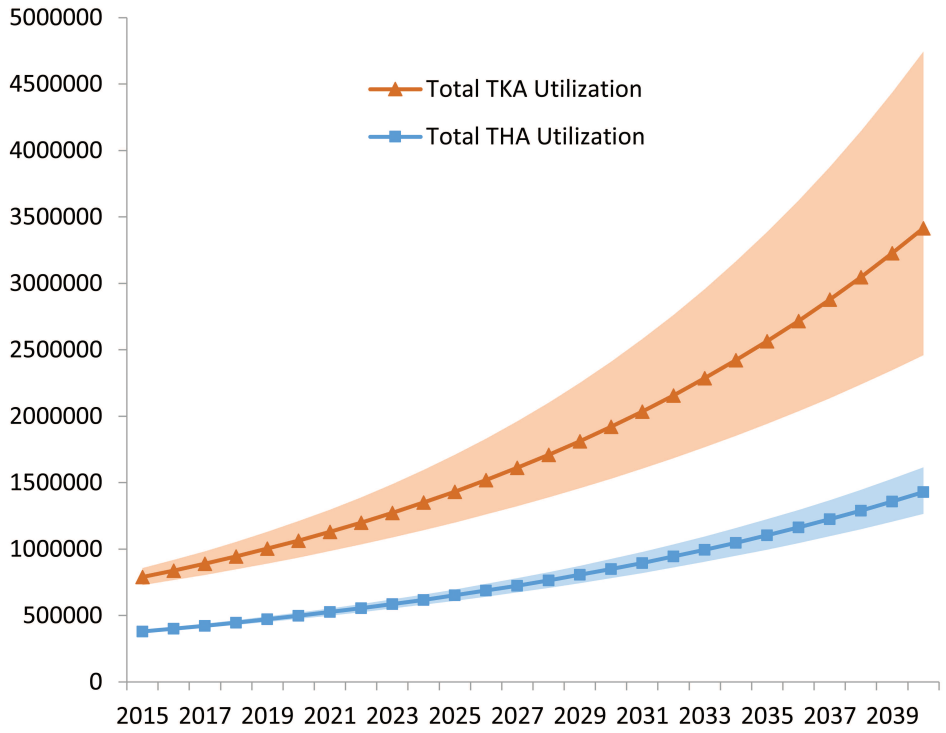


Figure 1. The projected annual use of primary total hip arthroplasty (THA) and primary total knee arthroplasty (TKA) procedures in the United States from 2015 to 2040. The X-axis shows years and the Y-axis shows the number of annual procedures for primary THA (blue) or primary TKA (orange). The shaded area (THA, blue; TKA, orange) represents the 95% prediction interval for respective projections at each timepoint. The CI are much wider after 2030. If the current rate of increase slows down, the lower 95% prediction interval value of the projection may be more accurate. If the current rate of increase in arthroplasty accelerates, the upper 95% prediction interval value might be more accurate.

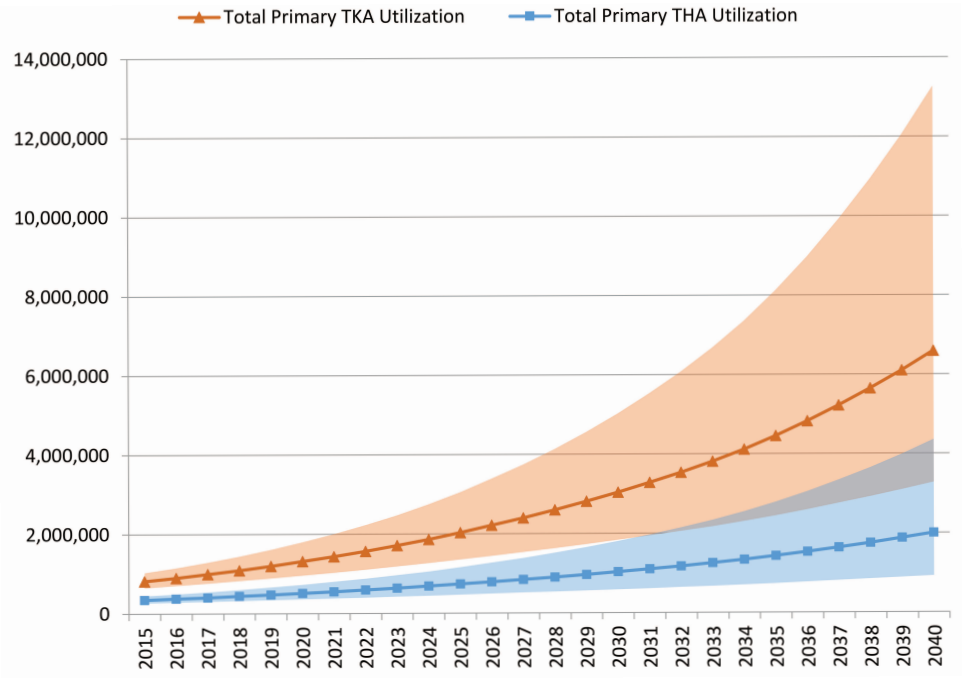
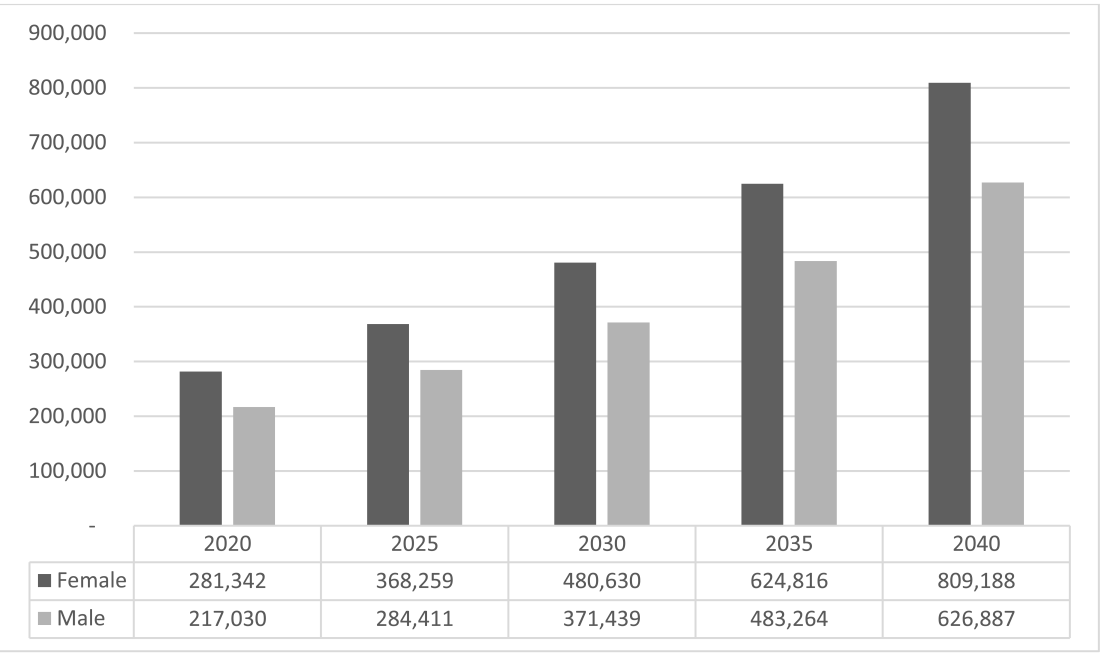


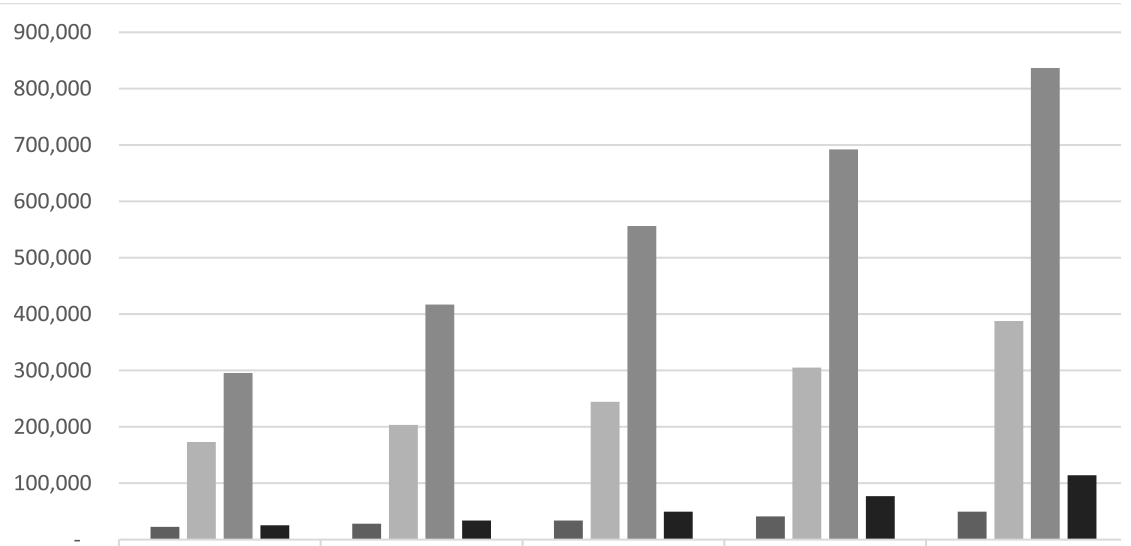
Figure 2. Sensitivity analyses for primary THA and primary TKA projections in the United States from 2015 to 2040 using binomial regression. The X-axis shows years and the Y-axis shows the number of annual procedures. THA: total hip arthroplasty; TKA: primary total knee arthroplasty.

A. Sex



	2020	2025	2030	2035	2040
Female	281,342	368,259	480,630	624,816	809,188
Male	217,030	284,411	371,439	483,264	626,887

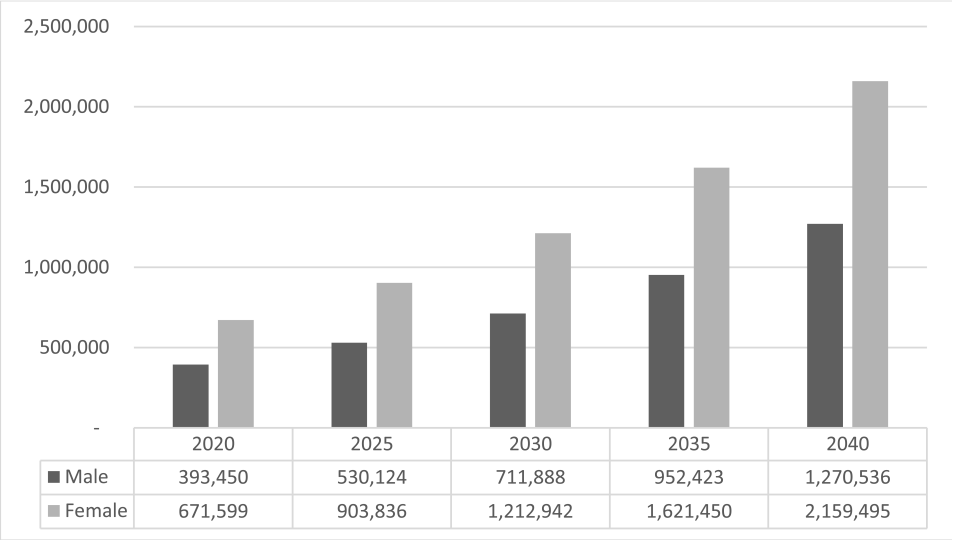
B. Age



	2020	2025	2030	2035	2040
< 45	22,874	28,040	34,130	41,278	49,707
45-64	172,880	203,223	244,260	304,884	387,881
65-84	295,466	416,824	556,437	692,397	836,349
85+	25,207	33,657	49,343	77,324	114,198

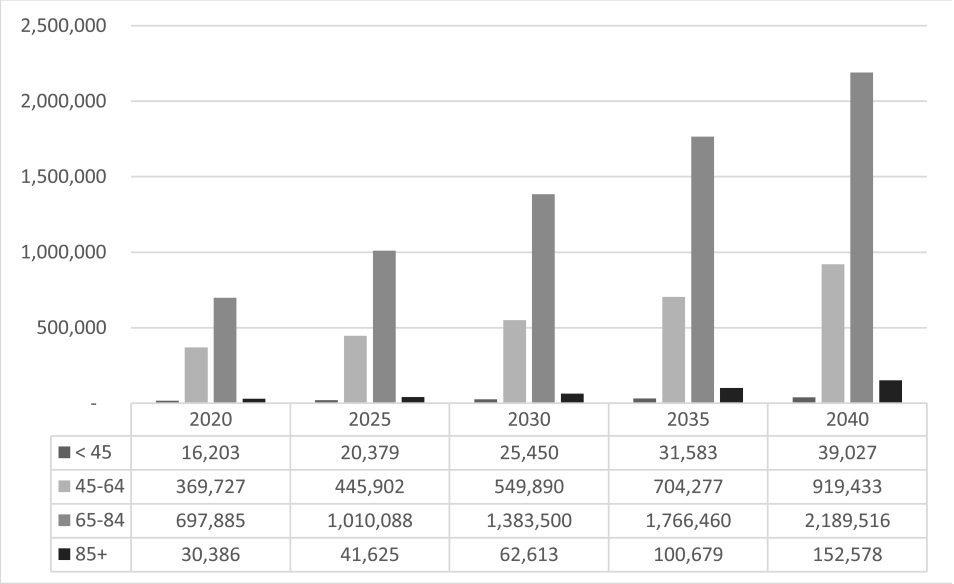
Figure 3. The projected annual use of primary total hip arthroplasty (THA) procedures in the United States from 2020 to 2040 by sex (A) and age (B). The bars indicate the number of primary THA procedures for each subgroup for each year.

A. Sex



	2020	2025	2030	2035	2040
Male	393,450	530,124	711,888	952,423	1,270,536
Female	671,599	903,836	1,212,942	1,621,450	2,159,495

B. Age



	2020	2025	2030	2035	2040
< 45	16,203	20,379	25,450	31,583	39,027
45-64	369,727	445,902	549,890	704,277	919,433
65-84	697,885	1,010,088	1,383,500	1,766,460	2,189,516
85+	30,386	41,625	62,613	100,679	152,578

Figure 4. The projected annual use of primary total knee arthroplasty (TKA) procedures in the United States from 2020 to 2040 by sex (A) and age (B). The bars indicate the number of primary THA procedures for each subgroup for each year.

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