Joint Replacement Access in 2016
A Supply Side Crisis

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Abstract: Demand for primary and revision arthroplasty is expected to double in 10 years. Coincident with this is a decreased interest in arthroplasty by residents. Retirement of arthroplasty surgeons further threatens access. This study determines if supply will meet demand. Survey data were used to calculate the 2016 workforce. Demand in 2016 was estimated using the Nationwide Inpatients Sample. Between 2008 and 2016, 400 arthroplasty specialists and 1584 generalists will enter the workforce. By 2016, 1896 arthroplasty surgeons will retire using 65 years as a conservative retirement age, whereas 4239 will retire using 59 years as a baseline retirement age. In 2016, the model estimated a procedural shortfall ranging from 174 409 (↓18.6%) using conservative retirement assumptions (age, 65 years) to 1 177 761 (↓69.4%) using baseline retirement assumptions (age, 59 years). This economic model predicts a supply side crisis that threatens patient access to specialty care. Immediate steps to stimulate supply must be taken. Keywords: total hip arthroplasty, total knee arthroplasty, revision knee arthroplasty, revision hip arthroplasty.
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Total hip and knee arthroplasties are some of the most successful procedures in surgical history. Demand for these procedures is expected to grow exponentially in the next 10 years [1], primarily driven by the aging of the baby boomer generation and the obesity epidemic in the United States. Coincident with this increased demand is a decreased interest in adult reconstructive careers by graduating orthopedic residents [1]. In the last 5 years, 10 orthopedic fellowships have closed, whereas in 2007 to 2008, only 45% of the remaining 120 fellowship positions were filled by US graduates [2]. In addition, the retirement of many high-volume joint arthroplasty surgeons is predicted further threatening access to these procedures as we enter the decade of peak demand. The ramifications of these data also bode poorly for patient access to revision surgery in the future because physicians without specialized training in this area are hesitant to perform these procedures.

These access problems created by the increased demand for primary total joint arthroplasty could be avoided if general orthopedists with an interest in hip and knee arthroplasty absorb these cases. Such optimism concerning access does not take into account the ramifications of an aging workforce and the effect retirement of busy hip and knee surgeons will have on access.

The purpose of this study was to determine the arthroplasty workforce in 2016. By calculating the current workforce and the number of retiring arthroplasty surgeons, we hoped to determine if the number of orthopedic surgeons entering the supply chain would be able to meet the growing demands of joint arthroplasty patients.

Materials and Methods

To determine the arthroplasty workforce in 2016, the American Academy of Orthopaedic Surgeons’ (AAOS) database was queried. In addition, the 2004 and 2006 AAOS Orthopedic Practice in the United States Surveys (OPUS) [3,4] were queried. In the OPUS reports,
demographic characteristics of the orthopedic workforce were documented. In these surveys, respondents were asked to identify all areas of orthopedic surgery they considered their primary or specialty area of focus.

To determine the current arthroplasty workforce that performs total knee or total hip arthroplasty, the AAOS database was queried. Orthopedic surgeons who identified themselves as generalists with a hip and knee focus or specialists in hip and knee surgery were included in the calculation of the current arthroplasty workforce. In addition, those surgeons older than 75 years in each of these subgroups were deleted as we felt that the likelihood of these surgeons performing significant numbers of joint arthroplasties after the age of 75 years was remote.

To determine how many joint arthroplasties are performed annually by the current arthroplasty workforce, the OPUS 2004-2005 survey was queried [3]. In the OPUS survey, the number of total knee and total hip arthroplasties performed per month by generalists and adult reconstructive surgeons were recorded. The number of joint arthroplasties performed per month by these groups was then used to annualize the number of hip and knee arthroplasties performed per year by generalists with a hip and knee focus and specialists in hip and knee arthroplasty. The number of hip and knee arthroplasties performed per year was then multiplied by the number of arthroplasty surgeons to determine the current annual arthroplasty production in the United States.

The future demand of primary total hip arthroplasty and total knee arthroplasty was estimated based on the historical incidence of arthroplasty reflected in the Nationwide Inpatient Sample (NIS). Details about the NIS and the arthroplasty projection method are published elsewhere [2,5] but are summarized here briefly for completeness. The Nationwide Inpatient Sample (NIS) was used to identify primary arthroplasty procedures performed between 1993 and 2007 based on the Ninth Revision of the International Classification of Diseases codes for primary total hip arthroplasty (81.51) and knee arthroplasty (81.54). The prevalence of surgery was modeled using Poisson regression allowing for different rates as a function of age, sex, race, and census region subgroup, as reported previously [2,5]. The future size of each population subgroup was obtained from the population projection data reported by the Census Bureau. Our baseline national total joint arthroplasty projections were obtained by summing the projections for each subgroup, for which both the population and the prevalence of surgery were modeled to vary over time.

We also compiled a set of total hip arthroplasty and total knee arthroplasty projections under the conservative assumption that the future incidence would remain constant and equal to the average for most recent 4 years of NIS data (2004-2007). For the “constant rate” projections, the rates of surgery as a function of age, sex, race, and census region subgroup were held fixed over time, and the future growth in demand was modeled based solely on the Census projections of each population subgroup. These data were used to determine the anticipated demand for total knee and hip arthroplasties in the year 2016.

To determine the actual arthroplasty workforce in 2016, the number of arthroplasty surgeons entering the workforce between 2008 and 2016, as well as the number of arthroplasty surgeons retiring from 2008 to 2016 was calculated. To determine the actual number of new arthroplasty surgeons entering the workforce, the graduating resident pool was examined. Of the 620 orthopedic residents graduating, 90% did fellowships [6]. Those residents doing a sports medicine fellowship would perform hip and knee arthroplasties during their specialized careers. Any graduating resident who did not do a fellowship nor did a trauma fellowship were expected to perform arthroplasty during their career at the same rate as a generalist with a hip and knee focus. Any graduating resident doing a hip or knee fellowship was expected to perform arthroplasty at the same rate as a specialist in hip and knee arthroplasties. It was further assumed that one half of those physicians doing a sports medicine fellowship would perform hip and knee arthroplasties at the same rate as a general orthopedist with a hip and knee focus.

To determine the number of arthroplasty surgeons who would retire between 2008 and 2016, the AAOS database was again queried. The average age of retirement of an AAOS fellow and the age of those in the current arthroplasty workforce were used to calculate the number of physicians leaving the workforce between 2008 and 2016. To determine the actual number of retiring arthroplasty surgeons, 2 different AAOS surveys were used to calculate the mean retirement age. In the OPUS study, 1614 retired orthopedic surgeons were surveyed. Of them, 62% had retired in the last 2 years. The mean age at which AAOS fellows and nonmembers reported they fully retired from orthopedic practice was 59 years [4]. In a 2007 AAOS survey of 3001 orthopedic surgeons 50 years old and older, 1005 surgeons responded [7]. They found that practicing orthopedic surgeons planned to retire at a mean age of 65 years. Of those surveyed, 21% had actually retired and their median age of retirement was 65. Because of the discrepancy in these 2 surveys, our calculations were performed in 2 ways using 59 as the retirement age for the baseline results and 65 in a further conservative calculation.
Once we had established the available arthroplasty workforce in 2016, the above data were used to calculate the projected number of total knee and hip arthroplasties capable of being performed in the year 2016 using the following formula (number of general orthopedic surgeons with a hip and knee focus in 2016 × the number of hip or knee arthroplasties performed per year by a generalist with a hip and knee focus, plus the number of hip and knee arthroplasty specialists in 2016 × the number of hip or knee arthroplasties performed per year by a hip and knee arthroplasty specialist).

As noted previously, the arthroplasty workforce was calculated in 2 ways using 59 years as the mean retirement age as well as 65 years as the mean retirement age to determine the maximum number of hip or knee arthroplasties that the existing arthroplasty workforce could perform in the year 2016.

Once we had established the maximum number of arthroplasties that could be performed in the year 2016, this was compared to the projected number of total hip and knee arthroplasties needed in the year 2016 based on the NIS estimates.

A number of assumptions were made concerning our calculations:

1. The number of residents entering the workforce would be stable from 2008 to 2016.
2. The specialty mix of residents going into specific subspecialties would not change from 2008 to 2016.
3. The projections for the anticipated demand for joint arthroplasty were accurate.
4. The number of total joint arthroplasties per year performed by orthopedic surgeons would remain stable from 2008 to 2016.
5. Those entering the workforce would perform total joint arthroplasty at the same rate as experienced surgeons, and those leaving the workforce in their slowdown years would continue to do joint arthroplasty at the same rate up until their retirement. It was assumed that those entering the workforce would need time to ramp up, whereas those leaving the workforce would ramp down and these discrepancies would cancel each other out.
6. There would be no exits from the workforce other than retirement. This assumption would preclude the exit of residents and current orthopedic surgeons from the workforce due to death or disability.

We recognize that unforeseen changes in the US Healthcare System may influence the future workforce and its productivity. These undefined factors could influence the projections made in this study. This model estimates the future supply and demand of primary hip and knee procedures based on existing survey data and the previously stated assumptions.

Results

The current arthroplasty workforce includes 7585 AAOS fellows—5973 generalists with a hip and knee focus and 1612 hip and knee specialists. Removing those surgeons older than 75 years leaves an arthroplasty workforce of 5743 generalists and 1550 specialists (Table 1).

Currently generalists with a hip and knee focus perform 2.4 primary hip arthroplasties and 3.7 primary knee arthroplasties per month [3]. Annualized, this group produces 29 primary hip arthroplasties and 44 primary knee arthroplasties per year. Specialists in hip and knee arthroplasties perform 9.2 primary hip arthroplasties and 8.9 primary knee arthroplasties per month [3]. Annualized, this group produces 110 primary hips and 107 primary knee arthroplasties per year (Table 2).

Currently, 5743 generalists performing 29 primary hip arthroplasties and 44 primary knee arthroplasties per year will produce 166 547 primary hips and 252 692 primary knees. The 1550 specialists performing 110 primary hip and 107 primary knee arthroplasties per year will produce 170 500 primary hips and 165 850 primary knees, respectively.

Currently, the entire arthroplasty workforce (generalists with a hip and knee focus and hip and knee specialists) perform 337 047 primary hip arthroplasties and 418 542 primary knee arthroplasties.

As noted previously, data from the NIS (1993-2007) were used to project the demand for primary total hip arthroplasty and primary total knee arthroplasty under 2 scenarios. In the baseline scenario, where the rate of total hip arthroplasty and total knee arthroplasty is allowed to change over time, it is projected that by 2016, the demand for primary total hip arthroplasty will be 417 533 (95% confidence interval [CI], 386 456-450 230), and the demand for primary total knee arthroplasty will be 1 279 058 (95% CI, 1 201 158, 1 362 352) (Table 3).

Table 1. Current and 2016 Projected Total Joint Surgeon Workforce

<table>
<thead>
<tr>
<th></th>
<th>Generalists</th>
<th>Specialists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current workforce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total no. of AAOS fellows</td>
<td>5973</td>
<td>1612</td>
</tr>
<tr>
<td>No. of AAOS fellows &lt;75 y of age</td>
<td>5743</td>
<td>1550</td>
</tr>
<tr>
<td>Projected workforce: assumes age 59 for retirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeons entering workforce</td>
<td>1584</td>
<td>400</td>
</tr>
<tr>
<td>Surgeons exiting workforce</td>
<td>3338</td>
<td>901</td>
</tr>
<tr>
<td>Total</td>
<td>3989</td>
<td>1049</td>
</tr>
<tr>
<td>Percentage change in workforce by 2016</td>
<td>−31%</td>
<td>32%</td>
</tr>
<tr>
<td>Projected workforce: assumes age 65 for retirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeons entering workforce</td>
<td>1584</td>
<td>400</td>
</tr>
<tr>
<td>Surgeons exiting workforce</td>
<td>1493</td>
<td>403</td>
</tr>
<tr>
<td>Total</td>
<td>5834</td>
<td>1547</td>
</tr>
<tr>
<td>Percentage change in workforce by 2016</td>
<td>−1%</td>
<td>1.6%</td>
</tr>
</tbody>
</table>
In the conservative scenario, where the future incidence is held constant at the average level from 2004 to 2007, by 2016, the projected demand for primary total hip arthroplasty will be 284 871 (95% CI, 237 988-331 764), and the projected demand for primary total knee arthroplasty will be 651 119 (95% CI, 557 925-744 306).

To determine if the arthroplasty workforce will be able to meet the demand, the number of arthroplasty surgeons entering the workforce between 2008 and 2016 as well as the number of arthroplasty surgeons retiring during the same period was calculated. A total of 248 graduating residents per year are projected to perform primary hip and knee arthroplasties during their career, 198 generalists with a hip and knee focus and 50 specialists in hip and knee arthroplasties. Assuming that the number of graduating residents remains stable between 2008 and 2016, 1584 generalists with a hip and knee focus and 400 hip and knee specialists will enter the arthroplasty workforce by 2016.

Using the mean retirement age of 59 years, 3338 current generalists with a hip and knee focus and 901 hip and knee specialists will be retired by 2016. Combining those entering the workforce and those retiring leaves a workforce of 3989 generalists with a hip and knee focus and 1049 hip and knee specialists—an increase of 1.6% generalists and a less than 1% decrease in the number of hip and knee specialists.

Using 59 years old as the mean retirement age, the arthroplasty workforce will be able to produce 231 071 primary hip arthroplasties and 287 759 primary knee arthroplasties (Table 3). Using a conservative mean retirement age of 65 years, the arthroplasty workforce will be able to produce 339 356 primary hip arthroplasties and 422 225 primary knee arthroplasties.

The extent of the shortfall in 2016 in primary hip and knee arthroplasties depends upon the set of estimates used. The baseline results, which assume a 59-year retirement age and demand projections that take into account projected changes in surgery rates in the population, indicate a shortfall of 186 462 hips (44.7%) and 991 299 knees (77.5%) for a total shortfall of 1 177 761 total joint arthroplasty procedures (69.4%). The conservative results, which assume a 65-year retirement age and are based on a constant historical incidence level for the surgeries, produce a surplus of 54 485 hips (19.1%) and a shortfall of 228 894 knees (35.2%), for a total procedural shortfall of 174 409 procedures (18.6%). In sum, even under conservative assumptions, a significant shortage in the number of total joint arthroplasty procedures is likely to develop.

### Discussion

Access to quality health care is a concern for policymakers, health care providers, and most importantly patients. Isolated studies of orthopedic workforce requirements have produced varying opinions concerning supply and demand for orthopedic services. The Rand report of 1998 calculated that by 2010 a surplus of 4122 full-time orthopedic surgeons would exist [8]. In contrast, the Council on Graduate Medical Education calculated in 2005 a projected deficit of physicians, which encouraged medical schools to increase enrollment 15% by the year 2015 [9]. Translated to orthopedic surgery, these findings result in the need for an additional 12 000 to 15 600 orthopedic surgeons by the year 2020 [10]. Another study predicted that by 2020, the demand for orthopedic services will increase

### Table 3. Projected Supply and Demand in 2016

<table>
<thead>
<tr>
<th></th>
<th>Baseline Supply:</th>
<th>Conservative Supply:</th>
<th>Baseline Demand:</th>
<th>Conservative Demand:</th>
<th>Shortfall:</th>
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<tr>
<td></td>
<td>Supply Assuming</td>
<td>Supply Assuming</td>
<td>Incidence</td>
<td>Incidence</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>Mean Retirement</td>
<td>Mean Retirement</td>
<td>Varies with</td>
<td>Constant at</td>
<td>Supply vs</td>
</tr>
<tr>
<td></td>
<td>Age of 59 y</td>
<td>Age of 65 y</td>
<td>Population</td>
<td>Mean Level for</td>
<td>Baseline Demand</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Projections</td>
<td>2004-2007</td>
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<td>Primary total</td>
<td>231 071</td>
<td>339 356</td>
<td>417 533</td>
<td>284 871</td>
<td>44.7%</td>
</tr>
<tr>
<td>hip arthroplasty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary total knee</td>
<td>287 759</td>
<td>422 225</td>
<td>1 279 058</td>
<td>651 119</td>
<td>77.5%</td>
</tr>
<tr>
<td>arthroplasty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total both procedures</td>
<td>518 830</td>
<td>761 581</td>
<td>1 696 591</td>
<td>935 990</td>
<td>69.4%</td>
</tr>
</tbody>
</table>

* Negative values indicate shortfalls, and positive values indicate surpluses.
by 23%, whereas the supply of orthopedic surgeons will increase by only 2% during the same interval [11].

The accuracy of these shortfall predictions are supported by the demographics of the US population as we enter the next century. The US Census Bureau has predicted an 18% growth in the US population between 2000 and 2020 [9]. As the general population increases in size, the population of elderly Americans will increase faster than the population of younger Americans [2]. This rapid increase in the elderly population is a result of the baby boomer generation born between 1946 and 1964. Currently, 78 million people or 26% of the US population were born during this period. In 2011, the first baby boomers will turn 65 and be eligible for Medicare. As this patient population ages, the demand for health care services associated with the aging process such as joint arthroplasty will result in an exponential rise in the demand for arthroplasty. Many of the members of this generation have led a much more active lifestyle than previous generations and will embrace any surgery that allows them to maintain an active lifestyle.

Although one segment of the aging population remains active, another larger population segment is obese and sedentary. This obesity epidemic in the United States may lead to an increased need for hip and knee arthroplasties. Obesity has been shown to be a significant risk factor in the development of osteoarthritis [12]. Therefore, as the number of obese patients increases, those developing osteoarthritis will likewise increase. The prevalence of obesity in the American adult population has more than doubled since 1970 [13]. Most of all American adults are now classified as overweight or obese according to their body mass index [13]. In the United States, the body mass index increases with age reaching a peak in the sixth decade of life [13]. In the 65-year to 74-year age group, 66% of adults are either overweight or obese [14]. This peak in the prevalence of obesity among American adults coincides with the age at which most patients require joint arthroplasty [15, 16].

The need for arthroplasty services will increase exponentially in the early part of this century due to the sheer population of baby boomers and the obesity epidemic. It remains undetermined whether technological advances such as cartilage transplantation, earlier realignment surgery, and earlier anterior cruciate ligament reconstructions will significantly affect this trend.

As total joint arthroplasty has matured since its inception in the early 1970s, implantation techniques have become more efficient, implant technology has improved, and results have become more predictable. These improvements have increased the demand for total joint arthroplasties for a generation of patients expecting and demanding improved functional activity and independence. We have shown in this study that the supply of trained orthopedic arthroplasty surgeons will not meet the demands of an aging society. In this study, we have predicted a productivity shortfall ranging from nearly 175 000 to 1 2 million total joint procedures in the year 2016.

The inevitable delay in treatment that will ensue may be unacceptable to the American public. The American public demands timely high-quality care with unlimited access to technological innovations. These demands are unrealistic given the present supply side crisis predicted in this study. The predicted increased demand for joint arthroplasty could be absorbed by general orthopedic surgeons with an interest in hip and knee arthroplasties. However, this opinion is based on 3 nonvalidated assumptions:

1. that busy, established general orthopedic surgeons have the time or inclination to meet the additional arthroplasty demand,
2. that these general orthopedic surgeons would be willing to undergo additional training to increase joint arthroplasty quality and productivity [17], and
3. that economic incentives for general orthopedists would exist to make such an investment of time and energy worthwhile.

Reimbursement for joint arthroplasty is currently an economic disincentive to those entering joint reconstruction. In 1990, physicians were reimbursed $2418 for a total knee arthroplasty and $2575 for a total hip arthroplasty. In 2005, physician reimbursement decreased to $1508 for a total knee arthroplasty and $1396 for a total hip arthroplasty. From 1990 to 2005, physician reimbursement decreased 38% for a total knee arthroplasty and 46% for a total hip arthroplasty [18]. If one adjusts for inflation, the $2418 that was reimbursed to physicians in 1990 for a total knee arthroplasty should increase to $3667 to maintain the same value. In contrast, the reimbursement has decreased to $1508, which is a decrease of 59% in inflation-adjusted dollars [18, 19]. If one adjusts for inflation, the $2575 that was reimbursed to physicians in 1990 for a total hip arthroplasty should increase to $3905 to maintain the same value. In contrast, the reimbursement has decreased to $1396, which is a decrease of 64% in inflation-adjusted dollars [18, 19].

The reality of these numbers are not lost on our residents in training as reflected in the large number of arthroplasty fellowship positions that are currently going unfilled. Only 45% of the 120 fellowship positions were filled in 2007 by US graduates. In addition, graduating residents understand that joint arthroplasty work is mentally and physically taxing. Patient expectations are high, and liability is an issue when joint arthroplasty operations are not successful. Furthermore, reimbursement is relatively low compared with other subspecial-
ties such as sports medicine and spine [10], whereas inpatient care is more demanding.

The first step in resolving the access crisis in arthroplasty is recognition of the problem looming on the horizon. The present study should help health care economists understand the issues and allow them to respond appropriately to this supply side crisis. Few alternatives exist for resolution of this problem:

1. Allowing the access crisis to play out that will in effect result in rationing of arthroplasty services. This will result in extremely long waiting times similar to those seen in Canada and Great Britain where lengthy waits for arthroplasty are not unusual [20-23].

2. A second alternative is to train more arthroplasty surgeons. Given the years of training required for this subspecialty and the supply side crisis that is predicted within the next 10 years, training enough surgeons to meet this demand would be difficult. Also, the economic disincentives that currently exist make this option unrealistic.

3. A third option is to increase the reimbursement for hip and knee arthroplasties. Given the costs related to providing coverage for the large number of patients who will require arthroplasty in the future increasing physician reimbursement seems unlikely.

4. A viable, pragmatic option that would maintain access for future arthritis patients would be for the government to allow balance billing. Currently, Medicare regulations prevent any participating physician from charging more than the allowable Medicare rate for a service or procedure. Only nonparticipating physicians are permitted to balance bill for amounts greater than the Medicare fee schedule. Allowing participating physicians to balance bill may draw young surgeons into arthroplasty, encourage general orthopedists to share in the increased demand for arthroplasty, and encourage established arthroplasty surgeons to continue practicing at their current rate of production.

5. A final option would be to alter certificate of need and specialty hospital regulations to allow the development of high-volume, efficient arthroplasty centers.

This type of economic model has some limitations. We recognize that some of our estimates are based on survey data, which by nature is susceptible to selection and information bias. It is unknown how this may have affected our results. If the assumptions we have made are correct and the survey data are accurate, an access problem clearly exists. However, if our projected shortfall of 46% primary total hip procedures and 72% total knee procedures has overestimated the problem by 50%, an access problem is still inevitable.

Conclusion

In this economic model, we predict a supply side crisis that severely threatens access for our arthritic patients. These findings hold true under 2 conservative assumptions regarding retirement age of physicians and the future incidence level. Governmental agencies, health care economists, and our patients need to understand that in the near future, the arthroplasty workforce will be unable to meet the arthroplasty needs of a growing arthritic population. Immediate steps to stimulate the supply side of this model should be evaluated.

References


