AAOS
American Academy of Orthopaedic Surgeons

AJRR
American Joint Replacement Registry

ANNUAL REPORT 2021

The Eighth Annual Report of the AJRR on Hip and Knee Arthroplasty

Dedication

The *2021 Annual Report* is dedicated to William Maloney, MD, FAAOS. Dr. Maloney is a past president of the American Academy of Orthopaedic Surgeons (AAOS) and has been one of our country's strongest advocates for the establishment of a national registry. Well before the inception of the AJRR, Dr. Maloney and colleagues - including fellow past chairs of the AJRR – had the vision for this important quality improvement and research vehicle. Dr. Maloney's involvement with the AJRR over the past two decades has led us to where we are today and charted the path for where we are going in the future. As current chair of the Registry Oversight Committee, he now oversees our next phase of growth, the development and expansion of the entire AAOS family of registries.

Bryan Springer, MD, FAAOS
Chair, AJRR Steering Committee

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Foreword

This was an unprecedented year as the world was faced with the devastating impact of the COVID-19 pandemic, and we continue to navigate these challenges. Healthcare institutions were forced to adapt under the enormous strain on resources and barriers to access and prioritization in healthcare delivery. This year's *AJRR Annual Report* presents a glimpse into the data through 2020 to assess the direct impact on hip and knee procedural cases during the height of the COVID-19 pandemic and takes a deep dive into the target patient and procedural trends and outcomes that drive our clinical decision making. The American Joint Replacement Registry (AJRR) is the cornerstone Registry of the American Academy of Orthopaedic Surgeons (AAOS) Registry Program and a necessary resource for evaluating clinical hip and knee arthroplasty data and improving quality of care. With over 2.5 million (and counting) hip and knee arthroplasty procedures from over 2.1 million patients currently captured in the Registry, the AJRR is the largest orthopaedic Registry by annual procedure count.

We are proud to present this *2021 Annual Report*, which reflects data related to hip and knee arthroplasty procedures performed in AJRR participating institutions between 2012 and 2020. Our primary goal is to provide data that is actionable to orthopaedic surgeons in their journey to improve the lives of millions of Americans who suffer from hip and knee arthritis. In addition to descriptive statistics related to the demographic, clinical, and implant characteristics associated with hip and knee arthroplasty procedures performed in the United States, this report includes clinical insights, national trends, and risk-stratified outcome analyses related to Medicare patients who undergo hip and knee arthroplasty procedures.

These analyses were made possible by continued growth of the AJRR, as well as the successful integration of Medicare claims data into the AJRR, which provides a more complete picture of our patient population and their associated comorbidities and outcomes, including longitudinal outcomes of patients who receive care at non-AJRR participating sites. The information in this year's report gives the most comprehensive picture to date of patterns of hip and knee arthroplasty practice and outcomes in the United States.

The AAOS Registry Oversight Committee and AJRR Steering Committee trust you will find the information in this report interesting, useful, and in some cases, actionable. With the rapid growth of AJRR capabilities, we look forward to being able to provide all of our stakeholders with valuable data that can be used to change practice and improve patient outcomes.

In closing, I would like to thank Nathan Glusenkamp, MA, Chief Quality and Registries Officer; James Huddleston, III, MD, FAAOS, Vice Chair of the AJRR Steering Committee; James A. Browne, MD, FAAOS, Chair of the AJRR Publications Subcommittee and Editor, *AJRR Annual Report*; and all AJRR committee members for their tireless efforts to bring you this report. As always, we appreciate your strong and consistent support of the AJRR and the patients we are so fortunate to serve.

With regards,

Bryan D. Springer, MD, FAAOS
Chair, AJRR Steering Committee

Executive Summary

The American Joint Replacement Registry (AJRR) joined the AAOS Registry Program as the inaugural Registry in 2017. With oversight from the AAOS Registry Oversight Committee (ROC) and the AJRR Steering Committee, AJRR continues to work toward the AAOS Registry goals. Since then, the AAOS Registry Program has continued to grow adding registries from other anatomic sites and orthopaedic areas including the Shoulder & Elbow Registry (SER), the Musculoskeletal Tumor Registry (MsTR), the American Spine Registry (ASR) – a collaborative registry with the American Association of Neurological Surgeons, and the recently announced 2021 Fracture & Trauma Registry (FTR). The past year has been marked by a multitude of successes and growth for AJRR. This *Annual Report* represents almost 2.4 million hip and knee procedures from over 1,150 institutions submitting data with an overall cumulative procedural volume growth of 18.3% compared to the previous year. Much attention has been paid to ensuring AJRR maintains its position as the national Registry for total joint arthroplasty. Additional highlights for the year include:

Ambulatory Surgery Centers (ASCs) have not been strongly represented in AJRR historically, as much of the procedural information in the Registry has come from hospitals. Wanting to provide ASCs and private practices access to data quality, analysis, and benchmarking, AAOS began implementing plans to better serve these sites. The first step was to focus on actively recruiting, educating, and engaging ASCs. AAOS partnered with the Ambulatory Surgery Center Association (ASCA) and began a pilot program that provides the data submission framework necessary for ASCs with low-volume and/or limited technical capabilities. This partnership enables ASCs to demonstrate their value as viable sources of healthcare.

Patient-Reported Outcome Measures (PROMs) are increasingly being utilized to evaluate success of a hip or knee arthroplasty procedure. Many orthopaedic stakeholders are finding benefit in capturing this patient perspective to best provide a full picture for surgical outcome evaluation. Recognizing this, AJRR has made a commitment to facilitating capture of this useful data. Specifically, AJRR continues to support the RegistryInsights® PROM platform for facilities to easily collect and upload PROM submissions to the Registry. Additionally, AJRR has formed multiple partnerships, expanding our Authorized Vendor Program to include even more PROM technological vendors. These efforts have led to substantial growth in PROMs capture. By the end of 2020, 290 sites out of 1,152 (25.2%) have submitted PROMs, which is a 39% increase in sites compared to the previous *2020 AJRR Annual Report*.

Tracking and Monitoring Outcomes with longitudinal patient information continues to be a focus of the AAOS Registry Program. To help sites best utilize Registry data for this purpose, RegistryInsights® has been expanded and enhanced. This allows individual participating institutions access to their own real-time dashboard comparing their metrics to the AJRR national benchmark. Separately, the sites' surgeons have the ability to view their own dashboard based on data submitted on procedures they performed. Finally, for those needing more custom capabilities, AJRR offers either sites of service or surgeon-specific custom reports. AJRR has provided these reports to allow surgeons and participating institutions the ability to reuse their Registry data for internal performance measures or benchmarks.

Publications and Presentations based off AJRR data continue to be an important focus of AJRR over the past year. AJRR has been fortunate to publish in a number of peer-reviewed journals such as the Journal of Arthroplasty (JOA), Journal of American Academy of Orthopaedic Surgeons (JAAOS), and Clinical Orthopaedics and Related Research (CORR). A series of podium presentations and posters have been presented at the following 2020 and 2021 Annual Meetings: AAOS, American Association of Hip and Knee Surgeons (AAHKS), International Society of Arthroplasty Registries (ISAR), The Knee Society, The Hip Society, North Carolina Orthopaedic Association, and the Musculoskeletal Infection Society (MSIS). Topics have included patient-reported outcome measures, infection, arthroplasty for femoral neck fracture, patient migration, dual mobility, and more. Please see Appendix A for a full list of recent publications and presentations utilizing the AJRR database.

The Ability to Reuse Registry Data to enable performance measurement as well as facilitate national registry-driven quality improvement programs has been a concentration of the Registry over the past few years. Now, AJRR data can be reused toward:

- The Joint Commission (TJC) Advanced Certification for Total Hip and Total Knee Replacement
- American Board of Orthopaedic Surgery (ABOS) Maintenance of Certification (MOC) program for Part II Self-Assessment Examination (SAE) credit
- Centers for Medicare & Medicaid Services (CMS) Bundled Payments for Care Improvement Advanced (BPCI-A) for the 2021 reporting year
- CMS Comprehensive Care for Joint Replacement (CJR) Model
- CMS Merit-based Incentive Payment System (MIPS) Promoting Interoperability (PI) and Quality Payment Program (QPP)
- Accreditation Association for Ambulatory HealthCare (AAAHC) Advanced Orthopaedic Certification
- Aetna Institutes of Quality (IOQ) Orthopaedic Surgery
- BlueCross BlueShield Blue Distinction Specialty Care
- Blue Shield of California waiver of prior authorization for their patients' hip or knee replacement procedures
- Bree Collaborative
- Cigna Surgical Treatment Support Program
- Det Norske Veritas & Germanischer Lloyd (DNV GL) Orthopaedic Center of Excellence
- The Alliance QualityPath

To find out more about these and other ways to reuse Registry data please click here.

2021 AJRR Annual Report Highlights

The *2021 American Joint Replacement Registry Annual Report* represents 2,244,587 primary and revision hip and knee arthroplasty procedures performed between 2012 and 2020. Primary knee (54.5%) and primary hip (38.6%) procedures made up the majority. Sex breakdown was 58.5% female and 41.1% male for all cases. The average age of a total hip arthroplasty patient was 66.1 years and 67 years for total knee arthroplasty cases. Most of the patients in the data were white (75.6%) although race was unreported in 15.8% of cases. Among AJRR surgeons performing elective primary total hip arthroplasty and total knee procedures separately, the mean 2020 procedure count was 26.7 and 33.9, respectively.

Many trends identified in previous AJRR Annual Reports continued this year. For hip arthroplasty procedures, there is still a trend towards increased use of ceramic heads. The use of antioxidant polyethylene liners has remained stable. Usage of dual mobility constructs has continued to increase in both the primary and revision setting. While hemiarthroplasties still predominate for the treatment of femoral neck fractures, total hip arthroplasty usage has increased. The use of cement for femoral component fixation is slowly increasing for both elective primary total hip arthroplasty as well as arthroplasty for femoral neck fracture.

For total knee arthroplasty procedures, the use of cruciate retaining and ultracongruent implants continues to increase at the expense of posterior stabilized designs. Although cemented fixation still predominates, the use of cementless fixation continues to increase and is now used in 14% of all primary total knee arthroplasty procedures. Use of conventional polyethylene continues to slowly decrease as the usage of highly cross-linked polyethylene inserts continues to increase. Partial knee arthroplasties continue to represent a small percentage of knee arthroplasty cases in the Registry.

For both hip and knee arthroplasty procedures, postoperative length of stay continues to decrease. The use of general anesthesia appears to be slowly decreasing. An analysis of age by decade of life among Medicare patients ≥65 revealed an association between increased rates of revision and the younger age group (<75) for knee arthroplasty but increased rates of revision in the older population (85+) for hip arthroplasty.

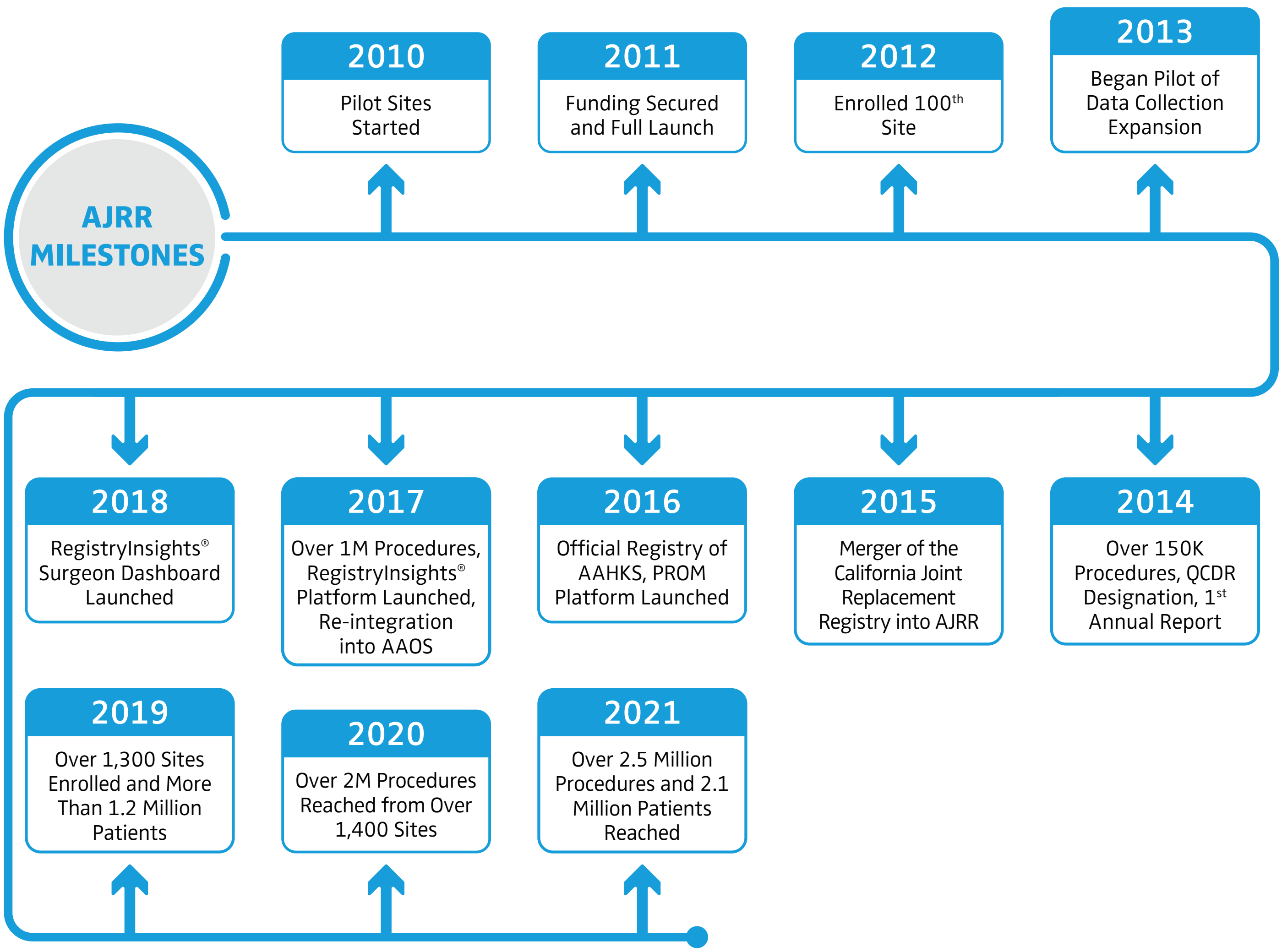
Finally, enhanced analytics is always the goal of each Annual Report. With the continued growth of AJRR, analyses with Registry data will continue to mature. For the first time this year, cumulative percent revision curves were produced with a diagnosis specific endpoint examining revision due to infection for TKA and revision due to periprosthetic fracture for THA patients ≥65 years of age. This year represents the fourth year completing curves of revision over time and utilizing CMS data. Device-specific cumulative percent revision estimates stratified by bearing and fixation type are also included in the report as presented in the *2020 AJRR Annual Report Supplement*. Much time was spent establishing a consensus-driven methodology determined by multiple stakeholders. This framework provides a foundation ensuring strength in all analyses moving forward, progressing toward more sophisticated and detailed survivorship curves in the future.

Our Vision

To be the National Registry for orthopaedics through comprehensive data and technology, resulting in optimal patient outcomes.

About AJRR

The American Joint Replacement Registry (AJRR) is the cornerstone of the AAOS Registry Program. AJRR is overseen by the AJRR Steering Committee which reports to the AAOS Registry Oversight Committee and ultimately the AAOS Board of Directors with many stakeholders involved. By end of 2020, there were over 2.3 million procedures from 1,152 hospitals, ambulatory surgery centers (ASCs), and private practice groups submitting data to the AJRR from across all 50 states and the District of Columbia; this is an 18% increase in procedures and 13% increase in submitting institutions from the previous report.



Data Quality and Sources

Data Reporting and Data Specifications

Since the beginning of AJRR, updating data specifications has been a necessary part of the process. Not only can specification updates improve the quality of data collected, but updates are made to reduce the data entry burden and ensure adaptation to changes in healthcare and the orthopaedic profession. A review of data elements collected at the time of this report can be found in Appendix B.

AJRR is committed to updating and refining its data specification each year. These updates are handled through our Annual Data Specification Sunset Cycle as shown in the diagram below. This update resulted in significant improvements by providing further collection of procedural and post-operative data. Moving forward, to simplify the transition and ensure routine enhancements, data specifications will be released and sunset on an annual basis. Specifically, the Annual Data Specification Sunset Cycle simplifies the transition of data specifications by informing users of when new ones will be released and older versions retired out.

On January 15 of each year, starting in 2020, AAOS releases an updated data specification and data dictionary. From this date until June 15 of the same year, AAOS will support the three most recent versions of data specifications. During this time, Registry staff will work with all key stakeholders through educational efforts that include webinars, email articles, and informative updates, communicating the changes made to the newest data specification. Finally, on June 15, AAOS will then retire the oldest of the three and support only the two latest versions.

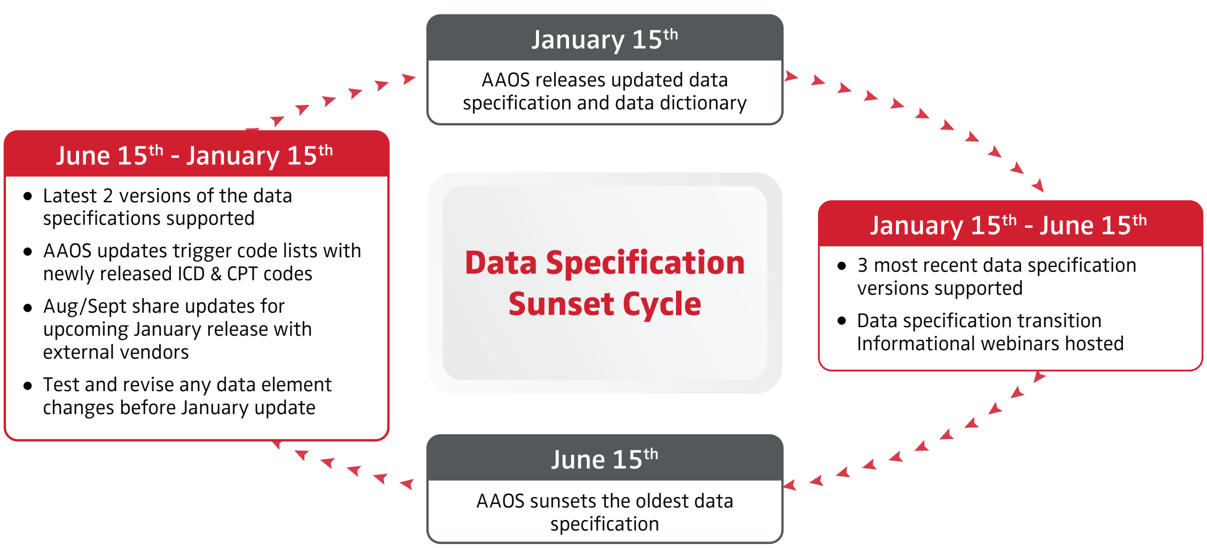
In general, making updates to a data specification is a lengthy process. Every change, large or small, requires thorough review and vetting from multiple areas of AJRR leadership. This continuous process is ongoing throughout the year, ensuring perspectives from all involved parties are included.

CMS Data

A long-term priority for AJRR has been to obtain claims data from the CMS to facilitate linkages between AJRR and Medicare to support AJRR's quality improvement and patient safety efforts.

These linkages allow AJRR to obtain data including more complete comorbidity information, knowledge of revisions performed in non-AJRR institutions, and to fill-in data gaps where information was not submitted to AJRR. In total, the CMS files include inpatient (148 data elements), outpatient (122 data elements), and the National Death Index data. Twelve of the provided data elements in CMS directly match AJRR data elements and can help fill in gaps in Registry information. Any additional data elements in CMS not in AJRR have been analyzed for completeness to be used in further analyses.

Annual Registry Data Specification Sunset Cycle



Audit of Registry Data

The AAOS Registry Program and AJRR are committed to providing data reports that are valid and accurate. To ensure the Registry Program achieves this objective, internal quality controls are in place, in addition to an external audit of data from the previous year. The audit process is completed annually, and this year AJRR executed a contract with Advent Advisory Group® to serve as the new vendor for auditing a sample of 2020 data. Advent Advisory Group is a National Committee for Quality Assurance (NCQA) licensed audit organization which provides audit, consulting, data validation, and technical assistance to health services organizations nationwide. With over 25 years of experience, Advent's staff of auditors, clinicians, analysts, statisticians, certified coders, and programmers perform validation services for a variety of health care organizations, including health plans, provider organizations, clinical registries, data aggregators, and health information exchanges. The intention of this audit was to select and review a sample of 2020 data. The Registry randomly selected N=37 (3%), actively submitting AJRR sites, both hospitals and ASCs, from January 1 to December 31, 2020 to participate. Two hospitals adjudicated during the prior year audit and were required to participate this year, creating a total of 39 sites for the current audit of 2020 data. The participating sites represented urban and rural locations, in addition to small and large institution size. There are two portions of the audit to evaluate Registry data: the first portion of the audit was a medical records review, structured to analyze randomly selected hip and knee arthroplasty procedures performed in 2020. The audit process ensures data submitted to AJRR correctly represents the data in the facility medical records, and that the data submitted to AJRR for a randomly selected month(s) in 2020 reflected all hip and knee arthroplasty procedures performed at that site. The audit was completed in early September 2021.

The overall medical record audit agreement rate was 95.0%, which was higher than the 93.9% overall audit agreement rate for the sites in the 2020 Annual Report (2019 year data) and between the 95.4% and 94.5% overall audit agreement rate for the prior Annual Reports in 2019 and 2018. Since inception of the AJRR Annual Audit, the overall audit agreement rate has consistently exceeded 90%, above the 85% acceptable threshold, indicating high reliability of the data within the AJRR. The overall record completeness assessment rate was 94.2%, up from 91.7% in the 2020 Annual Report. Challenges in the completeness agreement include formatting issues with reports that participants submitted to Advent, therefore creating mismatches on the Primary Procedure Codes submitted. Mismatches were also linked to documentation of laterality and institution NPI. There were no anomalous observations to suggest any cherry picking or selection of only the best cases being submitted.

This audit reflects agreement between the information in the institution record and the information as reported to AJRR. The audit does not reflect whether data and resulting codes assigned in the hospital record were the most appropriate or accurate for the procedure performed. Efforts to address accuracy and appropriateness of the submitted data, especially at the point of data entry, will continue in collaboration with all participating sites; please see Appendix C.

AAOS Authorized Vendor Program

To minimize the data entry burden and enhance ease of data submission, AAOS has partnered with a vetted list of technological vendors through the Authorized Vendor Program. These third-party electronic health record and user interface based technology vendors have made a commitment to prioritize data collection and submission by aiding sites in data collection, file configuration, and submission of procedural, post-operative, and patient-reported outcome (PRO) data.

As of October 2021, AAOS is currently engaged with dozens of vendors. For a complete list of authorized vendors please see Appendix D.

"Registries are the backbone of efforts to improve value. A North Star for all of us is to improve value for patients and deliver the greatest health we can to patients with resources that we have available."

Kevin J. Bozic, MD, MBA, FAAOS

Dell Medical School at University of Texas at Austin

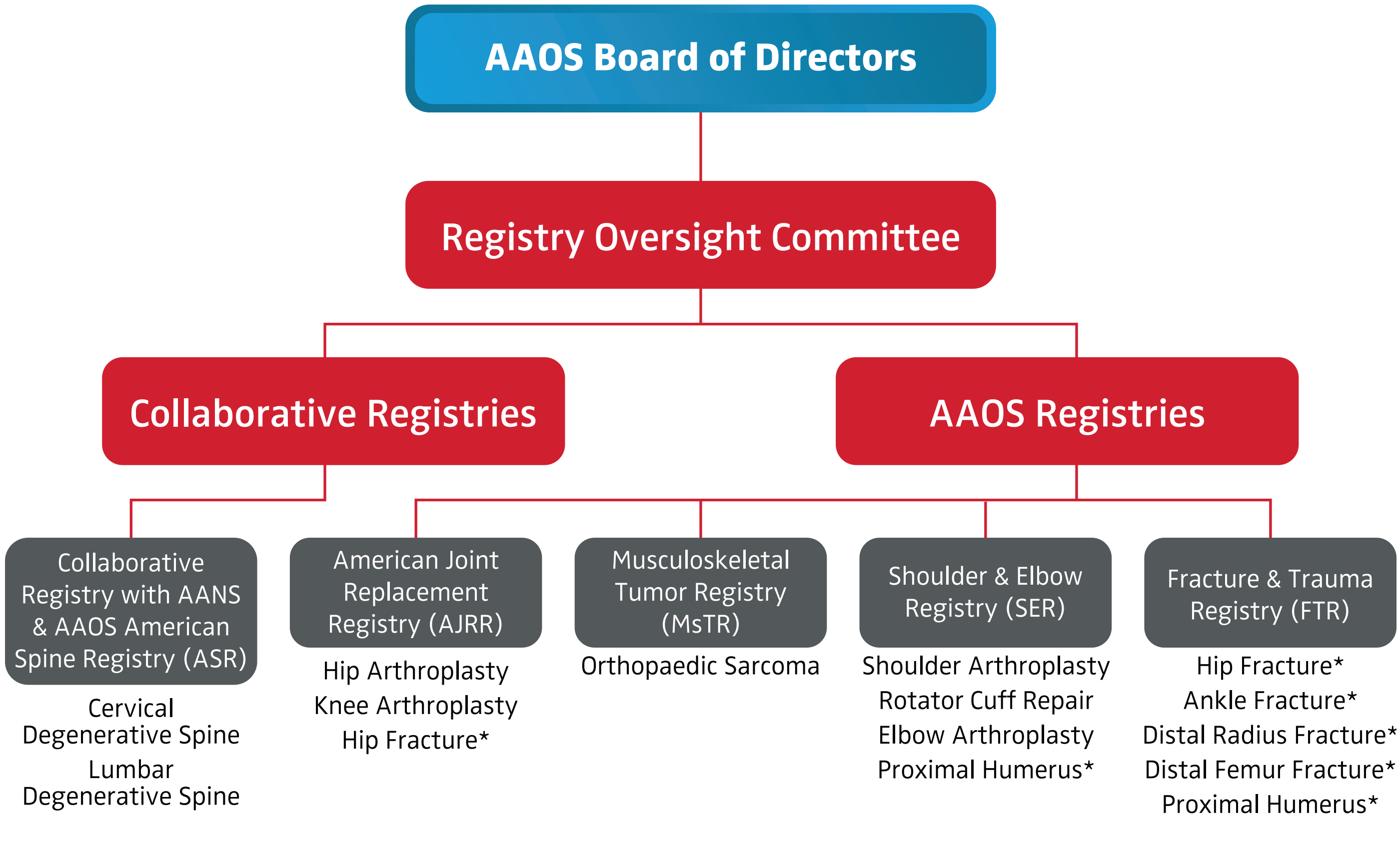
2nd Vice President, AAOS Board of Directors

Former AJRR Chair and AJRR Representative, Registry Oversight Committee

AAOS Registry Program

Commitment to developing a family of registries across the spectrum of orthopaedic specialties remains one of AAOS' top priorities. AJRR became the cornerstone of the AAOS Registry Program in 2017, and in 2018, was the addition of more registries including both procedural (Shoulder & Elbow Registry) and diagnosis-based (Musculoskeletal Tumor Pilot Registry) registries. The Musculoskeletal Tumor Registry (MsTR) completed its pilot in 2019 and converted into a full Registry in 2020. Additionally, in 2020, AAOS partnered with the American Association of Neurological Surgeons (AANS) to launch the American Spine Registry (ASR). In 2021, AAOS launched the Fracture & Trauma Registry (FTR) in a phased approach, with open enrollment planned for early 2022. FTR marks the first AAOS Registry built on a synergistic approach where collaborative modules will be available across the RegistryInsights® platform, offering expanded, crossover benefits to AAOS Registry Program including AJRR.

All registries receive governance from a Registry Oversight Committee that ultimately reports up to the AAOS Board of Directors.



**Modules in development*

Strength Through Collaboration – A Multi-Stakeholder Model

AJRR continues to build and enhance its collaborative relationships through strategic alliances and affiliations with other organizations, including:

Ambulatory Surgery Center Association (ASCA)

AJRR and ASCA run a collaborative program that provides the framework necessary for ASCs with low-volume and/or no technical capabilities. As the number of arthroplasty procedures performed in ASCs increases, it is important to capture data to understand efforts to improve quality, enhance practice efficiency, and reduce healthcare costs by groups migrating to this model of practice.

American Alliance of Orthopaedic Executives (AAOE)

AAOE is a premier management association serving orthopaedic practice executives, providing peer to peer networking and education for orthopaedic executives. AAOE provides content and resources for orthopaedic practice executives; encourages competence, excellence, and high standards for orthopaedic practice management; and facilitates connections to and between members, nonmembers, physicians, and affiliated groups. AAOE supports data submission to AAOS Registries.

American Association of Hip and Knee Surgeons (AAHKS)

AJRR is the official registry of AAHKS with continued collaboration on numerous initiatives. AAHKS members receive information on joining the Registry, AJRR is given complimentary advertisements in AAHKS publications as well as on their website, and the AAHKS journal, Arthroplasty Today, is AJRR's official journal.

American Hospital Association (AHA)

AHA is the national organization that represents and serves all types of hospitals, healthcare networks, and their patients and communities. Historically, AHA has been a strong collaborative partner with medical associations, aiding in guideline development to improve quality and the level of recommendations provided. The AHA continues to collaborate with AJRR by maintaining a seat on the Steering Committee.

The American Joint Replacement Research Collaborative (AJRR-C)

The AAOS Registry Program and Mayo Clinic are collaborating through the AJRR-C center, funded by the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) Core Centers for Clinical Research program (P30AR076312). AJRR-C is led by Mayo Clinic surgeons Drs. Daniel Berry and David Lewallen with the AAOS Registry Program as the resource core for the center. AJRR-C aims to build productive scientific collaborations to enhance national clinical research infrastructure and support the next generation of investigators. The multidisciplinary AJRR-C team provides customized methodology and educational support in areas of epidemiology, biostatistics, health sciences research and medical informatics to interested collaborators. AJRR-C also provides statistical support to AAOS for abstracts, presentations and publications, including the annual reports. High-priority areas of work include methods for handling bias, confounding, risk adjustment in TJA studies, outlier identification, development and application of TJA-specific natural language processing and computer vision tools for mining the electronic health records, standardization of analyses and reporting of TJA outcomes, and infrastructure efforts for large, multicenter trials. Please reach out to Reagan Bayer at Bayer@aaos.org to find out how you can collaborate with the AJRR-C methodology team.

America's Health Insurance Plans (AHIP)

AHIP is the national association whose members provide coverage for healthcare and related services to hundreds of millions of Americans every day. Through these offerings, AHIP improves and protects the health and financial security of consumers, families, businesses, communities and the nation. They are committed to market-based solutions and public-private partnerships that improve affordability, value, access, and well-being for consumers. AHIP continues to collaborate with AJRR by maintaining two seats on the AJRR Steering Committee.

International Society of Arthroplasty Registries (ISAR)

ISAR is a global consortium of joint replacement registries established by several of the mature national registries. The society facilitates the development of registry science and observational studies, encourages the development of new national registries around the world, and provides a forum for information sharing to enhance participating countries' ability to meet their own objectives. AJRR is proud to be an associate member of ISAR and the vendor for the International Protheses Library (IPL).

National Association of Orthopaedic Nurses (NAON)

NAON was incorporated in 1980 to advance the specialty of orthopaedic nursing through excellence in research, education, and nursing practice. AJRR is proud to participate in NAON Annual Meetings.

OrthoForum/OrthoConnect

The AAOS Registry Program is the official registry of OrthoForum and OrthoConnect. The OrthoForum and its sister organization, OrthoConnect, are a national specialty physician network whose membership includes many of the largest privately owned orthopaedic practices in the United States. Established to meet the unique challenges that independent orthopaedic group practices face in today's musculoskeletal healthcare environment, the OrthoForum selects its members individually to participate in activities that advance each group's presence throughout their markets. These activities include benchmarking, innovation, business ventures, networking, and best practices.

The Hip Society

Founded in 1968, The Hip Society was created to advance the knowledge and treatment of hip disorders to improve the lives of patients. The Society shares such values as education, innovation and collaboration, integrity, inspiration, and achievement. It supports the discovery and dissemination of information specific to hip disorders. Membership to The Hip Society is through invitation only and several members also serve on AJRR committees.

The Knee Society

The Knee Society was incorporated in 1983 to support the creation of a society for education and research in the area of total knee arthroplasty as well as in the pathogenesis of osteoarthritis and other disease processes that lead to end stage arthritis of the knee. Membership to The Knee Society is by invitation only. Several members of The Knee Society also serve on AJRR committees.

"I love registry data because there is power in numbers. Larger datasets are great for conducting research because one can see trends over time and aggregate data over more surgeons to better determine correlations and potential implant failures."

Antonia F. Chen, MD, MBA, FAAOS

Brigham and Women's Hospital

AJRR Steering Committee and Research Projects Subcommittee

2021 and Beyond

The AAOS Registry Program has been actively forging collaborations with a focus on minimizing the data entry burden and expanding opportunities for reuse of Registry data.

For a comprehensive list of all data reuse opportunities, please visit www.aaos.org/registries.

AAOS Registry Analytics Institute®

Launched in February 2019, the AAOS Registry Analytics Institute® allows for investigators with a well-defined hypothesis the opportunity to submit for access to Registry analytics. All submitted applications are first examined by the AAOS Registry Analytics team for feasibility. If feasible, members from the Research Projects Subcommittee complete a review to determine final decisions. In 2020, the RAI received 34 applications over three cycles, of which, 15 applications were approved. Thus far, of the approved applications, we have executed six analyses and the results of all these analyses were submitted in abstracts to conferences as AAOS collaborations. For more information on the AAOS Registry Analytics Institute®, please visit: www.aaos.org/registryanalyticsinstitute.

ABOS Maintenance of Certification (MOC)

The AAOS Registry Program has been approved by the American Board of Orthopaedic Surgery (ABOS) to support Maintenance of Certification. As of November 2018, a diplomate can receive Self-Assessment Education (SAE) credits for each year of registry participation as an alternative to 10 scored and recorded SAE credits needed to satisfy ABOS MOC requirements.

Aetna Institutes of Quality (IOQ) Orthopaedic Surgery

Aetna IOQ are healthcare sites that demonstrate high levels of quality and efficiency. Effective January 1, 2020, The Joint Commission started providing the IOQ quality review for Aetna's total hip and knee replacement (THKR) surgery program. To maintain IOQ designation after January 1, 2022, sites must achieve The Joint Commission Advanced Certification for THKR, for which AJRR is the registry requirement.

BlueCross BlueShield Blue Distinction Specialty Care

Through Blue Distinction Specialty Care, ASCs may be required to have advanced certification from The Joint Commission, AAAHC, or DNV GL. Participation in the AJRR supports obtaining a certification.

CMS Bundled Payments for Care Improvement Advanced (BPCI-A)

The AAOS Registry Program has been selected by CMS to participate in the BPCI-A Model. This program aims to enhance seamless, patient-centered care throughout each Clinical Episode. Sites are able to opt-in to utilize AAOS Registries as an alternative reporting pathway starting in 2021.

NESTcc Grant

To minimize the data entry burden, the Registry continuously looks for ways to connect to external payer sources. One step in this direction was the acceptance of AAOS for the National Evaluation System for health Technology Coordinating Center (NESTcc) pilot grant. NESTcc is an initiative of the Medical Device Innovation Consortium (MDIC). AAOS is the only registry that was selected and will be representing the interest of our industry partners. This grant, Testing the Feasibility of Registry and Claims Data Linkages, will allow for feasibility testing around linkage with private payer data.

Qualified Clinical Data Registry (QCDR)

The AAOS Registry Program is a CMS-designated QCDR. Participation in the AJRR can help physicians qualify for the Merit-based Incentive Payment System (MIPS) Quality Payment Program (QPP) and MIPS Promoting Interoperability (PI) category (previously known as Meaningful Use).

The Joint Commission Partnership

AAOS and The Joint Commission are in a collaboration to oversee scientific issues, performance measures, quality improvement activities, education, data sharing, and research related to the Advanced Total Hip and Knee Replacement (THKR) Certification.

Effective July 1, 2019, AJRR became the sole pathway for meeting the THKR registry requirement.

On the Advocacy, Regulatory, and Quality Improvement Frontlines

AAOS continues to advocate for greater Registry participation and impact. One of the major barriers to the success of the Registry stems from regulatory issues surrounding data sharing and the complex web of federal quality payment initiatives. The ongoing COVID-19 pandemic continues to create challenges to data collection. Many activities have been undertaken this year to promote the important work being conducted by AJRR.

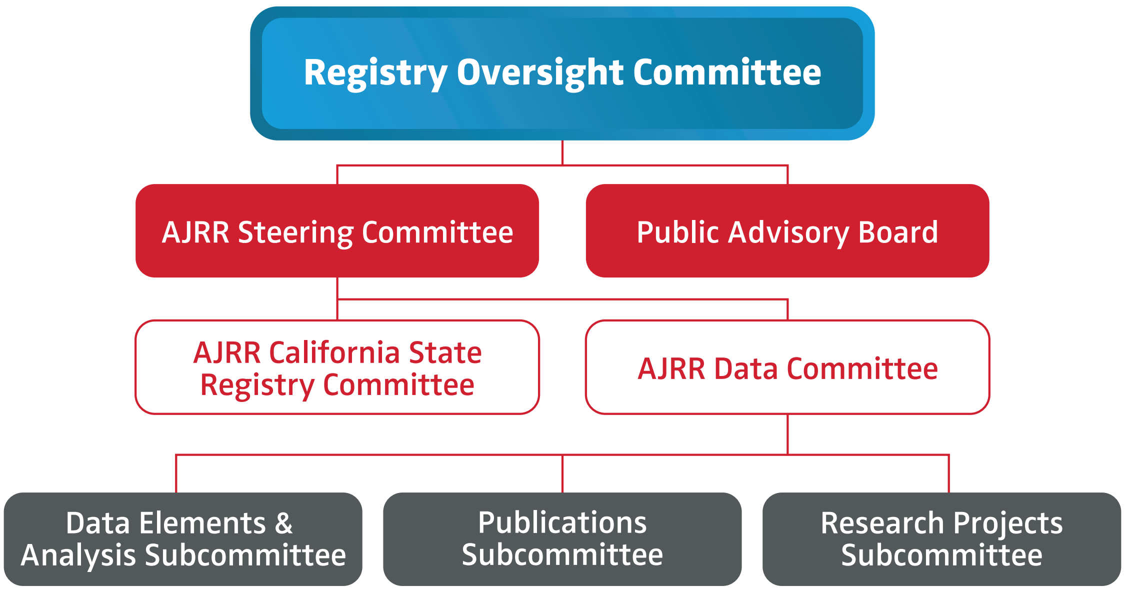
Some of these activities include:

- The COVID-19 public health emergency (PHE) continues to impact the regulatory environment of 2021. AAOS continues to advocate for flexibilities in quality reporting programs through the end of the PHE and points to the inclusion of clinical data registries as an effective mechanism for reducing such regulatory and administrative burden, while improving health outcomes.
- The CMS extended their Extreme and Uncontrollable Circumstances policy through the 2021 Performance Year in response to requests from AAOS and many other specialty societies. This flexibility allows clinicians, groups, and virtual groups to submit an application requesting reweighting of one or more Merit-based Incentive Payment System (MIPS) performance categories due to the COVID-19 public health emergency.
- In April 2021, AAOS signed onto a letter from the American Medical Association (AMA), which urged the CMS to immediately release the 2018, 2019, and 2020 MIPS cost measures benchmarks and further make cost measure benchmarks and patient attribution information available on a rolling, close to real-time basis during the 2021 performance year and future performance periods thereafter.
- AAOS co-developed two candidate MIPS Value Pathways (MVPs) specific to orthopaedic surgery, which were submitted to CMS in February 2021 for consideration in upcoming rulemaking. Both MVPs, one focused on lower extremity joint replacement (LEJR) and the other on rotator cuff repair, were designed so that all quality measures could be reported through AAOS Registries. The candidate MVPs also highlighted the many orthopaedic QCDR measures available in our registries.
- Submission of candidate MVPs led to a series of iterative meetings in January, April, and June 2021 with CMS leadership during which AAOS, the AAHKS, and other stakeholders discussed potential MVP designs, further reduction of reporting burden, and how to incentivize participation.
- AAOS participated in the AMA's MVP Strike Force, which met with leaders of CMMI in August 2021 to discuss MVP implementation proposals. AAOS used the opportunity to speak directly to the Agency about the resource prohibitive Research Data Assistance Center (ResDAC) process which registries must use to obtain access to Medicare claims data.
- CMS proposed an LEJR MVP, which reflected the feedback from orthopaedic specialty societies, in the Calendar Year (CY) 2022 Medicare Physician Fee Schedule (MPFS) Proposed Rule. To provide participants and registries more time to prepare for MVP reporting, CMS has proposed delaying MVP implementation until January 1, 2022.
- In June 2021, AAOS provided comments to the Fiscal Year 2022 Hospital Inpatient Prospective Payment System Proposed Rule, which included a request for information (RFI) on CMS's plan transition to digital quality measurement fully by 2025. AAOS highlighted registries as innovators in quality measure development and urged CMS to allow regulatory flexibility for registries in future rule-making.
- In July 2021, AAOS proffered feedback on the Cures 2.0 draft legislation being developed by U.S. Reps. Diana DeGette (D-CO) and Fred Upton (R-MI). Our comments noted the ability of registries to monitor adherence to current evidence-based guidelines while also offering real world evidence that provides insight into patient populations, disease presentation, care patterns or care variability, as well as outcomes.
- AAOS readdressed our arguments against the onerous QCDR measure testing and data collection requirements in our comments to the CY 2022 MPFS Proposed Rule. CMS previously introduced these requirements to maintain QCDR designation in the CY 2020 MPFS Final Rule, but they were delayed until 2022 due to the PHE.

Governance and Structure

In October 2017, AJRR was re-integrated back into AAOS and became the cornerstone of the AAOS Registry Program. Prior to this, AJRR was an independent 501(c)3 non-for-profit corporation with an independent Board of Directors. Once reintegrated, AJRR Board of Directors was transitioned to the AJRR Steering Committee.

Many of the original surgeon leaders on the Steering Committee have been involved in AJRR since the beginning. Their valuable service provided the knowledge needed to ensure a smooth transition to AAOS. The addition of members of the public has been pivotal to the success of the Registry. Their voices are included through the Public Advisory Board which allows for the inclusion of the patient perspective in all aspects of Registry governance.



2021 AAOS Registry Oversight Committee

Overseeing the Steering Committee is the Registry Oversight Committee (ROC). The ROC reports to the AAOS Board of Directors and provides guidance and recommendations for all major Registry initiatives.

The Registry Oversight Committee is led by the following orthopaedic surgeons:

William J. Maloney, MD, FAAOS, Chair
Stanford University School of Medicine (Redwood City, CA)

Joseph A Bosco, III MD, FAAOS, Immediate Past President
NYU Hospital for Joint Diseases (New York, NY)

Michael J. Gardner, MD, FAAOS
Stanford University Surgery (Redwood City, CA)

Steven D. Glassman, MD, FAAOS
Norton Leatherman Spine Center (Louisville, KY)

David S. Jevsevar, MD, MBA, FAAOS
Dartmouth-Hitchcock Medical Center (Lebanon, NH)

Benjamin J. Miller, MD, MS, FAAOS
University of Iowa (Iowa City, IA)

Kurt P. Spindler, MD
Cleveland Clinic (Lyndhurst, OH)

Bryan D. Springer, MD, FAAOS
OrthoCarolina Hip and Knee Center (Charlotte, NC)

Gerald R. Williams Jr., MD, FAAOS
The Rothman Institute (Philadelphia, PA)

2021 AJRR Steering Committee

Bryan D. Springer, MD, FAAOS, Chair
AJRR Representative
OrthoCarolina (Charlotte, NC)

James I. Huddleston, III, MD, FAAOS, Vice Chair
California State Registry Committee Representative
Stanford University (Woodside, CA)

Scott M. Sporer, MD, FAAOS, Secretary
AAOS Representative
Midwest Orthopaedics at Rush and Central DuPage Hospital (Wheaton, IL)

James A. Browne, MD, FAAOS
The Knee Society Representative
University of Virginia (Charlottesville, VA)

Antonia F. Chen, MD, MBA, FAAOS
AAOS Representative
Brigham and Women's Hospital (Boston, MA)

Paul J. Duwelius, MD, FAAOS
AAOS Representative
Orthopedic and Fracture Specialists (Portland, OR)

Richard L. Illgen II, MD, FAAOS
AAOS Representative
University of Wisconsin-School of Medicine and Public Health (Madison, WI)

William A. Jiranek, MD, FACS, FAAOS
AAHKS Representative
Duke University (Durham, NC)

Robert L. Krebbs
Optima Health Representative (Virginia Beach, VA)

Richard F. Seiden, Esq.
Patient/Public Representative (Manhattan Beach, CA)

James D. Slover, MD, MS
The Hip Society Representative
NYU Langone Health (New York, NY)

Jeffrey B. Stambough, MD
AAHKS Representative
University of Arkansas for Medical Sciences (Little Rock, AR)

AJRR Committees

Many volunteers contribute to the success of the Registry. These individuals devote countless hours to ensure that the Registry is of the highest possible quality.

Below is a description of all AJRR Registry committees. Full membership can be found in Appendix E.

California State Registry Committee

Members of the California State Registry Committee conduct clinical affairs and make decisions that support the mission of AJRR and California state-related activities. Activities include data collection and review, public reporting of its findings, coordinating programs with third-party payers, and presentations at national and international meetings.
Chair: James I. Huddleston, III, MD, FAAOS

Young Physicians Committee

The Young Physicians Committee assist in management of the registry science curriculum. Committee members play an intergral role in reviewing and authoring AJRR data driven publications and serving as champions for participating institutions and specialities. Their subject-matter expertise in registry data is utilized for a multitude of projects.
Chair: Jeffrey B. Stambough, MD

Data Elements and Analysis Subcommittee

This subcommittee monitors, receive requests, and makes recommendations for additions or deletions to data elements or assessment tools collected by AJRR. The subcommittee makes recommendations to the Data Management Committee for review prior to discussion and final approval by the AJRR Steering Committee. This subcommittee works with staff and statisticians to determine, develop, and oversee the implementation of appropriate data analysis methodology and algorithms. The subcommittee's purview includes risk adjustment, scientific integrity of data, rigor of conclusions drawn from Registry data, and consideration of optimal reporting and data analysis to provide actionable data for the benefit of patients and other AJRR stakeholders.
Chair: Scott M. Sporer, MD, FAAOS

Mission

To improve orthopaedic care through the collection, analysis, and reporting of actionable data.

Publications Subcommittee

In 2019, recognizing a need to have AJRR representatives review and ensure the integrity of all publications based on Registry data, the Publications Subcommittee was formed. Publications for review include potential abstracts, manuscripts, quarterly or special reports, as well as the Annual Report. The original Annual Report Subcommittee was rolled into the Publications Subcommittee and is one of the final signoffs on the completed Annual Report prior to the document being sent to the Commission and subsequently AJRR's Steering Committee for their review.
Chair: James A. Browne, MD, FAAOS

Research Projects Subcommittee

Members of the Research Projects Subcommittee review incoming external research proposals and requests and make recommendations for project approvals. The committee developed and now maintains the AAOS Registry Analytics Institute®, which launched in February 2019. Members provide guidance for the process and grading of submitted proposals.
Chair: Richard L. Illgen II, MD, FAAOS

AJRR Commission

Established in 2014, the AJRR Commission is a group of arthroplasty specialist orthopaedic surgeons without relevant financial conflicts who serve as independent reviewers of the data published in this Annual Report.

The Commission makes the final recommendation to the Steering Committee regarding the content of the Annual Report. The Commission members are known only to the Steering Committee to ensure members' independence and allow them to avoid undue outside influence pertaining to the report.

Public Advisory Board

The Public Advisory Board (PAB) provides direct input to the Steering Committee from both the patient and public perspective. The PAB members are drawn from a wide variety of public advocacy groups and members of the public who have had joint arthroplasties themselves.

Richard Seiden, Esq., Chair

Jane Beckette, MSN

Chris Michno

William Mulvihill, M.Ed.

Kristin Veno

Outgoing 2020 Volunteers

AJRR would like to express its gratitude and appreciation for the contributions made by all of our volunteers. The Registry would like to specifically recognize the work of the following volunteers whose terms concluded in 2020.

Registry Oversight Committee (ROC)

Kevin J. Bozic, MD, MBA, FAAOS (Austin, TX)

Kristy Weber, MD, FAAOS (Philadelphia, PA)

AJRR Steering Committee

Jonathan H. Lee, MD, FAAOS (Larchmont, NY)

Public Advisory Board

Diana Stilwell, MPH (Boston, MA)

"We are a national organization of orthopaedic surgeons. We should be the arbiter of the national databases in the form of registries to ensure best quality and ultimate value for the patient population. With registries, we truly own that calling."

Ronald A. Navarro, MD, FAAOS
Kaiser Permanente
AAOS Shoulder & Elbow Registry Steering Committee

Industry Collaborations

AJRR recognizes the importance of device surveillance and collecting quality data to improve outcomes. The Registry works with sites and manufacturers to understand how implants contribute to patient experience and quality of life. The AJRR allows for collaboration between providers and companies to evaluate poorly performing implants based on national trends of longitudinal patient data.

Thank You to AJRR Supporters and Partners

2021 Supporters

ConforMIS
djo surgical
stryker
DePuy Synthes – The Orthopaedics Company of Johnson & Johnson
Smith+Nephew
Zimmer Biomet – Your progress. Our promise.

Registry Partners

AAHKS – American Association of Hip and Knee Surgeons
ASCA – Ambulatory Surgery Center Association
The Joint Commission
The Hip Society – Founded in 1968
The Knee Society – Founded in 1983
cohere Health
The OrthoForum – Benchmarking. Networking. Innovation.

"There are individual and collective benefits for AAOS Fellows and their hospitals and practices to participate in this effort, and I hope that every single orthopaedic surgeon finds a way to do so."

Kristy Weber, MD, FAAOS
Penn Medicine
Registry Oversight Committee
Musculoskeletal Tumor Registry Steering Committee
Former AAOS President

Overall Results

2,373,088
procedures submitted to AJRR from Jan 1, 2012 – June 31, 2021

125,751
excluded duplicates and cases with invalid procedure date (before Jan 1, 2012 or after Dec 31, 2020)

2,247,337
procedures dated 2012–2020

2,750
excluded inapplicable, or invalid cases*

2,244,587
valid hip and knee procedures dated 2012–2020 included in analyses

**Invalid data=joint procedures not in the hip or knee, procedure codes outside of approved AJRR data specifications, and hemiarthroplasty procedures without a diagnosis of femoral neck fracture.*

All analyses are completed using a core dataset of hip and knee procedures submitted to the AJRR from January 1, 2012 through June 31, 2021. Cases with invalid data or procedures dated before January 1, 2012 or after December 31, 2020 were further excluded. Data were considered invalid when procedure codes did not match approved codes listed in the AJRR data specifications as well as cases of hemiarthroplasty procedures without a diagnosis of femoral neck fracture. Data from the American Hospital Association (AHA) and the Centers for Medicare & Medicaid Services (CMS) may be merged to supplement AJRR data when applicable, and this will be indicated in table/figure footnotes. Additional inclusion/exclusion criteria for each table or figure will be outlined as needed.

COVID-19 Impact Summary

This was an unprecedented year as the world was faced with the devastating impact of the COVID-19 pandemic, and we continue to navigate these challenges. Healthcare institutions were forced to adapt under the enormous strain on resources and barriers to access and prioritization in healthcare delivery. As a brief glimpse into the direct impact on hip and knee procedures, this year's *AJRR Annual Report* presents Figures 1.1 and 1.2 exploring the procedural case volume during the height of the COVID-19 pandemic; data reflects cases submitted to AJRR from July 2019 to December of 2020 reported as of June 30, 2021. From January 2020 to April 2020, arthroplasty cases submitted to AJRR decreased 89% from hospitals and 96% from ASCs. However, as a testament to the commitment and resiliency of healthcare institutions, clinicians, and patients, reported procedures appeared to rebound to average procedural volume by June of 2020, only two months following the maximal impact of the pandemic.

Figure 1.1 Hospital Case Volume by Month, Jul 2019-Dec 2020

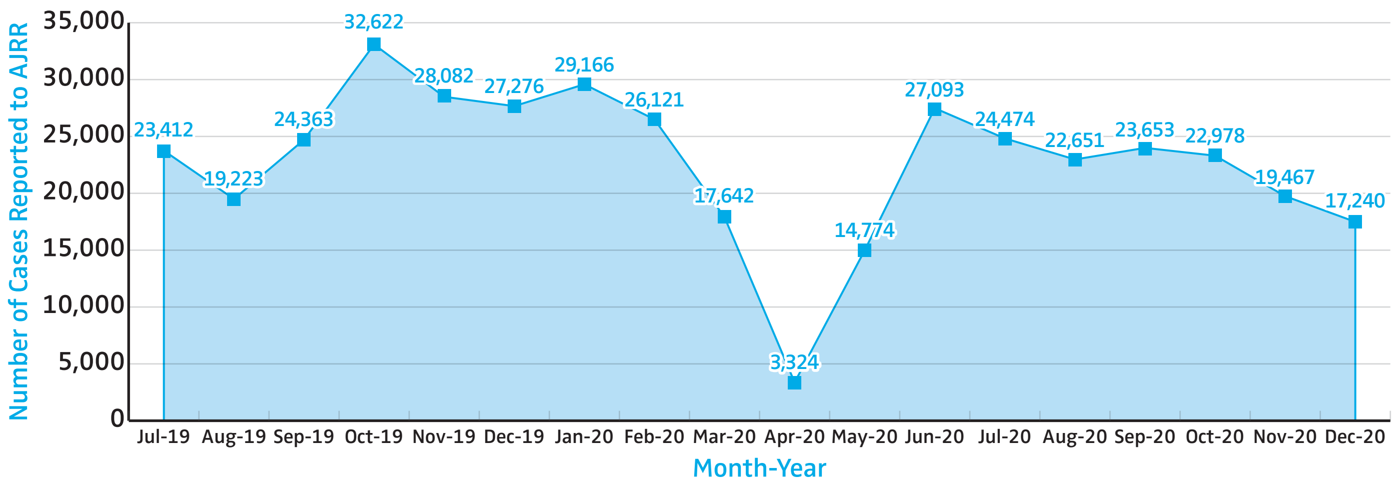
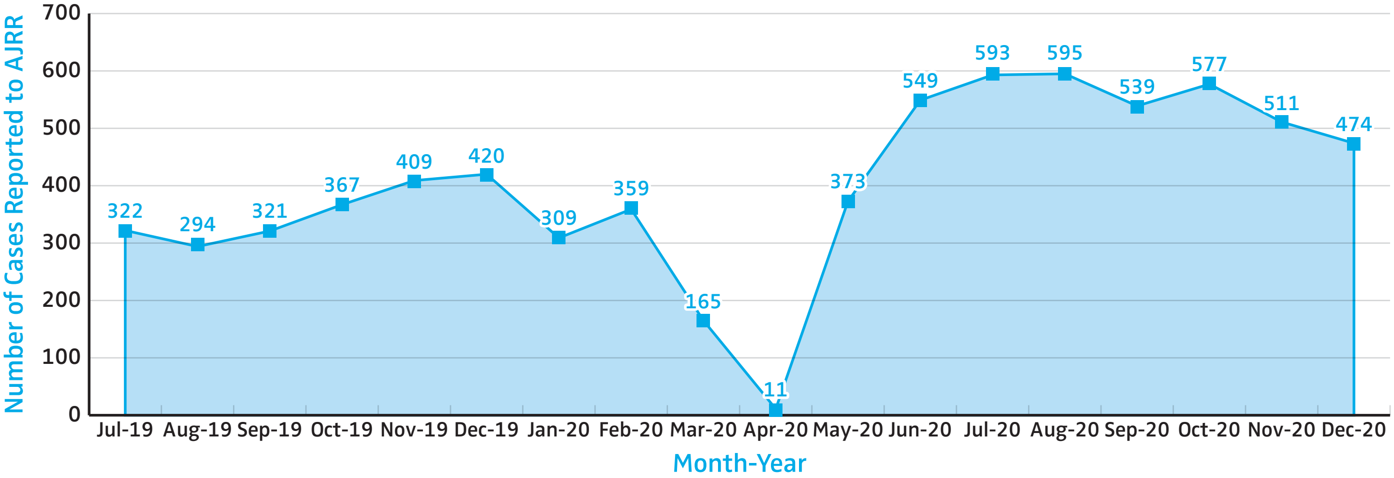


Figure 1.2 Ambulatory Surgical Center Case Volume by Month, Jul 2019-Dec 2020



Procedural Data Metrics

The *2021 American Joint Replacement Registry Annual Report* represents 2,244,587 primary and revision hip and knee arthroplasty procedures performed between 2012 and 2020 (Figure 1.3). Primary knee (54.5%) and primary hip (38.6%) procedures made up the majority of submitted cases (Figure 1.4). Sex breakdown was 58.5% female and 41.1% male for all cases (Figure 1.5). Most of the patients in the data were white (75.6%) although race was not recorded in 15.8% of cases (Figure 1.6).

INSIGHTS

Despite the COVID-19 pandemic, the *2021 Annual Report* had an overall cumulative procedural volume growth of 18.3% compared to the 2020 report.

AJRR accepts historical data back to 2012. Therefore, annual volumes from prior years are continually being updated. The cumulative procedural volume grew by 18.3% in 2020 when comparing to the previous Annual Report (347,537 additional cases). This dataset utilized in this Annual Report represents a snapshot of AJRR data taken on July 1, 2021.

Figure 1.3 Cumulative Procedure Volume, 2012-2020 (N=2,244,587)

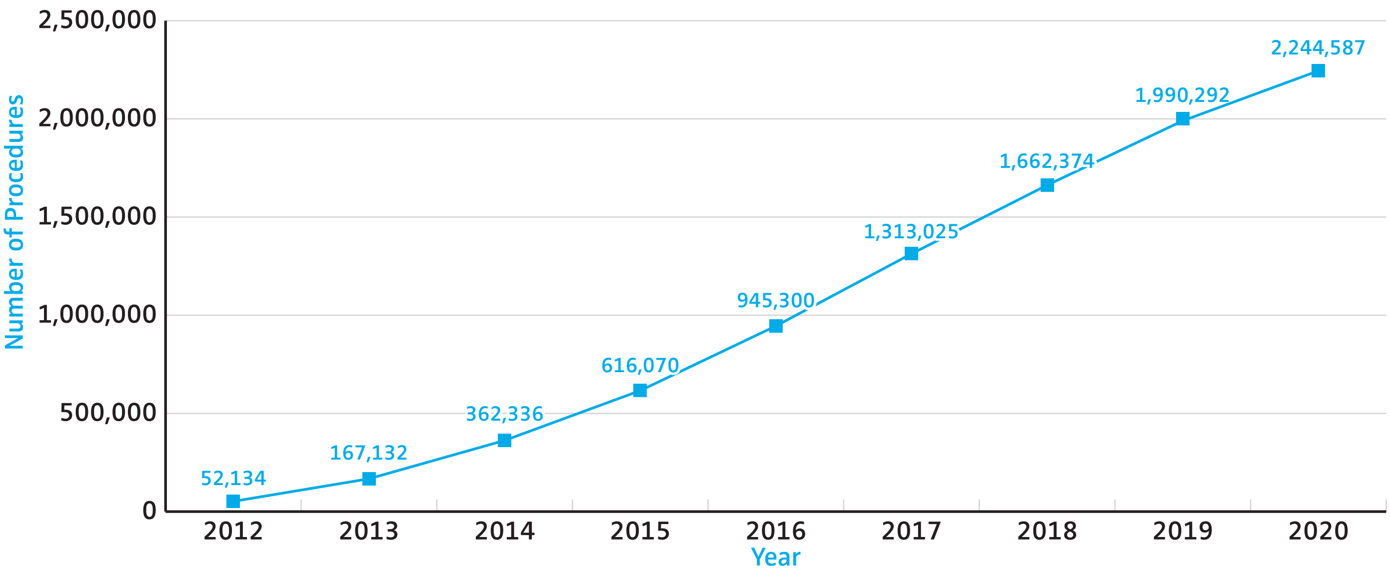


Figure 1.4 Distribution of Arthroplasty Procedures, 2012-2020 (N=2,244,587)

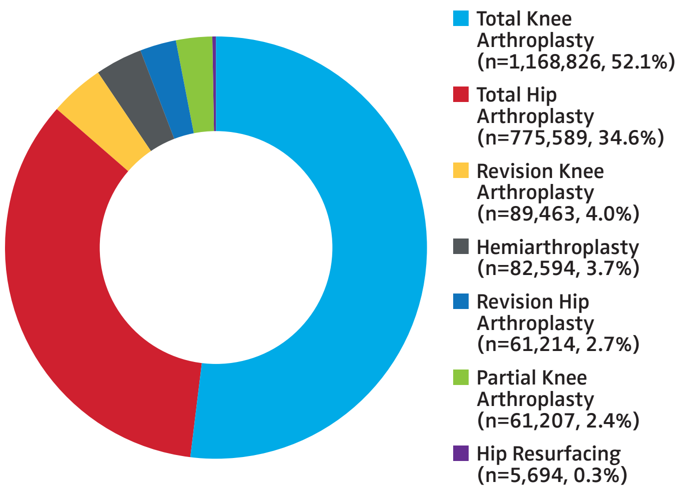
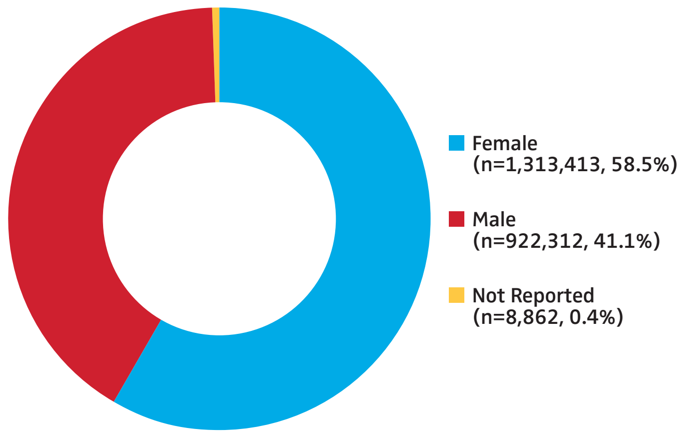


Figure 1.5 Sex of Patients Undergoing Procedures, 2012-2020 (N=2,244,587)



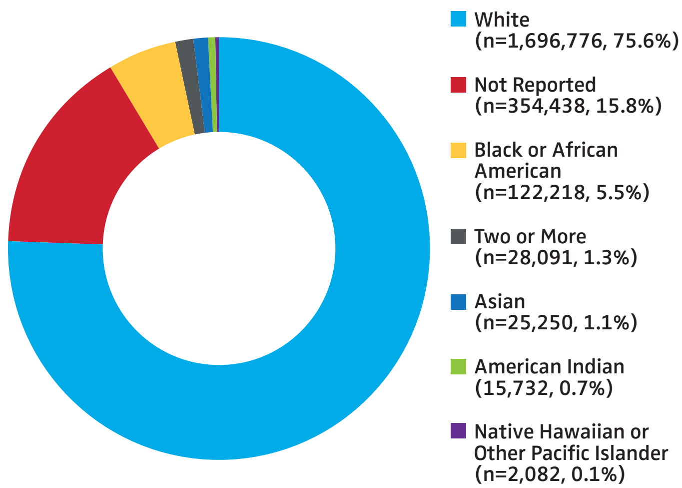
Submitting Facilities

Since inception, facility enrollment and data submission have been a major priority including growth in the number of hospitals, ASCs, and private practice groups submitting data to the Registry. By end of 2020, there were 1,152 institutions submitting data to the AJRR from across all 50 states and the District of Columbia; this represents a 13% increase from the previous report. A list of all enrolled facilities and those that submitted data used in the *2021 Annual Report* can be found in Appendix F.

AJRR has no requirements on the frequency of data submission but recommends as a best practice at least quarterly. In addition to increasing facility enrollment, the Registry is focused on promoting active data submission. To help with this, the Registry has a Registry Support Team and Support Specialists to expedite submissions and minimize the data submission burden.

Similar to past years, the majority of arthroplasty procedures submitted to the Registry were performed in medium-sized hospitals (43.7%, 100-399 beds) and minor teaching institutions (40.5%, reported medical school affiliation or approved residency/internship program) (Figures 1.7 and 1.8). Non-teaching institutions were close behind minor teaching institutions at 33.4%. Of those with institutional data in the American Hospital Association (AHA) survey, major and minor teaching hospitals accounted for 51.4% of all AJRR submitting hospitals.

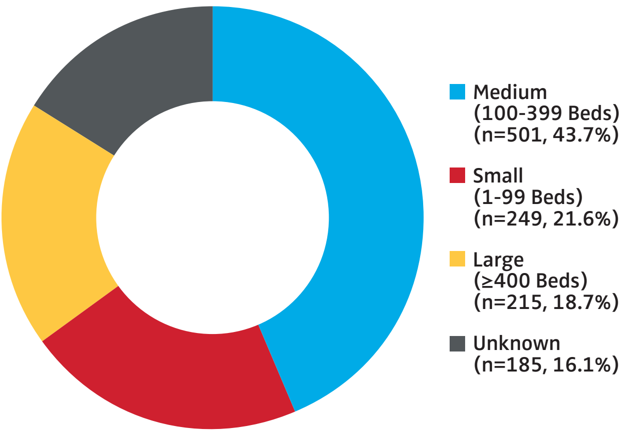
Figure 1.6 Race of Patients Undergoing Procedures, 2012-2020 (N=2,244,587)



INSIGHTS

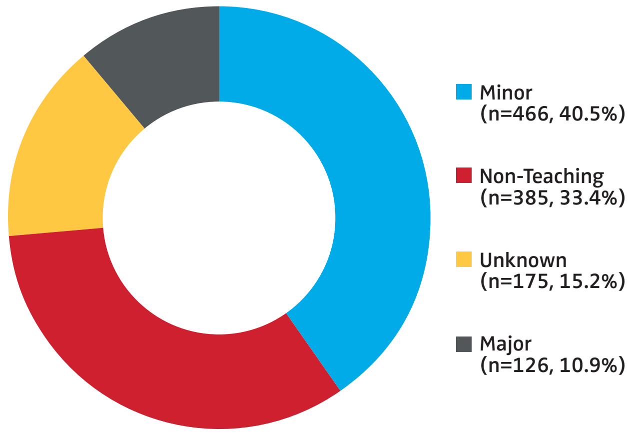
The majority of arthroplasty procedures submitted to the Registry were performed in medium-sized hospitals (43.7%) and minor teaching institutions (40.5%).

Figure 1.7 Hospital Bed Size of Submitting Facilties, 2012-2020 (N=1,152)



Data supplemented with American Hospital Association (AHA) Annual Survey Database Fiscal Year 2015

Figure 1.8 Distribution of Submitting Institution Teaching Affiliation, 2012-2020 (N=1,152)



Data supplemented with American Hospital Association (AHA) Annual Survey Database Fiscal Year 2015

Ambulatory Surgery Centers

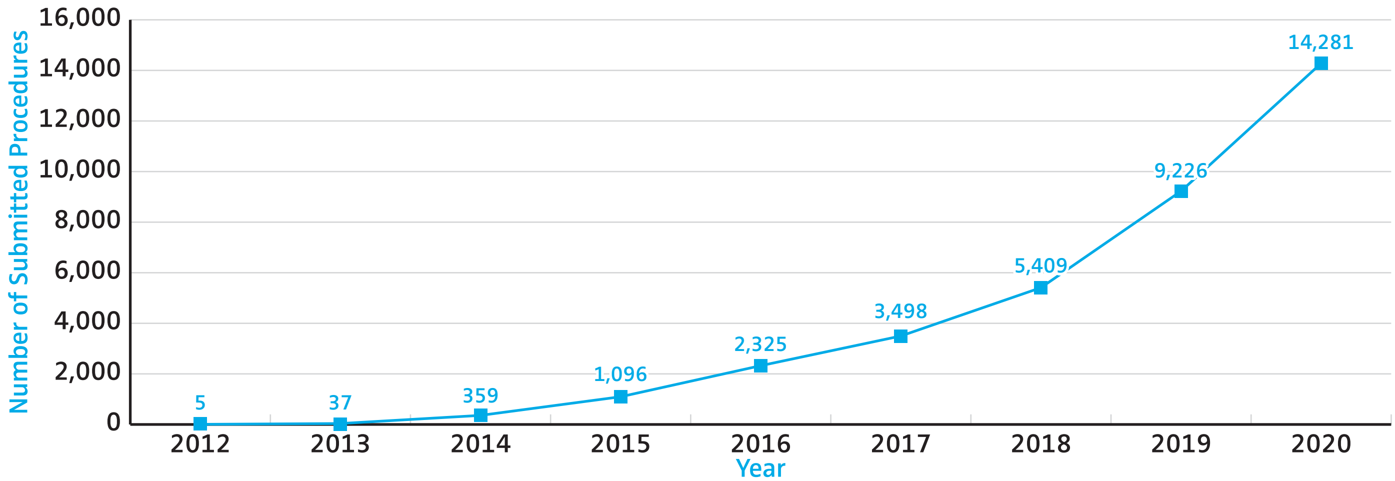
Ambulatory surgery centers (ASCs) play an increasingly important role in the delivery of total joint arthroplasty care in the United States. While historically much of the procedural information in the Registry has come from hospitals, the number of arthroplasties performed in outpatient settings continues to rise.[1] Considering this, AAOS understands the need to capture information from ASCs and private practices so these facilities have access to data quality, analysis, and benchmarking. In late 2018, AAOS took the first steps toward growing its ASC representation by restructuring the Registry Engagement Team.

An ASC is classified by a submitting institution on their AJRR application and can be either freestanding or affiliated with a hospital. The number of procedures submitted by ASCs has grown exponentially between 2012 (n=5) and 2020 (n=14,281) and has increased by 82% since the *2020 AJRR Annual Report* (Figure 1.9).

INSIGHTS

The number of procedures submitted by ASCs has grown exponentially between 2012 (n=5) and 2020 (n=14,281) and has increased by 55% since 2019.

Figure 1.9 Cumulative Procedure Volume from Ambulatory Surgery Centers by Year, 2012-2020



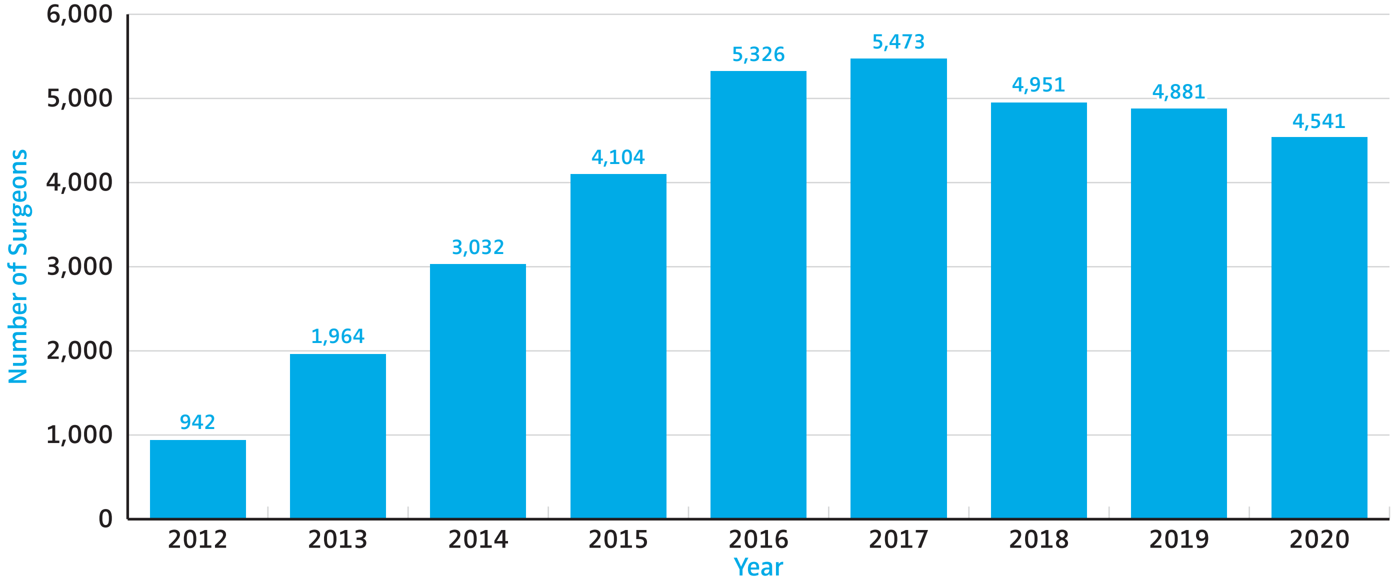
Submitting Surgeons

INSIGHTS

4,541 Surgeons have submitted at least one procedure in 2020 to AJRR, a number which is expected to grow as sites continue to submit data.

AJRR submitting institutions report data for an average of 13.2 surgeons (range 1-319). These numbers include surgeons that have done at least one arthroplasty procedure. As part of the contract, AJRR participating institutions are required to submit data from all surgeons conducting hip or knee joint arthroplasty procedures at their facility. This is validated by annual audits (See Appendix C). As of now, 4,541 surgeons have submitted at least one procedure in 2020 (Figure 1.10). As AJRR accepts historical data and many institutions submit towards the end of the following year, it is anticipated that the 2020 number of surgeons with cases submitted to the AJRR in recent years (2018-2020) will increase in future Annual Reports.

Figure 1.10 Number of Surgeons Represented in Annual Procedure Submissions by Year, 2012-2020



Data Completeness

In February 2017, AJRR significantly expanded on the elements being collected to include procedural data, patient risk factors and comorbidities, and post-operative complications. To allow time for participants to adjust to the additions, these changes were not made mandatory until June 2018. Elements that can automatically be extracted from an electronic health record (EHR), such as discharge disposition and length of stay, tend to have higher data completeness (Table 1.1). Other elements that require more manual submission such as anesthesia type or surgical approach are more difficult to submit. The data elements that are collected by AJRR and their completeness are frequently reviewed to ensure relevant data points are being captured. Making updates to a data specification is a lengthy process. Understanding how data is submitted to the Registry and what percentage has acceptable values can help guide these updates.

In the last year, a range of increases and decreases in data completeness were observed. Most notably, the completeness of incision start time and skin closure time has increased by approximately 20% over baseline in the last year. Key demographic variables such as race and ethnicity increased by approximately 6% over baseline. Other modest increases to clinically relevant data elements such as anesthesia type, surgical approach, and ASA classification are noted. The completion of the computer-assisted and robotic assisted surgery data elements dropped by approximately 10% and 6% respectively. However, more specific data elements detailing the model and software version of computerized or robotic technologies were released in the 2021 data specifications. For many elements, "not reported" or "NR" is an accepted value.

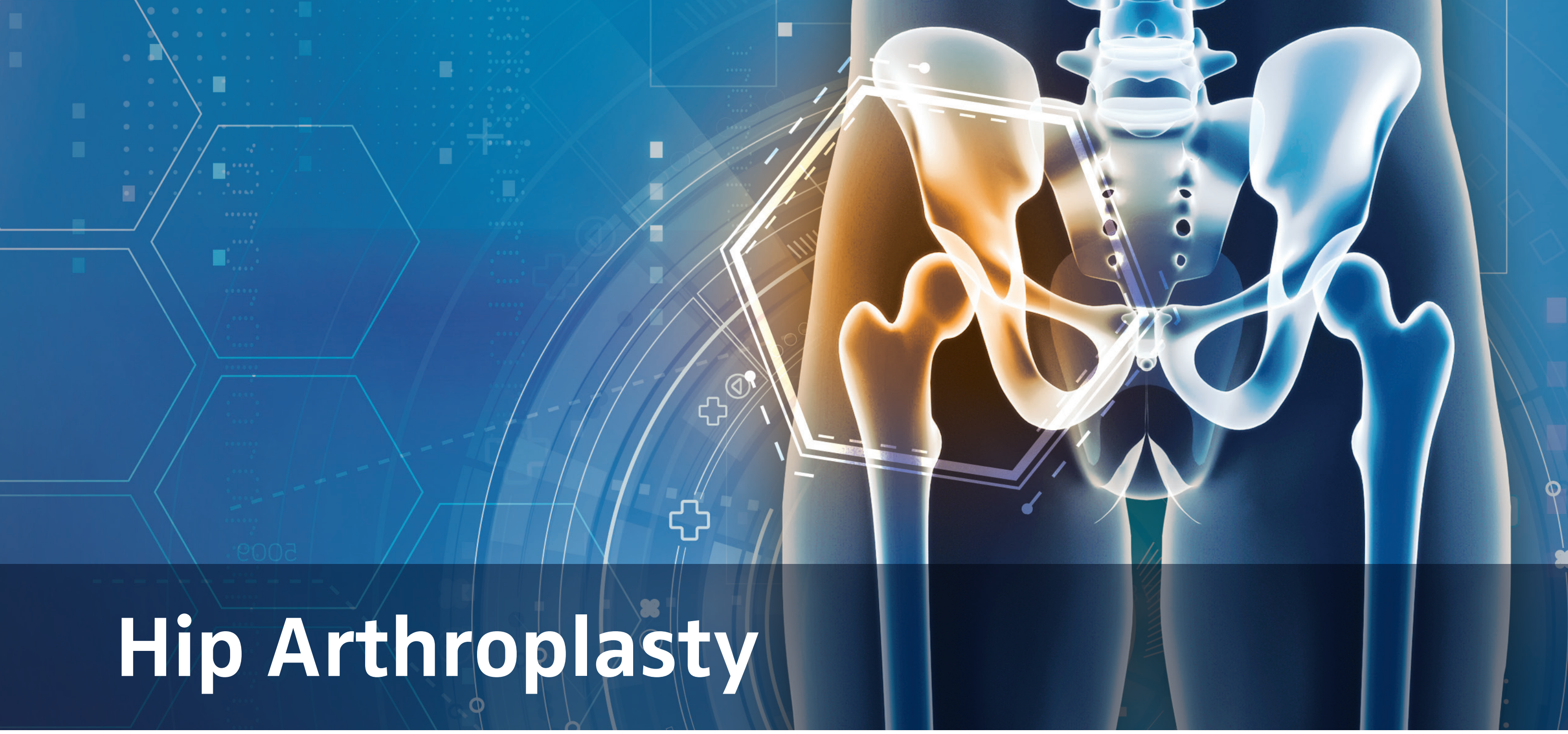
In February 2017, AJRR significantly expanded on the elements being collected to include procedural data, patient risk factors and comorbidities, and operative and post-operative complications.

INSIGHTS

Table 1.1 Completeness of AJRR Data Elements, 2012-2020

Specifications Period	Element	% Reported	% NR	% Invalid	1-Year % Reported (% Change)
AJRR Data 2012 - 2021Q2 (N=2,323,697) (1-Year N=407,722)					
All Versions	Surgeon Information	99.87	0	0.13	99.92 (+0.05)
	Principal Procedure Code	99.78	0	0.22	100 (+0.22)
	Principal Diagnosis Code	93.38	0	6.62	99.41 (+6.03)
	First Implant Catalog # Listed	95.3	0	4.7	86.8 (-8.5)
	First Implant Lot # Listed	93.15	0	6.85	87.12 (-6.03)
	Incision Start Time (Procedure Start Time)	68.33	30.24	1.43	88.41 (+20.08)
	Skin Closure Time (Procedure End Time)	68.25	30.39	1.36	89.32 (+21.07)
	Ethnicity	82.08	17.12	0.8	88.32 (+6.24)
	Race	84.33	14.83	0.84	90.62 (+6.29)
	Date of Birth	100	0	0	100 (+0)
	Gender	99.6	0.4	0	98.08 (-1.52)
	City	92.7	7.3	0	98.68 (+5.98)
	State	94.5	5.5	0	99.97 (+5.47)
	Zip Code	94.38	0	5.62	99.94 (+5.56)
AJRR Data 2012 - 2021Q2 Using Updated Specifications (N=1,149,951) (1-Year N=407,722)					
Late 2017-2021 Versions	Comorbidity - at least one code reported	73.56	25.24	1.2	68.01 (-5.55)
	Body Mass Index (BMI)	86.98	12.66	0.36	87.46 (+0.48)
	Discharge Disposition Code	92.6	6.18	1.23	91.46 (-1.14)
	Admission Date	98.03	1.97	0	96.54 (-1.49)
	Discharge Date	98.05	1.95	0	96.56 (-1.49)
	Length Of Stay	98.01	1.99	0	96.52 (-1.49)
	Surgical Approach (Hip/Knee)	14.21	79.8	5.99	17.43 (+3.22)
	Computer Navigation	34.24	64.86	0.9	24.4 (-9.84)
	Robotic Assisted	40.1	59.76	0.14	34.33 (-5.77)
	Anesthesia Type	65.17	27.47	7.36	67.95 (+2.78)
	Periarticular Injection	18.81	80.82	0.37	21.59 (+2.78)
	ASA Classification	23.62	75.88	0.5	26.2 (+2.58)
AJRR Data 2012 - 2021Q2 Using 2020 or Newer Specifications (N=122,691) (1-Year N=110,058)					
2020 - 2021 Versions	Tourniquet Use (N=68,968)*	37.15	62.82	0.03	33.67 (-3.48)
	Trainee	7.01	92.82	0.17	7.5 (+0.49)
	Payer Status	36.95	62.68	0.38	33.88 (-3.07)

**Knee procedures only*



Hip Arthroplasty

Hip Overview

Between 2012 and 2020, AJRR has collected data on 927,375 hip arthroplasty procedures.

The majority of surgeons with data in AJRR perform both elective primary total hip arthroplasties and hip arthroplasties for fracture. For those surgeons performing elective primary total hip arthroplasty procedures, the mean procedure count was 26.68 with an interquartile range (25th-75th percentile) of 3-34 procedures (Table 2.1). The case per surgeon median is lower, suggesting a higher frequency of lower volume surgeons in the Registry. This distribution of procedures is consistent with previous studies of hip arthroplasty in the United States.[2] Only surgeons with at least one relevant hip procedure were included. The types of hip procedures reported remained relatively constant as a percentage of all hip procedures performed in 2020 (Figure 2.1). The "other procedures" category includes procedures such as arthrotomy and conversion from prior hip surgery. The mean age for patients undergoing an elective primary total hip arthroplasty was 66.1 years. While hip resurfacing is reported infrequently in the AJRR, this patient population is younger with an average age of 53.6 years (Table 2.2, Figure 2.2).

Table 2.1 Average Procedural Volume for Participating Surgeons, 2020

Procedure	Surgeons	Number of Procedures	Mean	Median	25th Percentile	75th Percentile
Elective Primary THA	3,143	83,845	26.68	12	3	34
Hemiarthroplasty	2,210	9,510	4.3	3	1	5
Revision Hip Arthroplasty	1,220	3,803	3.12	2	1	3
THA for Fracture	1,231	3,288	2.67	2	1	3
Hip Resurfacing	43	146	3.4	1	1	3
Other Procedures	69	186	2.7	1	1	3

Figure 2.1 Distribution of Procedure Codes for All Hip Arthroplasty Procedures, 2012-2020 (N=927,375)

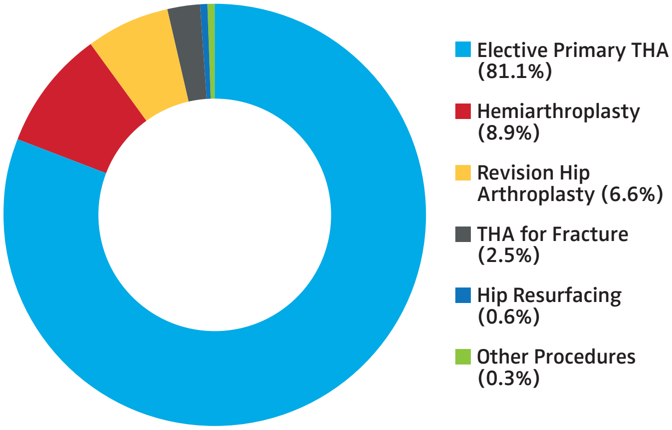
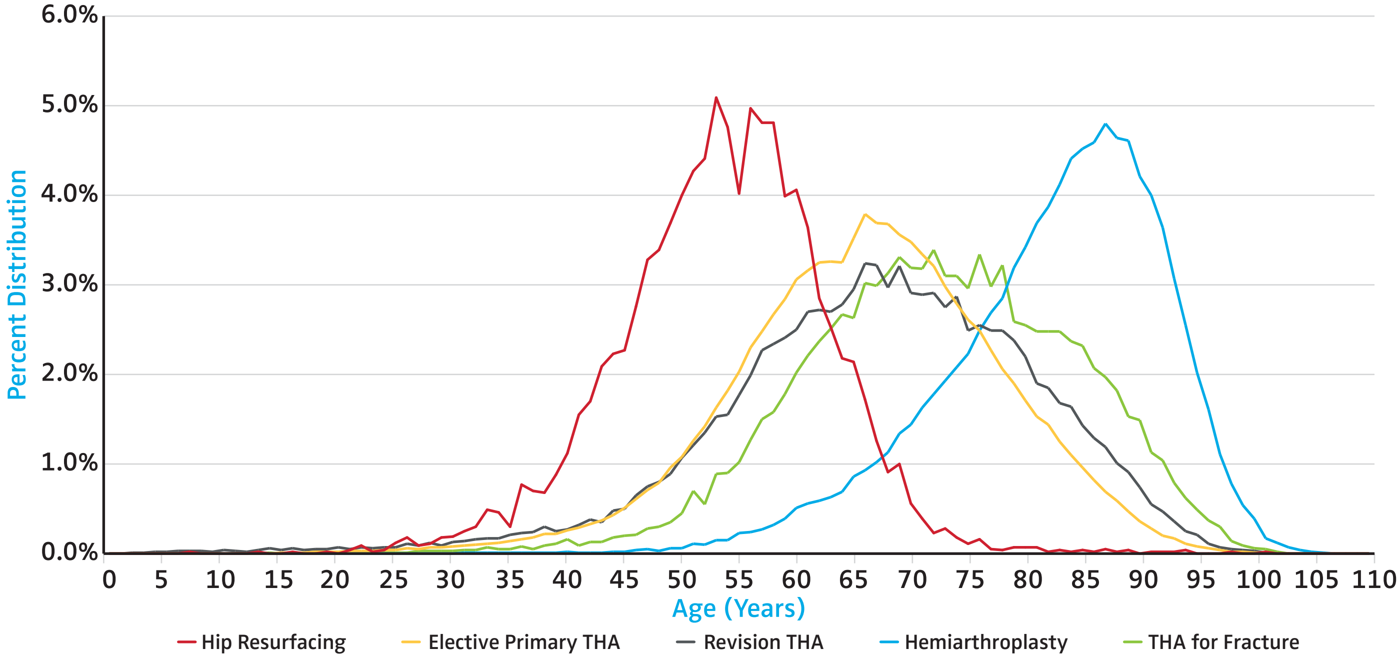


Table 2.2 Mean Age of Patients Undergoing Hip Arthroplasty Procedures, 2012-2020 (N=927,375)

Procedure	Total	Mean Age	Standard Deviation
Elective Primary THA	752,440	66.1	11.5
Hemiarthroplasty	82,594	82.3	9.8
Revision Hip Arthroplasty	61,214	67.1	13.6
THA for Fracture	23,149	72.3	11.8
Hip Resurfacing	5,694	53.6	9.0
Other Procedures	2,284	64.0	17.2

Figure 2.2 Age Distribution of Hip Arthroplasty Procedures, 2012-2020 (N=925,091)

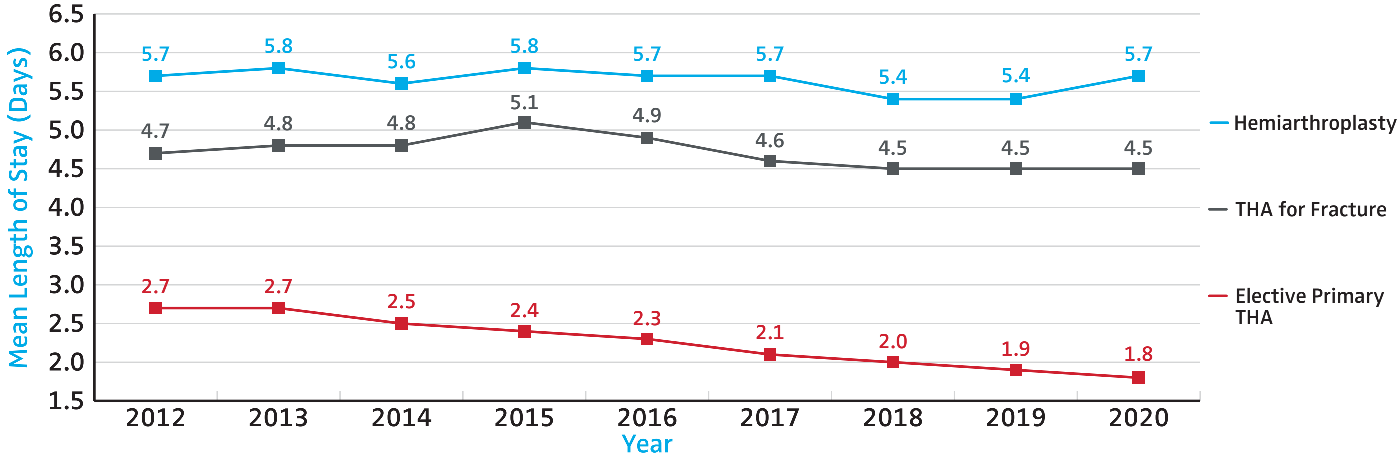


When evaluating mean length of stay in the AJRR cohort, there was a significant decrease of over 0.5 days when comparing mean length of stay for elective primary total hip arthroplasties from 2012 (2.7 days) to 2020 (1.8 days) ($p<0.0001$). Length of stay in patients with a fracture treated with total hip arthroplasty or hemiarthroplasty has remained relatively constant over time (Figure 2.3). For this analysis, length of stay was calculated by subtracting admission date from discharge date.

INSIGHTS

Length of stay for elective total hip arthroplasty procedures continues to decrease, whereas length of stay for arthroplasty for hip fracture has remained stable over the past decade.

Figure 2.3 Mean Length of Stay for Hip Arthroplasty Procedures, 2012-2020 (N=445,614)



Arthroplasty for Femoral Neck Fracture

Between 2012 and 2020, AJRR has collected data on 105,743 hip arthroplasty procedures for femoral neck fracture.

In the AJRR population, displaced femoral neck fractures (FNF) are commonly treated with either hemiarthroplasty or total hip arthroplasty (THA). The optimal treatment for these fractures remains a topic of debate and is typically individualized to the patient.[3] Given that AJRR only collects arthroplasty procedures, patients treated with open reduction and internal fixation (ORIF) are not included. While historically AJRR has seen hemiarthroplasty predominate as the most frequent arthroplasty option for FNF, there has been a significant decrease in its use compared to THA between 2012 and 2020 (Figure 2.4). This finding is consistent with reports from other national registries.[4,5] In AJRR, for patients <60 years of age, THA was the more common treatment for displaced FNF. This switches at age >60 years, where hemiarthroplasty becomes preferred, and becomes the predominant option for patients >70 years of age (Figure 2.5).

INSIGHTS

The trend towards increasing use of total hip arthroplasty instead of hemiarthroplasty for femoral neck fractures continues.

Figure 2.4 Total Hip Arthroplasty and Hemiarthroplasty Procedures Performed for Femoral Neck Fracture, 2012-2020 (N=105,743)

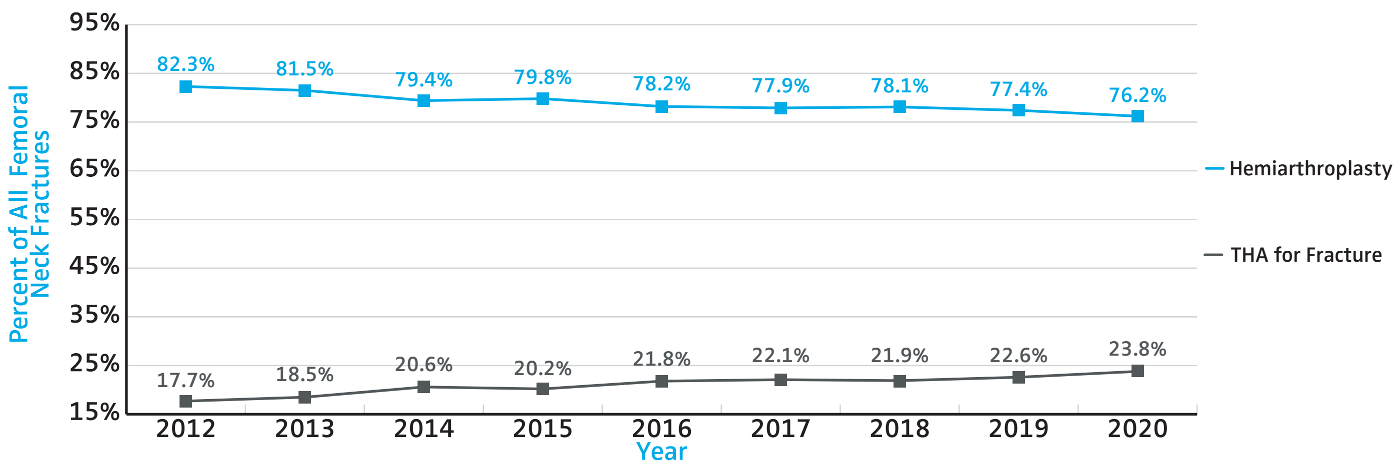
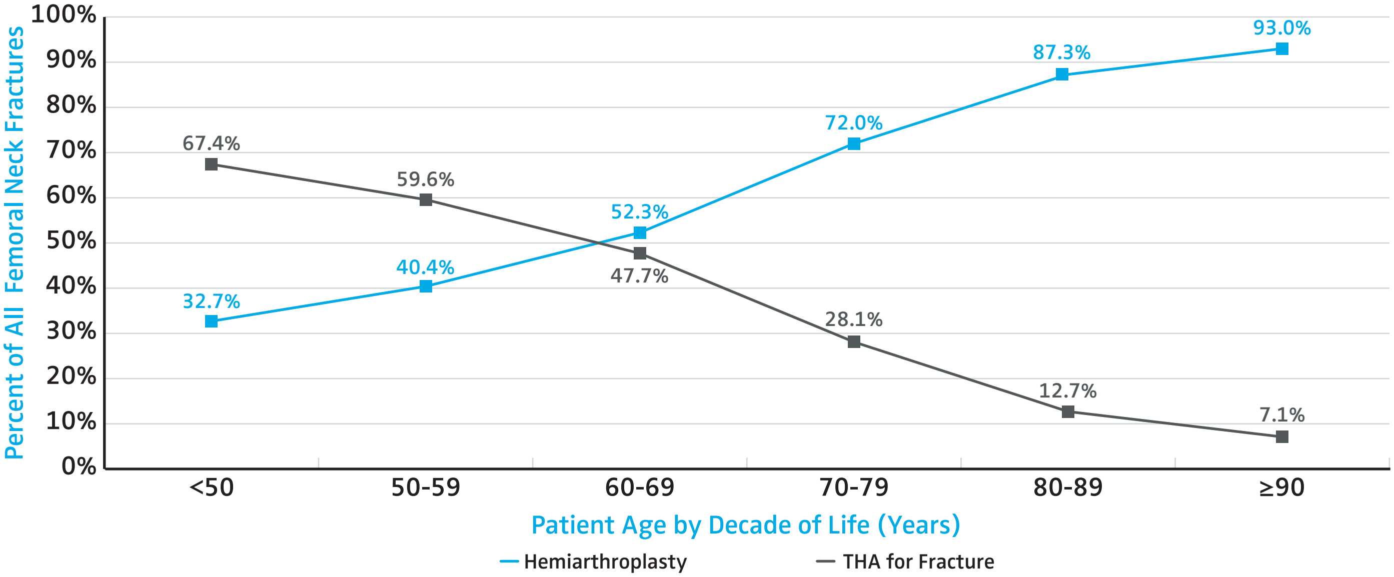


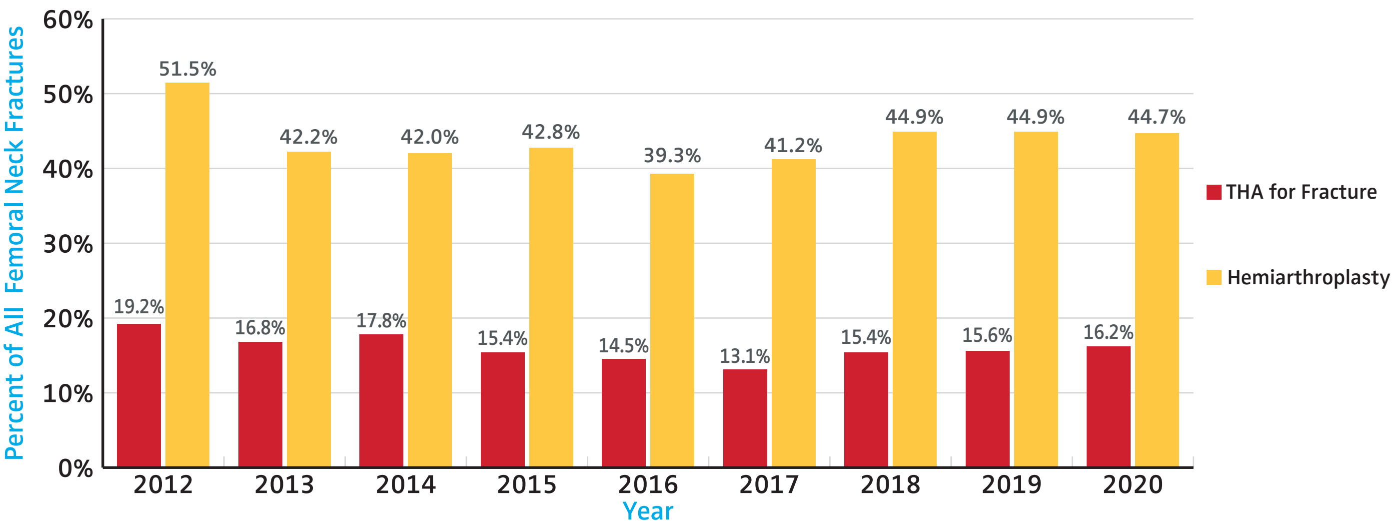
Figure 2.5 Percent of Total Hip Arthroplasty and Hemiarthroplasty Procedures for Treatment of Femoral Neck Fracture by Age Group, 2012-2020 (N=105,743)



Both cemented and cementless fixation for femoral stems are frequently used in the treatment of femoral neck fractures. Cemented fixation was more commonly utilized for hemiarthroplasty than total hip arthroplasty. While AJRR saw an increase is cementless stem use for hemiarthroplasty through 2016, this appears to have peaked in 2016 at 61.7%. The use of cement for femoral stem fixation in the setting of arthroplasty for femoral neck fracture appears stable over the past three years with little change in utilization (Figure 2.6).

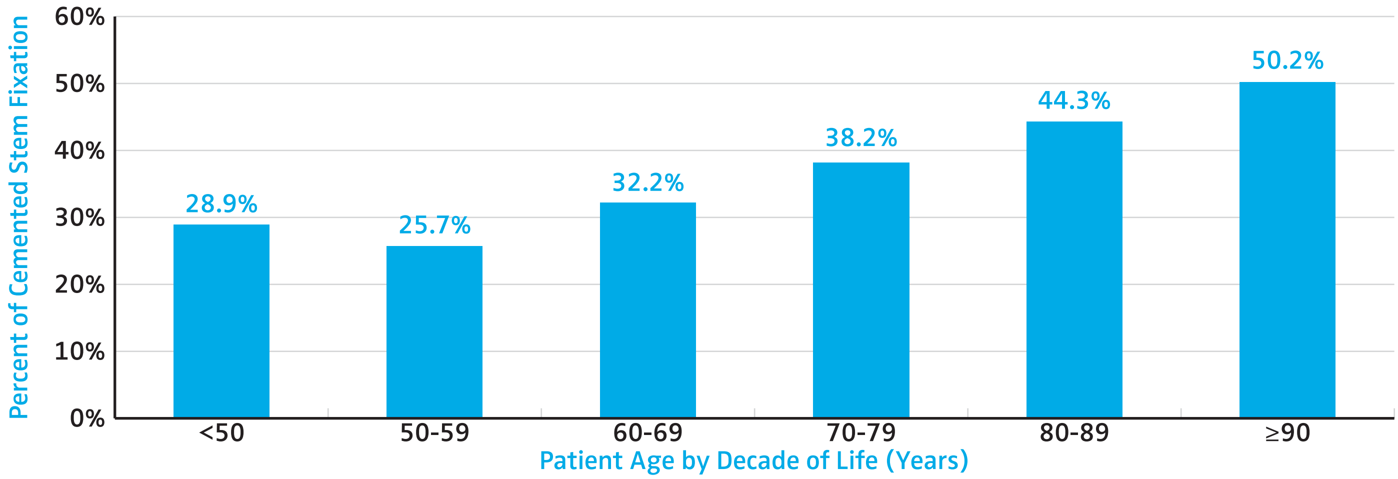
The use of cement for femoral stem fixation in the setting of arthroplasty for femoral neck fracture appears stable over the past three years with little change in utilization.

Figure 2.6 Cemented Fixation for Femoral Stems in Total Hip Arthroplasty and Hemiarthroplasty for Femoral Neck Fracture, 2012-2020 (N=32,356)



Cemented femoral component fixation used in hemiarthroplasty for the treatment of FNF increased in utilization with each advancing decade of life (Figure 2.7). In contrast to the majority of international registries, however, only 50% of the oldest age group received cemented stems.[6-8] Internationally, cemented femoral stem fixation for femoral neck fractures still predominates; in 2018, the National Joint Registry and Swedish Hip Arthroplasty Register reported that 19.6% and just under 2% (respectively) of all stems used to treat femoral neck fractures were cementless.[7,8]

Figure 2.7 Percent of Cemented Stem Fixation Used in Hemiarthroplasty for Femoral Neck Fracture by Age Group, 2012-2020 (N=29,521)

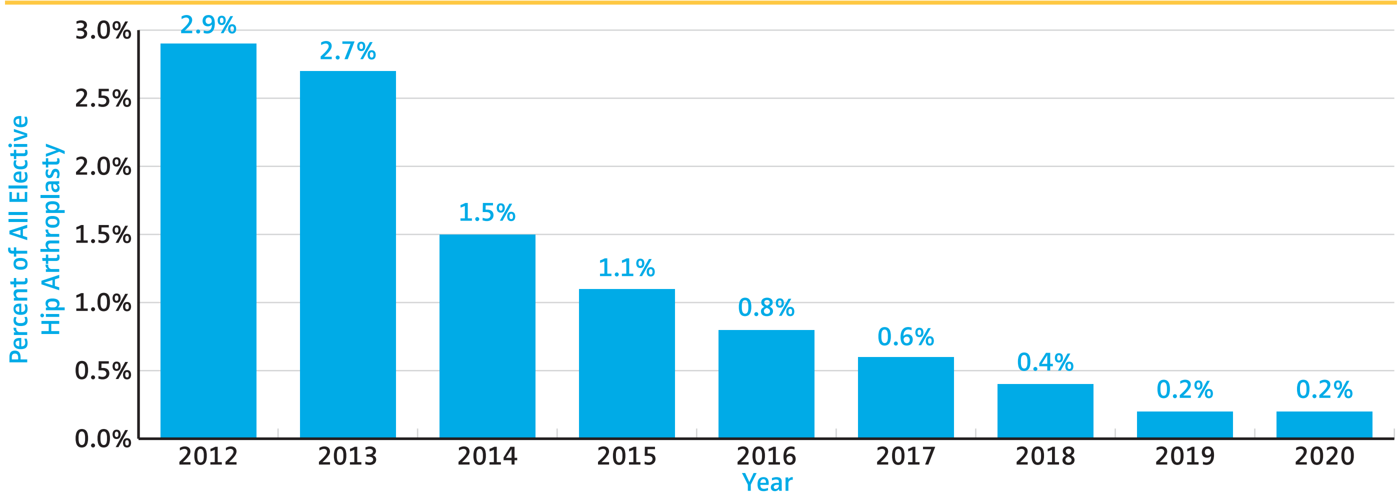


Hip Resurfacing

Between 2012 and 2020, AJRR has collected data on 5,675 hip resurfacing procedures.

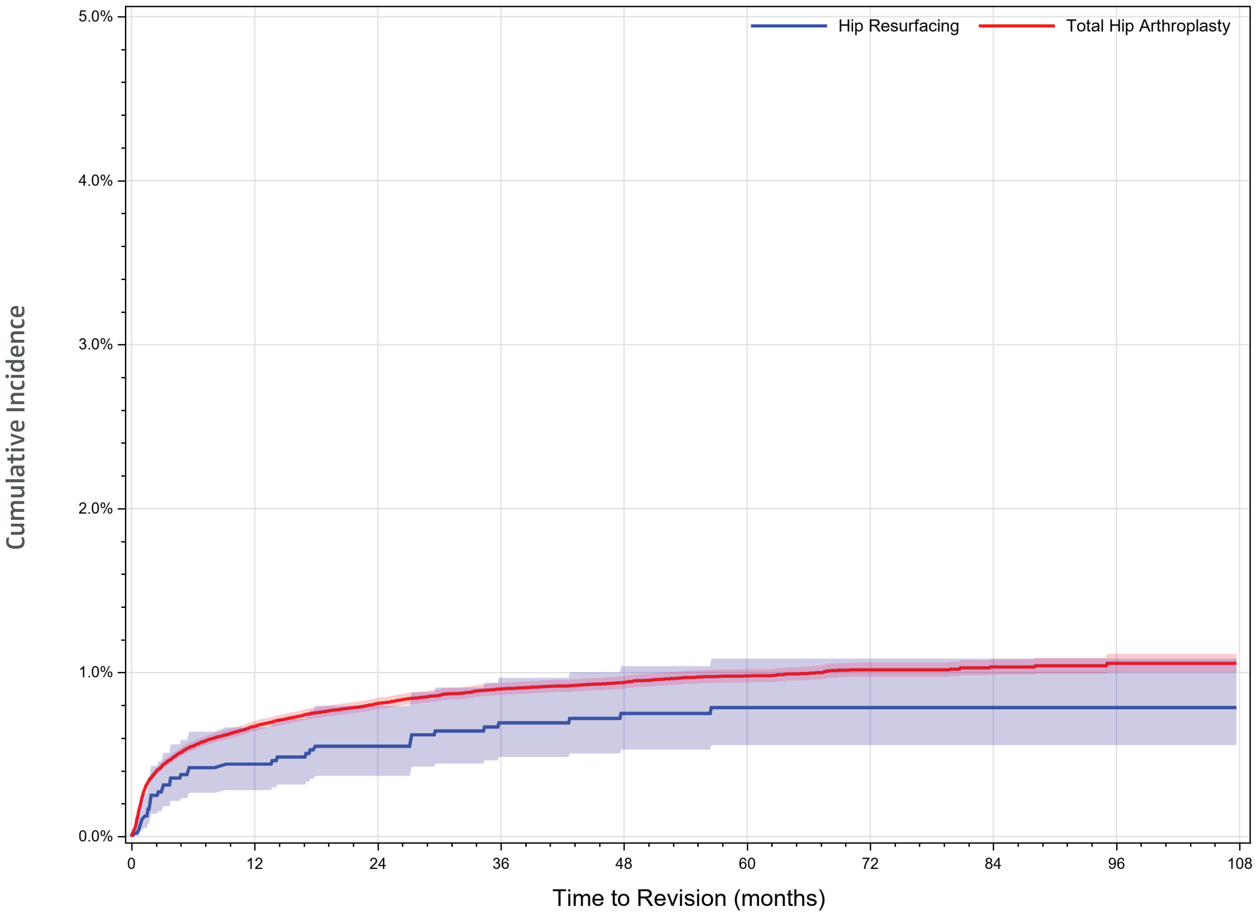
Hip resurfacing as a percentage of the total number of elective hip arthroplasty procedures submitted to AJRR continues to decline likely due to the diminished enthusiasm for metal-on-metal articulations.[9] In 2020, a total of 42 surgeons performed the 145 hip resurfacing procedures submitted to AJRR. Of these procedures, 100 (69%) were performed by eleven surgeons, and 48% of those procedures were performed by two surgeons. Males under the age of 65 made up 83% of cases with resurfaced hips.

Figure 2.8 Hip Resurfacing as a Percentage of Elective Hip Arthroplasty Procedures, 2012-2020 (N=5,675)



This is the first year that cumulative incidence function (CIF) curves to present cumulative percent revision over time have been presented for hip resurfacing (See Appendix G for CIF methodology). Figures 2.9 and 2.10 reflect all-age elective primary THA cases and are not merged with available Medicare data. When looking at revision rates following hip resurfacing versus primary total hip arthroplasty, young men tended toward decreased revision with resurfacing, though this did not reach statistical significance (Figure 2.9). Females were found to have significantly increased cumulative percent revision with hip resurfacing (Figure 2.10).

Figure 2.9 Cumulative Percent Revision for Hip Resurfacing for Elective Primary Total Hip Arthroplasty in All-Age Male Patients Submitted to AJRR with Primary Osteoarthritis, 2012-2020



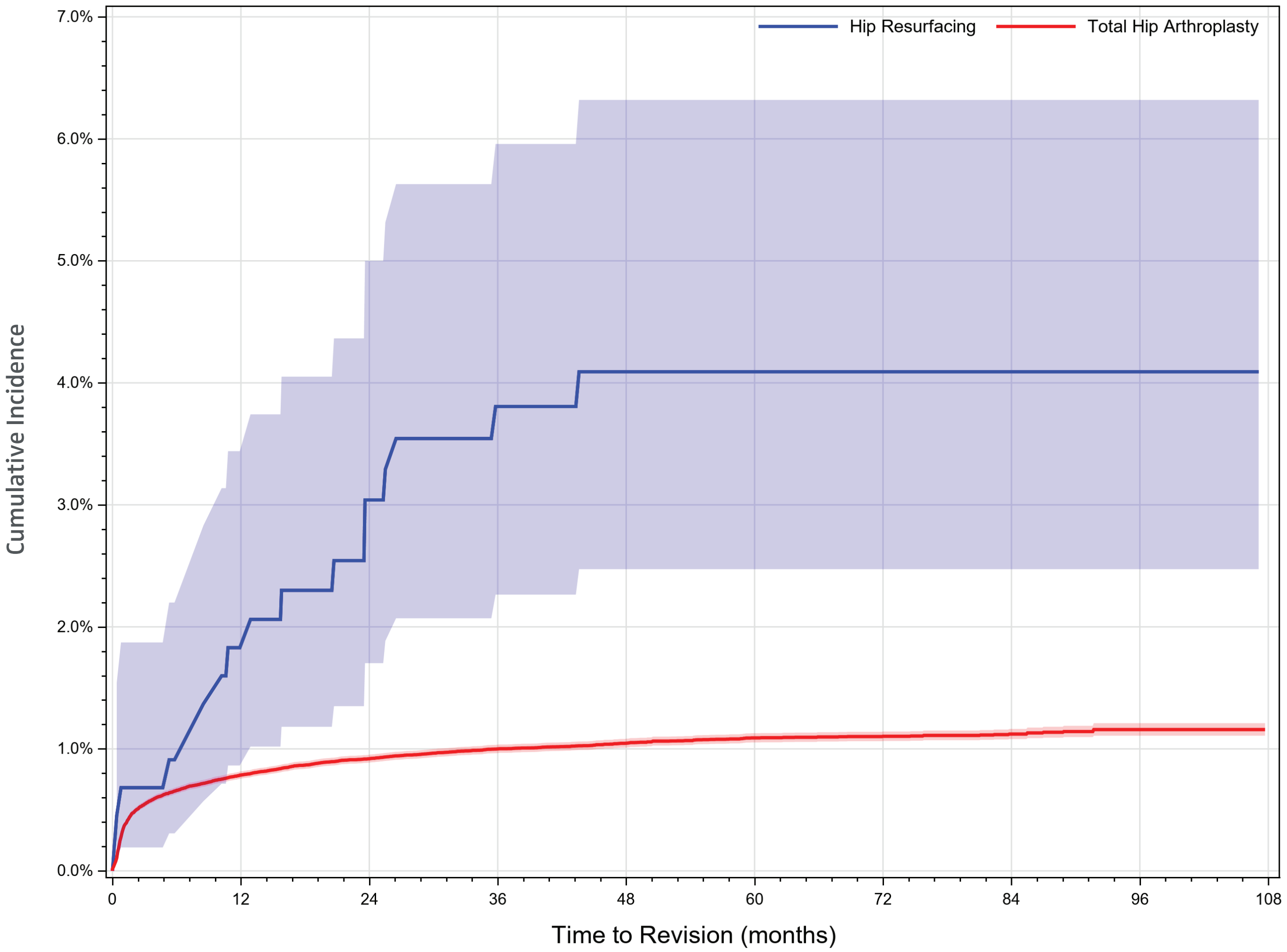
Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Hip Resurfacing	167	247	430	700	705	735	718	696	386	4,784
Total Hip Arthroplasty	38,657	45,261	45,613	45,971	40,256	29,954	22,048	12,639	5,551	285,950
Total	**38,824**	**45,508**	**46,043**	**46,671**	**40,961**	**30,689**	**22,766**	**13,335**	**5,937**	**290,734**

Age Adjusted Hazard Ratio (95% CI)
Hip Resurfacing vs. Total Hip Arthroplasty: *0.739 (0.527, 1.035) p=0.0781*

INSIGHTS

Females have a significantly higher cumulative percent revision rate with hip resurfacing versus primary total hip arthroplasty in cases submitted to the AJRR.

Figure 2.10 Cumulative Percent Revision for Hip Resurfacing for Elective Primary Total Hip Arthroplasty in All-Age Female Patients Submitted to AJRR with Primary Osteoarthritis, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Hip Resurfacing	17	34	24	49	63	59	76	74	44	440
Total Hip Arthroplasty	47,656	56,632	57,662	57,170	50,667	37,158	27,314	15,902	6,895	357,056
Total	**47,673**	**56,666**	**57,686**	**57,219**	**50,730**	**37,217**	**27,390**	**15,976**	**6,939**	**357,496**

Age Adjusted Hazard Ratio (95% CI)
Hip Resurfacing vs. Total Hip Arthroplasty: *3.410 (2.124, 5.475) p<0.0001*

Elective Primary Total Hip Arthroplasty

Between 2012 and 2020, AJRR has collected data on 752,440 elective primary total hip arthroplasty procedures.

Similar to previous *AJRR Annual Reports*, more than half of patients <60 years of age undergoing elective primary total hip arthroplasty were male. After the age of 60, females predominate and this trend increases with each additional decade of life (Figure 2.11).

Since 2012, AJRR data has shown an increase in use of 36mm heads, though this has remained relatively stable over the last four years. A corresponding decrease in utilization of 32mm femoral heads over this time period is also seen (p<0.0001). Use of larger (>40mm) head sizes has increased slightly, and smaller (<28mm) head sizes have been relatively stable over time accounting for only 3,300 cases in 2020. The use of dual mobility articulations in both primary and revision hip arthroplasty as reported to AJRR continues to increase (Figure 2.12).

The percentage utilization of 36mm femoral heads in primary elective THA appears to have peaked around 60%. Larger diameter heads >= 40mm and dual mobility show increasing utilization over time over time while the utilization of 32mm heads continues to decline.

INSIGHTS

Figure 2.11 Sex Distribution for Elective Primary Total Hip Arthroplasty Procedures by Age Group, 2012-2020 (N=749,259)

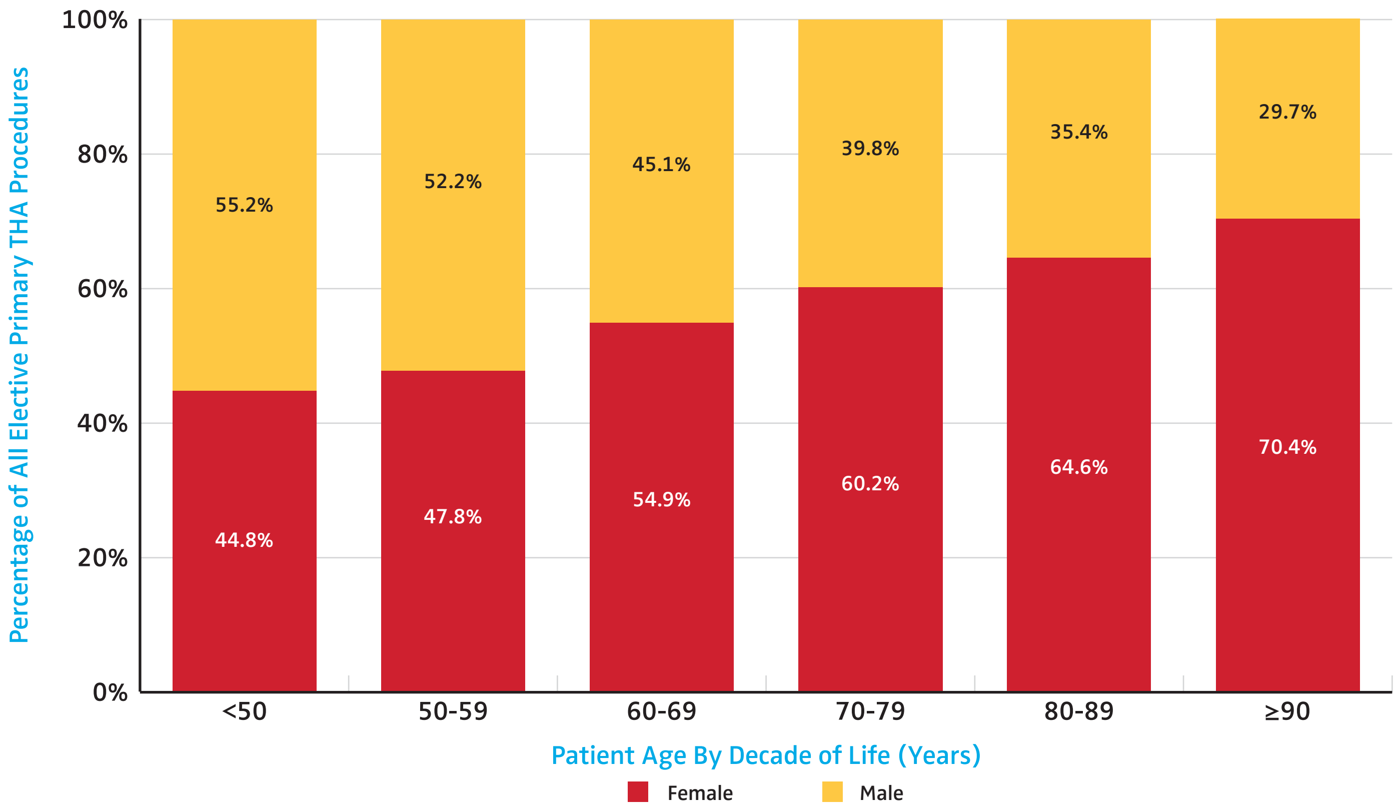
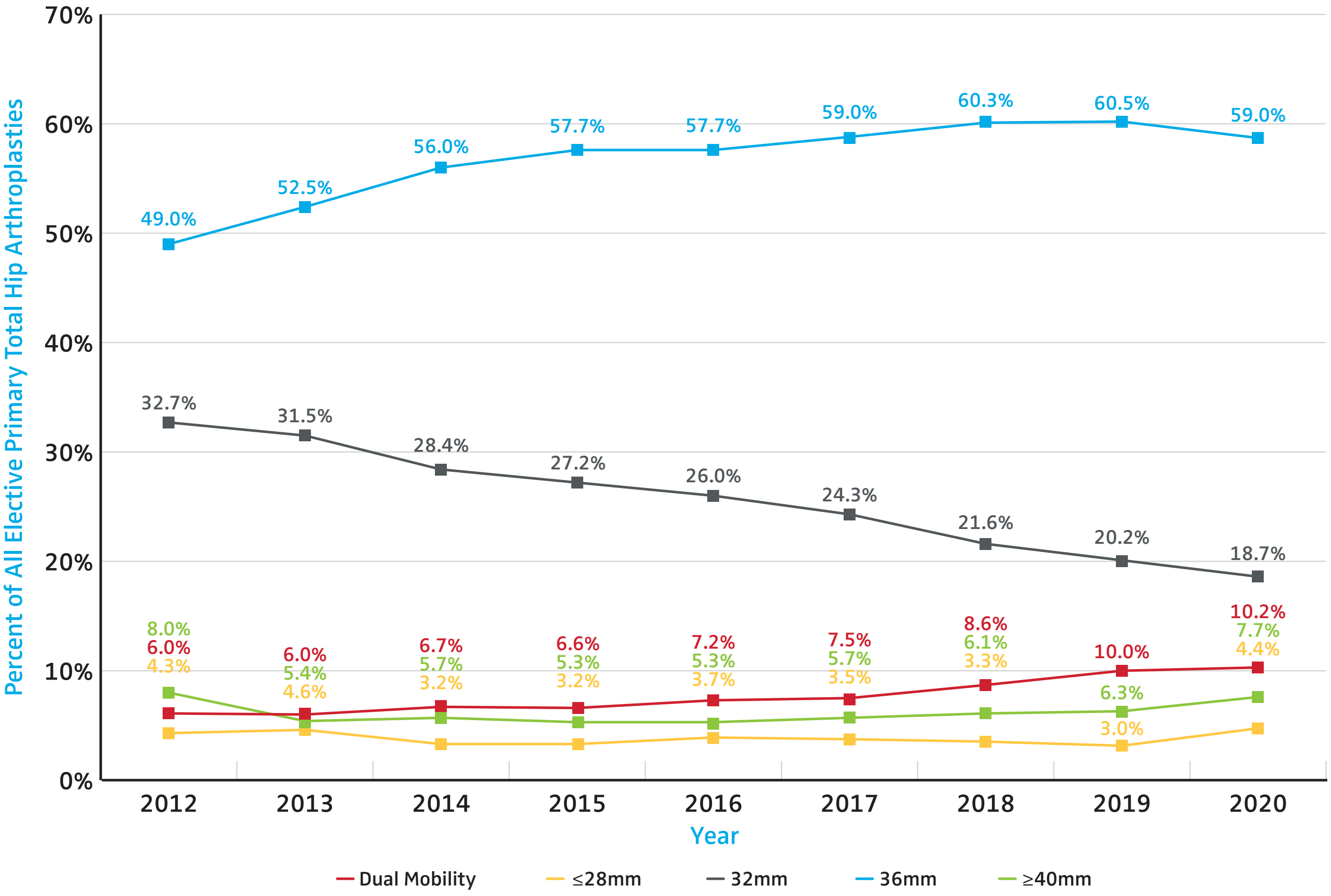


Figure 2.12 Percent Dual Mobility Usage and Femoral Head Sizes Implanted in Elective Primary Total Hip Arthroplasty, 2012-2020 (N=630,421)

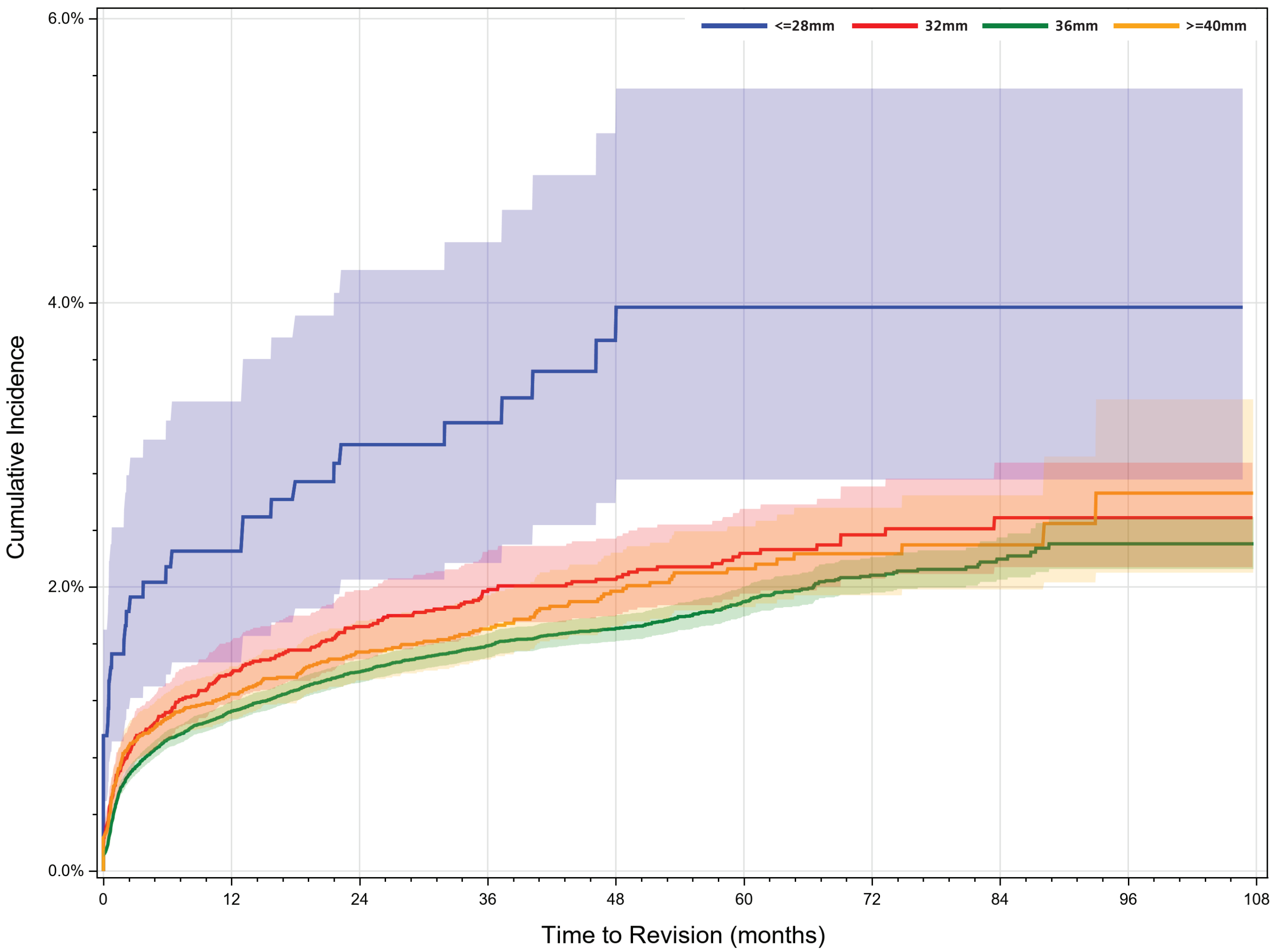


In male patients greater than 65 year of age, the early cumulative percent revision rate of elective primary THA utilizing smaller diameter femoral heads (32mm or less) is higher when compared to those procedures utilizing 36mm femoral heads (Figure 2.13). In females, <28mm and >40mm femoral heads were found to have an increased cumulative percent revision (Figure 2.14) However, these differences were small and there were far fewer <28mm and >40mm femoral heads used. This analysis does not account for other potential confounders that could include risk for revision. 28mm heads used in dual mobility constructs were excluded from this analysis.

INSIGHTS

In patients greater than 65 year of age, the early cumulative percent revision rate of elective primary THA utilizing smaller diameter femoral heads (32mm or less for males and 28mm or less for females) is higher when compared to those procedures utilizing 36mm femoral heads.

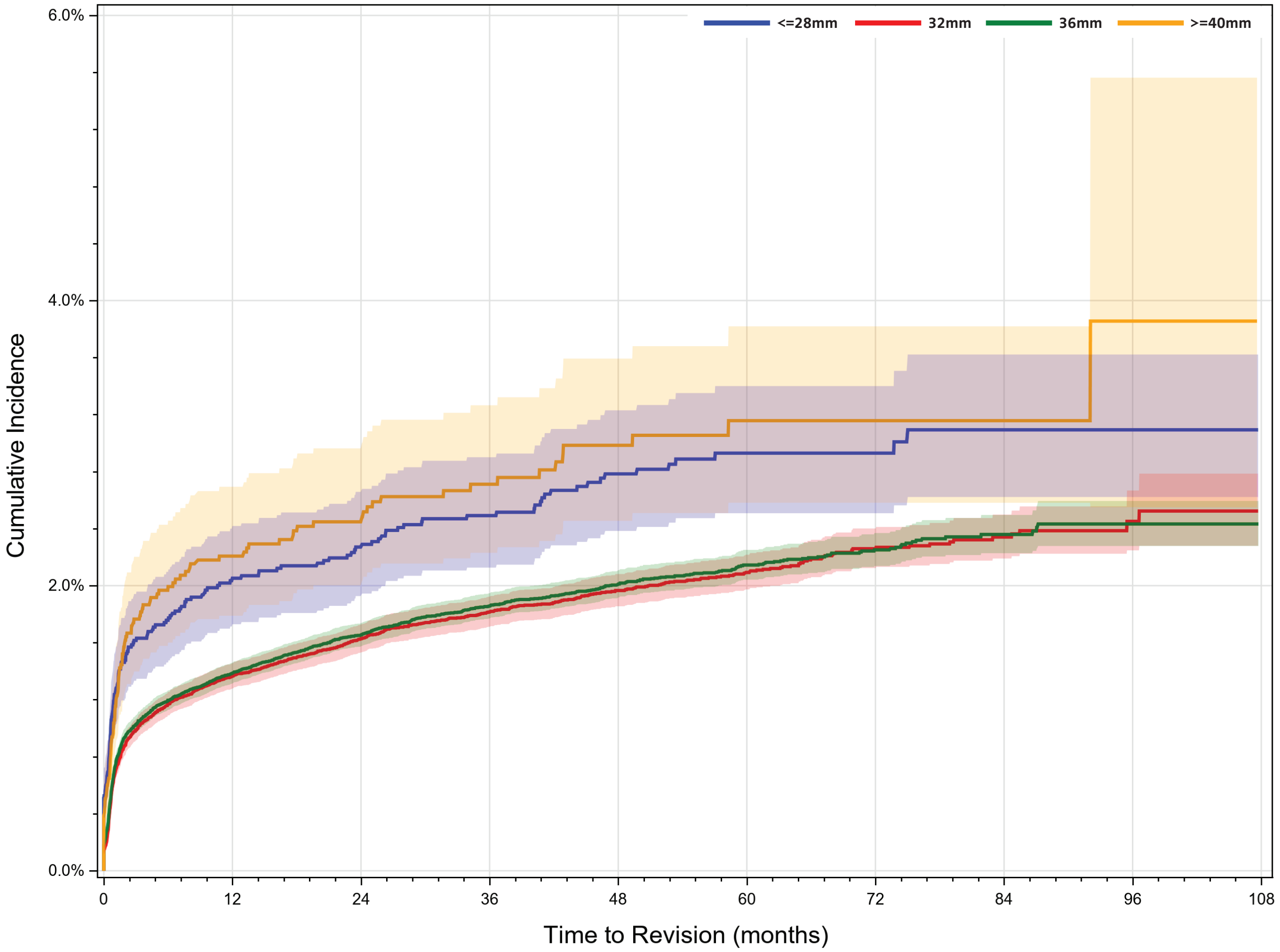
Figure 2.13 Cumulative Percent Revision for Diameter of Femoral Heads for Elective Primary Total Hip Arthroplasty in Male Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
≤28mm	242	100	148	160	136	100	84	61	18	1,049
32mm	1,095	1,323	1,558	1,888	1,866	1,432	1,125	834	339	11,460
36mm	12,562	15,177	15,853	15,922	13,340	9,241	6,257	3,233	1,206	92,791
≥40mm	2,369	2,364	2,373	2,286	1,906	1,290	945	497	315	14,345
Total	**16,268**	**18,964**	**19,932**	**20,256**	**17,248**	**12,063**	**8,411**	**4,625**	**1,878**	**119,645**

Age Adjusted Hazard Ratio (95% CI)
≤28mm vs. 36mm: *2.089 (1.485, 2.938) p<0.0001*
32mm vs. 36mm: *1.187 (1.033, 1.364) p=0.0155*
≥40mm vs. 36mm: *1.106 (0.968, 1.264) p=0.1398*

Figure 2.14 Cumulative Percent Revision for Diameter of Femoral Heads for Elective Primary Total Hip Arthroplasty in Female Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
≤28mm	927	719	895	1,057	1,030	764	587	487	184	6,650
32mm	7,596	9,411	10,533	11,539	10,428	7,514	5,448	3,125	1,335	66,929
36mm	14,204	17,016	17,566	16,561	14,010	9,554	6,748	3,371	1,410	100,440
≥40mm	708	708	721	631	544	358	254	149	89	4,162
Total	**23,435**	**27,854**	**29,715**	**29,788**	**26,012**	**18,190**	**13,037**	**7,132**	**3,018**	**178,181**

Age Adjusted Hazard Ratio (95% CI)
≤28mm vs. 36mm: *1.372 (1.174, 1.603) p<0.0001*
32mm vs. 36mm: *0.986 (0.917, 1.059) p=0.6901*
≥40mm vs. 36mm: *1.500 (1.240, 1.814) p<0.0001*

AJRR saw a statistically significant increase in dual mobility usage for elective primary hip arthroplasty procedures when comparing 2012 to 2020 (p<0.0001). The increase in popularity may be explained by the perception of increased stability and reduced risk of dislocation with larger diameter dual mobility articulations.[10] These constructs were used most commonly in the youngest (<50 years) patients and least frequently in the 60-69 year age range (Figure 2.15).

INSIGHTS

Dual mobility constructs continue to show most frequent use in the youngest (<50 years) group of patients.

As reported to AJRR for all ages, there was increased revision when comparing dual mobility to conventional femoral head usage for elective primary total hip arthroplasty procedures in males (HR=1.436, 95% CI, 1.245-1.655, p<0.0001) and females (HR=1.269, 95% CI, 1.121-1.436, p=0.0002) (Figure 2.16-2.17). Findings were similar when looking at patients ≥65 years of age as reported to either AJRR or CMS (Figure 2.18-2.19). As previously noted, this represents an association rather than a causal relationship and does not account for potential confounders, such as the patient's inherent risk of dislocation.

AJRR data continues to show a reduced cumulative incidence of revision surgery for conventional femoral heads when compared to dual mobility for elective primary total hip arthroplasty procedures, although potential patient selection bias and confounding needs to be considered when interpreting this finding.

INSIGHTS

Figure 2.15 Dual Mobility Usage as a Percent of all Elective Primary Total Hip Arthroplasty Procedures by Age Group, 2012-2020 (N=51,304)

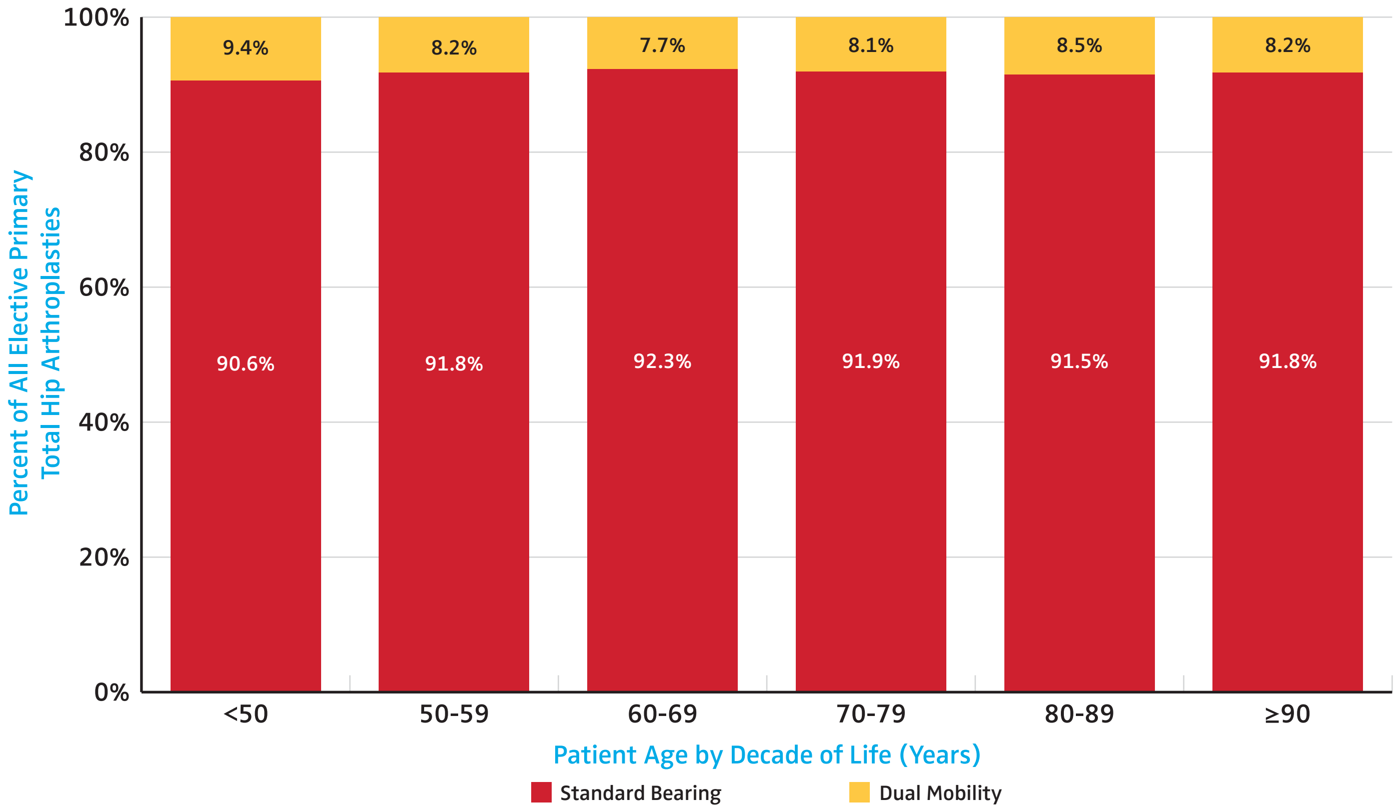
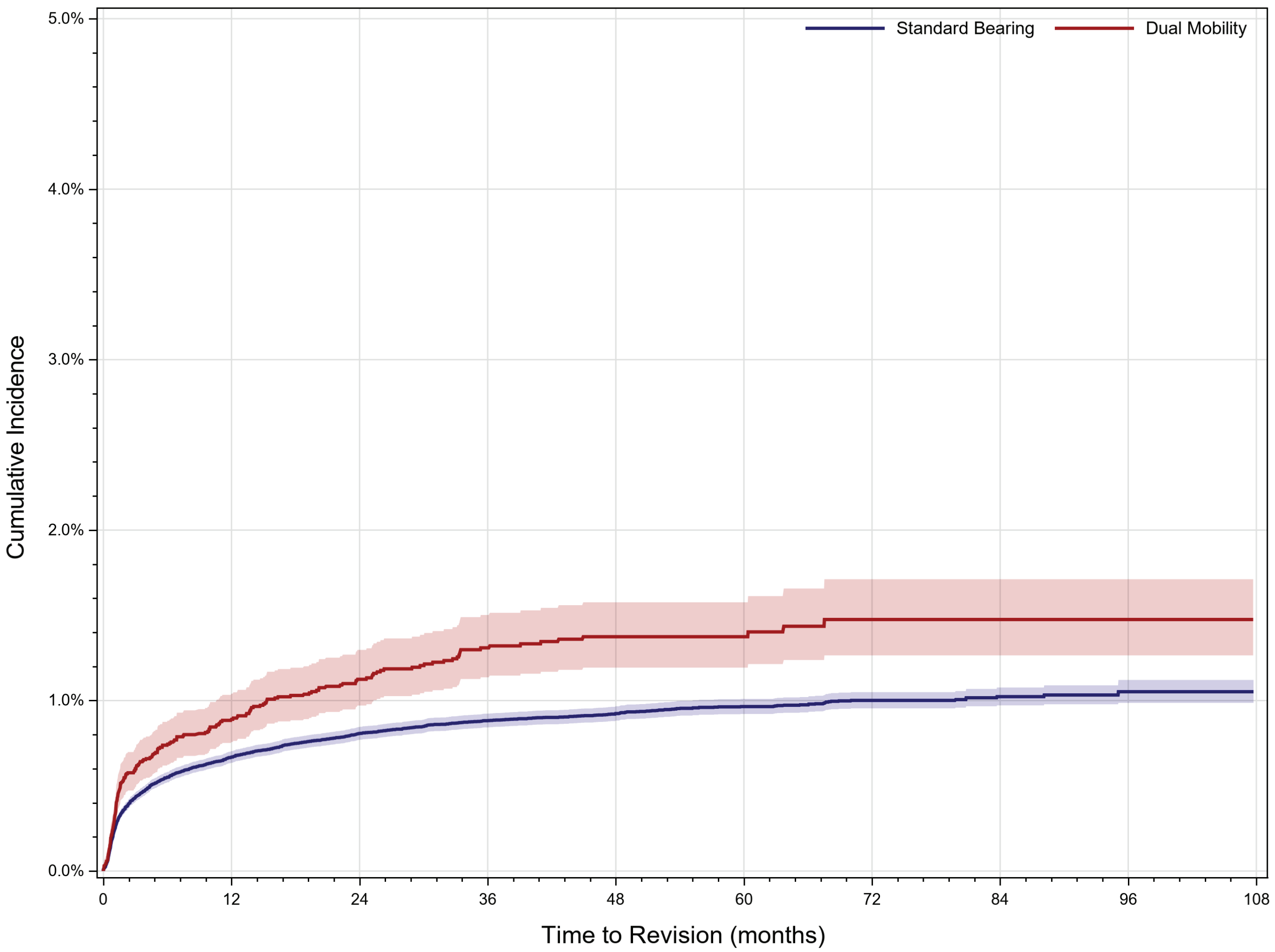


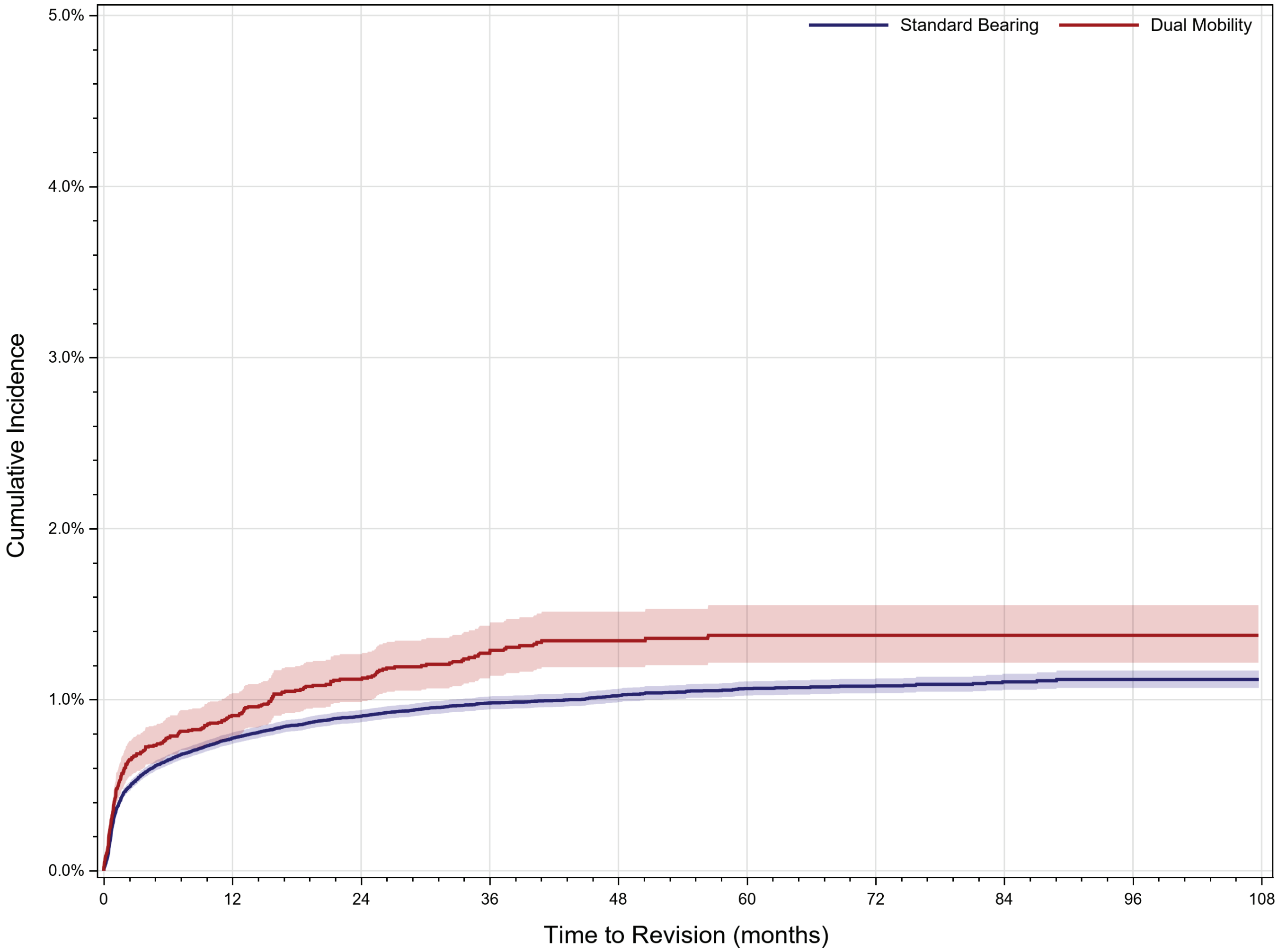
Figure 2.16 Cumulative Percent Revision for Dual Mobility Used for Elective Primary Total Hip Arthroplasty for Male Patients with Primary Osteoarthritis as Submitted Only to AJRR, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Standard Bearing	27,714	33,346	36,749	38,786	34,210	25,053	17,964	10,012	4,150	227,984
Dual Mobility	2,737	3,185	3,005	2,784	2,334	1,544	1,136	507	266	17,498
Total	**30,451**	**36,531**	**39,754**	**41,570**	**36,544**	**26,597**	**19,100**	**10,519**	**4,416**	**245,482**

Age Adjusted Hazard Ratio (95% CI)
Dual Mobility vs. Standard Bearing: *1.436 (1.245, 1.655) p<0.0001*

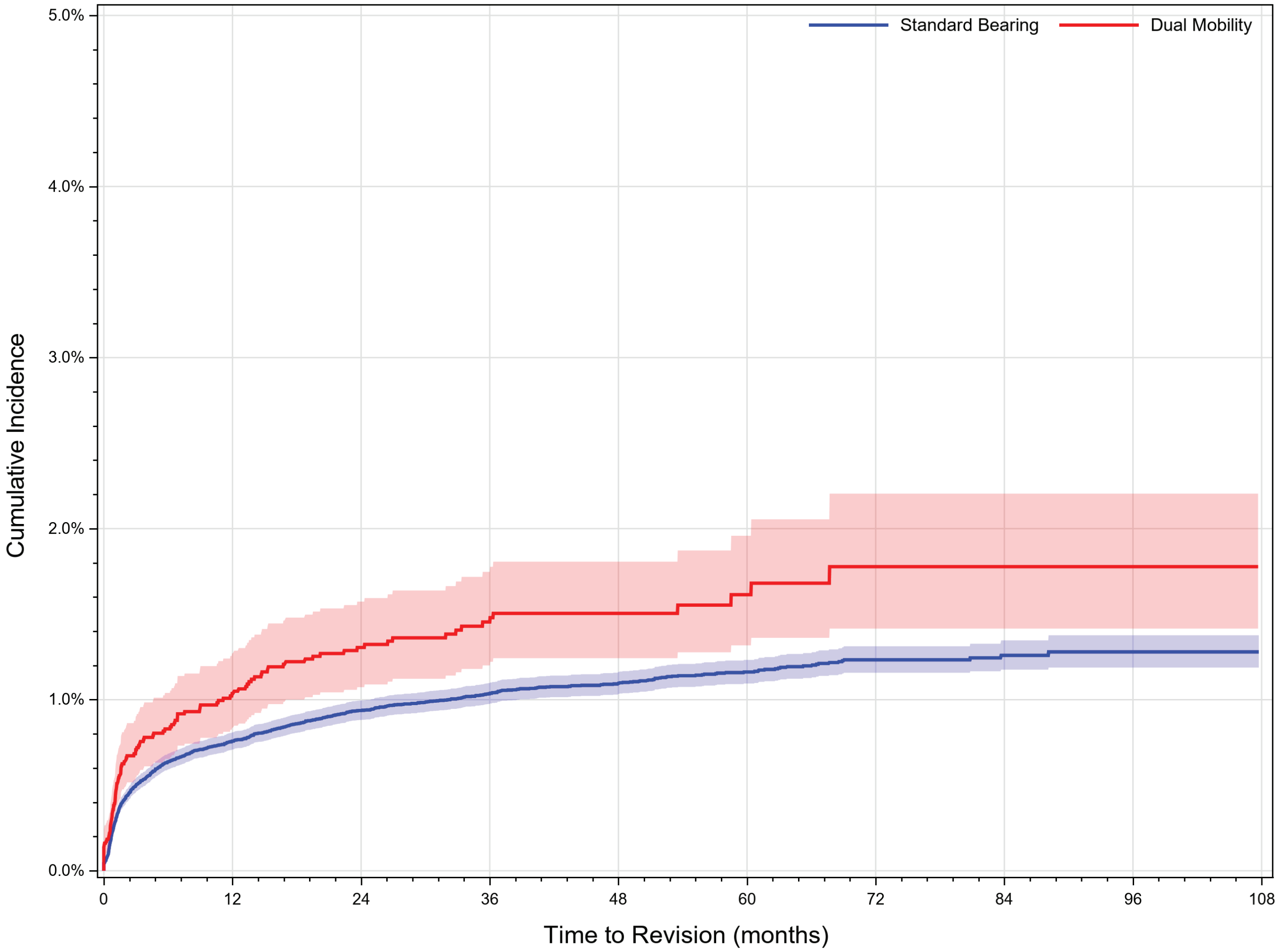
Figure 2.17 Cumulative Percent Revision for Dual Mobility Used for Elective Primary Total Hip Arthroplasty for Female Patients with Primary Osteoarthritis as Submitted Only to AJRR, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Standard Bearing	33,865	41,808	46,251	47,783	42,817	30,956	22,328	12,,630	5,399	283,837
Dual Mobility	3,753	4,443	3,872	3,714	3,122	2,017	1,433	790	321	23,465
Total	**37,618**	**46,251**	**50,123**	**51,497**	**45,939**	**32,973**	**23,761**	**13,420**	**5,720**	**307,302**

Age Adjusted Hazard Ratio (95% CI)
Dual Mobility vs. Standard Bearing: *1.269 (1.121, 1.436) p=0.0002*

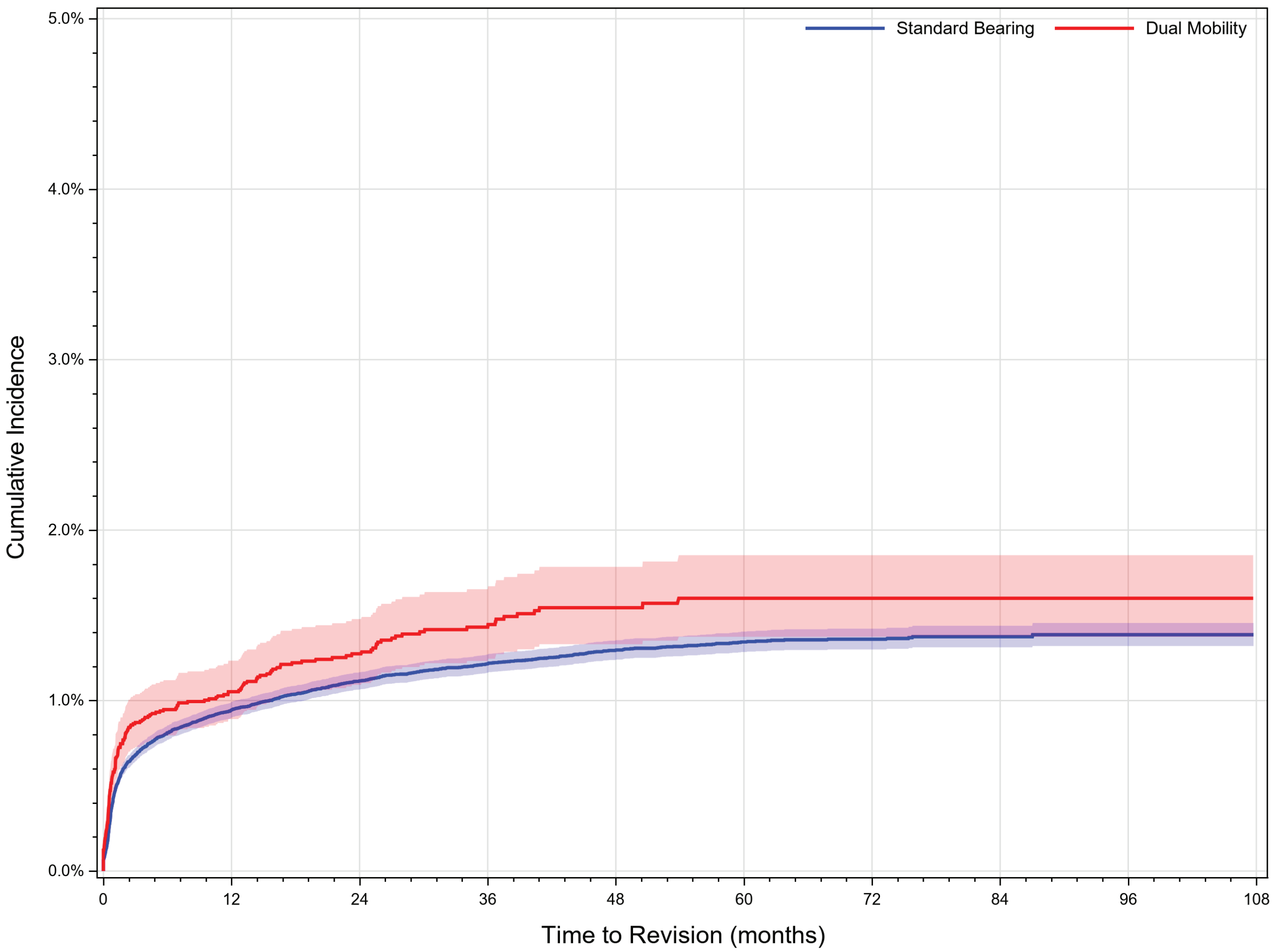
Figure 2.18 Cumulative Percent Revision for Dual Mobility Used for Elective Primary Total Hip Arthroplasty for Male Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Standard Bearing	15,532	18,702	19,854	20,109	17,115	11,954	8,309	4,603	1,857	118,035
Dual Mobility	1,534	1,763	1,562	1,354	1,046	665	482	195	92	8,693
Total	**17,066**	**20,465**	**21,416**	**21,463**	**18,161**	**12,619**	**8,791**	**4,798**	**1,949**	**126,728**

Age Adjusted Hazard Ratio (95% CI)
Dual Mobility vs. Standard Bearing: *1.397 (1.156, 1.687) p=0.0005*

Figure 2.19 Cumulative Percent Revision for Dual Mobility Used for Elective Primary Total Hip Arthroplasty for Female Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Standard Bearing	22,307	27,520	29,735	29,590	25,778	18,010	12,888	7,054	2,982	175,864
Dual Mobility	2,393	2,879	2,402	2,127	1,751	1,125	754	397	141	13,969
Total	**24,700**	**30,399**	**32,137**	**31,717**	**27,529**	**19,135**	**13,642**	**7,451**	**3,123**	**189,833**

Age Adjusted Hazard Ratio (95% CI)
Dual Mobility vs. Standard Bearing: *1.184 (1.020, 1.373) p=0.0261*

For all elective primary total hip arthroplasty procedures, ceramic head usage has continued to increase, while there has been a corresponding and statistically significant decrease in cobalt chromium (CoCr) usage ($p<0.0001$) (Figure 2.20). This increase in ceramic head use is likely explained by concerns over trunnion and taper corrosion seen with CoCr heads.[11] CoCr femoral heads are used more commonly in elderly patients, with CoCr heads predominating in patients >72 years of age (Figure 2.21). Over the last nine years, ceramic on polyethylene (CoP) has consistently risen in its application while metal on polyethylene (MoP) combinations have declined. Dual-mobility systems and ceramicized metal on polyethylene (CMoP) combinations have increased in utilization nearly two-fold since 2012 in elective primary hip arthroplasty (Figure 2.22).

INSIGHTS

Less than 16% of elective primary THA were performed using a metal-on-polyethylene articulation in 2020 with ceramic-on-polyethylene continuing to be the dominant bearing choice.

Figure 2.20 Composition of Femoral Heads for All Elective Primary Total Hip Arthroplasty Procedures Excluding Dual Mobility by Year, 2012-2020 (N=574,182)

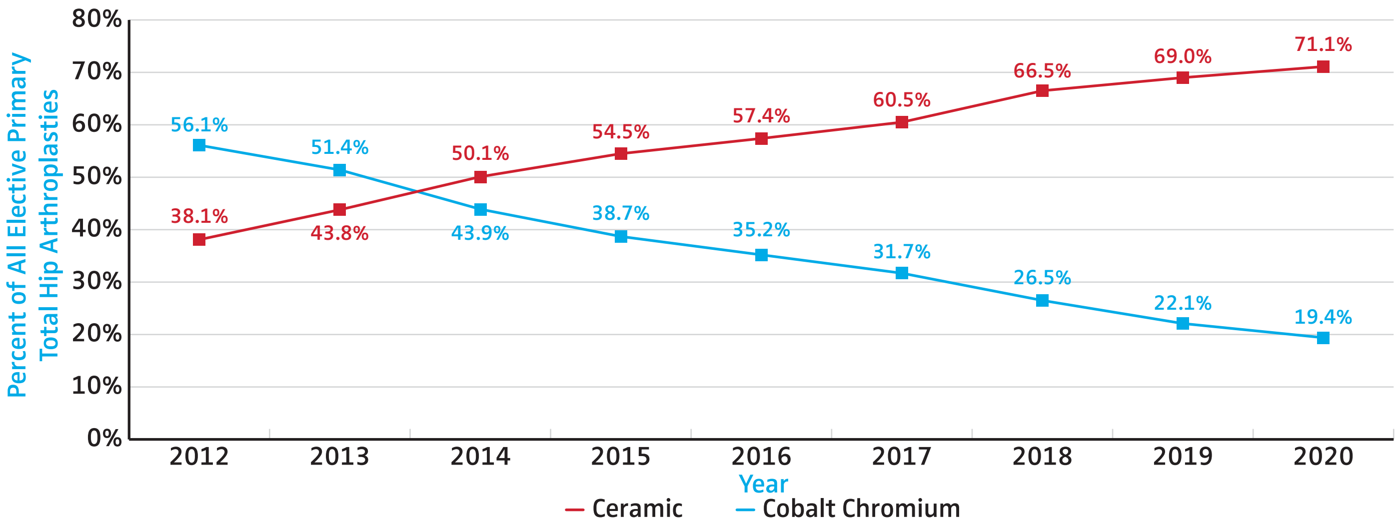


Figure 2.21 Composition of Femoral Heads for All Elective Primary Total Hip Arthroplasty Procedures Excluding Dual Mobility by Age Group, 2012-2020 (N=574,182)

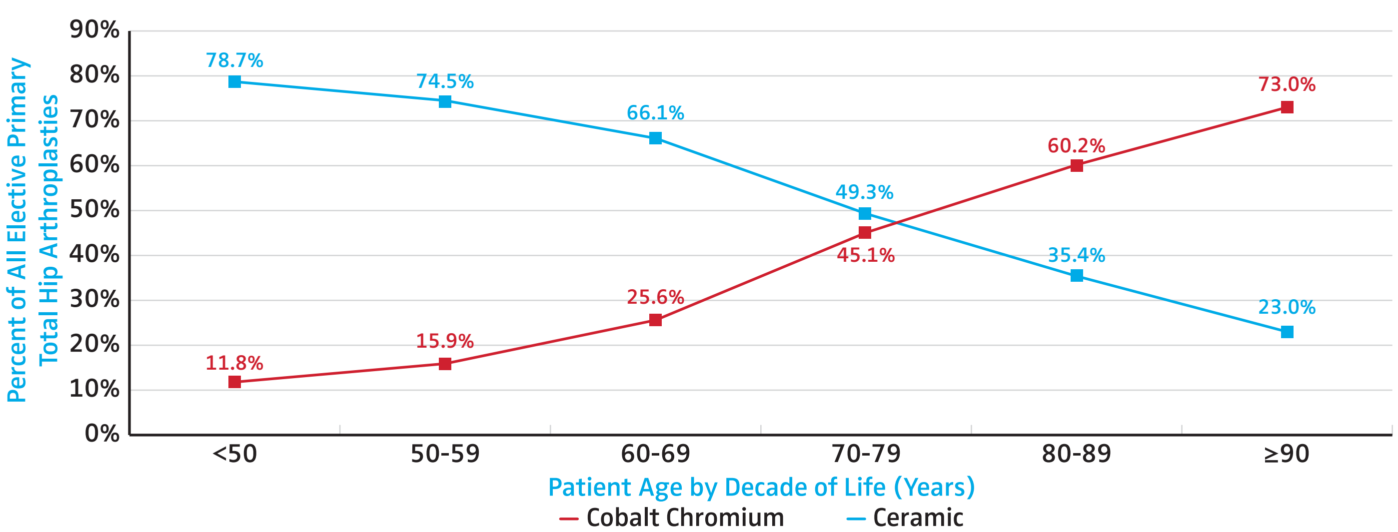
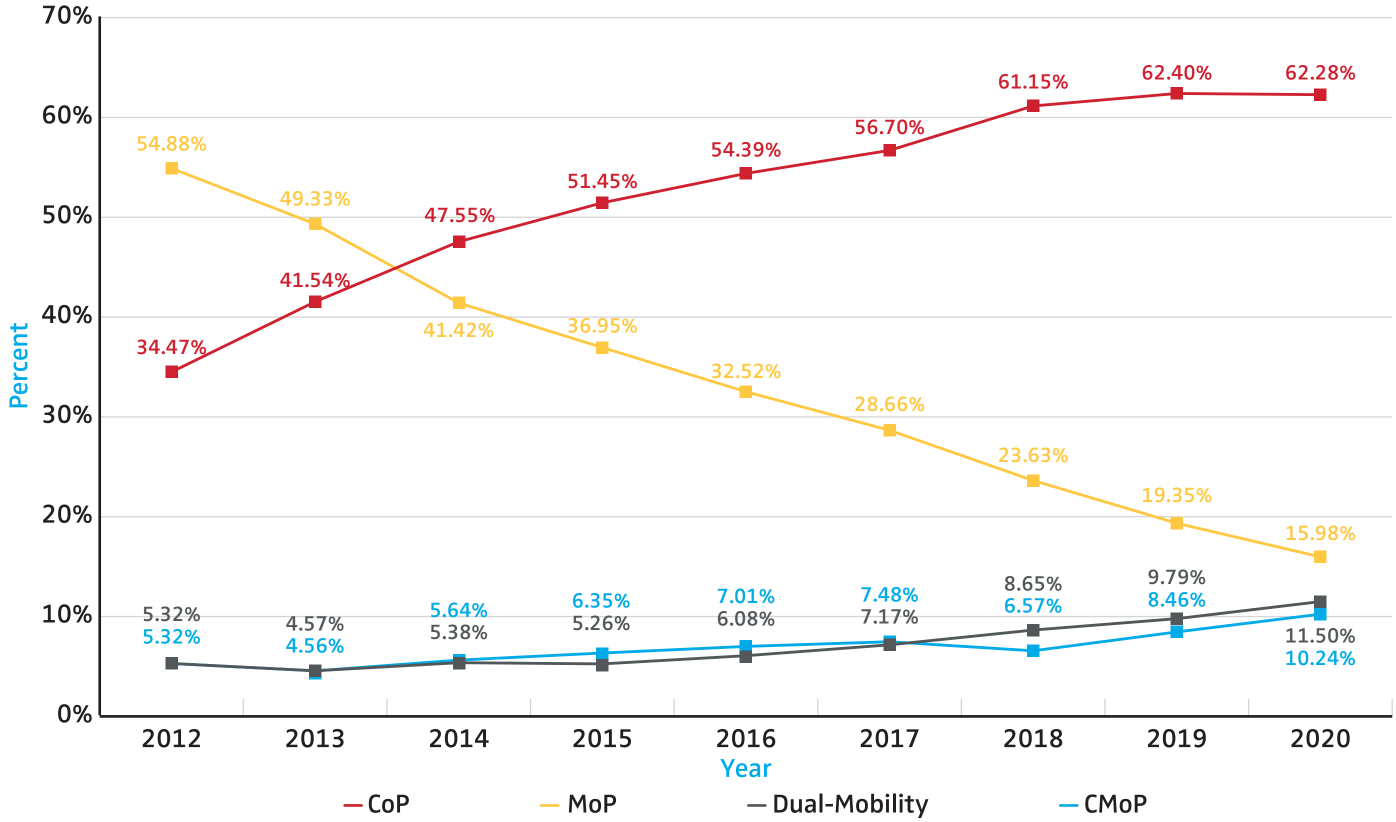


Figure 2.22 Elective Primary Total Hip Arthroplasty Bearing Surface Materials by Year, 2012-2020 (N=690,062)



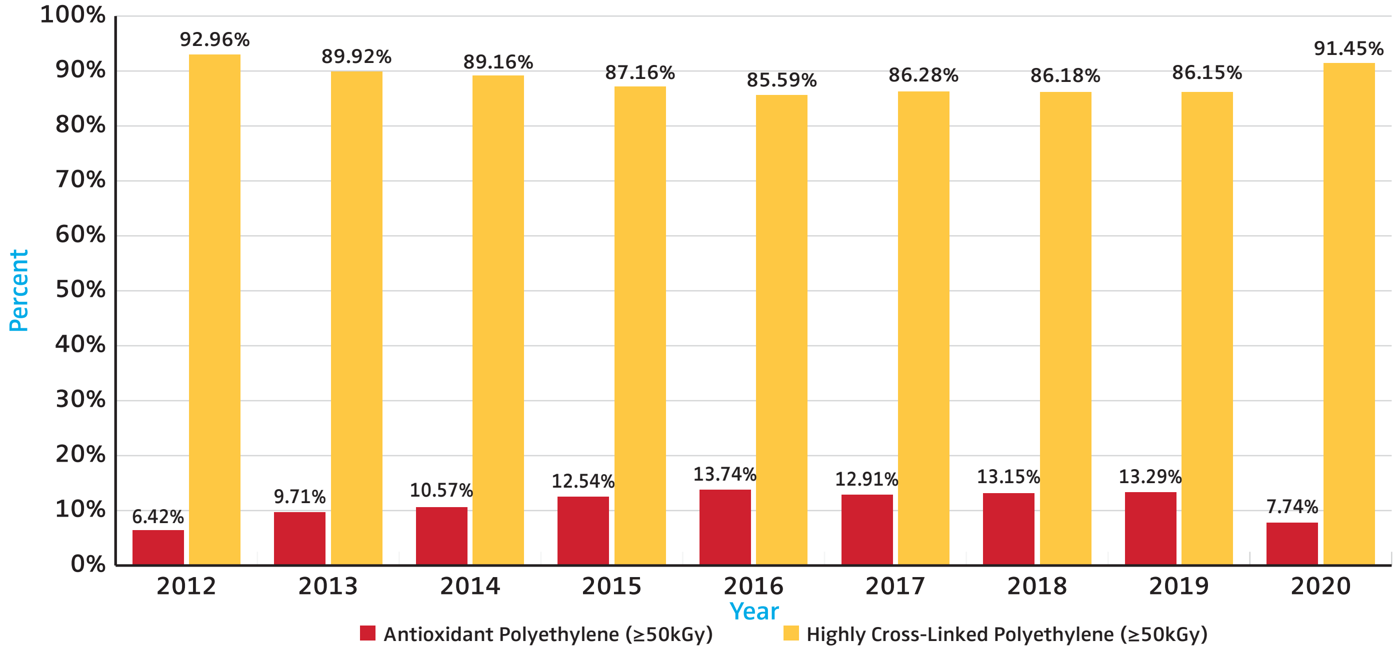
	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Total N	15,466	31,579	55,939	75,080	101,255	114,277	112,639	105,243	78,584	690,062

For both cobalt chromium and ceramic heads used by surgeons in the AJRR cohort, highly cross-linked polyethylene was more commonly utilized compared to antioxidant polyethylene for all elective primary total hip arthroplasty procedures (Figures 2.23). The threshold for classification of a polyethylene liner as highly cross-linked polyethylene is a total radiation dose of 50 kGy (5 Mrad) or more. Antioxidant polyethylene is defined as a highly cross-linked polyethylene liner with an antioxidant component infused or blended in manufacturing. The use of antioxidant polyethylene has remained fairly stable since 2015 with a notable decline to 7.7% in 2020. The use of conventional polyethylene (UHMWPE) in the AJRR primary total hip arthroplasty cohort has become vanishingly small with <1.0% of annual cases, as surgeons have almost entirely moved to either highly cross-linked or antioxidant polyethylene alternatives.

Cementless femoral component fixation for elective primary total hip arthroplasty dramatically outweighs the use of cemented fixation in the AJRR population. From 2012-2020, only 4.2% of all elective primary total hip arthroplasty procedures in AJRR utilized cemented femoral component fixation. When examining usage by age, there was a significant increase in cemented fixation with advancing age ($p<0.0001$) (Figure 2.24) and over time ($p<0.0001$) (Figure 2.25).

The use of cemented femoral component fixation in the AJRR remains lower than that seen in international registries. The *2021 Annual Report* for the National Joint Registry reported much higher use of cemented femoral component fixation across all age groups (32.3%).[7] The Australian Orthopaedic Association National Joint Replacement Registry also reports a higher use of cemented fixation compared to AJRR, although the use of cementless stem fixation has been increasing from 51.3% in 2003 to 60.8% in 2020.[6] In their *2019 Annual Report*, the Swedish Hip Arthroplasty Register noted that the proportion of cemented prostheses in that year was 58%. They also commented that completely cementless fixation has been increasing from 2% in 2000 to 28% in 2019.[8]

Figure 2.23 Elective Primary Total Hip Arthroplasty Liner Polyethylene Material by Year, 2012-2020 (N=612,715)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Total N	14,367	29,848	52,841	71,615	94,165	101,976	98,235	90,976	58,692	612,715

Figure 2.24 Cemented and Cementless Femoral Stem Fixation in Elective Primary Total Hip Arthroplasty Procedures by Age Group, 2012-2020 (N=597,511)

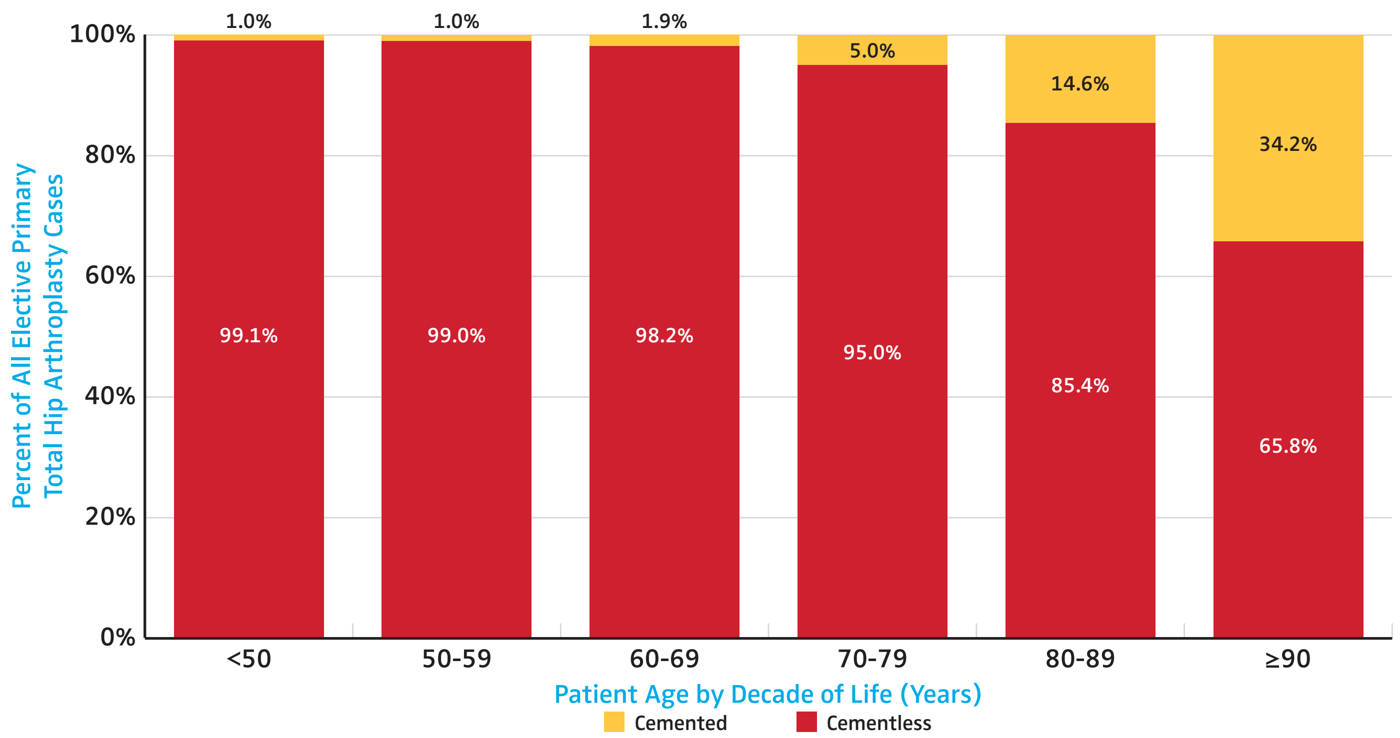
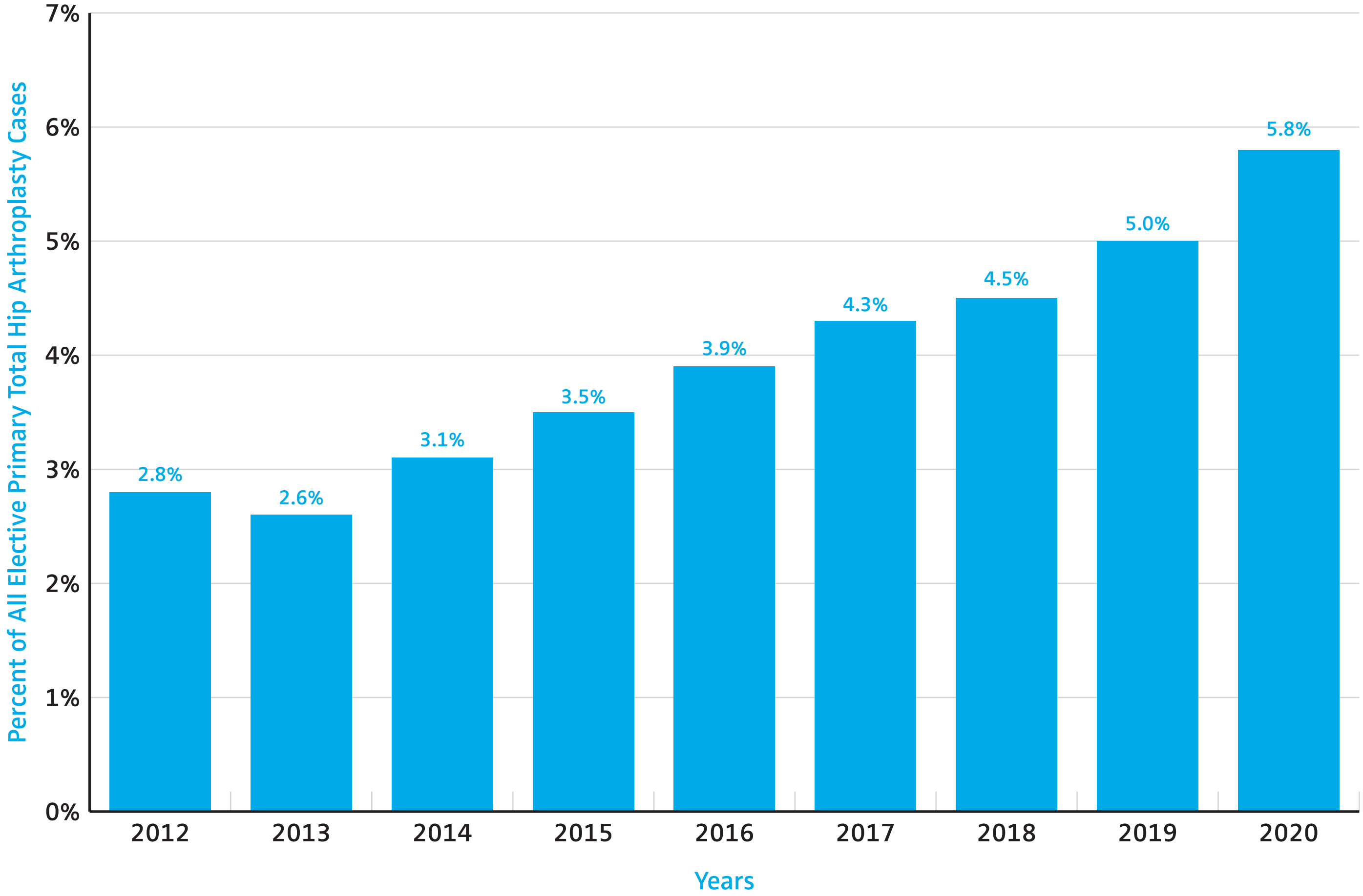


Figure 2.25 Cemented Femoral Stem Fixation in Elective Primary Total Hip Arthroplasty Procedures, 2012-2020 (N=597,511)

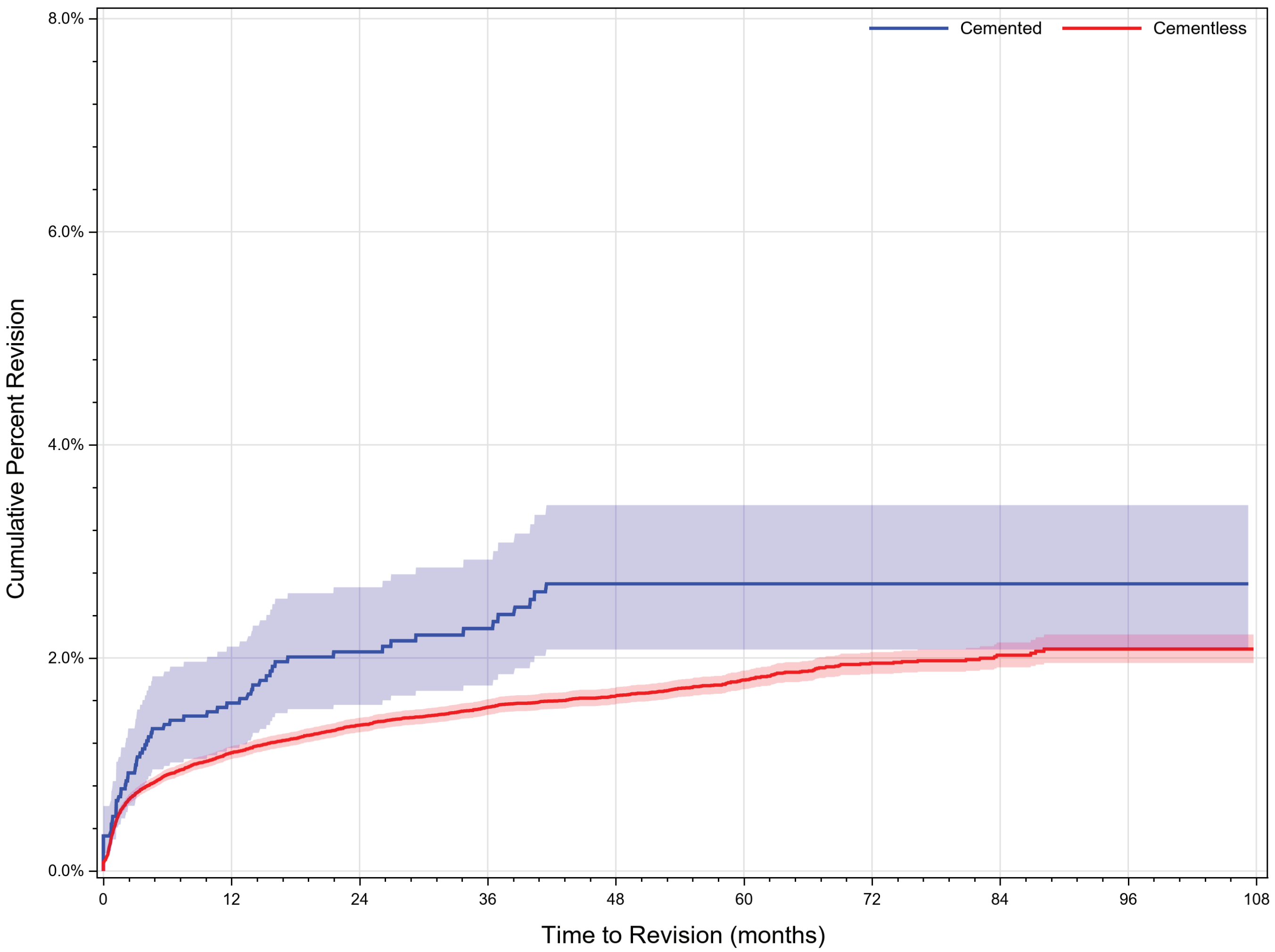


When examining cumulative percent revision of cementless versus cemented femoral component fixation for patients ≥65 years of age as reported to either AJRR or CMS, cemented femoral components had a higher cumulative percent revision in males but lower cumulative percent revision in females (Figures 2.26-2.27). It is important to note this does not account for potential confounders that were not examined.

INSIGHTS

The trend towards increasing use of cement for femoral component fixation in primary elective THA continues to increase and has doubled since 2013.

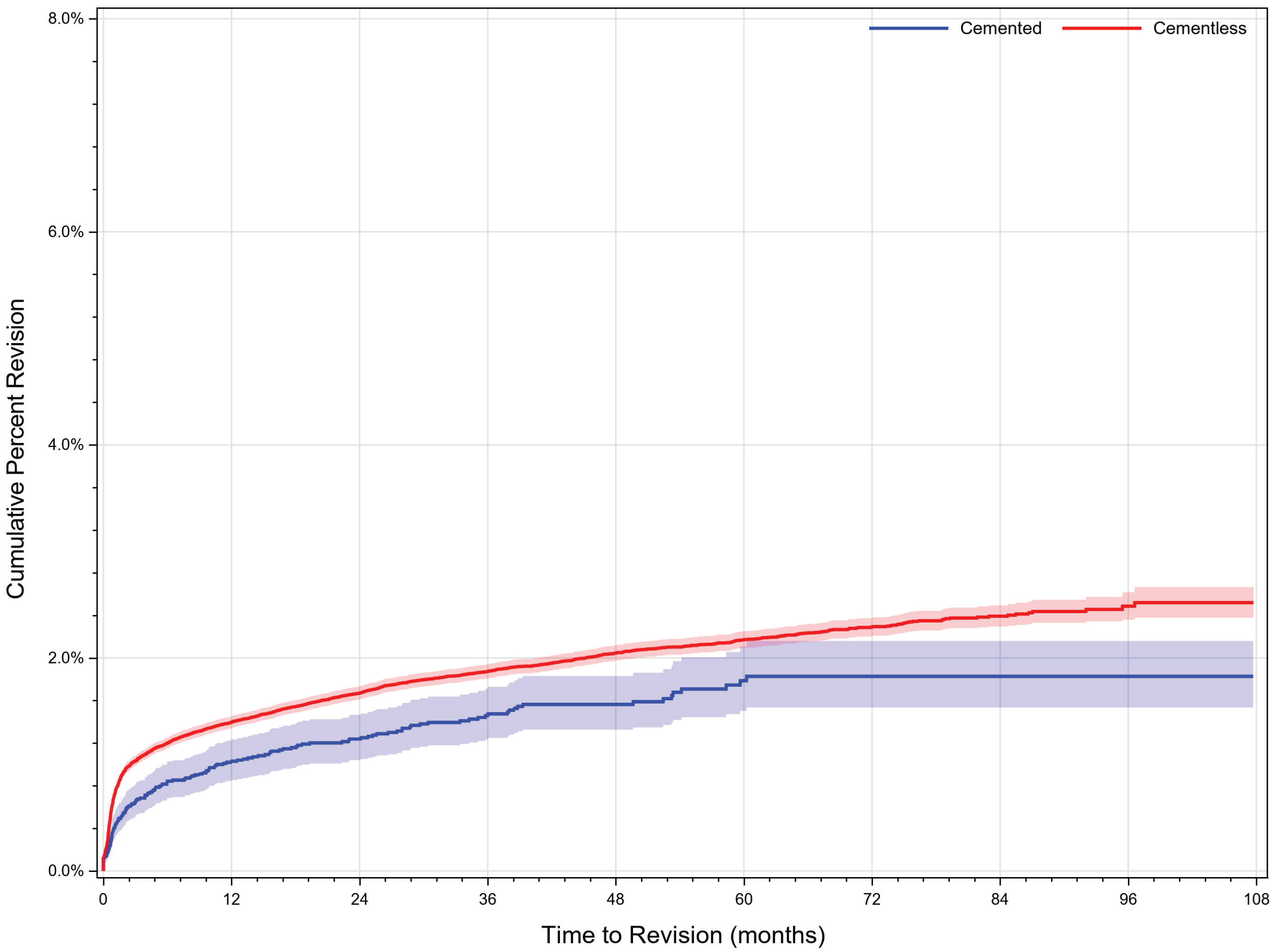
Figure 2.26 Cumulative Percent Revision for Femoral Stem Fixation for Elective Primary Total Hip Arthroplasty Males ≥65 Years of Age with Primary Osteoarthritis Age Adjusted, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Cementless	15,260	18,347	22,776	20,881	17,122	12,012	8,387	4,596	1,894	121,275
Cemented	422	412	468	423	435	298	168	73	30	2,729
Total	**15,682**	**18,759**	**23,244**	**21,304**	**17,557**	**12,310**	**8,555**	**4,669**	**1,924**	**124,004**

Age Adjusted Hazard Ratio (95% CI)
Cemented vs. Cementless: *1.414 (1.098, 1.821) p=0.0072*

Figure 2.27 Cumulative Percent Revision for Femoral Stem Fixation for Elective Primary Total Hip Arthroplasty Females ≥65 Years of Age with Primary Osteoarthritis Age Adjusted, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Cementless	21,201	26,141	32,963	29,749	25,158	17,644	12,421	6,913	2,898	175,088
Cemented	1,589	1,706	2,164	1,849	1,574	1,137	706	294	165	11,184
Total	**22,790**	**27,847**	**35,127**	**31,598**	**26,732**	**18,781**	**13,127**	**7,207**	**3,063**	**186,272**

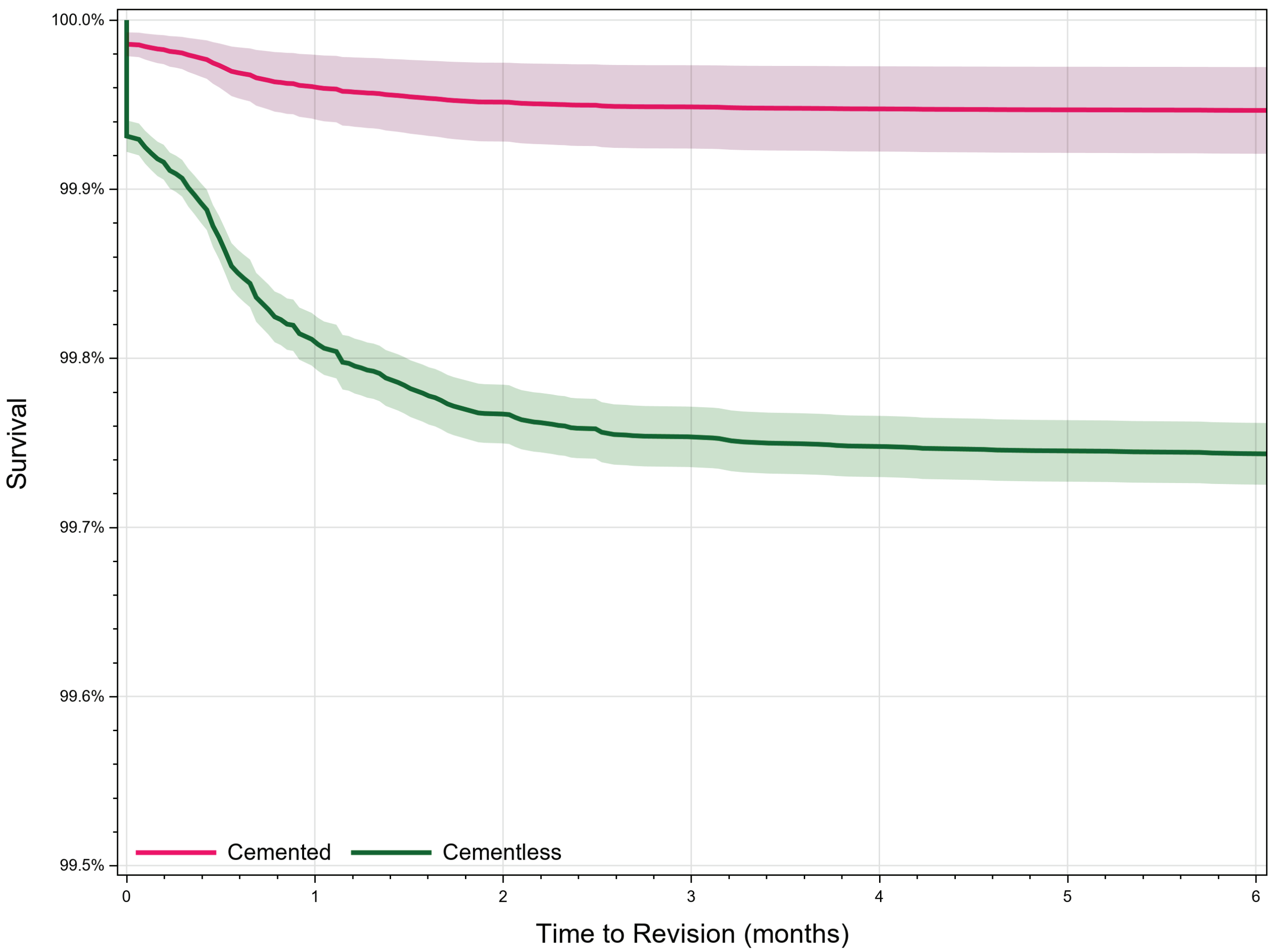
Age Adjusted Hazard Ratio (95% CI)
Cemented vs. Cementless: *0.728 (0.619, 0.856) p=0.0001*

Adjusting for age and gender, cemented fixation showed a statistically significant reduction in early revision due to periprosthetic fracture compared to cementless fixation in elective primary THA patients ≥65 years of age.

INSIGHTS

This is the first year the *AJRR Annual Report* has included a survival curve with a diagnosis-specific outcome. For this report, revision for periprosthetic fracture was analyzed based on the fixation method of the femoral component. Figure 2.28 displays the results of a cause-specific survivorship model accounting for death and revision of non-target diagnoses as competing risks. While both curves resulted in high initial survival through the first six months, cemented fixation showed a statistically significant reduction in revision due to periprosthetic fracture compared to cementless fixation in elective primary THA patients ≥65 years of age (HR: 0.208, 95% CI, 0.127-0.341, p<0.0001).

Figure 2.28 Percent Survival for Revision due to Periprosthetic Fracture for Elective Primary Total Hip Arthroplasty ≥65 Years of Age Adjusted for Age and Gender, 2012-2020



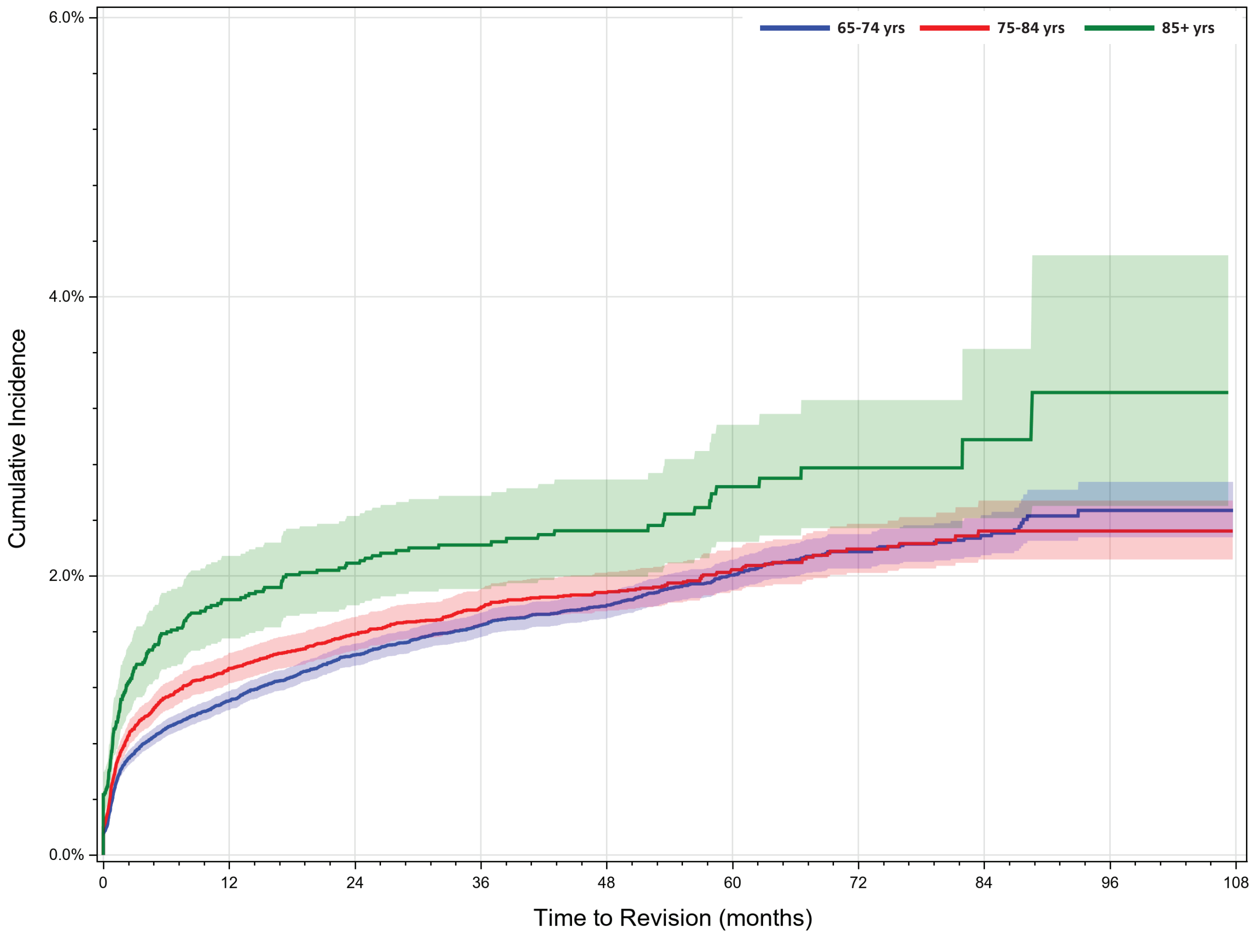
Age/Gender Adjusted Hazard Ratio (95% CI)
Cemented vs. Cementless: *0.208 (0.127-0.341) p<0.0001*

Patient factors, such as age and comorbidities, are known to influence the rates of failure and revision surgery following total hip arthroplasty. The AJRR can also be used to better understand the association of patient factors and revision incidence following total hip arthroplasty. For this year's Annual Report, age by decade for those 65 and older was analyzed. A trend was identified suggesting older age was associated with increased cumulative percent revision; this reached statistical significance comparing those older than 84 to 65-74 year old males (HR=1.406, 95% CI, 1.207-1.638, p<0.0001) and comparing those 75-84 to 65-74 year old females (HR=1.087, 95% CI, 1.020-1.159, p=0.0105) (Figures 2.29-2.30).

INSIGHTS

Older age was found to be associated with an increased cumulative percent revision in primary total hip arthroplasty patients ≥65 years primarily due to early failures.

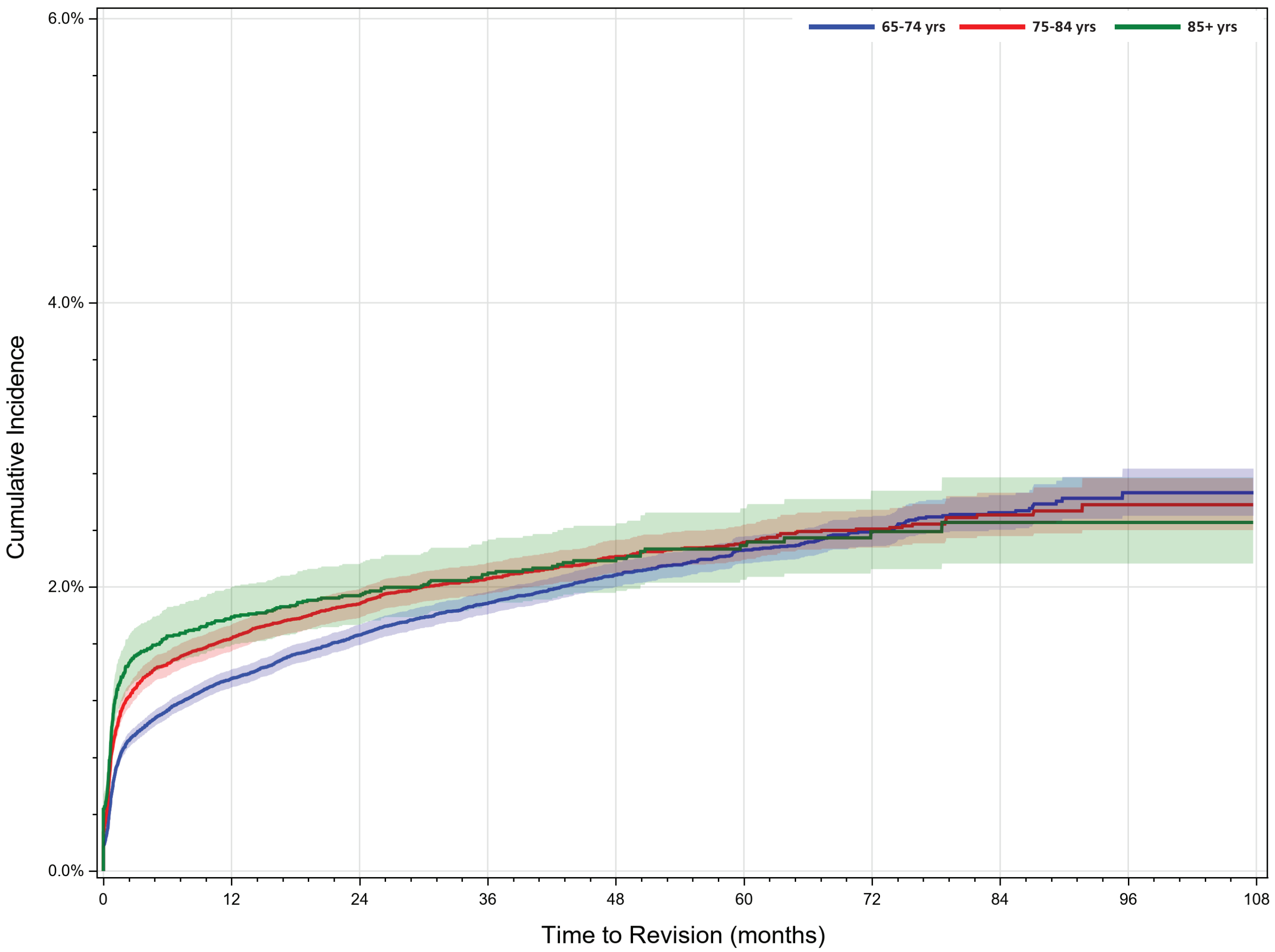
Figure 2.29 Cumulative Percent Revision for Age by Decade for Elective Primary Total Hip Arthroplasty with Primary Osteoarthritis for Males, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Age 65-74	14,169	15,993	15,608	15,298	12,956	9,311	6,651	3,686	1,497	95,169
Age 75-84	6,970	7,324	7,415	7,112	5,841	4,094	3,061	1,772	788	44,377
Age 85+	1,324	1,412	1,364	1,296	1,074	765	499	253	105	8,092
Total	**22463**	**24,729**	**24,387**	**23,706**	**19,871**	**14,170**	**10,211**	**5,711**	**2,390**	**147,638**

Age Adjusted Hazard Ratio (95% CI)
***Age 75-84 vs. 65-74:** 1.066 (0.978, 1.162) p=0.1438*
***Age 85+ vs. 65-74:** 1.406 (1.207, 1.638) p<0.0001*

Figure 2.30 Cumulative Percent Revision for Age by Decade for Elective Primary Total Hip Arthroplasty with Primary Osteoarthritis for Females, 2012-2020



Number at Risk	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Age 65-74	19,396	21,686	21,803	21,059	18,256	13,002	9,310	5,151	2,219	131,882
Age 75-84	10,847	12,123	12,158	11,575	9,754	6,897	5,109	3,024	1,220	72,707
Age 85+	2,471	2,586	2,698	2,702	2,223	1,626	1,211	607	245	16,369
Total	**32,714**	**36,395**	**36,659**	**35,336**	**30,233**	**21,525**	**15,630**	**8,782**	**3,684**	**220,958**

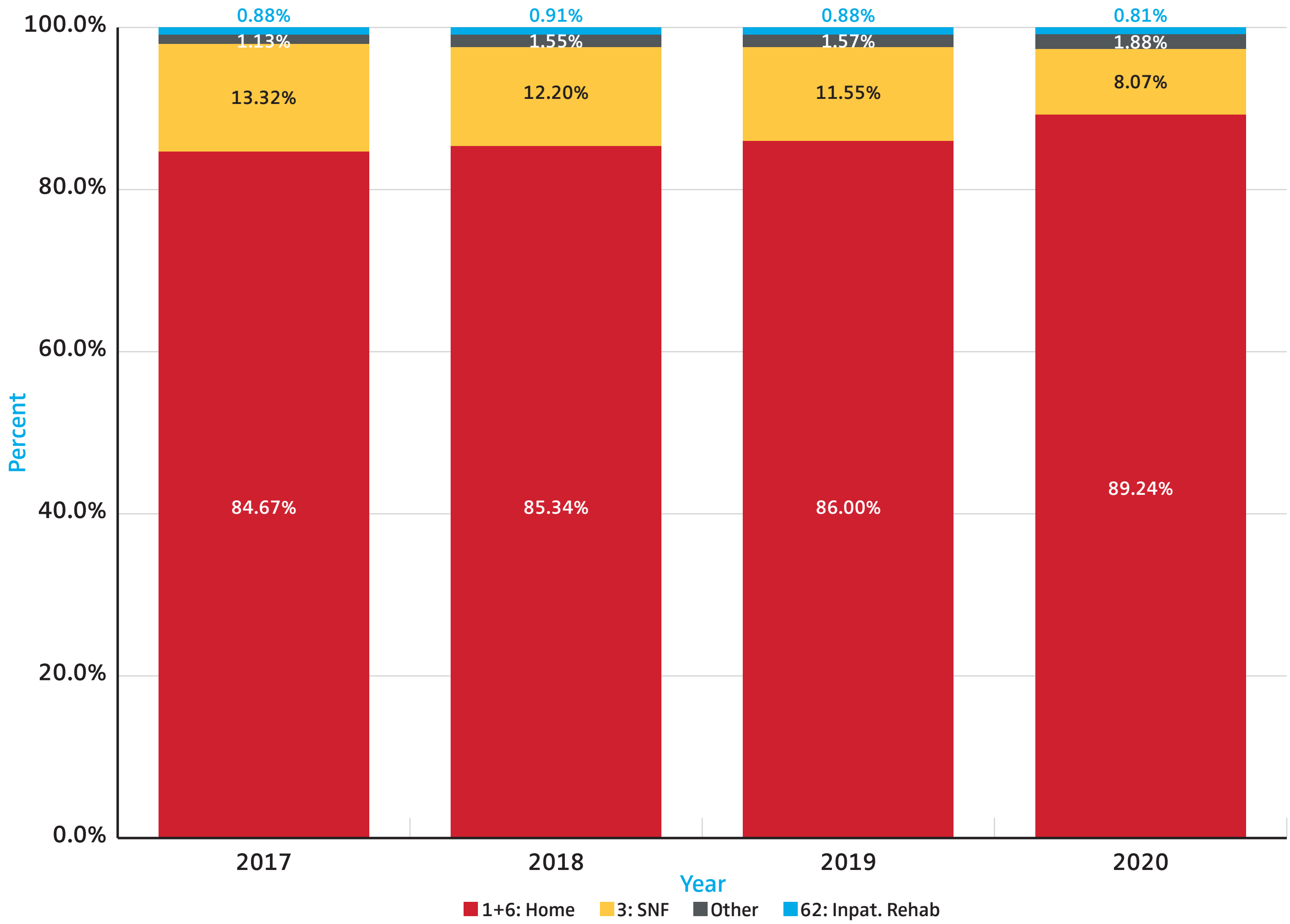
Age Adjusted Hazard Ratio (95% CI)
Age 75-84 vs. 65-74: *1.087 (1.020, 1.159) p=0.0105*
Age 85+ vs. 65-74: *1.110 (0.991, 1.243) p=0.0701*

AJRR data can also be used to look at resource utilization and practice trends over time. Figure 2.31 tabulates the discharge disposition reported for elective THA cases for the years 2017 through 2020, when data collection began. AJRR collects the CMS-defined Patient Discharge Status Code values. Discharge to home, represented by discharge codes 1 and 6, are reported in over 85% of cases and almost 90% by 2020. Discharge to a skilled nursing facility (SNF) is reported in approximately 12% of cases. Other discharge codes represent only a small portion of cases.

INSIGHTS

Approximately 90% of patients are now being discharged to home following elective primary total hip arthroplasty with far fewer patients being discharged to skilled nursing facilities compared to just a few years ago.

Figure 2.31 Total Hip Arthroplasty Discharge Disposition Codes by Year, 2017-2020 (N= 357,345)



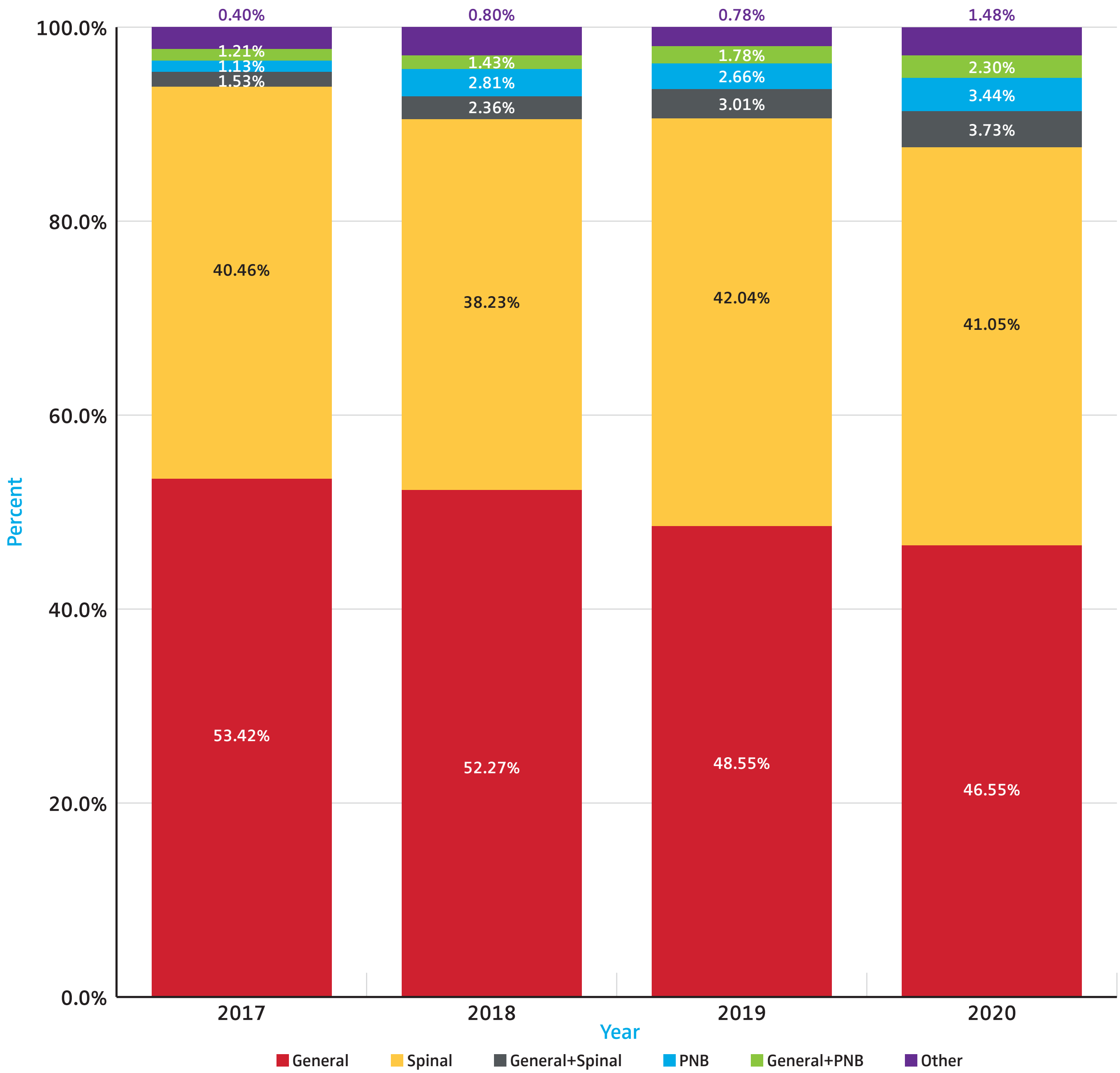
Code	Code Value
1: Home	Discharged to home/self-care (routine charge).
6: Home Care Org.	Discharged/transferred to home care of organized home health service organization.
3: SNF	Discharged/transferred to skilled nursing facility (SNF) with Medicare certification in anticipation of covered skilled care — (For hospitals with an approved swing bed arrangement, use Code 61 - swing bed. For reporting discharges/ transfers to a non-certified SNF, the hospital must use Code 04 - ICF.)
62: Inpat. Rehab	Discharged/transferred to an inpatient rehabilitation facility including distinct units of a hospital (eff. 1/2002).

Fewer patients appear to be receiving general anesthesia for primary total hip arthroplasty with increasing use of regional anesthesia over time.

INSIGHTS

Figure 2.32 shows a tabulation of the two primary anesthesia techniques chosen for patients undergoing an elective primary total hip arthroplasty. Over the last four years, general and spinal techniques have been utilized in comparable rates. Fewer patients appear to be receiving general anesthesia for primary total hip arthroplasty with increasing use of regional anesthesia over time.

Figure 2.32 Elective Primary Total Hip Arthroplasty Anesthesia Technique by Year, 2017-2020 (N=241,565)



The AJRR can also be used to follow the utilization of individual implants over time. Figures 2.33, 2.34, and 2.35 provide utilization data of implants used in elective primary total hip arthroplasty procedures in AJRR by year for the years 2012 through 2020. Figure 2.33 tabulates the most implanted stem, cup, and bearing surface combinations for the most frequent stems by year. The Accolade II stem and a Trident cup with a ceramic and polyethylene (CoP) bearing surface has been the most frequently implanted combination overall. However, the last two years show the Actis Duofix/Pinnacle CoP as the most frequent combination with Accolade II/Trident II combination as a close second (Figure 2.33). Figure 2.34 tabulates the eight most implanted stem components used in THA by year and shows that since 2014 the Accolade II stem has been implanted most frequently. Figure 2.35 tabulates the eight most implanted cup components in THA by year and shows that since 2012 the Pinnacle cup has been implanted most frequently.

Figure 2.33 Elective Primary Total Hip Arthroplasty Stem/Shell Component Combinations by Year, 2012-2020 (N= 594,575)

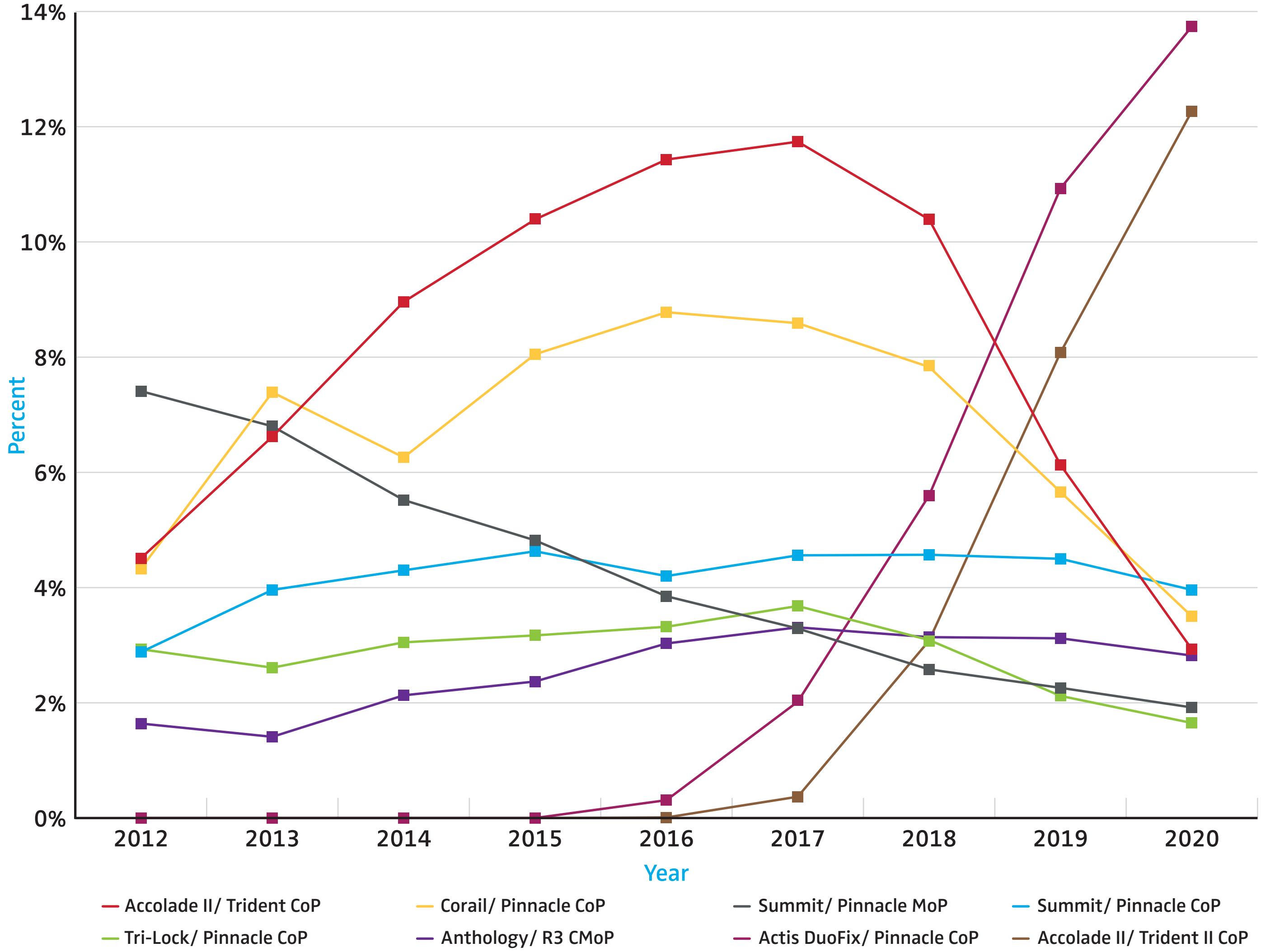


Figure 2.34 Elective Primary Total Hip Arthroplasty Stem Components by Year, 2012-2020 (N=635,106)

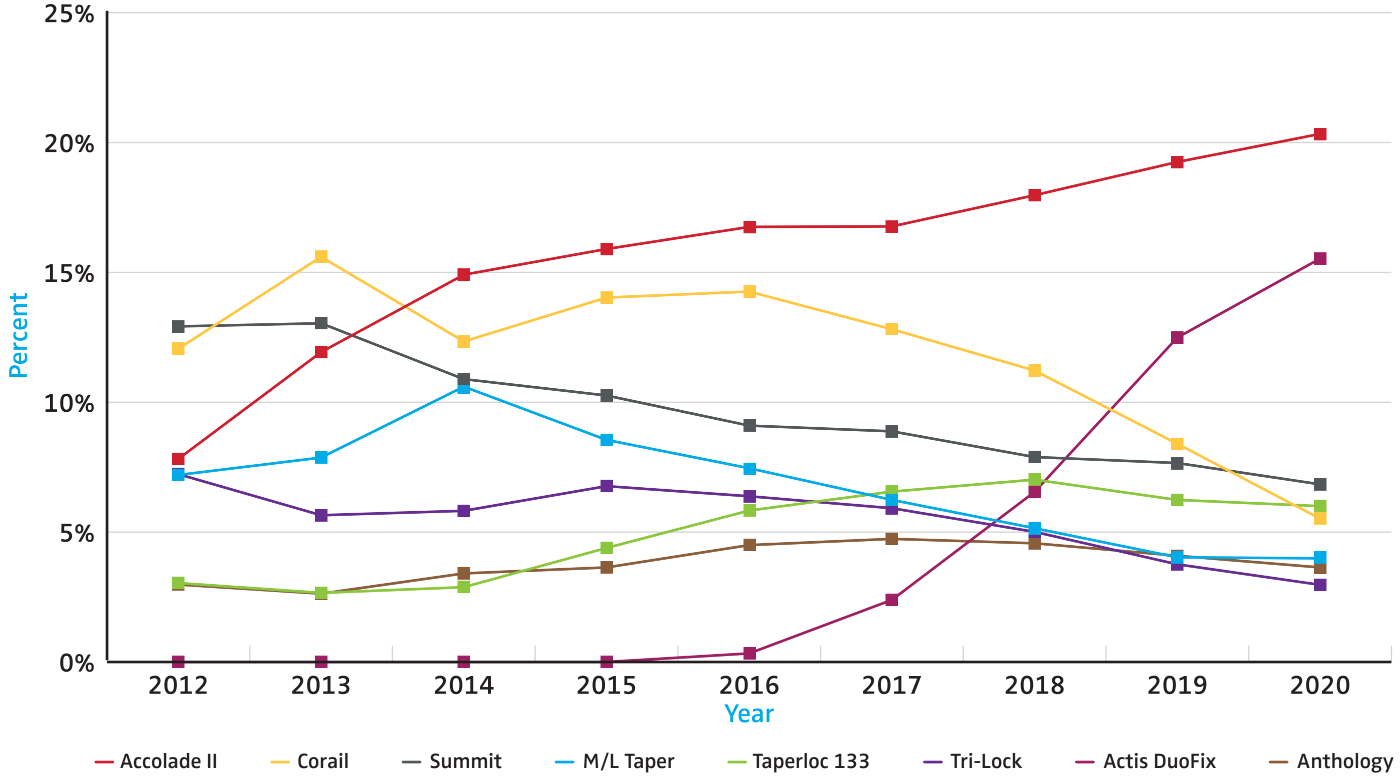
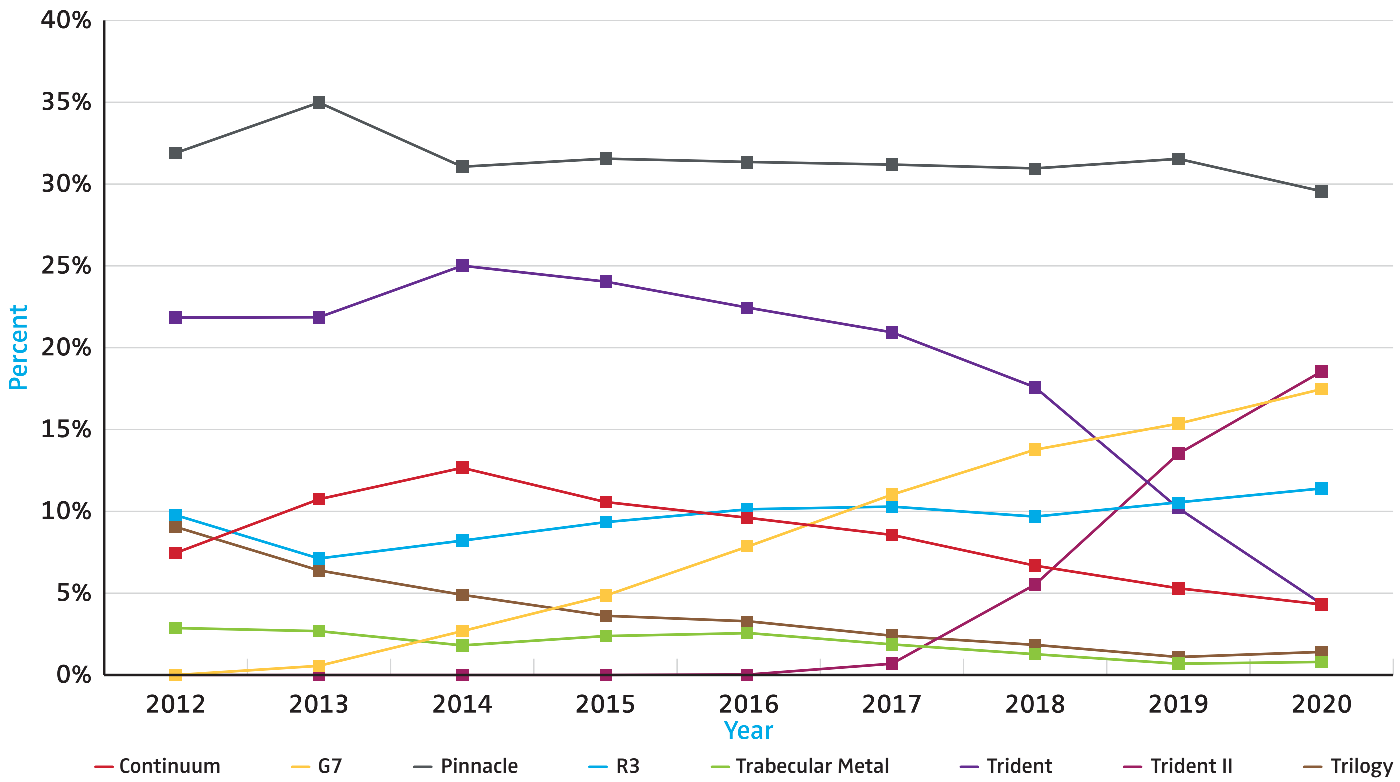


Figure 2.35 Elective Primary Total Hip Arthroplasty Cup Components by Year, 2012-2020 (N= 642,534)



One important and powerful aspect of the AJRR is the ability to look at cumulative revision rates specific to different implants. The majority of the variation in the hip device-specific survivorship appeared to occur within one year of the primary procedure. Early failure is typically a result of infection, dislocation, or periprosthetic fracture, which may or may not be related to the implant itself. Results showed all device constructs included in analysis have a cumulative percent revision of less than 2.8% at one year and less than 4.7% at final follow-up for each respective device (Tables 2.3 - 2.6). Metal-on-metal hip constructs were excluded from all analyses. Cemented acetabular components did not have sufficient procedure volume to be included in this supplement but will be included in future publications when numbers permit. Additional device-specific cumulative percent revision details and methodology are presented in the *2020 AJRR Annual Report Supplement*, which can be found at www.aaos.org/AJRRannualreport.

Table 2.3 Cumulative Percent Revision of Cementless Hip Arthroplasty Construct Combinations, 2012-2019

Acetabular Shell	Femoral Stem	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Trident	Accolade II	34,477	670	1.40 (1.28, 1.53)	2.03 (1.88, 2.19)	2.37 (2.17, 2.58)	2.59 (2.32, 2.87)
Pinnacle	Corail	32,180	327	0.73 (0.64, 0.83)	1.04 (0.93, 1.16)	1.24 (1.10, 1.40)	1.26 (1.11, 1.42)
Pinnacle	Summit	21,385	325	1.25 (1.11, 1.41)	1.55 (1.39, 1.74)	1.72 (1.53, 1.92)	1.86 (1.58, 2.17)
Pinnacle	Tri-Lock	14,409	194	0.98 (0.83, 1.15)	1.34 (1.16, 1.56)	1.67 (1.42, 1.96)	2.11 (1.53, 2.85)
R3	Anthology	10,371	178	1.48 (1.26, 1.74)	1.85 (1.59, 2.14)	1.95 (1.66, 2.28)	2.07 (1.71, 2.49)
Continuum	M/L Taper	10,310	250	1.82 (1.57, 2.10)	2.46 (2.16, 2.79)	2.83 (2.47, 3.21)	2.95 (2.56, 3.38)
Pinnacle	Actis DuoFix	9,159	52	0.64 (0.48, 0.84)	0.78 (0.54, 1.08)	—	—
G7	Taperloc 133	8,063	124	1.44 (1.19, 1.73)	1.74 (1.45, 2.08)	1.80 (1.49, 2.15)	—
Trident II	Accolade II	6,569	64	1.17 (0.90, 1.50)	1.24 (0.94, 1.60)	—	—
G7	Taperloc 133 Microplasty	5,486	76	1.23 (0.96, 1.56)	1.52 (1.20, 1.89)	1.60 (1.25, 2.01)	—
R3	Synergy	5,469	133	2.07 (1.71, 2.48)	2.59 (2.18, 3.07)	2.77 (2.31, 3.30)	2.77 (2.31, 3.30)
Trilogy	M/L Taper	3,924	95	1.48 (1.14, 1.90)	2.14 (1.71, 2.66)	2.87 (2.29, 3.56)	3.82 (2.77, 5.12)
Pinnacle	S-ROM	3,339	75	1.47 (1.09, 1.93)	2.35 (1.82, 2.97)	2.92 (2.22, 3.76)	3.78 (2.68, 5.15)
R3	PolarStem	3,281	37	0.94 (0.64, 1.33)	1.35 (0.96, 1.86)	1.35 (0.96, 1.86)	—
Trident	Secur-Fit Max	2,956	72	1.64 (1.23, 2.16)	2.37 (1.85, 2.99)	2.54 (1.99, 3.19)	3.36 (2.33, 4.67)
Trident	Accolade TMZF	2,928	63	1.13 (0.79, 1.56)	1.50 (1.10, 1.99)	2.09 (1.59, 2.71)	2.69 (2.02, 3.51)
Continuum	Trabecular Metal	2,354	50	1.79 (1.31, 2.39)	2.19 (1.65, 2.86)	2.19 (1.65, 2.86)	2.19 (1.65, 2.86)
Trident	Secur-Fit	2,291	68	1.96 (1.45, 2.60)	2.95 (2.27, 3.75)	3.59 (2.79, 4.54)	—
G7	Echo Bi-Metric	2,084	22	0.89 (0.55, 1.38)	1.15 (0.73, 1.75)	1.42 (0.82, 2.32)	—
R3	Synergy HA	2,037	47	1.70 (1.20, 2.34)	2.23 (1.64, 2.96)	2.58 (1.89, 3.44)	3.03 (2.01, 4.37)
FMP	Linear	1,971	18	0.78 (0.46, 1.26)	0.93 (0.56, 1.46)	1.28 (0.64, 2.31)	—
Trident	Secur-Fit Plus Max	1,946	31	1.20 (0.78, 1.77)	1.63 (1.12, 2.30)	1.63 (1.12, 2.30)	1.84 (1.23, 2.65)
Trabecular Metal	M/L Taper	1,569	37	1.99 (1.38, 2.78)	2.38 (1.69, 3.24)	2.89 (1.81, 4.36)	2.89 (1.81, 4.36)
Mallory Head	Taperloc 133	1,381	16	0.88 (0.48, 1.50)	1.16 (0.68, 1.88)	1.37 (0.79, 2.24)	1.37 (0.79, 2.24)
Continuum	Avenir-Muller	1,245	29	1.94 (1.28, 2.84)	2.44 (1.67, 3.45)	2.44 (1.67, 3.45)	—
G7	M/L Taper	1,207	21	1.77 (1.11, 2.67)	1.91 (1.21,2.87)	—	—
Continuum	Fitmore	1,189	33	2.20 (1.48, 3.16)	2.57 (1.77, 3.60)	2.97 (2.03, 4.19)	3.50 (2.23, 5.21)
Trilogy	VerSys	1,177	27	1.46 (0.89, 2.28)	1.96 (1.27, 2.91)	2.69 (1.79, 3.87)	2.69 (1.79, 3.87)
G7	Avenir-Muller	1,173	9	0.83 (0.41, 1.53)	0.83 (0.41, 1.53)	—	—
Trident	Citation	1,159	45	2.77 (1.93, 3.83)	3.52 (2.56, 4.72)	3.93 (2.88, 5.21)	4.67 (3.27, 6.44)
Continuum	VerSys	1,051	22	1.25 (0.70, 2.08)	2.19 (1.39, 3.27)	2.35 (1.51, 3.49)	2.35 (1.51, 3.49)
Continuum	Taperloc 133	971	13	1.15 (0.62, 2.00)	1.30 (0.71, 2.20)	1.83 (0.86, 3.47)	—
Continuum	Accolade II	957	18	1.84 (1.12, 2.87)	2.00 (1.23, 3.09)	2.00 (1.23, 3.09)	—

Table 2.4 Cumulative Percent Revision of Cementless Stems in Hip Arthroplasty Constructs, 2012-2019

Femoral Stem	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Accolade II	43,366	776	1.38 (1.28, 1.50)	1.98 (1.84, 2.13)	2.31 (2.12, 2.50)	2.52 (2.26, 2.79)
Corail	34,812	350	0.73 (0.65, 0.83)	1.03 (0.92, 1.15)	1.23 (1.10, 1.39)	1.28 (1.13, 1.45)
Summit	22,050	335	1.24 (1.10, 1.40)	1.55 (1.38, 1.72)	1.71 (1.52, 1.91)	1.86 (1.59, 2.16)
M/L Taper	17,604	423	1.76 (1.57, 1.96)	2.40 (2.17, 2.64)	2.86 (2.57, 3.16)	3.32 (2.79, 3.92)
Tri-Lock	14,768	199	0.99 (0.83, 1.16)	1.35 (1.16, 1.56)	1.66 (1.42, 1.94)	2.10 (1.52, 2.81)
Taperloc 133	13,544	210	1.38 (1.19, 1.60)	1.69 (1.47, 1.94)	1.88 (1.60, 2.20)	1.88 (1.60, 2.20)
Anthology	10,788	183	1.47 (1.26, 1.72)	1.83 (1.57, 2.11)	1.93 (1.64, 2.25)	2.05 (1.69, 2.46)
Actis DuoFix	9,385	55	0.66 (0.50, 0.86)	0.79 (0.56, 1.09)	—	—
Taperloc 133 Microplasty	6,975	97	1.16 (0.93, 1.44)	1.53 (1.25, 1.86)	1.58 (1.28, 1.92)	1.58 (1.28, 1.92)
Synergy	5,881	150	2.17 (1.81, 2.57)	2.70 (2.29, 3.16)	2.91 (2.45, 3.43)	2.91 (2.45, 3.43)
S-ROM	3,603	84	1.56 (1.18, 2.01)	2.46 (1.94, 3.07)	2.98 (2.31, 3.78)	3.80 (2.75, 5.10)
Trabecular Metal	3,597	81	1.82 (1.42, 2.30)	2.31 (1.84, 2.86)	2.43 (1.94, 3.01)	2.43 (1.94, 3.01)
PolarStem	3,579	43	1.04 (0.74, 1.43)	1.42 (1.03, 1.90)	1.42 (1.03, 1.90)	—
Echo Bi-Metric	3,388	67	1.50 (1.12, 1.96)	2.21 (1.70, 2.83)	2.66 (2.01, 3.46)	2.66 (2.01, 3.46)
Secur-Fit Max	3,328	77	1.63 (1.24, 2.11)	2.31 (1.82, 2.88)	2.46 (1.95, 3.07)	3.10 (2.25, 4.17)
Accolade TMZF	3,091	65	1.13 (0.81, 1.56)	1.48 (1.10, 1.96)	2.04 (1.56, 2.63)	2.60 (1.96, 3.38)
VerSys	3,008	67	1.48 (1.10, 1.97)	2.18 (1.68, 2.77)	2.60 (2.02, 3.30)	2.60 (2.02, 3.30)
Avenir-Muller	2,882	46	1.42 (1.03, 1.91)	1.75 (1.29, 2.32)	1.75 (1.29, 2.32)	—
Secur-Fit	2,832	81	2.03 (1.55, 2.61)	2.91 (2.29, 3.63)	3.60 (2.84, 4.50)	—
Secur-Fit Plus Max	2,629	57	1.62 (1.19, 2.16)	2.23 (1.70, 2.88)	2.32 (1.77, 3.00)	2.51 (1.87, 3.31)
Synergy HA	2,257	48	1.58 (1.12, 2.16)	2.05 (1.51, 2.73)	2.39 (1.75, 3.19)	2.82 (1.86, 4.09)
Linear	2,157	20	0.77 (0.46, 1.22)	0.97 (0.60, 1.49)	1.27 (0.68, 2.20)	1.27 (0.68, 2.20)
Fitmore	1,880	48	2.08 (1.50, 2.81)	2.45 (1.81, 3.25)	2.76 (2.01, 3.70)	3.83 (2.34, 5.86)
Novation	1,306	16	0.54 (0.24, 1.07)	0.62 (0.30, 1.19)	1.70 (0.99, 2.75)	1.70 (0.99, 2.75)
AMIStem-H	1,225	20	1.14 (0.66, 1.79)	1.39 (0.84, 2.17)	1.95 (1.18, 3.03)	1.14 (0.66, 1.79)
ABG II	1,219	30	2.36 (1.60, 3.34)	2.73 (1.84, 3.90)	2.73 (1.84, 3.90)	2.36 (1.60, 3.34)
Citation	1,177	45	2.73 (1.91, 3.78)	3.49 (2.53, 4.67)	3.89 (2.85, 5.16)	4.64 (3.24, 6.39)
TaperFill	972	12	1.04 (0.54, 1.86)	1.46 (0.77, 2.56)	1.46 (0.77, 2.56)	—
M/L Taper Kinectiv	938	24	1.85 (1.12, 2.89)	2.51 (1.62, 3.72)	2.73 (1.77, 4.03)	3.26 (1.98, 5.04)
Ovation Hip Stem	848	8	0.85 (0.38, 1.69)	1.03 (0.48, 1.96)	1.03 (0.48, 1.96)	—
Alteon	803	17	1.67 (0.94, 2.76)	2.77 (1.56, 4.56)	—	—

Table 2.5 Cumulative Percent Revision of Cementless Acetabular Components in Hip Arthroplasty Constructs, 2012-2019

Acetabular Shell	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Pinnacle	84,033	1,044	0.95 (0.89, 1.02)	1.30 (1.22, 1.39)	1.55 (1.45, 1.66)	1.72 (1.56, 1.90)
Trident	51,036	1,062	1.48 (1.37, 1.58)	2.09 (1.96, 2.23)	2.45 (2.30, 2.62)	2.88 (2.60, 3.17)
R3	24,887	464	1.54 (1.39, 1.70)	2.00 (1.82, 2.19)	2.20 (1.99, 2.43)	2.41 (2.10, 2.75)
G7	23,353	335	1.31 (1.17, 1.47)	1.63 (1.46, 1.82)	1.76 (1.54, 2.00)	—
Continuum	21,696	502	1.78 (1.61, 1.97)	2.33 (2.13, 2.55)	2.65 (2.41, 2.90)	2.87 (2.57, 3.19)
Trident II	8,998	101	1.29 (1.05, 1.57)	1.36 (1.10, 1.67)	—	—
Trilogy	7,379	174	1.49 (1.23, 1.79)	2.05 (1.74, 2.41)	2.69 (2.29, 3.14)	3.17 (2.61, 3.82)
Trabecular Metal	4,456	106	1.82 (1.45, 2.24)	2.19 (1.78, 2.66)	2.74 (2.22, 3.36)	3.36 (2.44, 4.52)
FMP	2,937	31	0.91 (0.61, 1.31)	1.14 (0.78, 1.63)	1.45 (0.85, 2.34)	—
Restoration ADM	2,702	48	1.35 (0.96, 1.84)	1.80 (1.34, 2.38)	1.96 (1.45, 2.58)	1.96 (1.45, 2.58)
Mallory Head	1,873	21	0.75 (0.43, 1.24)	1.14 (0.72, 1.74)	1.26 (0.79, 1.90)	1.26 (0.79, 1.90)
RingLoc+	1,617	35	1.49 (0.99, 2.18)	1.95 (1.35, 2.72)	2.17 (1.53, 2.99)	2.51 (1.66, 3.62)
Novation	1,538	27	1.46 (0.95, 2.17)	2.16 (1.39, 3.21)	2.16 (1.39, 3.21)	2.16 (1.39, 3.21)
Dynasty BioFoam	1,434	40	1.98 (1.35, 2.81)	2.69 (1.92, 3.67)	3.11 (2.23, 4.23)	3.52 (2.40, 4.95)
Regenerex RingLoc+	1,251	29	1.62 (1.02, 2.45)	2.16 (1.43, 3.13)	2.90 (1.92, 4.20)	2.90 (1.92, 4.20)
Escalade Acetabular System	1,149	8	0.53 (0.22, 1.10)	0.62 (0.28, 1.24)	0.80 (0.37, 1.55)	—
Trinity	1,010	17	1.44 (0.83, 2.36)	1.94 (1.16, 3.07)	1.94 (1.16, 3.07)	1.94 (1.16, 3.07)
Versafitcup DM	964	19	1.56 (0.91, 2.50)	1.89 (1.16, 2.91)	2.08 (1.28, 3.18)	2.08 (1.28, 3.18)
Interface Acetabular System	826	17	1.34 (0.71, 2.32)	1.91 (1.12, 3.06)	2.57 (1.47, 4.17)	—
Ranawat-Burnstein	841	20	2.03 (1.23, 3.16)	2.35 (1.46, 3.59)	2.70 (1.65, 4.16)	2.70 (1.65, 4.16)

Table 2.6 Cumulative Percent Revision of Cemented Stems in Hip Arthroplasty Constructs, 2012-2019

Femoral Stem	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Summit	1,614	31	1.28 (0.81, 1.93)	1.83 (1.24, 2.63)	2.67 (1.64, 4.10)	3.13 (1.86, 4.92)
Accolade C	1,318	19	1.13 (0.65, 1.84)	1.55 (0.95, 2.40)	2.07 (1.08, 3.61)	2.07 (1.08, 3.61)
VerSys Advocate	1,151	13	0.71 (0.34, 1.35)	1.17 (0.64, 2.00)	1.32 (0.74, 2.22)	1.32 (0.74, 2.22)
VerSys	1,050	18	1.18 (0.65, 2.00)	1.43 (0.82, 2.34)	2.90 (1.53, 4.99)	2.90 (1.53, 4.99)
Exeter	985	14	0.95 (0.47, 1.74)	1.37 (0.76, 2.38)	1.89 (1.04, 3.18)	1.89 (1.04, 3.18)
Synergy	950	14	1.24 (0.66, 2.15)	1.65 (0.94, 2.69)	1.65 (0.94, 2.69)	1.65 (0.94, 2.69)
Avenir	819	9	0.79 (0.33, 1.65)	1.56 (0.74, 2.95)	1.56 (0.74, 2.95)	—

INSIGHTS

All device constructs included in analysis have a cumulative percent revision of less than 2.8% at one year and less than 4.7% at final follow-up for each respective device.

Revision Hip Arthroplasty

Between 2012 and 2020, AJRR has collected data on 61,214 revision hip arthroplasty procedures.

A substantial amount of work has been done since the last *AJRR Annual Report* to better identify and characterize the reasons for revision hip arthroplasty procedures. The data submitted to AJRR contains variability in coding with respect to primary reason for revision. The reason for revision surgery was determined by the primary diagnosis code submitted for each revision. AJRR accepts up to 10 diagnosis codes which can be submitted as either ICD (International Classification of Diseases)-9 or-10 codes depending on the year of the procedure. To best produce analyses, much time was spent with surgeon leadership to identify the best approach for grouping and characterizing the numerous different codes. This has resulted in substantially improved accuracy of the diagnostic categories.

The primary reasons for revision were examined and categorized as follows: periprosthetic osteolysis, fracture/periprosthetic fracture/fracture related sequelae, articular bearing surface wear and osteolysis, infection and inflammatory reaction, other mechanical complications, aseptic loosening, instability related codes, pain, and hematoma/wound complications. If the primary code submitted did not fall into one of these categories, the subsequent reported codes were examined for a match. If none of the submitted codes matched a defined category, the primary reason for revision was placed in an "other" category. This category was then examined and all procedures with a non-relevant or obviously erroneous diagnosis were removed. Differences can be identified from this year to the previous Annual Reports, as there has been substantial data cleaning efforts to ensure duplicate procedures and irrelevant codes are removed along with large swaths of historical data submissions being included from new and existing sites.

Using this methodology, the most common reason for hip revision surgery was infection at 20.1% (Figure 2.36). Revision surgeries can also be further examined based on their occurrence from the time of the index primary procedure. An early revision is considered one that occurred <3 months after the primary procedure. There were 4,554 early "linked" revision procedures in AJRR (Table 2.7). A "linked" revision is one in which the patient had the primary and revision surgery both done in a facility that submitted data to AJRR. Although not all patients will return to the same facility for their revision procedure, a significant majority of revisions done in the early postoperative period are expected to return to the same AJRR hospital as the primary.[21] Among early revisions, 3,040 had a primary diagnosis that was relevant using the methodology above. For all early revisions, the primary reason was again infection (32.9%) followed by fracture (24.9%) (Figure 2.37).

INSIGHTS

Infection remains the most common reason for early revision surgery following total hip arthroplasty, followed by fracture and instability, when looking at linked revisions at AJRR facilities.

Infection is also the most common diagnosis for all revision hip arthroplasty surgeries in the AJRR.

INSIGHTS

Figure 2.36 Distribution of Diagnosis Associated with All Hip Revisions, 2012-2020 (N=51,714)

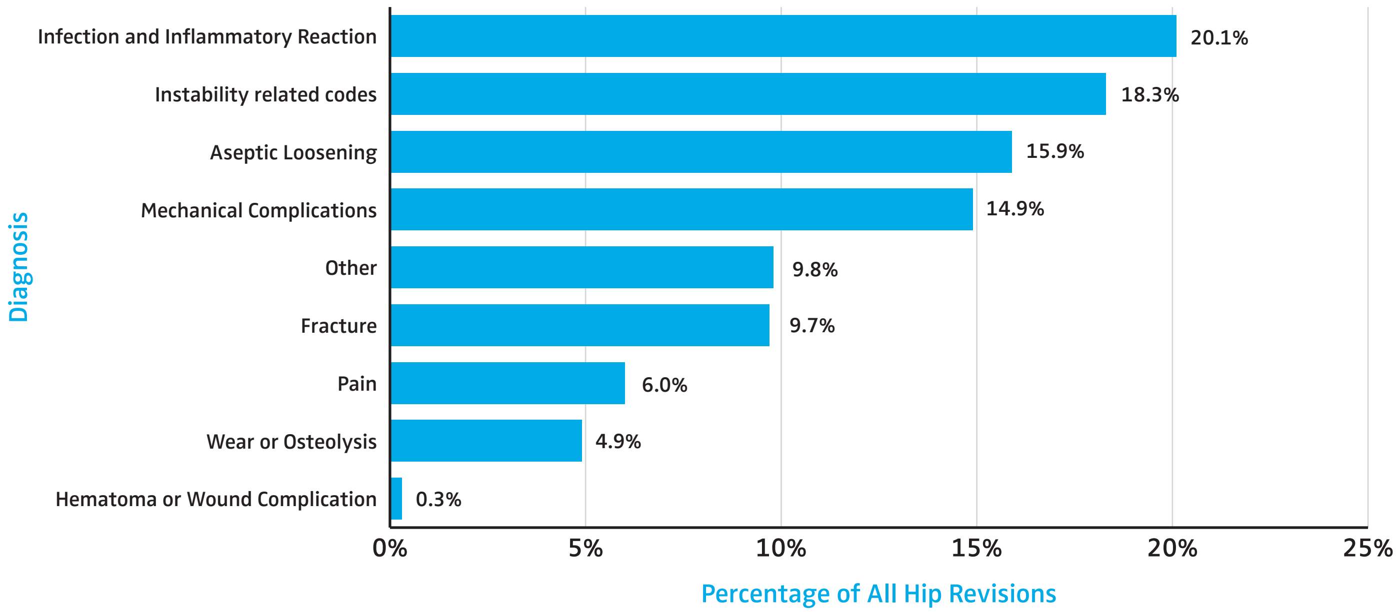
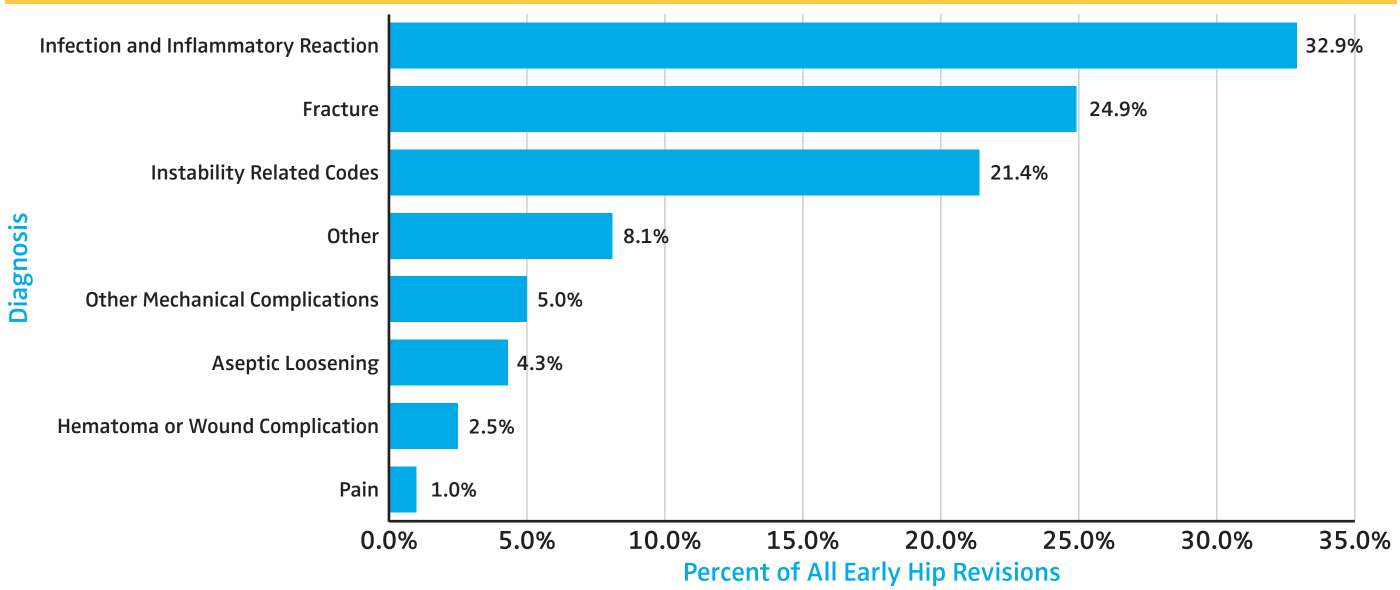


Table 2.7 Distribution of Time Interval Between Elective Primary Hip Arthroplasty Procedures and Revision for Linked Patients, 2012-2020 (N=8,628)*

Time	Frequency	Percent
<3 Months	4,554	52.8
3-5 Months	1,129	13.1
6-12 Months	1,119	13.0
>1 Year	1,826	21.2

***Linked revision requires matching patient ID, laterality, and procedure site*

Figure 2.37 Distribution of Diagnosis Associated With all Early "Linked" Hip Revisions, 2012-2020 (N=3,040)*



**Linked revision requires matching patient ID, laterality, and procedure site*

The prevalence of early hip revisions between the ages of 50 and 90 appears fairly stable regardless of patient age (Figure 2.38). When trending the percentage of all hip arthroplasty revisions with a primary diagnosis of infection, the percentage varies from 11.3-25.7% over the years 2012-2020 (Figure 2.39). Similarly, for hip revisions due to instability/dislocation, the value appears to be increasing before dropping off in 2018 and continued decline through 2020 (Figure 2.40). As AJRR collects historical data, these numbers could change with further data collection.

Figure 2.38 Early "Linked" Revisions as a Percent of Elective Primary Hip Arthroplasty Procedures by Age Group, 2012-2020 (N=4,554)

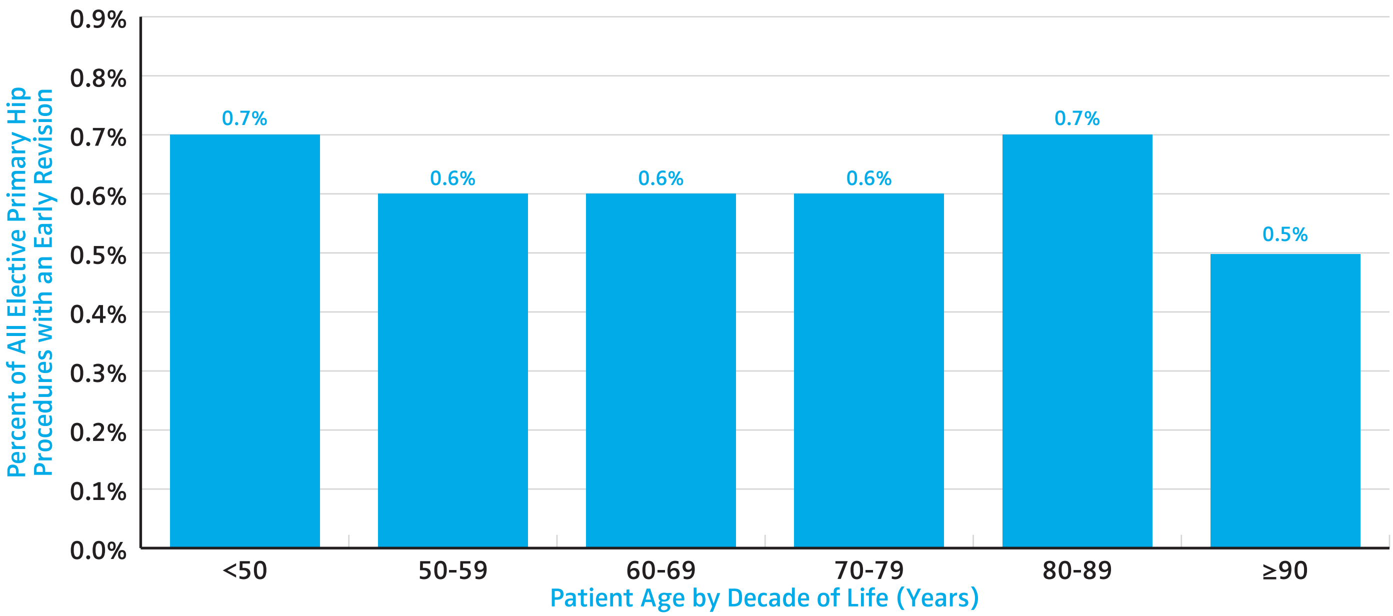


Figure 2.39 Revisions Due to Infection as a Percentage of All Hip Revisions, 2012-2020 (N=10,399)

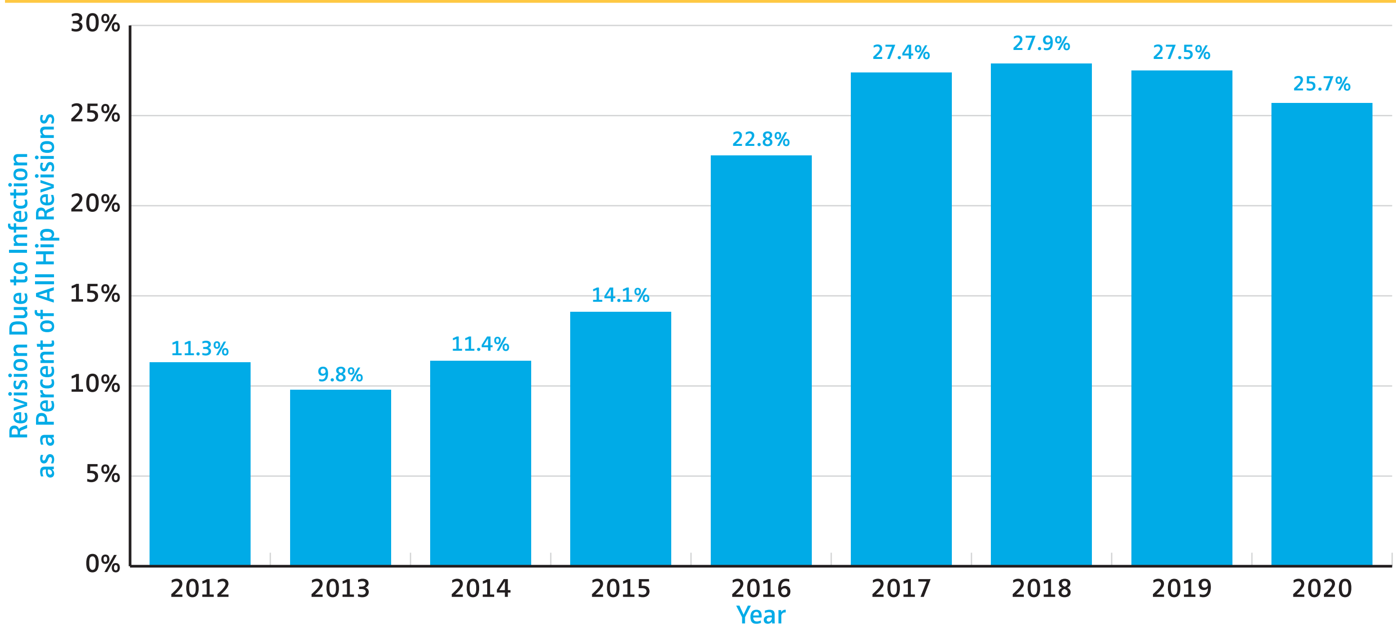
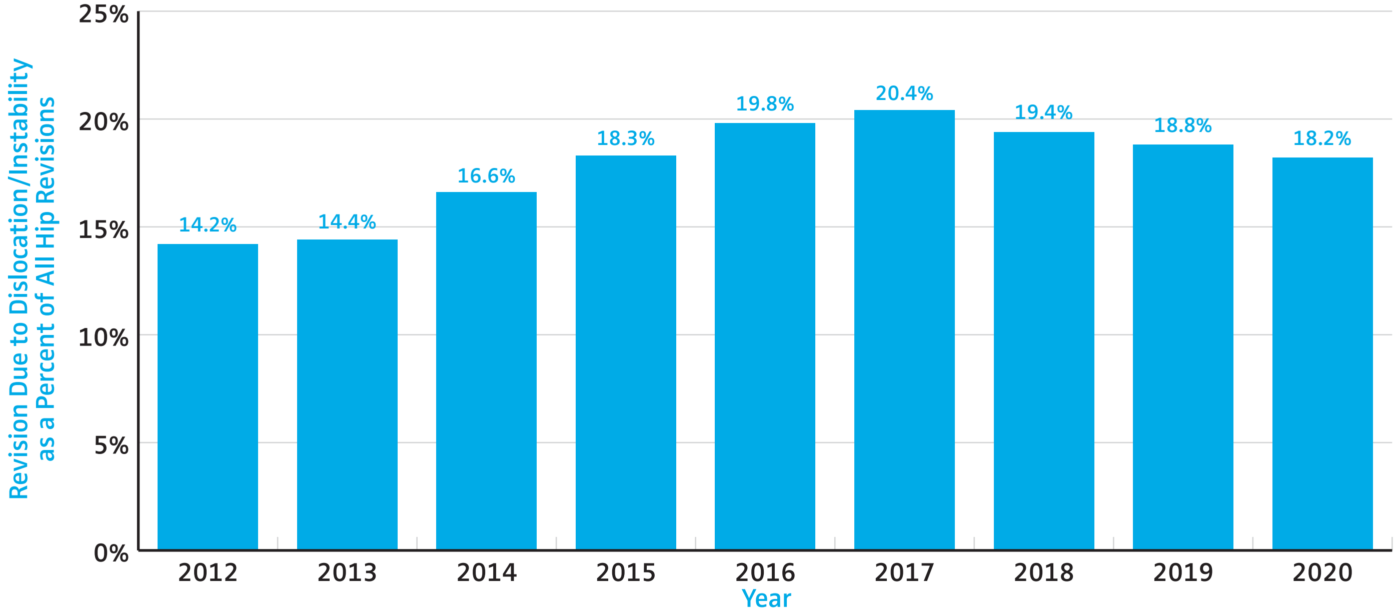


Figure 2.40 Revisions Due to Dislocation/Instability as a Percentage of All Hip Revisions, 2012-2020 (N=9,470)



As with primary total hip arthroplasty, AJRR saw a statistically significant increase in dual mobility usage for revision hip arthroplasty procedures when comparing 2012 to 2020 with 19.8% of articulations classified as dual mobility in 2020 ($p<0.0001$) (Figure 2.41). Not surprisingly, there has been a significant increase in overall dual mobility usage for revisions specifically to treat dislocation/instability from 2012 to 2020 (17.7% to 27.1%, $p<0.0001$) (Figure 2.42). A corresponding decrease has been seen in the use of conventional 36mm femoral heads.

INSIGHTS

The use of dual mobility articulations continues to rapidly increase in revision hip procedures and was utilized in over one quarter of all hip revision procedures in 2020.

Revision burden is calculated by dividing the number of revision arthroplasties performed in one year by the total number of arthroplasties (revisions plus primaries) during the same year. Although crude, and influenced by numerous factors, revision burden can be used across registries as a simple unit of measure for comparison and quality improvement measures. In 2020, AJRR's sample population had a revision burden for all total hip arthroplasty procedures of 4.6%, which is a slight increase from a steep decline of 8.6% between 2013-2019 (Figure 2.43). McGrory et al. compared revision burden among international hip and knee joint registries and noted an overall decrease in hip revision burden from 2011-2014.[13] Similarly, the Australian Orthopaedic Association National Joint Replacement Registry reported an 8% revision burden in 2020, an all-time low for the Registry.[6]

Although hip arthroplasty revision burden appears to be declining when calculated using AJRR data, numerous factors may be at play. As the Registry grows and new institutions submit data, a disproportionately large number of primary procedures may be added to the database, or the distribution of institutions performing primary versus revision surgery may change. Finally, even with the growth of AJRR, revisions performed outside the AJRR capture area would falsely decrease revision burden. Still, it is possible that at least some of the decrease is due to improvements in techniques and implants (decreasing use of metal-on-metal implants, increasing use of ultra-high-molecular-weight polyethylene (UHMWPE), etc.).

Figure 2.41 Percent Dual Mobility Usage and Femoral Neck Head Sizes Implanted for Hip Revisions, 2012-2020 (N=40,988)

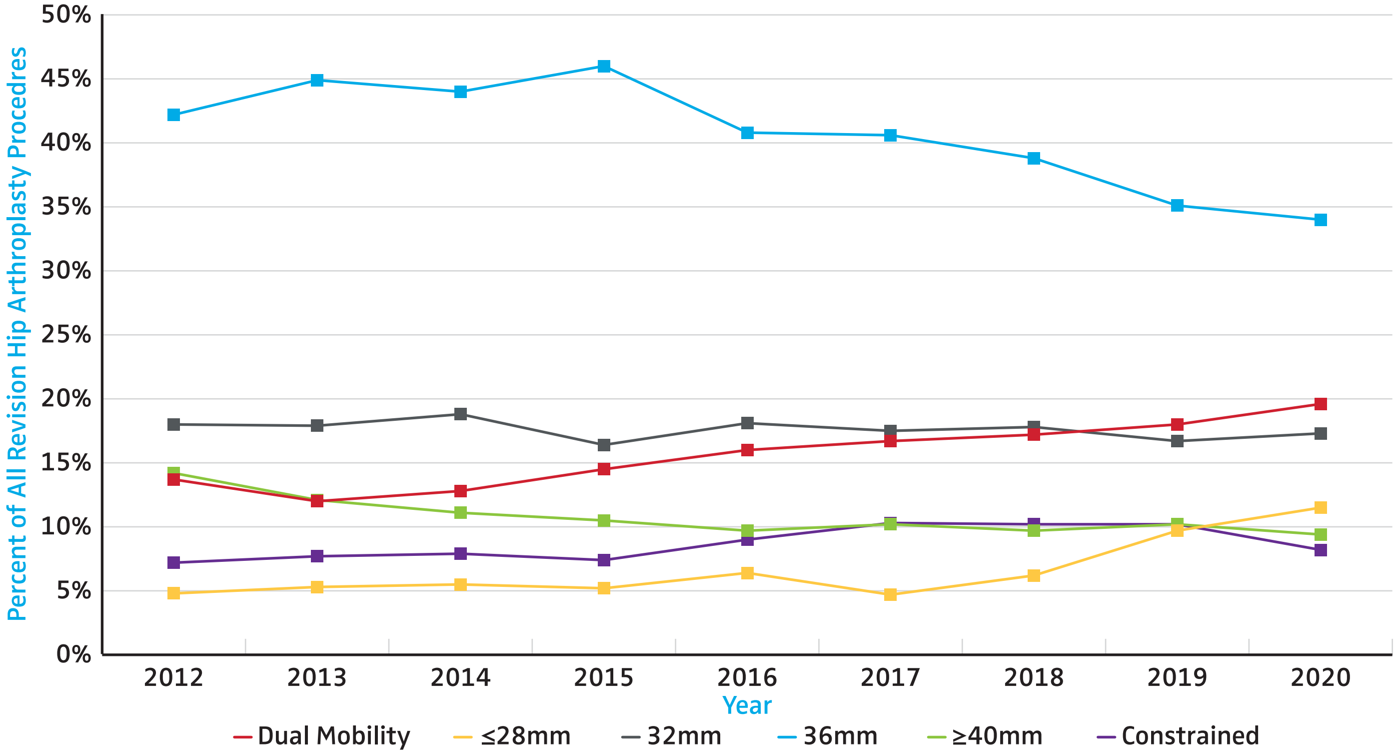


Figure 2.42 Dual Mobility Usage for Hip Revisions Secondary to Dislocation/Instability, 2012-2020 (N=6,536)

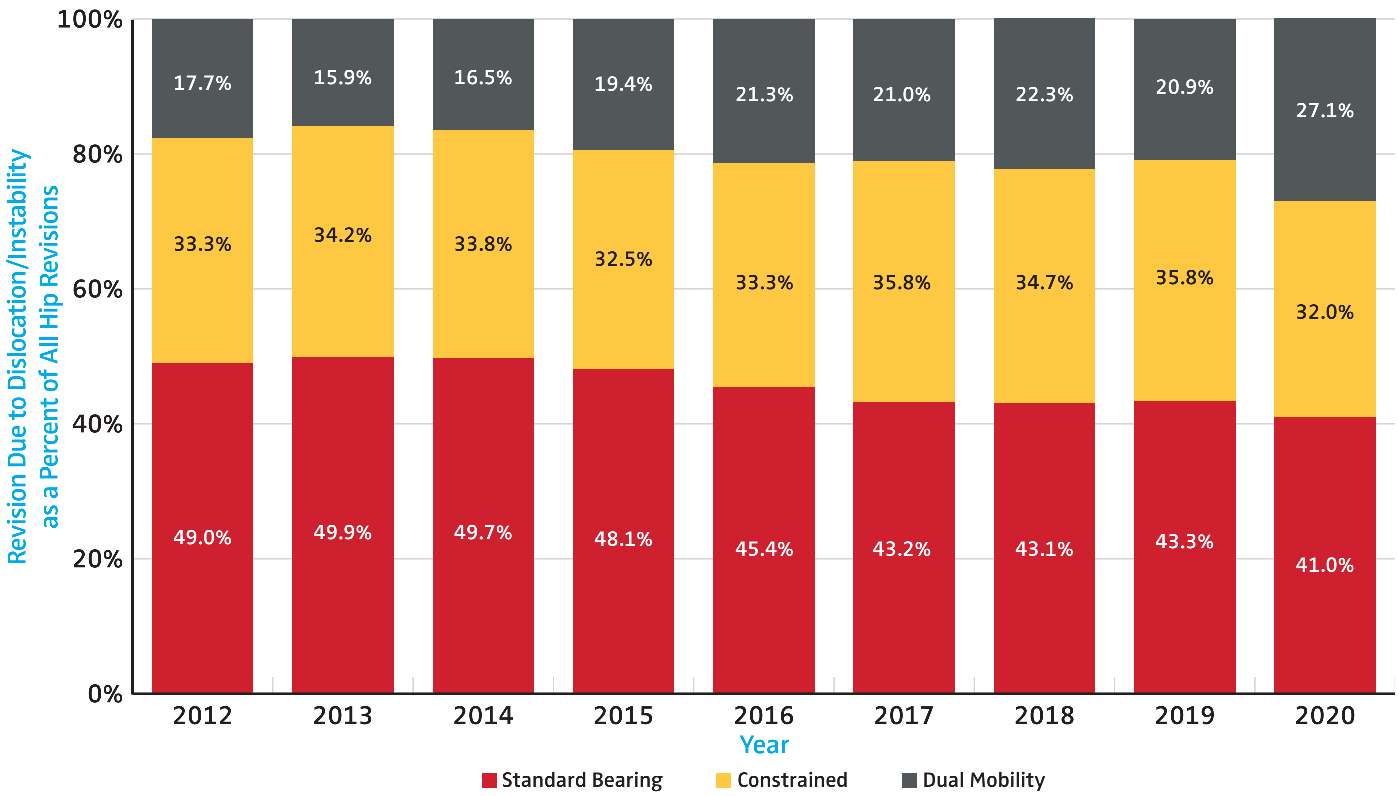
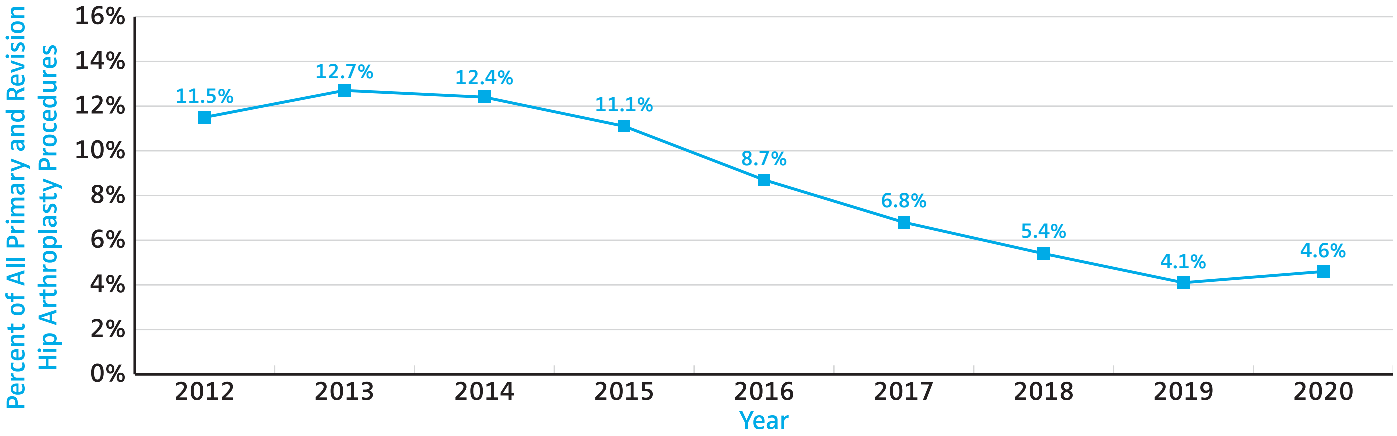


Figure 2.43 Revision Burden of Elective Primary Total Hip Arthroplasty Procedures, 2012-2020 (N=61,214)*

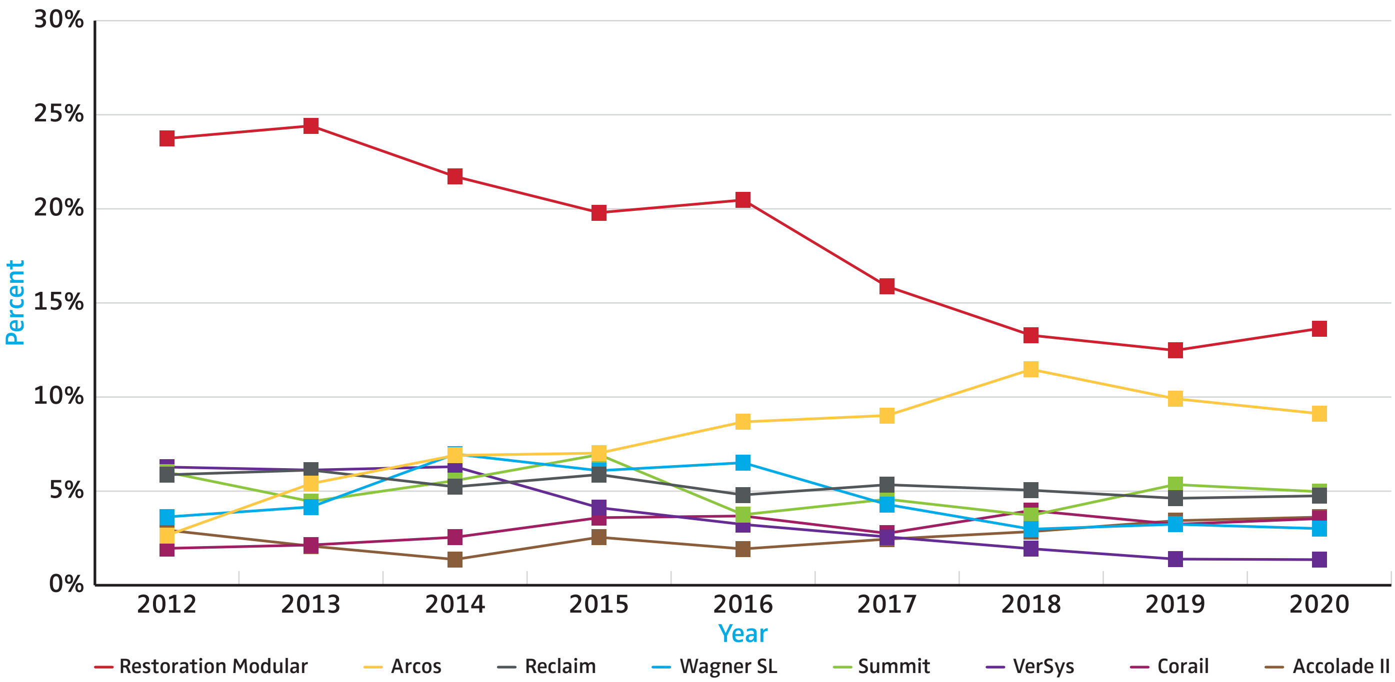


The following two figures provide utilization data of implants used in revision hip arthroplasty procedures in AJRR. Figure 2.44 tabulates the eight most commonly used stem components used in revision THA by year and shows that over the nine-year period, the Restoration Modular stem was implanted most frequently. Figure 2.45 tabulates the eight most commonly used cup components in THA by year and shows that over the nine-year period, the most frequently implanted cup has varied. In the last two years, G7 was the most frequently implanted cup.

INSIGHTS

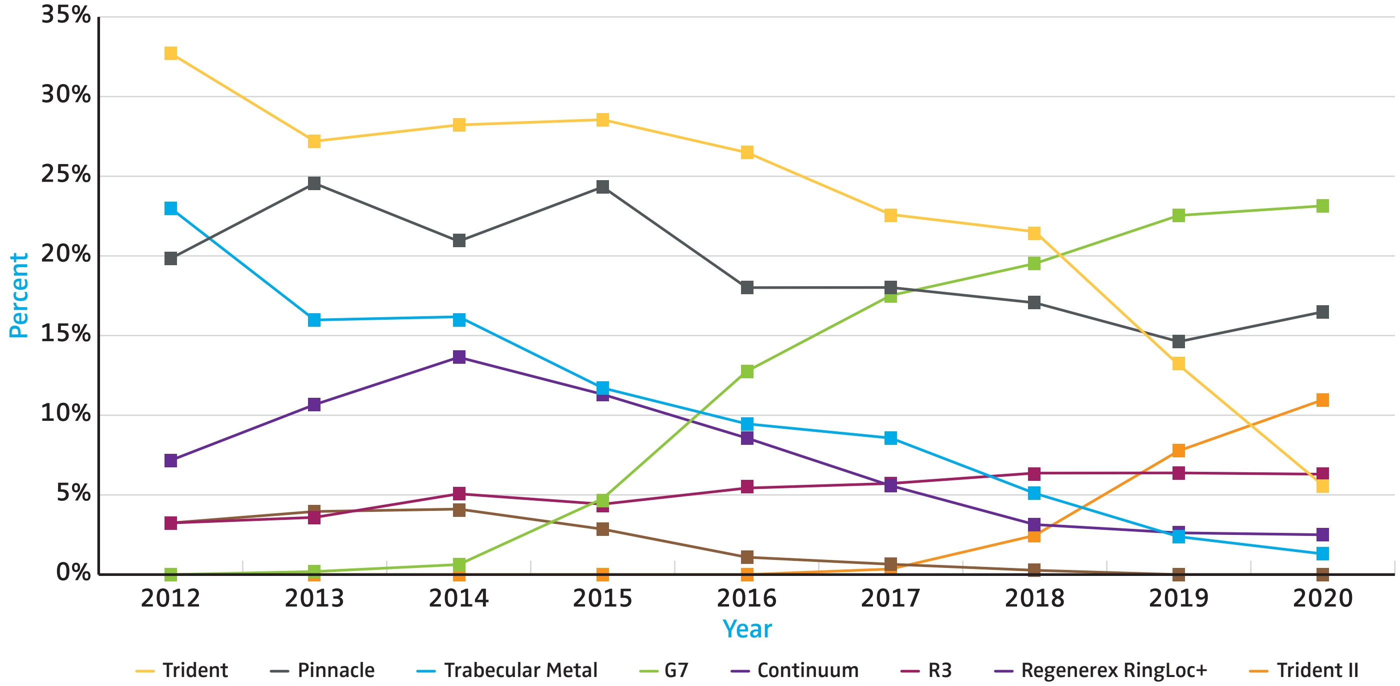
For the first time in several years, the revision burden of elective primary THA did not continue to decrease in 2020.

Figure 2.44 Revision Hip Arthroplasty Stem Components by Year, 2012-2020 (N=21,648)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Total N	716	1,684	2,984	3,960	3,996	3,148	2,319	1,514	1,327	21,648

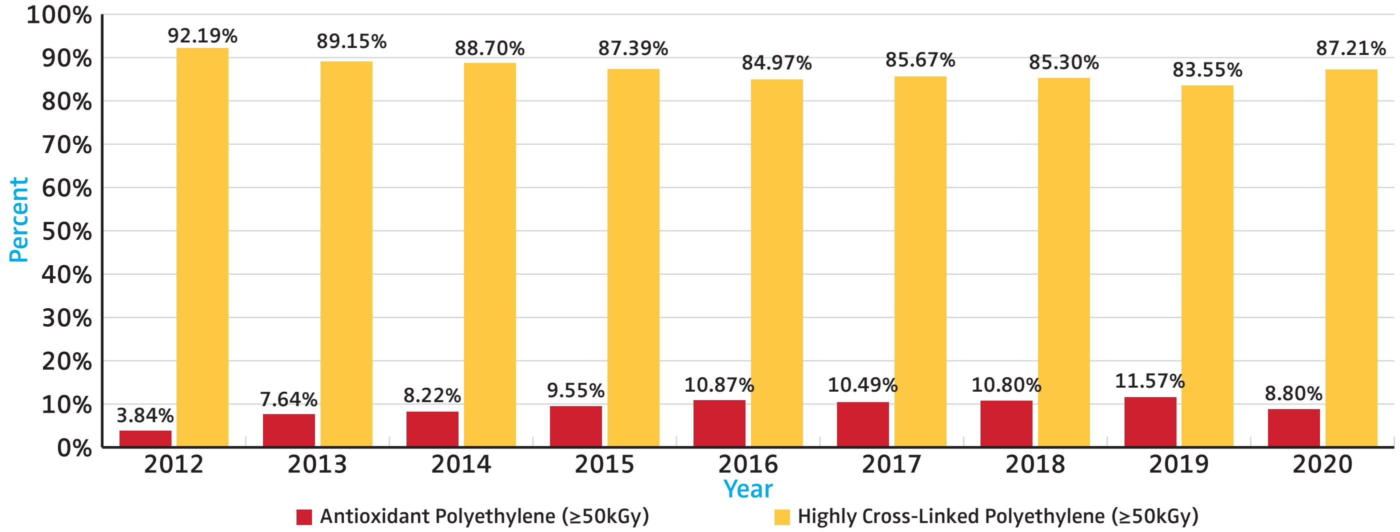
Figure 2.45 Revision Hip Arthroplasty Cup Components by Year, 2012-2020 (N=23,418)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Total N	1,018	2,147	3,628	4,526	4,036	3,407	2,198	1,300	1,158	23,418

Figure 2.46 shows the liner types utilized by year for revision hip arthroplasty. Highly cross-linked polyethylene was more commonly utilized compared to antioxidant polyethylene for all revision hip arthroplasty procedures. This mirrors the trend observed in primary total hip arthroplasty (Figure 2.23). In contrast with elective THA, a few percent of revision hip procedures (<5%) report using conventional polyethylene.

Figure 2.46 Revision Hip Arthroplasty Liner Polyethylene Material by Year, 2012-2020 (N=37,560)

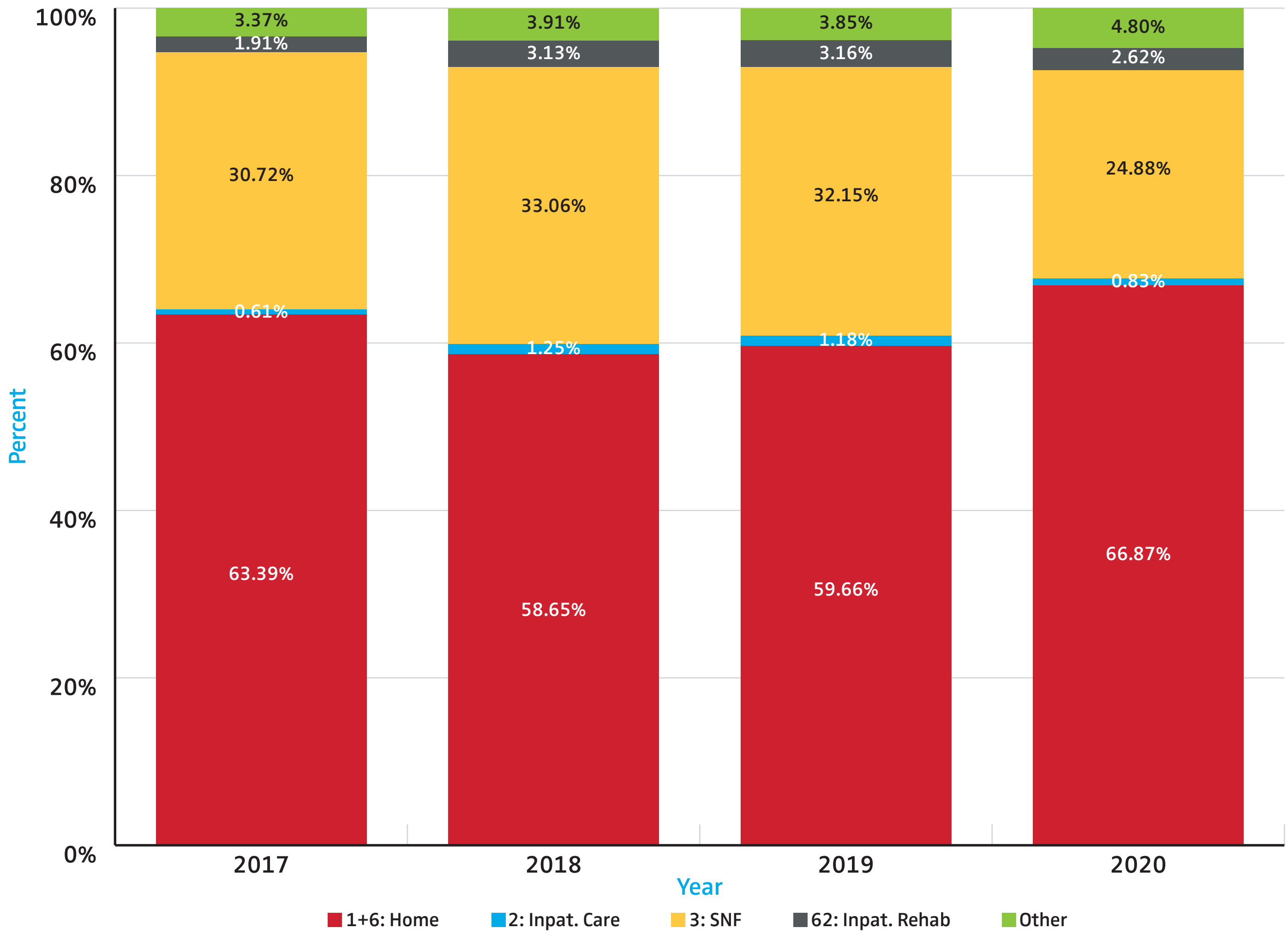


The percentage of patients discharged to a skilled nursing facility following revision THA declined in 2020 to the lowest level in several years.

INSIGHTS

Figure 2.47 shows a tabulation of discharge disposition after revision hip arthroplasty for the last four years. AJRR data shows that most patients were released to home or self-care with a 5.8% decline in those discharged to skilled nursing facilities from 2017-2020. However, nearly one quarter of patients were discharged to a skilled nursing facility in 2020, which is more than three times higher than the rate seen with primary total hip arthroplasty.

Figure 2.47 Revision Hip Arthroplasty Discharge Disposition Codes by Year, 2017-2020 (N=17,697)



Code	Code Value
1: Home	Discharged to home/self-care (routine charge).
6: Home Care Org.	Discharged/transferred to home care of organized home health service organization.
2: Inpat. Care	Discharged/transferred to other short-term general hospital for inpatient care.
3: SNF	Discharged/transferred to skilled nursing facility (SNF) with Medicare certification in anticipation of covered skilled care--(For hospitals with an approved swing bed arrangement, use Code 61 - swing bed. For reporting discharges/transfers to a non-certified SNF, the hospital must use Code 04 - ICF.)
62: Inpat. Rehab	Discharged/transferred to an inpatient rehabilitation facility including distinct units of a hospital (eff. 1/2002).

Patient-Reported Outcome Measures (PROMs)

Patient-reported outcome measures (PROMs) have received increased attention within AJRR and the wider practice of orthopaedic surgery. In the U.S., value-based payment models made capture of PROMs a prerequisite for various public and private alternative payment models. Internationally, in 2014 the International Society of Arthroplasty Registries (ISAR) Steering Committee established a working group in this area to advise on best practices.[14]

AJRR collects patient-reported outcome measures and encourages sites to submit this data at set intervals: a baseline measure obtained prior to the surgery, a measure 90-days post-operatively, and at one-year postoperatively. Patient-reported outcome measures capture information on the patient's overall health and function from the patient's perspective. The recommended intervals allow comparison over the course of a patient's care, but on a broader scope, provide a better picture of national outcomes and trends. AJRR provides national benchmarking for participating sites to review and compare this uniquely reported data.

With a growing emphasis on the value of PROMs data, the Registry in turn has expanded the ways in which sites submit this data. The Registry provides a tool for sites to collect PROMs data electronically on all eligible patients, via email or a computer or tablet device in the clinical setting. Sites also have the option to submit PROMs data through other methods, perhaps collected via a third-party vendor or a local system.

Quick Facts:

- Collection of PROMs was initiated in the California Joint Replacement Registry (CJRR) in early 2011 and following incorporation of CJRR within AJRR began for the larger U.S. population in April 2016.
- To help assist AJRR institutions with PROM data collection, AJRR offers a PROM platform within RegistryInsights® at no additional cost that allows for PROM storage and capture (both preoperatively and postoperatively). However, sites may utilize their existing PROMs solution if preferred.
- AJRR collects PROMs at any time but recommends at a minimum a preoperative (<90 days before the procedure) and a one-year postoperative PROM.
- As of 2019, AJRR recommends and supports (on their PROM platform) the collection of HOOS JR., KOOS JR., PROMIS-10, and VR-12. Other PROMs are collected but not used for analyses.
- As of December 31, 2020, 290 sites out of 1,152 (25.2%) have submitted PROMs, which is a 39% increase in sites compared to the previous *2020 AJRR Annual Report*.
- The completion rate for "linked" outcomes (those where both a preoperative and one-year postoperative PROM is available on the same procedure) varies between 25.0-27.8%.

Based on the HOOS, JR. score, 93% of patients achieved a meaningful improvement after elective primary total hip arthroplasty.

INSIGHTS

Table 2.8 Preoperative and 1-Year Postoperative PROM Mean Scores After Elective Primary Hip Arthroplasty by PROM

Patient-Reported Outcome Measure (PROM)	PROM Component	Pre or 1-year Postoperative	N	Mean	Standard Deviation
HOOS, JR. (Hip disability and Osteoarthritis Outcome Score)	Score	Preoperative	32,929	47.0	16.0
		Postoperative	13,615	85.2	15.8
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	Preoperative	21,720	49.0	9.0
		Postoperative	10,239	52.7	8.4
	Physical T	Preoperative	21,720	39.5	7.1
		Postoperative	10,239	49.7	8.9
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	Preoperative	13,598	51.6	12.9
		Postoperative	6,124	55.8	10.1
	Physical Health Component	Preoperative	13,454	29.6	9.0
		Postoperative	6,132	44.8	11.1

Table 2.9 Change Between Preoperative and 1-Year Postoperative PROM Scores after Elective Primary Hip Arthroplasty by PROM, 2012-2020

Patient-Reported Outcome Measure (PROM)	PROM Component	Patients with Preoperative Score	Patients with Linked Postoperative Score	Response Rate, Percentage of Patients Who Completed a Preoperative and 1-Year Score	Patients with Meaningful Improvement*
HOOS, JR. (Hip disability and Osteoarthritis Outcome Score)	Score	32,929	8,241	25.0%	93.0%
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	21,720	5,768	26.6%	39.2%
	Physical T	21,720	5,768	26.6%	75.6%
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	13,598	3,737	27.5%	40.9%
	Physical Health Component	13,454	3,743	27.8%	79.5%

**Meaningful improvement was calculated by minimal clinical important difference (MCID). MCID was determined to be a positive change score of half the pooled standard deviation*

Knee Arthroplasty

Knee Overview

Between 2012 and 2020, AJRR has collected data on 1,319,496 knee arthroplasty procedures.

The majority of knee surgeons submitting data to AJRR are performing primary total knee arthroplasties. The mean per surgeon volume of total knee arthroplasties was 33.9 with a median of 15 and an interquartile range (25th-75th percentile) of 4-40 (Table 3.1). These volumes are similar to what has previously been reported in the literature.[15] Partial knee arthroplasties include medial unicompartmental, lateral unicompartmental, and patellofemoral arthroplasty. Only surgeons with at least one relevant knee procedure were included.

The mean age for individuals undergoing total knee arthroplasty was 67.0 (SD 9.9) years (Table 3.2 and Figure 3.1). There was a statistical difference in the average age between patients undergoing total knee arthroplasty (67.0 years) and partial knee arthroplasty (64.4 years) ($p<0.0001$) as well as total knee and revision knee arthroplasty ($p<0.0001$).

When examining mean length of stay as reported to AJRR, there has been a significant decrease of more than one day for total knee arthroplasties comparing 2012 (2.9) to 2019 (1.7). A significant decrease in mean length of stay for partial knee arthroplasties of 1.5 days was also seen (Figure 3.2) ($p<0.0001$). For this analysis, length of stay was calculated by subtracting admission date from the discharge date. Data to accurately calculate length of stay was provided on only 47% of all knee cases.

INSIGHTS

Mean length of stay following revision total knee arthroplasty has remained fairly constant over time despite substantial decreases for partial and primary total knee arthroplasty.

Table 3.1 Average Procedural Volume for Participating Surgeons, 2020

Procedure	Total Surgeons	Total Procedures	Per Surgeon Mean	Per Surgeon Median	25th Percentile	75th Percentile
Total Knee Arthroplasty	3,669	124,307	33.9	15.0	4.0	40.0
Revision Knee Arthroplasty	2,008	10,526	5.2	2.0	1.0	5.0
Partial Knee Arthroplasty	1,094	5,857	5.4	2.0	1.0	5.0

Table 3.2 Mean Age of Patients Undergoing Knee Arthroplasty Procedures, 2012-2020 (N=1,319,496)

Procedures	Total	Mean Age (Years)	Standard Deviation
Total Knee Arthroplasty	1,168,826	67.0	9.9
Revision Knee Arthroplasty	89,463	65.5	11.8
Partial Knee Arthroplasty	61,207	64.4	10.9

Figure 3.1 Age Distribution of Knee Arthroplasty Procedures, 2012-2020 (N=1,319,496)

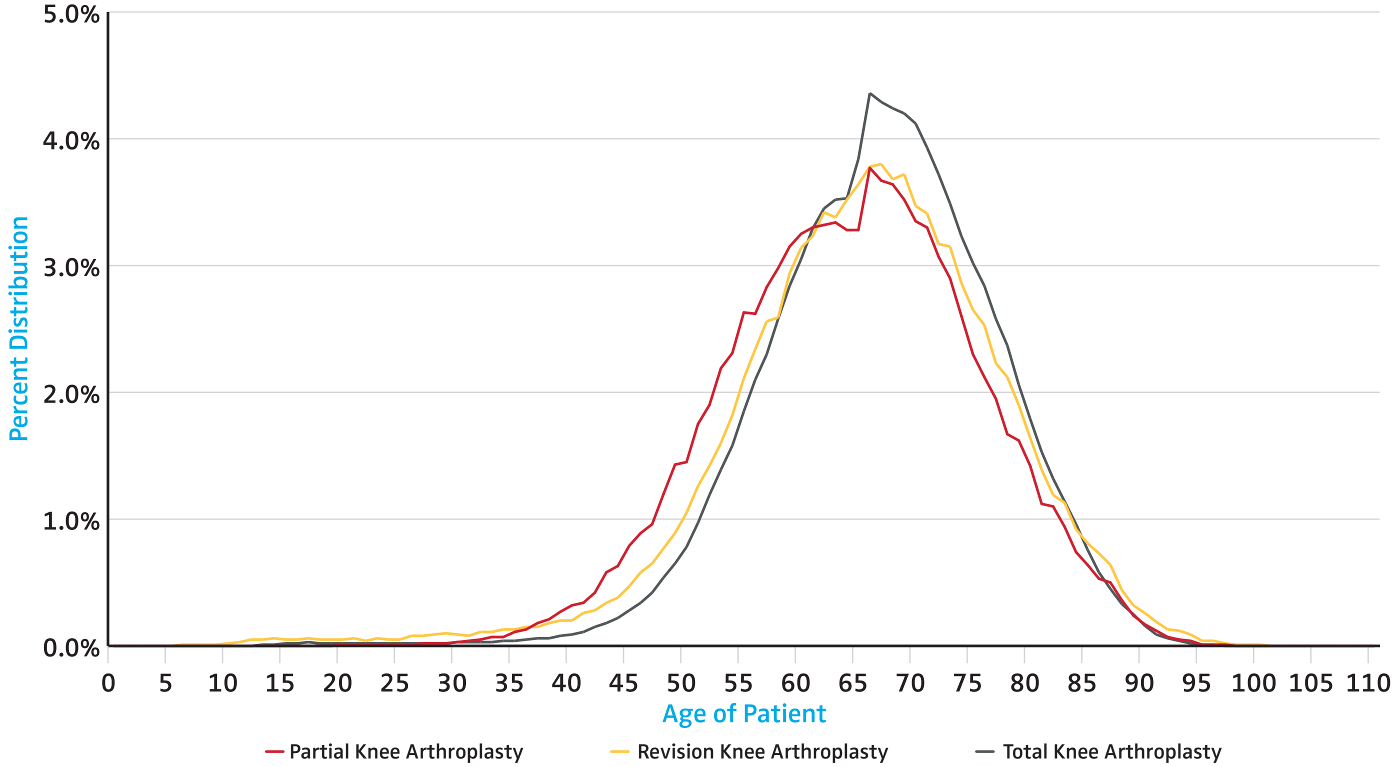
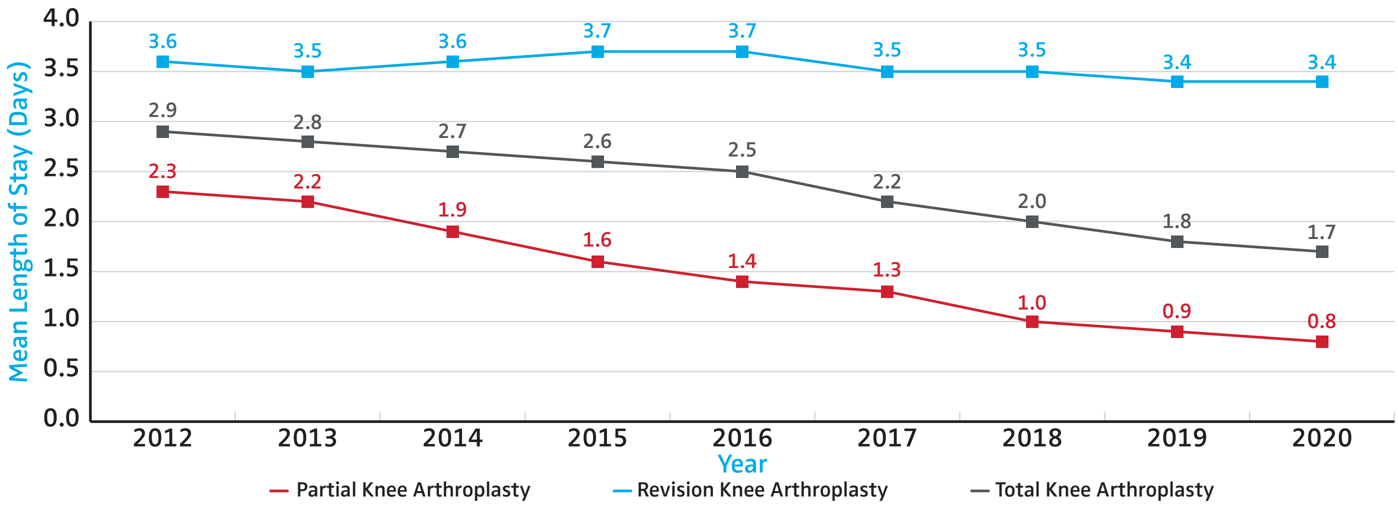


Figure 3.2 Mean Length of Stay for Knee Arthroplasty Procedures, 2012-2019 (N=625,990)



Primary Total Knee Arthroplasty

Between 2012 and 2020, AJRR has collected data on 1,168,826 primary total knee arthroplasty procedures.

More than half of patients at all age points receiving a total knee arthroplasty were female (Figure 3.3). The sex distribution of patients follows an increasing trend but remains fairly consistent as age increases. More than half of all primary total knee arthroplasty procedures utilized posterior stabilized implants until 2019 when that rate dropped below 50%. Cruciate retaining designs increased annually since 2016 to reach 46.2% in 2020. The use of ultracongruent components has increased between 2012 and 2019 (Figure 3.4).

INSIGHTS

The trend towards increased use of ultracongruent designs for primary total knee arthroplasty continues at the expense of posterior stabilized designs.

Figure 3.3 Sex Distribution of All Total Knee Arthroplasty Procedures by Age Group, 2012-2020 (N=1,164,634)

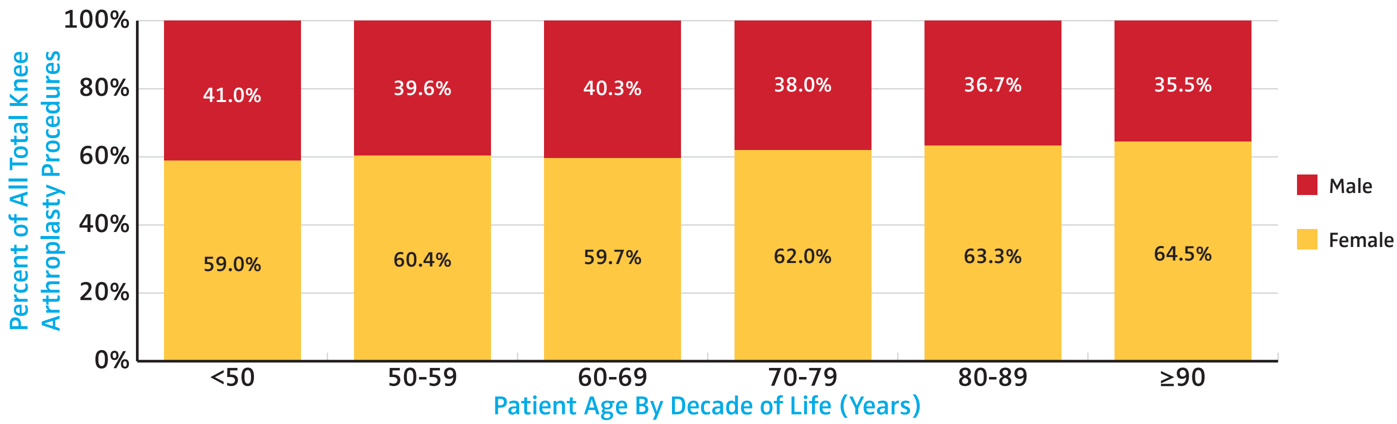
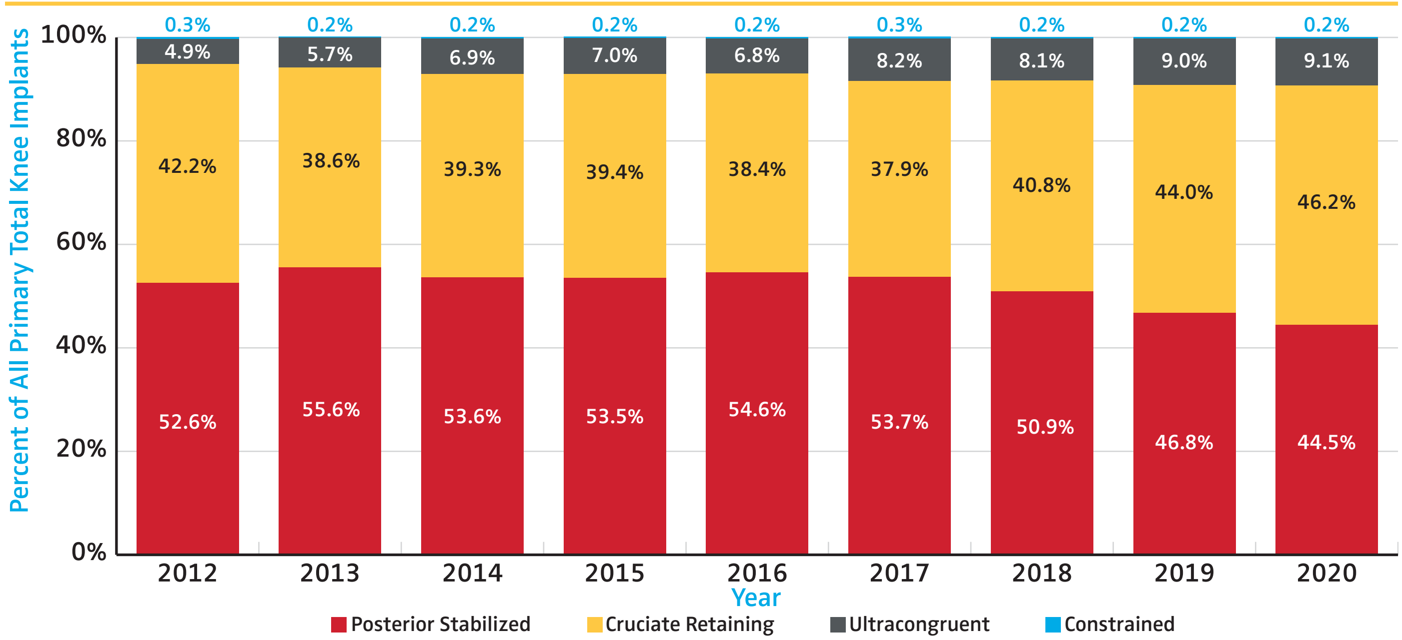


Figure 3.4 Distribution of Primary Total Knee Arthroplasty Implant Designs, 2012-2020 (N=950,016)

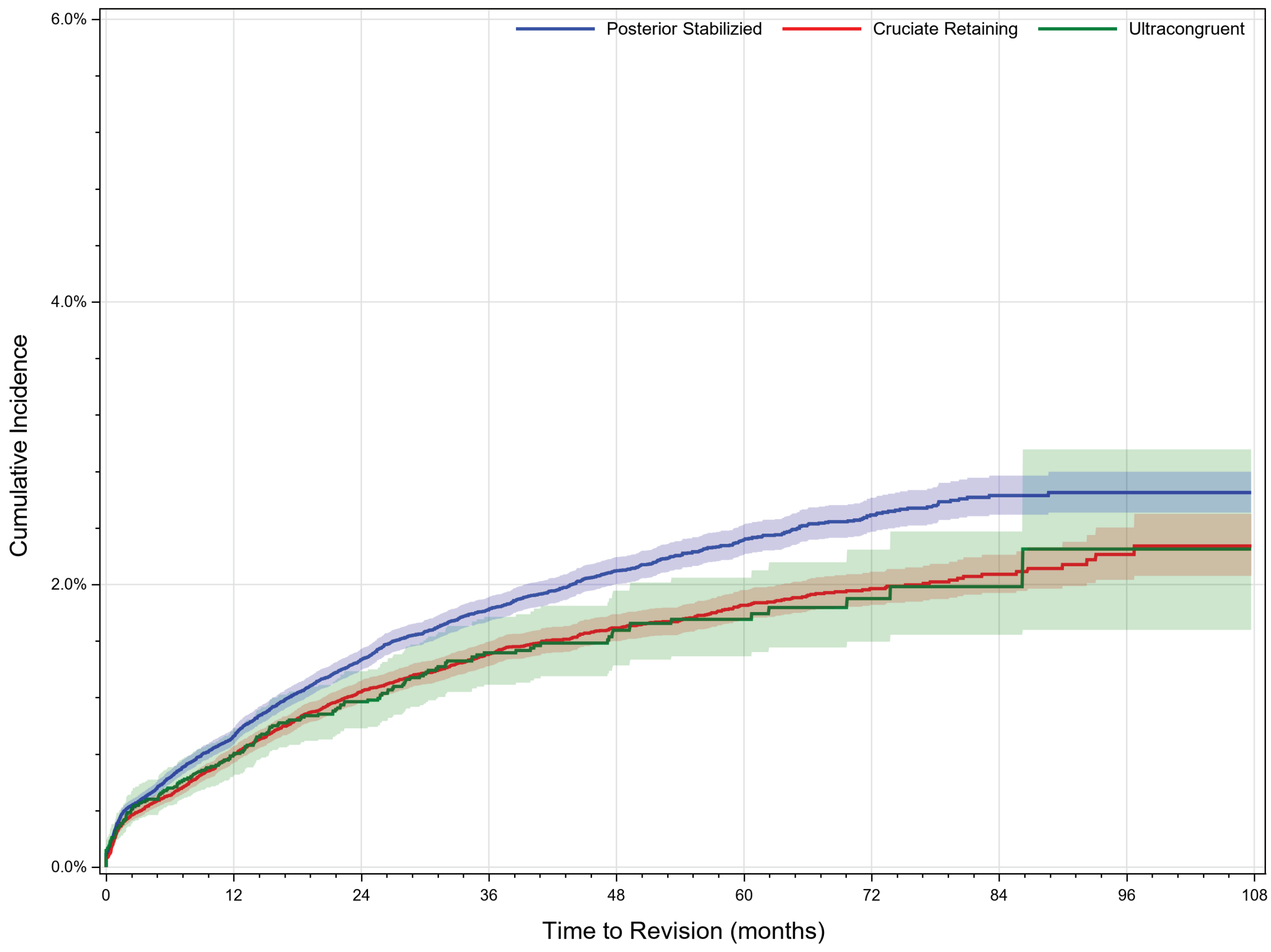


After adjusting for age and sex in patients ≥65 years of age as reported to either AJRR or CMS, ultracongruent and cruciate retaining designs showed significantly reduced cumulative percent revision compared to posterior stabilized designs; age adjusted hazard ratio (HR) of 0.8 for males and 0.7 for females (Figures 3.5-3.6). This analysis does not account for numerous potential confounders and the reasons for revision may be unrelated to the implant type. See Appendix G for cumulative percent revision curve methodology.

INSIGHTS

Cruciate retaining and ultracongruent designs have reduced rates of cumulative revision when compared to posterior stabilized designs in the AJRR.

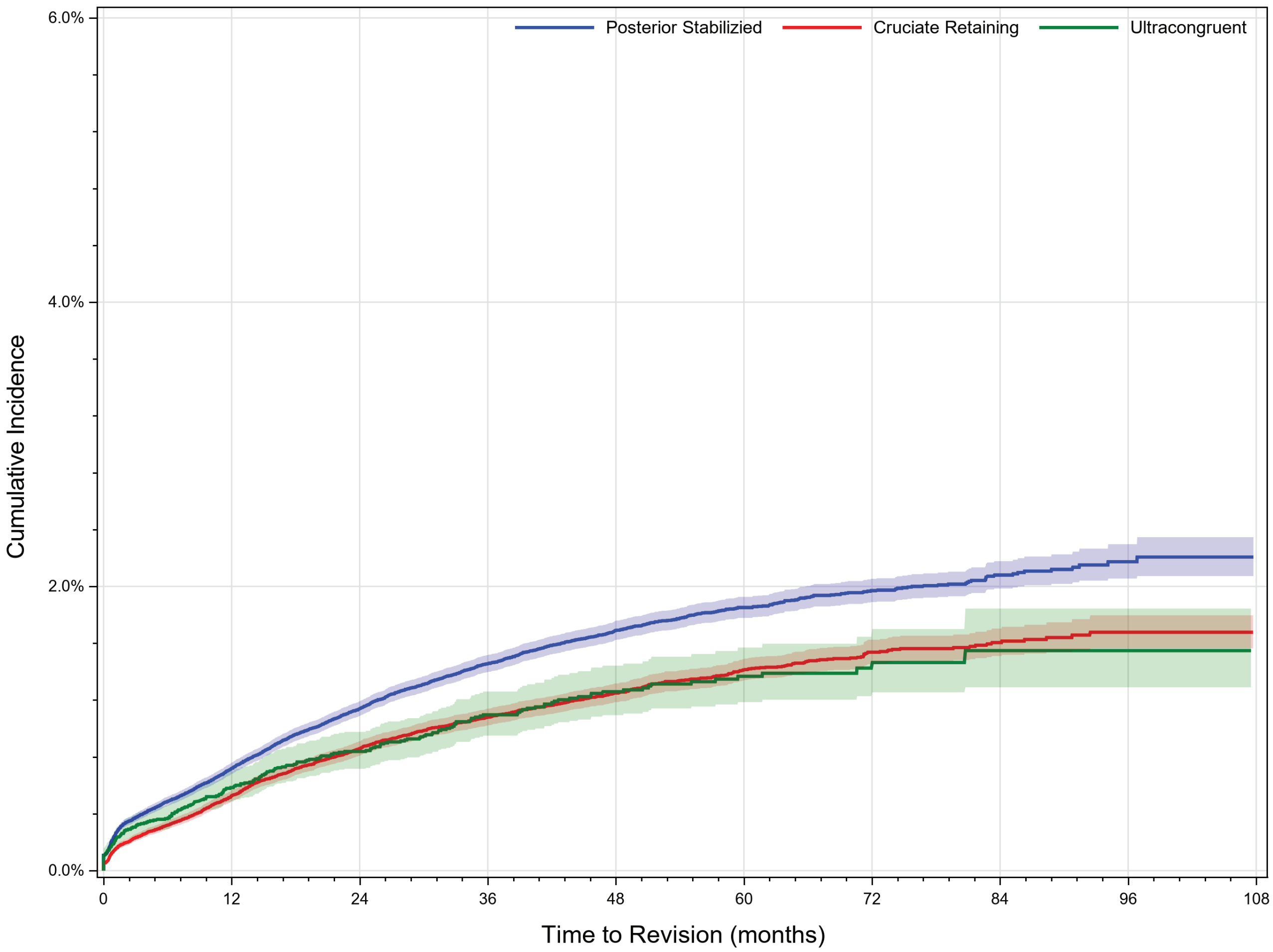
Figure 3.5 Cumulative Percent Revision for Primary Total Knee Arthroplasty Implant Designs in Male Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Posterior Stabilized	11,282	14,654	17,181	19,887	17,675	12,253	8,248	4,966	1,742	107,888
Cruciate Retaining	11,726	14,446	14,628	15,154	13,126	9,681	6,579	3,808	1,640	90,788
Ultracongruent	1,571	1,969	2,065	2,255	1,674	1,164	833	318	116	11,965
Total	**24,579**	**31,069**	**33,874**	**37,296**	**32,475**	**23,098**	**15,660**	**9,092**	**3,498**	**210,641**

Age Adjusted Hazard Ratio (95% CI)
Cruciate Retaining vs. Posterior Stabilized: *0.810 (0.756, 0.867) p<0.0001*
Ultracongruent vs. Posterior Stabilized: *0.801 (0.686, 0.936) p=0.0052*

Figure 3.6 Cumulative Percent Revision for Primary Total Knee Arthroplasty Implant Designs in Female Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Posterior Stabilized	16,868	23,647	27,912	32,901	29,074	20,363	14,177	8,449	3,037	176,428
Cruciate Retaining	16,877	22,446	22,863	23,655	20,810	15,411	10,894	6,510	3,010	142,476
Ultracongruent	2,387	3,336	3,429	3,858	2,972	2,259	1,587	633	213	20,674
Total	**36,132**	**49,429**	**54,204**	**60,414**	**52,856**	**38,033**	**26,658**	**15,592**	**6,260**	**339,578**

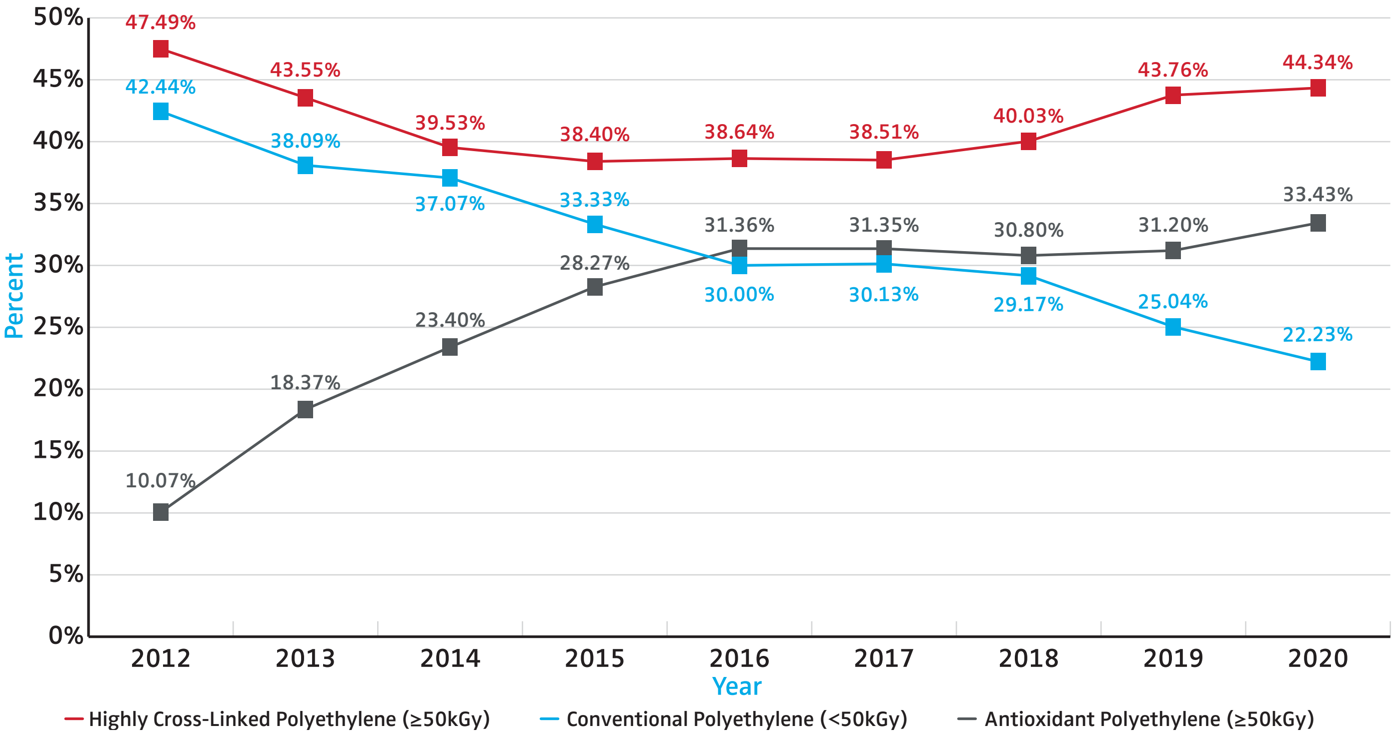
Age Adjusted Hazard Ratio (95% CI)
Cruciate Retaining vs. Posterior Stabilized: *0.747 (0.702, 0.795) p<0.0001*
Ultracongruent vs. Posterior Stabilized: *0.742 (0.647, 0.850) p<0.0001*

For primary total knee arthroplasty procedures in the AJRR, antioxidant polyethylene usage has substantially increased at the expense of non-antioxidant polyethylene inserts (including conventional UHMWPE and highly cross-linked) between 2012 and 2020 (Figure 3.7). A highly cross-linked polyethylene insert is defined by having received a total radiation dose of 50 kGy (5 Mrad) or more. Antioxidant polyethylene is a highly cross-linked polyethylene with an antioxidant component infused or blended in manufacturing.

INSIGHTS

The use of conventional polyethylene continues to decrease in primary total knee arthroplasty.

Figure 3.7 Primary Total Knee Arthroplasty Insert Polyethylene Material by Year, 2012-2020 (N= 931,729)



The majority of primary total knee arthroplasties continue to include a resurfaced patella although a slight trend towards unresurfaced patellae is apparent.

INSIGHTS

Utilization of patellar resurfacing in the AJRR shows a decreasing trend over time but remained above 90% in 2020 (Figure 3.8). While patellar resurfacing remains the predominant practice in the U.S., this is not necessarily the case in other international registries. In 2021, the Australian Orthopaedic Association National Joint Replacement Registry reported patellar resurfacing at the time of the primary total knee replacement had increased from a low of 41.5% in 2005 to 75.4% in 2020.[6] The Swedish Knee Arthroplasty Register reported use of patellar resurfacing has been decreasing since the mid-1980s and in 2020 was performed in only 2.7% of total knee arthroplasty cases.[16]

In patients ≥65 years of age in either AJRR or CMS, cases with resurfaced patellae showed decreased cumulative percent revision compared to cases where the patella was left unresurfaced, and this reached statistical significance in females (HR=1.419, 95% CI, 1.254-1.607, $p<0.0001$). However, there were far more procedures with resurfaced patellae, particularly for females, and this finding does not account for numerous potential confounders (Figures 3.9-3.10).

INSIGHTS

Patellar resurfacing was associated with a lower early cumulative percent revision in primary total knee arthroplasty, a trend that reached statistical significance in females over 65 years of age, although patient selection and confounding must be considered when interpreting this data.

Figure 3.8 Percentage of Primary Total Knee Arthroplasty with Patellar Resurfacing, 2012-2020 (N=838,178)

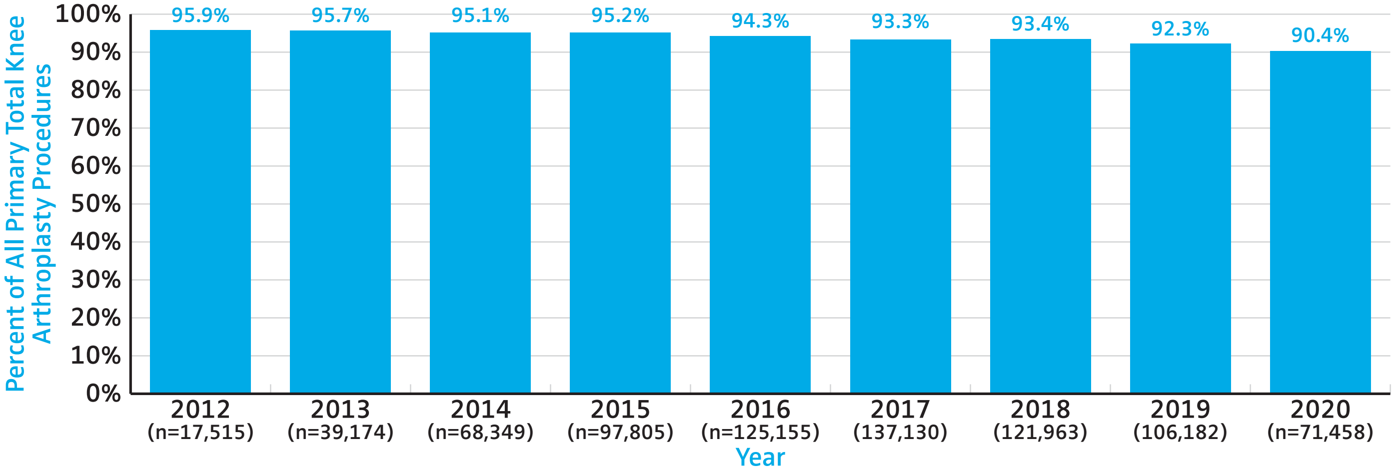
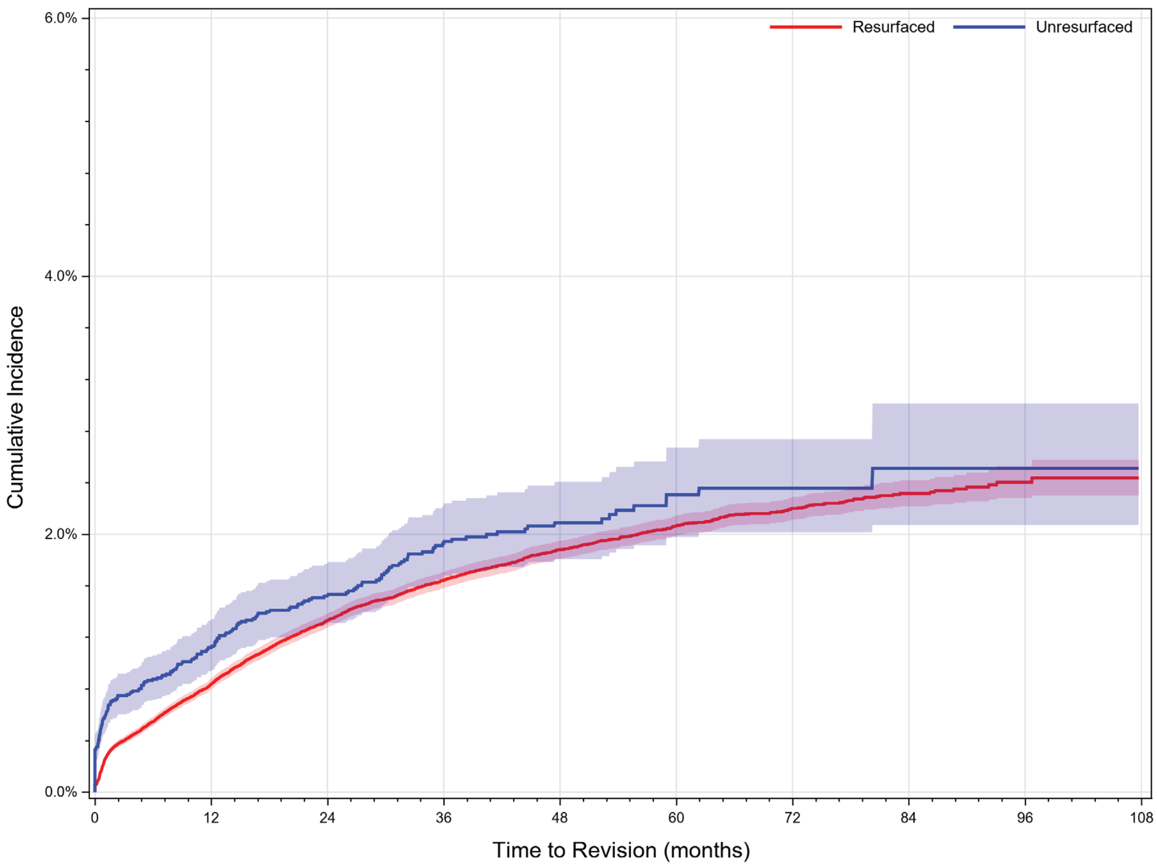


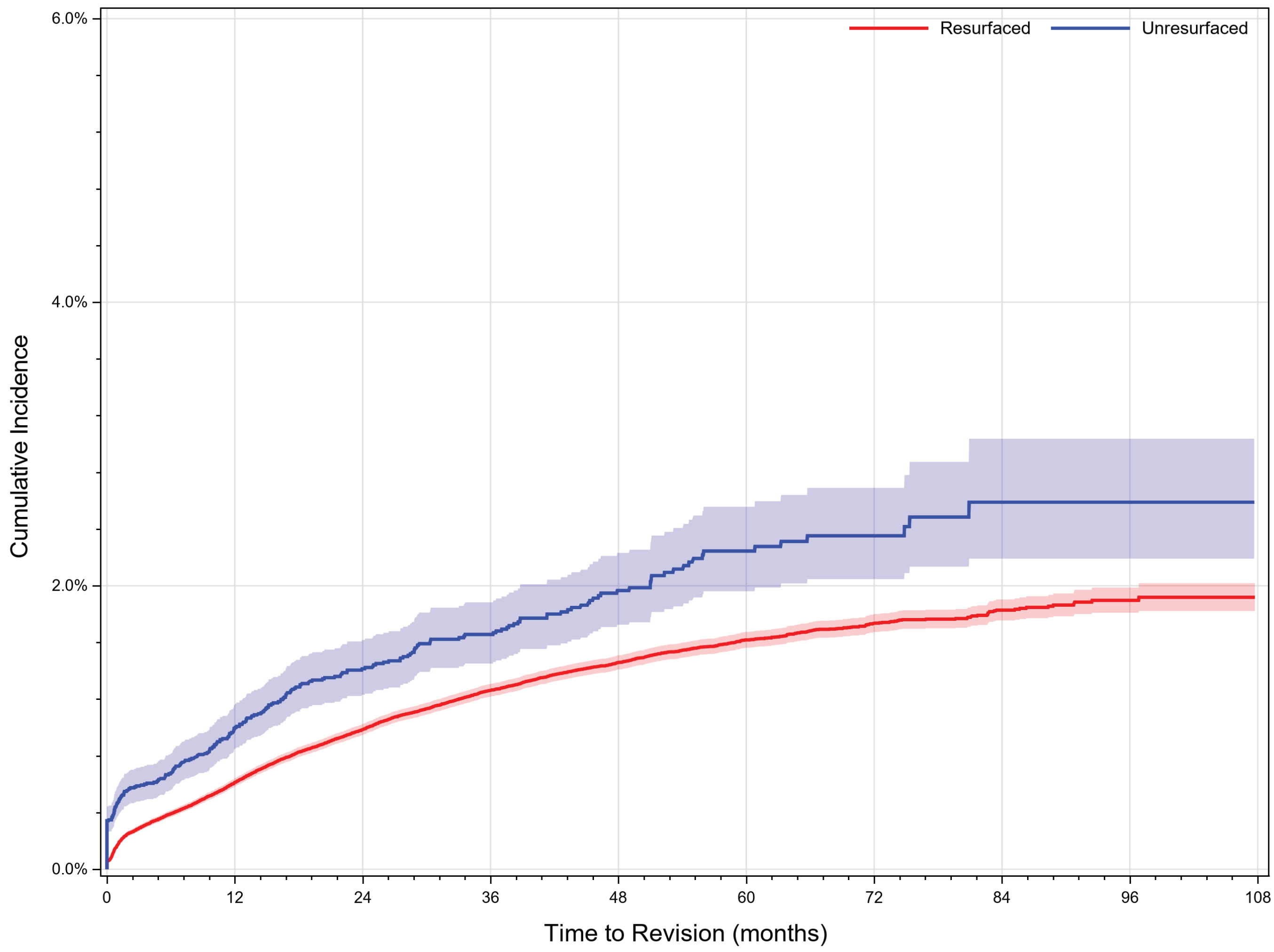
Figure 3.9 Cumulative Percent Revision for Total Knee Arthroplasty Patellar-Resurfacing of Male Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Unresurfaced	2,030	1,926	1,881	2,025	1,592	1,023	628	334	119	2,030
Resurfaced	20,997	27,146	29,987	32,816	28,618	20,394	13,508	7,669	2,959	184,094
Total	**23,027**	**29,072**	**31,868**	**34,841**	**30,210**	**21,417**	**14,136**	**8,003**	**3,078**	**195,652**

Age Adjusted Hazard Ratio (95% CI)
Unresurfaced vs. Resurfaced: *1.150 (0.998, 1.325) p=0.0528*

Figure 3.10 Cumulative Percent Revision for Total Knee Arthroplasty Patellar-Resurfacing of Female Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Unresurfaced	2,581	2,869	2,638	2,906	2,022	1,340	1,023	482	186	16,047
Resurfaced	30,324	42,287	46,308	50,640	43,833	31,838	21,295	12,030	4,655	283,210
Total	**32,905**	**45,156**	**48,946**	**53,546**	**45,855**	**33,178**	**22,318**	**12,512**	**4,841**	**299,257**

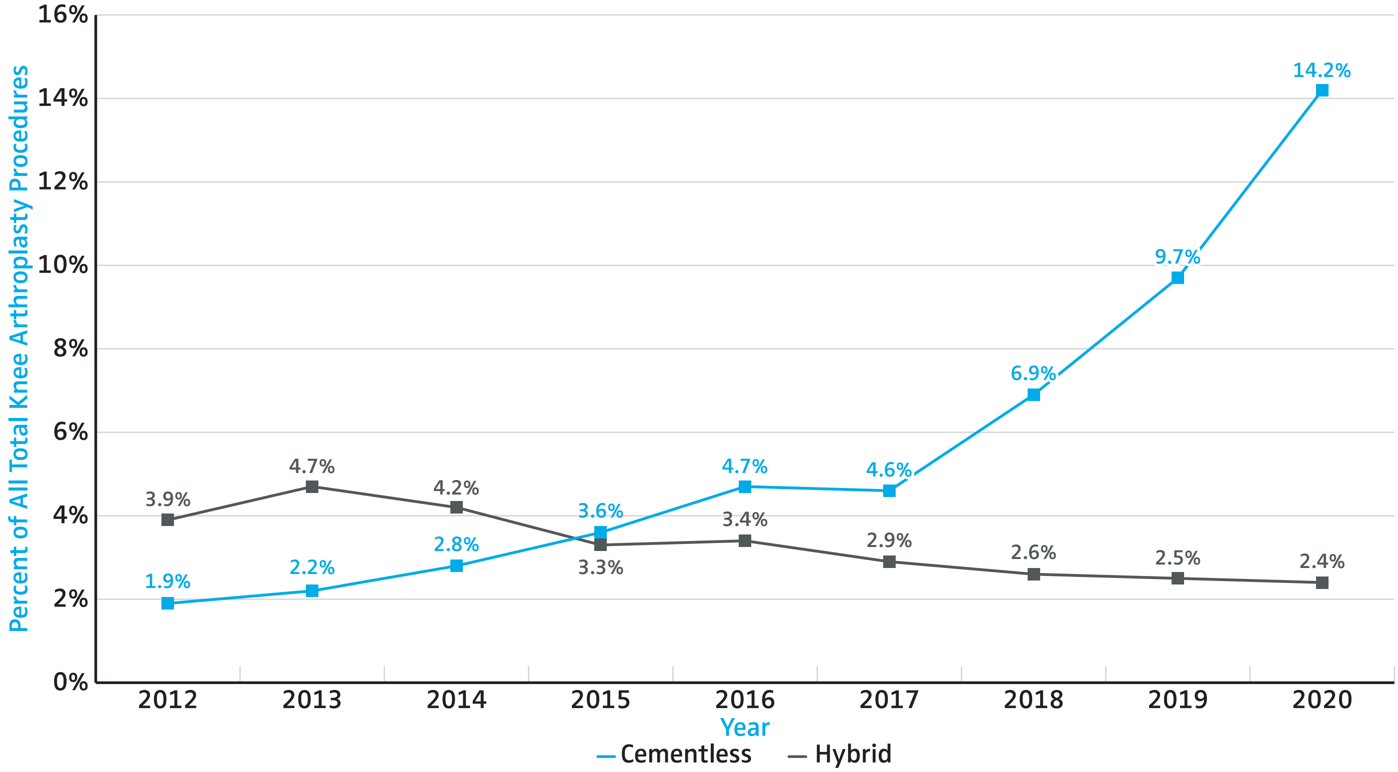
Age Adjusted Hazard Ratio (95% CI)
***Unresurfaced vs. Resurfaced:** 1.419 (1.254, 1.607) p<0.0001*

In the United States, the use of polymethylmethacrylate (bone cement) for the fixation of primary total knee arthroplasty components is typical. However, the use of cementless fixation has seen a substantial increase since 2012 (p<0.0001) (Figure 3.11). Similarly, the Swedish Knee Arthroplasty Register reported in their 2020 Annual Report that cementless fixation had become slightly more common and was now used in 8% of the total knee arthroplasties.[16] In the 2021 National Joint Registry, more than 80% of all primary total knee arthroplasties utilized all cemented fixation and 4.2% using all cementless and hybrid total knee replacements in 2020.[7]

INSIGHTS

The use of cementless fixation in primary total knee arthroplasty is rapidly increasing in the AJRR and was reported for over 14% of all primary total knee arthroplasties in 2020.

Figure 3.11 Distribution of Hybrid and Cementless Fixation Utilization for Primary Total Knee Arthroplasty, 2012-2020 (N=837,475)

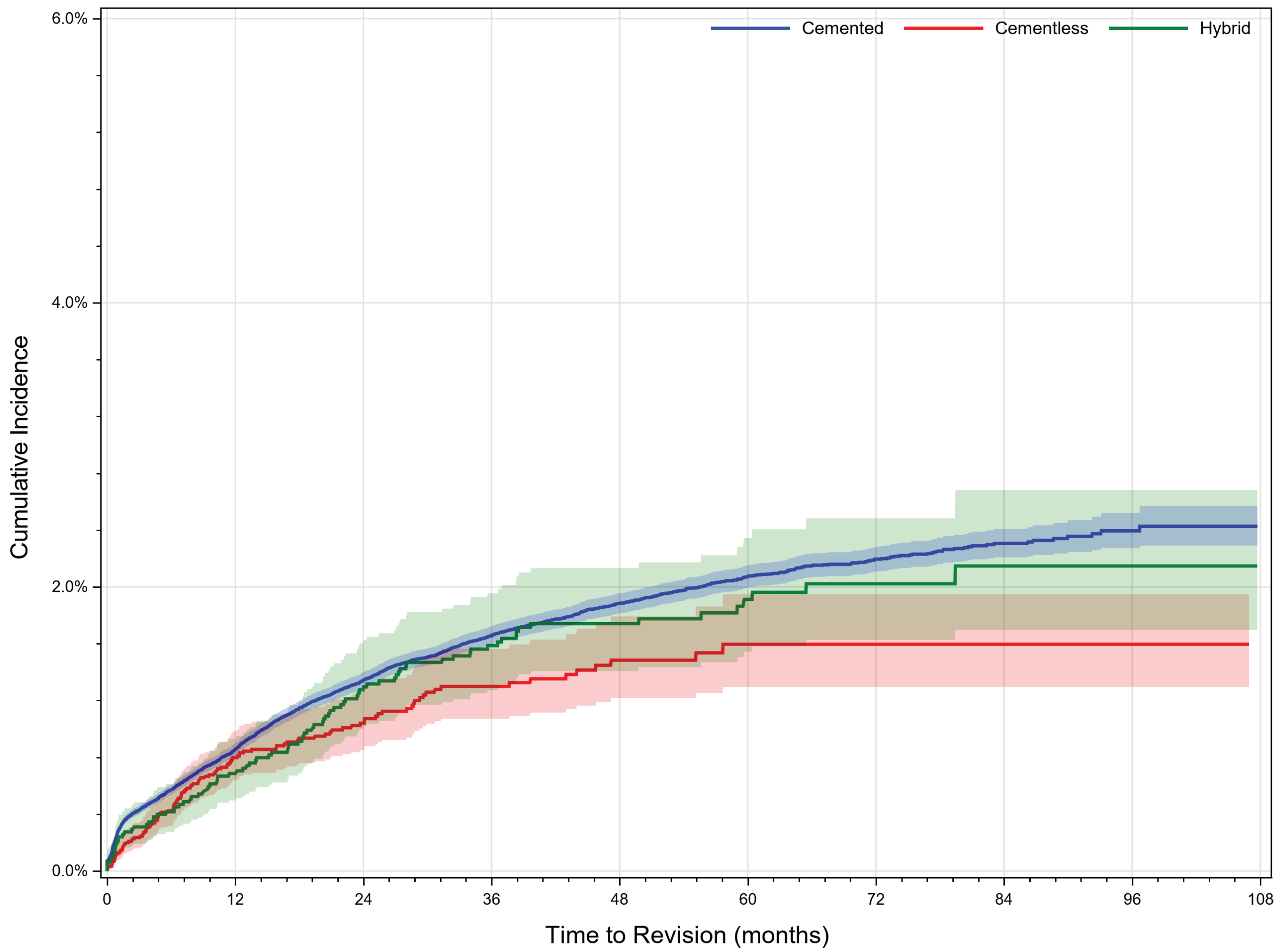


INSIGHTS

Cementless fixation for primary total knee arthroplasty is associated with a significantly decreased rate of cumulative percent revision compared to cemented fixation in males.

Cementless fixation was found to have a significant decrease in cumulative percent revision compared to cemented fixation in males ≥65 years of age in AJRR and CMS databases (HR=0.755, 95% CI, 0.631-0.905, p=0.0023) and in patients <65 years of age reported to AJRR (HR=0.785, 95% CI, 0.664-0.927, p=0.0044). These findings did not reach statistical significance for females of either age group. Hybrid fixation was found to have no statistical difference in revision when compared to cemented fixation (Figures 3.12-3.15).

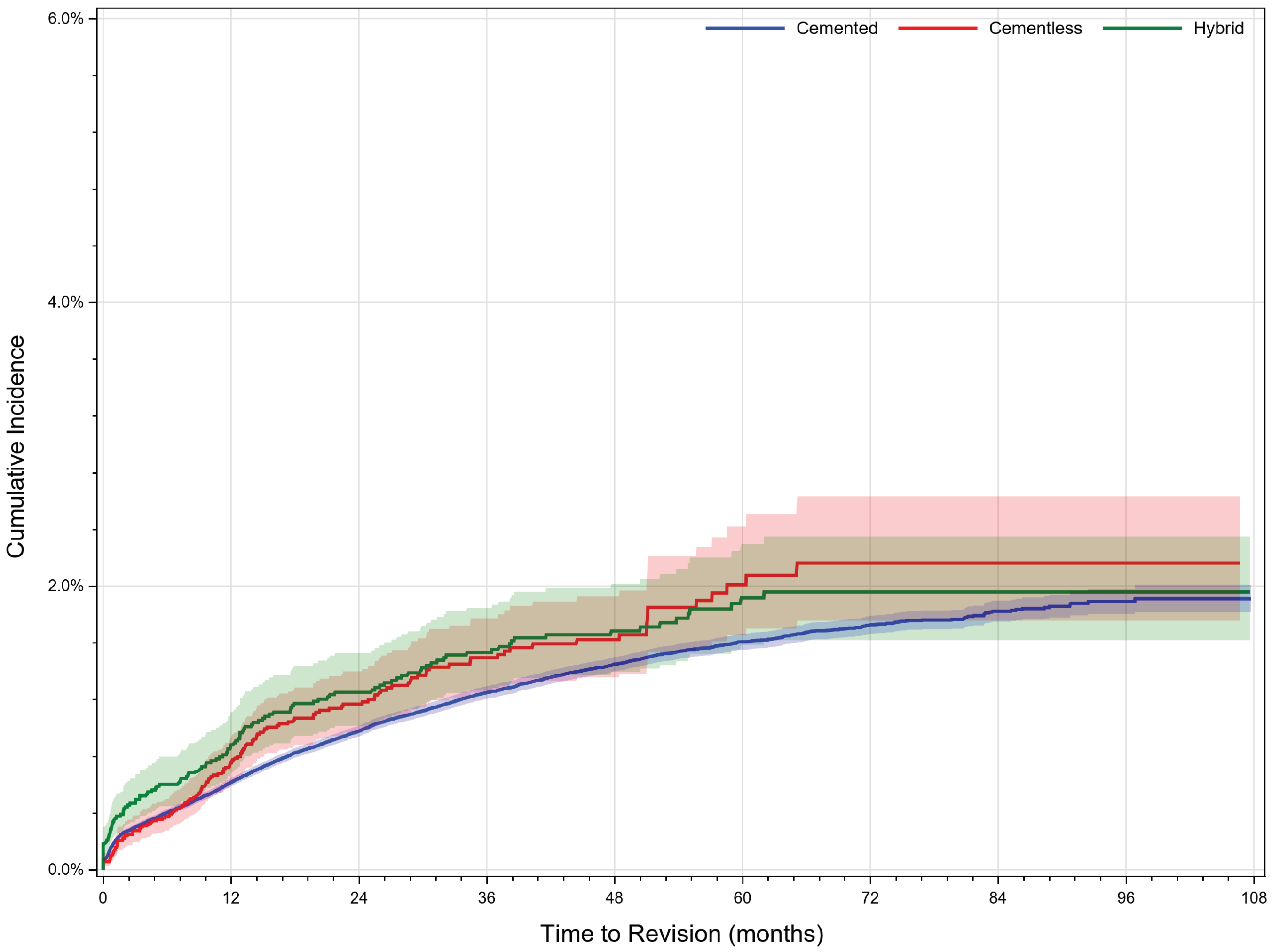
Figure 3.12 Cumulative Percent Revision for Cemented Versus Cementless Fixation for a Primary Total Knee Arthroplasty for Male Patients ≥65 Years of Age Diagnosed with Primary Osteoarthritis, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Cemented	19,936	25,732	28,529	32,376	27,735	19,904	13,511	7,713	2,921	178,357
Cementless	3,118	2,579	1,986	1,384	1,253	769	372	144	49	11,654
Hybrid	455	712	767	962	984	761	670	376	127	5,814
Total	**23,509**	**29,023**	**31,282**	**34,722**	**29,972**	**21,434**	**14,553**	**8,233**	**3,097**	**195,825**

Age Adjusted Hazard Ratio (95% CI)
Cementless vs. Cemented: *0.755 (0.631, 0.905) p=0.0023*
Hybrid vs. Cemented: *0.912 (0.745, 1.118) p=0.3764*

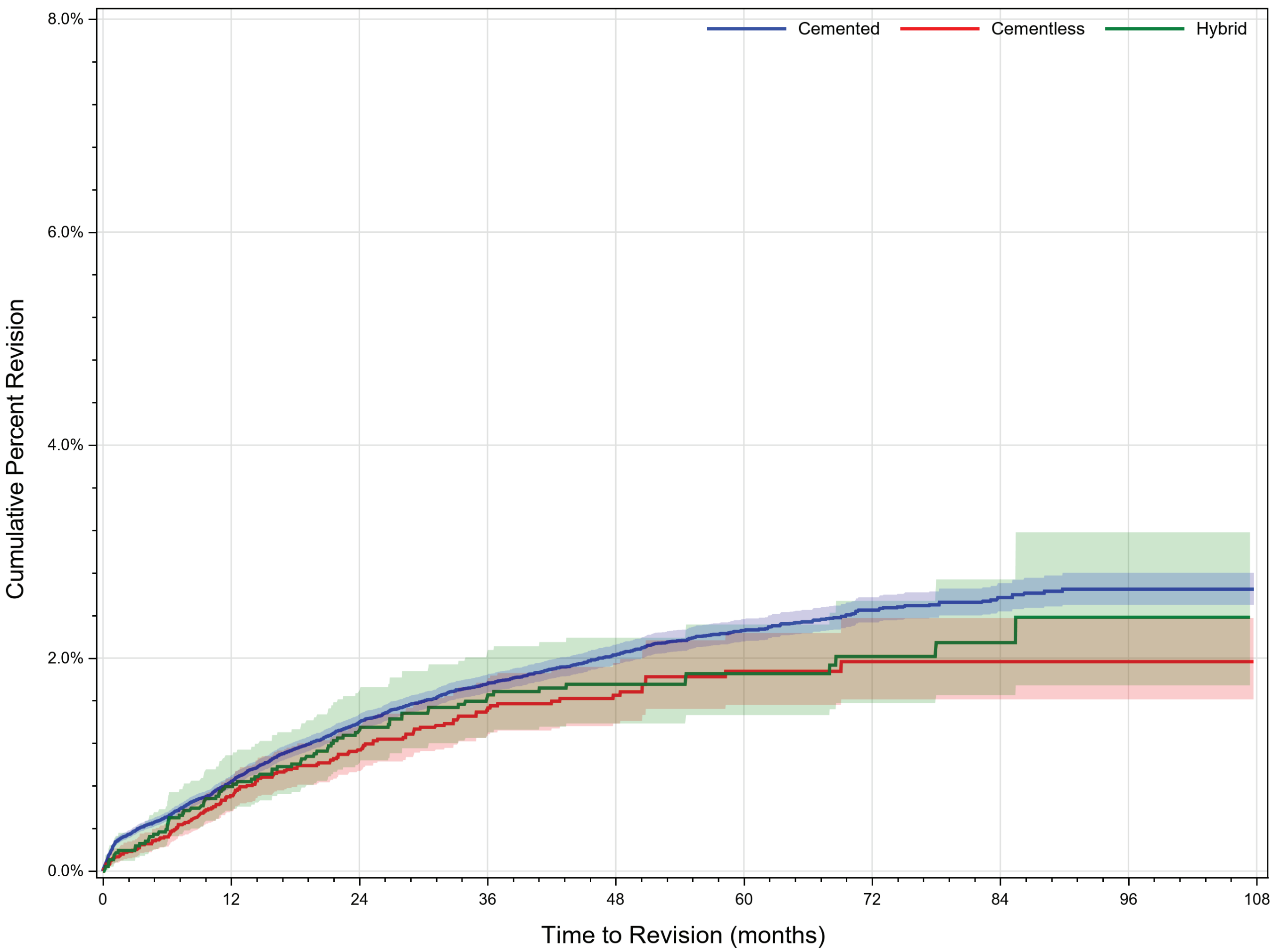
Figure 3.13 Cumulative Percent Revision for Cemented Versus Cementless Fixation for a Primary Total Knee Arthroplasty in Female Patients ≥65 Years of Age Diagnosed with Primary Osteoarthritis, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Cemented	29,734	41,034	45,141	50,458	42,716	31,295	21,790	12,357	4,717	279,242
Cementless	3,159	2,810	2,014	1,340	1,365	899	374	148	49	12,158
Hybrid	744	1,058	1,009	1,251	1,226	911	830	524	147	7,700
Total	**33,637**	**44,902**	**48,164**	**53,049**	**45,307**	**33,105**	**22,994**	**13,029**	**4,913**	**299,100**

Age Adjusted Hazard Ratio (95% CI)
Cementless vs. Cemented: *1.160 (0.985, 1.366) p=0.0754*
Hybrid vs. Cemented: *1.177 (0.982, 1.410) p=0.0775*

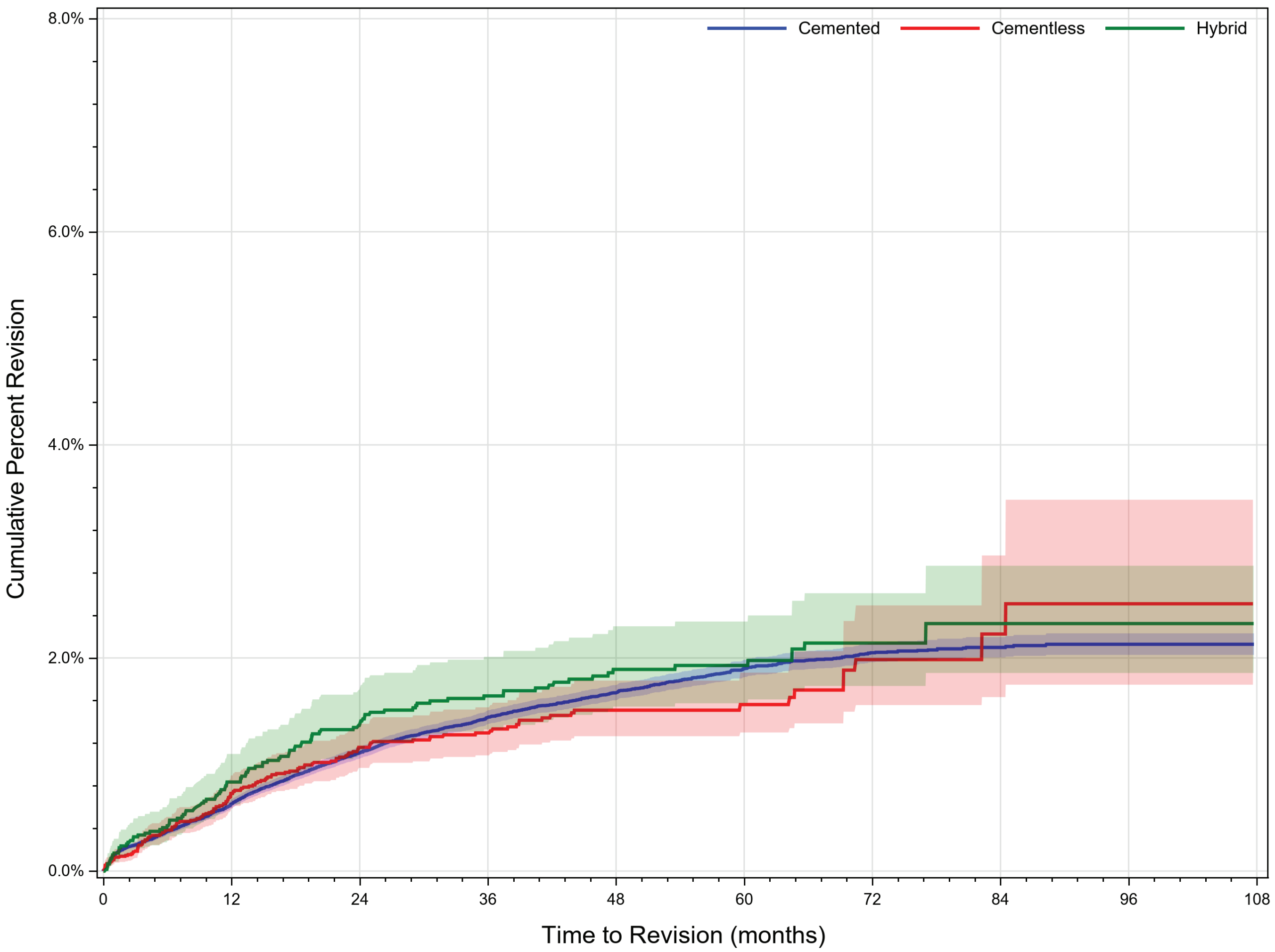
Figure 3.14 Cumulative Percent Revision for Cemented Versus Cementless Fixation for a Primary Total Knee Arthroplasty for Males <65 Years of Age Diagnosed with Primary Osteoarthritis as Submitted Only to AJRR, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Cementless	2,771	2,358	2,028	1,797	1,469	775	505	269	107	12,079
Cemented	10,209	12,635	15,534	18,752	17,272	13,665	9,778	5,599	2,308	105,752
Hybrid	363	424	664	826	803	571	571	331	122	4,675
Total	**13,343**	**15,417**	**18,226**	**21,375**	**19,544**	**15,011**	**10,854**	**6,199**	**2,537**	**122,506**

Age Adjusted Hazard Ratio (95% CI)
Cementless vs. Cemented: *0.785 (0.664, 0.927) p=0.0044*
Hybrid vs. Cemented: *0.852 (0.681, 1.067) p=0.1630*

Figure 3.15 Cumulative Percent Revision for Cemented Versus Cementless Fixation for a Primary Total Knee Arthroplasty for Females <65 Years of Age Diagnosed with Primary Osteoarthritis as Submitted Only to AJRR, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Cementless	2,973	2,758	2,164	1,816	1,614	910	529	253	89	13,106
Cemented	14,881	19,405	23,118	27,939	25,298	19,713	14,685	8,240	3,287	156,566
Hybrid	514	607	739	1,053	954	717	727	502	154	5,967
Total	**18,368**	**22,770**	**26,021**	**30,808**	**27,866**	**21,340**	**15,941**	**8,995**	**3,530**	**175,639**

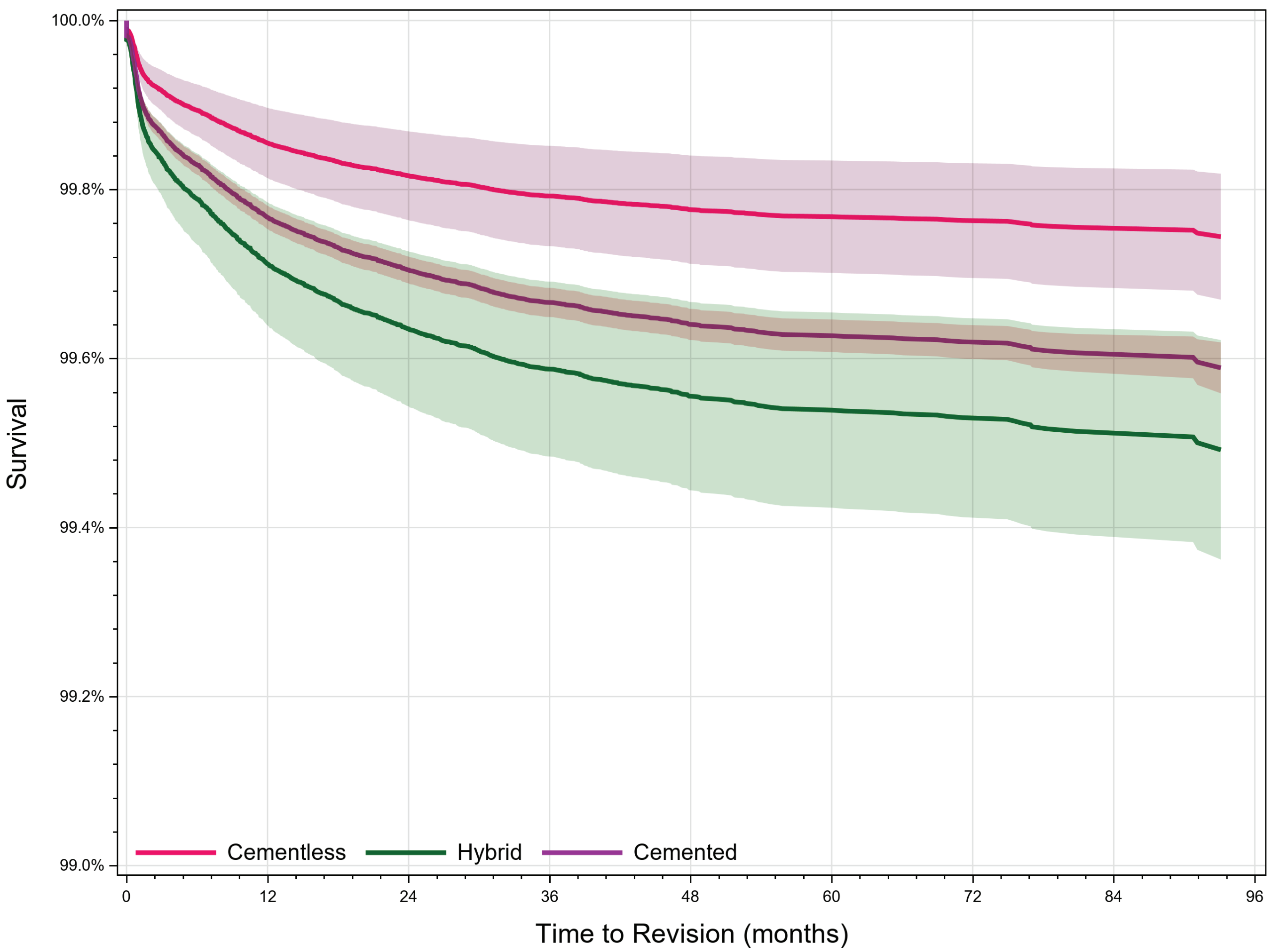
Age Adjusted Hazard Ratio (95% CI)
Cementless vs. Cemented: *0.886 (0.751, 1.045) p=0.1515*
Hybrid vs. Cemented: *1.076 (0.885, 1.309) p=0.4628*

Cementless fixation for primary total knee arthroplasty was associated with improved survivorship when looking at revision for infection in patients ≥65 years of age, although potential confounders of patient health and surgical time could not be examined.

INSIGHTS

This is the first year the AJRR Annual Report has included a survival curve with a diagnosis-specific outcome. For this year's report, survival rates due to infection were analyzed based on the method of component fixation. Figure 3.16 displays the results of a cause-specific survivorship model accounting for death and revision of non-target diagnoses as competing risks. All three curves resulted in over 99% survival beyond seven years, and cementeless fixation showed significantly less revision due to infection in elective primary TKA patients ≥65 years of age (HR=0.622, 95% CI, 0.465-0.831, p=0.0013).

Figure 3.16 Percent Survival for Revision due to Infection for Elective Primary Total Knee Arthroplasty ≥65 Years of Age Adjusted for Age and Gender, 2012-2020



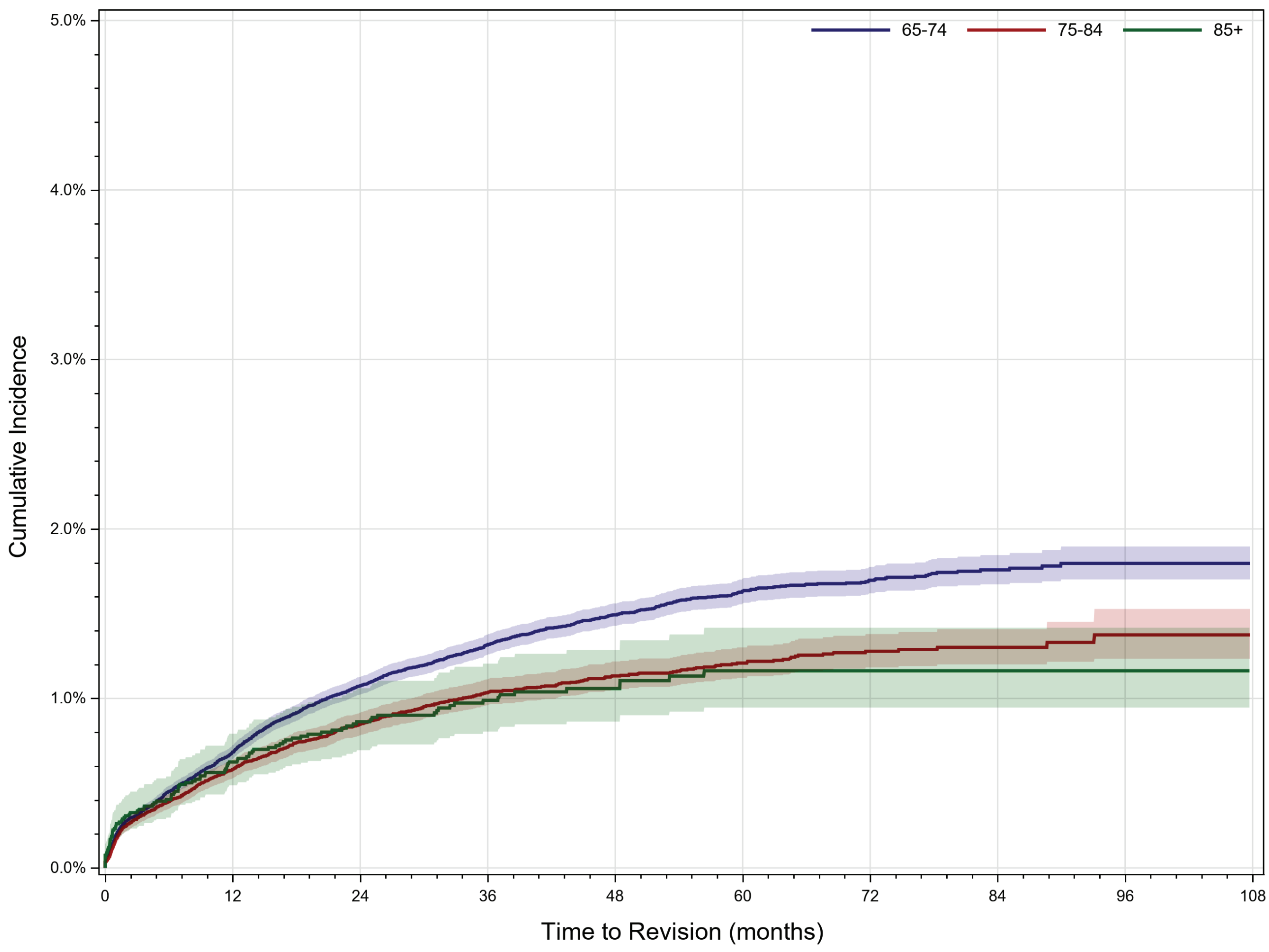
Age/Gender Adjusted Hazard Ratio (95% CI)
Cementless vs. Cemented: *0.622 (0.465-0.831) p=0.0013*
Hybrid vs. Cemented: *1.237 (0.957-1.598) p=0.1037*

The association between patient factors, such as demographics and comorbidities, and the incidence of revision following primary TKA has been an important area of investigation for AJRR. For this year's Annual Report, age by decade for those 65 and older was analyzed. In contrast to the THA analyses, the younger age group (65-74) was found have a significantly higher cumulative percent revision than the older age groups for elderly TKA patients (Figures 3.17-3.18). These analyses do not account for other potential confounders that may influence the risk of failure and revision surgery.

INSIGHTS

Patients aged 65-74 have a higher cumulative percent revision than older age groups for primary TKA cases.

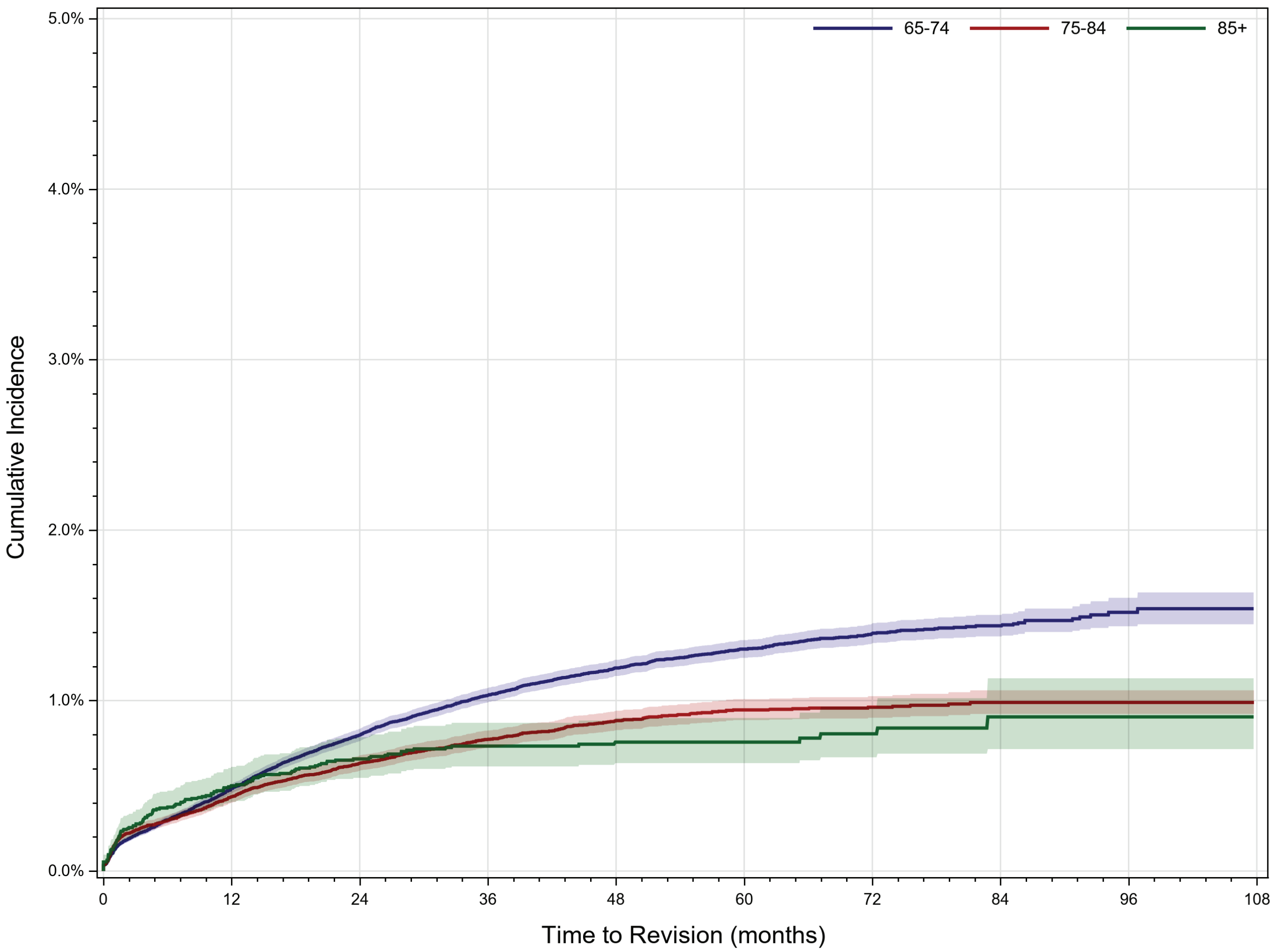
Figure 3.17 Cumulative Percent Revision for Age by Decade for Primary Total Knee Arthroplasty with Primary Osteoarthritis for Males, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Age 65-74	21,314	25,447	26,160	28,546	24,295	17,602	12,654	7,487	2,765	166,270
Age 75-84	10,367	12,446	12,948	13,633	11,337	8,018	5,882	3,494	1,327	79,452
Age 85+	1,493	1,708	1,737	1,808	1,535	1,126	768	397	175	10,747
Total	**33,174**	**39,601**	**40,845**	**43,987**	**37,167**	**26,746**	**19,304**	**11,378**	**4,267**	**256,469**

Age Adjusted Hazard Ratio (95% CI)
Age 75-84 vs. 65-74: *0.771 (0.710, 0.836) p<0.0001*
Age 85+ vs. 65-74: *0.751(0.616, 0.915) p=0.0045*

Figure 3.18 Cumulative Percent Revision for Age by Decade for Primary Total Knee Arthroplasty with Primary Osteoarthritis for Females, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Age 65-74	30,769	39,919	41,595	45,363	38,574	28,335	20,871	12,410	4,705	262,541
Age 75-84	16,321	21,123	21,777	22,837	19,147	13,714	10,158	6,195	2,515	133,787
Age 85+	2,200	3,003	2,909	3,121	2,739	2,095	1,537	893	397	18,894
Total	**49,290**	**64,045**	**66,281**	**71,321**	**60,460**	**44,144**	**32,566**	**19,498**	**7,617**	**415,222**

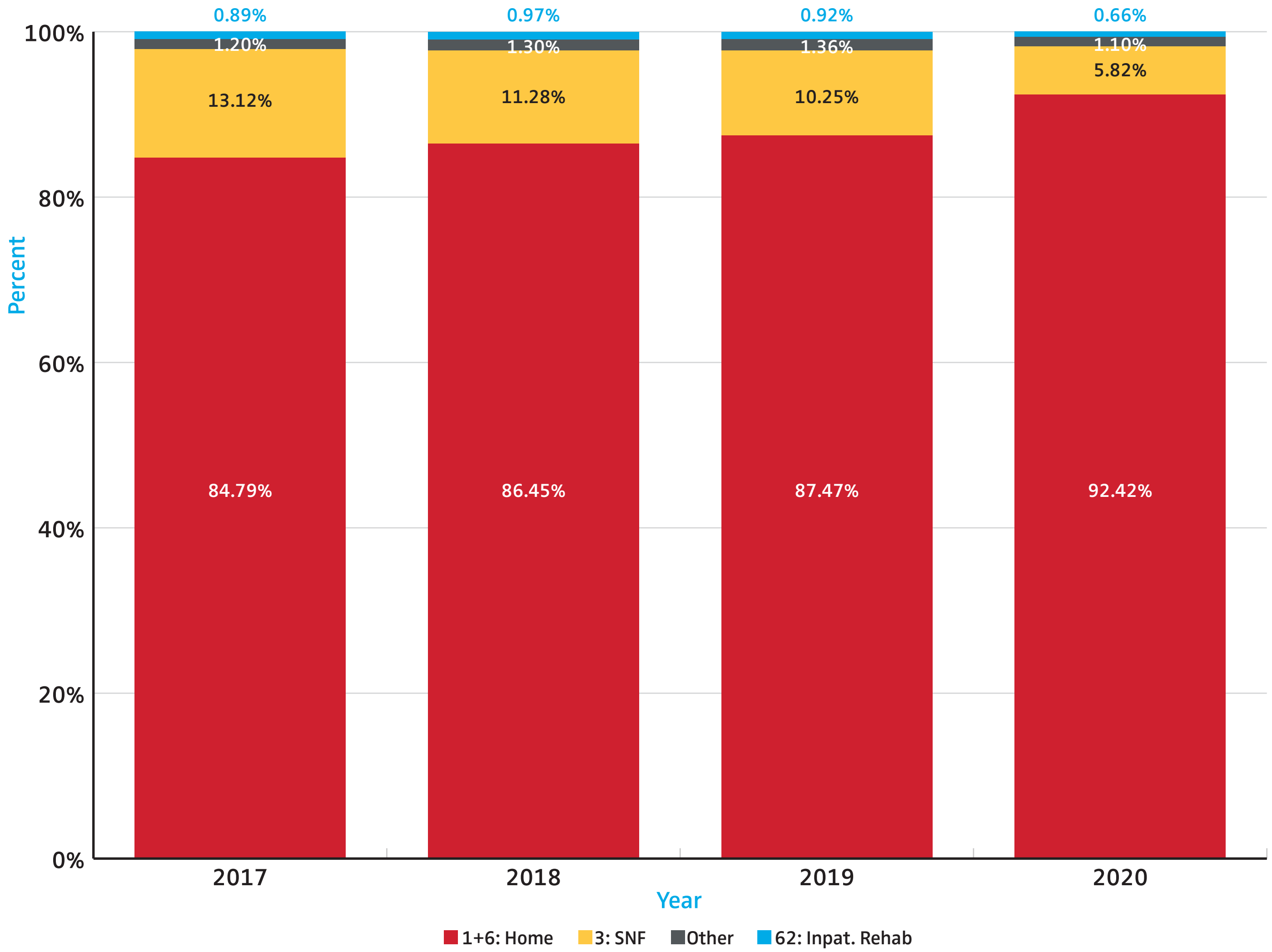
Age Adjusted Hazard Ratio (95% CI)
Age 75-84 vs. 65-74: *0.742 (0.690, 0.798) p<0.0001*
Age 85+ vs. 65-74: *0.684 (0.574, 0.814) p<0.0001*

Figure 3.19 tabulates the discharge disposition reported for primary total knee arthroplasty procedures by year for the years 2017 through 2020, when data collection began. AJRR collects the CMS-defined Patient Discharge Status Code values. Discharge to home, represented by discharge codes 1 and 6, are reported in more than 92% by 2020. Discharge to a skilled nursing facility (SNF) dropped from 13.1% in 2012 to only 5.8% in 2020. Other discharge codes represent only a small portion of cases.

INSIGHTS

The percentage of patients being discharged to skilled nursing following primary total knee arthroplasty continues to decrease and now represents less than 6% of all discharges.

Figure 3.19 Total Knee Arthroplasty Discharge Disposition Codes by Year, 2017-2020 (N=505,206)



Code	Code Value
1: Home	Discharged to home/self-care (routine charge).
6: Home Care Org.	Discharged/transferred to home care of organized home health service organization.
3: SNF	Discharged/transferred to skilled nursing facility (SNF) with Medicare certification in anticipation of covered skilled care--(For hospitals with an approved swing bed arrangement, use Code 61 - swing bed. For reporting discharges/transfers to a non-certified SNF, the hospital must use Code 04 - ICF.)
62: Inpat. Rehab	Discharged/transferred to an inpatient rehabilitation facility including distinct parts units of a hospital (eff. 1/2002).

The use of general anesthesia without a regional block continues to decrease for primary total knee arthroplasty.

INSIGHTS

Figure 3.20 shows a tabulation of primary anesthesia techniques chosen for patients undergoing an elective primary total knee arthroplasty. Over the last four years, general anesthesia use has decreased 9% while the slightly more commonly used spinal anesthesia has remained relatively steady.

Figure 3.20 Primary Total Knee Arthroplasty Anesthesia Type by Year, 2017-2020 (N=336,783)

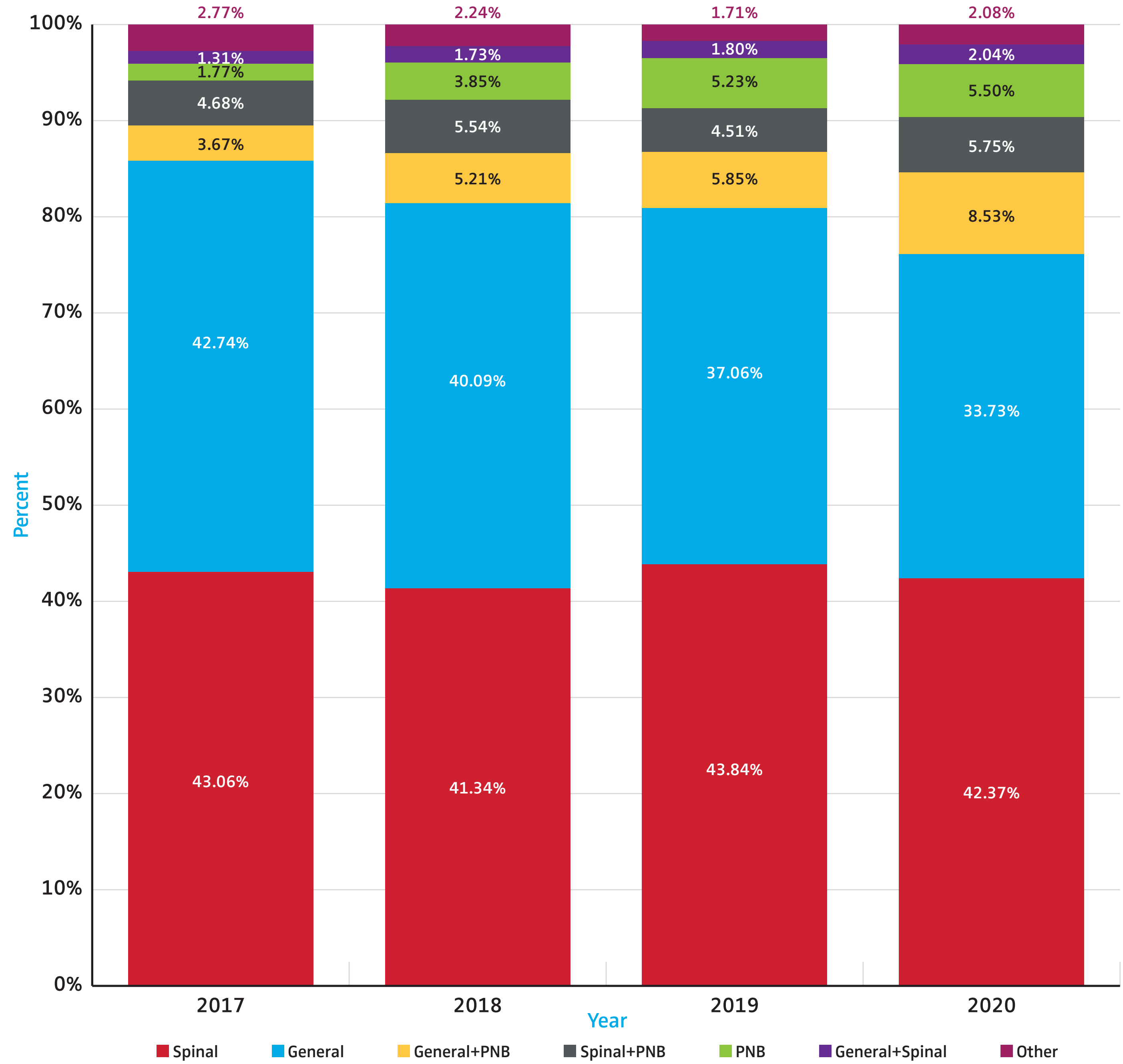
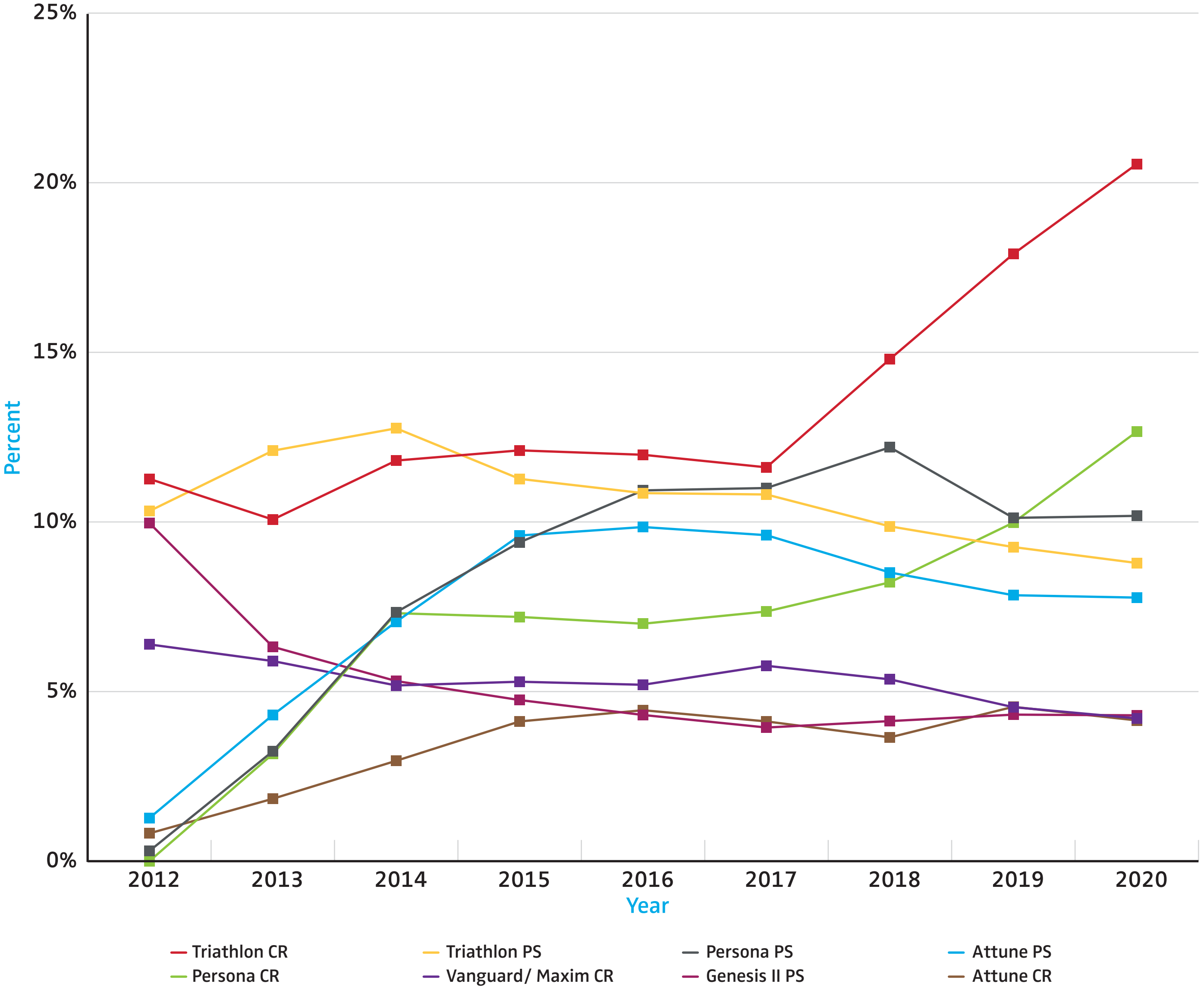


Figure 3.21 provides utilization data of implants used in primary total knee arthroplasty procedures in AJRR by year for the years 2012 through 2020. Figure 3.21 tabulates the eight most implanted femoral and tibial component combinations along with their overall bearing design for TKA by year and shows that for the eight-year period, the combinations most frequently implanted have varied. For 2020, the Triathlon Cruciate Retaining construct was the most frequently implanted combination.

Figure 3.21 Primary Total Knee Arthroplasty Femoral/Tibial Component Combinations by Year, 2012-2020 (N=908,223)



The ability to look at revision rates for particular implants is one of the great strengths of the AJRR. Unlike the hip device-specific survivorship which showed some divergence in the first year, the knee-device curves showed very little divergence for both posterior stabilized and minimally stabilized (cruciate retaining) constructs. All TKA device constructs included in analysis have a cumulative percent revision of less than 2.5% at three years and less than 3.7% at final follow-up for each respective device (Tables 3.3 - 3.4). Cementless TKA constructs did not have sufficient procedure volume to be included in this supplement but will be included in future publications when numbers permit. Additional device-specific cumulative percent revision data and methods are presented in the *2020 AJRR Annual Report Supplement*, which can be found at www.aaos.org/AJRRannualreport.

Table 3.3 Cumulative Percent Revision of Cemented Knee Arthroplasty Construct Combinations, 2012-2019

Femoral Component	Tibial Component	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Triathlon CR	Triathlon	47,829	497	0.65 (0.58, 0.73)	1.14 (1.04, 1.26)	1.39 (1.26, 1.53)	1.70 (1.44, 1.99)
Triathlon PS	Triathlon	45,342	634	0.79 (0.71, 0.88)	1.46 (1.35, 1.59)	1.82 (1.67, 1.98)	2.01 (1.80, 2.24)
Persona PS	Persona	44,586	607	0.74 (0.67, 0.83)	1.52 (1.40, 1.66)	2.17 (1.95, 2.39)	2.21 (1.98, 2.45)
Attune PS	Attune	37,719	532	0.69 (0.61, 0.78)	1.55 (1.41, 1.70)	2.06 (1.86, 2.28)	2.85 (2.09, 3.79)
Persona CR	Persona	33,086	305	0.54 (0.47, 0.63)	1.14 (1.01, 1.28)	1.35 (1.18, 1.53)	—
Vanguard CR	Maxim	20,932	330	0.62 (0.53, 0.74)	1.14 (0.99, 1.30)	1.46 (1.27, 1.69)	1.50 (1.29, 1.74)
Genesis II PS	Genesis II	22,957	244	0.84 (0.72, 0.97)	1.74 (1.55, 1.95)	2.08 (1.85, 2.33)	2.30 (1.97, 2.68)
Attune CR	Attune	17,426	164	0.52 (0.42, 0.64)	1.08 (0.91, 1.27)	1.40 (1.16, 1.66)	1.58 (1.25, 1.97)
Sigma CR	PFC Sigma	16,574	149	0.45 (0.36, 0.57)	0.82 (0.68, 0.98)	1.16 (0.97, 1.38)	1.32 (1.09, 1.59)
Sigma PS	PFC Sigma	15,395	199	0.67 (0.55, 0.81)	1.28 (0.10, 1.48)	1.53 (1.32, 1.77)	1.82 (1.55, 2.13)
NexGen LPS-Flex PS	NexGen	13,054	198	0.72 (0.58, 0.87)	1.38 (1.18, 1.60)	1.87 (1.61, 2.16)	2.03 (1.73, 2.37)
Journey II PS	Journey II	11,784	219	1.22 (1.03, 1.44)	2.26 (1.96, 2.60)	2.82 (2.33, 3.38)	3.03 (2.41, 3.74)
Vanguard PS	Maxim	11,414	194	0.95 (0.78, 1.14)	1.72 (1.48, 2.00)	2.18 (1.87, 2.53)	2.43 (2.02, 2.90)
Genesis II CR	Genesis II	9,832	113	0.69 (0.54, 0.87)	1.24 (1.01, 1.50)	1.48 (1.20, 1.79)	1.75 (1.32, 2.28)
Legion PS	Genesis II	9,783	132	0.77 (0.61, 0.96)	1.38 (1.14, 1.65)	1.94 (1.58, 2.34)	3.60 (1.43, 7.42)
Sigma PS	MBT	6,715	110	0.63 (0.46, 0.85)	1.38 (1.11, 1.71)	2.04 (1.66, 2.47)	2.45 (1.96, 3.01)
Natural-Knee II GS CR	Natural-Knee II	5,223	54	0.50 (0.33, 0.73)	0.96 (0.71, 1.28)	1.35 (1.01, 1.78)	1.61 (1.06, 2.36)
Legion CR	Genesis II	3,961	70	0.65 (0.43, 0.95)	1.50 (1.09, 2.02)	1.65 (1.20, 2.22)	1.65 (1.20, 2.22)
Evolution MP PS	Evolution MP	3,890	46	0.81 (0.56, 1.14)	1.62 (1.23, 2.10)	2.39 (1.84, 3.05)	2.99 (2.05, 4.21)
NexGen CR-Flex CR	NexGen	3,729	39	0.46 (0.28, 0.73)	0.94 (0.65, 1.31)	1.29 (0.91, 1.77)	1.39 (0.97, 1.93)
Apex Knee CR	Apex Knee	3,156	36	0.71 (0.45, 1.07)	1.59 (1.09, 2.25)	1.74 (1.18, 2.48)	—
Sigma CR	MBT	2,500	41	0.77 (0.48, 1.18)	1.42 (0.99, 1.97)	2.10 (1.49, 2.87)	2.10 (1.49, 2.87)
GMK Sphere CR	GMK Primary	1,895	18	0.80 (0.45, 1.34)	1.41 (0.77, 2.39)	1.84 (0.93, 3.29)	—
NexGen CR-Flex CR	NexGen Pegged	1,538	16	0.54 (0.26, 1.03)	1.16 (0.69, 1.84)	1.16 (0.69, 1.84)	1.16 (0.69, 1.84)
NexGen LPS-Flex GS PS	NexGen	1,217	24	0.85 (0.44, 1.51)	1.59 (0.98, 2.46)	2.09 (1.34, 3.11)	2.64 (1.65, 4.00)
Optetrak Logic PS	Optetrak Logic	1,174	15	0.61 (0.28, 1.22)	1.23 (0.69, 2.05)	1.80 (0.97, 3.07)	1.80 (0.97, 3.07)
LCS Complete CR	MBT	1,097	14	0.56 (0.24, 1.18)	0.99 (0.51, 1.76)	1.57 (0.85, 2.68)	1.95 (1.02, 3.39)
NexGen CR	NexGen	854	8	0.35 (0.10, 0.99)	0.65 (0.25, 1.47)	1.06 (0.46, 2.14)	1.51 (0.63, 3.11)

Table 3.4 Cumulative Percent Revision of Hybrid Knee Arthroplasty Construct Combinations, 2012-2019

Femoral Component	Tibial Component	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Sigma CR	PFC Sigma	2,306	21	0.24 (0.09, 0.54)	0.99 (0.60, 1.53)	1.29 (0.81, 1.99)	1.29 (0.81, 1.99)
Vanguard CR	Maxim	1,563	37	1.74 (1.16, 2.50)	2.46 (1.74, 3.37)	2.90 (2.00, 4.06)	2.90 (2.00, 4.06)
Triathlon CR	Triathlon	1,521	25	0.69 (0.36, 1.24)	1.66 (1.07, 2.47)	2.07 (1.35, 3.04)	2.07 (1.35, 3.04)
Persona CR	Persona	818	15	0.76 (0.32, 1.59)	2.00 (1.14, 3.26)	2.76 (1.34, 5.04)	—

Hybrid constructs include those with a cemented tibial and cementless femoral component

Partial Knee Arthroplasty

Between 2012 and 2020, AJRR has collected data on 61,207 partial knee arthroplasty procedures.

Medial or lateral unicompartmental knee arthroplasty (UKA) use has decreased in prevalence since 2012 and accounted for just 2.7% of all primary knee arthroplasties reported to AJRR for 2017. These numbers have slightly increased to 4.2% by 2020 (Figure 3.22). Since there was a slight increase from the 2.7% usage seen in 2017, and AJRR collects historical data not submitted in real time, further changes in usage prevalence may be expected as data continues to be collected.

Internationally, the Swedish Knee Arthroplasty Register noted in 2019 that the use of UKA accounted for almost 11% of their primary knee arthroplasty cases (a small increase from the previous year).[16] Similarly, in 2020, the Australian Orthopaedic Association National Joint Replacement Registry reported a small increase but remaining as a small proportion of all knee arthroplasty procedures (6.2%).[6]

The use of patellofemoral arthroplasty (PFA) in the AJRR remains a small percentage of single compartment arthroplasty and has been <1% since 2012 with the exception of 2016 reaching only 1.7% (Figure 3.23). These low numbers are consistent with international registries, where the New Zealand Joint Registry reported from 1999-2019 a total of 119,109 primary knee arthroplasties of which only 679 (0.6%) represented patellofemoral prostheses.[17] The National Joint Registry of England and Wales and the Swedish Knee Arthroplasty Register reported PFA in 2020 at 1.2% and 0.4% respectively.[7, 16] Only 5.8% of all surgeons who submitted primary knee arthroplasty procedures to AJRR performed PFAs, and only 20.1% performed medial and/or lateral UKAs in 2020 (Table 3.5).

Figure 3.22 Medial or Lateral Unicompartmental Knee Arthroplasty as a Percentage of All Primary Knee Arthroplasty, 2012-2020 (N=52,846)

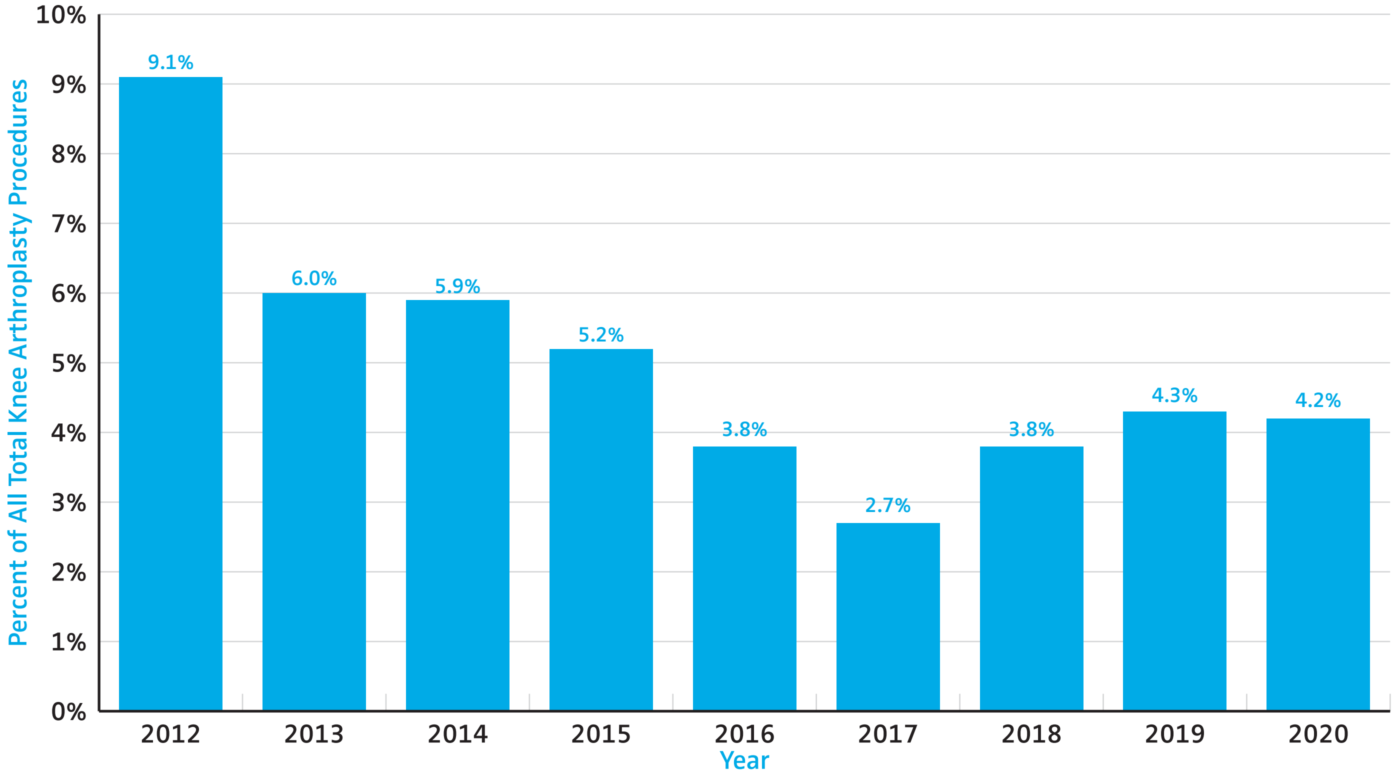


Figure 3.23 Patellofemoral Arthroplasty as a Percentage of All Primary Knee Arthroplasty, 2012-2020 (N=8,361)

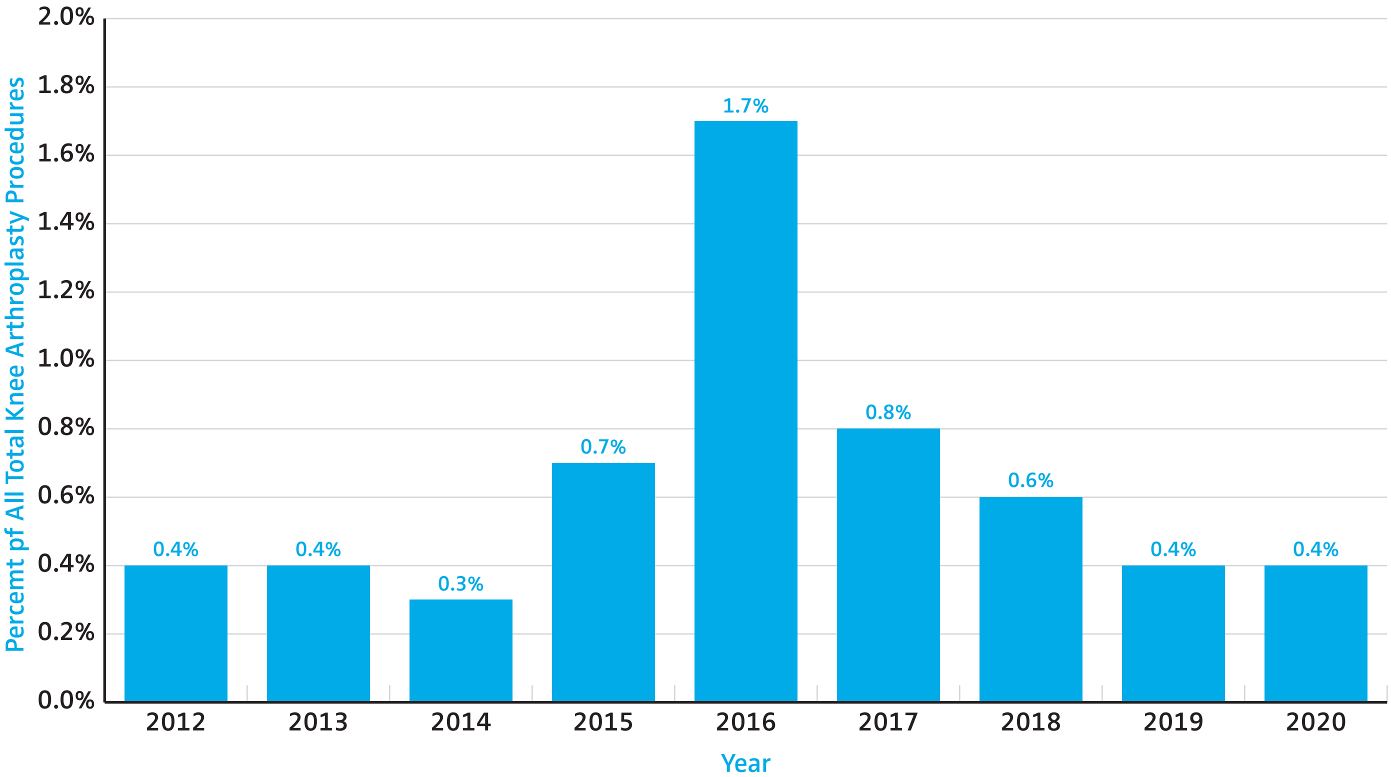


Table 3.5 Surgeons Performing Patellofemoral and Unicompartmental Knee Arthroplasty, 2012-2019 (N=31,902)

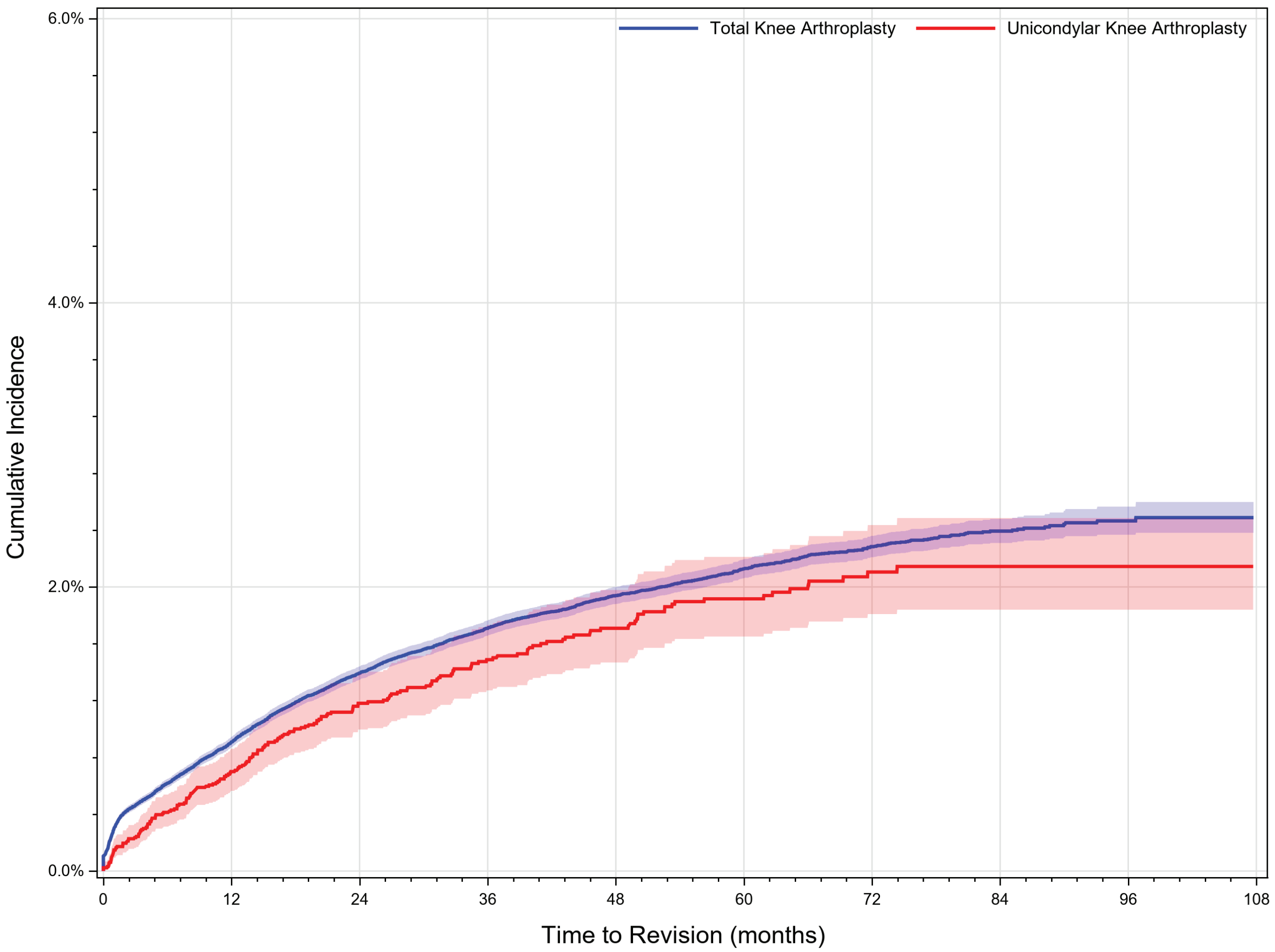
Surgeons Performing Type of Knee Arthroplasty	2012	2013	2014	2015	2016	2017	2018	2019	2020
Surgeons Performing Unicompartmental Knee Arthroplasty	208 (20.5%)	432 (21.1%)	705 (22.2%)	937 (21.1%)	1,066 (18.9%)	991 (17.2%)	1,083 (19.5%)	1,146 (20.8%)	993 (20.1%)
Surgeons Performing Patellofemoral Arthroplasty	54 (5.3%)	95 (4.6%)	143 (4.5%)	380 (8.6%)	657 (11.6%)	726 (12.6%)	572 (10.3%)	395 (7.2%)	289 (5.8%)
Total number of Surgeons submitting TKA	751	1,525	2,327	3,115	3,922	4,044	3,894	3,962	3,669

In the AJRR or CMS database, total knee arthroplasty procedures demonstrated significantly decreased cumulative percent revision compared to unicondylar knee arthroplasty constructs in females ≥65 years of age (HR=1.283, 95% CI, 1.126-1.461, p=0.0002) though this comparison did not reach statistical significance for males (Figures 3.24-3.25). This finding is similar to other registries. In 2020, the National Joint Registry reported the chance of revision with UKA at any estimated time point being approximately doubled or more than that of TKA and overall revision with cemented UKA was 3.2 times higher that TKA at 10 years.[7]

The cumulative incidence of revision is significantly higher with unicompartmental knee arthroplasty when compared with primary total knee arthroplasty in females but did not reach statistical significance in males.

INSIGHTS

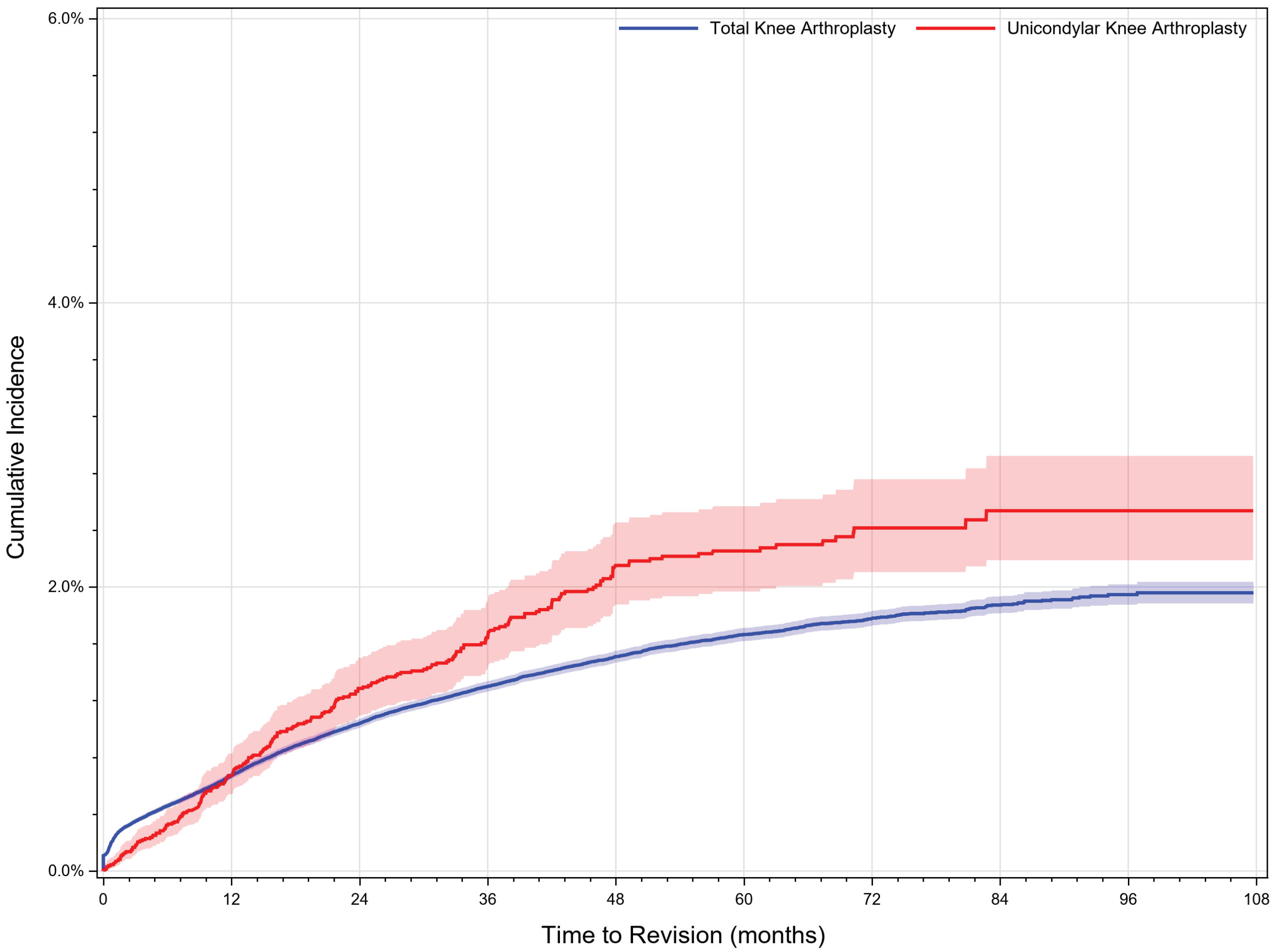
Figure 3.24 Cumulative Percent Revision of Total Knee Versus Unicondylar Knee Constructs for Femoral Components in Male Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020



Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Total Knee Arthroplasty	33,913	39,812	46,639	46,072	37,733	26,820	19,158	11,306	4,296	265,749
Unicondylar Knee Arthroplasty	1,557	2,017	2,048	1,299	1,539	1,647	1,400	797	512	12,816
Total	**35,470**	**41,829**	**48,687**	**47,371**	**39,272**	**28,467**	**20,558**	**12,103**	**4,808**	**278,565**

Age Adjusted Hazard Ratio (95% CI)
Unicondylar Knee Arthroplasty vs. Total Knee Arthroplasty: *0.875 (0.759, 1.009) p=0.0659*

Figure 3.25 Cumulative Percent Revision of Total Knee Versus Unicondylar Knee Constructs for Femoral Components in Female Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020

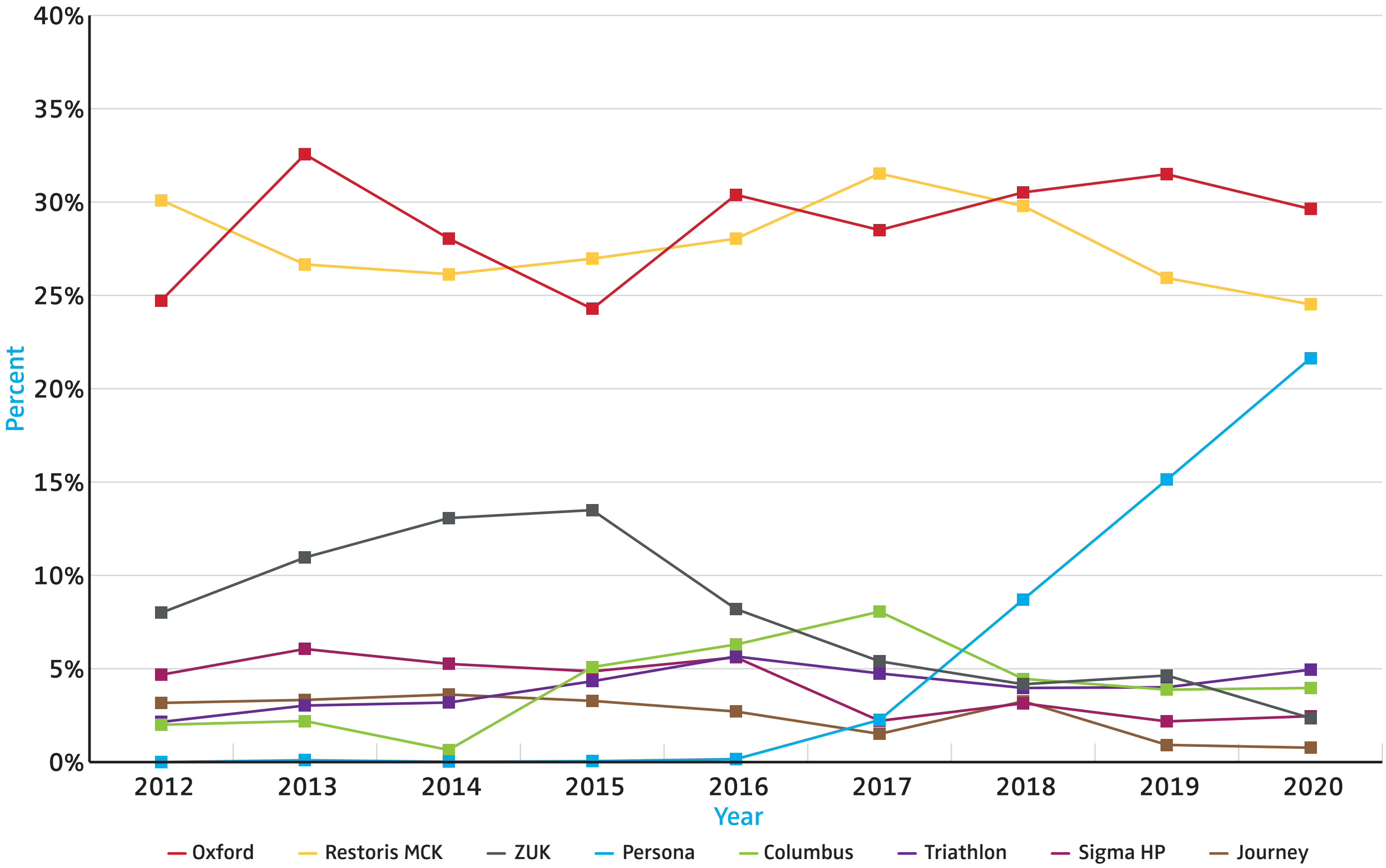


Number at Risk (Months)	0-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	Total
Total Knee Arthroplasty	50,361	64,369	76,066	75,190	61,475	44,222	32,358	19,429	7,719	431,189
Unicondylar Knee Arthroplasty	1,515	1,978	2,198	1,419	1,654	1,713	1,480	836	508	13,301
Total	**51,876**	**66,347**	**78,264**	**76,609**	**63,129**	**45,935**	**33,838**	**20,265**	**8,227**	**444,490**

Age Adjusted Hazard Ratio (95% CI)
Unicondylar Knee Arthroplasty vs. Total Knee Arthroplasty: *1.283 (1.126, 1.461) p=0.0002*

Figure 3.26 provides utilization data of implants used in partial knee arthroplasty procedures in AJRR. Figure 3.26 tabulates the eight most commonly used femoral and tibial combinations in UKA by year and shows that, for the eight-year period, the combinations most frequently implanted have also varied. For 2020, the Oxford Partial Knee System components was the most frequently implanted combination with the Restoris MultiCompartmental Knee (MCK) following a similar utilization level since 2012. Over the last four years, the Persona Knee component has shown a steep and steady increase to become the third most common implant by 2020.

Figure 3.26 Unicondylar Knee Arthroplasty Femoral/Tibial Component Combinations by Year, 2012-2020 (N=40,994)

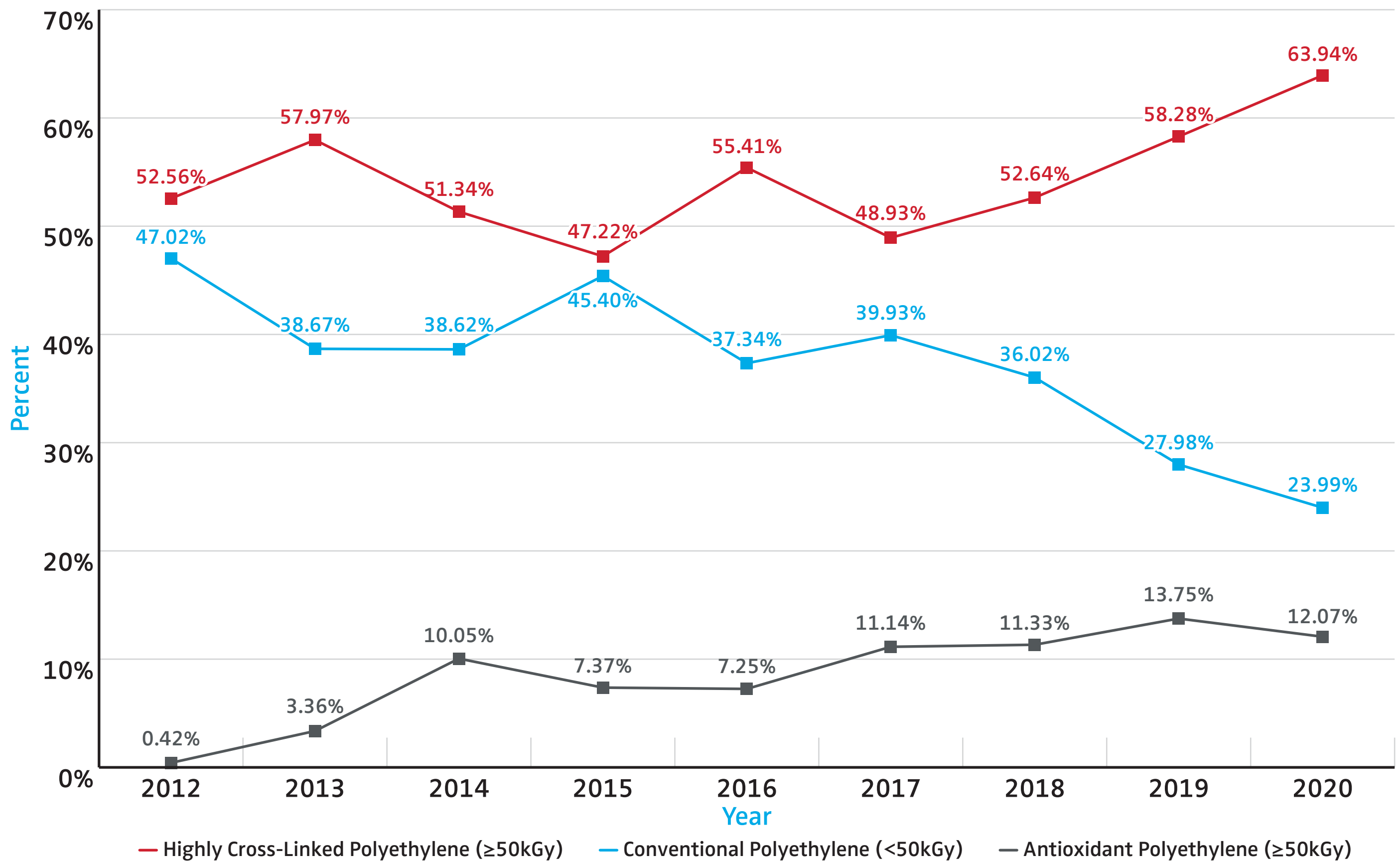


	2012	2013	2014	2015	2016	2017	2018	2019	2020	All
Total N	2,050	3,001	4,920	6,281	5,792	4,168	5,468	5,538	3,776	40,994

Figure 3.27 shows the liner types utilized by year for partial knee arthroplasty. These results show that highly cross-linked polyethylene is the most frequently used material. The use of conventional polyethylene has decreased while the use of antioxidant polyethylene for UKA has increased.

As is also the case with primary total knee arthroplasty, the use of conventional polyethylene inserts continues to decrease in unicompartmental knee arthroplasty.

Figure 3.27 Unicondylar Knee Arthroplasty Insert Polyethylene Material by Year, 2012-2020 (N=38,137)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	All
Total N	1,897	3,217	5,205	6,539	5,763	3,879	4,747	4,314	2,576	38,137

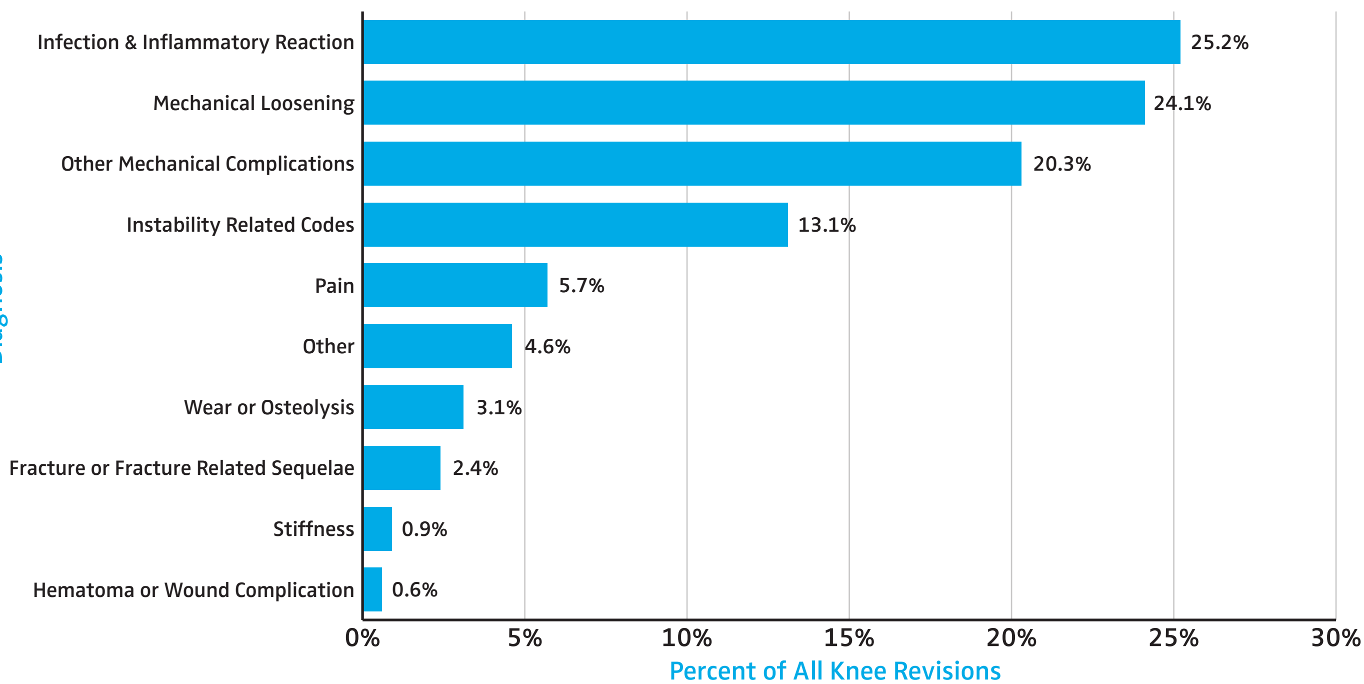
Revision Knee Arthroplasty

Between 2012 and 2020, AJRR has collected data on 89,463 revision knee arthroplasty procedures.

As discussed in the revision hip arthroplasty section, a substantial amount of work has been done since the last *AJRR Annual Report* to better identify and characterize the reasons for revision knee arthroplasty procedures. The data submitted to AJRR contains variability in coding with respect to primary reason for revision. Substantial efforts involving surgeon leadership were undertaken to identify best practices for this critical coding step. First, reason for revision was determined by the primary diagnosis code submitted for each revision. AJRR accepts up to 10 diagnosis codes which can be submitted as either ICD (International Classification of Diseases)-9 or -10 codes depending on the year of the procedure. To best produce analyses, much time was spent with surgeon leadership to identify the best approach for grouping and characterizing the numerous different codes.

The primary reason for revision was then examined and categorized as follows: fracture (fracture, fracture related sequelae), other mechanical complications, articular bearing surface wear and/or osteolysis, instability related codes, infection and inflammatory reaction, mechanical loosening, pain, stiffness, and hematoma/wound complications. If the primary code submitted did not fall into one of these categories, the subsequent reported codes were examined for a match. If none of the submitted codes matched a defined category, the primary reason for revision was placed in an ''other'' category. This category was then examined and all procedures with a non-relevant or clearly erroneous diagnosis were removed. Revisions were removed from analyses due to irrelevant codes such as those for medical comorbidities or anatomic areas other than the knee. Using this methodology, the most common reason for knee revision surgery was infection and inflammatory reaction at 25.2% (Figure 3.28).

Figure 3.28 Distribution of Diagnosis Associated with All Knee Revisions, 2012-2020 (N=77,520)



Revision surgeries can also be further examined based on their occurrence from the time of the index primary procedure. An early revision is considered one that occurred <3 months after the primary procedure. There were 4,181 early "linked" revision procedures in AJRR (Table 3.6). In a study quantifying the level of migration of primary arthroplasty patients ≥65 years of age, Etkin et al. noted only 0.62% of Medicare patients moved out of state and to a different county one year after the primary procedure.[12] Migration to a different state or county increased to >10% at 5 years and 18% at 10 years. As a result, AJRR might be more likely to capture an early revision, as those are most likely to return to the same AJRR hospital as the primary.[12] Among early revisions, 2,488 procedures had a primary diagnosis that was relevant using the methodology above. For all early revisions, the primary reason was again infection and inflammatory reaction (63.9%) (Figure 3.29).

INSIGHTS

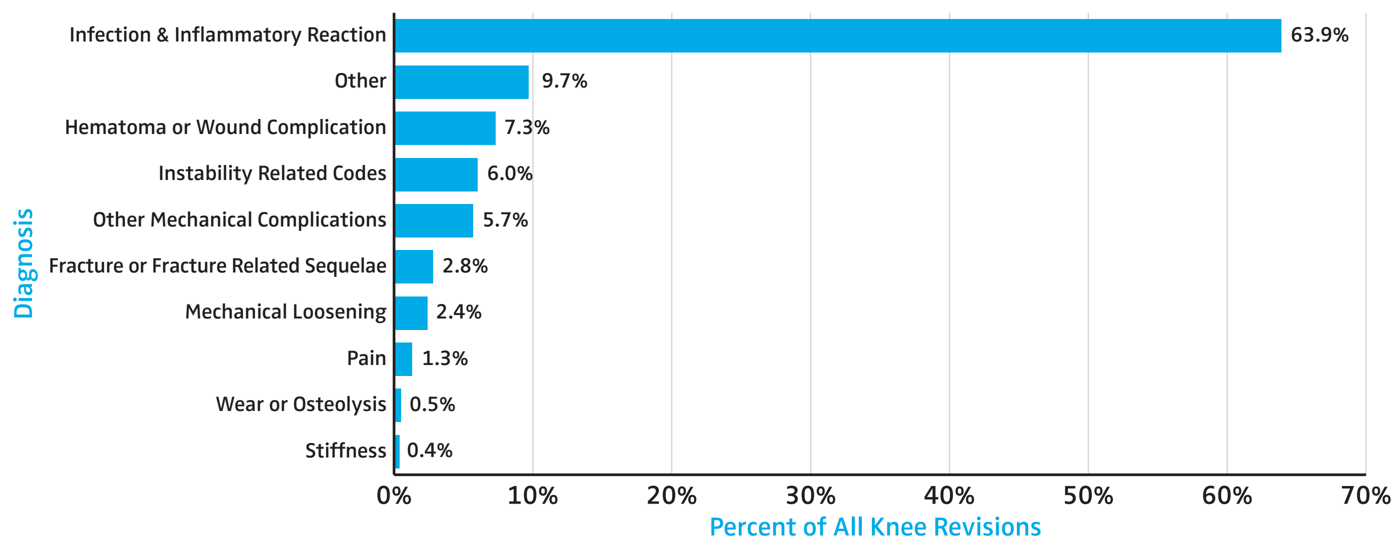
Infection remains the most common reason for revision surgery following total knee arthroplasty, particularly for early revisions within three months of the index surgery.

As reported to AJRR, the percentage of primary total knee arthroplasty procedures with an early revision (<3 months from primary procedure) ranged from 0.4% to 0.6% and was most common in the <50 age group (Figure 3.30). When comparing the percentage of revisions for all total knee arthroplasties with a primary diagnosis of infection, there has been an increase from 17.5% in 2012 to 27.2% in 2020 (Figure 3.31).

INSIGHTS

Patients <50 years of age had the highest incidence of early revision following total knee arthroplasty.

Figure 3.29 Distribution of Diagnosis Associated with Early "Linked" Knee Revisions, 2012-2020 (N=2,488)*



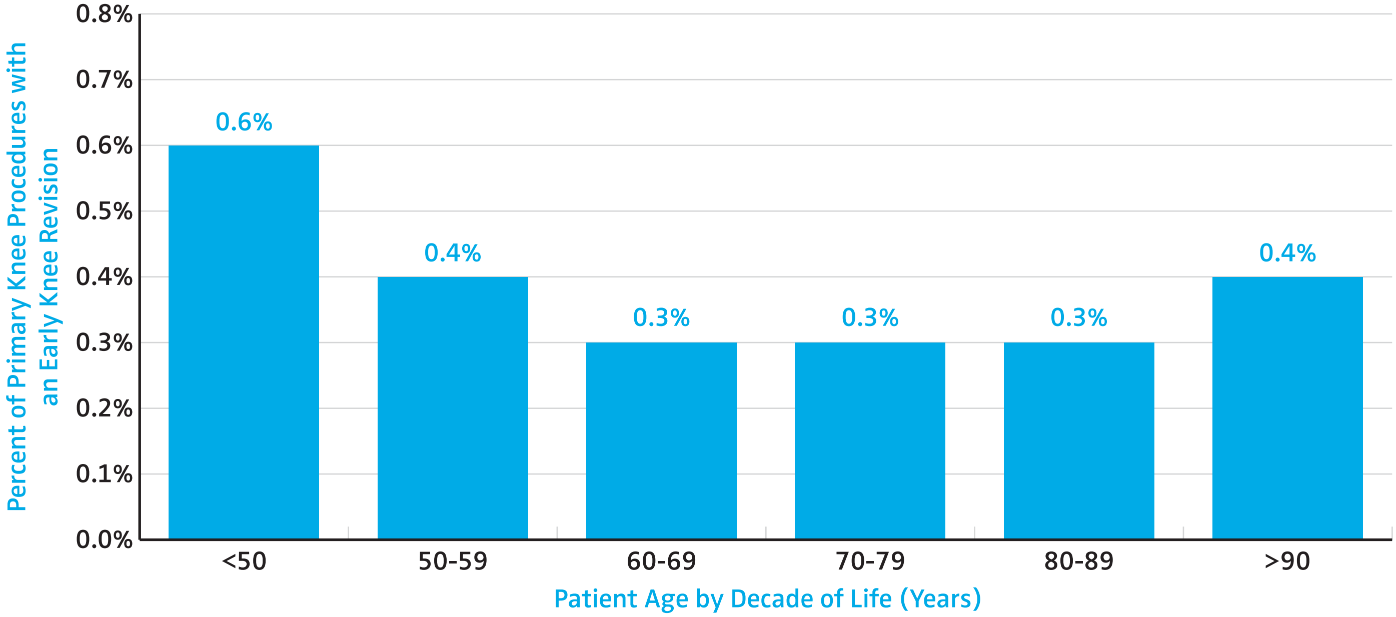
**Linked revisions require matching patient ID, procedure site, and laterality*

Table 3.6 Distribution of Time Interval Between Primary Total Knee Arthroplasty and Revision Procedures for "Linked" Patients, 2012-2020 (N=16,316)*

Time	Frequency	Percent	Cumulative Frequency	Cumulative Percent
<3 Months	4,181	25.6	4,181	25.63
3-5 Months	2,014	12.3	6,195	37.97
6-12 Months	2,687	16.5	8,882	54.44
>1 Year	7,434	45.6	16,316	100

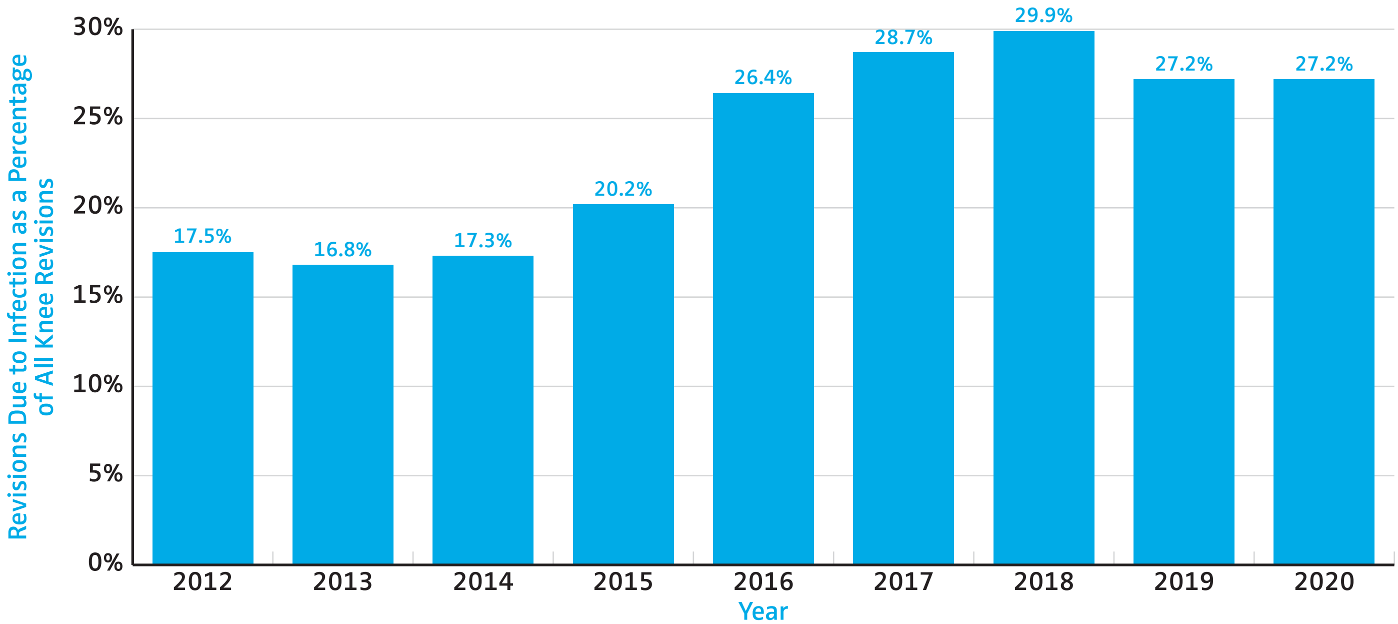
**Linked revisions require matching patient ID, procedure site, and laterality*

Figure 3.30 Early "Linked" Revisions as a Percent of All Primary Total Knee Arthroplasty Procedures by Age Group, 2012-2020 (N=4,181)*



*Linked revisions require matching patient ID, procedure site, and laterality

Figure 3.31 Percent of Revision Total Knee Arthroplasty Procedures Due to Infection, 2012-2020 (N=19,500)



Antioxidant polyethylene usage in revision knee arthroplasties has been significantly increasing since 2012 ($p<0.001$) (Figure 3.32). Those listed as non-antioxidant polyethylene include other highly cross-linked polyethylene and conventional polyethylene (UHMWPE). Figure 3.33 provides utilization data of implants used in revision total knee arthroplasty procedures in AJRR by year for the years 2012 through 2020. Over the nine-year period, utilization of Triathlon components and the Sigma/MBT system has predominated. In 2018 and 2019, an increased usage of Legion and Attune systems and a declining usage of Sigma/MBT are observed.

INSIGHTS

2020 marked the first year where both highly cross-linked polyethylene and antioxidant polyethylene inserts were used more commonly than conventional polyethylene for revision TKA procedures.

Figure 3.32 Revision Knee Arthroplasty Insert Polyethylene Material by Year, 2012-2020 (N=61,868)

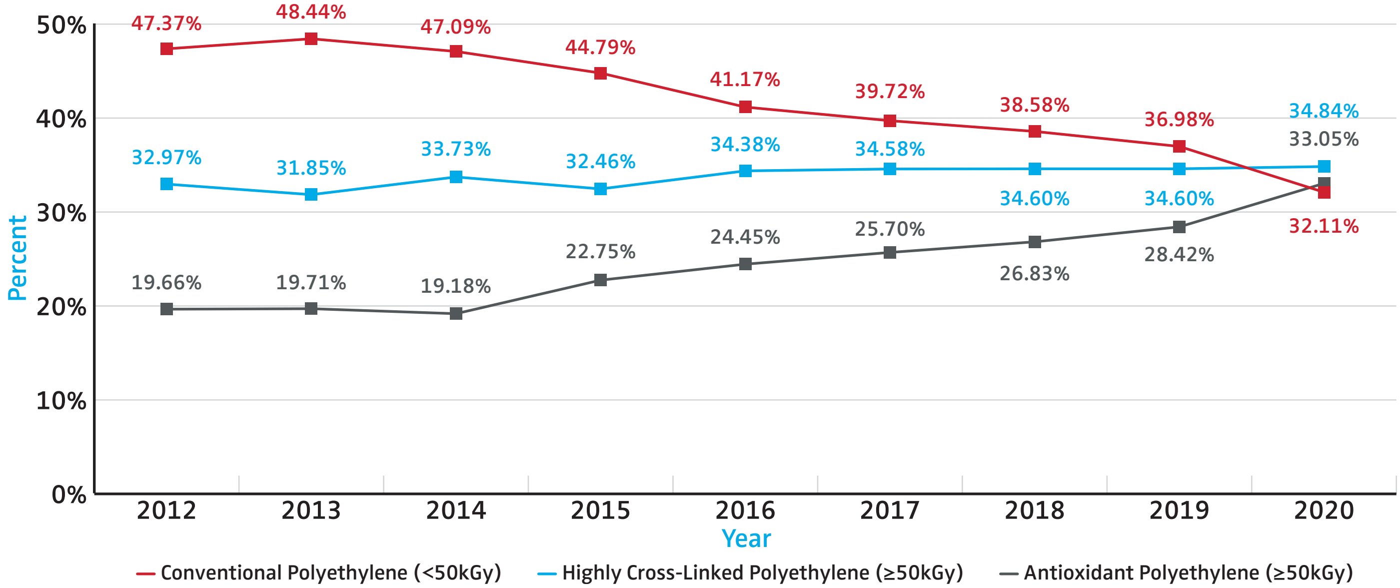
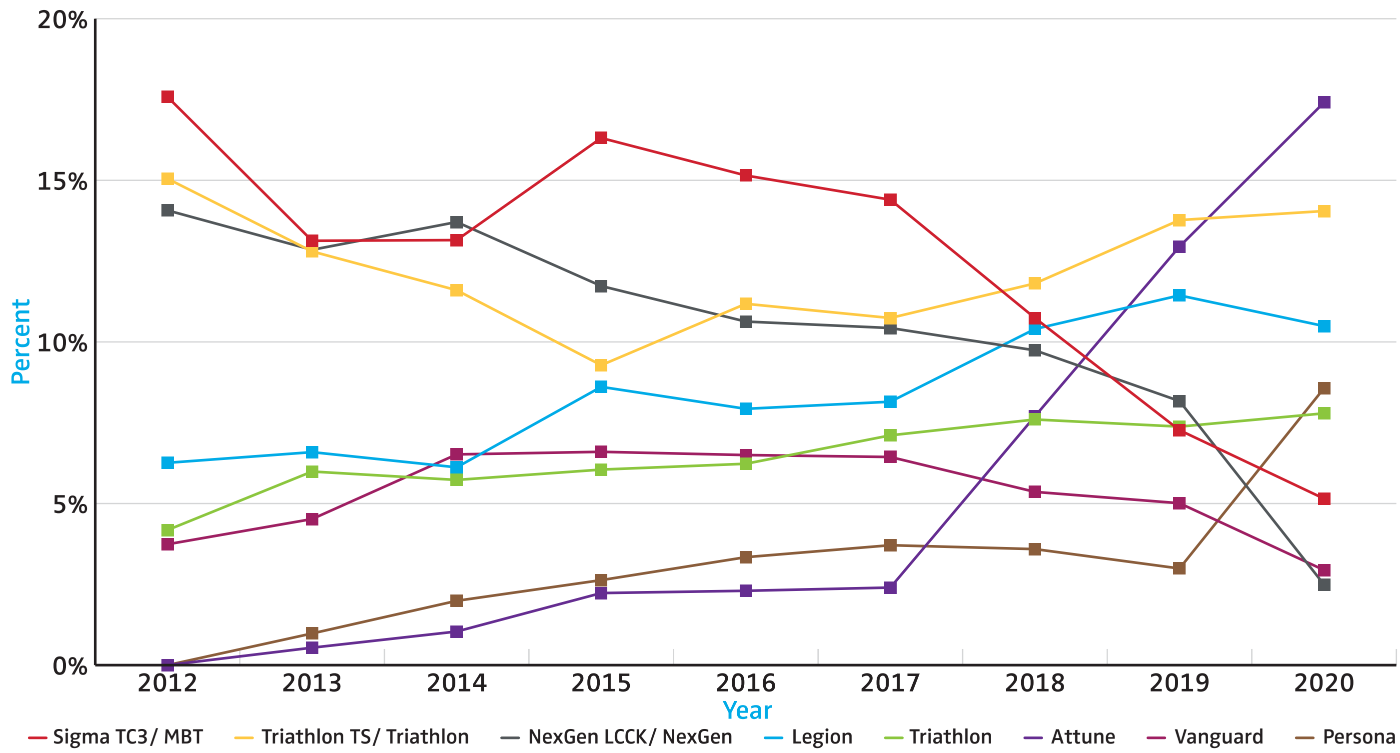


Figure 3.33 Revision Total Knee Arthroplasty Femoral/Tibial Component Combinations by Year, 2012-2020 (N=34,124)

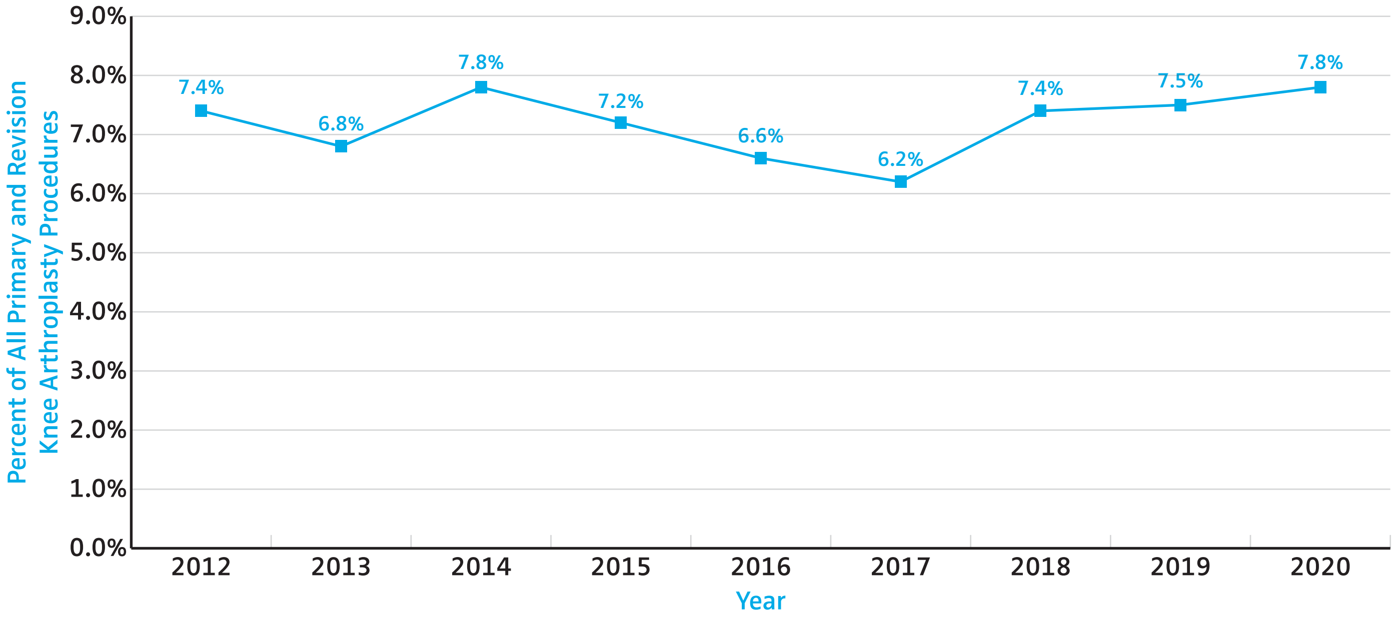


	2012	2013	2014	2015	2016	2017	2018	2019	2020	All
Total N	910	1,836	3,560	4,483	5,295	5,092	4,961	4,649	3,338	34,124

As discussed earlier in the revision hip arthroplasty section, revision burden can be used across registries as a simple unit of measure for comparison and quality improvement. In 2020, AJRR's sample population had a revision burden for all total knee arthroplasty procedures of 7.8%, which has been relatively consistent since 2012 (Figure 3.34). Previous reports in the literature that have compared revision burden among international hip and knee joint registries have also noted relatively stable rates between 2011 and 2014.[13] In 2020, the Australian Orthopaedic Association National Joint Replacement Registry reported a revision burden of 7.3%, an all-time low for the Registry.[6]

Although knee arthroplasty revision burden appears to be relatively stable when calculated with AJRR data, numerous factors may be at play. As the Registry grows and new institutions submit data, a disproportionately large number of primary procedures may be added to the database, or the distribution of institutions performing primary versus revision surgery may change. Finally, even with the growth of AJRR, revisions performed outside the AJRR capture area would falsely decrease revision burden.

Figure 3.34 Revision Burden of Total Knee Arthroplasty Procedures, 2012-2020 (N=89,463)*



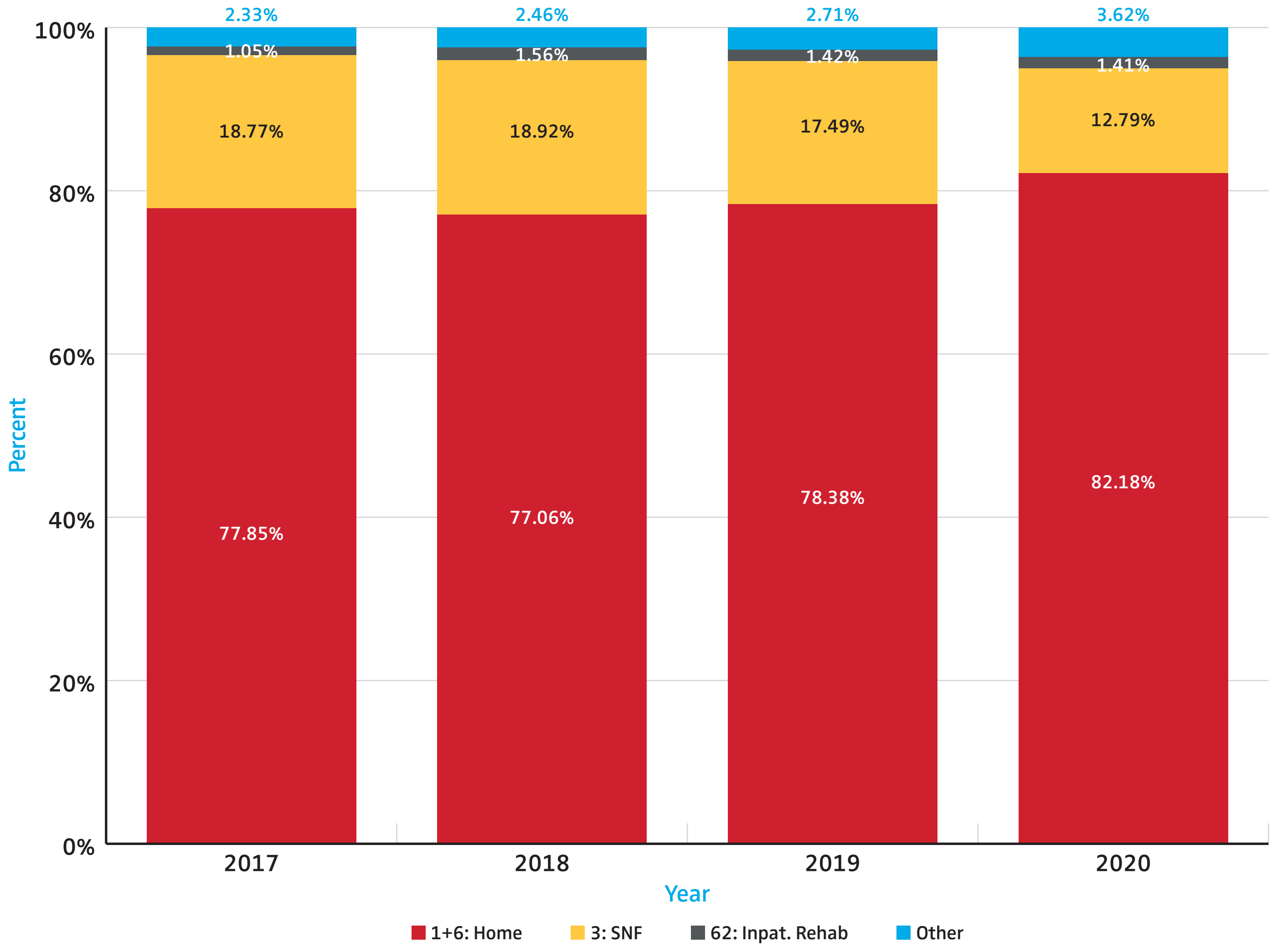
**Linked revisions require matching patient ID, procedure site, and laterality*

Revision burden for all total knee arthroplasty procedures was 7.8% in 2020, which is an increase from a nadir of 6.2% in 2017.

INSIGHTS

Figure 3.35 tabulates the discharge disposition reported for revision TKA cases for the years 2017 through 2020, when data collection began. AJRR collects the CMS-defined Patient Discharge Status Code values. Discharge to home, represented by discharge codes 1 and 6, are reported in over 75% of cases with over 82% in 2020. Discharge to a skilled nursing facility (SNF) is reported in approximately 18% of cases but dropped to 13% by 2020. Other discharge codes represent only a small portion of cases.

Figure 3.35 Revision Knee Arthroplasty Discharge Disposition Codes by Year, 2017-2020 (N=40,356)



Patient-Reported Outcome Measures (PROMs)

As noted in the hip arthroplasty section, patient-reported outcome measures (PROMs) have received increased attention within AJRR and the wider practice of orthopaedic surgery. In the U.S., value-based payment models made capture of PROMs a prerequisite for various public and private alternative payment models. Internationally, in 2014 the ISAR Steering Committee established a working group in this area to advise on best practices.[14]

AJRR collects patient-reported outcome measures and encourages sites to submit this data at set intervals: a baseline measure obtained prior to the surgery, a measure 90-days preoperatively, and at one-year postoperatively. Patient-reported outcome measures capture information on the patient's overall health and function from the patient's perspective. The recommended intervals allow comparison over the course of a patient's care, but on a broader scope, provide a better picture of national outcomes and trends. AJRR provides national benchmarking for participating sites to review and compare this uniquely reported data.

With a growing emphasis on the value of PROMs data, the Registry in turn has expanded the ways in which sites submit this data. The Registry provides a tool for sites to collect PROMs data electronically on all eligible patients, via email or a computer or tablet device in the clinical setting. Sites also have the option to submit PROMs data through other methods, perhaps collected via a third-party vendor or a local system.

Quick Facts:

- Collection of PROMs was initiated in the California Joint Replacement Registry (CJRR) in early 2011 and following incorporation of CJRR within AJRR began for the larger U.S. population in April 2016.
- To help assist AJRR institutions with PROM data collection, AJRR offers a PROM platform within RegistryInsights® at no additional cost that allows for PROM storage and capture (both preoperatively and postoperatively). However, AJRR sites are able to utilize their own PROMs portal if preferred.
- AJRR collects PROMs at any time but recommends at a minimum a preoperative (<90 days before the procedure) and a one-year postoperative PROM.
- As of 2020, AJRR recommends and supports (on their PROM platform) the collection of HOOS JR., KOOS JR., PROMIS-10, and VR-12. Other PROMs are collected but not used for analyses.
- As of December 31, 2020, 290 sites out of 1,152 (25.2%) have submitted PROMs, which is a 39% increase in sites compared to the previous *2020 AJRR Annual Report*.
- The completion rate for "linked" outcomes (those where both a preoperative and one-year postoperative PROM is available on the same procedure) varies between 25.7-27.6%.

Based on the KOOS, JR. score, 88% of patients achieved a meaningful improvement after total knee arthroplasty.

INSIGHTS

Table 3.7 Preoperative and 1-Year Postoperative PROM Mean Scores After Primary Knee Arthroplasty by PROM

Patient-Reported Outcome Measure (PROM)	PROM Component	Pre or 1-year Postoperative	N	Mean	Standard Deviation
KOOS, JR. (Knee disability and Osteoarthritis Outcome Score)	Score	Preoperative	55,016	46.8	14.4
		Postoperative	22,840	76.8	16.3
PROMIS-10 (Patient-ReportedOutcomes Measurement Information System 10)	Mental T	Preoperative	37,943	49.7	8.6
		Postoperative	17,780	52.3	8.2
	Physical T	Preoperative	37,943	40.4	6.8
		Postoperative	17,780	48.4	8.4
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	Preoperative	20,416	53.0	12.7
		Postoperative	8,930	56.3	10.1
	Physical Health Component	Preoperative	20,213	30.7	9.2
		Postoperative	8,929	43.0	10.8

Table 3.8 Change Between Preoperative and 1-Year Postoperative PROM Scores after Primary Knee Arthroplasty by PROM, 2012-2020

Patient-Reported Outcome Measure (PROM)	PROM Component	Patients with Preoperative Score	Patients with Linked Postoperative Score	Response Rate, Percentage of Patients Who Completed a Preoperative and 1-Year Score	Patients with Meaningful Improvement*
KOOS, JR. (Knee disability and Osteoarthritis Outcome Score)	Score	55,016	14,127	25.7%	87.9%
PROMIS-10 (Patient-ReportedOutcomes Measurement Information System 10)	Mental T	37,943	10,415	27.5%	33.8%
	Physical T	37,943	10,415	27.5%	67.8%
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	20,416	5,574	27.3%	33.7%
	Physical Health Component	20,213	5,581	27.6%	74.8%

**Meaningful improvement was calculated by minimal clinical important difference (MCID). MCID was determined to be a positive change score of half the pooled standard deviation*

Appendices and References

Appendix A

Recent AJRR Publications and Presentations

The goal of the AAOS Registry Analytics Institute® (RAI) is to provide a resource to the scientific community to further understand and improve orthopaedic and musculoskeletal care by making data analyses available. RAI also provides physicians and clinician-scientists access to information beyond what is already published in the AJRR Annual report. Investigators can submit hypotheses regarding information in AAOS registries and linked CMS clinical databases. The AJRR Research Subcommittee provides a systematic and transparent peer review process for proposal approval. The RAI was launched in February of 2019 completed 6 application cycles 2019-2020 and two cycles in 2021. To date, the RAI has reviewed 101 applications and approved 41 clinical projects. Data analysis for approved clinical projects are completed by the AAOS combined analytics team. Completed RAI approved clinical projects have been submitted to a variety of orthopaedic conferences for presentation and to peer reviewed journals for publication. Please see a list of recent posters, presentations, and publications derived from AJRR data projects below. Click to learn more about the RAI application process.

Posters and Presentations

Huddleston JI, De A, Jaffri H, Barrington JW, Duwelius PJ, and Springer BD. Cementless Fixation, Total Hip Arthroplasty, and Increased Age Are Risk Factors for Revision after Arthroplasty for Femoral Neck Fracture: Results from the American Joint Replacement Registry. Podium presentation at AAOS 2021 Annual Meeting; August 31 – September 3, 2021; San Diego, CA.

Springer BD, De A, Odum SM, Stambough JB, Huddleston JI, and Illgen RL MD, Della Valle AG. The influence of femoral fixation on mortality and revision following femoral neck fractures. A matched cohort analysis from the American Joint Replacement Registry. Podium presentation at AAOS 2021 Annual Meeting; August 31 – September 3, 2021; San Diego, CA.

Della Valle AG, De A, Odum SM, Barrington JW, Huddleston JI, Illgen RL, Springer BD. The Effect of Femoral Stem Fixation on Revision and Mortality in Patients Over the Age of 65 Years Undergoing Elective Total Hip Arthroplasty. An Analysis of The American Joint. Podium presentation at AAOS 2021 Annual Meeting; August 31 – September 3, 2021; San Diego, CA.

Chen AF, Barrington JW, Duwelius PJ, Browne JA, Sporer SM, Gioe TJ, Porter KR, Hsiue PP, Stavrakis AI. Trends of Femoral Neck Fracture Treatment using Total Hip Arthroplasty: Reported from the American Joint Replacement Registry (AJRR). Podium presentation at AAOS 2021 Annual Meeting; August 31 – September 3, 2021; San Diego, CA.

Gray CF, Rizk PA, Bozic KJ, Parvataneni HK. Predictors of one-year outcomes after THA via the AJRR. Podium presentation at AAOS 2021 Annual Meeting; August 31 – September 3, 2021; San Diego, CA.

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Appendix B

Data Element Review

Procedural

Patient

- Name (Last, First)
- Date of Birth
- Social Security Number
- Diagnosis (ICD-9/10)
- Gender
- Ethnicity
- Height and Weight/BMI

Site of Service

- Name (TIN/NPI)
- Address

Surgeon

- Name
- National Provider Identifier (NPI)

Procedure

- Type (ICD-9/10 and CPT)
- Date of surgery
- Laterality
- Implants
- Surgical Approach
- Anesthesia Technique
- Discharge Disposition
- Implants (Manufacturer, Lot #)
- Operative Duration
- Computer/Robotic Assisted Surgery
- Tourniquet Use
- Blood Transfusion
- TXA Usage
- PT Day 0
- VTE Prophylaxis
- Perioperative Antibiotics
- Multi-modal Pain Management

Post-Operative, Complications

Patient Risk Factors (ICD-9/10)*

- Comorbidities (ICD-9/10, CPT)
- CJR Risk Variables
- Height + Weight/Body Mass Index
- Length of Stay
- American Society of Anesthesiologists (ASA) Score
- Charlson Index
- Operative and Post-operative Complications

**Comorbidities listed of focus, all comorbidities are accepted*

Post-Operative Complications

- Early revisions
- Hospital re-admission

Patient-Reported Outcome Measures (PROMs)

Hip dysfunction and Osteoarthritis Outcome Score for Joint Replacement (HOOS, JR.)*

Knee injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS, JR.)*

Patient-Reported Outcomes Measurement Information System (PROMIS) 10-item Global Health*

The Veterans RAND 12 Item Health Survey (VR-12)*

Harris Hip Score

Hip disability and Osteoarthritis Outcome Score (HOOS)

Knee injury and Osteoarthritis Outcome Score (KOOS)

Medical Outcomes Study 36-Item Short Form Health Survey (SF-36)

Oxford Hip and Knee Scores

The Knee Society Knee Scoring System

Western Ontario and McMaster Universities Arthritis Index (WOMAC)

**PROMs recommended by AJRR and supported on the PROM platform*

Appendix C

Audit of Registry Data

The AAOS Registry Program and AJRR are committed to providing data reports that are valid and accurate. To ensure the Registry Program achieves this objective, internal quality controls are in place, in addition to an external audit of data from the previous year. The audit process is completed annually, and this year AJRR executed a contract with Advent Advisory Group® to serve as the new vendor for auditing a sample of 2020 data. Advent Advisory Group is a National Committee for Quality Assurance (NCQA) licensed audit organization which provides audit, consulting, data validation, and technical assistance to health services organizations nationwide. With over 25 years of experience, Advent's staff of auditors, clinicians, analysts, statisticians, certified coders, and programmers perform validation services for a variety of health care organizations, including health plans, provider organizations, clinical registries, data aggregators, and health information exchanges. The intention of this audit was to select and review a sample of 2020 data. The Registry randomly selected N=37 (3%), actively submitting AJRR sites, both hospitals and ambulatory surgical centers (ASCs), from January 1 to December 31, 2020 to participate. Two hospitals adjudicated during the prior year audit and were required to participate this year, creating a total of 39 sites for the current audit of 2020 data. The participating sites represented urban and rural locations, in addition to small and large institution size. There are two portions of the audit to evaluate Registry data: the first portion of the audit was a medical records review, structured to analyze randomly selected hip and knee arthroplasty procedures performed in 2020. The audit process ensures data submitted to AJRR correctly represents the data in the facility medical records, and that the data submitted to AJRR for a randomly selected month(s) in 2020 reflected all hip and knee arthroplasty procedures performed at that site. The audit was completed in early September 2021.

Ten of the randomly selected sites for the 2021 audit were unable to participate and were issued an exclusion waiver due to COVID-19 related personnel changes. Additionally, 10 randomly selected sites were issued an exclusion waiver due to non-COVID-19 related personnel changes and inability to process the request by the established timeline. Audit participation is required, and verbiage is included in all AJRR site contracts; these 20 sites will be required to participate in the 2021 Annual Audit. This resulted in 19 participating sites for inclusion in the aggregate summary.

The overall medical record audit agreement rate was 95.0%, which was higher than the 93.9% overall audit agreement rate for the sites in the 2020 Annual Report (2019 year data) and between the 95.4% and 94.5% overall audit agreement rate for the prior Annual Reports in 2019 and 2018. Since inception of the AJRR Annual Audit, the overall audit agreement rate has consistently exceeded 90%, above the 85% acceptable threshold, indicating high reliability of the data within the AJRR.

The overall record completeness assessment rate was 94.2%, up from 91.7% in the *2020 Annual Report*. Challenges in the completeness agreement include formatting issues with reports that participants submitted to Advent, therefore creating mismatches on the Primary Procedure Codes submitted. Mismatches were also linked to documentation of laterality and institution NPI. There were no anomalous observations to suggest any cherry picking or selection of only the best cases being submitted.

This audit reflects agreement between the information in the institution record and the information as reported to AJRR. The audit does not reflect whether data and resulting codes assigned in the hospital record were the most appropriate or accurate for the procedure performed. Efforts to address accuracy and appropriateness of the submitted data, especially at the point of data entry, will continue in collaboration with all participating sites.

Appendix D

AAOS Authorized Vendor Program

The AAOS Authorized Vendor Program was created to minimize the data entry burden and enhance the data submission process. The following vendors have been approved for this program.

- ✓ Algos Pathways
- ✓ American Association of Orthopedic Executives (AAOE)
- ✓ Amkai Solutions
- ✓ Cedaron
- ✓ Cerner*
- ✓ Clarify Health Solutions
- ✓ CODE Technology
- ✓ Consensus Medical Systems, Inc.
- ✓ Direct Difference
- ✓ Duet Health
- ✓ Epic*
- ✓ FORCE Therapeutics
- ✓ Invivolink, Inc.
- ✓ Kermit
- ✓ MedTrak, Inc. (CareSense System)
- ✓ Medtronic
- ✓ [m]pirik
- ✓ Navion HealthCare Solutions
- ✓ OM1
- ✓ Ortech, Inc.
- ✓ OrthoSensor, Inc.
- ✓ OrthoVitals
- ✓ OutcomeMD
- ✓ PatientIQ
- ✓ Pro-Mapp Health
- ✓ Q-Centrix
- ✓ Ratchet Health
- ✓ Ready Surgery
- ✓ Revo Health
- ✓ Twistle
- ✓ URS-Oberd, Inc.
- ✓ ValidCare
- ✓ VisionTree
- ✓ VitalHealth Software
- ✓ Vox Telehealth
- ✓ Wellbe, Inc.

**Vendors who have data extract templates*

For updates to the list and more information on the AAOS Authorized Vendor Program, please visit here.

Appendix E

AJRR Committees

AJRR California State Registry Committee

James I. Huddleston, III, MD, FAAOS–Chair
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Young Physicians Committee (YPC)

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Los Angeles County Harbor

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Plano Orthopaedics and Sports Medicine

Paul J. Duwelius, MD, FAAOS
Orthopedic and Fracture Specialists

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University of Michigan

Susan M. Odum, PhD
OrthoCarolina Research Institute

Brian S. Parsley, MD, FAAOS
UTHealth

Bryan D. Springer, MD, FAAOS
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University of Wisconsin

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University of Wisconsin

Jesse E. Otero, MD, PhD
OrthoCarolina

Adam J. Schwartz, MD, FAAOS
Mayo Clinic

James Slover MD, MS, FAAOS
NYU Langone Orthopedic Hospital

Timothy Wright, PhD
Hospital for Special Surgery

Public Advisory Board

Richard Seiden, Esq., Chair

Jane Beckette, MSN

Chris Michno

William (Bill) Mulvihill, M.Ed.

Kristin Veno

Appendix F

Participating Institutions

Institutions that joined AJRR by 8/3/21 are included. Those that contributed data for this *Annual Report* by 7/26/21 are highlighted in blue.

Alabama

Cullman Regional Medical Center
Huntsville Hospital
Jack Hughston Memorial Hospital
South Baldwin Regional Medical Center
St. Vincent's Birmingham
USA Health University Hospital

Alaska

Alpine Surgery Center
Central Peninsula Hospital
Creekside Surgery Center
Providence Alaska Medical Center
Providence Kodiak Island Medical Center
Alaska Regional Hospital

Arizona

Arizona Spine & Joint Hospital
Banner-University Medical Center South
Banner-University Medical Center Tucson
Carondelet St. Joseph's Hospital
Flagstaff Medical Center
Mayo Clinic in Arizona
Mountain Vista Medical Center
Northwest Medical Center
OASIS Hospital
Verde Valley Medical Center
Chandler Regional Medical Center
Gateway Surgery Center
Mercy Gilbert Medical Center
North Valley Surgery Center
Oro Valley Hospital
Shane Martin, MD of Greater Phoenix Orthopedics
Sonoran Orthopaedic Trauma Surgeons
St. Luke's Medical Center
Tempe St. Luke's Hospital
University Orthopedic Specialists

Arkansas

Arkansas Surgical Hospital
CHI St. Vincent Hot Springs*
CHI St. Vincent Infirmary
Martin Knee & Sports Medicine Center
Mercy Hospital Fort Smith
Mercy Hospital Northwest Arkansas
Mercy Orthopedic Hospital Fort Smith
Northwest Health Physicians' Specialty Hospital*
Northwest Medical Center-Bentonville*
Northwest Medical Center-Springdale*
OrthoSurgeons
University of Arkansas for Medical Sciences
Washington Regional Medical Center
White River Medical Center
National Park Medical Center

California

Adventist Health Bakersfield
Adventist Health Hanford
Adventist Health Lodi Memorial
Adventist Health St. Helena*
Alta Bates Summit Medical Center Alta Bates Campus
Alta Bates Summit Medical Center Summit Campus
Arroyo Grande Community Hospital
Bakersfield Memorial Hospital
Barton Memorial Hospital
California Pacific Medical Center*
Casa Colina Hospital and Centers for Healthcare
Cedars-Sinai Medical Center
Clovis Community Medical Center
Community Hospital of the Monterey Peninsula
Community Memorial Hospital
Dameron Hospital
Doctors Medical Center of Modesto
Eisenhower Medical Center
El Camino Hospital, Los Gatos Campus
Emanuel Medical Center
Enloe Medical Center
Feather River Hospital
French Hospital Medical Center
Fresno Surgical Hospital
Glendale Adventist Medical Center
Goleta Valley Cottage Hospital*
Hoag Orthopedic Institute
Howard Memorial Hospital
Huntington Hospital*
Inland Valley Medical Center
John Muir Health, Concord Medical Center
John Muir Health, Walnut Creek Medical Center
Keck Medicine of USC
Long Beach Medical Center
Los Robles Regional Medical Center
Marian Regional Medical Center
Marina del Rey Hospital
Memorial Medical Center
Mercy General Hospital*
Mercy Hospital of Folsom
Mercy Medical Center Merced*
Mercy San Juan Medical Center
Methodist Hospital of Sacramento
Mills-Peninsula Medical Center
Mission Hospital-Mission Viejo
Monterey Peninsula Surgery Center
NorthBay VacaValley Hospital
Novato Community Hospital*
Orange Coast Medical Center
Palomar Medical Center Escondido
Palomar Medical Center Poway
Petaluma Valley Hospital
PIH Health-Whittier
Pomona Valley Hospital Medical Center

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 7/26/21.*

Institutions that joined AJRR by 8/3/21 are included. Those that contributed data for this *Annual Report* by 7/26/21 are highlighted in blue.

Presidio Surgery Center*
Providence Holy Cross Medical Center
Providence Little Company of Mary Medical Center-San Pedro
Providence Little Company of Mary Medical Center Torrance
Providence Saint John's Health Center
Providence Saint Joseph Medical Center
Providence Santa Rosa Memorial Hospital
Providence St. Joseph Hospital of Orange
Providence St. Jude Medical Center*
Providence Tarzana Medical Center
Queen of the Valley Medical Center
Redwood Memorial Hospital
Riverside Community Hospital
Riverside University Health System*
Ronald Reagan UCLA Medical Center
Saddleback Medical Center
Saint Agnes Medical Center
Salinas Valley Memorial Healthcare System
San Antonio Regional Hospital*
Santa Barbara Cottage Hospital*
Scripps Green Hospital
Sequoia Hospital
Sharp Chula Vista Medical Center
Sharp Coronado Hospital
Sharp Grossmont Hospital
Sharp Memorial Hospital
Shasta Regional Medical Center
Simi Valley Hospital
Sonoma Valley Hospital
Sonora Regional Medical Center
St. Joseph Hospital Eureka
St. Joseph's Medical Center
St. Mary Medical Center
St. Bernardine Medical Center
Stanford Health Care
Sutter Alhambra Surgery Center
Sutter Medical Center, Sacramento Surgery Center
Sutter Sierra Surgery Center
Sutter Surgical Hospital North Valley
Tahoe Forest Hospital
Temecula Valley Hospital
The Bahamas Surgery Center
The Center for Orthopedic Surgery
Torrance Memorial Medical Center
Tri-city Medical Center
UCLA Medical Center, Santa Monica
UCSF Medical Center
Ukiah Valley Medical Center
Washington Hospital Healthcare System
West Hills Hospital & Medical Center
White Memorial Medical Center
Alvarado Hospital Medical Center
Campus Surgery Center
Carlsbad Surgery Center
Coast Surgery Center
Corona Regional Medical Center
Desert Regional Medical Center
Dignity Health-St. Mary Medical Center
Dominican Hospital
Eden Medical Center
Fort Sutter Surgery Center
Good Samaritan Hospital
Henry Mayo Newhall Hospital
La Jolla Orthopedic Surgery Center
Mammoth Hospital
Memorial Hospital Los Banos
Mercy Hospital Downtown-Bakersfield
Mercy Medical Center Redding
Mission Valley Heights Surgery Center
North Bay Regional Surgery Center
North Tahoe Orthopedics
NorthBay Medical Center
Northridge Hospital Medical Center
Ojai Valley Community Hospital
Otay Lakes Surgery Center
Palmdale Regional Medical Center
Poway Surgery Center
Rancho Springs Medical Center*
Redlands Community Hospital
San Leandro Surgery Center
Santa Rosa Surgery and Endoscopy Center
St. John's Pleasant Valley Hospital
St. John's Regional Medical Center
Stockton Surgery Center
Surgery Center of Long Beach
Sutter Amador Hospital
Sutter Auburn Faith Hospital
Sutter Auburn Surgery Center
Sutter Davis Hospital Outpatient (Ambulatory) Surgery Center
Sutter Elk Grove Surgery Center
Sutter Fairfield Surgery Center
Sutter Maternity & Surgery Center
Sutter North Surgery and Endoscopy Center
Sutter Roseville Medical Center Surgery Center
Sutter Solano Medical Center Surgery Center
Sutter Tracy Community Hospital
USC Verdugo Hills Hospital

Colorado

Animas Surgical Hospital
Avista Adventist Hospital
Boulder Community Health
Castle Rock Adventist Hospital
Colorado Joint Replacement
Crown Point Surgery Center
Denver Health Medical Center
Littleton Adventist Hospital
Longmont United Hospital
Mercy Regional Medical Center
North Suburban Medical Center
OrthoColorado Hospital
Parker Adventist Hospital
Penrose Hospital
Porter Adventist Hospital
Pueblo Bone & Joint Clinic, LLC
Rose Medical Center
Sky Ridge Medical Center*
St. Anthony Hospital
St. Anthony North Health Campus
St. Anthony Summit Medical Center

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 7/26/21.*

Institutions that joined AJRR by 8/3/21 are included. Those that contributed data for this *Annual Report* by 7/26/21 are highlighted in blue.

St. Francis Medical Center
St. Mary-Corwin Medical Center
St. Mary's Medical Center
St. Thomas More Hospital
Swedish Medical Center
The Medical Center of Aurora
UCHealth Medical Center of the Rockies
UCHealth Poudre Valley Hospital
UCHealth University of Colorado Hospital
Panorama Orthopedics & Spine Center
Penrose-St. Francis Urgent Care
Presbyterian St. Luke's Medical Center
UCHealth Broomfield Hospital
UCHealth Grandview Hospital
UCHealth Greeley Medical Center
UCHealth Highlands Ranch Hospital
UCHealth Inverness Orthopedics and Spine Surgery Center
UCHealth Longs Peak Hospital
UCHealth Memorial Hospital Central
UCHealth Pikes Peak Regional Hospital
UCHealth Yampa Valley Medical Center

Connecticut

Glastonbury Surgery Center
Hartford Hospital
MidState Medical Center*
Saint Francis Hospital and Medical Center*
St. Vincent's Medical Center*
The Hospital of Central Connecticut - New Britain General Campus
Windham Hospital
Yale New Haven Health Bridgeport Hospital
Yale New Haven Health Greenwich Hospital
Yale New Haven Health Lawrence + Memorial Hospital
Yale New Haven Health Saint Raphael Campus*
Yale New Haven Hospital York Street Campus*
Backus Hospital
Bridgeport Hospital Milford Campus - Milford
Danbury Hospital
Johnson Memorial Hospital
Norwalk Hospital
Saint Mary's Hospital
Sharon Hospital
Valley Orthopaedic Specialists, LLC

Delaware

Bayhealth Hospital, Kent Campus
Bayhealth Hospital, Sussex Campus
Christiana Hospital
St. Francis Hospital
Wilmington Hospital
First State Orthopaedics
Orthopaedic Associates of Southern Delaware, P.A.

District of Columbia

Providence Hospital
Sibley Memorial Hospital-Johns Hopkins Medicine
George Washington University Hospital

Florida

AdventHealth Altamonte Springs
AdventHealth Carrollwood
AdventHealth Celebration
AdventHealth Orlando
AdventHealth Waterman
AdventHealth Wesley Chapel
AdventHealth Winter Park
AdventHealth-Zephyrhills Hospital*
Aventura Hospital and Medical Center
Baptist Hospital
Bartow Regional Medical Center
Blake Medical Center
Brandon Regional Hospital
Broward Health North*
Cape Coral Hospital
Cleveland Clinic Florida
Cleveland Clinic Florida-Weston
Cleveland Clinic Indian River Hospital*
Cleveland Clinic Tradition Hospital
Coral Gables Hospital*
Doctors Hospital of Sarasota
Dr. P. Phillips Hospital*
Fawcett Memorial Hospital
Flagler Hospital
Fort Walton Beach Medical Center
Gulf Breeze Hospital
Gulf Coast Medical Center
Gulf Coast Regional Medical Center
Health Central Hospital*
Holy Cross Hospital
JFK Medical Center
Jupiter Medical Center
Kendall Regional Medical Center
Largo Medical Center
Lee Memorial Hospital
Martin Memorial Medical Center
Mayo Clinic in Florida
Mease Countryside Hospital
Mease Dunedin Hospital
Medical Center of Trinity
Memorial Hospital Jacksonville*
Memorial Hospital of Tampa
Memorial Hospital West
Morton Plant Hospital
Morton Plant North Bay Hospital
North Florida Regional Medical Center
Oak Hill Hospital
Ocala Regional Medical Center
Orlando Health Orlando Regional Medical Center*
Orlando Health South Seminole Hospital*
Orthopaedic Surgery Center
Orthopaedic Surgery Center of Ocala
Osceola Regional Medical Center
Palms of Pasadena Hospital
Regional Medical Center Bayonet Point
Rockledge Regional Medical Center
Sarasota Memorial
South Bay Hospital

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 7/26/21.*

Institutions that joined AJRR by 8/3/21 are included. Those that contributed data for this *Annual Report* by 7/26/21 are highlighted in blue.

South Florida Baptist Hospital
St. Anthony's Hospital
St. Joseph's Hospital-North
St. Joseph's Hospital Tampa
St. Joseph's Hospital-South
St. Lucie Medical Center
Tallahassee Memorial HealthCare*
The Orthopaedic Institute
Toman Orthopedics and Sports Medicine
UF Health Shands Hospital
University Hospital & Medical Center
University of Florida Health
University of Miami Hospital
Westside Regional Medical Center
Winter Haven Hospital
AdventHealth Ocala
Andrews Institute Ambulatory Surgery Center
Andrews Institute for Orthopaedics & Sports Medicine
Ascension St. Vincent's Medical Center Clay County Hospital
Ascension St. Vincent's Medical Center Riverside Hospital
Ascension St. Vincent's Southside Hospital
Broward Health Medical Center
Cleveland Clinic Martin South Hospital
Florida Joint & Spine Institute
Lakewood Ranch Medical Center
Manatee Memorial Hospital
Medical Center Clinic
OrthoCare Florida
Orthopedic Center of Palm Beach County
Orthopedic Special Surgery of Palm Beaches
Pensacola Orthopaedics & Sports Medicine
Physicians Regional Medical Center-Collier Boulevard
Physicians Regional Medical Center-Pine Ridge
Wellington Regional Medical Center
West Florida Hospital
Weston Outpatient Surgical Center

Georgia

Atlanta Medical Center
Atlanta Medical Center South
Cartersville Medical Center
Coliseum Medical Centers
Colquitt Regional Medical Center
Eastside Medical Center
Houston Medical Center
Memorial University Medical Center
Navicent Health
Northwest Plaza ASC, LLC
Optim Medical Center-Tattnall
Optim Surgery Center
Perry Hospital
Piedmont Atlanta Hospital
Piedmont Columbus Regional Northside Campus
Piedmont Fayette Hospital
Piedmont Henry Hospital
Piedmont Newnan Hospital
Redmond Regional Medical Center
Southeast Georgia Health System-Brunswick Campus
Southeast Georgia Health System-Camden Campus
WellStar Cobb Hospital
WellStar Douglas Hospital
WellStar Kennestone Hospital*
WellStar Paulding Hospital
WellStar Spalding Regional Hospital
WellStar West Georgia Medical Center
Wellstar Windy Hill Hospital
Advanced Center for Joint Surgery
Coliseum Northside Hospital
Emory University Orthopaedics & Spine Hospital*
Floyd Medical Center
St. Mary's Good Samaritan Hospital
St. Mary's Hospital
Summit Sports Medicine & Orthopedic Surgery

Hawaii

Adventist Health Castle
Hawaii Pacific Health
Pali Momi Medical Center
Straub Clinic and Hospital
The Queen's Medical Center*
Wilcox Memorial Hospital

Idaho

Cassia Regional Medical Center
Northwest Specialty Hospital
St. Alphonsus Medical Center Nampa Campus
St. Alphonsus Regional Medical Center
St. Joseph Regional Medical Center
St. Luke's Boise Medical Center
St. Luke's Meridian Medical Center
Kootenai Outpatient Surgery
Madison Memorial Hospital

Illinois

Adult & Pediatric Orthopedics
Advocate Lutheran General Hospital
AMITA Health Adventist Medical Center Hinsdale
AMITA Health Alexian Brothers Medical Center Elk Grove Village
AMITA Health St. Alexius Medical Center Hoffman Estates
Blessing Health System
Centegra Hospital McHenry
Centegra Hospital Woodstock
Evanston Hospital
Genesis Medical Center, Silvis
Gibson Area Hospital
Glenbrook Hospital
Highland Park Hospital
HSHS St. Anthony's Memorial Hospital*
Memorial Medical Center-Springfield
Mount Sinai Hospital
Northwestern Medicine Central DuPage Hospital
Northwestern Medicine Delnor Hospital

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 7/26/21.*

Institutions that joined AJRR by 8/3/21 are included. Those that contributed data for this *Annual Report* by 7/26/21 are highlighted in blue.

Northwestern Medicine Kishwaukee Hospital*
Northwestern Medicine Lake Forest Hospital
Northwestern Memorial Hospital
OrthoIllinois
Orthopedic & Sports Medicine Clinic
Palos Community Hospital
Rockford Memorial Hospital
Rush University Medical Center
Skokie Hospital
South Shore Hospital
UnityPoint Health-Methodist
UnityPoint Health-Proctor
UnityPoint Health-Trinity Rock Island
Valley Ambulatory Surgery Center
Weiss Memorial Hospital
Advocate BroMenn Medical Center
Advocate Christ Medical Center
Advocate Condell Medical Center
Advocate Eureka Hospital
Advocate Good Samaritan Hospital
Advocate Good Shepherd Hospital
Advocate Illinois Masonic Medical Center
Advocate Sherman Hospital
Advocate South Suburban Hospital
Advocate Trinity Hospital
AMITA Health Adventist Medical Center La Grange
AMITA Health Resurrection Medical Center Chicago
AMITA Health Saint Joseph Hospital Chicago
AMITA Health Saint Joseph Hospital Elgin
AMITA Health St. Mary's Hospital Kankakee
Bonutti Orthopedic Clinic
Center For Minimally Invasive Surgery
Decatur Orthopaedic Center
DuPage Medical Group
Gold Coast Surgicenter
Gottlieb Memorial Hospital
HSHS St. John's Hospital
Loyola University Medical Center
Memorial Hospital of Carbondale
Mercy Hospital & Medical Center
NorthShore Orthopaedic & Spine Institute
OSF Heart of Mary Medical Center
OSF Holy Family Medical Center
OSF Sacred Heart Medical Center
OSF Saint Anthony Medical Center
OSF Saint Anthony's Health Center
OSF Saint Elizabeth Medical Center
OSF Saint Francis Medical Center
OSF Saint James-John W. Albrecht Medical Center
OSF Saint Luke Medical Center
OSF Saint Paul Medical Center
OSF St. Joseph Medical Center
OSF St. Mary Medical Center
Raycraft & Jones Orthopaedics
Riverside Medical Center
Sarah Bush Lincoln Health Center
SIH Herrin Hospital
Swedish American Hospital

Indiana

Allied Physicians Surgery Center
Columbus Regional Health Orthopedics and Sports Medicine
Elkhart General Hospital*
Franciscan Health Carmel
Franciscan Health Indianapolis
Franciscan Health Moorseville
Hancock Regional Hospital
Indiana University Health West Hospital
IU Health Ball Memorial Hospital*
IU Health Bloomington Hospital*
IU Health North Hospital
IU Health Saxony Hospital
IU Health Saxony Surgery Center
Main Hospital
Major Health Partners Medical Center
Memorial Hospital and HealthCare Center
OrthoIndy Northwest
Plymouth Medical Center
Porter Regional Hospital
Riverview Health Westfield Hospital
Schneck Medical Center
St. Joseph Regional Medical Center
St. Mary Medical Center*
The Orthopedic Hospital
Indiana Hand to Shoulder Center
Indiana University Health Methodist Hospital
Indiana University Health White Memorial Hospital
IU Health Arnett Hospital
IU Health Bedford Hospital
IU Health Beltway Surgery Centers
IU Health Blackford Hospital
IU Health Eagle Highlands Surgery Center
IU Health Jay Hospital
IU Health Meridian South Surgery Center
IU Health Morgan
IU Health Paoli Hospital
IU Health Tipton Hospital
IU Health University Hospital*
Memorial Hospital of South Bend*
Riley Hospital for Children at IU Health
Senate Street Surgery Center

Iowa

Allen Hospital
Buena Vista Regional Medical Center
CHI Health Mercy Council Bluffs*
Finley Hospital
Genesis Medical Center, Davenport
Great River Orthopaedic Specialists
Iowa Lutheran Hospital
Iowa Methodist Medical Center
Iowa Specialty Hospital-Clarion
Lakes Regional Healthcare
Marengo Memorial Hospital
Mercy Medical Center-Cedar Rapids
Mercy Medical Center-Clinton
Mercy Medical Center-Des Moines
Mercy Medical Center-Dubuque

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 7/26/21.*

Institutions that joined AJRR by 8/3/21 are included. Those that contributed data for this *Annual Report* by 7/26/21 are highlighted in blue.

Mercy Medical Center-Sioux City
Mercy Medical Center-West Lakes
MercyOne North Iowa Medical Center
Methodist West Hospital
Mississippi Valley Surgery Center
Orthopaedic Outpatient Surgery Center
Spencer Hospital
St. Luke's Hospital
St. Luke's Regional Medical Center
UnityPoint Health-Trinity Bettendorf
UnityPoint Health-Trinity Muscatine
UnityPoint Health-Trinity Regional Medical Center
UnityPoint Marshalltown
University of Iowa Hospitals & Clinics
CHI Health Mercy Corning
MercyOne Des Moines Medical Center
MercyOne New Hampton Medical Center
MercyOne Primghar Medical Center
Steindler Orthopedic Clinic

Kansas

AdventHealth Shawnee Mission
Hays Medical Center
Hutchinson Regional Medical Center
Kansas City Orthopaedic Institute
Lawrence Memorial Hospital*
LMH Health
Menorah Medical Center
Newton Medical Center
St. Catherine Hospital
Stormont-Vail Health*
The University of Kansas Health System
Wesley Medical Center
Wesley Woodlawn Hospital & ER
AdventHealth Ottawa
Bob Wilson Memorial Hospital
St. Rose Ambulatory & Surgery Center

Kentucky

Hardin Memorial Hospital*
Jewish Hospital
Mercy Health-Lourdes Hospital
Methodist Hospital
Norton Audubon Hospital
Norton Brownsboro Hospital
Norton Hospital
Norton Women's & Children's Hospital
Pomeroy & Rhoads Orthopaedics, PLLC
Saint Joseph East
St. Elizabeth Hospital Edgewood
TriStar Greenview Regional Hospital
Bluegrass Orthopaedics
King's Daughters Medical Center
Owensboro Health Regional Hospital
South Central Kentucky Orthopedics

Louisiana

Doctors Hospital at Deer Creek
Lafayette General Medical Center
Lafayette Surgical Specialty Hospital
Ochsner Baptist-A Campus of Ochsner Medical Center
Ochsner Hospital for Orthopedics & Sports Medicine
Ochsner Medical Center
Ochsner Medical Center-Kenner
Ochsner Medical Center-West Bank Campus
Our Lady of Lourdes Regional Medical Center
Park Place Surgical Hospital
Specialists Hospital Shreveport
Thibodeaux Regional Medical Center
Christus Ochsner St. Patrick Hospital
East Jefferson General Hospital
Lafayette Bone & Joint Clinic
Red River Surgery Center
West Bank Surgery Center

Maine

Central Maine Orthopaedics
Falmouth Orthopedic Center
Maine Medical Center
MaineGeneral Medical Center
OA Centers for Orthopaedics

Maryland

Anne Arundel Medical Center
Atlantic General Hospital
GBMC HealthCare*
Harborside Surgery Center
Holy Cross Germantown Hospital
Holy Cross Hospital
Howard County General Hospital
Johns Hopkins Bayview Medical Center*
MedStar Union Memorial Hospital
Meritus Medical Center
Peninsula Regional Medical Center*
Saint Agnes Healthcare
Suburban Hospital
Surgery Center of Easton
University of Maryland Baltimore Washington Medical Center
University of Maryland Charles Regional Medical Center
University of Maryland Harford Memorial Hospital
University of Maryland Medical Center
University of Maryland Medical Center Midtown Campus
University of Maryland Rehabilitation & Orthopaedic Institute
University of Maryland Shore Medical Center at Easton
University of Maryland St. Joseph Medical Center
University of Maryland Upper Chesapeake Health
Western Maryland Health System
Capitol Orthopaedics and Rehabilitation, LLC
Frederick Health Hospital
Greenspring Surgery Center, LLC
Sinai Hospital of Baltimore
SurgCenter of Western Maryland, LLC

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Massachusetts

Berkshire Medical Center
Beth Israel Deaconness Hospital-Plymouth
Beth Israel Deaconness Medical Center
Beverly Hospital
Boston Medical Center
Charlton Memorial Hospital
Good Samaritan Medical Center
Holy Family Hospital*
Lahey Hospital & Medical Center
Massachusetts General Hospital
New England Baptist Hospital*
Orthopedic Surgery Center of the North Shore
Quincy Medical Center
Saint Anne's Hospital*
Signature Healthcare Brockton Hospital
South Shore Hospital
Sports Medicine North Orthopedic Surgery
St. Luke's Hospital
Boston Out-Patient Surgical Suites, LLC
Brigham and Women's Faulkner Hospital
Brigham and Women's Hospital
Longview Orthopaedic Center, LLC
Lowell General Hospital
Mercy Medical Center
Mercy Medical Center of Sisters of Providence

Michigan

Ascension Borgess Medical Center
Ascension Providence Hospital, Southfield
Bronson Battle Creek Hospital
Bronson LakeView Hospital
Bronson Methodist Hospital
Bronson South Haven Hospital
Henry Ford Hospital
Henry Ford Macomb Hospital
Henry Ford West Bloomfield Hospital
Henry Ford Wyandotte Hospital
Holland Hospital
Hurley Medical Center
McLaren Flint
McLaren Greater Lansing
Mercy Health Hackely
Mercy Health Muskegon
Mercy Health St. Mary's
Michigan Surgical Hospital
MidMichigan Medical Center-Midland
Munson Healthcare Cadillac Hospital
Munson Medical Center
Red Cedar Surgery Center, LLC*
Sparrow Health System
Spectrum Health Hospitals Blodgett Hospital
Spectrum Health Lakeland
Spectrum Health Ludington Hospital
St. Joseph Mercy Ann Arbor*
St. Joseph Mercy Chelsea
St. Joseph Mercy Oakland Hospital
St. Mary Mercy Livonia Hospital
St. Joseph Mercy Livingston Hospital
University of Michigan Health System
UP Health System-Marquette
William Beaumont Hospital
Ascension Genesys Hospital
Ascension Macomb-Oakland Hospital, Madison Heights Campus
Ascension Macomb-Oakland Hospital, Warren Campus
Ascension Providence Hospital, Novi Campus
Memorial Healthcare
Mercy Health Lakeshore
Mercy Health Southwest
Muskegon Surgery Center
OSF St. Francis Hospital & Medical Group
St. Joseph Mercy Brighton Health Center

Minnesota

Abbott Northwestern Hospital*
Alomere Health
Buffalo Hospital
Cambridge Medical Center
CHI St. Gabriel's Health
Crosstown Surgery Center
Cuyuna Regional Medical Center
Douglas County Hospital
Eagan Surgery Center
Essentia Health-St. Joseph's Medical Center (Brainerd)*
Essentia Health-St. Mary's Medical Center
Fairview Northland Medical Center
Fairview Ridges Hospital
Fairview Southdale Hospital
HealthEast Clinic-Woodwinds
HealthEast St. John's Hospital
HealthEast St. Joseph's Hospital
Hennepin County Medical Center
High Pointe Surgery Center
Lakeview Hospital
Mayo Clinic Health System in Austin
Mayo Clinic Health System in Mankato
Mayo Clinic Health System in Red Wing
Mayo Clinic in Rochester
Mercy Hospital
Mercy Hospital-Unity Campus
Minnesota Valley Surgery Center, LLC
New Ulm Medical Center
North Memorial Health Hospital
Orthopaedic & Fracture Clinic
Owatonna Hospital
Park Nicollet Methodist Hospital
Regina Hospital
Regions Hospital
Ridgeview Medical Center
River's Edge Hospital and Clinic
Riverwood Healthcare Center
St. Cloud Hospital
St. Francis Regional Medical Center
St. Gabriel's Hospital
St. Luke's
Two Twelve Surgery Center
United Hospital
University of Minnesota Medical Center
Vadnais Heights Surgery Center*

*

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WestHealth Surgery Center
Abbott Northwestern-WestHealth
St. Cloud Surgical Center
TRIA Orthopaedic Center

Mississippi

Baptist Medical Center
Columbus Orthopaedic Outpatient Center*
Merit Health River Oaks
Mississippi Valley Surgery Center and Endoscopy Center
OrthoSouth Southaven Surgery Center
Singing River Hospital
St. Dominic Hospital
Univeristy of Mississippi Medical Center
North Mississippi Medical Center
Ocean Springs Hospital
Specialty Surgical Center

Missouri

CoxHealth
Mercy Hospital Carthage
Mercy Hospital Jefferson
Mercy Hospital Joplin
Mercy Hospital Lebanon
Mercy Hospital Lincoln
Mercy Hospital South
Mercy Hospital Springfield
Mercy Hospital St. Louis
Mercy Hospital Washington
Mercy Orthopedic Hospital Springfield
Meyer Orthopedic & Rehabilitation Hospital
Mosaic Life Care
North Kansas City Hospital*
Phelps County Regional Medical Center
Saint Luke's East Hospital*
Saint Luke's Surgicenter-Lee's Summit, LLC
Signature Medical Group
St. Joseph Outpatient Surgery Center, LLC
St. Luke's Hospital
St. Luke's Hospital-Chesterfield
The Surgical Center at Columbia Orthopaedic Group
Truman Medical Center-Lakewood*
Orthopedic Associates
Pawsat, M.D. & Maeda, M.D. P.C.
Southeast Hospital

Montana

Benefis Health System
Providence St. Joseph Medical Center
St. Patrick Hospital
Great Falls Clinic Hospital

Nebraska

CHI Health Immanuel
CHI Health Lakeside
CHI Health Midlands
Creighton University Medical Center-Bergan Mercy
Great Plains Health
Lincoln Surgical Hospital
Midwest Surgical Hospital
Nebraska Medicine
Nebraska Orthopaedic Hospital
CHI Health Good Samaritan
CHI Health St. Elizabeth
Columbus Community Hospital
Creighton Univeristy Medical Center
MercyOne Oakland Medical Center

Nevada

MountainView Hospital
Northern Nevada Medical Center*
Renown Regional Medical Center
Renown South Meadows Medical Center
Southern Hills Hospital & Medical Center
Centennial Hills Hospital Medical Center
Desert Springs Hospital
Henderson Hospital
Orthopaedic Institute of Henderson
Orthopedic Specialty Hospital of Nevada
Reno Orthopedic Surgery Center
Spring Valley Hospital Medical Center
Summerlin Hospital Medical Center
Sunrise Hospital & Medical Center
Valley Hospital Medical Center

New Hampshire

Atlantic Coast Surgical Suites*
Concord Hospital
Dartmouth-Hitchcock Medical Center
North Atlantic Surgical Suites
Portsmouth Regional Hospital
Concord Orthopaedics
Elliot Hospital
Lighthouse Surgical Suites, LLC
Southern NH Medical Center

New Jersey

Bayshore Medical Center
Chilton Medical Center
Hackensack University Medical Center*
Jersey City Medical Center
Jersey Shore University Medical Center*
JFK Medical Center
Morristown Medical Center*
Newton Medical Center
Northern Monmouth Regional Surgery Center
Ocean Medical Center
Overlook Medical Center
Palisades Medical Center
Raritan Bay Medical Center
Riverview Medical Center*
Robert Wood Johnson University Hospital New Brunswick
Robert Wood Johnson University Hospital Somerset
Southern Ocean Medical Center
St. Francis Medical Center
St. Peter's University Hospital
The Valley Hospital

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Virtua Marlton Hospital
Virtua Memorial Hospital
Virtua Voorhees Hospital
Clara Maass Medical Center
Community Medical Center
Eastern Orthopedic Associates
Holy Name Medical Center
Hudson Crossing Surgery Center
Lourdes Medical Center of Burlington County
Monmouth Medical Center
Monmouth Medical Center Southern Campus
Newark Beth Israel Medical Center
Princeton Medical Center*
Robert Wood Johnson University Hospital Hamilton
Robert Wood Johnson University Hospital Rahway
Saint Barnabas Medical Center
Surgical Center at Millburn, LLC
The Center for Ambulatory Surgery

New Mexico

Memorial Medical Center-Las Cruces
MountainView Regional Medical Center
Presbyterian Hospital
Presbyterian Rust Medical Center
UNM Sandoval Regional Medical Center

New York

Crouse Hospital
Glen Falls Hospital
Highland Hospital*
Hospital for Special Surgery
Huntington Hospital*
John T. Mather Memorial Hospital
Kenmore Mercy Hospital
Long Island Jewish Forest Hills
Long Island Jewish Medical Center*
Long Island Jewish Valley Stream
Maimonides Medical Center
Mohawk Valley Health System
Montefiore Medical Center*
Mount Sinai Brooklyn
Mount Sinai Queens
Mount Sinai St. Luke's
Mount Sinai West*
Newark-Wayne Community Hospital
NewYork-Presbyterian Brooklyn Methodist Hospital
NewYork-Presbyterian Queens
NewYork-Presbyterian/Columbia University Irving Medical Center
North Shore University Hospital*
Northern Westchester Hospital
NYC Health + Hospitals/Elmhurst*
Phelps Hospital
Plainview Hospital
Rochester General Hospital*
South Shore University Hospital*
St. Charles Hospital*
St. Francis Hospital
St. Joseph's Hospital Health Center
St. Peter's Hospital
Staten Island University Hospital
Syosset Hospital
The Hospital for Joint Diseases
The Mount Sinai Hospital
UHS Binghamton General Hospital
UHS Wilson Medical Center
Unity Hospital*
Upstate University Hospital-Community Campus
Upstate University Hospital-Downtown Campus
Winthrop-University Hospital
Wyoming County Community Health System
Wyoming County Community Hospital*
Albany Memorial Hospital
Excelsior Orthopaedics
Lenox Hill Hospital*
Lourdes Hospital
Mercy Hospital of Buffalo
Mount St. Mary's Hospital and Health Center
NewYork-Presbyterian Lawrence Hospital
NewYork-Presbyterian Lower Manhattan Hospital
NewYork-Presbyterian/Weill Cornell Medical Center
Northern Dutchess Hospital
Oswego Hospital
Peconic Bay Medical Center
Putnam Hospital
Saint Mary's Hospital
Samaritan Hospital
Sisters of Charity Hospital
Sisters of Charity Hospital, St. Joseph Campus
Vassar Brothers Medical Center
White Plains Hospital

North Carolina

Atrium Health Mercy, a facility of Carolinas Medical Center
Blue Ridge Surgery Center
Capital City Surgery Center
Cone Health Annie Penn Hospital
Cone Health Wesley Long Hospital
Davie Medical Center*
EmergeOrtho-Triangle Orthopedic Associates
FirstHealth Moore Regional Hospital
Greensboro Orthopaedics
Hugh Chatham Memorial Hospital*
Lexington Medical Center
Mission Hospital
Moses H. Cone Memorial Hospital
New Hanover Regional Medical Center
North Carolina Specialty Hospital
Northern Hospital of Surry County
Novant Health Brunswick Medical Center
Novant Health Charlotte Orthopaedic Hospital
Novant Health Clemmons Medical Center
Novant Health Forsyth Medical Center
Novant Health Huntersville Medical Center

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Novant Health Kernersville Medical Center
Novant Health Matthews Medical Center
Novant Health Rowan Medical Center
Novant Health Thomasville Medical Center
Novant Health UVA Prince William Medical Center
Sentara Albemarle Medical Center
Surgical Center of Greensboro
The Surgical Center of Morehead City
Wake Forest Baptist Medical Center
WakeMed Cary Hospital
WakeMed North Hospital
WakeMed Raleigh Campus
AdventHealth Hendersonville
Atrium Health Lincoln
Atrium Health's Carolinas Medical Center
Carolina Sports Medicine & Orthopaedic Specialists
Cary Orthopaedics
Viewmont Surgery Center

North Dakota

CHI St. Alexius Health Bismark*
Sanford Medical Center Fargo

Ohio

Adena Regional Medical Center*
Bethesda Butler Hospital
Bethesda North Hospital
Blanchard Valley Health System
Cleveland Clinic Fairview Hospital
Cleveland Clinic Lakewood
Cleveland Clinic Main Campus
Crystal Clinic Orthopaedic Center
Euclid Hospital
Fort Hamilton Hospital
Genesis Healthcare System
Good Samaritan Hospital*
Grandview Medical Center
Grant Medical Center
Greene Memorial Hospital
Hillcrest Hospital
Indu and Raj Soin Medical Center
Kettering Medical Center
Lutheran Hospital
Marymount Hospital
McCullough-Hyde Memorial Hospital
Medina Hospital
Mount Carmel East
Mount Carmel New Albany
Mount Carmel St. Ann's
Mount Carmel West
Ohio Valley Surgical Hospital
OhioHealth Mansfield Hospital
Selby General Hospital
South Pointe Hospital
Southview Medical Center
Southwest General Health Center
St. Vincent Medical Center (Sisters of Charity-OH)
Sycamore Medical Center
The Jewish Hospital-Mercy Health
The Ohio State University Wexner Medical Center
The Surgical Hospital at Southwoods
TriHealth Evendale Hospital
Trumbull Regional Medical Center*
UH Ahuja Medical Center
UH Bedford Medical Center, a campus of Regional Hospitals
UH Cleveland Medical Center*
UH Conneaut Medical Center
UH Elyria Medical Center
UH Geauga Medical Center
UH Geneba Medical Center
UH Parma Medical Center
UH Portage Medical Center
UH Richmond Medical Center, a campus of Regional Hospitals
UH St. John Medical Center
White Fence Surgical Suites*
Amherst Family Health Center
Ashtabula County Medical Center
Cleveland Clinic Children's Hospital for Rehabilitation
First Settlement Orthopaedics
Greater Dayton Surgery Center
King's Daughters Medical Center Ohio
Licking Memorial Hospital
Mercy Health-West Hospital
Mercy Health Anderson Hospital
Mercy Health Clermont Hospital
Mercy Health Fairfield Hospital
MetroHealth System
Northpointe Surgical Suites*
Northside Regional Medical Center
Ohio Specialty Surgical Suites*
Ontario Hospital
Summa Health System-Barberton Campus
Summa Health Wadsworth-Rittman Medical Center

Oklahoma

Community Hospital North Campus
Community Hospital South Campus
Duncan Regional Hospital*
Mercy Hospital Ada
Mercy Hospital Ardmore*
Mercy Hospital Oklahoma City
Northwest Surgical Hospital
Southwestern Medical Center
St. John Broken Arrow
St. Mary's Regional Medical Center*
Stillwater Medical Center

Oregon

Adventist Health Portland
Good Samaritan Regional Medical Center
Hope Orthopedics
Legacy Emanuel Medical Center
Legacy Good Samaritan Medical Center
Legacy Meridian Park Medical Center
Legacy Mount Hood Medical Center
Legacy Silverton Medical Center
Oregon Health & Science University
Providence Hood River Memorial Hospital
Providence Medford Medical Center

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Providence Milwaukie Hospital
Providence Newberg Medical Center
Providence Portland Medical Center
Providence Seaside Hospital
Providence St. Vincent Medical Center
Providence Willamette Falls Medical Center
Salem Health
Samaritan Albany General Hospital
St. Alphonsus Medical Center Baker City
St. Alphonsus Medical Center Ontario
St. Charles Health System
Tillamook Regional Medical Center
Willamette Surgery Center*
Willamette Valley Medical Center*
Oregon Surgical Institute*
Bend Surgery Center
CHI Mercy Health Mercy Medical Center
Oregon Orthopedic & Sports Medicine Clinic
Orthopedic + Fracture Specialists
Portland Knee Clinic
South Portland Surgical Center

Pennsylvania

Abington-Lansdale Hospital, Jefferson Health
Abington Hospital-Jefferson Health
ACMH Hospital
Advanced Surgical Hospital
Barry A. Ruht MD PC
Butler Memorial Hospital
Conemaugh Memorial Medical Center*
Doylestown Hospital
Excela Health Latrobe Hospital
Excela Health Westmoreland Hospital
Heritage Valley Beaver
Indiana Regional Medical Center
Lancaster General Hospital
Monongahela Valley Hospital*
Moses Taylor Hospital
Mount Nittany Medical Center
Nazareth Hospital
Orthopaedic & Spine Specialists
OSS Orthopaedic Hospital
Penn Highlands Healthcare
Penn Presbyterian Medical Center
Penn State Milton S. Hershey Medical Center
Pennsylvania Hospital
Phoenixville Hospital*
Reading Hospital*
Regional Hospital of Scranton*
Rothman Orthopaedic Institute
St. Clair Hospital
St. Mary Medical Center
Thomas Jefferson University Hospital
UPMC Altoona
UPMC Carlisle
UPMC East
UPMC Hamot
UPMC Hanover
UPMC Horizon
UPMC Jameson
UPMC Magee-Womens Hospital
UPMC McKeesport
UPMC Memorial
UPMC Mercy
UPMC Northwest
UPMC Passavant-McCandless
UPMC Pinnacle
UPMC Pinnacle Community Osteopathic
UPMC Pinnacle Harrisburg
UPMC Pinnacle Lititz
UPMC Pinnacle West Shore
UPMC Presbyterian
UPMC Shadyside
UPMC St. Margaret
UPMC Williamsport*
ValueHealth Muve-Warminster*
ValueHealth Muve-West Chester*
WellSpan Gettysburg Hospital
WellSpan Surgery & Rehabilitation Hospital
WellSpan York Hospital
Allegheny General Hospital
Bryn Mawr Hospital
Chan Soon-Shion Medical Center at Windber
Geisinger Community Medical Center
Geisinger Jersey Shore Hospital
Geisinger Lewistown Hospital
Geisinger Medical Center
Geisinger Shamokin Area Community Hospital
Geisinger South Wilkes-Barre
Geisinger Woodbine Lane
Geisinger Wyoming Valley Medical Center
Lankenau Medical Center
Mercy Catholic Medical Center-Mercy Philadelphia Campus
Mercy Fitzgerald Hospital
North Pointe Surgery Center
Paoli Hospital
Richards Orthopaedics Center & Sports Medicine
Riddle Hospital
Rothman Orthopaedic Specialty Hospital
Surgery Center of Allentown
The Hospital of the University of Pennsylvania
UPMC Children's Hospital of Pittsburgh

Rhode Island

South County Hospital
The Miriam Hospital*
Yale New Haven Health Westerly Hospital
Kent Hospital

South Carolina

Beaufort Memorial Hospital*
Bon Secours St. Francis Hospital
Carolina Orthopedics
Carolina Pines Regional Medical Center
East Cooper Medical Center
Grand Strand Medical Center
Medical University of South Carolina*

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Oconee Memorial Hospital
Palmetto Health Baptist
Palmetto Health Richland
Pelham Medical Center
Prisma Health Baptist Hospital
Prisma Health Patewood Hospital*
Providence Orthopedic Hospital
Roper St. Francis Hospital
Roper St. Francis Mount Pleasant Hospital
Self Regional Healthcare
Trident Medical Center
Baptist Easley Hospital
Carolina Coast Surgery Center
Conway Medical Center
Novant Health Gaffney Medical Center
Prisma Health Baptist Parkridge Hospital
St. Francis Downtown

South Dakota

Sanford USD Medical Center
Avera McKennan Hospital & University Health Center
Black Hills Surgical Hospital
Dunes Surgical Hospital

Tennessee

Baptist Memorial Hospital-Collierville
Bristol Regional Medical Center*
CHI Memorial Hospital Chattanooga
Erlanger Baroness Hospital
Erlanger East Hospital
Fort Loudoun Medical Center
Fort Sanders Regional Medical Center
Henry County Medical Center
Huntsville Hospital
Indian Lake Surgery Center
Indian Path Community Hospital
Johnson City Medical Center
LeConte Medical Center
Maury Regional Medical Center
Methodist Medical Center of Oak Ridge
Morristown-Hamblen Healthcare System
OrthoSouth Germantown Surgery Center
OrthoTennessee
Parkridge East Hospital
Parkridge Medical Center
Parkwest Medical Center
Physicians Regional Medical Center
Physicians Surgery Center
Premier Orthopedic Surgery Center
Roane Medical Center
Saint Thomas Midtown Hospital
Saint Thomas West Hospital
St. Francis Hospital
Tennessee Orthopaedic Alliance
TriStar Centennial Medical Center
TriStar Hendersonville Medical Center
TriStar Horizon Medical Center
TriStar Skyline Medical Center
TriStar Southern Hills Medical Center
TriStar StoneCrest Medical Center
TriStar Summit Medical Center
Turkey Creek Medical Center
University of Tennessee Medical Center*
Wolf River Surgery Center
CHI Memorial Hospital Hixson
Claiborne Medical Center
Cookeville Regional Medical Center
Cumberland Medical Center
Mid-Tennessee Bone & Joint Clinic, P.C.
Saint Thomas Rutherford Hospital
Vanderbilt University Medical Center

Texas

AdventHealth Central Texas
Ascension Seton Hays
Ascension Seton Medical Center Austin
Ascension Seton Northwest Hospital
Ascension Seton Southwest
Ascension Seton Williamson
Baptist Beaumont Hospital of Southeast Texas
Baylor Scott & White All Saints Medical Center-Fort Worth
Baylor Scott & White Medical Center-Carrollton
Baylor Scott & White Medical Center-Frisco*
Baylor Scott & White Medical Center-Garland
Baylor Scott & White Medical Center-Grapevine
Baylor Scott & White Medical Center-Irving
Baylor Scott & White Medical Center-McKinney
Baylor Scott & White Medical Center-Plano
Baylor Scott & White Medical Center-Uptown*
Baylor Scott & White Medical Center-Waxahachie
Baylor Surgical Hospital at Las Colinas
Baylor University Medical Center*
CHRISTUS Good Shepherd Medical Center-Longview*
CHRISTUS Good Shepherd Medical Center-Marshall
CHRISTUS Mother Frances Hospital-Tyler*
Christus Southeast Texas Hospital-St. Elizabeth
College Station Medical Center
Collom & Carney Clinic Association
Cornerstone Regional Hospital*
Corpus Christi Medical Center
Covenant Children's Hospital
Covenant Health Plainview
Covenant Medical Center
Covenant Specialty Hospital
Dallas Orthopedic & Shoulder Institute
Dell Seton Medical Center at The University of Texas
Doctors Hospital at Renaissance*
El Paso Specialty Hospital
Harlingen Medical Center
Hill Country Memorial Hospital
Houston Methodist Hospital
JPS Health Network

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Las Palmas Medical Center
Medical City Dallas Hospital
Medical City Denton
Memorial Hermann Memorial City Medical Center*
Memorial Hermann Orthopedic & Spine Hospital
Memorial Hermann Southwest Hospital
Methodist Hospital
Methodist Stone Oak Hospital
Methodist Texsan Hospital
Metropolitan Methodist Hospital
Midland Memorial Hospital
Muve-Lakeway Ambulatory Surgical Center, LLC*
Nix Health
North Central Surgical Center Hospital*
Northeast Baptist Hospital
Northeast Methodist Hosptial
Paris Orthopedics & Sports Medicine
Scott & White Memorial Hospital-Temple
Seton Highland Lakes Hospital
South Texas Spine and Surgical Hospital
South Texas Surgical Hospital
St. David's Georgetown Hospital
St. David's Medical Center
St. David's North Austin Medical Center
St. David's Round Rock Medical Center
St. David's South Austin Medical Center
St. David's Surgical Hospital
St. Joseph Health System
Texas Health Harris Methodist Hospital Southwest Fort Worth
Texas Health Presbyterian Hospital Flower Mound
Texas Health Presbyterian Hospital Plano
Texas Health Presbyterian Hospital Rockwall
Texas Health Surgery Center Addison
Texas Health Surgery Center Cleburne
Texas Institute for Surgery
Texas Orthopaedic Associates
Texas Orthopedic Hospital*
Texas Orthopedics, Sports & Rehabilitation Associates
Texas Spine and Joint Hospital
Texoma Medical Center
The Carrell Clinic
The Physicians Centre Hospital
United Regional HealthCare System*
University Hospital
UT Southwestern Medical Center
W.B. Carrell Clinic
Wise Health Surgical Hospital
Advanced Surgical Care of Boerne
Advent Orthopaedics
CHRISTUS Spohn Hospital Corpus Christi-Memorial
Covenant Hospital Levelland
Cross Timbers Orthopedics
Del Sol Medical Center
Doctors Hospital of Laredo
Edinburg Regional Medical Center
Fort Duncan Regional Medical Center
HCA Houston Healthcare Clear Lake
Houston Methodist Sugar Land Hospital
Inov8 Surgical
Jeff Zhao, D.O.
Lake Granbury Medical Center*
Legent Orthopedic Hospital
McAllen Medical Center
Methodist Hospital for Surgery
Methodist McKinney Hospital, LLC
Northwest Texas Healthcare System
Peterson Health
Seton Medical Center Harker Heights
St. Luke's Health-Lakeside Hospital
Stefan Kreuzer
Texas Health Surgery Center Heritage
Texas Orthopedics
The Medical Center of Southeast Texas

Utah

Altaview Hospital
American Fork Hospital
Bear River Valley Hospital
Cedar City Hospital
Dixie Regional Medical Center
Heber Valley Hospital
Intermountain Medical Center
Lakeview Hospital*
Layton Hospital
LDS Hospital
Logan Regional Hospital
Maple Grove Hospital
McKay-Dee Hospital*
Mountain View Hospital
North Memorial Health at Maple Grove Medical Center
North Memorial Health Hospital
Ogden Regional Medical Center*
Park City Hospital
Primary Children's Hospital
Riverton Hospital
Salt Lake Regional Medical Center
Sevier Valley Hospital
Timpanogos Regional Hospital
TOSH-The Orthopedic Specialty Hospital
Univeristy of Utah Health
Utah Valley Hospital
Cedar Orthopedic Surgery Center
McKay-Dee Surgical Center
Orem Community Hospital
St. Mark's Hospital

Vermont

Central Vermont Medical Center
Copley Hospital
Rutland Regional Medical Center
The University of Vermont Medical Center
Northeastern Vermont Regional Hospital
Northwestern Medical Center, Inc.

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 7/26/21.*

Institutions that joined AJRR by 8/3/21 are included. Those that contributed data for this *Annual Report* by 7/26/21 are highlighted in blue.

Virginia

Carilion New River Valley Medical Center
Carilion Roanoke Memorial Hospital*
CJW Medical Center*
Henrico Doctors' Hospital
Inova Fair Oaks Hospital
Inova Loudoun Hospital
Inova Mount Vernon Hospital
Johnston Memorial Hospital
Mary Washington Hospital
Novant Health Prince William Medical Center
Novant Health UVA Haymarket Medical Center
OrthoVirginia
Reston Hospital Center*
Riverside Doctors' Hospital Williamsburg
Riverside Regional Medical Center
Riverside Tappahannock Hospital
Riverside Walter Reed Hospital
Sentara CarePlex Hospital
Sentara Leigh Hospital
Sentara Martha Jefferson Hospital
Sentara Norfolk General Hospital
Sentara Northern Virginia Medical Center
Sentara Obici Hospital
Sentara Princess Anne Hospital
Sentara RMH Medical Center
Sentara Virginia Beach General Hospital
Sentara Williamsburg Regional Medical Center
University of Virginia Health System University Hospital
VCU Medical Center
Virginia Hospital Center
Inova Fairfax Hospital

Washington

Capital Medical Center
Central Washington Hospital
Everett Bone and Joint
EvergreenHealth Medical Center
Harrison Medical Center
Highline Medical Center
Kadlec Regional Medical Center
Lakewood Surgery Center
Legacy Salmon Creek Medical Center
MultiCare Allenmore Hospital & Medical Center
MultiCare Auburn Medical Center
MultiCare Deaconess Hospital
MultiCare Good Samaritan Hospital
MultiCare Tacoma General Hospital
Multicare Valley Hospital*
Northwest Hospital & Medical Center
Overlake Medical Center
Proliance Center for Outpatient Spine and Joint Surgery of Puget Sound
Proliance Eastside Surgery Center
Proliance Highlands Surgery Center
Providence Centralia Hospital
Providence Holy Family Hospital-Spokane
Providence Mount Carmel Hospital
Providence Regional Medical Center Everett Colby Campus
Providence Sacred Heart Medical Center
Providence St. Joseph's Hospital
Providence St. Mary Medical Center
Providence St. Peter Hospital
Samaritan Healthcare
Seattle Orthopedic Center Surgery
Seattle Surgery Center
Skagit Northwest Orthopedics
St. Anthony Hospital
St. Clare Hospital
St. Elizabeth Hospital
St. Francis Hospital
St. Joseph Medical Center
Swedish Health Ballard Campus
Swedish Health Edmonds Campus
Swedish Health First Hill Campus
Swedish Health Issaquah Campus
The Surgery Center at Rainier
The Surgery Center at TCO Kennewick
Trios Health
Valley Medical Center
Virginia Mason Medical Center
Walla Walla General Hospital
Yakima Valley Memorial Hospital
Dan Downey, MD
Edmonds Center for Outpatient Surgery
MultiCare Covington Medical Center
Olympia Surgery Center
Providence Regional Medical Center Everett Pacific Campus
Southwest Seattle Ambulatory Surgery Center
Wenatchee Valley Hospital & Clinics

West Virginia

Cabell Huntington Hospital*
Ruby Memorial Hospital
West Virginia University Hospital*
Thomas Memorial Hospital

Wisconsin

Amery Hospital & Clinic
Ascension St. Mary's Hospital
Ascension St. Michael's Hospital
Aurora BayCare Medical Center
Aurora Lakeland Medical Center
Aurora Medical Center in Grafton
Aurora Medical Center in Kenosha
Aurora Medical Center in Manitowoc County
Aurora Medical Center in Oshkosh
Aurora Medical Center in Summit
Aurora Medical Center in Washington County
Aurora Memorial Hospital of Burlington
Aurora Sheboygan Memorial Medical Center
Aurora Sinai Medical Center
Aurora St. Luke's Medical Center
Aurora St. Luke's South Shore of Aurora HealthCare Metro, Inc.
Aurora West Allis Medical Center
Beaver Dam Community Hospitals
Beloit Memorial Hospital*

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Berlin Memorial Hospital
Columbus Community Hospital
Community Memorial Hospital
Fort HealthCare
Froedtert Hospital
Froedtert Community Memorial Hospital*
Gundersen Health System
Hayward Area Memorial Hospital
HSHS St. Mary's Hospital Medical Center
HSHS St. Nicholas Hospital
HSHS St. Vincent Hospital
Hudson Hospital & Clinic
Lakeview Hospital
Lakeview Medical Center
Marshfield Medical Center-Eau Claire
Marshfield Medical Center-Marshfield
Marshfield Medical Center-Minocqua
Marshfield Medical Center-Neillsville
Marshfield Medical Center-Rice Lake
Marshfield Medical Center-Weston
Mayo Clinic Health System-Franciscan Healthcare
Mayo Clinic Health System in Eau Claire
Memorial Medical Center
Mercyhealth Hospital & Trauma Center
Mercyhealth Hospital and Medical Center-Walworth
Midwest Orthopedic Specialty Hospital*
Monroe Clinic Hospital
OakLeaf Surgical Hospital
Oconomowoc Memorial Hospital
Orthopedic & Sports Surgery Center
Orthopedic Hospital of Wisconsin
Osceola Medical Center
ProHealth Waukesha Memorial Hospital
Ripon Medical Center
River Falls Area Hospital
Sauk Prairie Hospital
Southwest Health
St. Agnes Hospital
St. Croix Regional Medical Center
St. John's Hospital
St. Joseph's Hospital, West Bend
ThedaCare Medical Center-New London
ThedaCare Medical Center-Shawano
ThedaCare Medical Center-Waupaca
ThedaCare Regional Medical Center-Appleton
ThedaCare Regional Medical Center-Neenah
Tomah Memorial Hospital
UnityPoint Health-Meriter
University of Wisconsin Hospitals and Clinics
Vernon Memorial Healthcare
Watertown Regional Medical Center
Waupun Memorial Hospital
Westfields Hospital & Clinic
Wisconsin Specialty Surgery Center
Ascension All Saints Hospital-Spring Street Campus
Aspirus HealthCare
Aurora Medical Center in Milwaukee
Divine Savior Healthcare
Marshfield Clinic Minocqua Center
Marshfield Clinic Wasau Center
Marshfield Medical Center-Beaver Dam
Orthopedic & Sports Medicine Specialists of Green Bay
SSM Health St. Clare Hospital-Baraboo
SSM Health St. Clare Hospital-Janesville
SSM Health St. Mary's Hospital-Madison

Wyoming

Cheyenne Regional Medical Center
Fairview Lakes Medical Center
Mountain View Regional Hospital
St. John's Medical Center
Summit Medical Center
Wyoming Medical Center

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Appendix G

2021 AJRR Annual Report Cumulative Percent Revision Curve Methodology

Dataset Development

All AJRR patients undergoing a primary total joint replacement or revision surgery were identified using International Classification of Disease (ICD)-9/10 and Current Procedural Terminology (CPT) codes in both the AJRR and the Centers for Medicare & Medicaid Services (CMS) dataset. Revisions were "linked" to primary when known laterality was the same for both a primary and revision, and when revision surgery and the revision procedure postdated the primary procedure. AJRR collects a discrete laterality data element. Since ICD-9 does not identify laterality, but ICD-10 does, when laterality was in question, it was cross-referenced with AJRR data as well as the modifiers LT and RT from CPT codes as provided in AJRR and the CMS data.

For ICD-9 codes, the assumption was made that a revision code postdating a primary procedure was a "linked" revision, which was later validated in the AJRR database. ICD-10 coding allows for (but does not require) both removal and replacement codes but has the advantage of including laterality. The same postdating assumptions were made with either acceptable single codes for revision or with the dual code permutations. In short, appropriate laterality was used to identify revision and primary procedures when ICD-10 coding was used and, when ICD-9 was used, subsequent revisions were linked to previous primary procedures with laterality verified at a later step.

Patients were tracked for the data set of 2012-2020. Their follow-up was from time of procedure until 12/31/2020 and the primary time-scale was "months to revision." Patients were tracked for potential outcomes (e.g., death, dislocation, and instability) from the procedure date until 12/31/2020. Patients were right censored if they did not have the outcome of interest. Death was identified from the National Death Index (2012-2016) or AJRR data (collected as an optional discrete data element, 2012-2020).

Primary procedures were counted as failed and the survivorship recorded if revision was identified or found within either the AJRR or Medicare dataset. Failure of the primary arthroplasty was the outcome, unless specified otherwise.

The CMS Research Data Assistance Center (ResDAC) data team provided AJRR with a unique identifier that matches an AJRR case record to a CMS claim file. Observations from ICD-9 codes were excluded where patients were noted to have mismatched laterality for primary and revision, or revisions without a previous record of a primary in the AJRR database. When laterality remained unknown after these methods, the primary and revision procedures were not "linked" and were subsequently removed from analyses. A merged AJRR and CMS dataset was used for all survivorship analyses unless otherwise specified.

Analysis and Interpretation

Cumulative incidence function (CIF) curves were constructed using the proportional subdistribution hazards model for procedures with the endpoint of all-cause revision rate presented as cumulative percent revision figures. Patients were tracked for the data set of 2012-2020. Their follow-up was from time of procedure until 12/31/2020 and the primary timescale was "months to revision." Patients were considered "not failed" if they did not have the outcome of interest (revision within the study period). Primary procedures were counted as failed and the survivorship recorded if revision was identified or found within either the AJRR or Medicare dataset. If a patient does not appear as a revision or death event in AJRR or CMS databases, they were assumed to have a functioning implant throughout the cutoff date of analysis. Cumulative incidence was applied in the presence of patient death, so these competing risk events did not impact the analyses or event rate calculations.

Direct adjustment methods were used to produce adjusted cumulative percent revision curves based on the empirical age and sex distribution of the full dataset.[19] 95% confidence intervals were computed for the entire adjusted curves and are graphically represented. When comparing groups, the 95% confidence intervals and p-values of the hazard ratios were used to determine statistical significance. When interpreting any cumulative percent revision curve produced, it is important to consider that these analyses represent retrospective observational data from a large registry and administrative database. Therefore, causation cannot be established and only associations are offered. Based off any association likely further analyses are needed to appropriately determine the root cause.

Finally, information collected in the Registry is not on a component specific basis. AJRR does not have insight on component specific failure. For example, if four components were implanted in a patient who had a subsequent revision, it is unknown which of the four components failed. Therefore, AJRR reports on a construct basis and not on component basis.

SAS Version 9.4 was used for all statistical analyses.

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