AAOS
American Academy of Orthopaedic Surgeons

AJRR American Joint Replacement Registry

ANNUAL REPORT 2022

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

Dedication

The *2022 Annual Report* is dedicated to Terence J. Gioe, MD, FAAOS. Dr. Gioe served as Editor of the AJRR Annual Report from 2016 to 2019 after serving on the AJRR Board of Directors from 2010-2014 as The Knee Society Representative. Additionally, he served as Chair of the AJRR Annual Report Subcommittee and was on the Data Management Committee. Dr. Gioe led the development of all Annual Report content and reviewed analyses, yearly areas of interest topics, and innumerable report drafts. He was a source of stability and continuity for the AJRR during his years of service and laid the foundations for the report as we know it today. Dr. Gioe forged connections with experts both in the US and internationally and steadfastly worked to ensure ever-higher data quality and completeness standards for AJRR, on par with other large national registries. He continues to provide review and content expertise on key AJRR analyses.

Bryan Springer, MD, FAAOS
Chair, AJRR Steering Committee

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Foreword

Five years ago, almost to the date of this Report's publication, the American Joint Replacement Registry (AJRR) was reintegrated back into the American Academy of Orthopaedic Surgeons (AAOS) and put us on the road to creating and sustaining a US-based Registry Program for all of orthopaedics.

There is much power in data, and AJRR has been collecting data since 2012 – we now have a decade of clinical hip and knee arthroplasty data that helps us to improve the quality of care we deliver to our patients. With over 3 million (and counting) hip and knee arthroplasty procedures through 2022 from over 2.6 million patients currently captured in the Registry, the AJRR is the largest orthopaedic Registry by annual procedure count.

This year's AJRR Annual Report presents a glimpse into the data over the last decade through 2021 and provides 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. This linkage 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 Annual 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 interesting, useful, and in some cases, actionable. With the rapid growth of AJRR capabilities, we look forward to being able to provide 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; Reagan Bayer, MBA, PMP, CSM, CMP, Director, Registries; Kyle Mullen, MPH, General Manager of Combined Analytics; Mita De, PhD, Director of Research; 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; AAOS Analytics Team, 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 (AANS), and the Fracture & Trauma Registry (FTR).

The past year has been marked by a multitude of successes and growth for AJRR, including capturing data for 10 years. This Annual Report represents over 2.8 million hip and knee procedures from over 1,250 institutions submitting data with an overall cumulative procedural volume growth of 14% 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:

Patient-Reported Outcome Measures (PROMs) are increasingly being utilized to evaluate success of a hip or knee arthroplasty procedure. In fact, the AAOS Board of Directors met in December of 2021 to discuss the inconsistent use of PROMs in orthopaedic practice and the varied perspective in the orthopaedic community regarding the perceived value and impact of consistently utilizing PROMs in clinical practice. A PROMs Project Team (comprised of member volunteers, non-member experts, and staff) was formed and is charged with developing a multifaceted, cross organizational strategy to promote and incentivize the use of PROMs in clinical practice by orthopaedic surgeons and their patients.

AJRR continues to support its 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 the Authorized Vendor Program to include even more PROM technological vendors. These efforts have led to substantial growth in PROMs capture. By the end of 2021, 401 sites out of 1,250 (32%) have submitted PROMs, which is a 38% increase in sites compared to the previous 2021 AJRR Annual Report.

Ambulatory Surgery Centers (ASCs) have been identified as an important part of the healthcare delivery system, and AJRR has made considerable effort to increase ASC participation in the Registry. The past year AJRR continued to provide ASCs and private practices access to data quality, analysis, and benchmarking, in fact, there are now 22,427 procedural cases reported by ASCs, a 57% increase over the previous year.

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® expanded and enhanced its capabilities and utility to our users. 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. AJRR data has been published in several 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 2021 and 2022 Annual Meetings: AAOS, American Association of Hip and Knee Surgeons (AAHKS), International Society of Arthroplasty Registries (ISAR), The Knee Society, The Hip Society, and Western Orthopaedic Association (WOA). Topics have included AJRR data representativeness, revision risk factors, racial disparities, infection, arthroplasty for femoral neck fracture, the use of dual mobility articulations, and more. Please see Appendix A for a full list of recent publications and presentations utilizing the AJRR database.

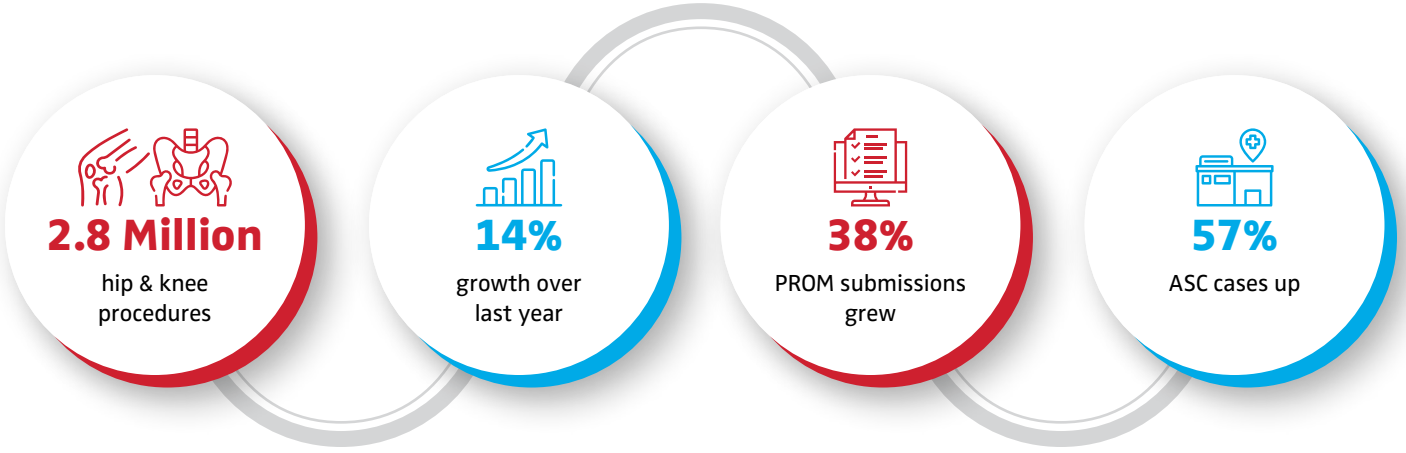
2022 AJRR Annual Report Highlights

The 2022 American Joint Replacement Registry (AJRR) Annual Report represents 2,550,532 primary and revision hip and knee arthroplasty cases after limiting to valid procedures dated 2012-2021. Primary knee (53.8%) and primary hip (37.3%) procedures constituted 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 65.7 years and 67.2 years for total knee arthroplasty cases. While race was unreported in almost 15% of AJRR cases, when reported, non-Hispanic White was the predominant race (75.6%). Among AJRR surgeons performing exclusively either elective primary total hip arthroplasties or total knee arthroplasties, the mean 2021 procedure count was 27.4 and 35.5, respectively.

Many trends identified in previous AJRR Annual Reports were also applicable this past year. For hip arthroplasty procedures, there is still a trend towards increased use of ceramic heads. The use of antioxidant polyethylene liners has slightly declined in recent years. Usage of dual mobility constructs has been increasing in both the primary and revision setting although appears to have leveled off. While hemiarthroplasties still predominate for the treatment of femoral neck fractures, total hip arthroplasty usage has increased substantially over the last ten years. 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. Similar to prior reports, postoperative length of stay continues to decrease, and use of general anesthesia appears to be slowly decreasing.

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. Postoperative length of stay continues to decrease, and use of general anesthesia appears to be decreasing with a slight increase in spinal anesthesia.

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, age-stratified patient reported outcome scores were evaluated. Patients older than 75 years of age were found to have poorer scores compared to younger groups, most notably on the PROMIS-10 quality of life assessment tool. Additionally, trends in utilization of technology in THA and TKA procedures were new to this report. Utilization of robotics in TKA has increased has increased over six-fold and nearly doubled in THA since 2017; computer navigation has remained relatively stable but has increased particularly for THA. 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.

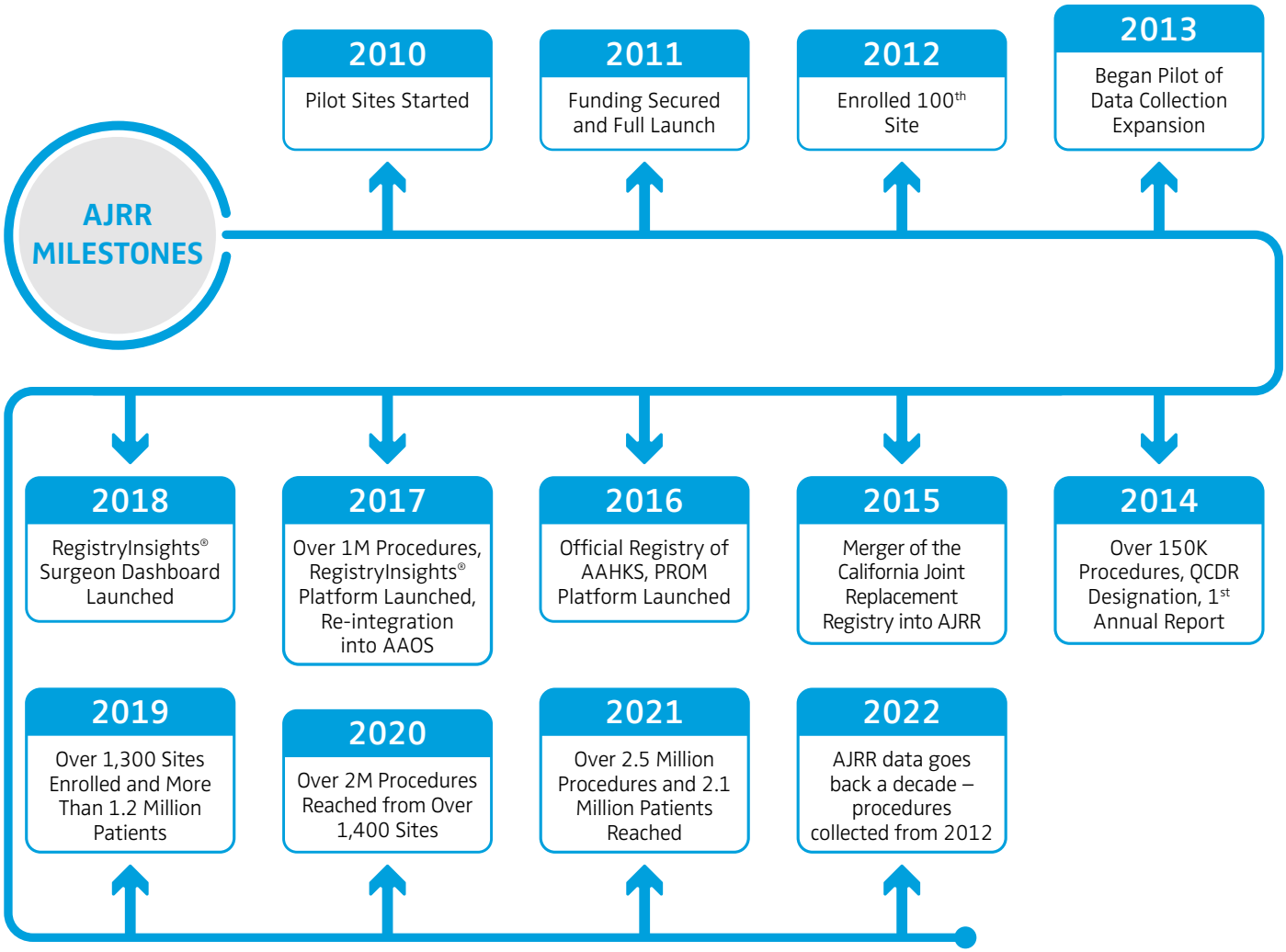


Our Vision

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 2021, there were over 2.8 million procedures from 1,251 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 14% increase in procedures and 9% increase in submitting institutions from the previous report.



The Power of Data

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 when appropriate. These updates are handled through our Data Specification Sunset Cycle and include significant improvements in collection of procedural, post-discharge, and PROMs data. Moving forward, to transition and ensure routine enhancements, data specifications will be released and sunset on an as-needed basis. Specifically, the Data Specification Sunset Cycle simplifies the transition of data specifications by informing users of when new ones will be released, and older versions will be retired out. On years when updated data specifications are prepared, AAOS will release an updated data specification and data dictionary as needed. Upon update of data specifications, 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, AAOS will transition over the update year to retire the oldest of the three versions and support 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 and thoughtful, ensuring perspectives from all involved parties are included.

CMS Data

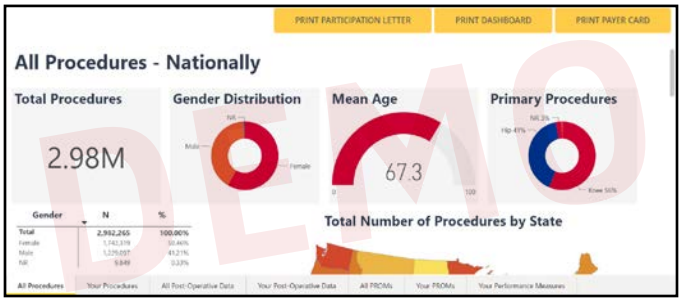
A long-term priority for AJRR has been to obtain claims data from the CMS to facilitate linkages between AJRR and Medicare to support AJRR's quality improvement and patient safety efforts. These linkages allow AJRR to obtain data including more complete comorbidity information, knowledge of revisions 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.

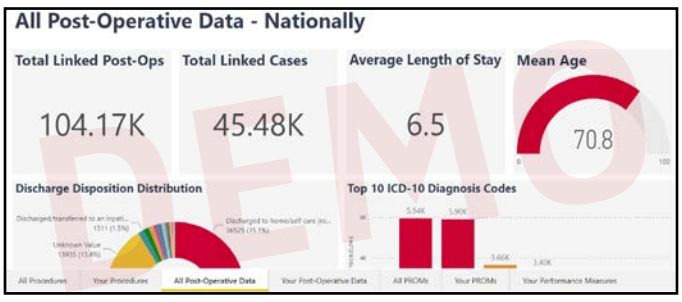
Three Ways to Access Data

There are three main channels available to access data.

Custom Reports are created by the AJRR analytics team upon participant request to help understand and package site data in an actionable format. Custom reports can include site specific metrics and shape continuous improvements to the standard dashboards provided. In addition, aggregated reports across all data submitted including procedural, post-operative, and PROMs data can be provided at each site level.

***RegistryInsights*® Dashboards** have on-demand clinical-specific visualizations. They compare institution data to national data and provide insights on performance benchmarks. Unlimited surgeon accounts with access to the entire hospital system, institution, and surgeon level dashboards are available. Surgeons can view their procedural, post-operative, and PROMs data in a meaningful





manner. In addition to standard reports, requests for custom reports can also be submitted for the following: National benchmarks for comparison measures or data quality initiatives (ie: TJC, Aetna IOQ, etc)

AAOS Registry Analytics Institute® provides a resource to the scientific community to further understand and improve orthopaedic and musculoskeletal care by making data analyses available. Investigators can submit hypotheses about information available in AAOS Registries through the RAI page of the AAOS website. The RAI supports the AAOS mission while also providing clinicians and scientist-clinicians access to information beyond what is already published. Appropriate AAOS committees provide appropriate peer review and oversight before proposals are approved. Data analysis will be completed by AAOS Registry Analytics team members for all approved proposals. Selected awardees receive statistical support, data analyses, and potential monetary support.

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 2022, AAOS is currently engaged with dozens of vendors. For a complete list of authorized vendors please see Appendix C.

AJRR Ankle Arthroplasty Module

Osteoarthritis (OA) is a global health concern and is a leading cause of pain, loss of function, and even disability. Arthritis can affect the ankle joint as well as other joints in the foot. Ankle OA often develops following ankle trauma and can be attributed to a majority of foot injuries. Over time, the smooth cartilage on the surface of the bones wears away, resulting in pain, inflammation, and swelling of the joint. One popular remedy is ankle replacement surgery, which replaces the damaged ankle joint with an artificial implant. The AJRR will be launching a new module to capture ankle arthroplasty procedures, Ankle Arthroplasty, in the coming months. Stay tuned for the expansion of the capture of joint arthroplasty procedures for further information.

"The AJRR Annual Report provides orthopedic surgeons with important information regarding clinical issues that directly impact patient care. It also summarizes significant independent investigator initiated registry based research using AJRR data that have been published in peer review journals and presented at national and international orthopedic meetings."

Richard Illgen II, MD, FAAOS

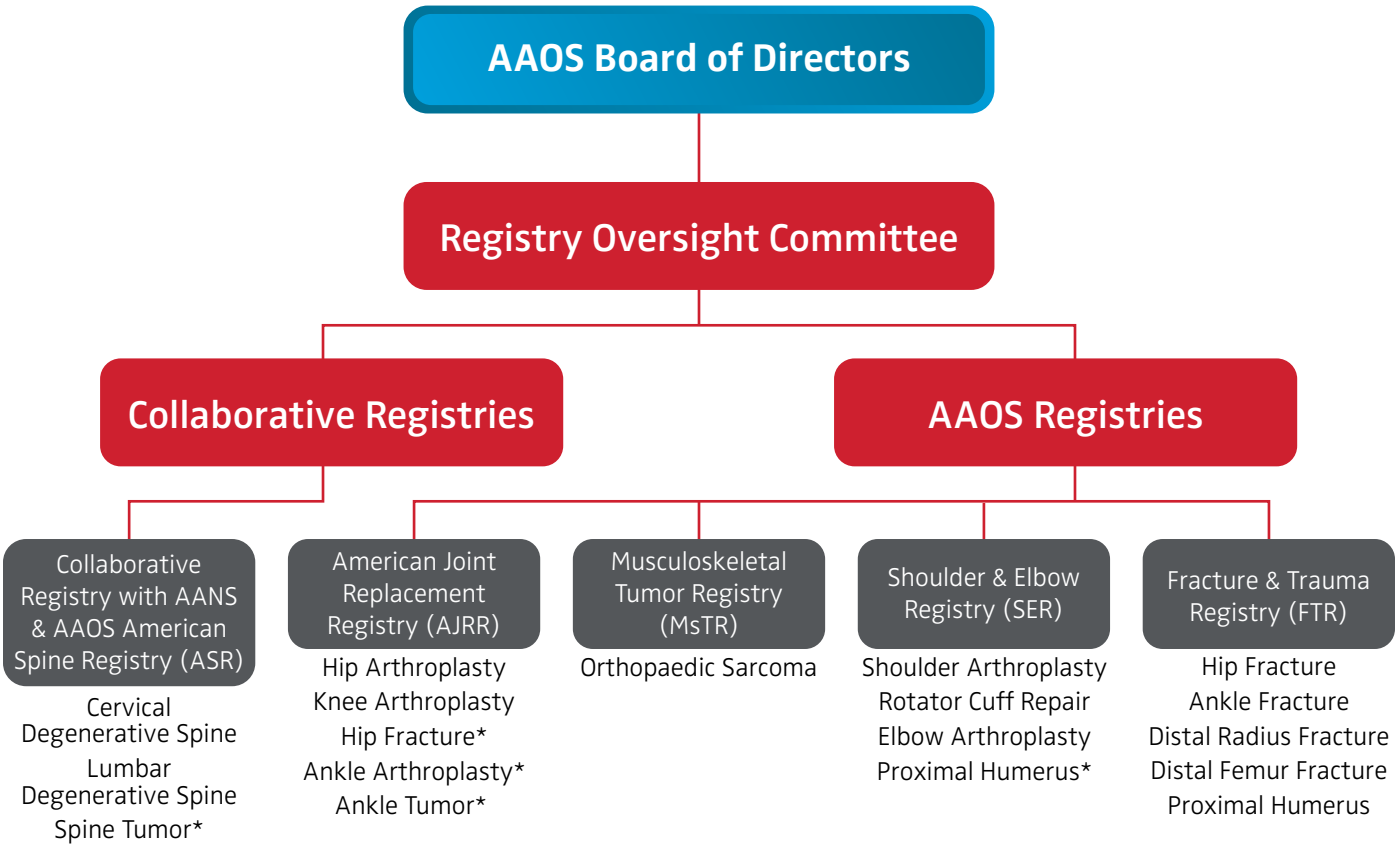
Chair, AJRR Research Projects Sub-committee

Member, AJRR Steering 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, the addition of more registries including both procedural (Shoulder & Elbow Registry) and diagnosis-based (Musculoskeletal Tumor 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 beginning in 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 to the AAOS Board of Directors.



**Modules in development*

Strength Through Collaboration

AJRR was built on the concept of a multi-stakeholder model and the belief of smarter data collection and reuse. If a site or surgeon is using data for one quality use, it's important to reduce the data burden and use it for another purpose. With these goals in mind, AJRR continues to build and enhance its collaborative relationships through strategic alliances and affiliations with other organizations, including:

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.

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.

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.

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.

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 were able to opt-in to utilize AAOS Registries as an alternative reporting pathway starting in 2021.

International Society of Arthroplasty Registries (ISAR)

ISAR is a global consortium of joint replacement registries established by several 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).

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 US. 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.

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 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 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.

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.

Dedicated to Quality Improvement Initiatives

Advocacy and Quality of Care Improvement

AAOS continues to advocate for policies that will incentivize clinician participation in the AAOS Registry Program. The key advocacy issues for 2022 were ease of access to Medicare claims data for Qualified Clinical Data Registries (QCDR), cost of acquiring the claims data, quality reporting requirements in the Quality Payment Program (QPP), and patient-reported outcome measures.

Medicare Claims Data

Background: The Centers for Medicare & Medicaid Services' (CMS) implementation of the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) as it relates to QCDRs and clinician-led clinical data registries has been far from satisfactory and has not been per statutory intent. Contrary to Section 105(b) of MACRA, CMS has not provided QCDRs with a meaningful way of accessing Medicare claims data to link to their own data. As an alternative, the AAOS Registry Program has been using the Research Data Assistance Center (ResDAC) process to access Medicare claims data for the last several years. The formal process to request ResDAC is very resource intensive and regular data upgrades come at a prohibitive cost. Other alternatives provided by CMS include the CMS Qualified Entity Certification Program wherein QCDRs can apply to be certified as quasi qualified entities (quasi QEs) if they wish to use their own data (combined with the CMS Medicare data) to publicly report. However, this program is limited to data on clinicians that specifically report to the particular QCDR.

Advocacy efforts: AAOS staff has been meeting regularly with the CMS leadership team to ease access to Medicare claims data and find more cost-effective alternative pathways. AAOS is also advocating on changing data sharing requirements so that Medicare data linked to our own registry data can be used for surgeon-level metric reporting. Such expanded data usage is helpful to track outcomes.

The Ability to Reuse Registry Data to enable performance measurement as well as facilitate national registry-driven quality improvement programs has been a focus 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 2022 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.

Quality Measurement and Reporting

Background: CMS recently finalized a policy that a QCDR measure must be face valid and fully tested for all subsequent MIPS payment years for which it is approved. Measure testing requirements are onerous for medical specialty societies and are contrary to the policymakers' intent of incentivizing quality reporting through QCDRs. CMS has also begun to remove topped-out measures from the QPP which might be an issue for specialties an insufficient number of approved measures. At the time of publication, CMS proposed to remove four quality measures (numbers 375 (Functional Status Assessment for Total Knee Replacement), 460 (Back Pain After Lumbar Fusion), 469 (Functional Status After Lumbar Fusion), and 473 (Leg Pain After Lumbar Fusion)) which are reported through our QCDR from the MIPS program in order to decrease the number of duplicative measures.

In addition, CMS recently finalized adoption of the (1) Hospital-Level Total Hip Arthroplasty (THA) and/or Total Knee Arthroplasty (TKA) Patient-Reported Outcome performance measure beginning with two voluntary reporting periods (July 1, 2023 through June 30, 2024 and July 1, 2024 through June 30, 2025), followed by mandatory reporting for the reporting period which runs from July 1, 2025 through June 30, 2026, impacting the FY 2028 payment determination. And (2) Hospital-Level Risk-Standardized Complication Rate Following Elective Primary THA/TKA measure beginning with the FY 2024 payment determination.

Advocacy efforts: AAOS provides regular comments on Medicare payment rules and has been successful in delaying the testing requirements at least until the end of the public health emergency. AAOS has raised concern with CMS that when abrupt changes are made, it has a ripple effect which negatively impacts the ability to robustly participate in quality reporting. In this regard, AAOS requested that CMS consider longer intervals between the proposed removal of measures and the finalization of such changes. AAOS continues to work with lawmakers and regulators to urge collaboration with specialty societies like us in measure development and harmonization to utilize our clinical expertise and existing infrastructure.

"The 9th Annual Report of the AJRR provides a valuable snapshot into the current state of hip and knee arthroplasty practice in the United States for Medicare patients. It contains a wealth of information that tells many stories. The actionable data should enable our stakeholders to make informed decisions that will improve the value of care we deliver to our patients."

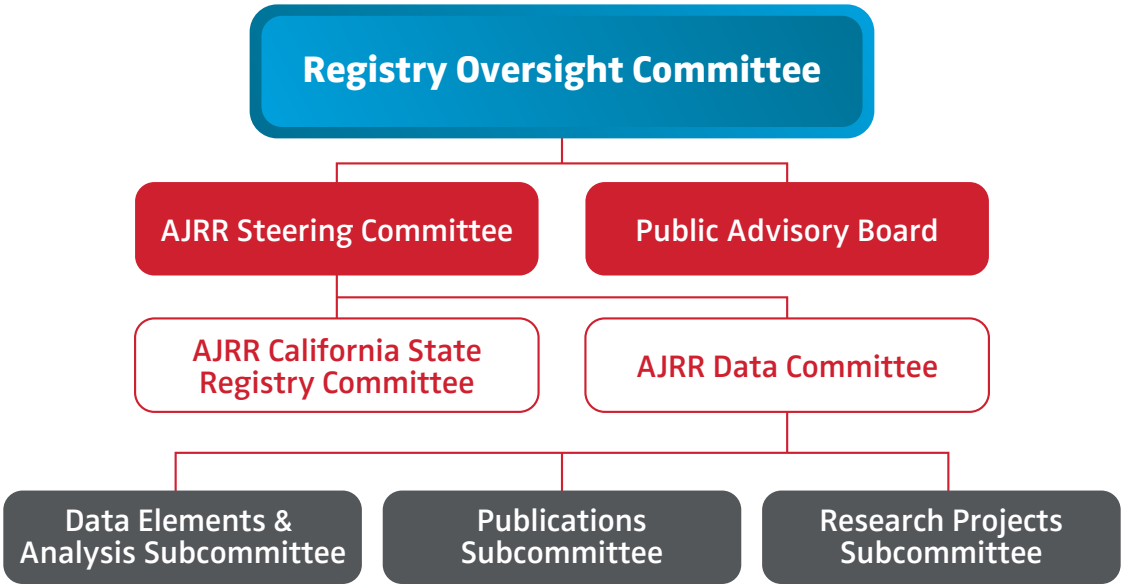
James I. Huddleston, III, MD, FAAOS

Vice Chair, AJRR Steering Committee

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.



2022 AAOS Registry Oversight Committee

Overseeing the AJRR 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)

Daniel K. Guy, MD, FAAOS, Immediate Past President
Emory Southern Orthopedics (LaGrange, GA)

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

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

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

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

Kurt P. Spindler, MD
Cleveland Clinic Foundation (Weston, FL)

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

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

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AJRR Representative
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James D. Slover, MD, FAAOS
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 D.

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 integral role in reviewing and authoring AJRR data driven publications and serving as champions for participating institutions and specialties. 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

Our Mission

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

Publications Subcommittee

The Publications Subcommittee representatives review and ensure the integrity of all publications based on Registry data. Publications for review include potential abstracts, manuscripts, custom 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®. 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 2021 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 2021.

Data Elements and Analysis Subcommittee (DEAS)

John W. Barrington, MD, FAAOS

Research Projects Subcommittee

Adam J. Schwartz, MD, FAAOS

"As Chair of the Public Advisory Board of AJRR, I commend the Registry for collecting critical data on knee and hip replacements. This data is invaluable to the orthopedic community, but also provides key information for patients who are candidates for such surgery. It is critical to patient management of expectations regarding protocols and outcomes."

Richard Seiden
Public Advisory Board Chair

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 the performance of implants based on national trends of longitudinal patient data.

Thank You to AJRR Supporters and Partners

2022 Supporters

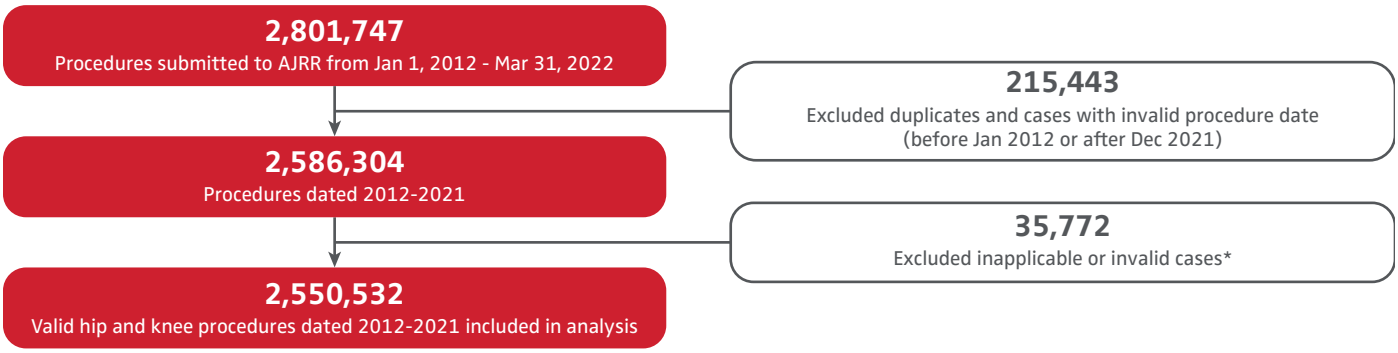
Registry Partners

"The progress the registry is making is very exciting to see because it directly impacts my practice of delivering better patient care. We've been using registry data to help with the Advanced Total Hip and Total Knee Replacement Certification program from The Joint Commission. Whenever we can repurpose our data for quality purposes, is a win in our book!"

Jeffrey B. Stambough, MD

Member, AJRR Steering Committee

Overall Results



**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.*

Analyses are completed using a core dataset of hip and knee procedures submitted to the AJRR from January 1, 2012 through Mar 31, 2022. Cases with invalid data or procedures dated before January 1, 2012 or after December 31, 2021 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 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

Orthopaedic surgeons continue to navigate the challenges associated with the lingering COVID-19 pandemic. This year's AJRR Annual Report presents Figures 1.1 and 1.2 further monitoring the procedural case volume over the course of the pandemic. From January 2020 to April 2020, arthroplasty cases submitted to AJRR decreased from hospitals and ASCs by 90% and 95% respectively. 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 highlights the continued challenges through 2021 as procedural volume slowed particularly in quarter four of 2021 where COVID-19 case incidence peaked drastically. Interestingly, ASC procedure volume did not appear to be substantially impacted by this increase in COVID-19 incidence, as they saw a slow increase in procedure volume through the end of 2021.

Figure 1.1 Hospital Case Volume by Month, Jul 2019 - Dec 2021

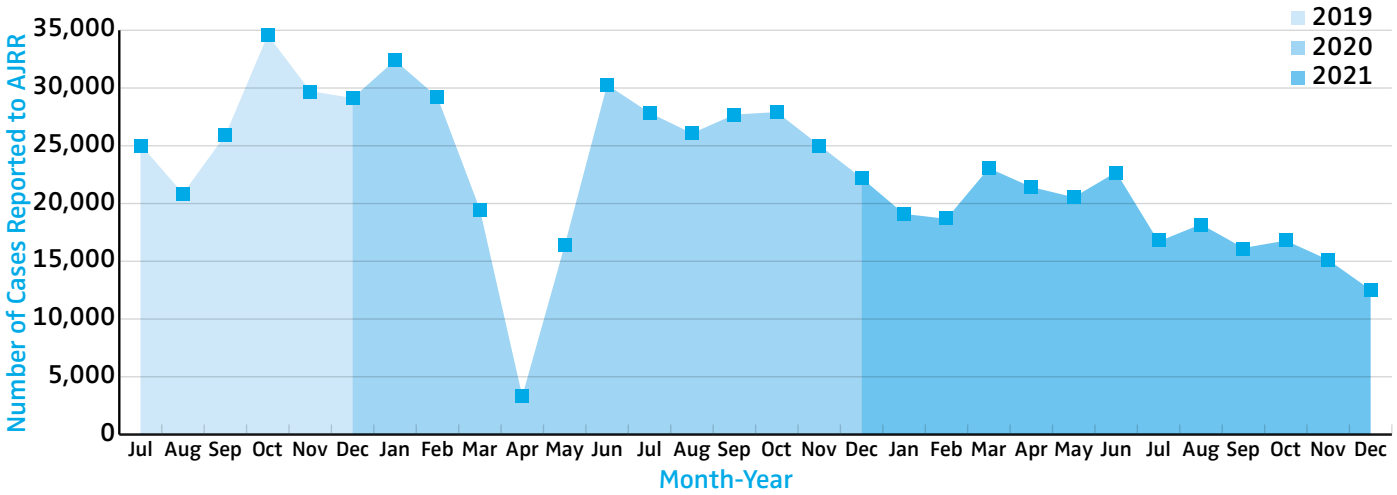
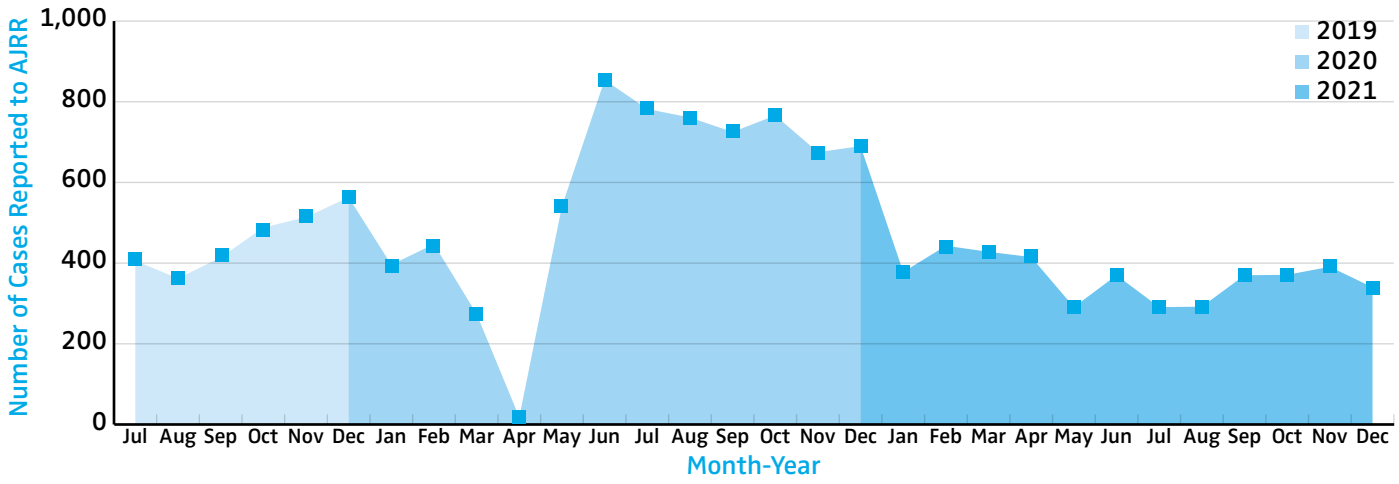


Figure 1.2 Ambulatory Surgical Center Case Volume by Month, Jul 2019 - Dec 2021



Procedural Data Metrics

Despite the lasting impact of the COVID-19 pandemic, the 2022 Annual Report had an overall cumulative procedural volume growth of 14% compared to the 2021 report.

The 2022 American Joint Replacement Registry Annual Report represents 2,550,232 primary and revision hip and knee arthroplasty procedures performed between 2012 and 2021 (Figure 1.3). Primary knee (53.8%) and primary hip (37.3%) procedures comprised 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 14.6% of cases (Figure 1.6). The patient's identified race category is based on the Department of Health and Human Services (HHS) Implementation Guidance, which is in accordance with the Office of Management and Budget Directive on Race and Ethnicity.

AJRR accepts historical data back to 2012. Therefore, annual volumes from prior years are continually being updated. The cumulative procedural volume grew by 14% in 2021 when comparing to the previous Annual Report (305,645 additional cases). This dataset utilized in this Annual Report represents a snapshot of AJRR data taken on Apr 1, 2022.

Figure 1.3 Cumulative Procedure Volume, 2012-2021 (N=2,550,232)

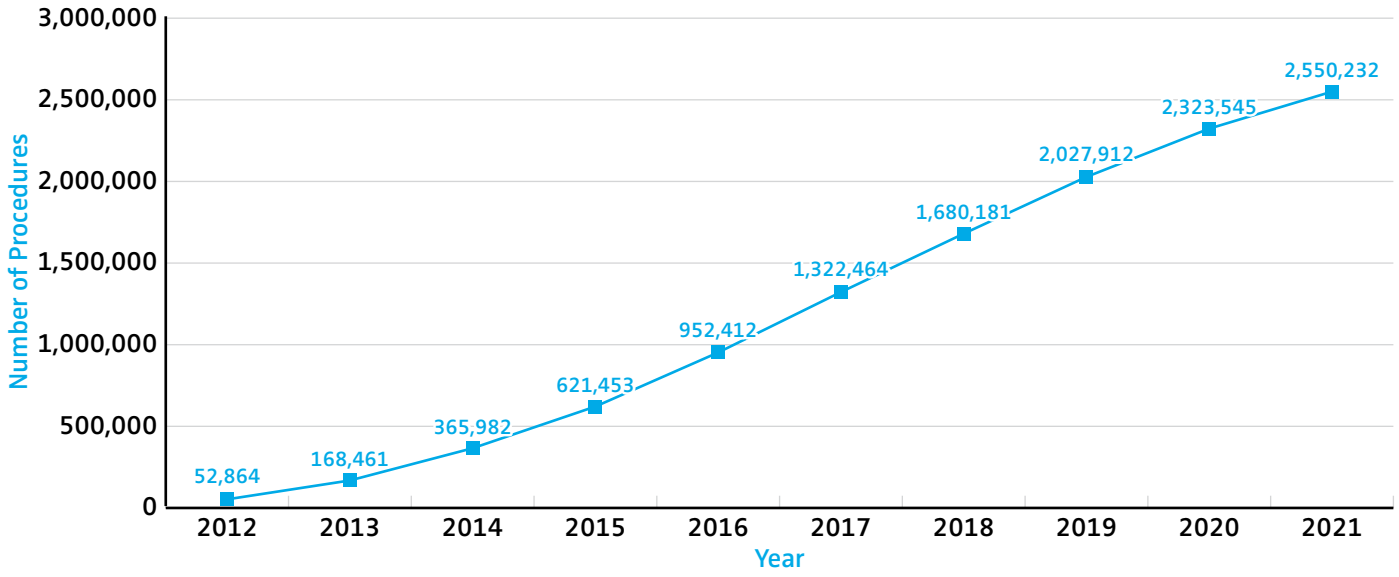


Figure 1.4 Distribution of Arthroplasty Procedures, 2012-2021 (N=2,550,232)

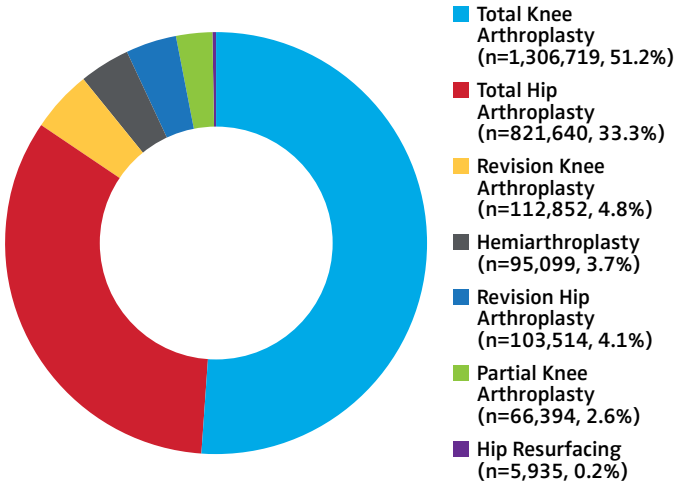
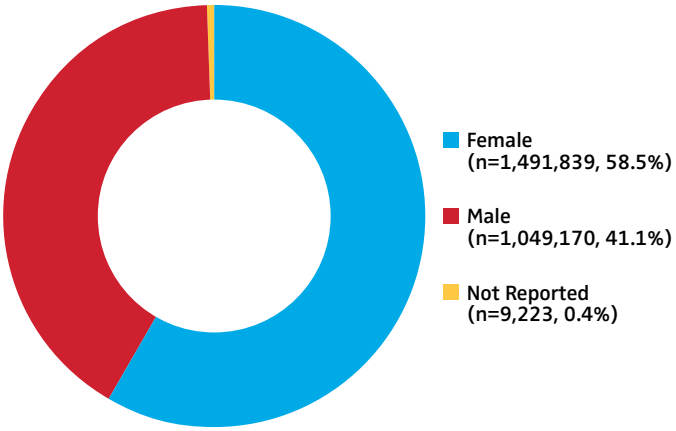


Figure 1.5 Sex of Patients Undergoing Procedures, 2012-2021 (N=2,550,232)

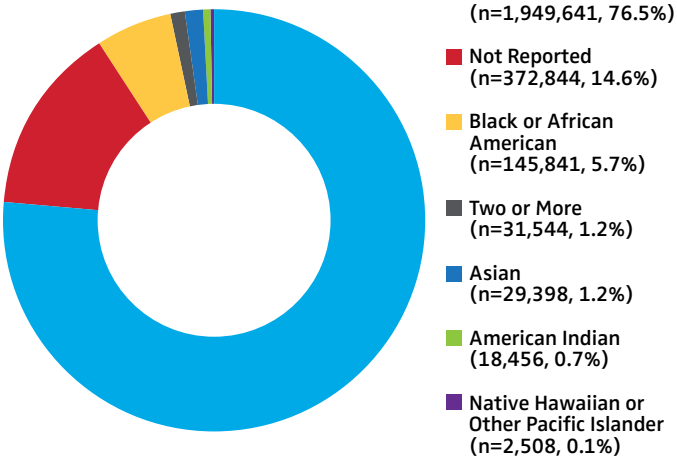


Submitting Facilities

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 2021, there were 1,251 institutions submitting data to the AJRR from across all 50 states and the District of Columbia; this represents a 9% increase from the previous report. A list of all enrolled facilities and those that submitted data used in the 2022 Annual Report can be found in Appendix E.

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.

Figure 1.6 Race of Patients Undergoing Procedures, 2012-2021 (N=2,550,232)



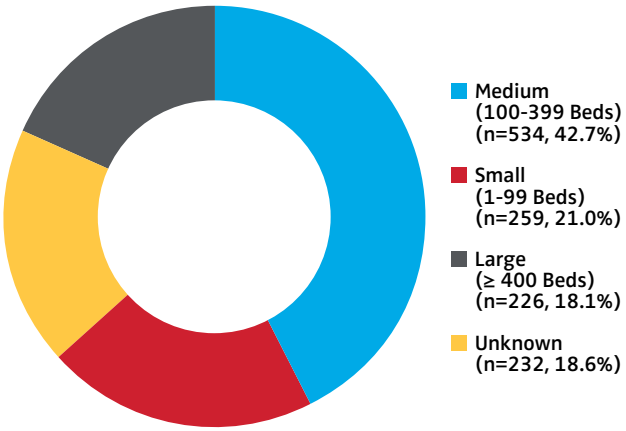
Similar to past years, the majority of arthroplasty procedures submitted to the Registry were performed in medium-sized hospitals (42.7%, 100-399 beds) and minor teaching institutions (39.1%, reported medical school affiliation or approved residency/internship program) (Figures 1.7 and 1.8). Non-teaching institutions performed slightly fewer than minor teaching institutions at 32.5%. Major (Hospitals with COTH designation) and minor teaching hospitals accounted for 60% of all AJRR submitting hospitals with institutional data available in the American Hospital Association (AHA) survey.

INSIGHTS

A recent analysis published in the *Journal of the American Academy of Orthopaedic Surgeons* suggests that AJRR data is generalizable to the larger U.S. cohort.

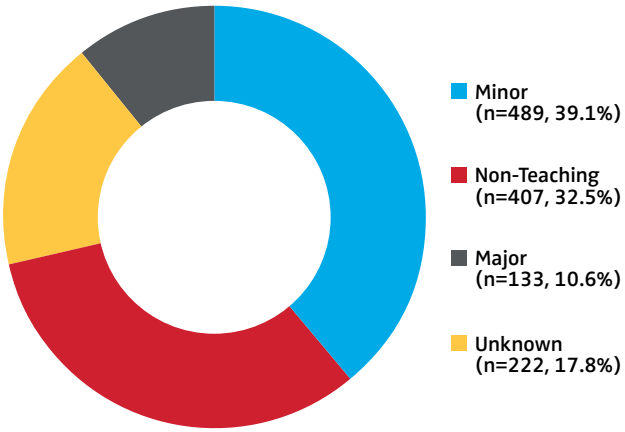
A recent study published in the Journal of the American Academy of Orthopaedic Surgeons found that the distribution of data across patient age, hospital volume, and geography were proportionally similar to the national experience with hip and knee arthroplasty in the United States.[1]

Figure 1.7 Hospital Bed Count of Submitting Facilities, 2012-2021 (N=1,251)



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

Figure 1.8 Distribution of Submitting Institution Teaching Affiliation, 2012-2021 (N=1,251)



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

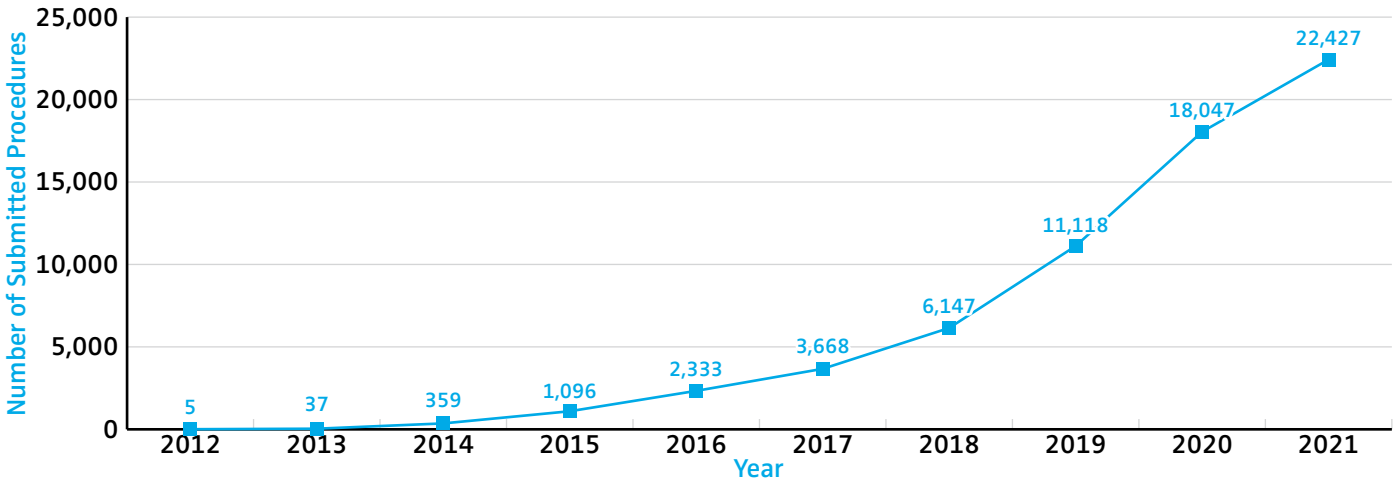
Ambulatory Surgery Centers

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.[2] 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 2021 (n=22,427) and has increased by 57% since the 2021 AJRR Annual Report (Figure 1.9).

The number of procedures submitted by ASCs has grown exponentially between 2012 (n=5) and 2021 (n=22,427) and has increased by 57% since the 2021 AJRR Annual Report.

Figure 1.9 Cumulative Procedure Volume from Ambulatory Surgery Centers by Year, 2012-2021 (N=22,427)



Submitting Surgeons

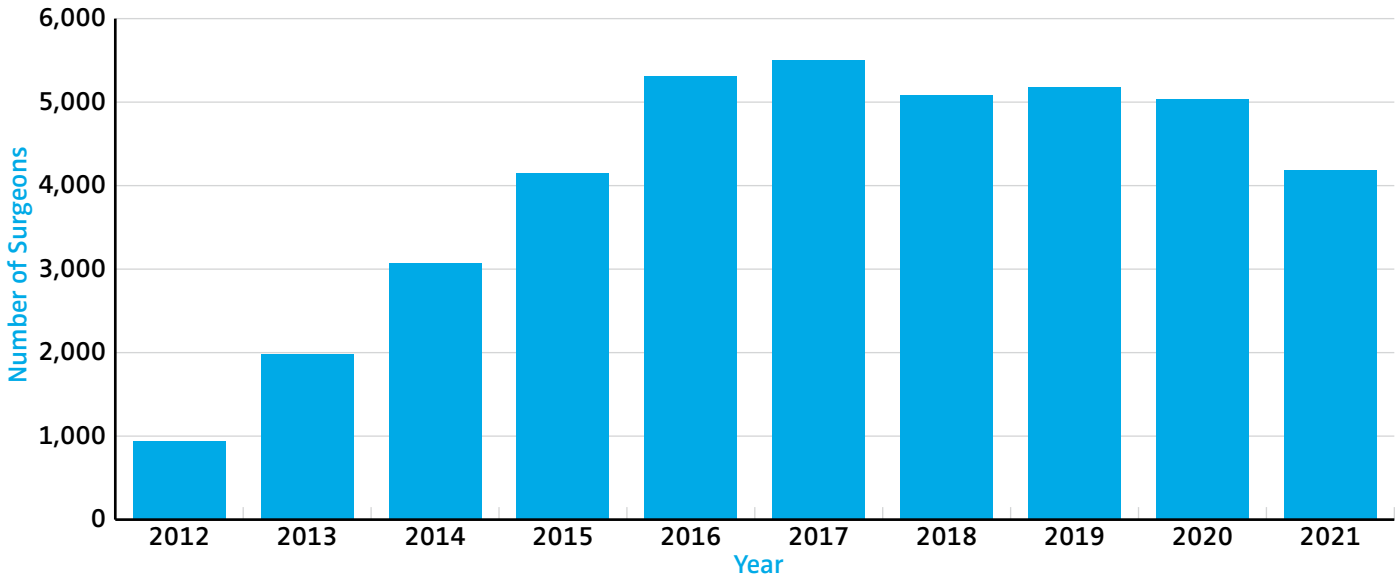
AJRR submitting institutions report data for an average of 13 surgeons (range 1-319). These numbers include surgeons that have done at least one arthroplasty procedure. As part of the contract, AJRR participating institutions are required to submit data from all surgeons conducting hip or knee joint arthroplasty procedures at their facility. This is validated by annual audits (See Appendix F).

INSIGHTS

4,190 surgeons have submitted at least one procedure in 2021 to AJRR, a number which is expected to grow as sites continue to submit data.

As of now, 10,595 surgeons have submitted at least one procedure to the AJRR (Figure 1.10). As AJRR accepts historical data and many institutions submit towards the end of the following year, it is anticipated that the number of surgeons with cases submitted to the AJRR in recent years (2018-2021) will increase in future Annual Reports.

Figure 1.10 Number of Surgeons Represented in Annual Procedure Submissions, 2012-2021



Data Completeness

In February 2017, AJRR significantly expanded data collection on elements in the following areas: 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.

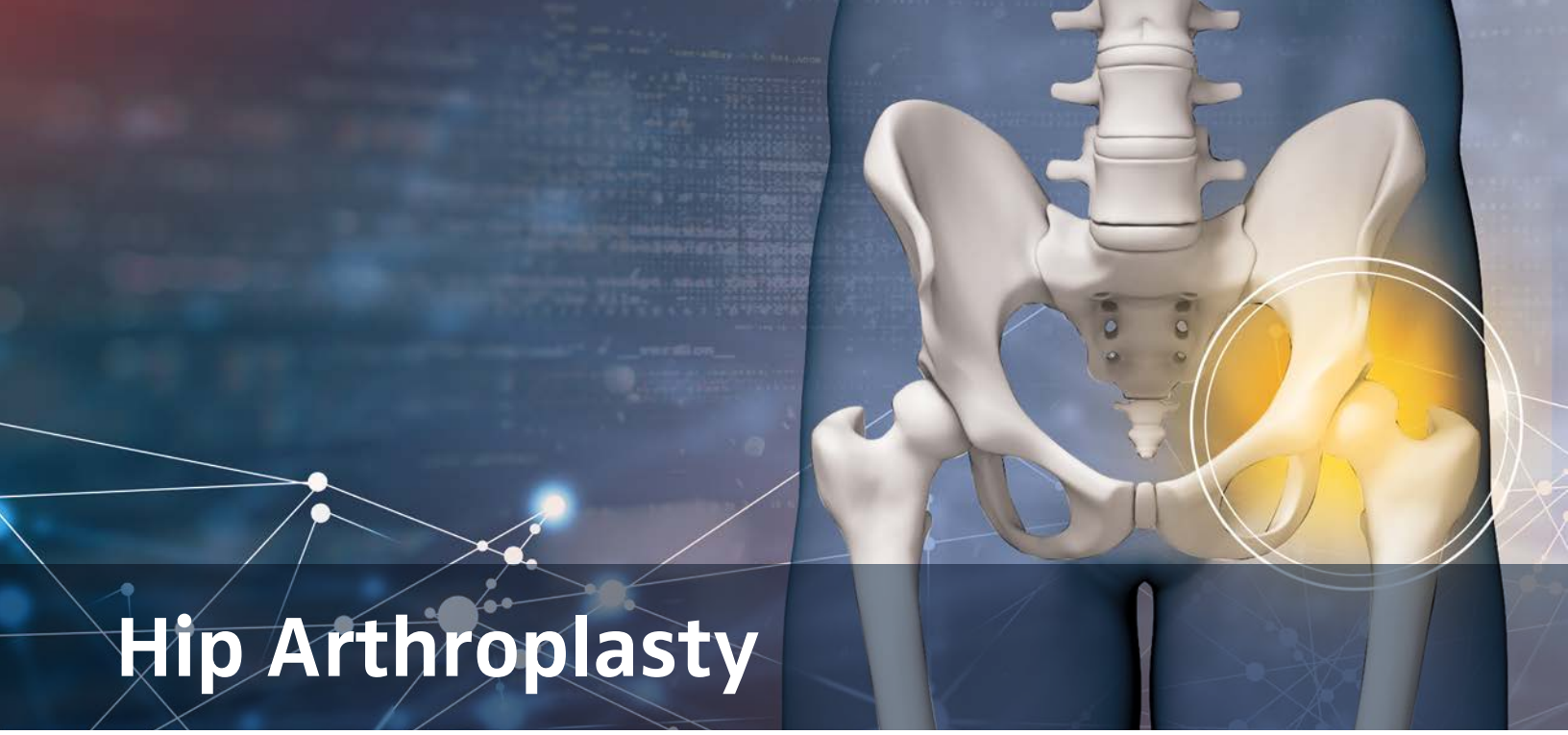
In the last year, a range of increases and decreases in data completeness were observed. Most notably, key demographic and procedural information such as age, sex, length of stay, procedure, and implant information all exceed 95% completeness. Most of the elements described have remained stable compared to the previous Annual Report. Elements of interest such as BMI and comorbidities have seen a slight increase in completeness. For many elements, ''not reported'' or ''NR'' is an accepted value, so this should be considered when assessing valid entries and utilization of available data.

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.

Table 1.1 Completeness of AJRR Data Elements, 2012-2021

Specifications Version	Element	% Reported	% NR	% Invalid
AJRR Data 2012 - 2022Q1 (N=2,637,325)				
All Versions	Surgeon Information	99.7	0.0	0.3
	Principal Procedure Code	99.9	0.0	0.1
	Principal Diagnosis Code	94.2	0.0	5.9
	First Implant Catalog # Listed	93.9	0.0	6.1
	First Implant Lot # Listed	91.7	0.0	8.3
	Incision Start Time (Procedure Start Time)	70.3	28.5	1.3
	Skin Closure Time (Procedure End Time)	70.4	28.4	1.2
	Ethnicity	83.4	16.2	0.3
	Race	85.4	14.2	0.4
	Date of Birth	100.0	0.0	0.0
	Sex	99.7	0.4	0.0
	City	93.5	6.5	0.0
	State	94.5	5.5	0.0
	Zip Code	95.0	0.0	5.0
AJRR Data 2012 - 2022Q1 Using 2017 or Newer Specifications (N=1,405,742)				
2017-2021 Versions	Comorbidity - at least one code reported	74.0	24.9	1.1
	Body Mass Index (BMI)	89.6	0.0	10.4
	Discharge Disposition Code	92.7	6.2	1.1
	Admission Date	97.8	2.2	0.0
	Discharge Date	97.8	2.2	0.0
	Length Of Stay	97.8	0.0	2.2
	Surgical Approach (Hip/Knee)	14.0	80.8	5.2
	Computer Navigation	32.9	66.4	0.8
	Robotic Assisted	39.1	60.8	0.1
	Anesthesia Type	65.5	28.1	6.4
	Periarticular Injection	19.6	80.1	0.3
	ASA Classification	26.7	72.9	0.4
AJRR Data 2012 - 2022Q1 Using 2020 or Newer Specifications (N=288,126)				
2020 or Newer Versions	Tourniquet Use (N=157,768*)	39.7	60.3	0.0
	Trainee	7.1	91.9	1.0
	Payer Status	39.0	60.7	0.3

**Knee procedures only*



Hip Arthroplasty

Hip Overview

Between 2012 and 2021, AJRR has collected data on 1,064,750 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 in 2021, the mean procedure count was 27.[4] with an interquartile range (25th-75th percentile) of 4-34 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.[3] 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 2021 (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 65.7 years. While hip resurfacing is reported infrequently in the AJRR, this patient population is younger with an average age of 53.7 years (Table 2.2, Figure 2.2).

Table 2.1 Average Procedural Volume for Participating Surgeons, 2021

Procedure	Surgeons	Procedures	Mean	Median	25th Percentile	75th Percentile
Elective Primary THA	2,592	71,079	27.4	12	4	34
Hemiarthroplasty	1,889	7,283	3.9	2	1	5
Revision Hip Arthroplasty	1,444	6,806	4.7	2	1	6
THA for Fracture	1,147	3,002	2.6	2	1	3
Hip Resurfacing	21	79	3.8	1	1	2
Other Procedures	593	1,423	2.4	1	1	2

Figure 2.1 Distribution of Procedure Codes for All Hip Arthroplasty Procedures, 2012-2021 (N=1,064,750)

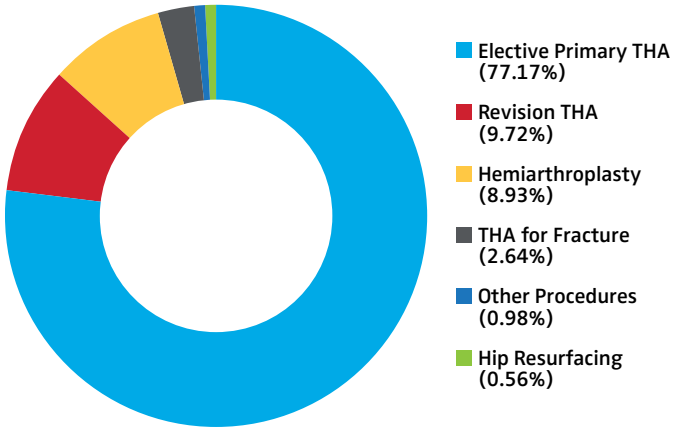
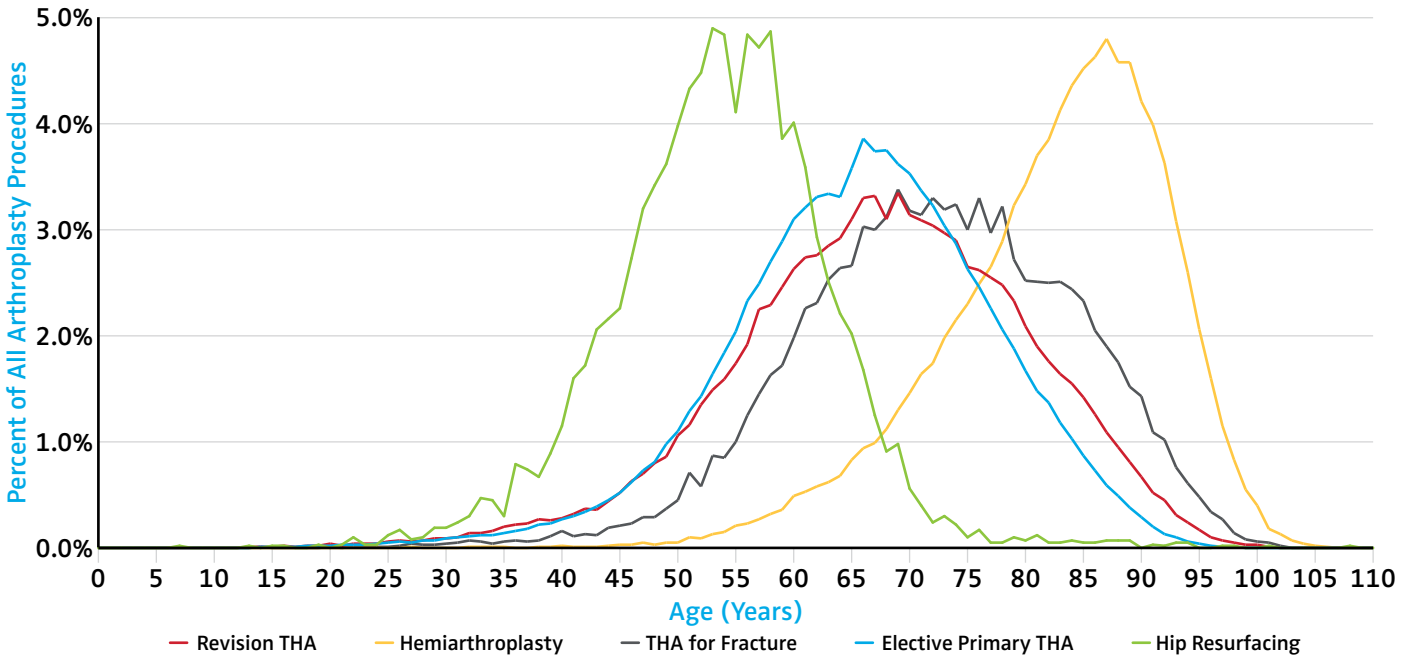


Table 2.2 Mean Age of Patients Undergoing Hip Arthroplasty Procedures, 2012-2021 (N=1,064,750)

Procedure	Total	Mean Age (Yrs)	Standard Deviation
Elective Primary THA	821,640	65.7	11.3
Revision Hip Arthroplasty	103,514	67.4	12.6
Hemiarthroplasty	95,099	82.4	9.7
THA for Fracture	28,079	72.2	11.8
Other Procedures	10,483	65.4	21.8
Hip Resurfacing	5,935	53.7	9.3

Figure 2.2 Age Distribution of Hip Arthroplasty Procedures, 2012-2021 (N=1,064,750)

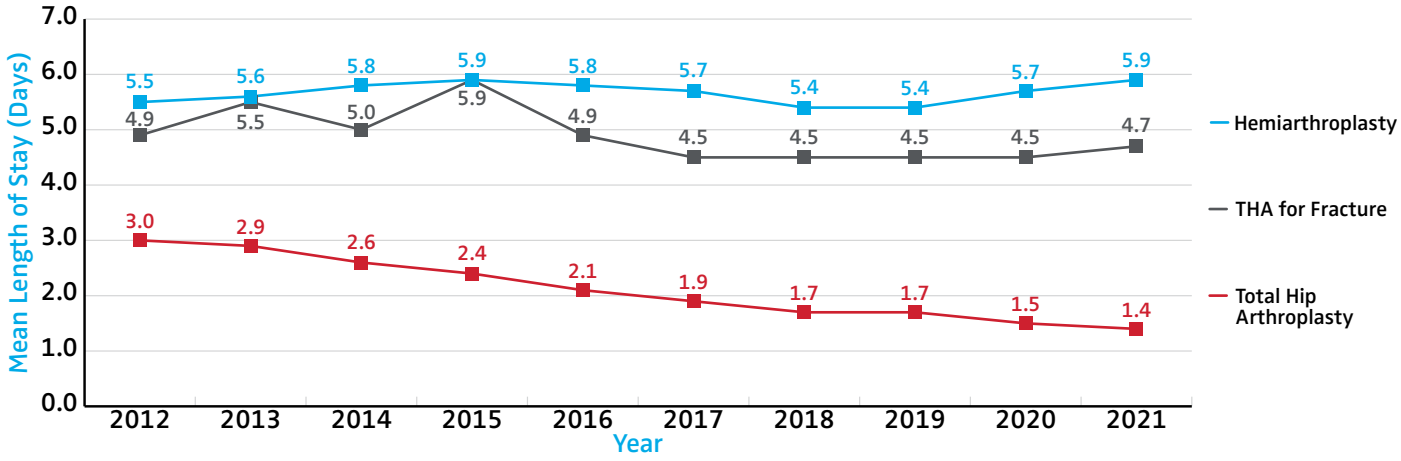


When evaluating mean length of stay in the AJRR cohort, there was a significant decrease of over 1 day when comparing mean length of stay for elective primary total hip arthroplasties from 2012 (3.0 days) to 2021 (1.4 days) ($p<0.0001$). Length of stay in patients with a fracture treated with total hip 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.

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.

INSIGHTS

Figure 2.3 Mean Length of Stay for Hip Arthroplasty Procedures, 2012-2021 (N=537,686)



Arthroplasty for Femoral Neck Fracture

Between 2012 and 2021, AJRR has collected data on 123,178 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 2021 (Figure 2.4). This finding is consistent with reports from other national registries.[5,6] 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). THA for FNF is increasingly more common in females with each decade increase in age with females reaching a majority of cases in groups >50 years of age and over two-thirds of cases aged >90 years (Fig 2.6).

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, 2012-2021 (N=123,178)

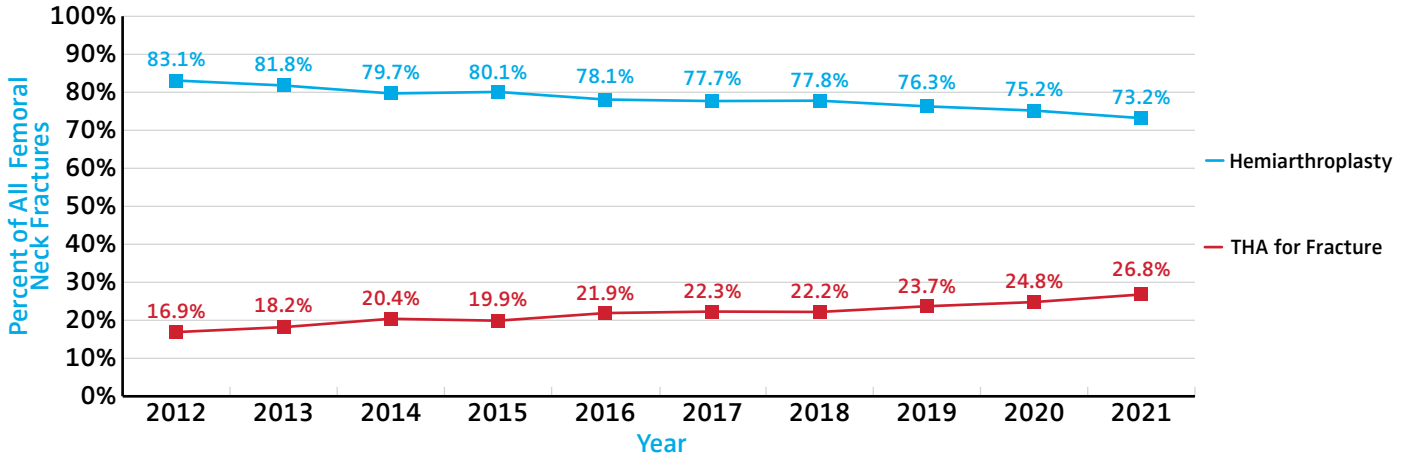


Figure 2.5 Percent of Total Hip Arthroplasty and Hemiarthroplasty Procedures for Treatment of Femoral Neck Fracture by Age Group, 2012-2021 (N=123,178)

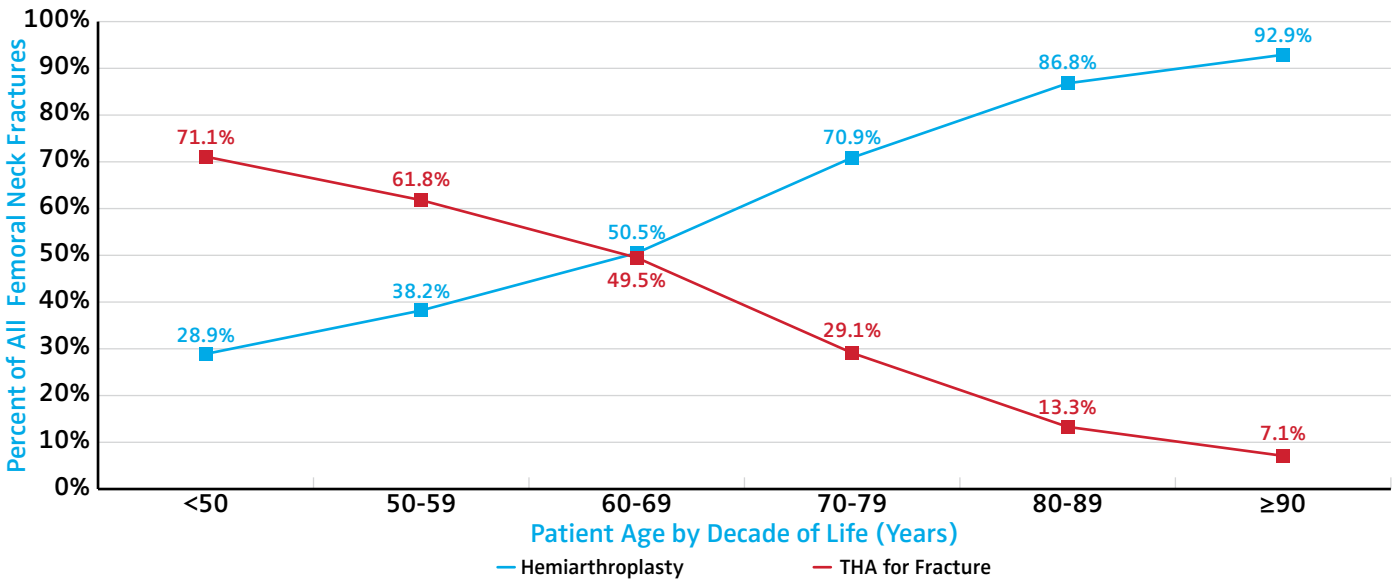
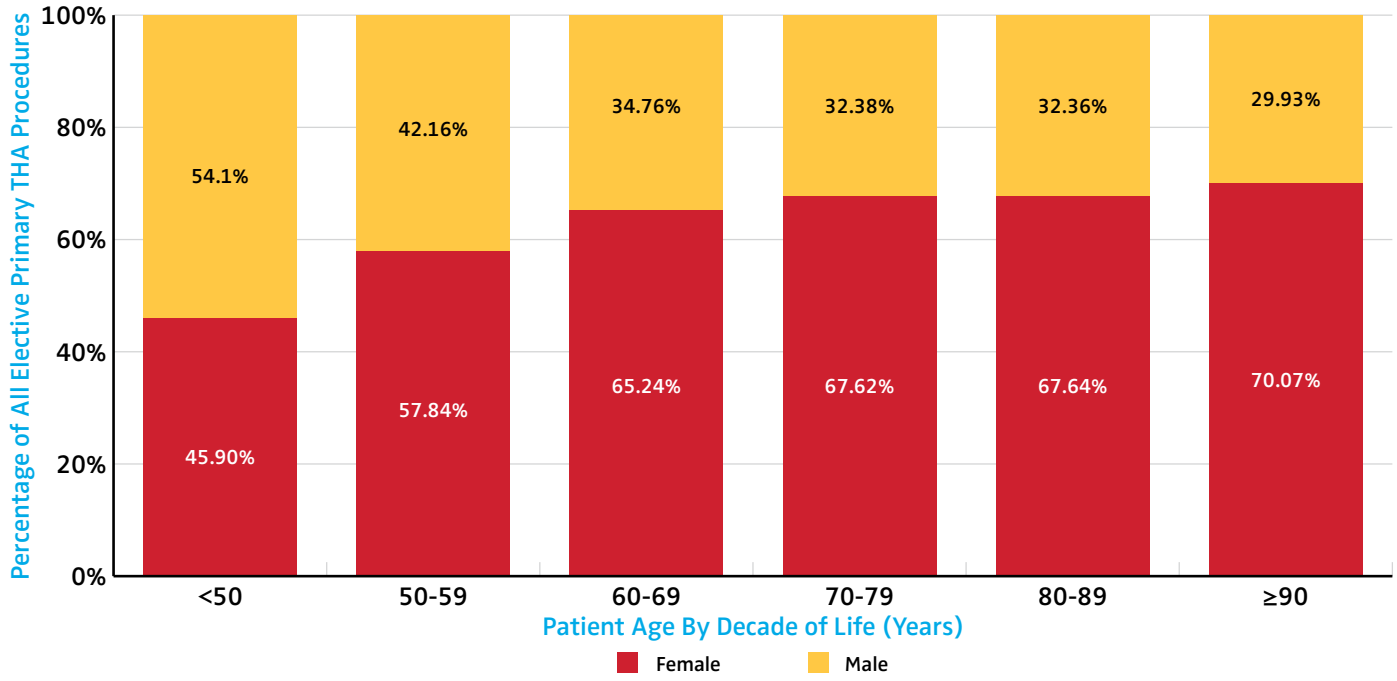


Figure 2.6 Sex Distribution for Total Hip Arthroplasty for Femoral Neck Fracture by Age Group, 2012-2021 (N=27,983)

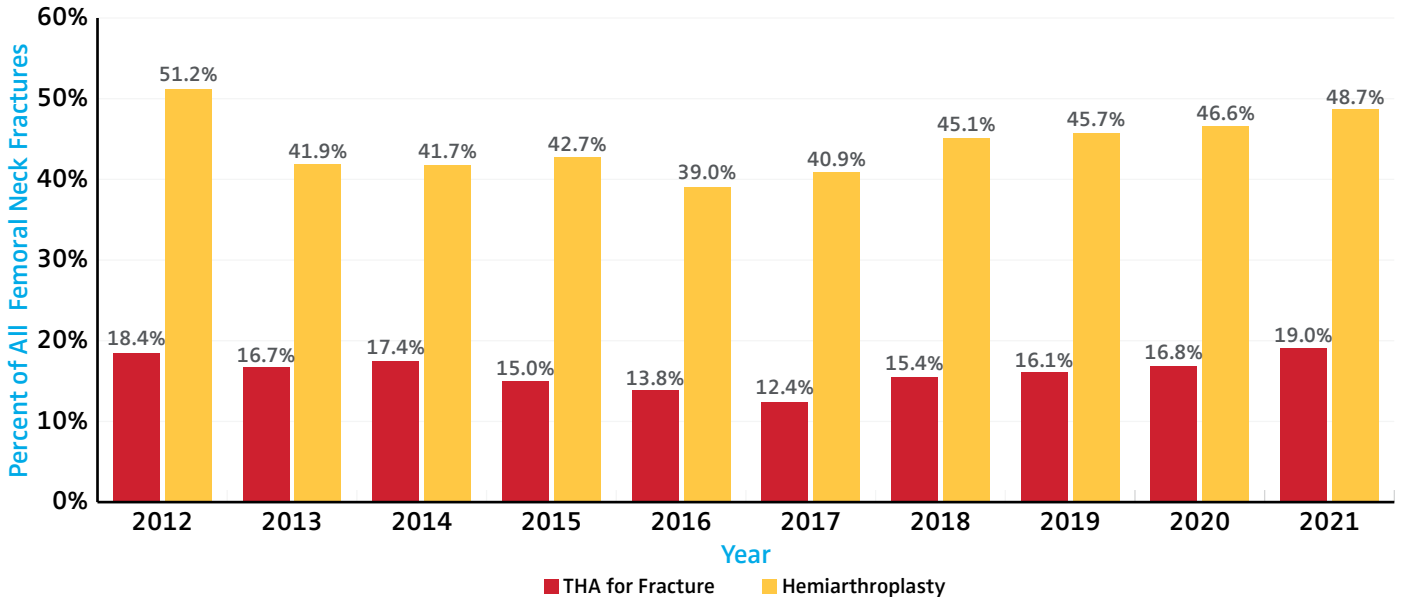


Both cemented and cementless fixation for femoral stems are frequently used in the treatment of femoral neck fractures. Cemented fixation was more commonly utilized for hemiarthroplasty than total hip arthroplasty. There has been a trend towards increased use of cement for stem fixation in both hemiarthroplasty and total hip arthroplasty for femoral neck fractures over the past five years (Figure 2.7).

INSIGHTS

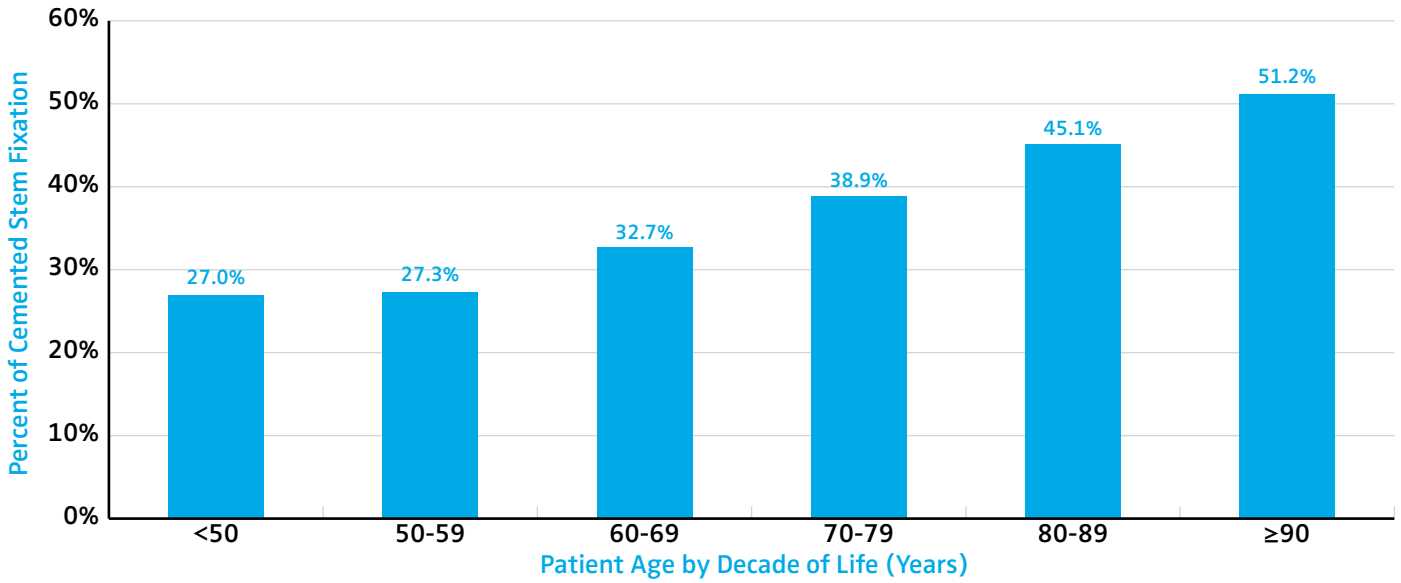
The use of cement for femoral stem fixation in the setting of arthroplasty for femoral neck fracture has been slowly increasing over the past 5 years.

Figure 2.7 Cemented Fixation for Femoral Stems in Total Hip Arthroplasty and Hemiarthroplasty for Femoral Neck Fracture, 2012-2021 (N=36,941)



Cemented femoral component fixation used in hemiarthroplasty for the treatment of FNF increased in utilization with each advancing decade of life (Figure 2.8). In contrast to the majority of international registries, however, only 51% of the oldest age group received cemented stems.[7-9] Internationally, cemented femoral stem fixation for femoral neck fractures still predominates; in 2021, the National Joint Registry reported that only 19.6% of all stems used to treat femoral neck fractures were cementless.[8]

Figure 2.8 Percent of Cemented Stem Fixation Used in Hemiarthroplasty for Femoral Neck Fracture by Age Group, 2012-2021 (N=33,619)



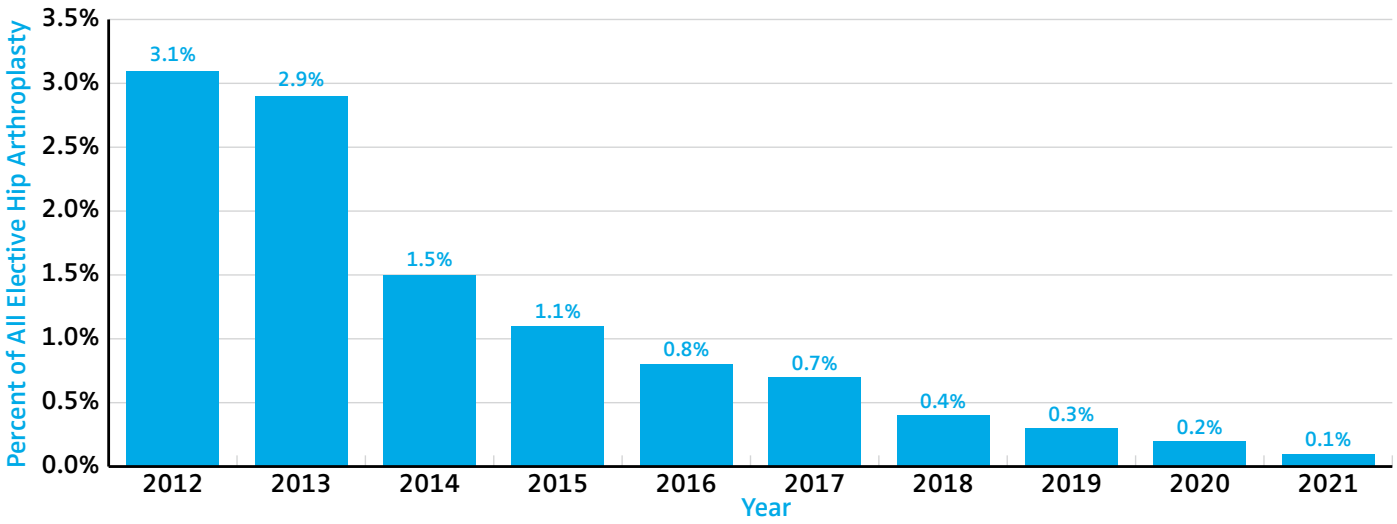
Hip Resurfacing

Between 2012 and 2021, AJRR has collected data on 5,903 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 (Figure 2.9).[10] Males under the age of 60 made up 75% of cases of hip resurfacing.

Hip resurfacing as a percentage of the total number of elective hip arthroplasty procedures submitted to AJRR continues to decline and are mostly performed in young males.

Figure 2.9 Hip Resurfacing as a Percentage of Elective Hip Arthroplasty Procedures, 2012-2021 (N=5,903)



Elective Primary Total Hip Arthroplasty

Between 2012 and 2021, AJRR has collected data on 821,640 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 2.10).

The trend towards increased utilization of larger diameter heads ≥40mm and dual mobility over the past decade continues but may be slowing.

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 1,944 cases in 2021. The use of dual mobility articulations in both primary and revision hip arthroplasty as reported to AJRR increased substantially since 2012 but has remained relatively stable over the last three years (Figure 2.11).

Figure 2.10 Sex Distribution for Elective Primary Total Hip Arthroplasty Procedures by Age Group, 2012-2021 (N=818,692)

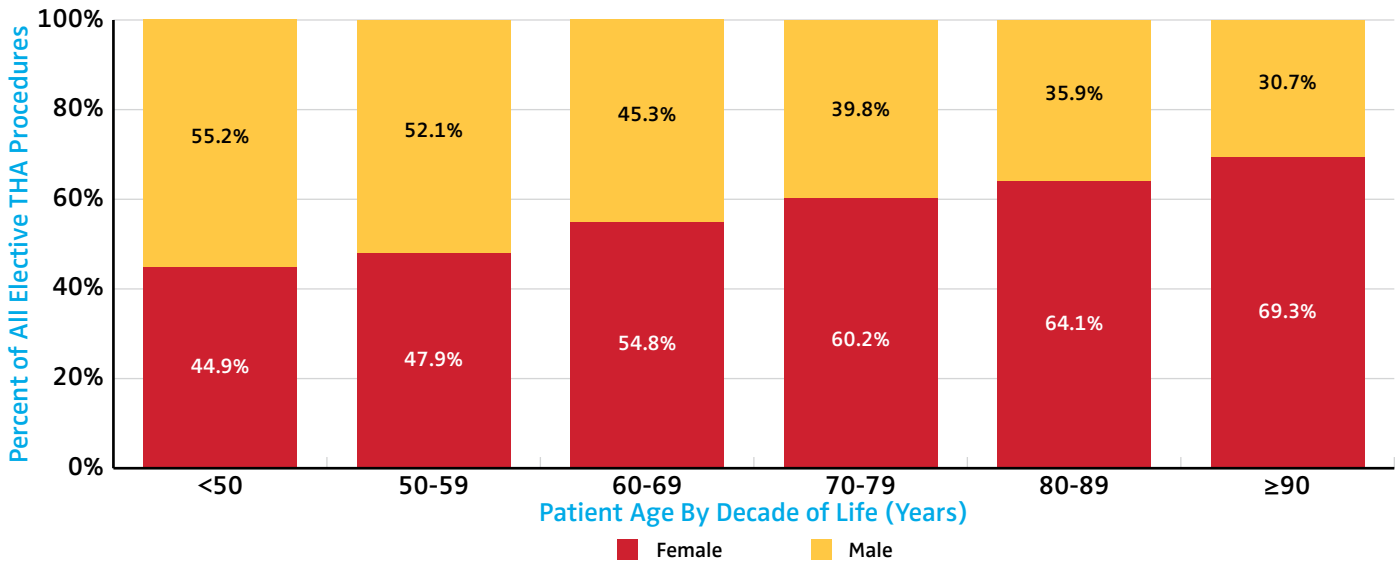
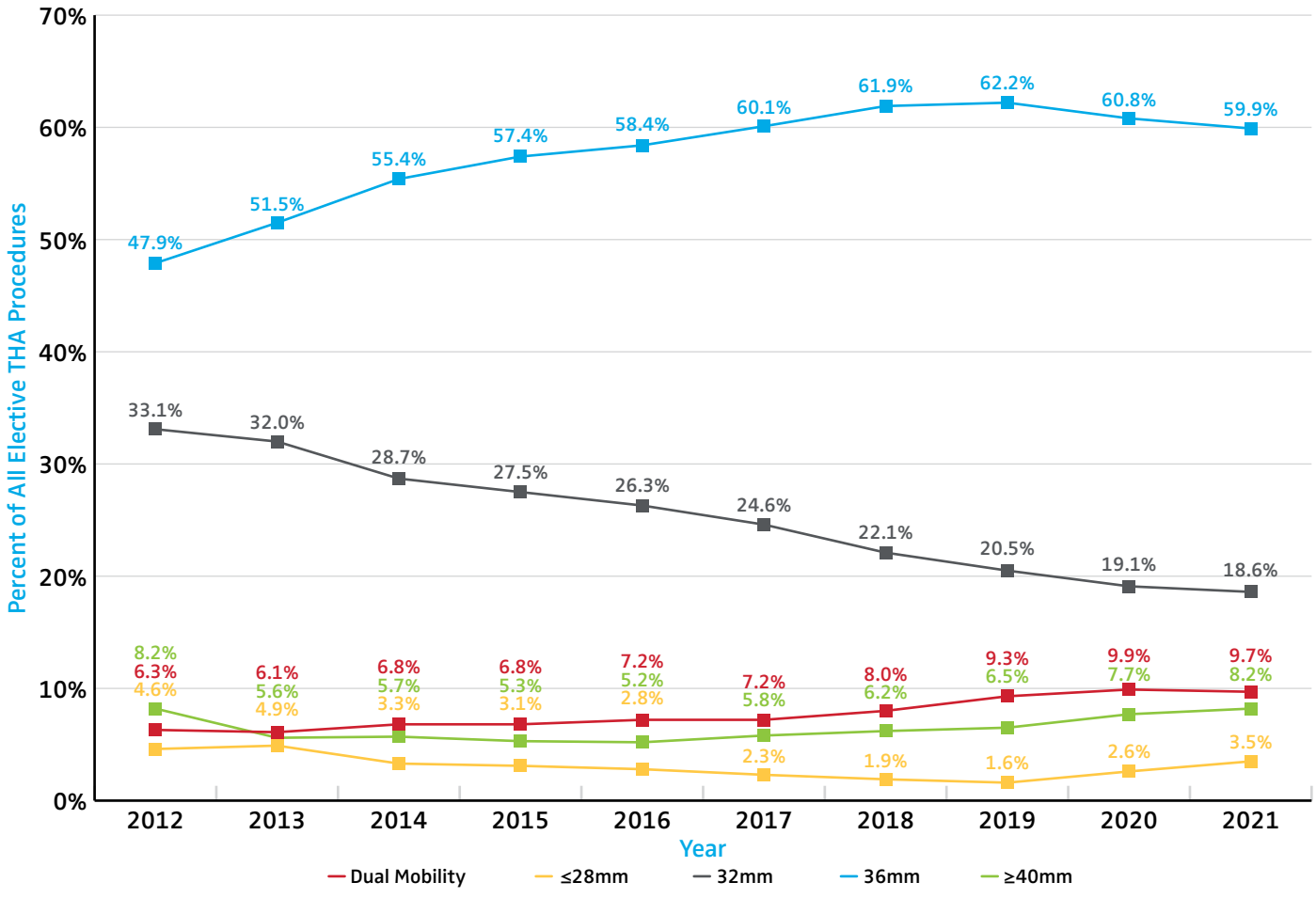


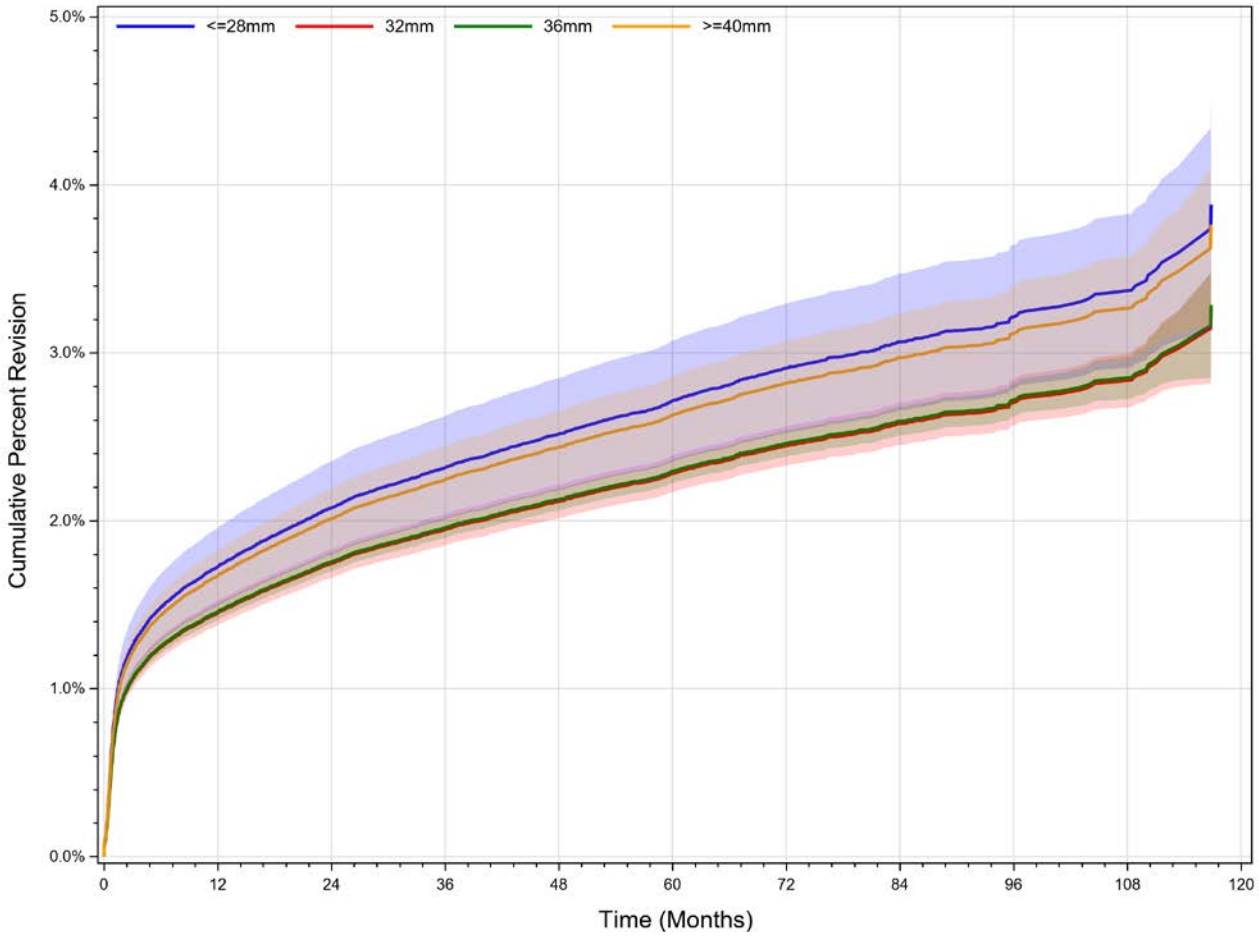
Figure 2.11 Percent Dual Mobility Usage and Femoral Head Sizes Implanted in Elective Primary Total Hip Arthroplasty, 2012-2021 (N=683,043)



Unless otherwise noted, all survival analyses are limited to Medicare patients aged 65 years and older and merged with available CMS claims data in order to maximize outcome capture of cases performed at non-AJRR reporting institutions. After adjusting for age and sex, the cumulative percent revision rate of elective primary THA cases in patients greater than 65 years of age is higher when utilizing smaller diameter (28mm or less) and larger diameter (40mm and greater) femoral heads compared to those procedures utilizing 36mm femoral heads (Figure 2.12). The 32mm and 36mm heads were not found to be statistically different.

The cumulative percent revision rate of elective primary THA cases in patients greater than 65 years of age is higher when utilizing smaller diameter (28mm or less) and larger diameter (40mm and greater) femoral heads compared to those procedures utilizing 36mm femoral heads. The 32mm and 36mm heads were not found to be statistically different.

Figure 2.12 Cumulative Percent Revision for Diameter of Femoral Heads for Elective Primary Total Hip Arthroplasty in Medicare Patients 65 Years of Age and Older with Primary Osteoarthritis, 2012-2021

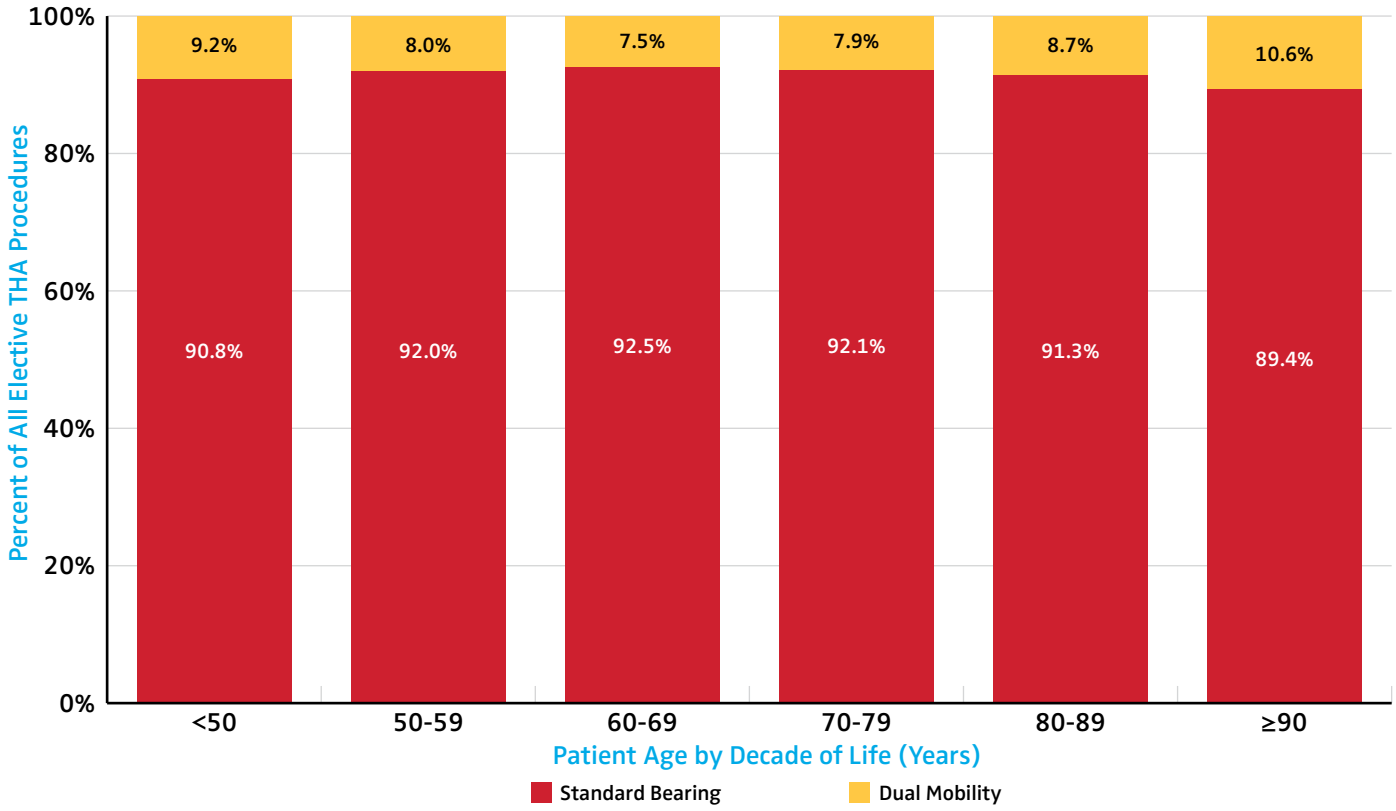


Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
≤28mm	8,453	7,137	6,117	5,387	4,484	3,360	2,238	1,394	746	212	1
32mm	84,324	76,058	67,715	56,896	45,204	32,109	20,103	11,600	5,339	1,594	6
36mm	215,119	189,219	162,557	129,711	96,996	64,898	38,108	20,552	8,483	2,470	1
≥40mm	22,676	19,390	16,022	12,565	9,217	6,126	3,679	2,121	1,012	411	1
Total	330,572	291,804	252,411	204,559	155,901	106,493	64,128	35,667	15,580	4,687	9

Age/Sex adjusted HR (95%CI), p-value
32mm vs. 36mm:0.994 (0.936,1.056), p=0.8546
≤28mm vs. 36mm:1.185 (1.03,1.364), p=0.0179
≥40mm vs. 36mm:1.148 (1.039,1.269), p=0.0068

AJRR illustrated a statistically significant increase in dual mobility usage for elective primary hip arthroplasty procedures when comparing 2012 to 2021 (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.[11] These constructs were used most commonly in the oldest (>90 years) and youngest (<50 years) patients and least frequently in the 60-69 year age range (Figure 2.13).

Figure 2.13 Dual Mobility Usage as a Percent of all Elective Primary Total Hip Arthroplasty Procedures by Age Group, 2012-2021 (N=54,524)



Dual mobility constructs show most frequent use in the oldest (≥90) and youngest (<50 years) groups of patients.

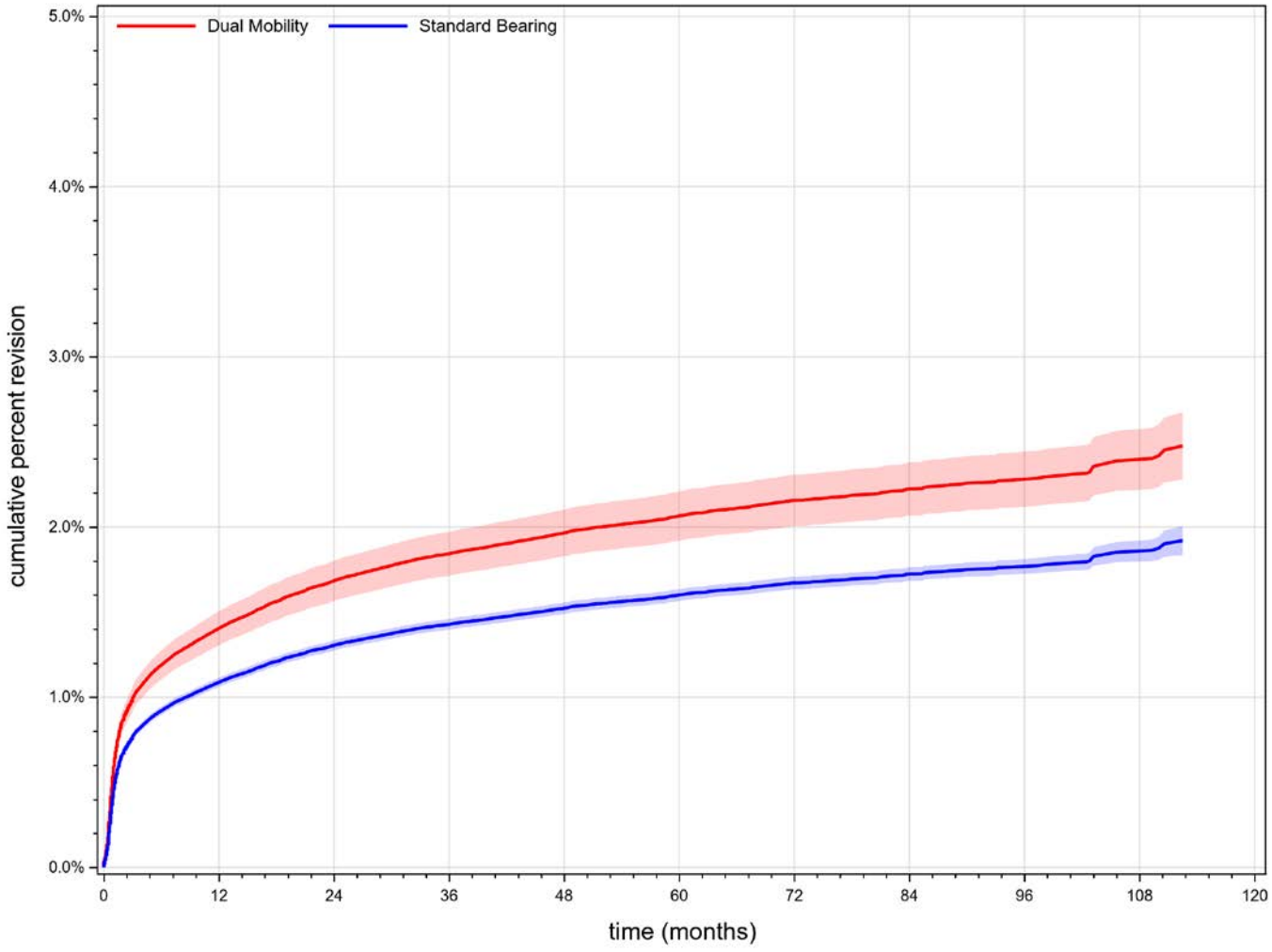
INSIGHTS

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 after adjusting for age and sex (HR=1.293, 95% CI, 1.194-1.4, p<0.0001) (Figure 2.14). Findings were similar when looking at patients ≥65 years of age as reported to either AJRR or CMS (Figure 2.15). 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.

INSIGHTS

A higher cumulative incidence of revision surgery is associated with dual mobility bearings when compared to conventional femoral heads for elective primary total hip arthroplasty procedures, which may reflect underlying patient characteristics and baseline risk for dislocation.

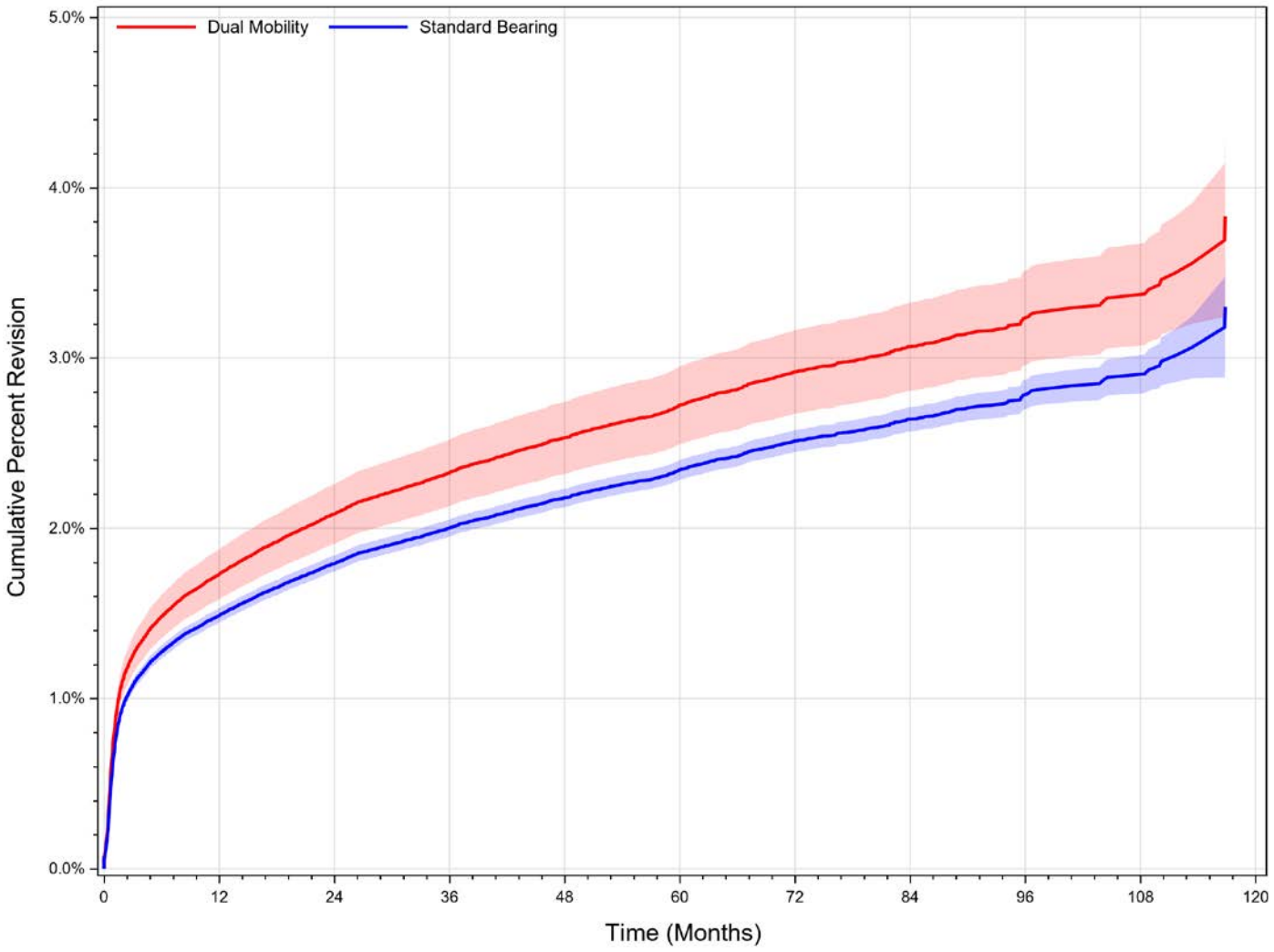
Figure 2.14 Cumulative Percent Revision for Dual Mobility Used for Elective Primary Total Hip Arthroplasty for Patients with Primary Osteoarthritis as Submitted Only to AJRR, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Dual Mobility	42,504	36,302	30,104	23,212	16,967	11,370	6,748	3,697	1,641	584	4
Standard Bearing	570,267	523,515	463,731	381,204	296,444	209,144	129,341	72,973	32,183	9,669	32
Total	612,771	559,817	493,835	404,416	313,411	220,514	136,089	76,670	33,824	10,253	36

Age/Sex adjusted HR (95%CI), p-value
Dual Mobility vs. Standard Bearing: *1.293 (1.194,1.4), p=<0.0001*

Figure 2.15 Cumulative Percent Revision for Dual Mobility Used for Elective Primary Total Hip Arthroplasty for Medicare Patients 65 Years of Age and Older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Dual Mobility	23,120	19,381	15,791	11,847	8,389	5,403	3,069	1,587	680	227	1
Standard Bearing	314,201	285,365	250,826	203,627	155,720	107,058	64,633	35,879	15,563	4,605	1
Total	337,321	304,746	266,617	215,474	164,109	112,461	67,702	37,466	16,243	4,832	2

Age/Sex adjusted HR (95%CI), p-value
Dual Mobility vs. Standard Bearing: *1.164 (1.061,1.277), p=0.0013*

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 2.16). This increase in ceramic head use is likely explained by concerns over trunnion and taper corrosion more commonly seen with CoCr heads.[12] CoCr femoral heads are used more commonly in patients >70 years of age, but ceramic still predominates across age groups accounting for more than 55% of patients older than 90 (Figure 2.17). Over the last decade, 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 two-fold since 2012 in elective primary hip arthroplasty (Figure 2.18).

INSIGHTS

The use of metal-on-polyethylene articulations in elective primary total hip arthroplasty continues to decrease, with less than 14% of procedures utilizing this bearing in 2021.

Figure 2.16 Composition of Femoral Heads for All Elective Primary Total Hip Arthroplasty Procedures Excluding Dual Mobility by Year, 2012-2021 (N=620,134)

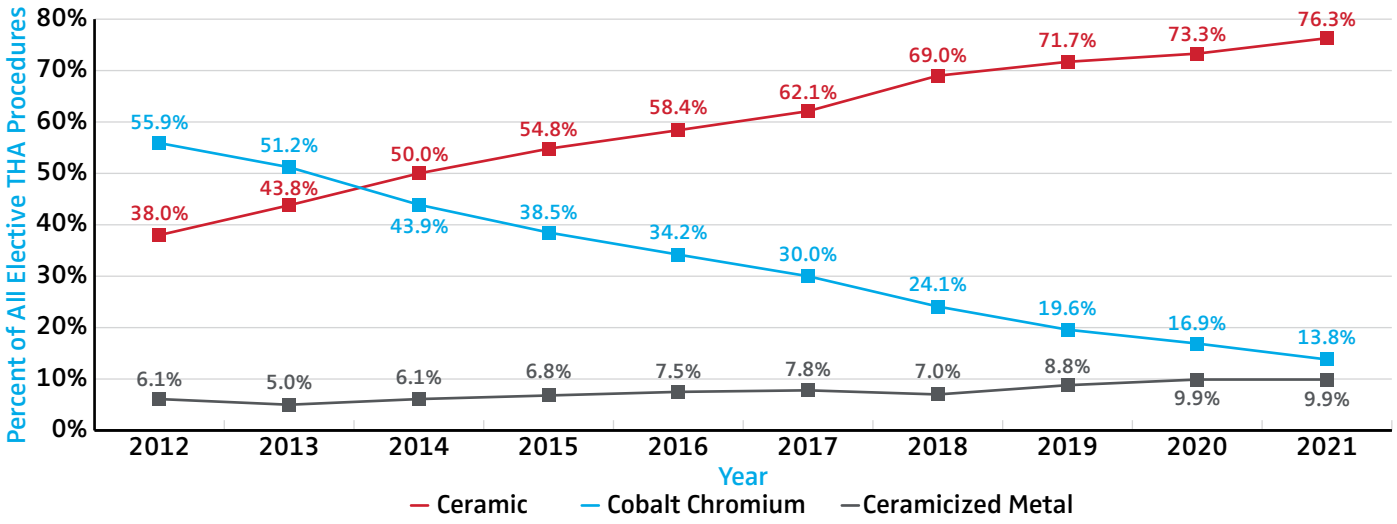


Figure 2.17 Composition of Femoral Heads for All Elective Primary Total Hip Arthroplasty Procedures Excluding Dual Mobility by Age Group, 2021 (N=48,745)

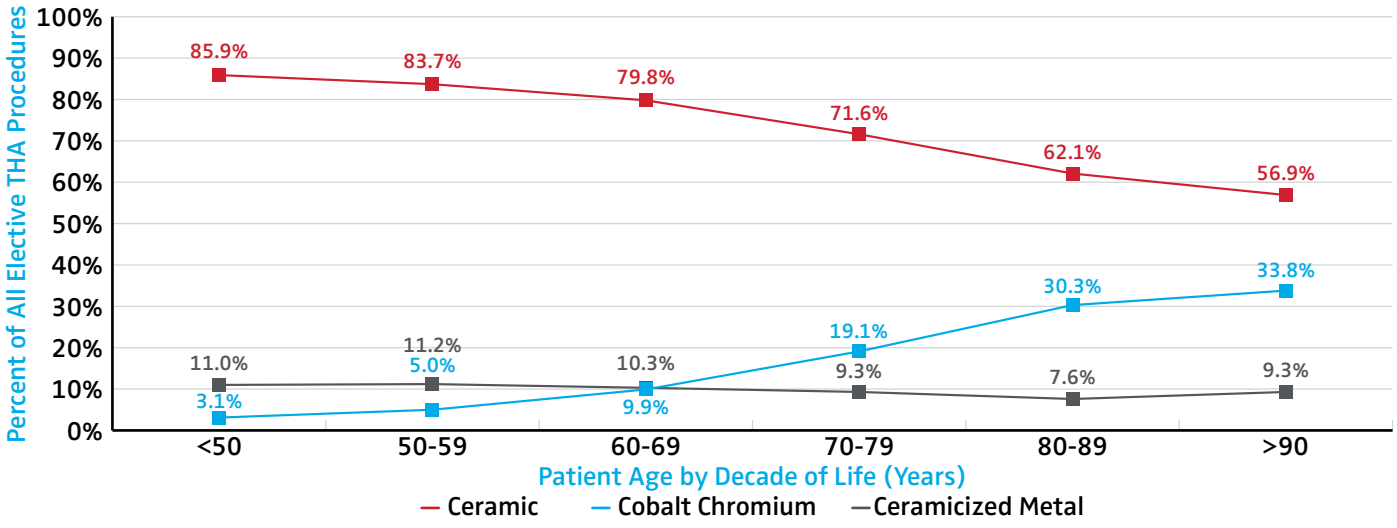
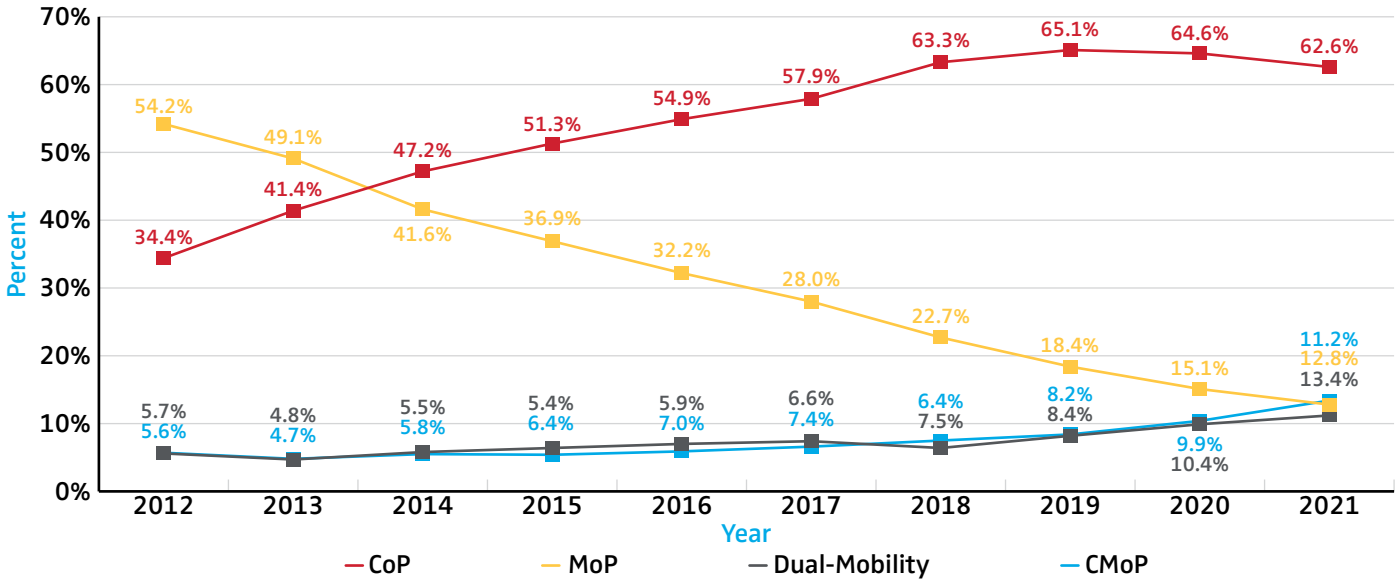


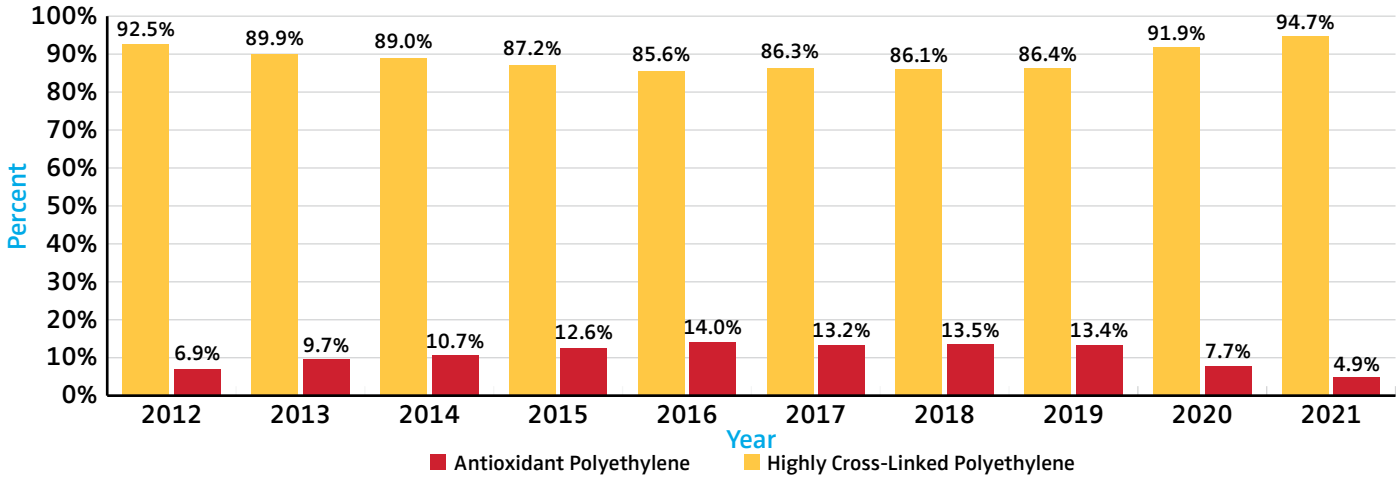
Figure 2.18 Elective Primary Total Hip Arthroplasty Bearing Surface Materials by Year, 2012-2021 (N=743,562)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Total N	12,994	26,871	48,799	67,385	92,431	99,986	98,192	95,500	68,721	42,081	**652,960**

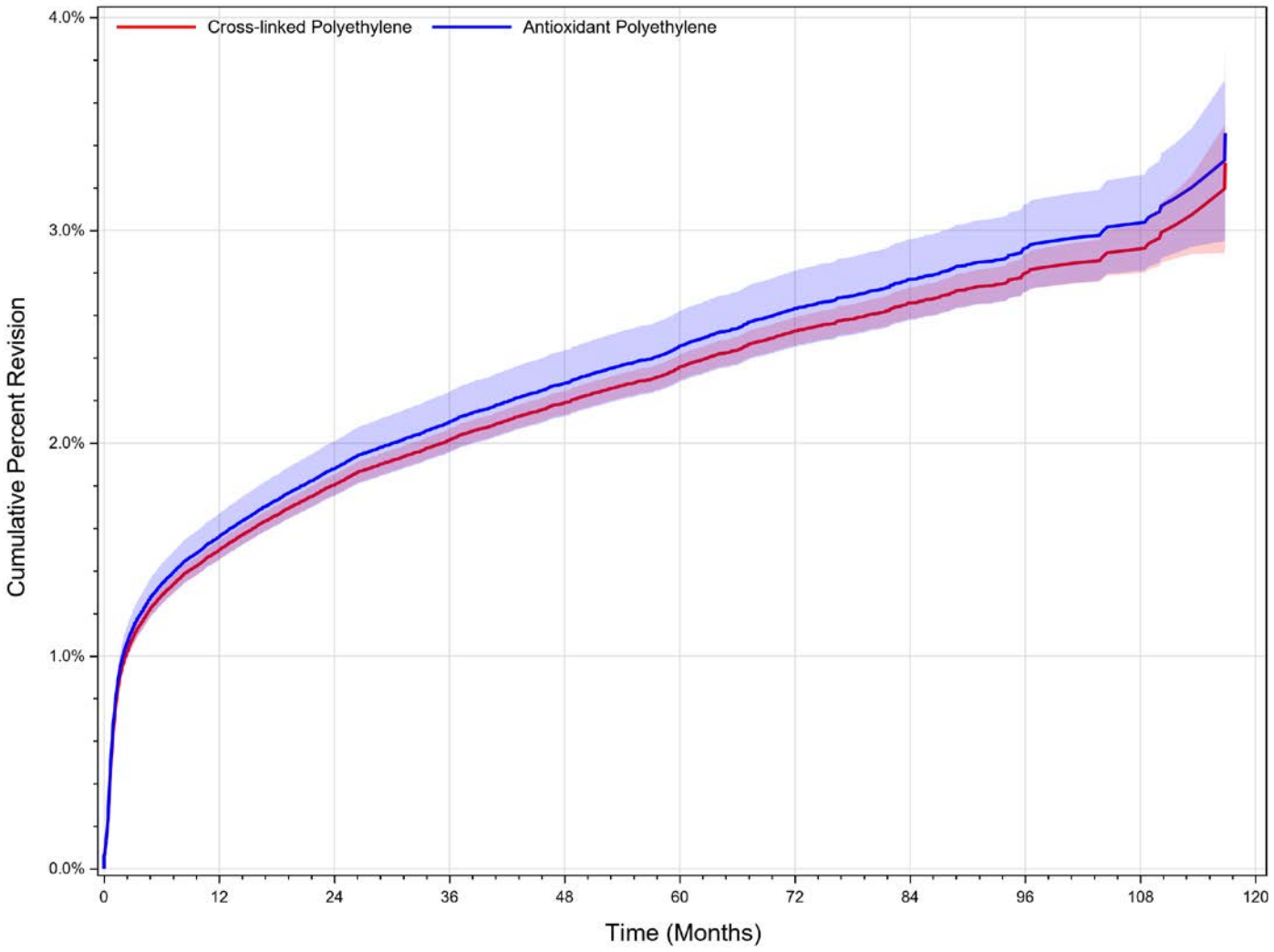
For both cobalt chromium and ceramic heads used by surgeons in the AJRR cohort, highly cross-linked polyethylene was more commonly utilized compared to antioxidant polyethylene for all elective primary total hip arthroplasty procedures (Figures 2.19). The threshold for classification of a polyethylene 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 had remained fairly stable since 2015 with a notable decline in recent years to just 4.9% in 2021. 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. After adjusting for age and sex, highly cross-linked and antioxidant polyethylene showed statistical equivalence in cumulative percent revision (Figure 2.20).

Figure 2.19 Elective Primary Total Hip Arthroplasty Liner Polyethylene Material by Year, 2012-2021 (N=661,299)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Total N	13,442	28,349	51,413	69,685	94,304	101,820	99,255	95,180	67,084	40,767	**661,299**

Figure 2.20 Cumulative Percent Revision for Polyethylene Material for Elective Primary Total Hip Arthroplasty for Medicare Patients 65 Years of Age and Older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Antioxidant Polyethylene	36,551	34,641	31,396	24,517	17,778	11,461	6,077	3,097	1,250	363	1
Cross-linked Polyethylene	293,140	264,826	231,656	188,813	145,092	100,277	61,243	34,093	14,859	4,416	1
Total	329,691	299,467	263,052	213,330	162,870	111,738	67,320	37,190	16,109	4,779	2

Age/Sex adjusted HR (95%CI), p-value
Cross-linked Polyethylene vs. Antioxidant Polyethylene: *0.959 (0.889,1.035), p=0.2824*

Cementless femoral component fixation for elective primary total hip arthroplasty dramatically outweighs the use of cemented fixation in the AJRR population. From 2012-2021, only 2.7% of all elective primary total hip arthroplasty procedures in AJRR utilized cemented femoral component fixation. When examining usage by age in 2021, there was a significant increase in cemented fixation with advancing age ($p<0.0001$) (Figure 2.21) and over time ($p<0.0001$) (Figure 2.22).

Figure 2.21 Cemented and Cementless Femoral Stem Fixation in Elective Primary Total Hip Arthroplasty Procedures by Age Group, 2021 (N=48,915)

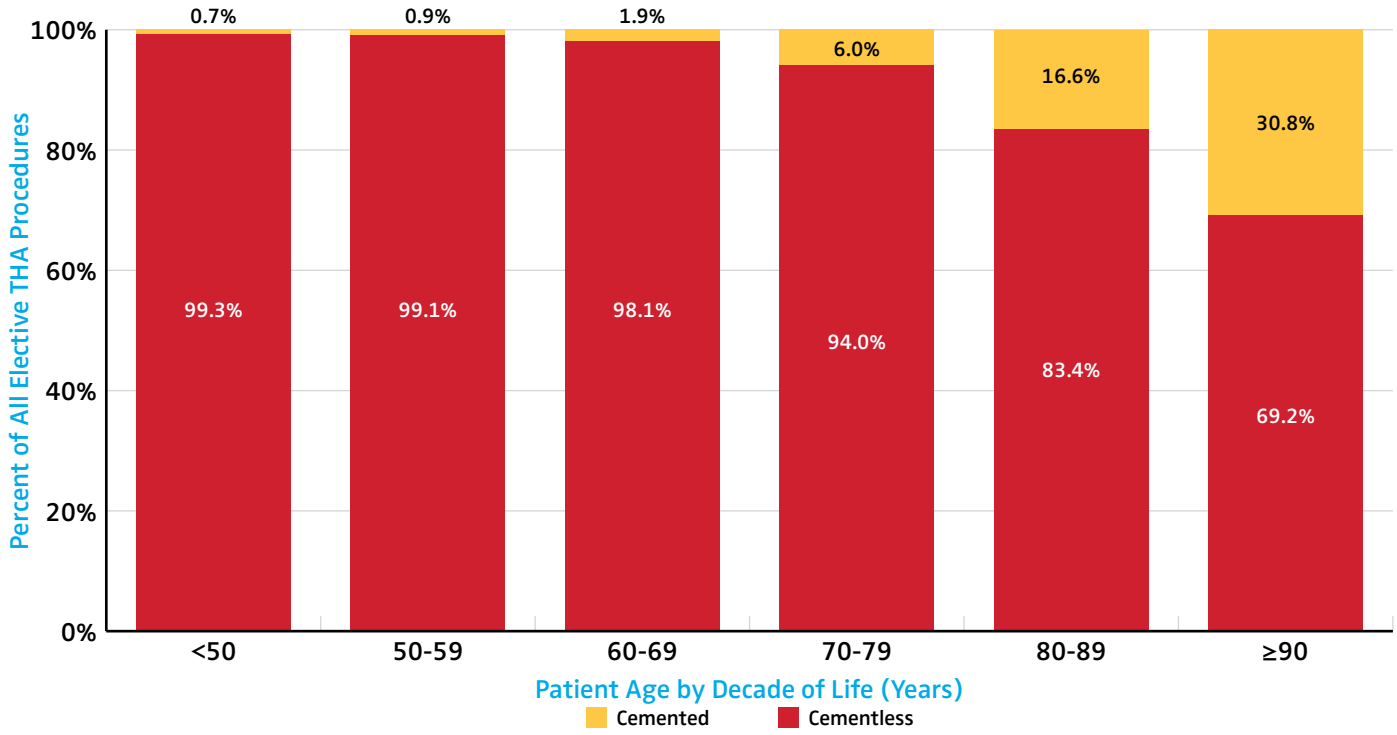
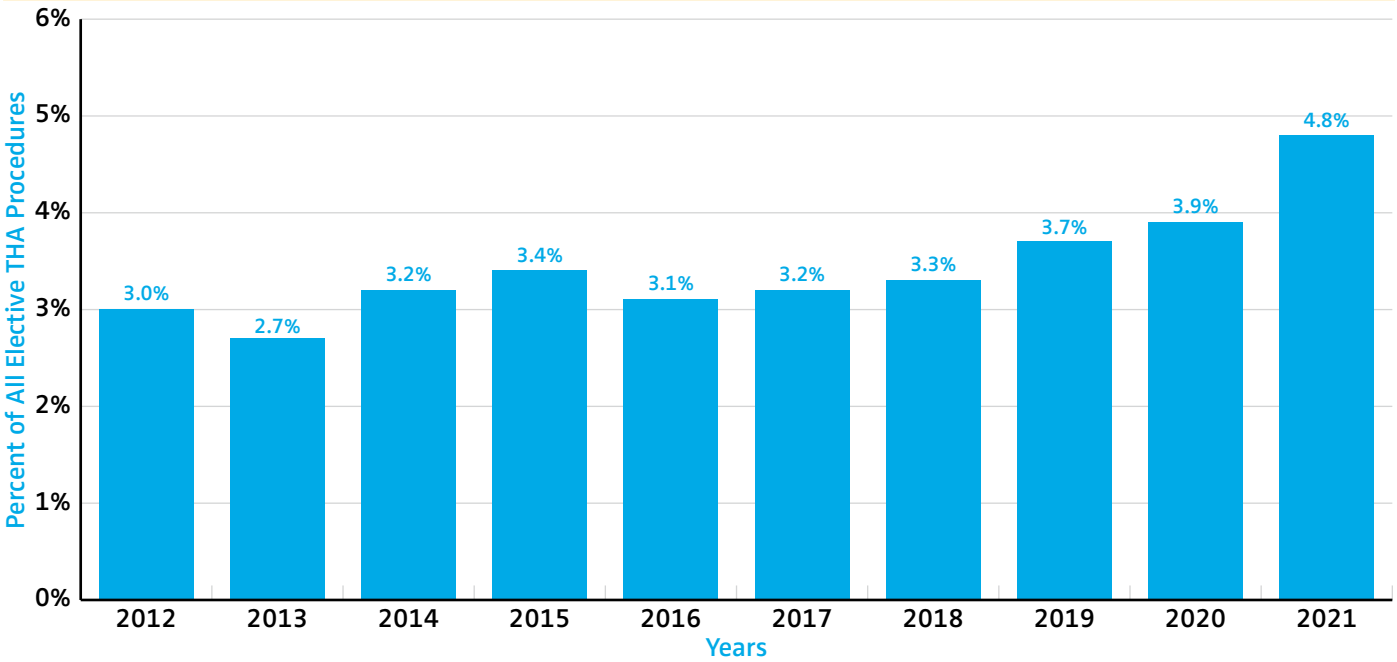


Figure 2.22 Cemented Femoral Stem Fixation in Elective Primary Total Hip Arthroplasty Procedures, 2012-2021 (N=22,246)



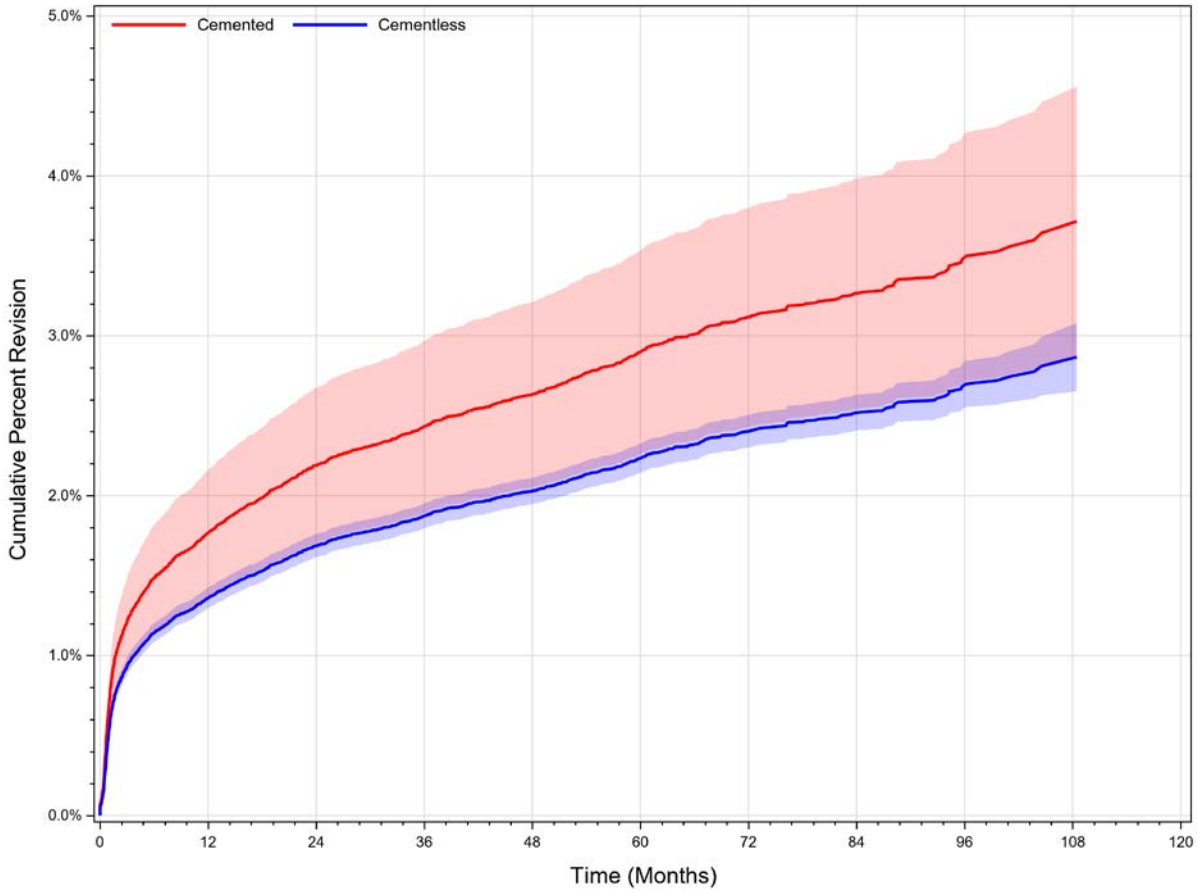
The trend towards increasing use of cement for femoral component fixation in primary elective THA has increased over 75% since 2013. In 2021, almost 5% of femoral stems were cemented, which represents the highest percentage utilization since the inception of AJRR.

INSIGHTS

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%).[8] 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.[7] In their 2021 Annual Report, the Swedish Arthroplasty Register noted that the proportion of cemented prostheses in that year was 50%. They also commented that completely cementless fixation has been increasing from 2% in 2000 to 30% in 2020.[9]

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 statistically increased cumulative percent revision in males but lower cumulative percent revision in females (Figures 2.23-2.24). It is important to note this does not account for potential confounders that were not examined.

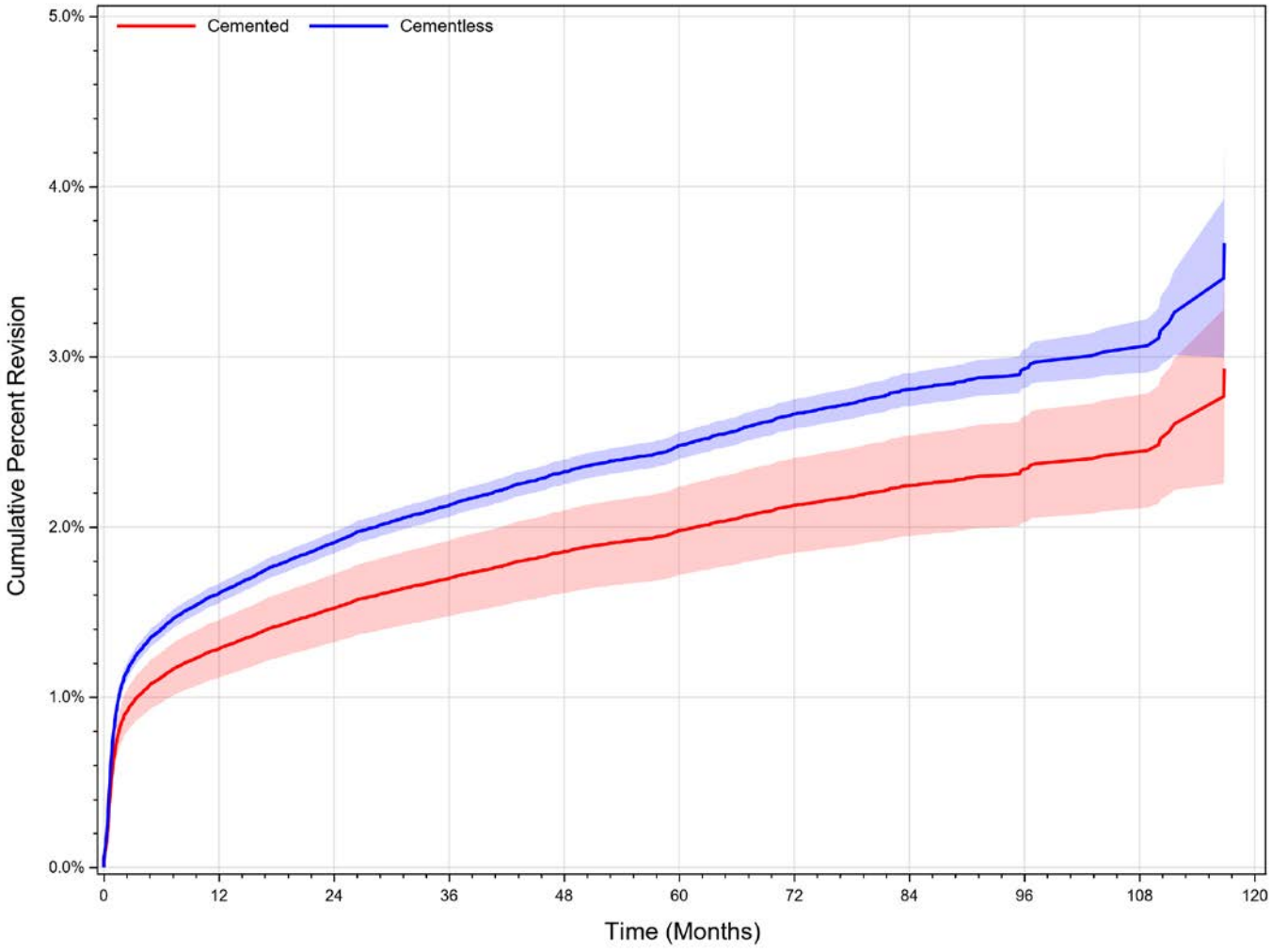
Figure 2.23 Cumulative Percent Revision for Femoral Stem Fixation Used for Elective Primary Total Hip Arthroplasty for Male Medicare Patients 65 Years of Age and Older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cemented	3,045	2,549	2,169	1,733	1,333	942	544	262	99	33	1
Cementless	127,114	112,713	97,690	79,514	60,822	41,366	24,980	13,782	5,939	1,776	1
Total	130,159	115,262	99,859	81,247	62,155	42,308	25,524	14,044	6,038	1,809	2

Age adjusted HR (95%CI), p-value
Cemented vs. Cementless: *1.302 (1.026,1.652) p=0.0301*

Figure 2.24 Cumulative Percent Revision for Femoral Stem Fixation Used for Elective Primary Total Hip Arthroplasty for Female Medicare Patients 65 Years of Age and Older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cemented	12,783	10,831	9,171	7,283	5,448	3,704	2,201	1,109	432	160	1
Cementless	186,241	164,898	143,850	116,926	89,209	61,395	37,141	20,631	9,040	2,679	11
Total	199,024	175,729	153,021	124,209	94,657	65,099	39,342	21,740	9,472	2,839	12

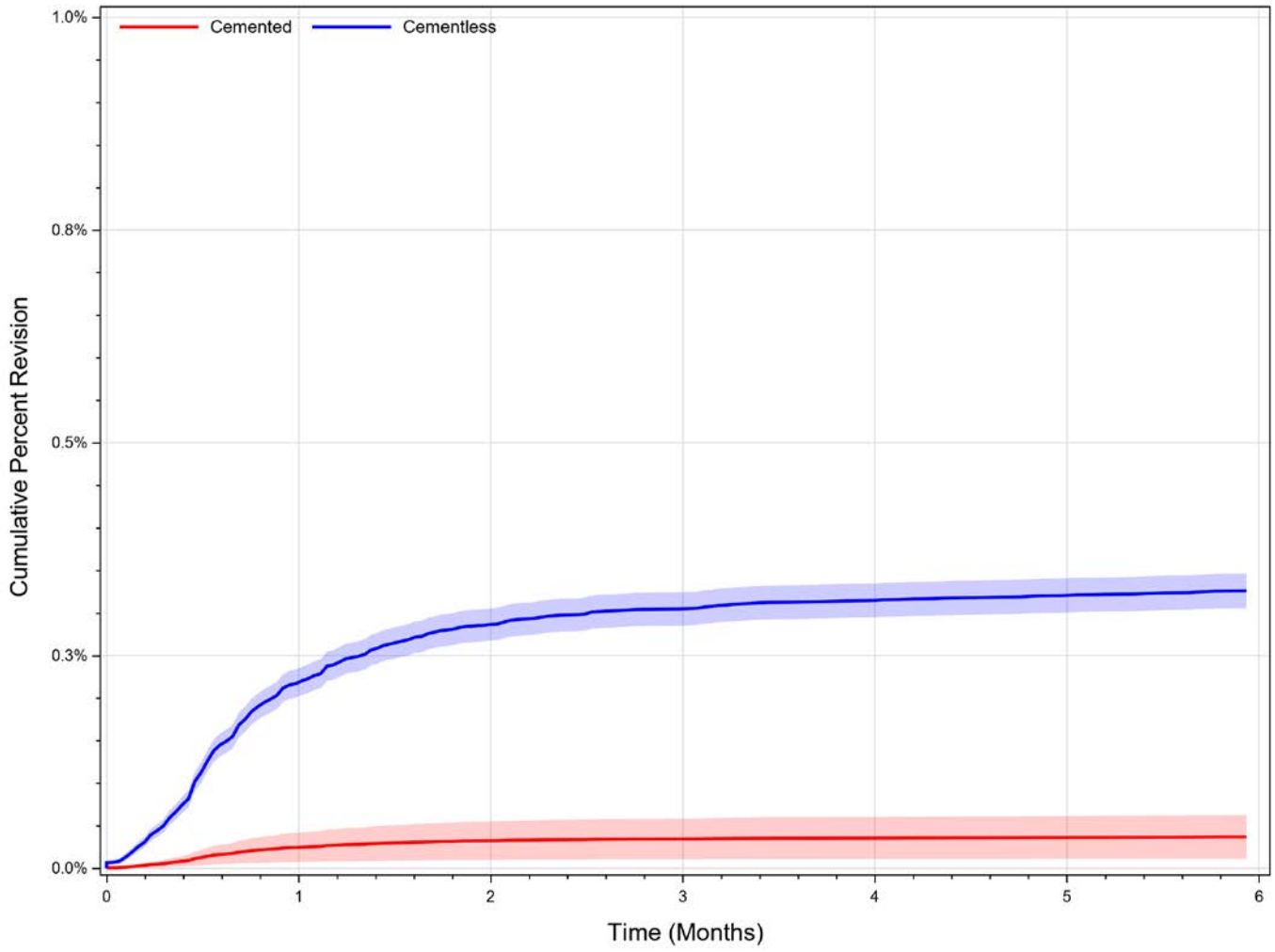
Age adjusted HR (95%CI), p-value
Cemented vs. Cementless: *0.796 (0.69,0.92), p=0.0019*

Revision for periprosthetic fracture can be analyzed based on the fixation method of the femoral component. Figure 2.25 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=0.113, 95% CI, 0.052-0.245, p<0.0001).

INSIGHTS

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

Figure 2.25 Cumulative Percent Revision due to Periprosthetic Fracture for Elective Primary Total Hip Arthroplasty Patients 65 Years of Age and Older Adjusted for Age and Sex, 2012-2021



Number at Risk (Months)	1	2	3	4	5	6
Cemented	15,605	15,381	15,157	14,991	14,785	14,589
Cementless	309,254	305,774	303,062	300,416	297,588	295,170
Total	324,859	321,155	318,219	315,407	312,373	309,759

Age/Sex adjusted cause-specific HR (95%CI), p-value
Cemented vs. Cementless: *0.113 (0.052,0.245), p<0.0001*

For this year's Annual Report, utilization of technology for surgical assistance in primary total hip arthroplasty was analyzed. The utilization of both computer navigation and robotics has increased substantially over the past few years. The percentage of elective primary total hip arthroplasty cases utilizing robotic assistance is now over 5% (Figure 2.26). A detailed table comparing procedures performed with technology compared to conventional total hip arthroplasty is also included (Table 2.3).

INSIGHTS

Utilization of robotics in THA has more than doubled since 2017, and computer navigation use has increased 84% in that same time period.

Figure 2.26 Rate of Technology Use for Assistance in Elective Primary Total Hip Arthroplasty, Jan 2017 - Mar 2022

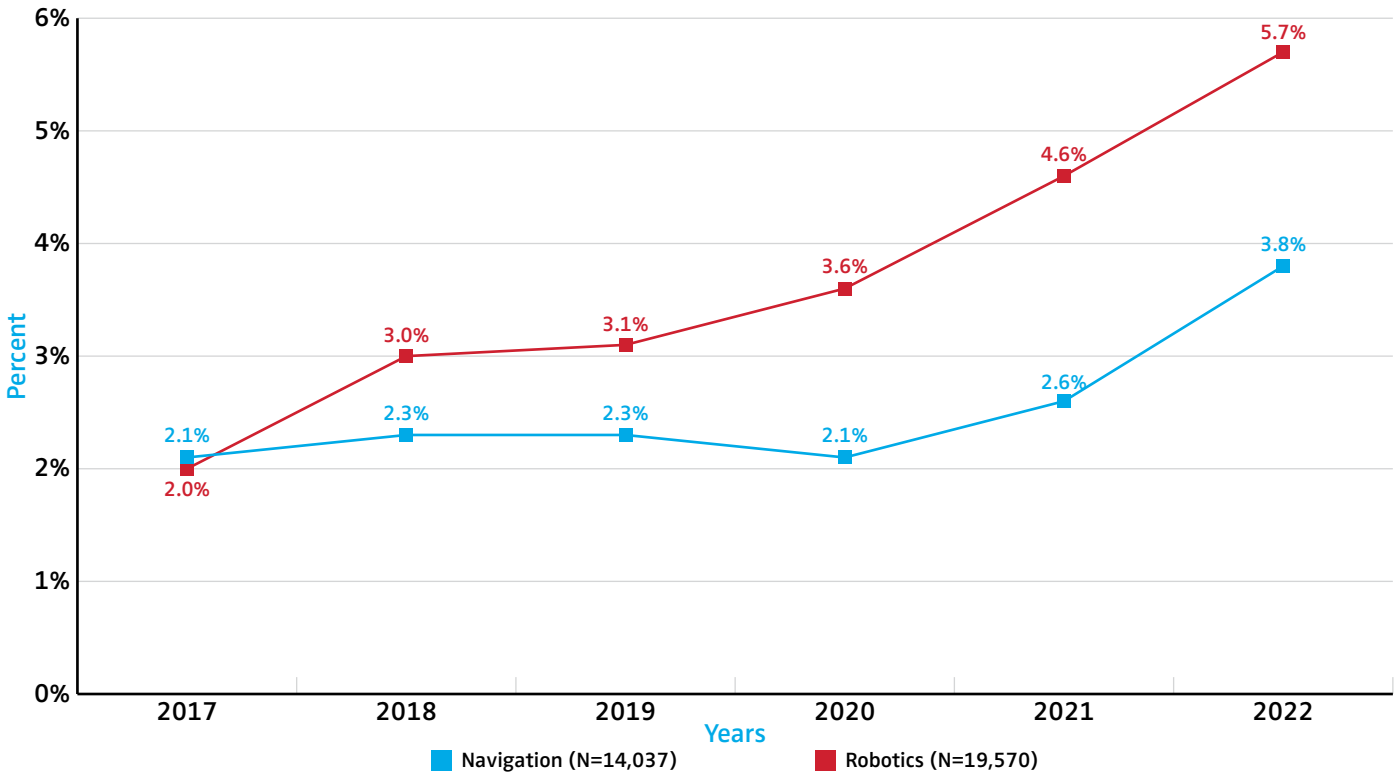


Table 2.3 Comparison of Patients Undergoing Elective Primary Total Hip Arthroplasty with or without the Assistance of Technology (Navigation or Robotics)

	Yes (N = 28,389)	No (N = 231,953)	NR (N = 564,135)	Total (N = 824,477)
Age				
Mean (SD)	65.87 (11.11)	66.03 (11.20)	65.64 (11.42)	65.75 (11.35)
N (N Missing)	28,389 (0)	231,953 (0)	564,135 (0)	824,477 (0)
Patient BMI				
Mean (SD)	29.71 (6.02)	30.10 (6.41)	30.02 (6.22)	30.03 (6.28)
N (N Missing)	21,787 (6602)	161,628 (70325)	263,095 (301040)	446,510 (377967)
Charlson Comorbidity Index (CCI)				
Mean (SD)	2.55 (1.53)	2.58 (1.58)	2.52 (1.59)	2.54 (1.59)
N (N Missing)	28,389 (0)	231,953 (0)	564,135 (0)	824,477 (0)
Age Category				
<50	1,987 (7.00%)	16,304 (7.03%)	42,818 (7.59%)	61,109 (7.41%)
50-59	5,455 (19.22%)	44,049 (18.99%)	113,225 (20.07%)	162,729 (19.74%)
60-69	10,086 (35.53%)	81,107 (34.97%)	195,840 (34.72%)	287,033 (34.81%)
70-79	7,965 (28.06%)	65,592 (28.28%)	151,971 (26.94%)	225,528 (27.35%)
80-89	2,660 (9.37%)	22,790 (9.83%)	55,464 (9.83%)	80,914 (9.81%)
≥90	236 (0.83%)	2,111 (0.91%)	4,817 (0.85%)	7,164 (0.87%)
Missing	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Sex				
Female	15,661 (55.17%)	128,291 (55.31%)	309,509 (54.86%)	453,461 (55.00%)
Male	12,716 (44.79%)	103,612 (44.67%)	251,739 (44.62%)	368,067 (44.64%)
NR/ Missing	12 (0.04%)	50 (0.02%)	2,887 (0.51%)	2,949 (0.36%)
BMI Category				
Normal	4,531 (20.69%)	31,889 (19.53%)	52,425 (19.83%)	88,845 (19.77%)
Underweight	171 (0.78%)	1,573 (0.96%)	2,626 (0.99%)	4,370 (0.97%)
Pre-Obesity	7,590 (34.67%)	53,629 (32.85%)	87,127 (32.96%)	148,346 (33.00%)
Obesity Class I	5,573 (25.45%)	42,305 (25.91%)	68,043 (25.74%)	115,921 (25.79%)
Obesity Class II	2,685 (12.26%)	22,409 (13.73%)	36,416 (13.78%)	61,510 (13.68%)
Obesity Class III	1,345 (6.14%)	11,465 (7.02%)	17,690 (6.69%)	30,500 (6.79%)
Missing	6,494 (22.88%)	68,683 (29.61%)	299,808 (53.14%)	374,985 (45.48%)
Region				
Midwest	3,172 (11.18%)	57,005 (24.58%)	178,502 (31.66%)	238,679 (28.96%)
North East	9,096 (32.05%)	34,777 (15.00%)	129,998 (23.06%)	173,871 (21.10%)
South	9,770 (34.42%)	67,032 (28.91%)	135,681 (24.07%)	212,483 (25.78%)
West	6,346 (22.36%)	73,074 (31.51%)	119,623 (21.22%)	199,043 (24.15%)
Missing	5 (0.02%)	65 (0.03%)	331 (0.06%)	401 (0.05%)
Teaching Type				
Major	4,936 (18.26%)	44,964 (20.75%)	143,372 (26.75%)	193,272 (24.79%)
Minor	11,273 (41.70%)	105,366 (48.63%)	280,176 (52.27%)	396,815 (50.89%)
Non Teaching	10,823 (40.04%)	66,343 (30.62%)	112,489 (20.99%)	189,655 (24.32%)
Missing	1,357 (4.78%)	15,280 (6.59%)	28,098 (4.98%)	44,735 (5.43%)
Institution Bed Size				
Between 1-99 Beds	6,503 (24.10%)	44,969 (21.18%)	84,385 (15.80%)	135,857 (17.57%)
Between 100-399 Beds	10,586 (39.24%)	96,164 (45.29%)	255,420 (47.82%)	362,170 (46.83%)
≥ 400 Beds	9,891 (36.66%)	71,212 (33.54%)	194,293 (36.38%)	275,396 (35.61%)
Missing	1,409 (4.96%)	19,608 (8.45%)	30,037 (5.32%)	51,054 (6.19%)
Year				
2012	159 (1.04%)	456 (2.98%)	14,705 (95.99%)	15,320 (1.86%)
2013	115 (0.35%)	989 (3.02%)	31,630 (96.63%)	32,734 (3.97%)
2014	107 (0.18%)	1,422 (2.43%)	56,926 (97.38%)	58,455 (7.09%)
2015	366 (0.47%)	4,990 (6.47%)	71,737 (93.05%)	77,093 (9.35%)
2016	2,845 (2.71%)	34,894 (33.24%)	67,248 (64.05%)	104,987 (12.73%)
2017	4,055 (3.44%)	39,975 (33.92%)	73,806 (62.63%)	117,836 (14.29%)
2018	5,450 (4.60%)	44,424 (37.48%)	68,647 (57.92%)	118,521 (14.38%)
2019	5,382 (4.54%)	43,759 (36.93%)	69,345 (58.53%)	118,486 (14.37%)
2020	4,996 (4.94%)	35,974 (35.60%)	60,070 (59.45%)	101,040 (12.26%)
2021	4,648 (6.07%)	24,012 (31.35%)	47,942 (62.59%)	76,602 (9.29%)
2022	266 (7.82%)	1,058 (31.09%)	2,079 (61.09%)	3,403 (0.41%)

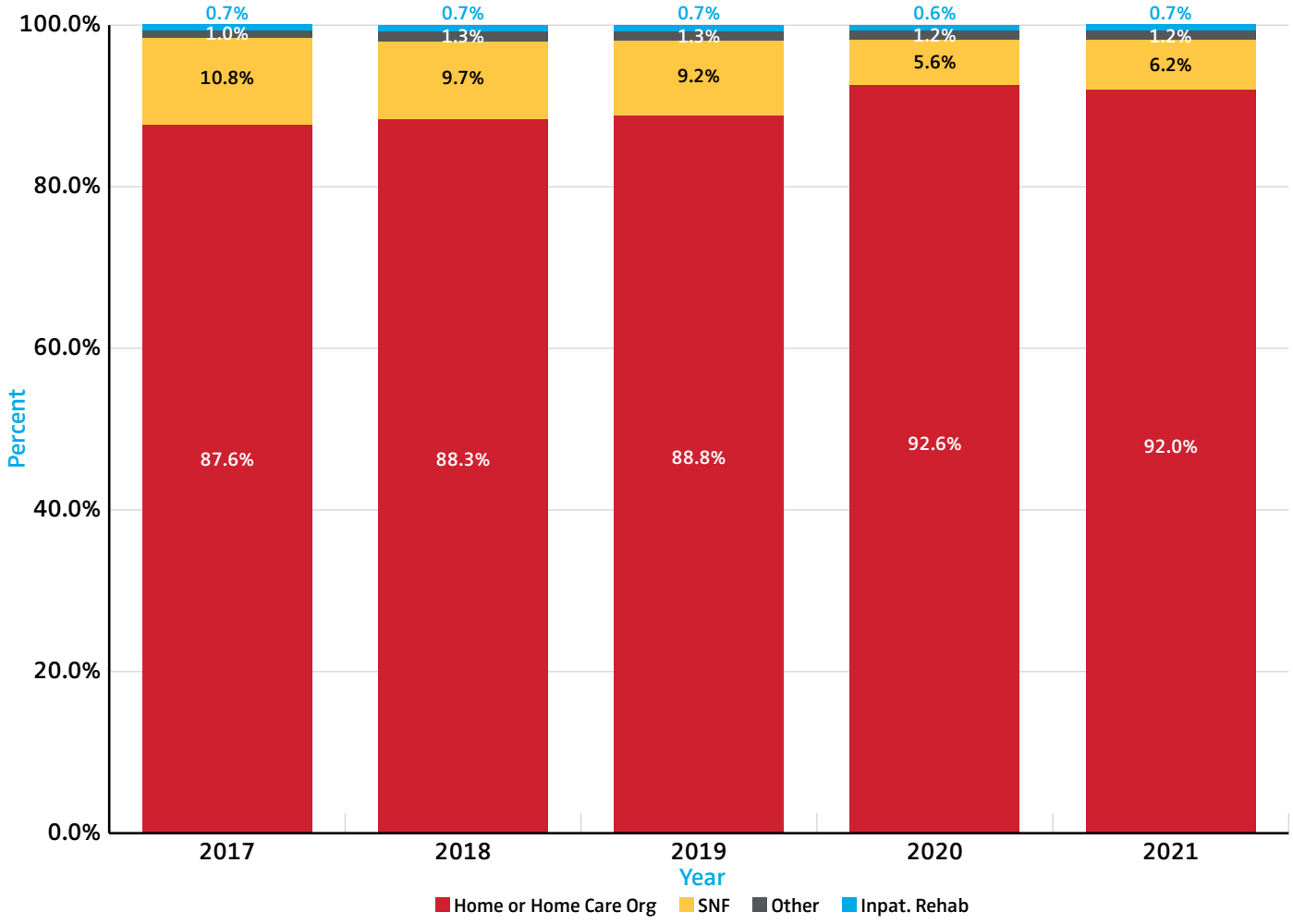
SD=Standard Deviation, NR=Not Reported, BMI=Body Mass Index

Approximately 92% 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.

INSIGHTS

AJRR data can also be used to look at resource utilization and practice trends over time. Figure 2.27 tabulates the discharge disposition reported for elective THA cases for the years 2017 through 2021, 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 over 90% in 2020 and 2021. Discharge to a skilled nursing facility (SNF) is reported in approximately 9% of cases. Other discharge codes represent only a small portion of cases.

Figure 2.27 Total Hip Arthroplasty Discharge Disposition Codes by Year, 2012-2021 (N=433,342)



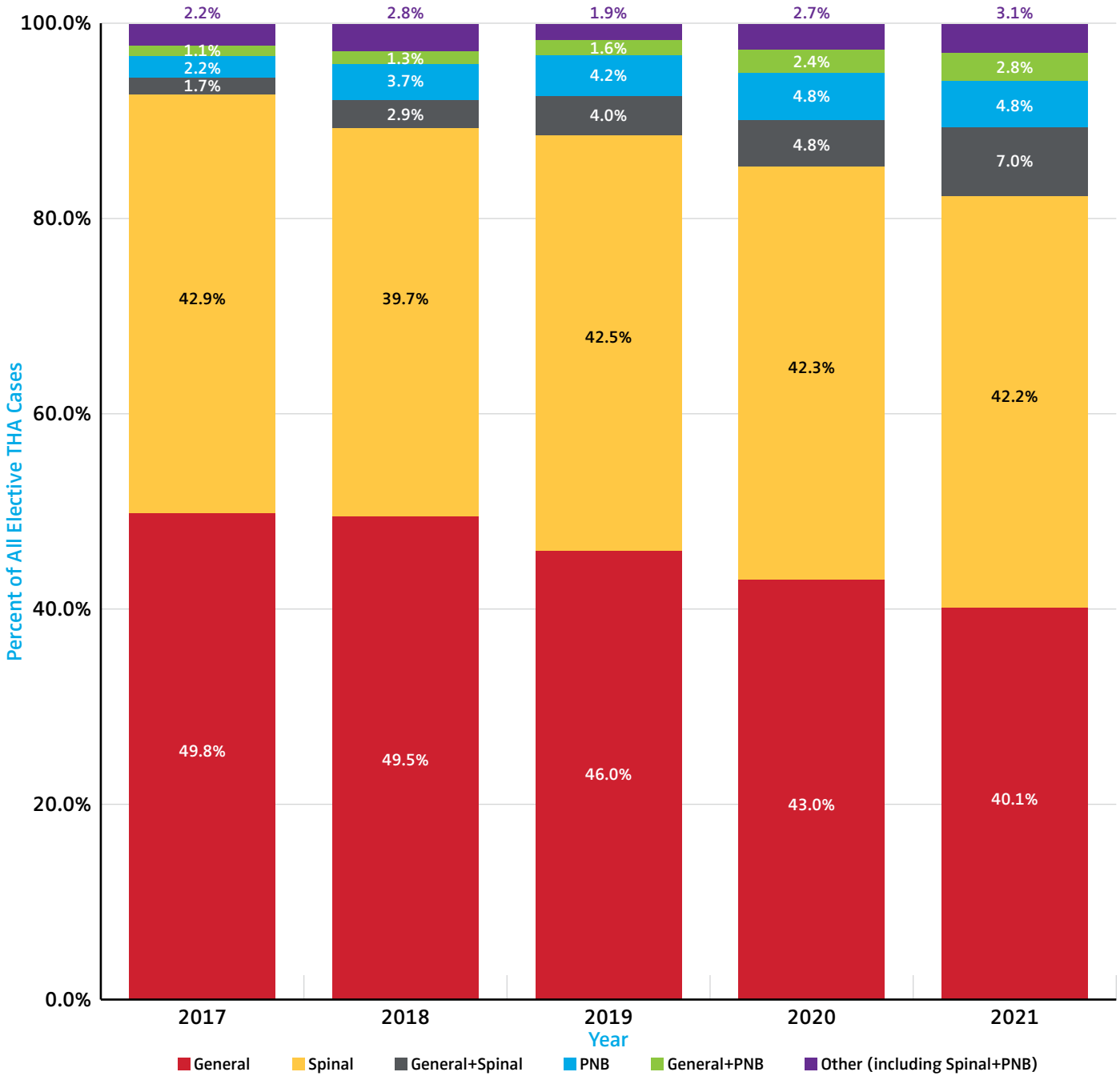
Code	Code Value
Home	Discharged to home/self-care (routine charge).
Home Care Org.	Discharged/transferred to home care of organized home health service organization.
SNF	Discharged/transferred to skilled nursing facility (SNF) with Medicare certification in anticipation of covered skilled care — (For 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.)
Inpat. Rehab	Discharged/transferred to an inpatient rehabilitation facility including distinct units of a hospital (eff. 1/2002).

Figure 2.28 shows a tabulation of the two primary anesthesia techniques chosen for patients undergoing an elective primary total hip arthroplasty. Fewer patients appear to be receiving general anesthesia for primary total hip arthroplasty with increasing use of regional anesthesia over time.

INSIGHTS

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

Figure 2.28 Elective Primary Total Hip Arthroplasty Anesthesia Technique by Year, 2017-2021 (N=298,612)



The AJRR can also be used to follow the utilization of individual implants over time. The following figures provide utilization data of implants used in elective primary total hip arthroplasty procedures in AJRR by year for the years 2012 through 2021. Figure 2.29 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 three years show the Actis Duofix/Pinnacle CoP as the most frequent combination with Accolade II/Trident II combination following in second. Figure 2.30 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 with Actis Duofix reaching a similar rate in 2021. Figure 2.31 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 2.29 Elective Primary Total Hip Arthroplasty Femoral Stem/Acetabular Component Combinations by Year, 2012-2021 (N= 664,995)

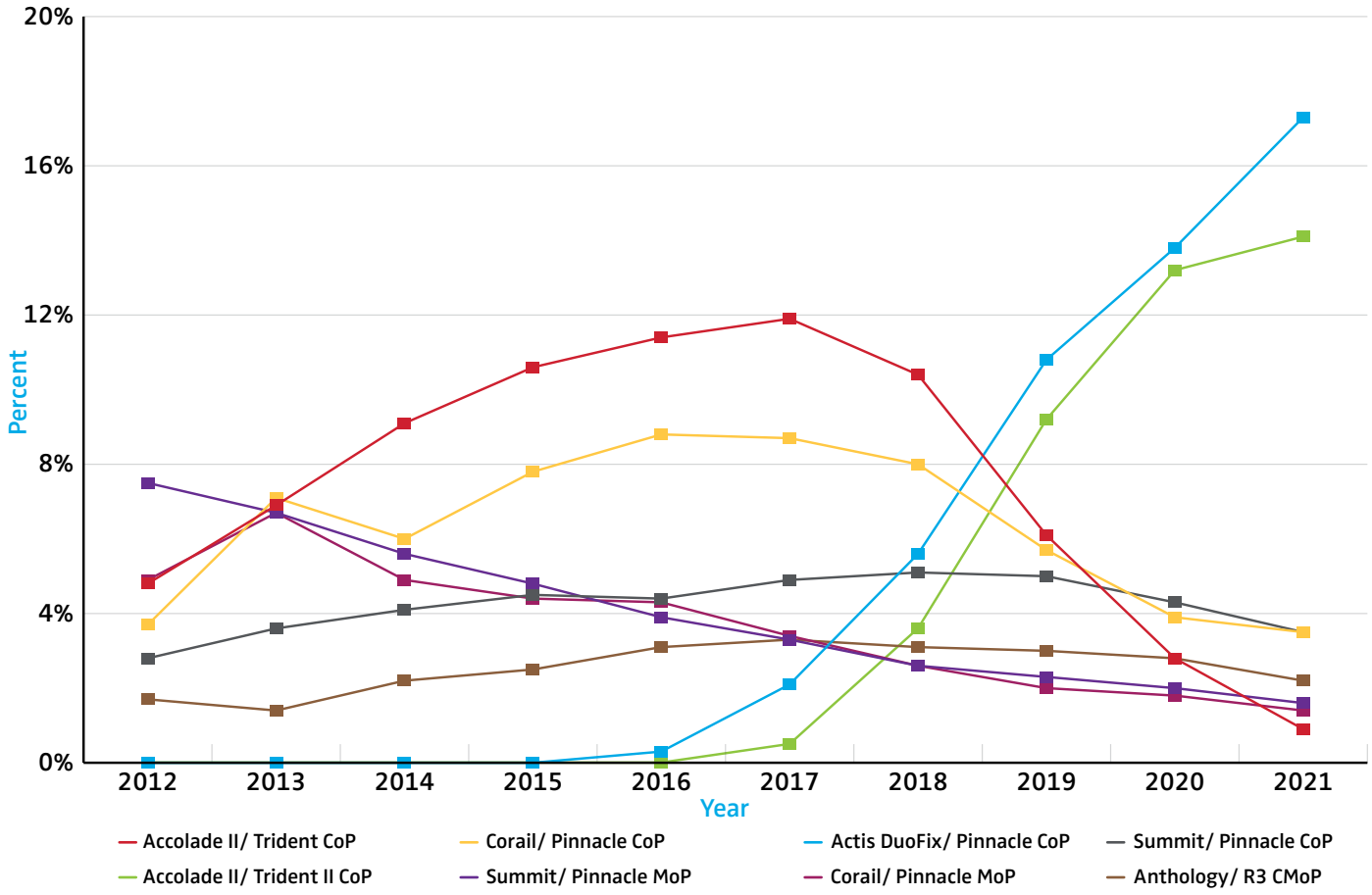


Figure 2.30 Elective Primary Total Hip Arthroplasty Femoral Stem Components by Year, 2012-2021 (N=695,450)

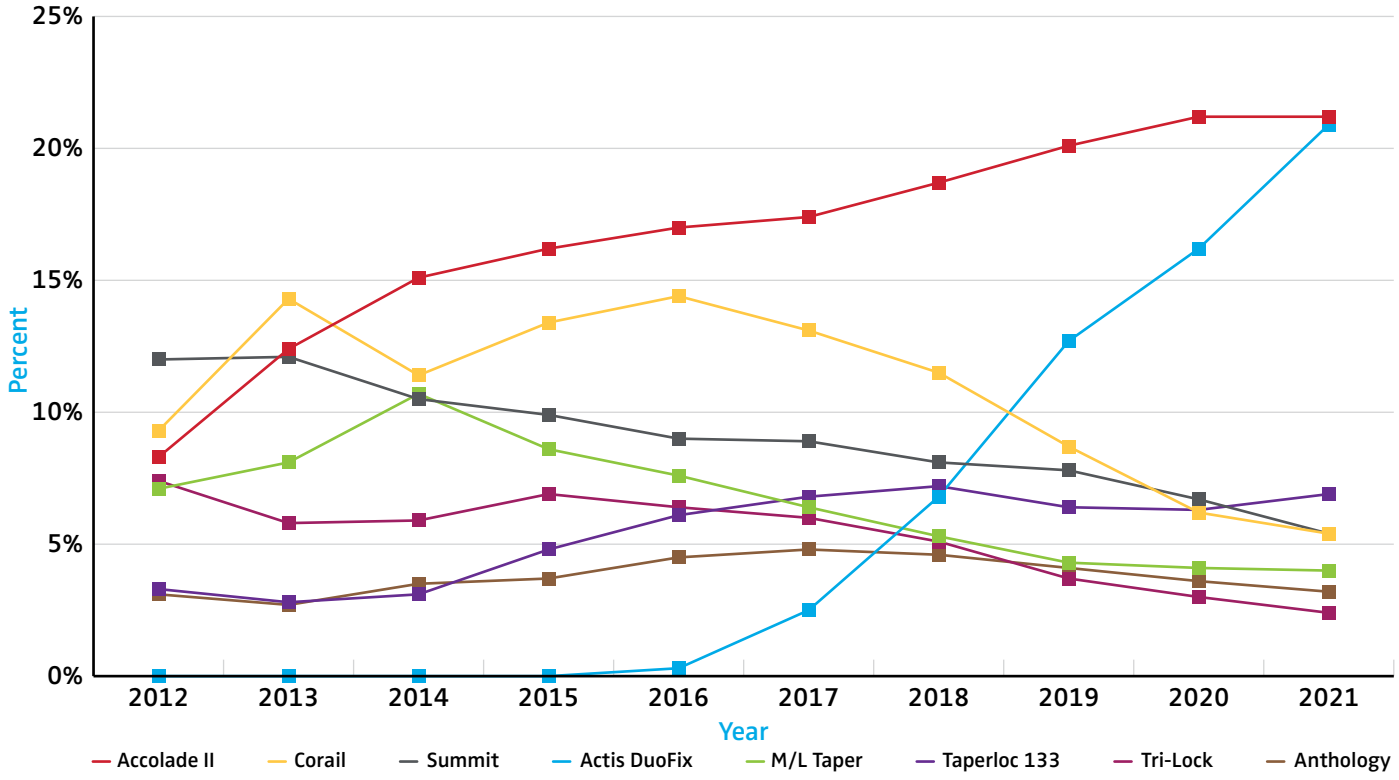
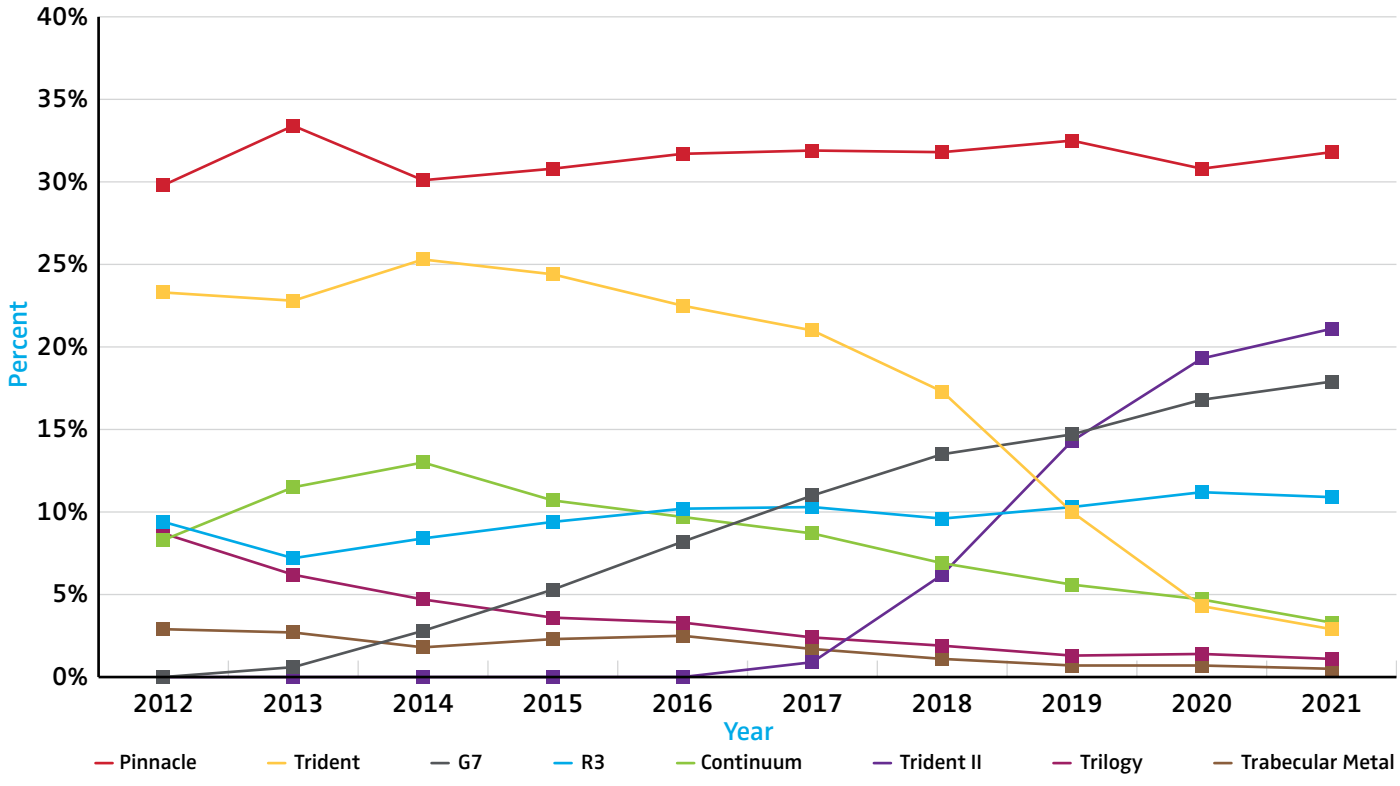


Figure 2.31 Elective Primary Total Hip Arthroplasty Acetabular Components by Year, 2012-2021 (N= 713,567)



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 curves appear 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. The tables below (2.4-2.7) display cumulative percent revision stratified by hip constructs as well as bearing and fixation types with 95% confidence intervals. The aggregate cumulative percent revision of included devices was less than 1.2% at one year and less than 2.1% at seven years for both cementless and cemented devices. It is important to reiterate that this analysis does not adjust for any potential confounders of patient, procedure, or hospital characteristics. Metal-on-metal hip constructs were excluded from all analyses. Cemented acetabular components are utilized very rarely and did not have sufficient procedure volume to be included in this supplement but will be included in future publications if 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.

The aggregate cumulative percent revision of included devices was less than 1.2% at one year and less than 2.1% at seven years for both cementless and cemented hip devices.

Table 2.4 Unadjusted Cumulative Percent Revision of Cementless Hip Arthroplasty Construct Combinations for Primary Total Hip Arthroplasty in Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020

Acetabular Shell	Femoral Stem	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Trident	Accolade II	37,367	787	1.47 (1.35, 1.59)	2.05 (1.9, 2.2)	2.32 (2.16, 2.5)	2.43 (2.25, 2.62)
Pinnacle	Corail	35,617	363	0.71 (0.63, 0.8)	1.01 (0.91, 1.12)	1.16 (1.04, 1.29)	1.21 (1.08, 1.35)
Pinnacle	Summit	25,350	365	1.17 (1.04, 1.31)	1.43 (1.28, 1.59)	1.58 (1.42, 1.76)	1.71 (1.5, 1.94)
Pinnacle	Actis DuoFix	17,265	76	0.45 (0.35, 0.56)	0.52 (0.41, 0.65)	—	—
Pinnacle	Tri-Lock	16,653	224	0.95 (0.81, 1.1)	1.30 (1.13, 1.49)	1.54 (1.34, 1.76)	1.72 (1.43, 2.05)
Trident II	Accolade II	15,182	107	0.75 (0.62, 0.91)	0.81 (0.66, 0.99)	—	—
R3	Anthology	12,655	203	1.34 (1.15, 1.56)	1.65 (1.43, 1.89)	1.77 (1.53, 2.03)	1.87 (1.6, 2.19)
Continuum	M/L Taper	11,618	280	1.77 (1.54, 2.03)	2.30 (2.03, 2.6)	2.70 (2.39, 3.04)	2.79 (2.46, 3.14)
G7	Taperloc 133	11,080	140	1.12 (0.93, 1.33)	1.39 (1.17, 1.65)	1.50 (1.23, 1.81)	1.50 (1.23, 1.81)
G7	Taperloc 133 Microplasty	6,798	98	1.30 (1.04, 1.59)	1.51 (1.24, 1.84)	1.56 (1.27, 1.9)	1.56 (1.27, 1.9)
R3	Synergy	6,437	145	1.92 (1.61, 2.29)	2.33 (1.97, 2.73)	2.50 (2.11, 2.95)	2.50 (2.11, 2.95)
R3	PolarStem	5,565	51	0.84 (0.61, 1.12)	1.10 (0.82, 1.45)	1.10 (0.82, 1.45)	1.10 (0.82, 1.45)
Trilogy	M/L Taper	4,365	102	1.42 (1.1, 1.8)	2.03 (1.63, 2.5)	2.49 (2.02, 3.04)	3.11 (2.43, 3.92)
Pinnacle	S-ROM	3,746	79	1.24 (0.92, 1.64)	2.07 (1.62, 2.6)	2.39 (1.87, 3.01)	3.48 (2.45, 4.78)
Trident	Secur-Fit Max	3,304	79	1.40 (1.04, 1.85)	2.19 (1.73, 2.75)	2.43 (1.92, 3.02)	2.81 (2.16, 3.59)
Trident	Accolade TMZF	2,954	66	1.22 (0.87, 1.67)	1.56 (1.16, 2.06)	2.07 (1.59, 2.65)	2.43 (1.88, 3.09)
G7	Echo Bi-Metric	2,809	29	0.79 (0.51, 1.18)	1.10 (0.75, 1.58)	1.20 (0.81, 1.72)	1.20 (0.81, 1.72)
Continuum	Trabecular Metal	2,773	63	1.85 (1.39, 2.4)	2.26 (1.74, 2.87)	2.42 (1.87, 3.09)	2.42 (1.87, 3.09)
FMP	Linear	2,431	24	0.83 (0.53, 1.26)	0.99 (0.64, 1.46)	1.18 (0.72, 1.85)	1.18 (0.72, 1.85)
Trident	Secur-Fit	2,380	71	1.94 (1.44, 2.56)	2.82 (2.2, 3.57)	3.28 (2.58, 4.1)	3.28 (2.58, 4.1)
R3	Synergy HA	2,212	50	1.65 (1.17, 2.25)	2.10 (1.55, 2.78)	2.44 (1.82, 3.22)	2.68 (1.94, 3.6)
Trident	Secur-Fit Plus Max	1,956	39	1.43 (0.98, 2.04)	1.94 (1.39, 2.64)	1.94 (1.39, 2.64)	2.07 (1.48, 2.82)
G7	M/L Taper	1,730	22	1.23 (0.77, 1.86)	1.41 (0.91, 2.11)	1.41 (0.91, 2.11)	—

Table 2.4 Continued on the next page

Table 2.4 Unadjusted Cumulative Percent Revision of Cementless Hip Arthroplasty Construct Combinations for Primary Total Hip Arthroplasty in Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020 *(Continued)*

Acetabular Shell	Femoral Stem	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Trabecular Metal	M/L Taper	1,628	41	1.91 (1.33, 2.67)	2.32 (1.66, 3.15)	2.51 (1.78, 3.44)	3.96 (2.35, 6.19)
Mallory Head	Taperloc 133	1,541	17	0.86 (0.48, 1.44)	1.10 (0.66, 1.75)	1.22 (0.74, 1.93)	1.22 (0.74, 1.93)
G7	Avenir-Muller	1,438	14	0.78 (0.42, 1.36)	0.99 (0.55, 1.66)	—	—
Continuum	Avenir-Muller	1,392	32	1.94 (1.31, 2.78)	2.36 (1.65, 3.28)	2.36 (1.65, 3.28)	2.36 (1.65, 3.28)
Continuum	VerSys	1,290	25	1.11 (0.64, 1.82)	1.96 (1.27, 2.88)	2.22 (1.47, 3.23)	2.22 (1.47, 3.23)
Trilogy	VerSys	1,287	28	1.33 (0.81, 2.09)	1.78 (1.15, 2.65)	2.47 (1.67, 3.52)	2.47 (1.67, 3.52)
Continuum	Fitmore	1,282	37	2.27 (1.56, 3.2)	2.68 (1.89, 3.68)	2.95 (2.09, 4.03)	3.21 (2.25, 4.43)
FMP	TaperFill	1,244	16	0.97 (0.54, 1.66)	1.42 (0.84, 2.26)	1.42 (0.84, 2.26)	—
Trident	Citation	1,175	45	2.64 (1.84, 3.68)	3.36 (2.43, 4.51)	3.57 (2.6, 4.76)	4.17 (3.02, 5.59)
Continuum	Accolade II	1,101	20	1.78 (1.11, 2.72)	1.90 (1.2, 2.87)	1.90 (1.2, 2.87)	1.90 (1.2, 2.87)
Continuum	Taperloc 133	1,086	16	1.03 (0.55, 1.78)	1.34 (0.77, 2.2)	1.76 (1.01, 2.87)	—
Trident II	Corail	1,005	6	0.63 (0.26, 1.31)	—	—	—
Trident	ABG II	941	23	2.35 (1.52, 3.47)	2.35 (1.52, 3.47)	2.52 (1.64, 3.7)	2.52 (1.64, 3.7)
Novation	Alteon	919	19	1.64 (0.96, 2.64)	2.22 (1.38, 3.4)	2.22 (1.38, 3.4)	—
Restoration ADM	Accolade II	871	10	0.94 (0.45, 1.79)	1.24 (0.64, 2.22)	1.24 (0.64, 2.22)	1.24 (0.64, 2.22)
Trinity	TriFit TS	834	16	1.41 (0.75, 2.44)	2.42 (1.41, 3.87)	2.42 (1.41, 3.87)	2.42 (1.41, 3.87)
G7	Corail	796	7	0.76 (0.32, 1.58)	0.76 (0.32, 1.58)	1.21 (0.45, 2.69)	—
RingLoc+	Taperloc 133	755	20	1.59 (0.87, 2.69)	2.44 (1.5, 3.74)	2.61 (1.63, 3.98)	2.61 (1.63, 3.98)
R3	Corail	706	3	0.28 (0.06, 0.97)	0.43 (0.12, 1.18)	0.43 (0.12, 1.18)	—
R3	Echelon	695	17	1.31 (0.65, 2.4)	2.25 (1.28, 3.68)	3.50 (1.91, 5.86)	3.50 (1.91, 5.86)
Escalade Acetabular System	Ovation Hip Stem	688	8	1.02 (0.46, 2.02)	1.18 (0.56, 2.24)	1.18 (0.56, 2.24)	1.18 (0.56, 2.24)
Continuum	M/L Taper Kinectiv	672	18	1.80 (0.98, 3.04)	2.48 (1.48, 3.91)	2.72 (1.64, 4.24)	3.12 (1.86, 4.89)
Versafitcup DM	AMIStem-H	670	13	1.64 (0.87, 2.84)	1.94 (1.09, 3.21)	1.94 (1.09, 3.21)	1.94 (1.09, 3.21)
Pinnacle	AML	668	15	0.91 (0.38, 1.89)	2.05 (1.15, 3.39)	2.43 (1.42, 3.89)	2.43 (1.42, 3.89)
Trident II	Secur-Fit	600	10	1.77 (0.91, 3.13)	1.77 (0.91, 3.13)	—	—
Restoration ADM	Novation	589	5	0.68 (0.23, 1.65)	0.68 (0.23, 1.65)	0.86 (0.33, 1.91)	0.86 (0.33, 1.91)
Trabecular Metal	Trabecular Metal	582	12	1.58 (0.78, 2.88)	2.02 (1.07, 3.5)	2.30 (1.25, 3.9)	2.30 (1.25, 3.9)
Trabecular Metal	VerSys	579	11	1.56 (0.77, 2.84)	1.92 (1.02, 3.31)	1.92 (1.02, 3.31)	1.92 (1.02, 3.31)
Regenerex RingLoc+	Taperloc 133	569	15	2.33 (1.3, 3.84)	2.56 (1.47, 4.16)	2.98 (1.7, 4.85)	2.98 (1.7, 4.85)
Consensus	TaperSet	528	12	1.52 (0.72, 2.86)	2.49 (1.35, 4.2)	2.49 (1.35, 4.2)	2.49 (1.35, 4.2)
Dynasty BioFoam	ProFemur Gladiator	517	11	1.77 (0.88, 3.22)	2.07 (1.05, 3.67)	2.59 (1.3, 4.63)	2.59 (1.3, 4.63)
Provident	Provident	512	10	1.57 (0.74, 2.97)	1.79 (0.88, 3.25)	2.11 (1.07, 3.75)	2.11 (1.07, 3.75)
Mpact	MasterLoc	509	7	1.39 (0.62, 2.73)	1.39 (0.62, 2.73)	—	—
G7	Fitmore	508	5	1.10 (0.42, 2.44)	1.10 (0.42, 2.44)	1.10 (0.42, 2.44)	—
Restoration ADM	Secur-Fit Plus Max	505	22	2.97 (1.74, 4.73)	4.37 (2.82, 6.42)	4.37 (2.82, 6.42)	—
Trident II	Secur-Fit Max	474	7	1.31 (0.55, 2.71)	—	—	—
Trident II	Actis DuoFix	428	1	0.24 (0.02, 1.26)	0.24 (0.02, 1.26)	—	—
Continuum	Taperloc 133 Microplasty	425	5	0.98 (0.33, 2.37)	1.27 (0.48, 2.81)	1.27 (0.48, 2.81)	—
Dynasty BioFoam	ProFemur Z	419	27	4.31 (2.65, 6.57)	6.02 (4.01, 8.6)	6.65 (4.49, 9.38)	6.65 (4.49, 9.38)
G7	Trabecular Metal	405	4	0.77 (0.22, 2.11)	1.47 (0.42, 3.87)	1.47 (0.42, 3.87)	—
RingLoc+	Echo Bi-Metric	402	9	1.99 (0.94, 3.74)	1.99 (0.94, 3.74)	2.26 (1.11, 4.09)	2.26 (1.11, 4.09)
Overall	—	266,295	4,112	1.18(1.14, 1.22)	1.57 (1.53, 1.63)	1.80 (1.74, 1.86)	2.07 (1.97, 2.18)

Table 2.5 Unadjusted Cumulative Percent Revision of Cementless Stems in Hip Arthroplasty Constructs for Primary Total Hip Arthroplasty in Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020

Femoral Stem	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Accolade II	54,976	952	1.32 (1.23, 1.42)	1.83 (1.72, 1.96)	2.10 (1.96, 2.25)	2.20 (2.04, 2.37)
Corail	38,509	382	0.70 (0.62, 0.79)	0.99 (0.89, 1.09)	1.14 (1.02, 1.26)	1.18 (1.05, 1.32)
Summit	26,211	375	1.16 (1.03, 1.3)	1.42 (1.28, 1.57)	1.57 (1.41, 1.74)	1.71 (1.5, 1.93)
M/L Taper	19,957	465	1.66 (1.49, 1.85)	2.21 (2, 2.43)	2.58 (2.35, 2.84)	2.93 (2.62, 3.26)
Actis DuoFix	18,126	81	0.46 (0.36, 0.57)	0.52 (0.41, 0.65)	—	—
Taperloc 133	17,320	242	1.17 (1.01, 1.34)	1.48 (1.29, 1.68)	1.64 (1.43, 1.88)	1.64 (1.43, 1.88)
Tri-Lock	17,086	231	0.96 (0.82, 1.11)	1.31 (1.14, 1.49)	1.54 (1.34, 1.76)	1.75 (1.46, 2.08)
Anthology	13,148	209	1.33 (1.14, 1.54)	1.64 (1.42, 1.87)	1.75 (1.52, 2.01)	1.86 (1.58, 2.16)
Taperloc 133 Microplasty	8,535	120	1.20 (0.98, 1.45)	1.48 (1.23, 1.76)	1.55 (1.28, 1.86)	1.55 (1.28, 1.86)
Synergy	6,886	158	1.94 (1.63, 2.3)	2.36 (2.01, 2.76)	2.56 (2.17, 2.99)	2.56 (2.17, 2.99)
PolarStem	6,009	57	0.88 (0.66, 1.16)	1.13 (0.85, 1.46)	1.13 (0.85, 1.46)	1.13 (0.85, 1.46)
Echo Bi-Metric	4,432	76	1.26 (0.96, 1.62)	1.76 (1.38, 2.21)	2.00 (1.57, 2.53)	2.12 (1.64, 2.69)
Trabecular Metal	4,276	97	1.79 (1.43, 2.23)	2.31 (1.88, 2.8)	2.45 (1.99, 2.98)	2.45 (1.99, 2.98)
Secur-Fit Max	4,094	91	1.37 (1.05, 1.77)	2.19 (1.75, 2.7)	2.41 (1.94, 2.95)	2.74 (2.15, 3.44)
S-ROM	4,063	86	1.27 (0.95, 1.65)	2.10 (1.66, 2.61)	2.40 (1.9, 2.99)	3.42 (2.44, 4.65)
VerSys	3,419	71	1.31 (0.96, 1.74)	1.94 (1.5, 2.46)	2.32 (1.82, 2.92)	2.53 (1.91, 3.28)
Avenir-Muller	3,310	54	1.34 (0.99, 1.78)	1.66 (1.25, 2.16)	1.84 (1.37, 2.41)	1.84 (1.37, 2.41)
Secur-Fit	3,200	87	1.94 (1.5, 2.47)	2.70 (2.15, 3.34)	3.18 (2.55, 3.91)	3.18 (2.55, 3.91)
Accolade TMZF	3,118	68	1.22 (0.88, 1.65)	1.55 (1.16, 2.03)	2.02 (1.56, 2.58)	2.36 (1.84, 2.99)
Linear	3,086	29	0.73 (0.47, 1.09)	1.05 (0.7, 1.51)	1.21 (0.78, 1.8)	1.21 (0.78, 1.8)
Secur-Fit Plus Max	2,776	66	1.71 (1.27, 2.25)	2.37 (1.84, 3.01)	2.44 (1.89, 3.08)	2.55 (1.97, 3.25)
Synergy HA	2,432	51	1.54 (1.1, 2.09)	1.95 (1.45, 2.57)	2.27 (1.69, 2.98)	2.49 (1.8, 3.36)
Fitmore	2,100	52	1.94 (1.41, 2.61)	2.32 (1.73, 3.05)	2.53 (1.88, 3.32)	3.26 (2.28, 4.51)
TaperFill	1,548	18	0.92 (0.53, 1.51)	1.31 (0.8, 2.05)	1.31 (0.8, 2.05)	—
ABG II	1,370	32	2.14 (1.47, 3.02)	2.23 (1.54, 3.13)	2.64 (1.79, 3.76)	2.64 (1.79, 3.76)
Novation	1,317	17	0.61 (0.29, 1.16)	0.69 (0.34, 1.27)	1.50 (0.9, 2.36)	1.50 (0.9, 2.36)
Citation	1,302	45	2.40 (1.67, 3.35)	3.11 (2.25, 4.19)	3.33 (2.43, 4.45)	3.93 (2.83, 5.29)
AMIStem-H	1,255	23	1.27 (0.76, 2.02)	1.59 (1.01, 2.41)	1.97 (1.28, 2.92)	1.97 (1.28, 2.92)
M/L Taper Kinectiv	1,075	28	1.51 (0.9, 2.4)	2.43 (1.6, 3.54)	2.90 (1.94, 4.16)	3.21 (2.12, 4.65)
Ovation Hip Stem	1,054	10	0.86 (0.43, 1.58)	0.99 (0.51, 1.76)	0.99 (0.51, 1.76)	0.99 (0.51, 1.76)
Alteon	978	19	1.56 (0.91, 2.5)	2.13 (1.32, 3.27)	2.13 (1.32, 3.27)	—
TriFit TS	910	16	1.28 (0.68, 2.23)	2.19 (1.28, 3.5)	2.19 (1.28, 3.5)	2.19 (1.28, 3.5)
ProFemur Gladiator	878	17	1.63 (0.94, 2.66)	1.96 (1.16, 3.12)	2.25 (1.33, 3.58)	2.25 (1.33, 3.58)
AML	732	17	0.97 (0.43, 1.91)	2.00 (1.15, 3.25)	2.51 (1.52, 3.92)	2.51 (1.52, 3.92)
Echelon	730	19	1.53 (0.81, 2.64)	2.42 (1.43, 3.83)	3.61 (2.04, 5.88)	3.61 (2.04, 5.88)
Alpine	721	7	0.28 (0.06, 0.95)	0.72 (0.28, 1.61)	1.21 (0.53, 2.44)	—
Taperloc	658	22	2.44 (1.45, 3.84)	2.79 (1.72, 4.29)	3.38 (2.15, 5.03)	3.65 (2.34, 5.4)
Provident	559	13	1.62 (0.8, 2.95)	2.02 (1.07, 3.48)	2.75 (1.49, 4.66)	2.75 (1.49, 4.66)
MasterLoc	538	7	1.32 (0.59, 2.59)	1.32 (0.59, 2.59)	—	—
TaperSet	537	12	1.49 (0.71, 2.81)	2.44 (1.33, 4.12)	2.44 (1.33, 4.12)	2.44 (1.33, 4.12)
Mallory-Head	520	9	1.18 (0.49, 2.45)	1.62 (0.76, 3.05)	1.94 (0.95, 3.57)	1.94 (0.95, 3.57)
ProFemur Z	515	28	3.52 (2.16, 5.38)	4.99 (3.32, 7.15)	5.54 (3.74, 7.84)	6.14 (4.08, 8.79)
ProFemur Renaissance	462	10	0.65 (0.18, 1.79)	1.33 (0.55, 2.74)	2.12 (1.05, 3.87)	2.48 (1.26, 4.4)
Taperloc Complete XR	454	6	0.66 (0.19, 1.82)	1.74 (0.7, 3.65)	1.74 (0.7, 3.65)	1.74 (0.7, 3.65)
Overall	285,182	4,475	1.19 (1.15, 1.23)	1.59 (1.55, 1.64)	1.83 (1.77, 1.89)	2.01 (1.93, 2.08)

Table 2.6 Unadjusted Cumulative Percent Revision of Cementless Acetabular Components in Hip Arthroplasty Constructs for Primary Total Hip Arthroplasty in Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020

Acetabular Shell	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Pinnacle	103,134	1,178	0.85 (0.79, 0.91)	1.17 (1.1, 1.24)	1.36 (1.28, 1.45)	1.50 (1.39, 1.62)
Trident	54,709	1,195	1.49 (1.39, 1.59)	2.07 (1.95, 2.19)	2.35 (2.22, 2.49)	2.56 (2.4, 2.73)
G7	32,020	394	1.08 (0.97, 1.2)	1.35 (1.22, 1.49)	1.44 (1.29, 1.61)	1.44 (1.29, 1.61)
R3	31,368	529	1.38 (1.25, 1.51)	1.75 (1.61, 1.91)	1.96 (1.79, 2.15)	2.05 (1.85, 2.26)
Continuum	24,950	566	1.70 (1.54, 1.86)	2.19 (2.01, 2.38)	2.51 (2.3, 2.73)	2.63 (2.41, 2.87)
Trident II	20,118	156	0.81 (0.68, 0.94)	0.91 (0.77, 1.08)	—	—
Trilogy	8,151	187	1.38 (1.14, 1.66)	1.96 (1.67, 2.29)	2.48 (2.13, 2.87)	2.82 (2.4, 3.28)
Trabecular Metal	4,810	111	1.63 (1.3, 2.02)	2.04 (1.66, 2.48)	2.46 (2.02, 2.96)	2.94 (2.32, 3.68)
FMP	3,867	41	0.86 (0.61, 1.2)	1.10 (0.8, 1.49)	1.25 (0.86, 1.76)	1.25 (0.86, 1.76)
Restoration ADM	2,974	52	1.29 (0.93, 1.76)	1.73 (1.29, 2.26)	1.83 (1.38, 2.39)	2.14 (1.46, 3.04)
Dynasty BioFoam	2,154	65	1.84 (1.33, 2.48)	2.86 (2.2, 3.66)	3.40 (2.62, 4.32)	3.57 (2.74, 4.57)
Mallory Head	2,048	23	0.79 (0.47, 1.26)	1.14 (0.73, 1.69)	1.22 (0.79, 1.8)	1.22 (0.79, 1.8)
RingLoc+	1,829	40	1.37 (0.91, 1.99)	1.89 (1.33, 2.6)	2.14 (1.54, 2.9)	2.29 (1.64, 3.12)
Novation	1,823	31	1.38 (0.92, 2)	1.82 (1.26, 2.56)	1.82 (1.26, 2.56)	1.82 (1.26, 2.56)
Trinity	1,782	28	1.28 (0.83, 1.9)	1.85 (1.24, 2.66)	1.85 (1.24, 2.66)	1.85 (1.24, 2.66)
Mpact	1,701	28	1.31 (0.85, 1.95)	1.87 (1.25, 2.69)	1.87 (1.25, 2.69)	1.87 (1.25, 2.69)
Regenerex RingLoc+	1,458	33	1.52 (0.98, 2.26)	1.90 (1.29, 2.72)	2.54 (1.77, 3.53)	2.54 (1.77, 3.53)
Escalade Acetabular System	1,207	11	0.66 (0.32, 1.27)	0.84 (0.43, 1.5)	0.96 (0.51, 1.67)	0.96 (0.51, 1.67)
Versafitcup DM	989	23	1.72 (1.04, 2.68)	2.13 (1.36, 3.18)	2.25 (1.46, 3.34)	2.58 (1.62, 3.89)
Ranawat-Burstein	939	22	1.92 (1.18, 2.96)	2.30 (1.47, 3.44)	2.54 (1.62, 3.79)	2.54 (1.62, 3.79)
Interface Acetabular System	864	18	1.05 (0.52, 1.92)	1.83 (1.07, 2.94)	2.48 (1.49, 3.89)	2.48 (1.49, 3.89)
Escalade Legend	745	6	0.82 (0.34, 1.71)	0.82 (0.34, 1.71)	—	—
Consensus	712	16	1.40 (0.72, 2.49)	2.12 (1.21, 3.45)	2.73 (1.57, 4.42)	2.73 (1.57, 4.42)
Restoris PST	704	34	3.69 (2.48, 5.28)	3.98 (2.71, 5.61)	4.74 (3.33, 6.51)	4.98 (3.51, 6.81)
Universal	662	10	0.91 (0.38, 1.89)	1.61 (0.82, 2.85)	1.61 (0.82, 2.85)	1.61 (0.82, 2.85)
Logical Equator	655	10	1.62 (0.83, 2.88)	1.62 (0.83, 2.88)	1.62 (0.83, 2.88)	—
Reflection	615	16	1.96 (1.07, 3.31)	2.57 (1.5, 4.12)	2.86 (1.69, 4.53)	2.86 (1.69, 4.53)
EMPOWR	550	1	0.19 (0.02, 1.01)	—	—	—
Klassic HD	542	5	0.76 (0.26, 1.85)	0.76 (0.26, 1.85)	1.51 (0.44, 3.95)	—
Provident	524	10	1.54 (0.73, 2.9)	1.75 (0.86, 3.18)	2.06 (1.05, 3.66)	2.06 (1.05, 3.66)
Legend	481	5	0.65 (0.18, 1.78)	1.67 (0.53, 4.11)	—	—
Converge	476	10	1.47 (0.66, 2.89)	2.10 (1.08, 3.71)	2.10 (1.08, 3.71)	2.10 (1.08, 3.71)
Procotyl Prime	476	5	0.89 (0.3, 2.14)	1.45 (0.49, 3.45)	—	—
Overall	311,600	4,895	1.18 (1.14, 1.22)	1.60 (1.55, 1.64)	1.85 (1.79, 1.90)	2.01 (1.94, 2.09)

Table 2.7 Unadjusted Cumulative Percent Revision of Cemented Stems in Hip Arthroplasty Constructs for Primary Total Hip Arthroplasty in Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020

Femoral Stem	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Summit	2,024	33	0.97 (0.61, 1.49)	1.57 (1.07, 2.25)	2.32 (1.51, 3.42)	2.57 (1.66, 3.79)
Accolade C	1,721	20	0.74 (0.4, 1.26)	1.23 (0.75, 1.91)	1.71 (0.96, 2.83)	1.71 (0.96, 2.83)
Exeter	1,319	18	0.93 (0.51, 1.58)	1.36 (0.8, 2.16)	1.73 (1.03, 2.74)	1.73 (1.03, 2.74)
VerSys Advocate	1,312	19	0.93 (0.51, 1.58)	1.39 (0.84, 2.18)	1.63 (1.01, 2.5)	1.63 (1.01, 2.5)
Avenir	1,311	10	0.56 (0.25, 1.12)	1.06 (0.52, 1.97)	1.06 (0.52, 1.97)	—
VerSys	1,277	24	1.37 (0.83, 2.14)	1.57 (0.98, 2.39)	2.50 (1.57, 3.77)	2.50 (1.57, 3.77)
Synergy	1,194	18	1.18 (0.67, 1.97)	1.62 (0.98, 2.53)	1.84 (1.11, 2.89)	1.84 (1.11, 2.89)
Omnifit	918	12	0.79 (0.35, 1.56)	1.09 (0.54, 2.01)	1.65 (0.89, 2.84)	1.65 (0.89, 2.84)
C-Stem	649	5	0.83 (0.32, 1.84)	0.83 (0.32, 1.84)	0.83 (0.32, 1.84)	0.83 (0.32, 1.84)
Spectron	541	11	1.51 (0.71, 2.85)	2.04 (1.04, 3.63)	2.62 (1.29, 4.74)	—
Echo FX	406	3	0.25 (0.02, 1.33)	0.59 (0.12, 1.99)	1.57 (0.33, 4.93)	1.57 (0.33, 4.93)
Overall	12,672	173	0.93 (0.77, 1.11)	1.35 (1.15, 1.58)	1.82 (1.54, 2.14)	1.86 (1.57, 2.19)

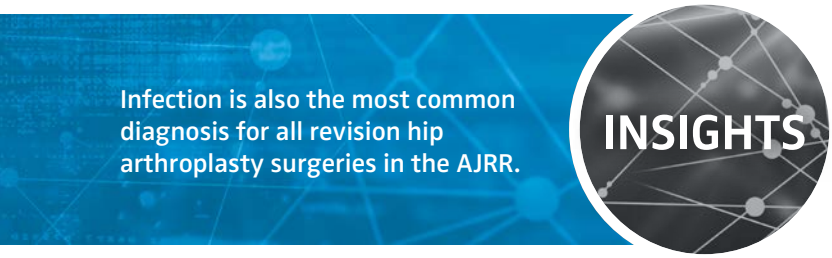
Revision Hip Arthroplasty

Between 2012 and 2021, AJRR has collected data on 103,514 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. AJRR continues to refine the way that revision procedures are classified in an attempt to improve the 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.

The most common reason for hip revision surgery overall was infection at 21.2% (Figure 2.32). 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 5,992 early ''linked'' revision procedures in AJRR (Table 2.8). 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.[12] Among early revisions, 3,912 had a primary diagnosis that was relevant using the methodology above. For all early revisions, the primary reason was again infection (34.0%) followed by fracture (26.1%) (Figure 2.33).



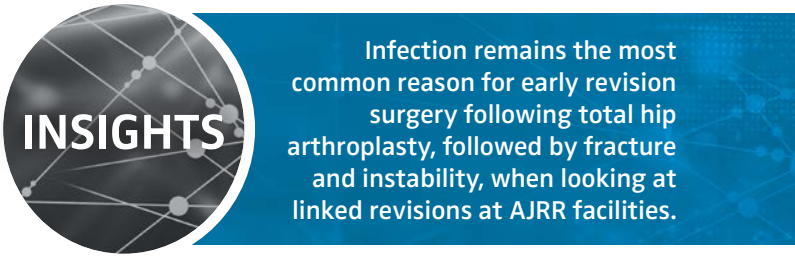


Figure 2.32 Distribution of Diagnosis Associated with All Hip Revisions, 2012-2021 (N=81,871)

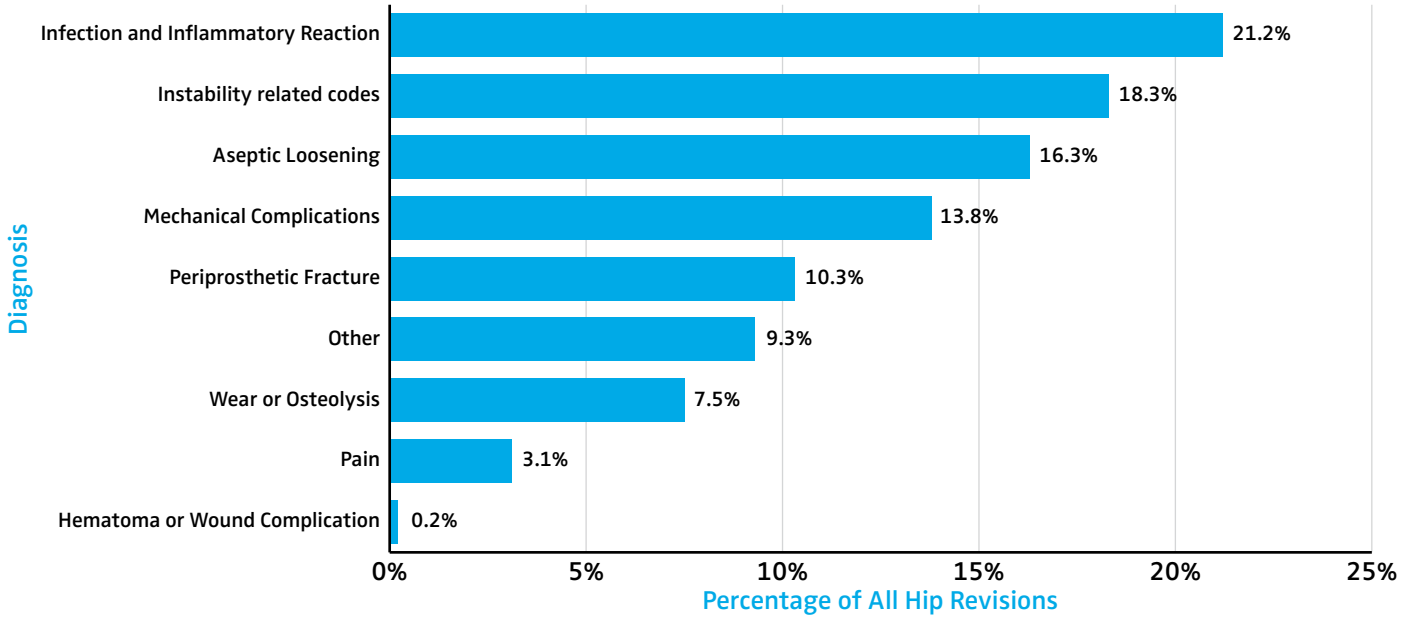
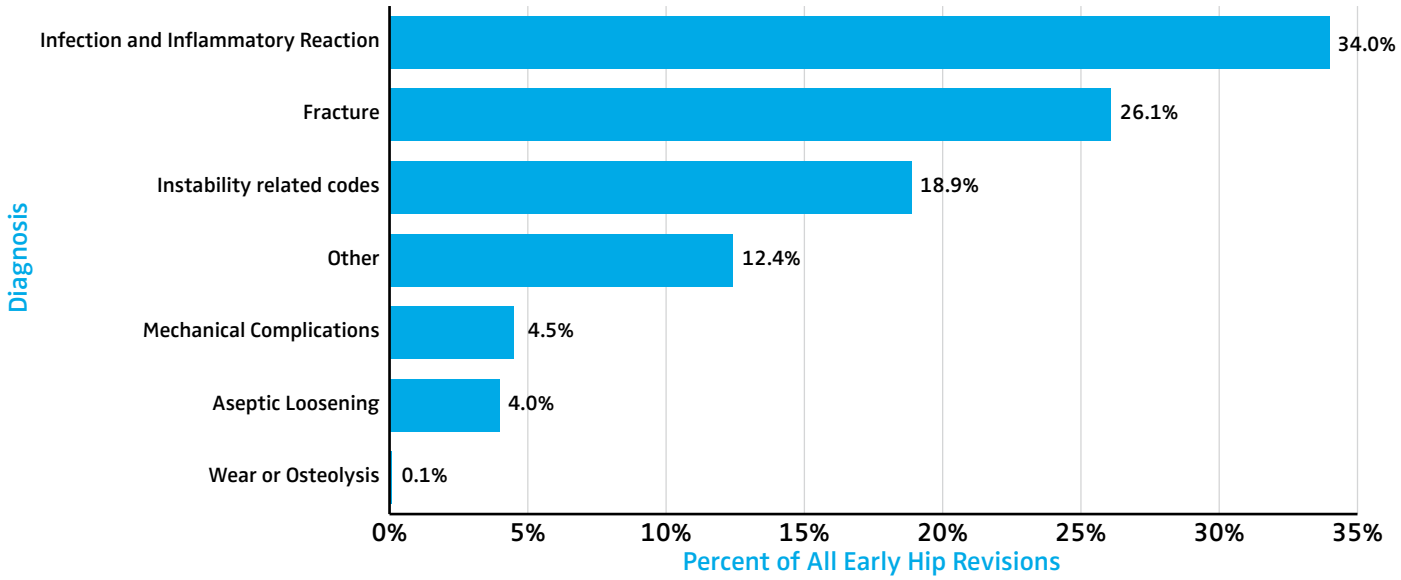


Table 2.8 Distribution of Time Interval Between Elective Primary Hip Arthroplasty Procedures and Revision for Linked Patients, 2012-2021*

Time	Frequency	Percent
<3 Months	5,992	50.3
3-5 Months	1,289	10.8
6-12 Months	1,408	11.8
>1 Year	3,235	27.1

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

Figure 2.33 Distribution of Diagnosis Associated With all Early "Linked" Hip Revisions, 2012-2021 (N=3,912)*



**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 2.34). When trending the percentage of all hip arthroplasty revisions with a primary diagnosis of infection, the percentage varies from 14.9-25.3% over the years 2012-2021 (Figure 2.35). Similarly, for hip revisions due to instability/dislocation, the value appears to be increasing before dropping off in 2018 and leveling off through 2021 (Figure 2.36). As AJRR collects historical data, these numbers could change with further data collection.

Figure 2.34 Early "Linked" Revisions as a Percent of Elective Primary Hip Arthroplasty Procedures by Age Group, 2012-2021 (N=5,992)

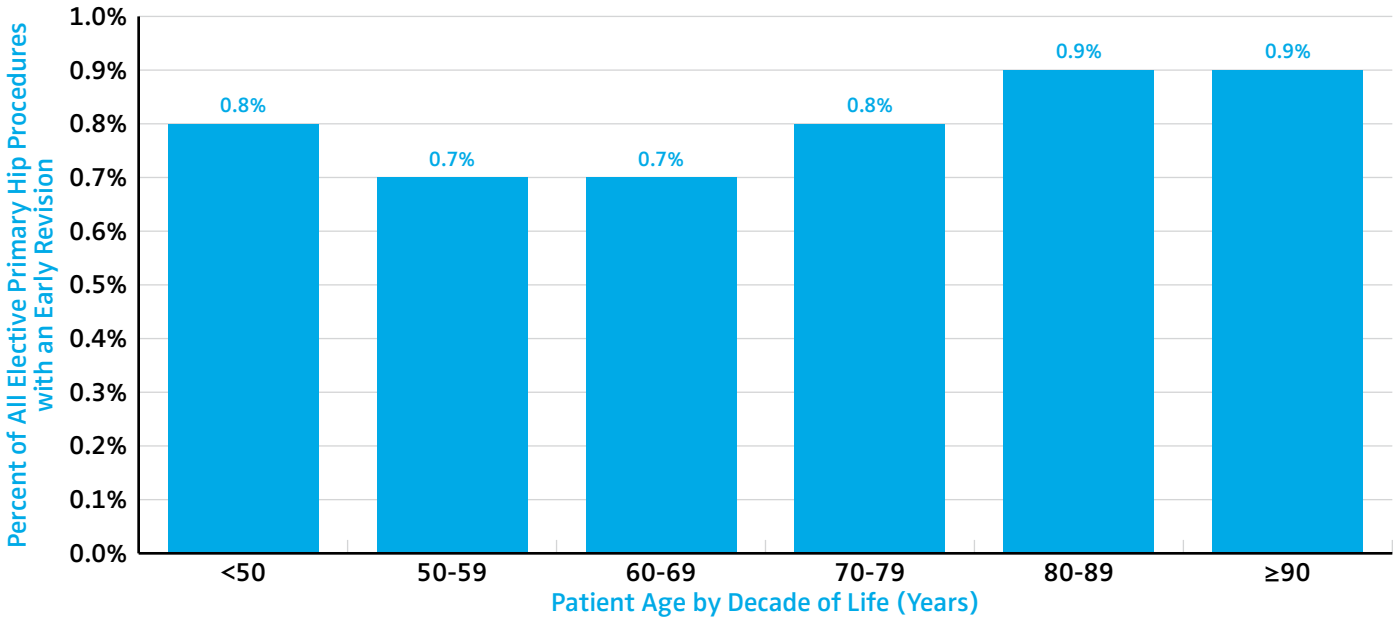


Figure 2.35 Revisions Due to Infection as a Percentage of All Hip Revisions, 2012-2021 (N=17,388)

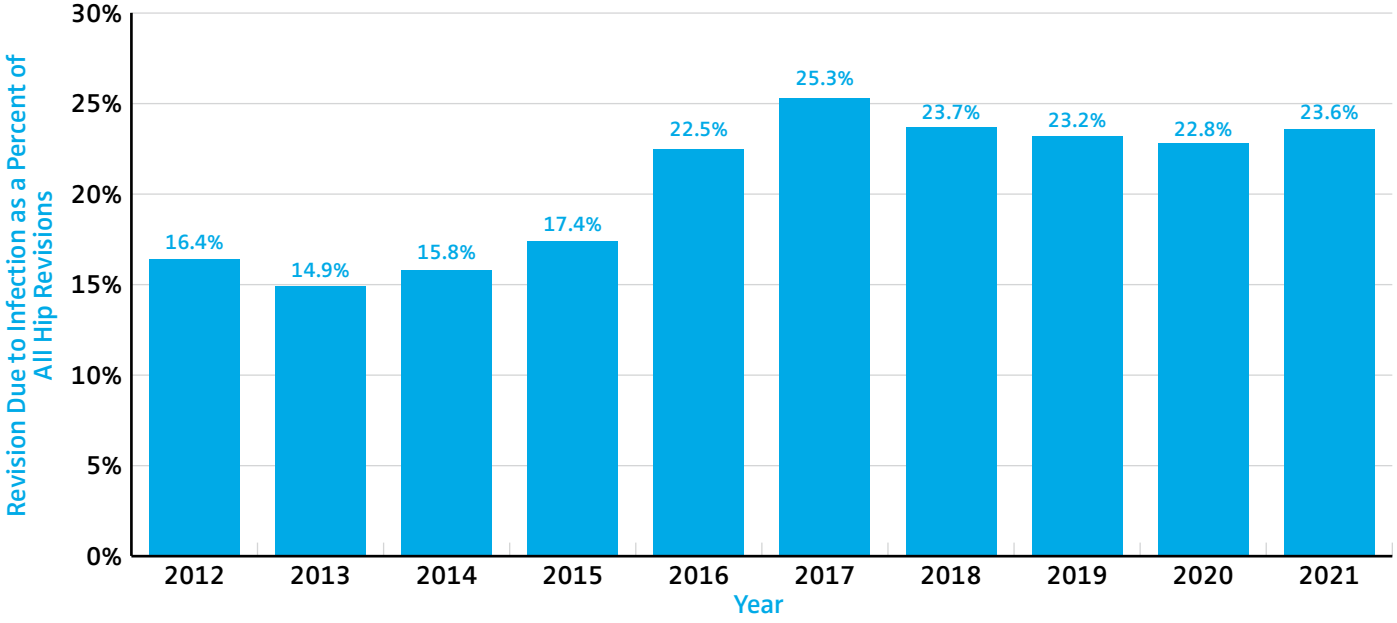
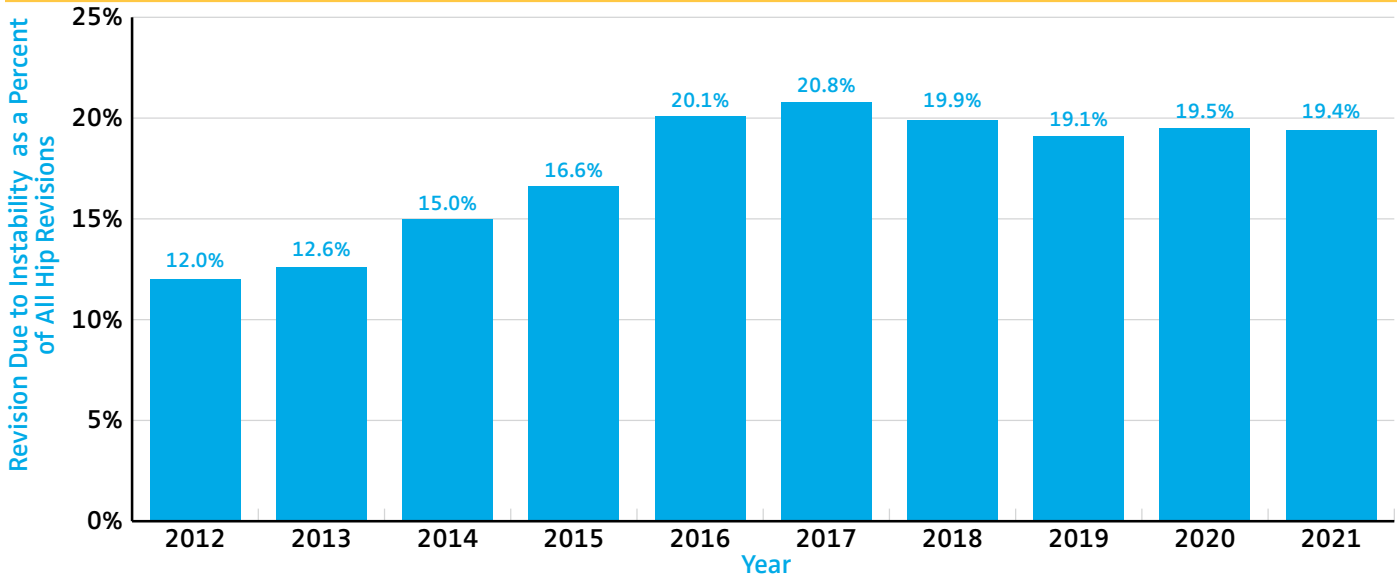


Figure 2.36 Revisions Due to Instability as a Percentage of All Hip Revisions, 2012-2021 (N=14,965)



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 2021 with 21.6% of articulations classified as dual mobility in 2021 (Figure 2.37). Not surprisingly, there has been a significant increase in overall dual mobility usage for revisions specifically to treat dislocation/instability from 2012 to 2021 (17.3% to 25.9%, p<0.0001) although the trend may be slowing (Figure 2.38). Some dual mobility heads may erroneously be classified as smaller diameter heads if reporting is insufficient to distinguish as dual mobility.

The utilization of dual mobility articulations remains over 20% in hip revision procedures.

Figure 2.37 Percent Dual Mobility Usage and Femoral Neck Head Sizes Implanted for Hip Revisions, 2012-2021 (N=70,722)

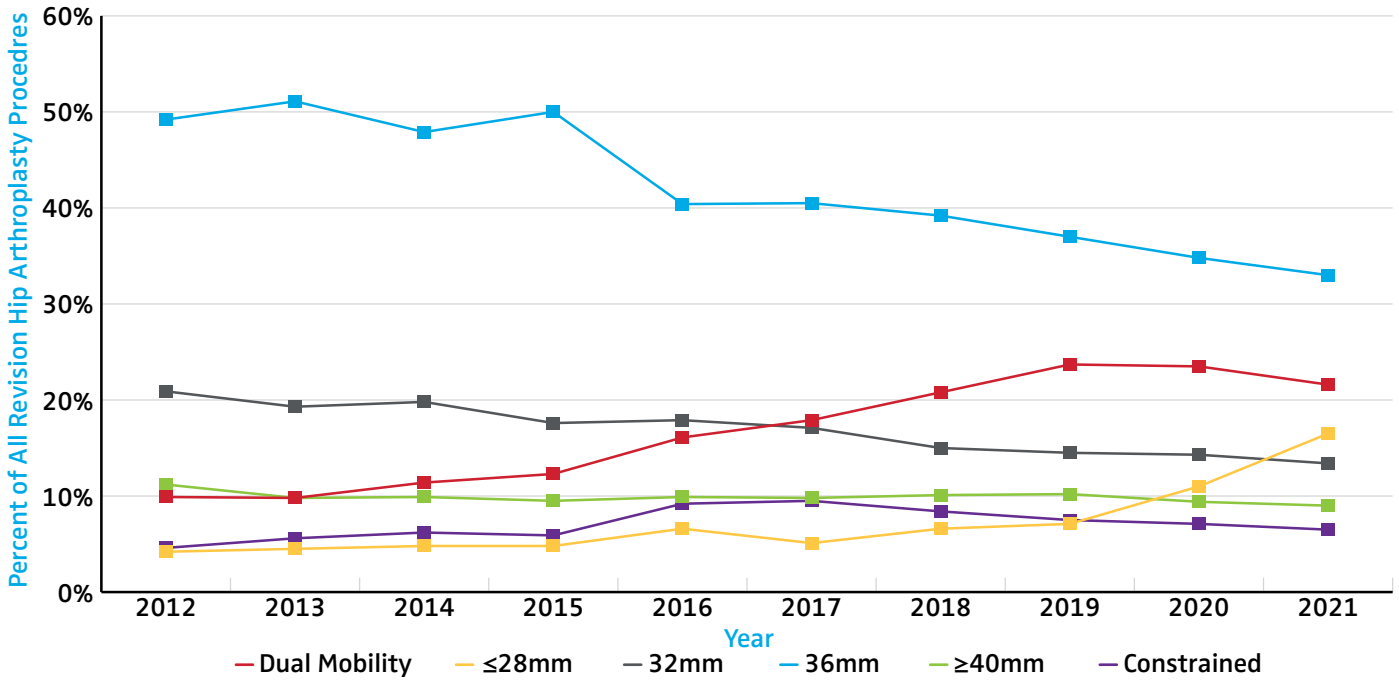
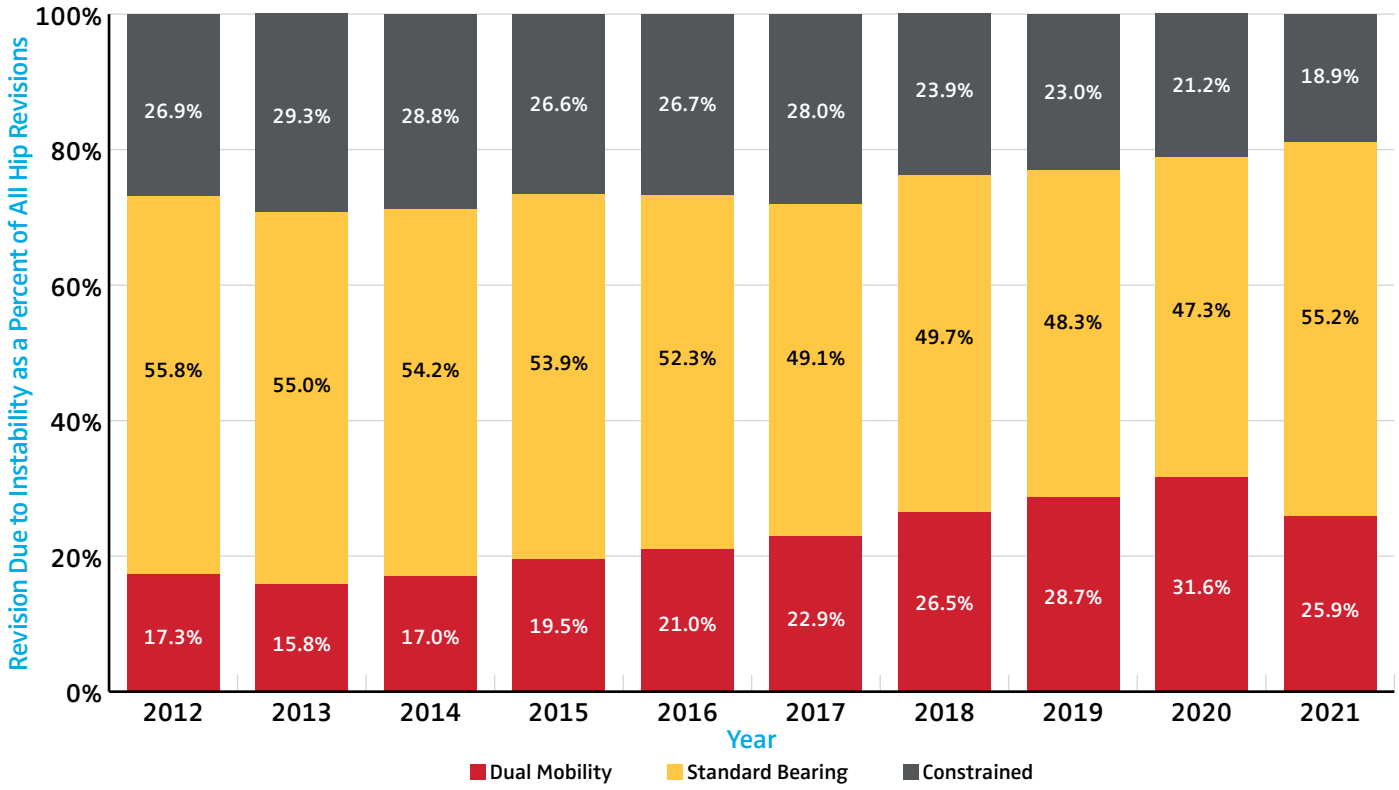


Figure 2.38 Dual Mobility Usage for Hip Revisions Secondary to Dislocation/Instability, 2012-2021 (N=10,552)



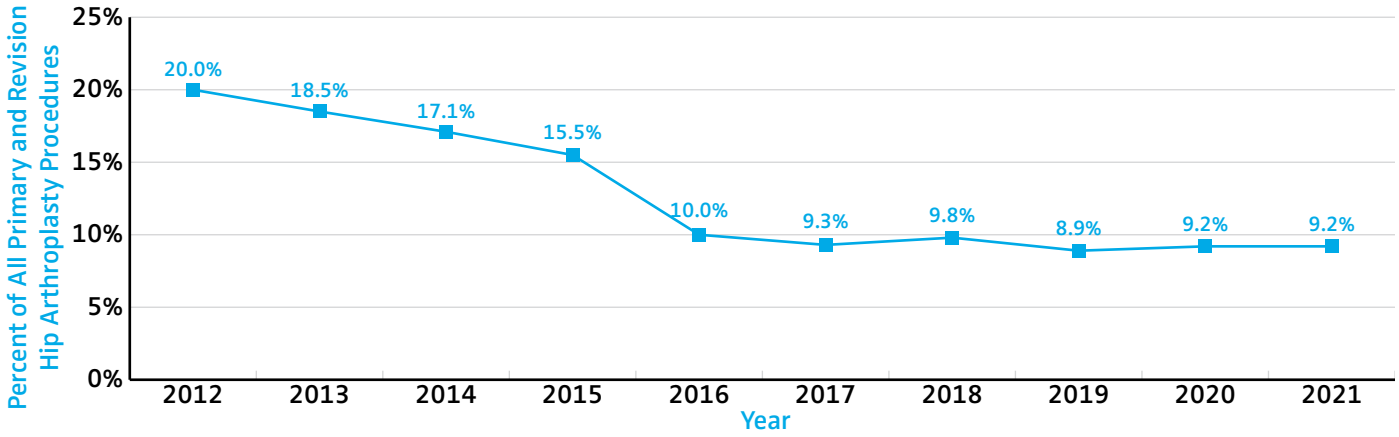
Revision burden is calculated by dividing the number of revision arthroplasties performed in one year by the total number of arthroplasties (revisions plus primaries) during the same year. Although crude, and influenced by numerous factors, revision burden can be used across registries as a simple unit of measure for comparison and quality improvement measures. Revision burden has decreased substantially 2012-2016, and since 2017, it has remained relatively stable at 9.2% in 2021 (Figure 2.39). 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.[14] Similarly, the Australian Orthopaedic Association National Joint Replacement Registry reported an 8% revision burden in 2020, an all-time low for the Registry.[7]

Although hip arthroplasty revision burden appears to be declining when calculated using AJRR data, numerous factors may contribute. 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 highly cross-linked polyethylene, etc.).

INSIGHTS

The revision burden for total hip arthroplasty has leveled off at just under 10% and has remained stable over the past 5 years.

Figure 2.39 Revision Burden of Elective Primary Total Hip Arthroplasty Procedures, 2012-2021 (N=103,514)



The following two figures provide utilization data of implants used in revision hip arthroplasty procedures in AJRR. Figure 2.40 tabulates the eight most commonly used stem components used in revision THA by year and shows that over the ten-year period, the Restoration Modular stem was implanted most frequently. Figure 2.41 tabulates the eight most commonly used cup components in THA by year and shows that over the ten-year period, the most frequently implanted cup has varied. In the last four years, G7 was the most frequently implanted cup.

Figure 2.40 Revision Hip Arthroplasty Stem Components by Year, 2012-2021 (N=41,848)

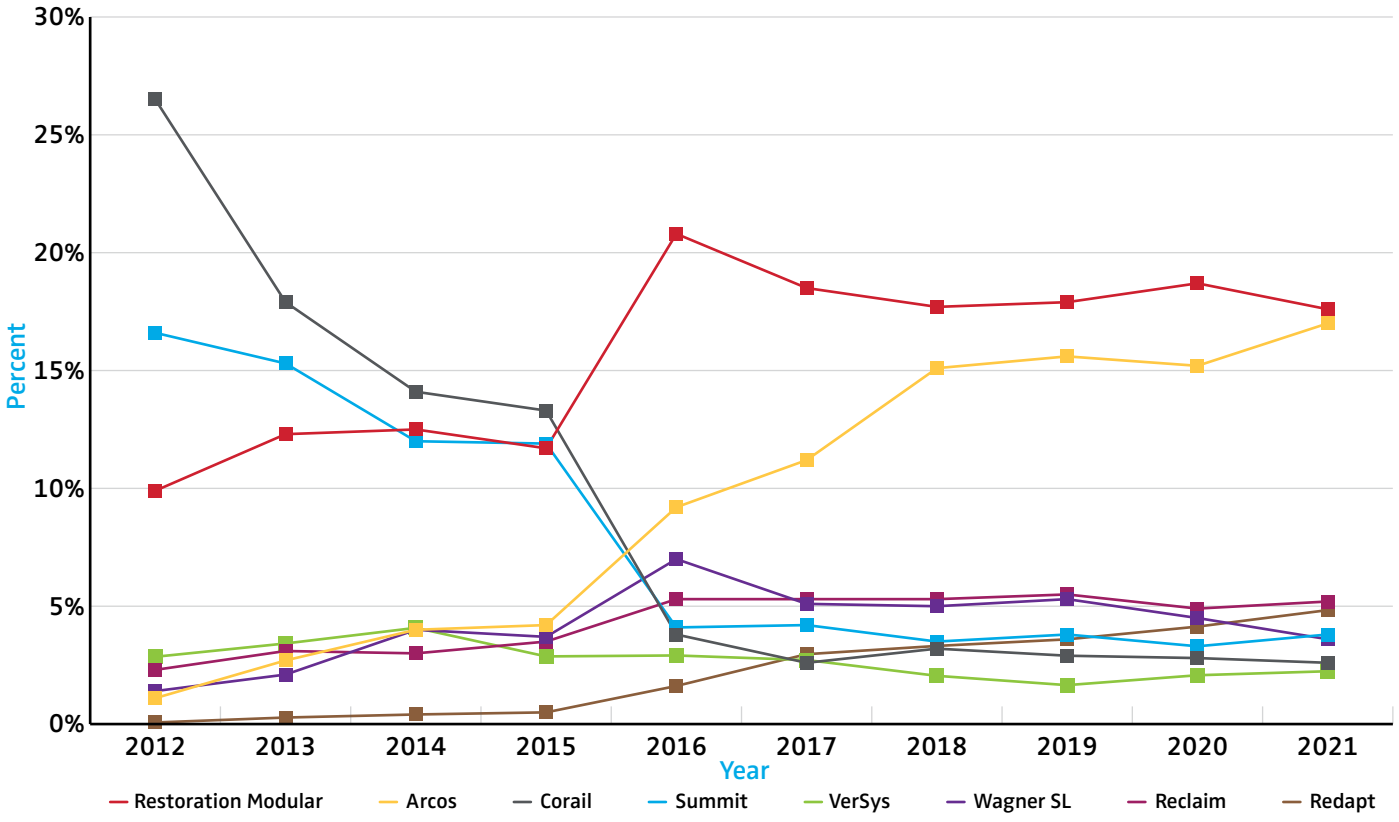


Figure 2.41 Revision Hip Arthroplasty Cup Components by Year, 2012-2021 (N=43,517)

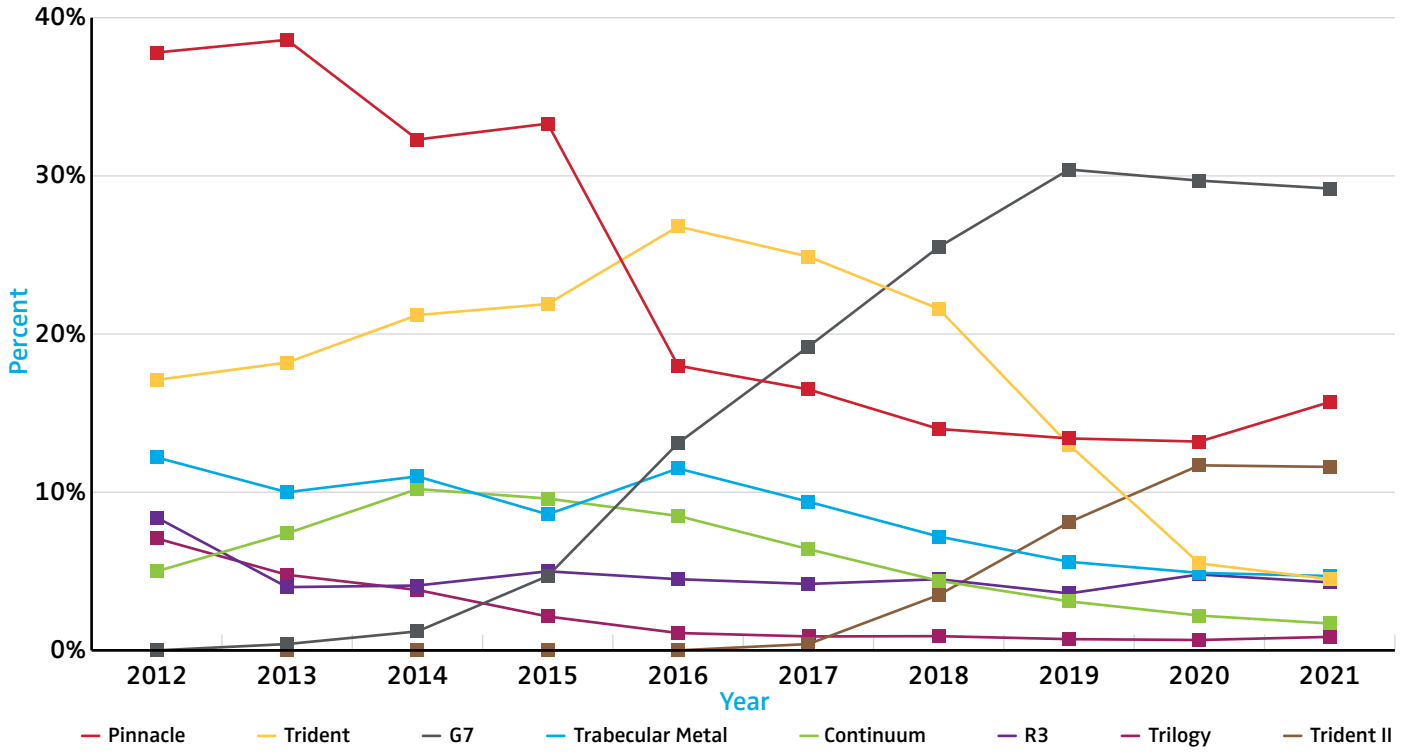
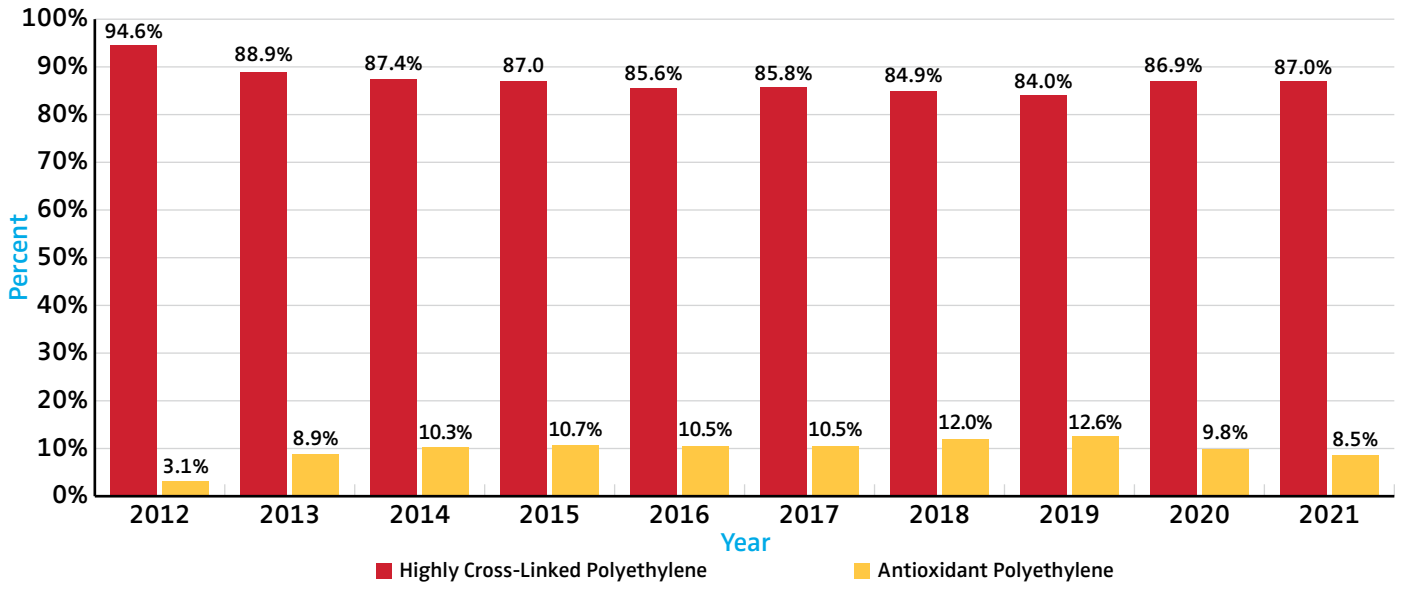


Figure 2.42 shows the liner types utilized by year for revision hip arthroplasty. Highly cross-linked polyethylene was more commonly utilized compared to antioxidant polyethylene for all revision hip arthroplasty procedures. This mirrors the trend observed in primary total hip arthroplasty (Figure 2.24). In contrast with elective THA, a few percent of revision hip procedures (<5%) report using conventional polyethylene.

Figure 2.42 Revision Hip Arthroplasty Liner Polyethylene Material by Year, 2012-2021 (N=64,069)

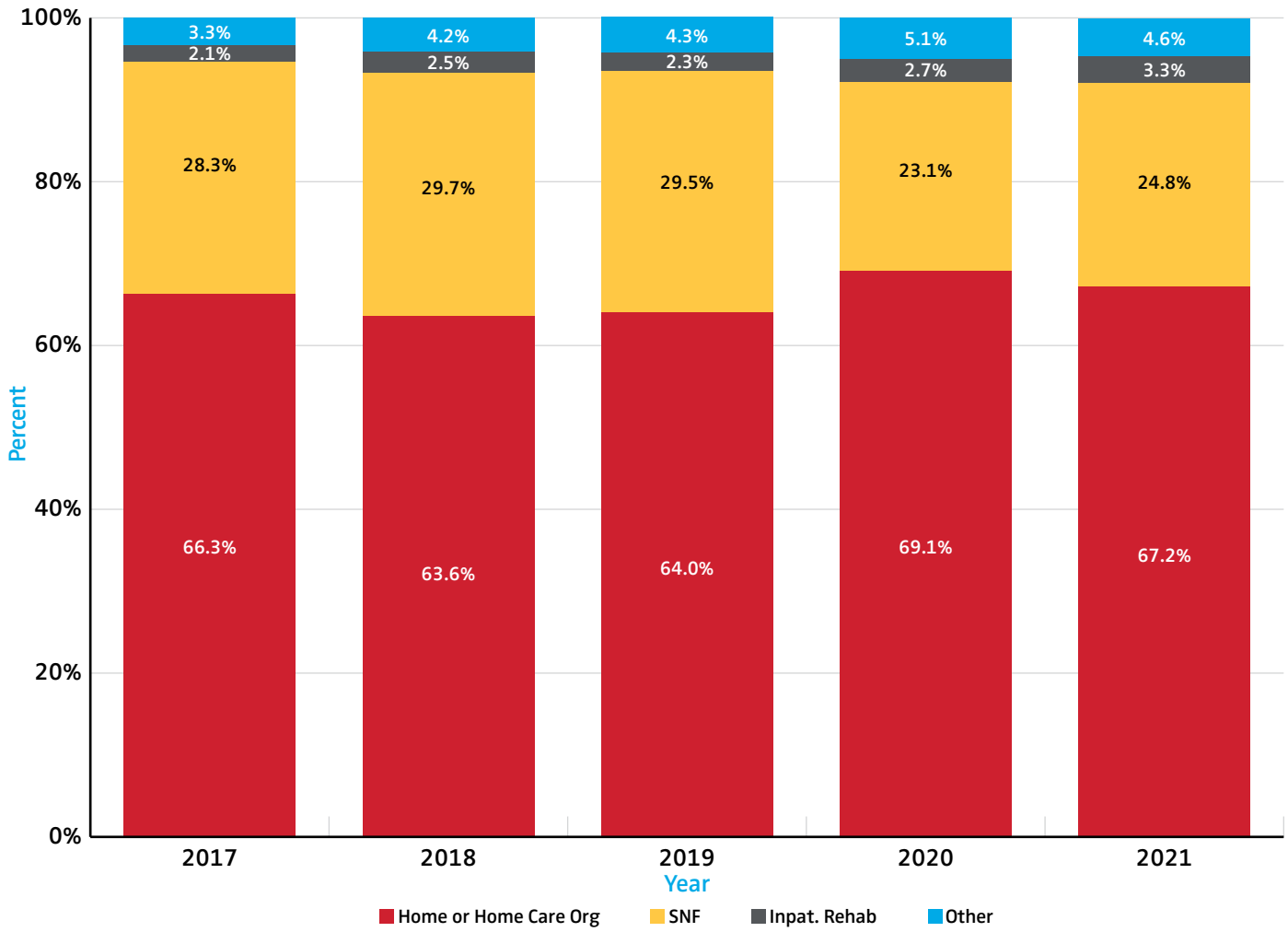


The percentage of patients discharged to a skilled nursing facility following revision THA declined in the last two years to less than a quarter of revision hip arthroplasty patients.

INSIGHTS

Figure 2.43 shows a tabulation of discharge disposition after revision hip arthroplasty for the last five years. AJRR data shows that most patients were released to home or self-care with a slight decline in those discharged to skilled nursing facilities from 2017-2021. However, nearly one quarter of patients were discharged to a skilled nursing facility in 2021, which is more than three times higher than the rate seen with primary total hip arthroplasty.

Figure 2.43 Revision Hip Arthroplasty Discharge Disposition Codes by Year, 2012-2021 (N=52,816)



Code	Code Value
Home	Discharged to home/self-care (routine charge).
Home Care Org.	Discharged/transferred to home care of organized home health service organization.
Inpat. Care	Discharged/transferred to other short-term general hospital for inpatient care.
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.)
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.[15]

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.

Based on the HOOS, JR. score, 91% of patients achieved a meaningful improvement after elective primary total hip arthroplasty.

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 PROMs 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, 2021, 401 sites out of 1,251 (32%) have submitted PROMs, which is a 38% increase in sites compared to the previous 2021 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 22-26%.

The number of institutions submitting PROMs to AJRR has increased by 38% over the past year.

Table 2.9 Preoperative and 1-Year Postoperative PROM Mean Scores After Elective Primary Hip Arthroplasty by PROM, 2012-2021

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	45,059	47.9	16.5
		Postoperative	17,422	85.6	15.5
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	Preoperative	31,811	48.4	9.7
		Postoperative	13,138	52.4	8.9
	Physical T	Preoperative	31,813	39.3	7.6
		Postoperative	13,137	49.7	9.1
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	Preoperative	15,088	51.2	12.6
		Postoperative	5,613	56.1	9.8
	Physical Health Component	Preoperative	14,955	30.9	9.7
		Postoperative	5,621	45.5	10.9

Table 2.10 Overall Change Between Preoperative and 1-Year Postoperative PROM Scores after Elective Primary Hip Arthroplasty by PROM, 2012-2021

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	45,059	10,577	23.5%	90.9%
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	31,811	7,534	23.7%	36.7%
	Physical T	31,813	7,531	23.7%	73.4%
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	15,088	3,386	22.4%	40.3%
	Physical Health Component	14,955	3,392	22.7%	78.3%

**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.*

Table 2.11 Age-stratified Change Between Preoperative and 1-Year Postoperative PROM Scores after Elective Primary Hip Arthroplasty by PROM for Patients 55 Years and Over, 2012-2021

Patient-Reported Outcome Measure (PROM)	PROM Component	Age Group (Years)	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	55-64	12,575	2,734	21.70%	91.70%
		65-74	16,665	4,295	25.80%	91.50%
		75-84	8,585	2,160	25.20%	89.70%
		>85	1,482	323	21.80%	86.70%
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	55-64	8,541	1,791	21.00%	39.60%
		65-74	11,937	3,182	26.70%	37.40%
		75-84	6,220	1,649	26.50%	32.90%
		>85	1,048	249	23.80%	26.90%
	Physical T	55-64	8,542	1,791	21.00%	76.40%
		65-74	11,937	3,179	26.60%	75.20%
		75-84	6,223	1,649	26.50%	68.70%
		>85	1,048	249	23.80%	58.60%

**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 2021, AJRR has collected data on 1,495,965 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 in 2021 was 35.5 with a median of 16 and an interquartile range (25th-75th percentile) of 4-41 (Table 3.1). These volumes are similar to what has previously been reported.[16] 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 67.2 (SD 9.4) years (Table 3.2 and Figure 3.1). There was a statistical difference in the average age between patients undergoing total knee arthroplasty (67.2 years) and partial knee arthroplasty (64.3 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 days) to 2021 (1.3 days). A significant decrease in mean length of stay for partial knee arthroplasties of 1.7 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 54% 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, 2021

Procedure	Total Surgeons	Total Procedures	Per Surgeon Mean	Per Surgeon Median	25th Percentile	75th Percentile
Partial Knee Arthroplasty	906	5,187	5.7	2.0	1.0	6.0
Revision Knee Arthroplasty	1,895	11,302	6.0	3.0	1.0	6.0
Total Knee Arthroplasty	3,141	111,571	35.5	16.0	4.0	41.0

Table 3.2 Mean Age of Patients Undergoing Knee Arthroplasty Procedures, 2012-2021 (N=1,495,965)

Procedures	Total	Mean Age (Years)	Standard Deviation
Partial Knee Arthroplasty	66,394	64.3	10.8
Revision Knee Arthroplasty	122,852	66.4	10.6
Total Knee Arthroplasty	1,306,719	67.2	9.4

Figure 3.1 Age Distribution of Knee Arthroplasty Procedures, 2012-2021 (N=1,495,965)

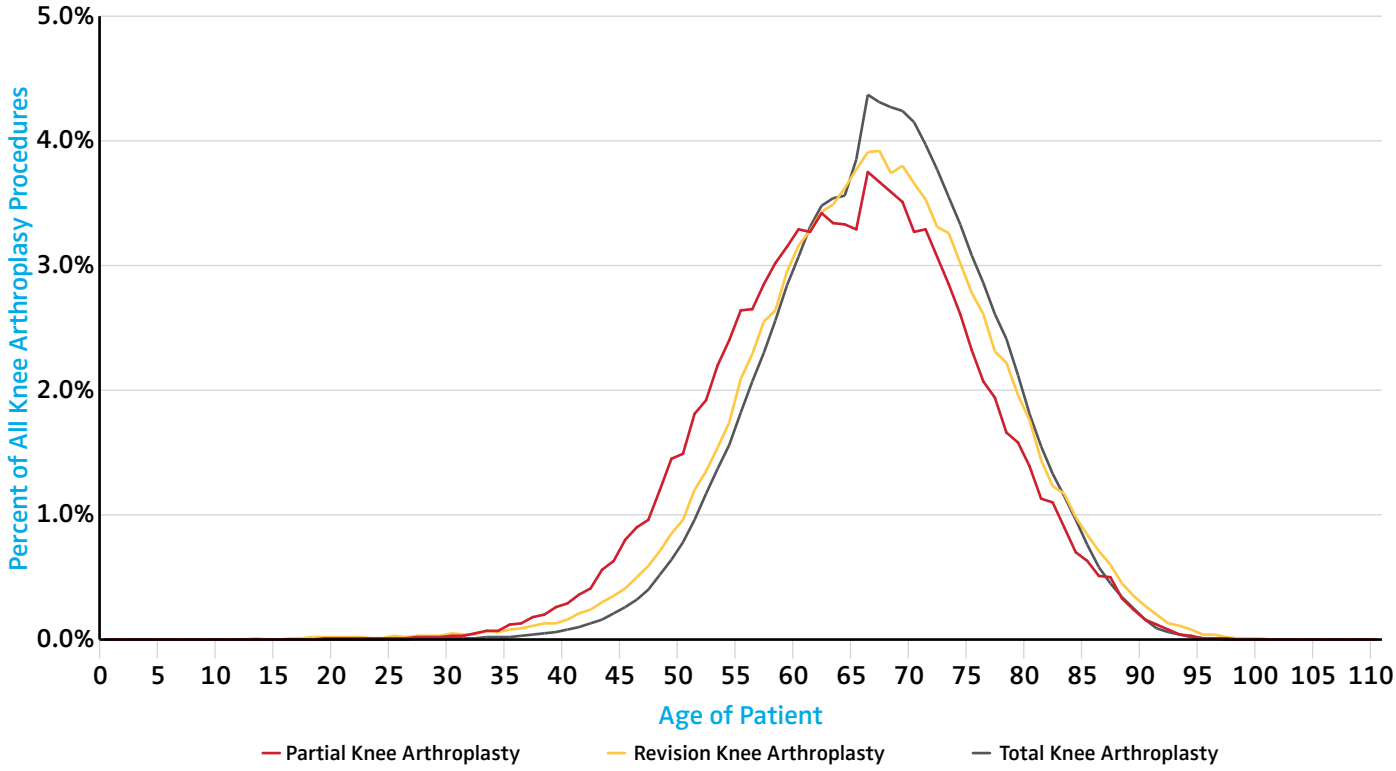
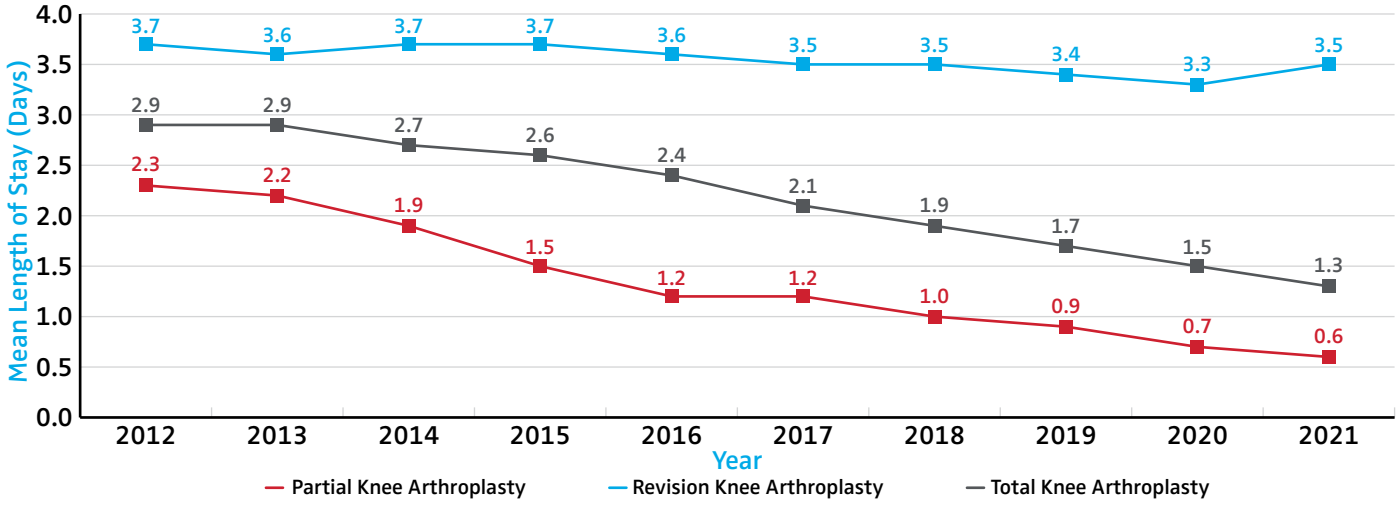


Figure 3.2 Mean Length of Stay for Knee Arthroplasty Procedures, 2012-2021 (N=805,296)



Primary Total Knee Arthroplasty

Between 2012 and 2021, AJRR has collected data on 1,306,719 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 49.7% in 2021. The use of ultracongruent components has increased 57% between 2012 and 2021 (Figure 3.4).

INSIGHTS

The trend towards increased use of cruciate retaining and 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, 2012-2021 (N=1,302,325)

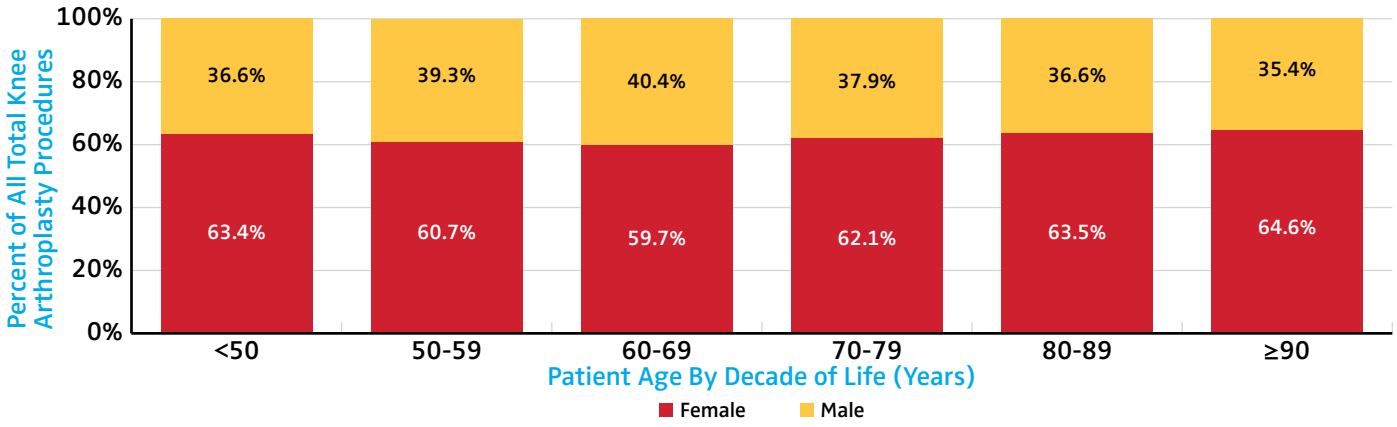
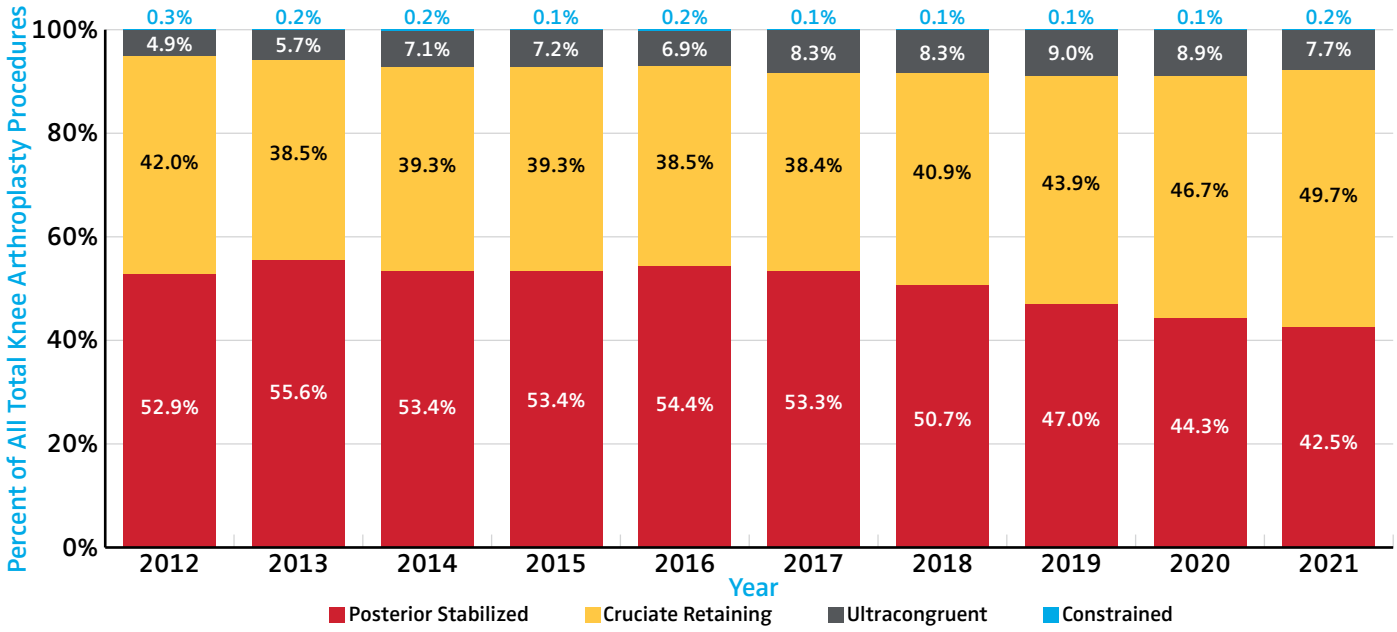


Figure 3.4 Distribution of Primary Total Knee Arthroplasty Implant Designs, 2012-2021 (N=1,056,074)

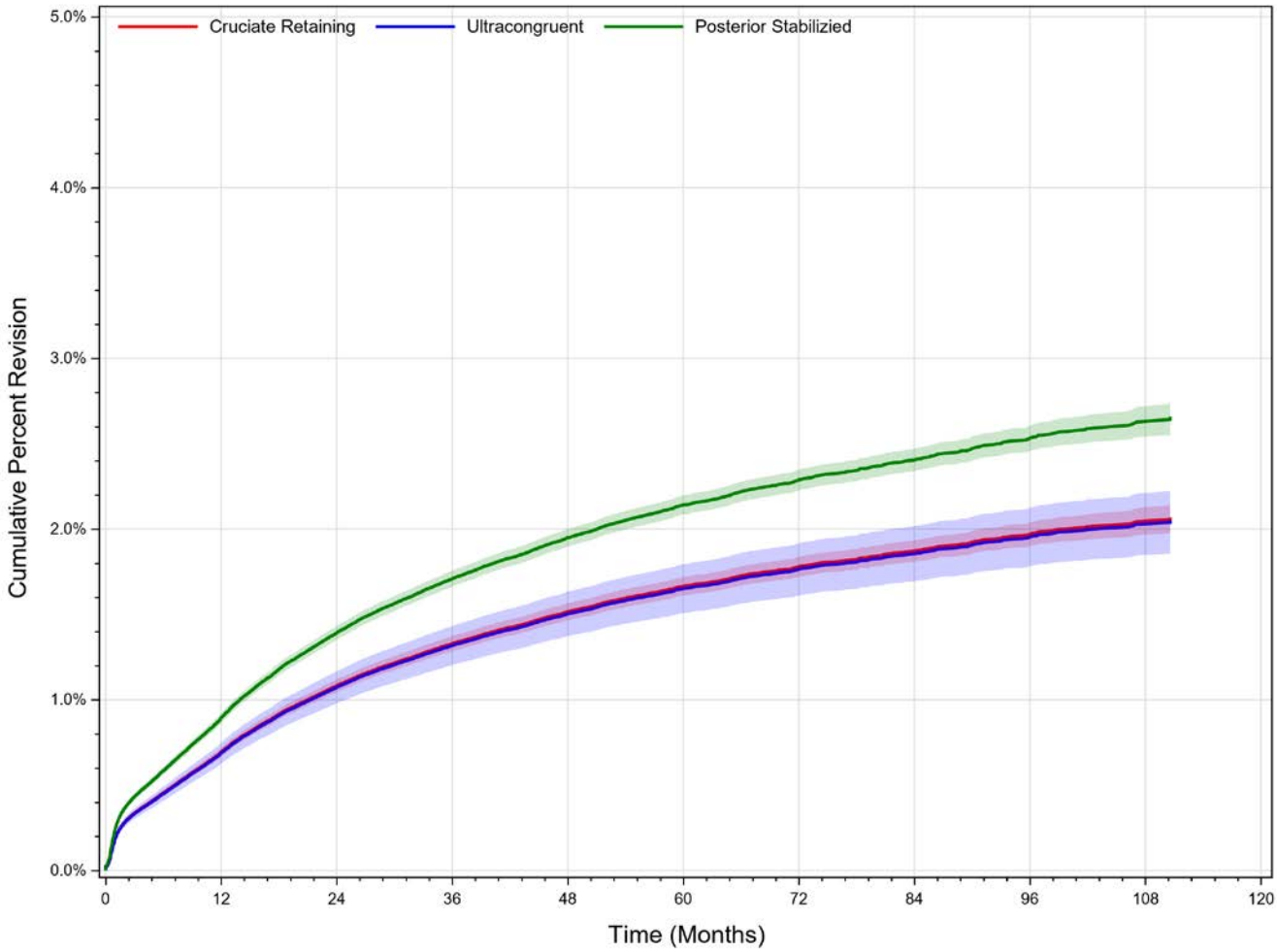


After adjusting for age and sex in patients ≥65 years of age as reported to either AJRR or CMS, ultracongruent and cruciate retaining designs showed significantly reduced cumulative percent revision compared to posterior stabilized designs; age adjusted hazard ratio (HR) of 0.8 (Figure 3.5). This analysis 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 implants are associated with 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 Medicare Patients 65 Years of Age and older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cruciate Retaining	264,443	232,894	202,500	165,630	128,423	89,641	56,023	31,623	14,832	4,727	4
Posterior Stabilized	307,606	280,803	251,994	213,505	169,679	118,271	71,951	39,789	18,094	4,891	1
Ultracongruent	36,630	32,992	28,808	23,302	17,894	11,753	7,091	3,681	1,280	340	1
Total	608,679	546,689	483,302	402,437	315,996	219,665	135,065	75,093	34,206	9,958	6

Age/Sex adjusted HR (95%CI), p-value
Cruciate Retaining vs. Posterior Stabilized: *0.776 (0.741,0.812), p<0.0001*
Ultracongruent vs. Posterior Stabilized: *0.769 (0.696,0.85), p<0.0001*

For primary total knee arthroplasty procedures in the AJRR, antioxidant polyethylene usage substantially increased at the expense of non-antioxidant polyethylene inserts (including conventional UHMWPE and highly cross-linked) between 2012 and 2021 (Figure 3.6). No statistical difference was found across polyethylene groups, when comparing cumulative percent revision adjusted for age and sex in Medicare patients aged 65 and older. 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. (Figure 3.7).

INSIGHTS

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

Figure 3.6 Primary Total Knee Arthroplasty Insert Polyethylene Material by Year, 2012-2021 (N= 1,044,420)

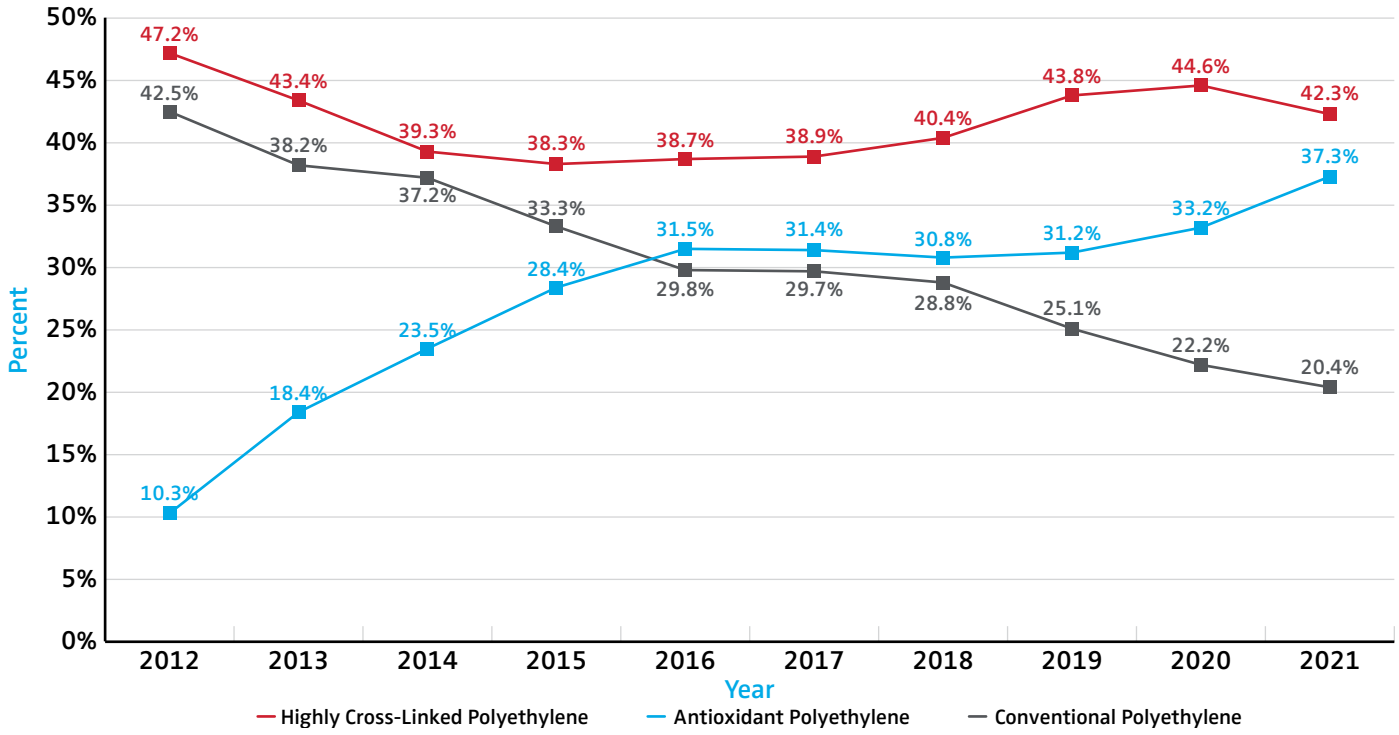
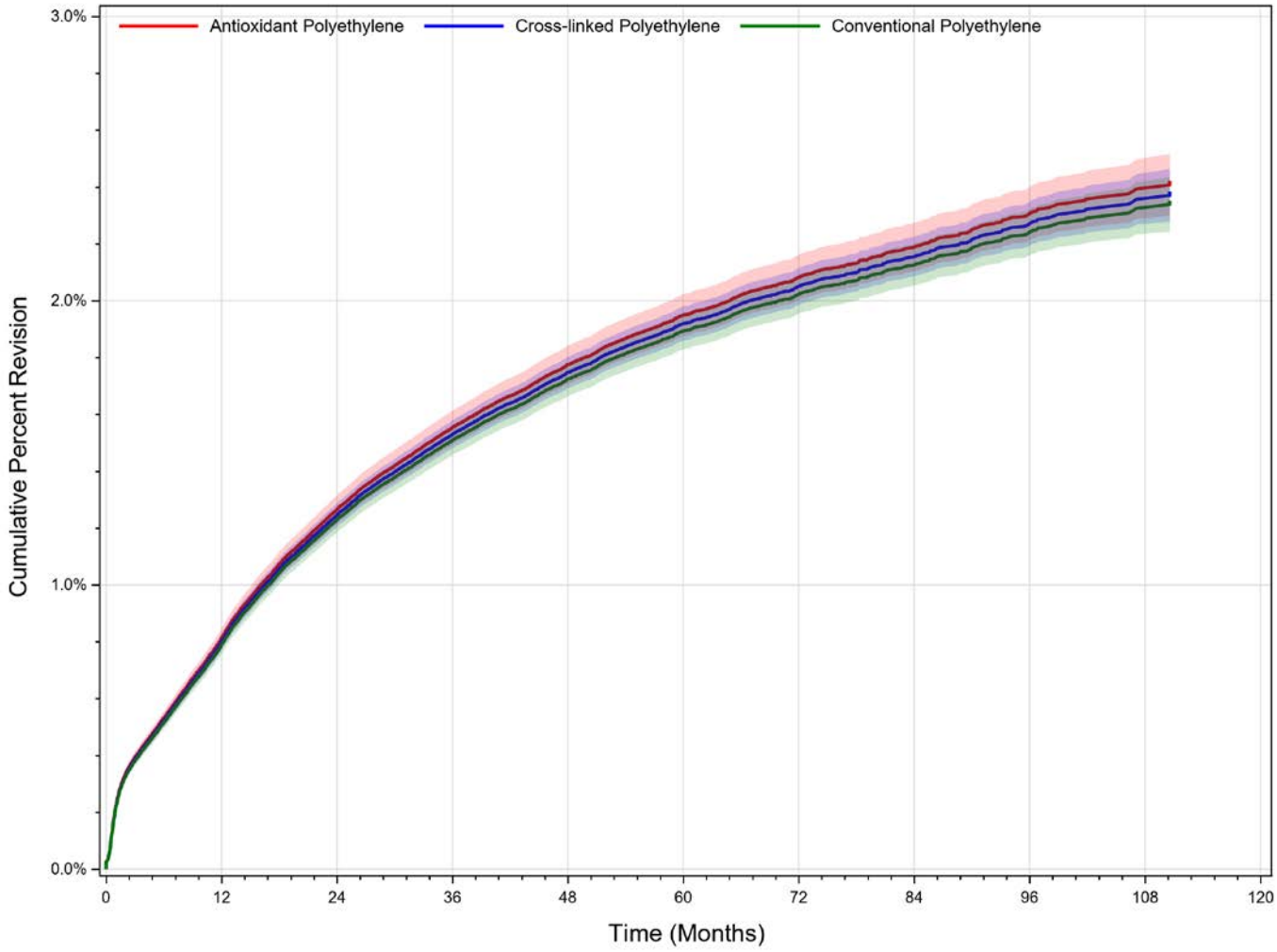


Figure 3.7 Cumulative Percent Revision for Polyethylene Material for Primary Total Knee Arthroplasty for Medicare Patients 65 Years of Age and Older with Primary Osteoarthritis, 2012-2021

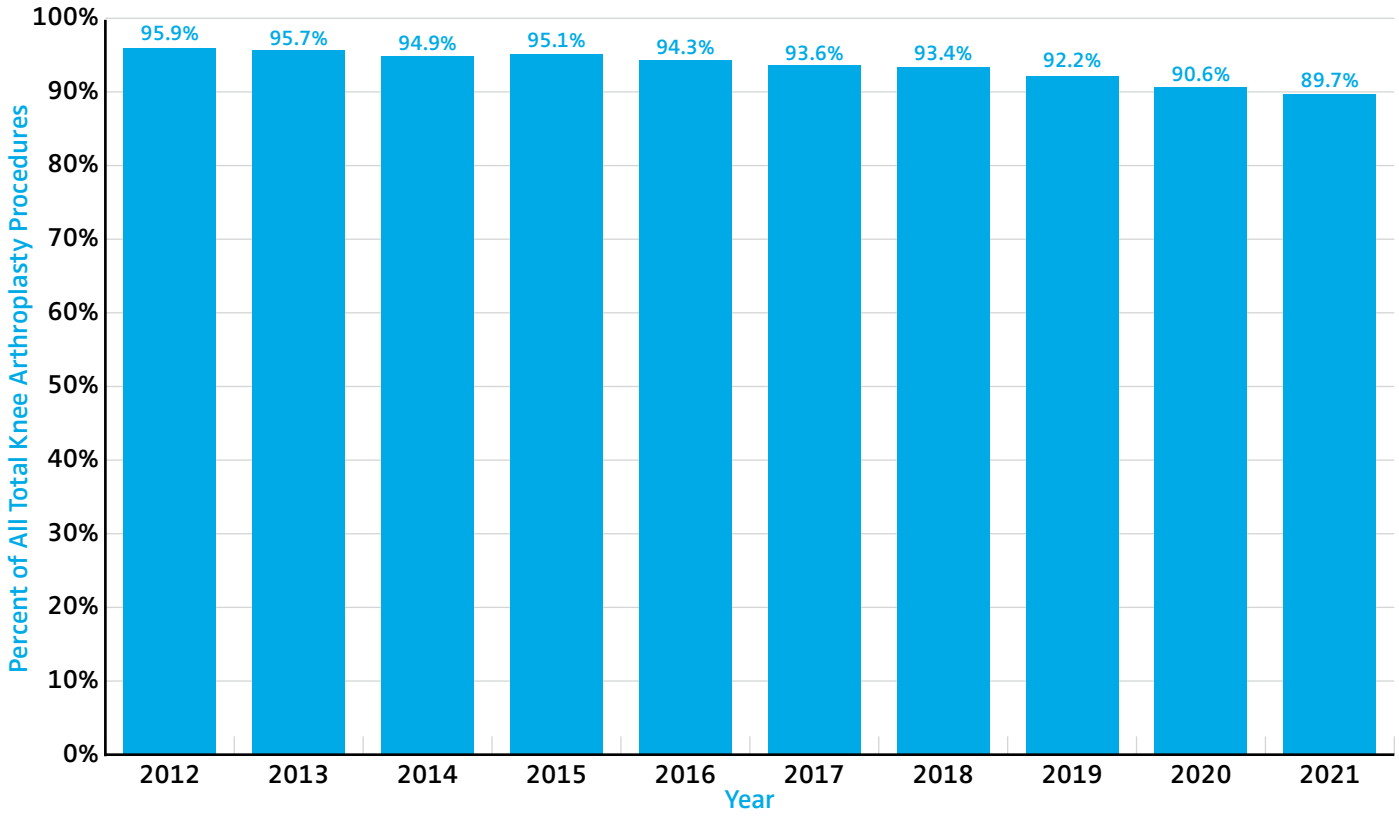


Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Antioxidant Polyethylene	167,933	146,518	126,574	103,081	78,264	50,174	26,513	11,817	3,946	585	1
Conventional Polyethylene	199,728	185,086	168,453	145,071	117,279	85,212	55,599	32,811	15,372	4,819	1
Cross-linked Polyethylene	245,452	218,323	190,471	155,366	121,158	84,811	53,275	30,660	14,975	4,578	4
Total	613,113	549,927	485,498	403,518	316,701	220,197	135,387	75,288	34,293	9,982	6

Age/Sex adjusted HR (95%CI), p-value
Antioxidant Polyethylene vs. Conventional Polyethylene: *1.03 (0.974,1.089), p=0.3060*
Cross-linked Polyethylene vs. Conventional Polyethylene: *1.014 (0.964,1.066), p=0.5949*

Utilization of patellar resurfacing in the AJRR shows a decreasing trend over time but was still performed in 90% of procedures in 2021 (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.[7] The Swedish Arthroplasty Register reported use of patellar resurfacing has been decreasing since the mid-1980s and in 2021 was performed in just over 3% of total knee arthroplasty cases.[9]

Figure 3.8 Percentage of Primary Total Knee Arthroplasty with Patellar Resurfacing, 2012-2021 (N=938,044)

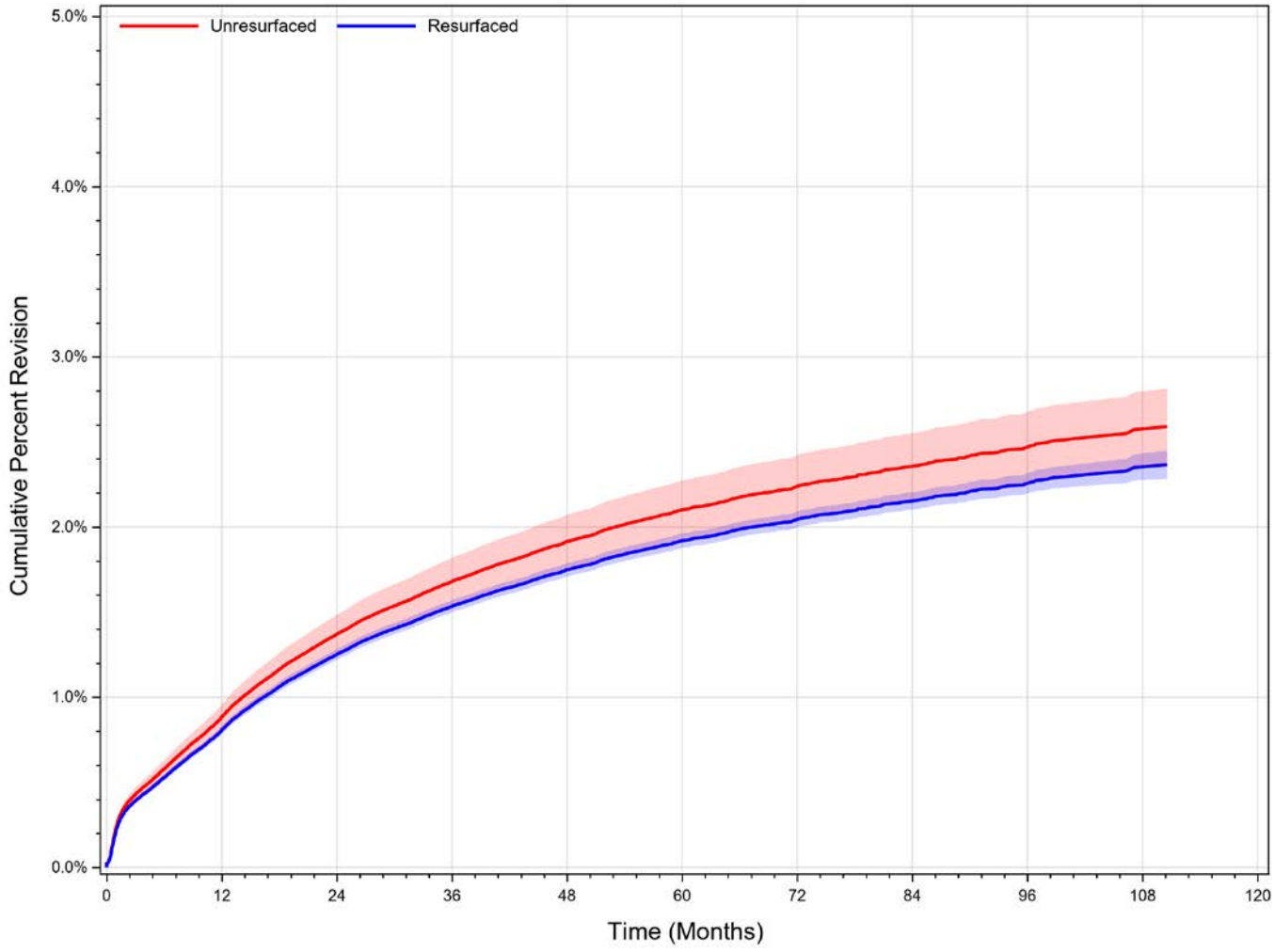


The majority of primary total knee arthroplasties continue to include a resurfaced patella although a slight trend towards unresurfaced patellae is apparent.

INSIGHTS

Cases with resurfaced patellae showed decreased cumulative percent revision compared to cases where the patella was left unresurfaced in patients 65 years of age and older in either AJRR or CMS, but this did not quite reach statistical significance after adjusting by age and sex (HR=1.096, 95% CI, 1-1.201, p=0.509). However, there were far more procedures with resurfaced patellae, and this finding does not account for numerous potential confounders (Figures 3.9).

Figure 3.9 Cumulative Percent Revision for Total Knee Arthroplasty Patellar-Resurfacing in Medicare Patients 65 Years of Age and older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Resurfaced	515,744	462,828	409,156	339,924	265,189	183,112	111,454	60,298	26,776	7,630	4
Unresurfaced	33,620	28,506	23,744	18,523	13,860	8,884	5,203	2,789	1,135	321	2
Total	549,364	491,334	432,900	358,447	279,049	191,996	116,657	63,087	27,911	7,951	6

Age/Sex adjusted HR (95%CI), p-value
Unresurfaced vs. Resurfaced: *1.096 (1,1.201), p=0.0509*

INSIGHTS

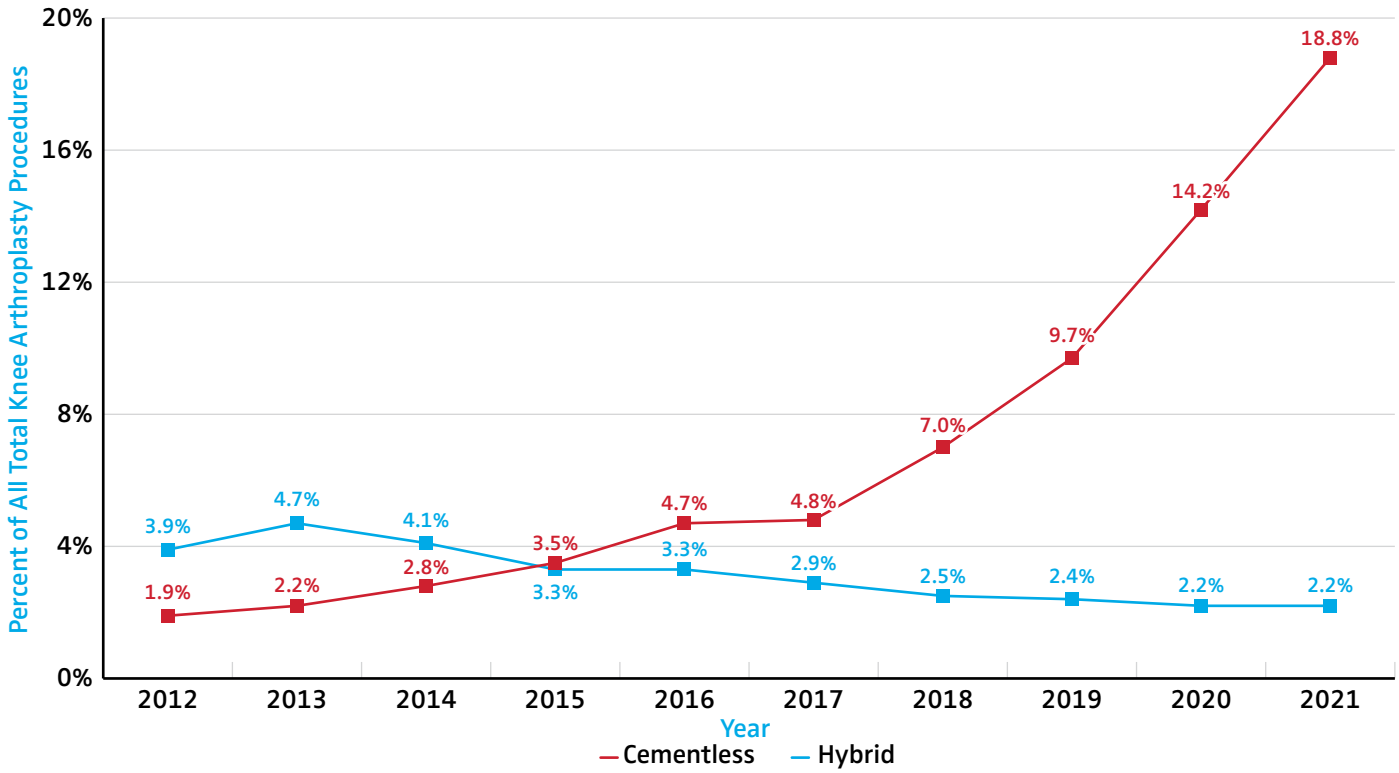
Patellar resurfacing did not have a statistically different cumulative percent revision compared to those without resurfacing in patients aged 65 years and older. Patient selection and confounding must be considered when interpreting this data.

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 3.10). Similarly, the Swedish Arthroplasty Register reported in their 2021 Annual Report that cementless fixation had become slightly more common and was now used in 8.7% of the total knee arthroplasties.[9] In the 2021 National Joint Registry, more than 80% of all primary total knee arthroplasties utilized all cemented fixation and 4.2% used all cementless and hybrid total knee replacements in 2020.[8]

INSIGHTS

The use of cementless fixation in primary total knee arthroplasty is rapidly increasing in the AJRR and was reported for over 18% of all primary total knee arthroplasties in 2021.

Figure 3.10 Distribution of Hybrid and Cementless Fixation Utilization for Primary Total Knee Arthroplasty, 2012-2021 (N=939,141)

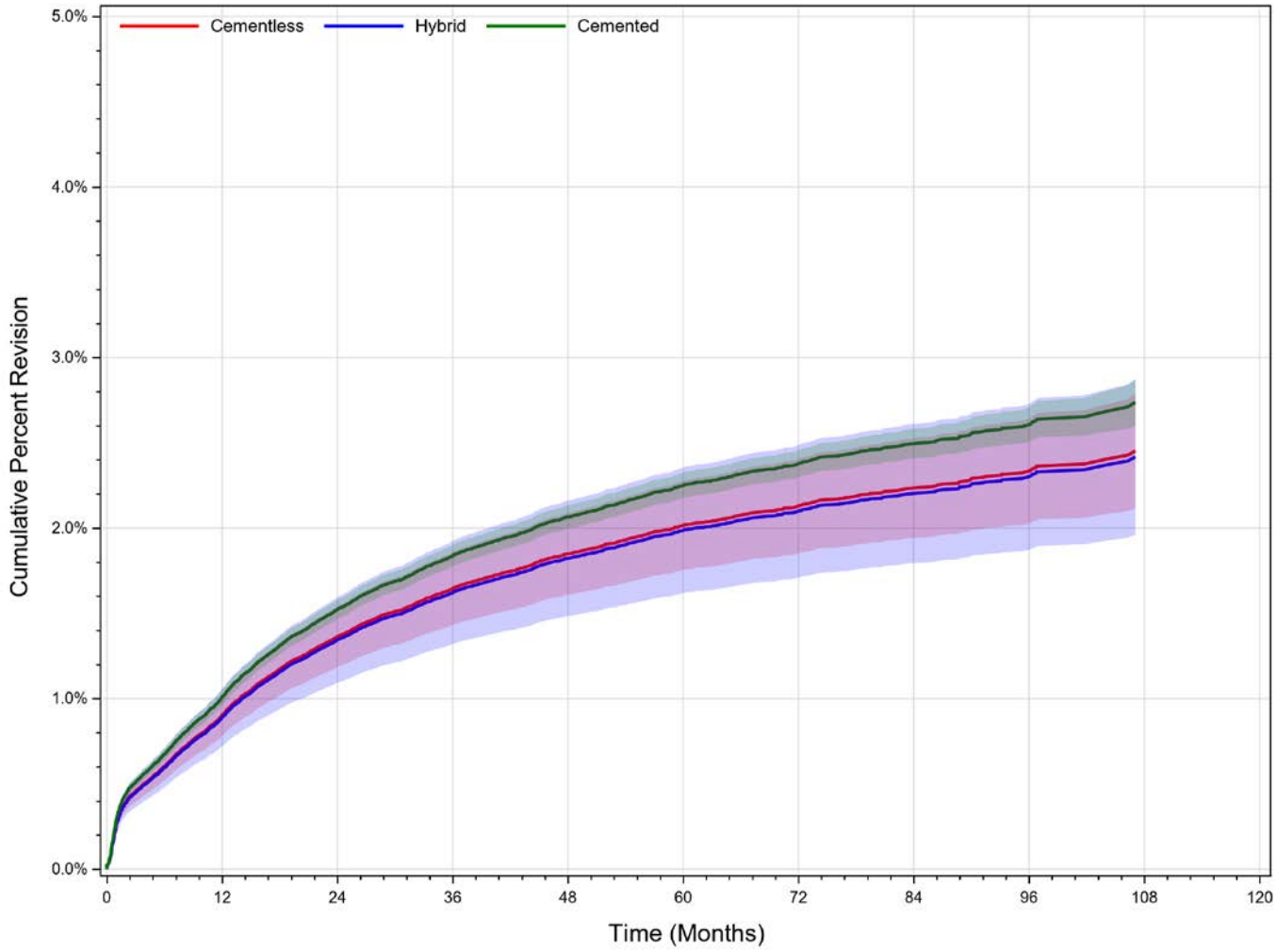


Cementless fixation for primary total knee arthroplasty is associated with a reduced rate of cumulative percent revision compared to cemented fixation in young males.

INSIGHTS

Cementless and hybrid fixation were found to be associated with decreased cumulative percent revision compared to cemented fixation in males <65 years of age in the AJRR database. There was a similar trend toward cementless and hybrid fixation in men aged 65 and older though this did not reach statistical significance. This represents a change from the prior Annual Report. Comparison of findings across fixation groups did not reach statistical significance for females of either age (Figures 3.11-3.14). This finding does not account for numerous potential confounders.

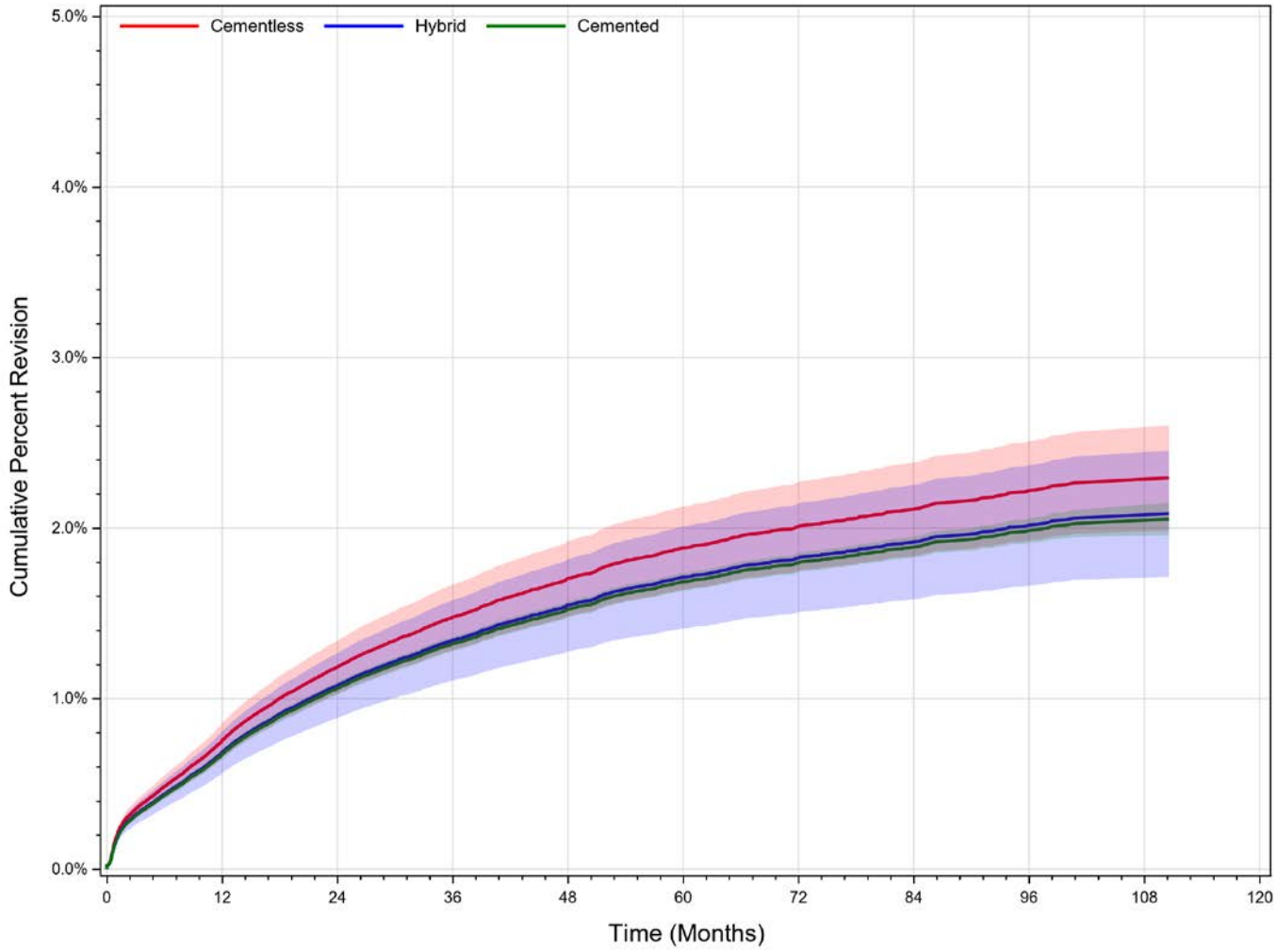
Figure 3.11 Cumulative Percent Revision for Cemented Versus Cementless Fixation Primary Total Knee Arthroplasty in Male Medicare Patients 65 Years of Age and older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cemented	193,481	174,784	154,716	129,397	101,949	70,356	43,071	23,492	10,469	2,969	3
Cementless	15,970	11,849	8,672	6,101	4,056	2,604	1,310	569	188	49	1
Hybrid	5,965	5,489	5,060	4,430	3,730	2,825	1,852	1,122	510	131	1
Total	215,416	192,122	168,448	139,928	109,735	75,785	46,233	25,183	11,167	3,149	5

Age adjusted HR (95%CI), p-value
Cementless vs. Cemented: *0.894 (0.771,1.038), p=0.1406*
Hybrid vs. Cemented: *0.882 (0.721,1.079), p=0.2206*

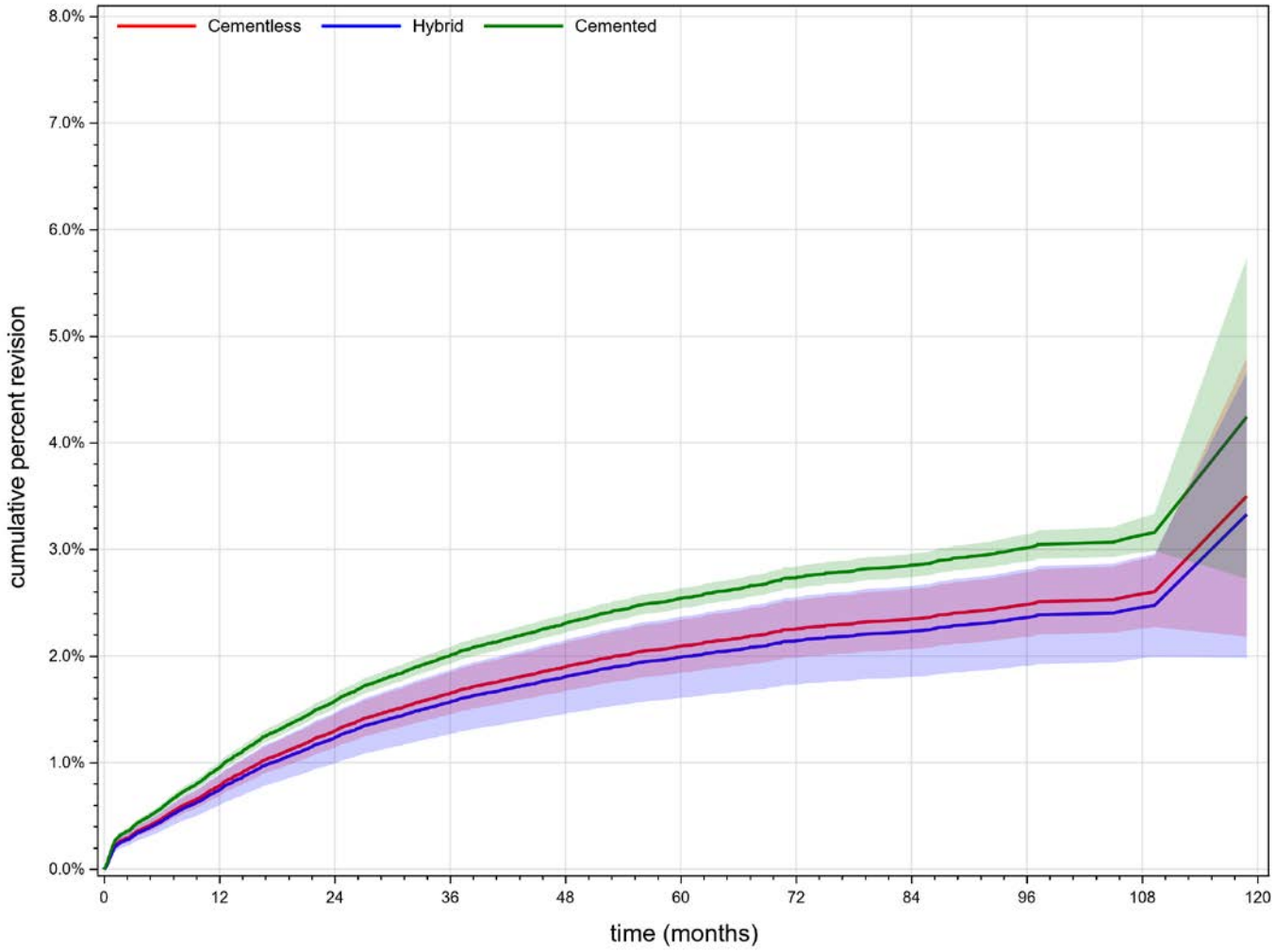
Figure 3.12 Cumulative Percent Revision for Cemented Versus Cementless Fixation Primary Total Knee Arthroplasty in Female Medicare Patients 65 Years of Age and older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cemented	308,986	278,654	246,980	205,162	160,521	110,796	68,431	37,763	16,738	4,722	1
Cementless	17,920	13,173	9,661	6,663	4,419	2,857	1,443	566	195	48	2
Hybrid	8,071	7,370	6,680	5,692	4,731	3,539	2,329	1,455	662	147	1
Total	334,977	299,197	263,321	217,517	169,671	117,192	72,203	39,784	17,595	4,917	4

Age adjusted HR (95%CI), p-value
Cementless vs. Cemented: *1.119 (0.964,1.299), p=0.1393*
Hybrid vs. Cemented: *1.016 (0.842,1.225), p=0.8705*

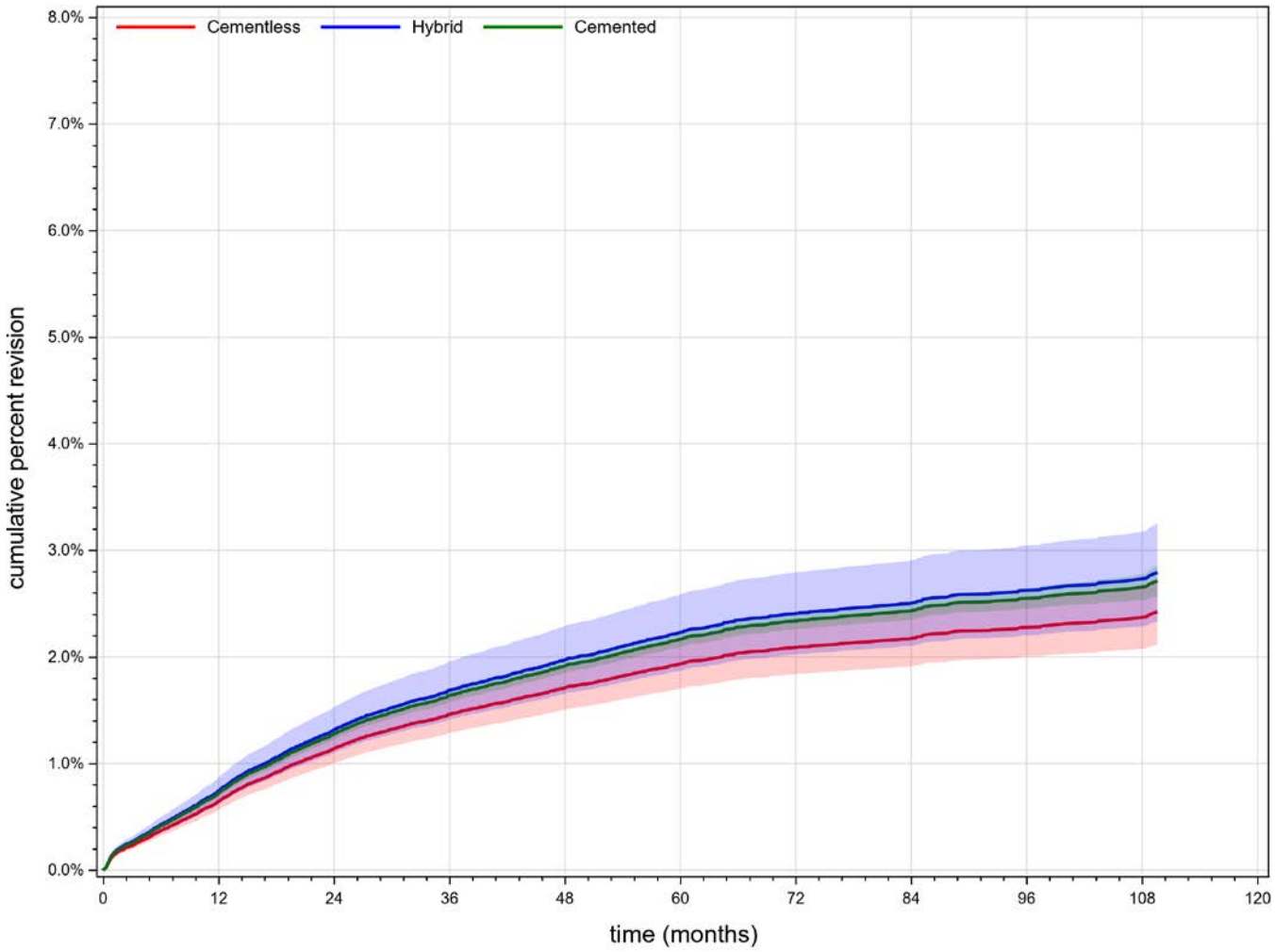
Figure 3.13 Cumulative Percent Revision for Cemented Versus Cementless Fixation Primary Total Knee Arthroplasty in Male Patients less than 65 Years of Age with Primary Osteoarthritis in AJRR Only, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cemented	132,298	121,619	109,046	93,652	76,142	55,236	35,516	20,064	9,082	2,834	9
Cementless	18,278	14,187	10,810	7,949	5,645	3,559	1,854	988	410	125	1
Hybrid	5,555	5,146	4,747	4,270	3,575	2,689	1,775	1,144	530	157	1
Total	156,131	140,952	124,603	105,871	85,362	61,484	39,145	22,196	10,022	3,116	11

Age/Sex adjusted HR (95%CI), p-value
Cementless vs. Cemented: *0.821 (0.712,0.948), p=0.0070*
Hybrid vs. Cemented: *0.781 (0.631,0.966), p=0.0227*

Figure 3.14 Cumulative Percent Revision for Cemented Versus Cementless Fixation Primary Total Knee Arthroplasty in Female Patients less than 65 Years of Age with Primary Osteoarthritis in AJRR Only, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cemented	196,180	180,309	161,504	137,850	111,624	80,675	51,863	29,694	13,214	3,926	7
Cementless	20,037	15,340	11,637	8,403	5,902	3,827	1,952	957	376	106	2
Hybrid	7,117	6,578	6,009	5,338	4,546	3,440	2,341	1,566	747	195	1
Total	223,334	202,227	179,150	151,591	122,072	87,942	56,156	32,217	14,337	4,227	10

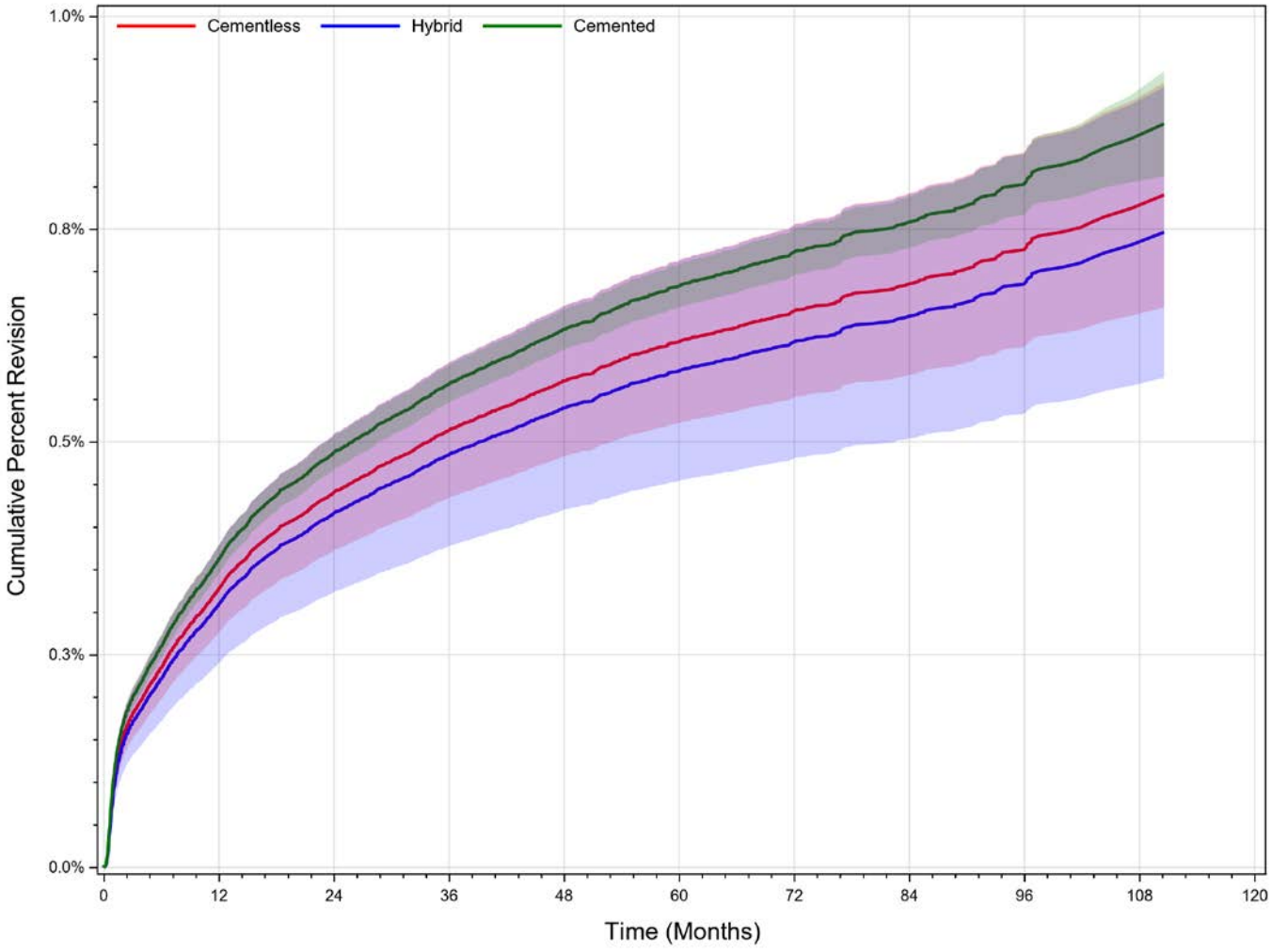
Age/Sex adjusted HR (95%CI), p-value
Cementless vs. Cemented: *0.892 (0.776,1.024), p=0.1056*
Hybrid vs. Cemented: *1.03 (0.859,1.235), p=0.7520*

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

Diagnosis-specific survival rates with the end-point of infection were analyzed based on the method of component fixation. Figure 3.15 displays the results of diagnosis-specific cumulative percent revision. There was no significant difference in revision due to infection in elective primary TKA patients ≥65 years of age. This relationship was not statistically significant as was seen in the 2021 Annual Report.

Figure 3.15 Cumulative Percent Revision for Infection of Cemented Versus Cementless Fixation for a Primary Total Knee Arthroplasty in Medicare Patients 65 Years of Age and older with Primary Osteoarthritis, 2012-2021

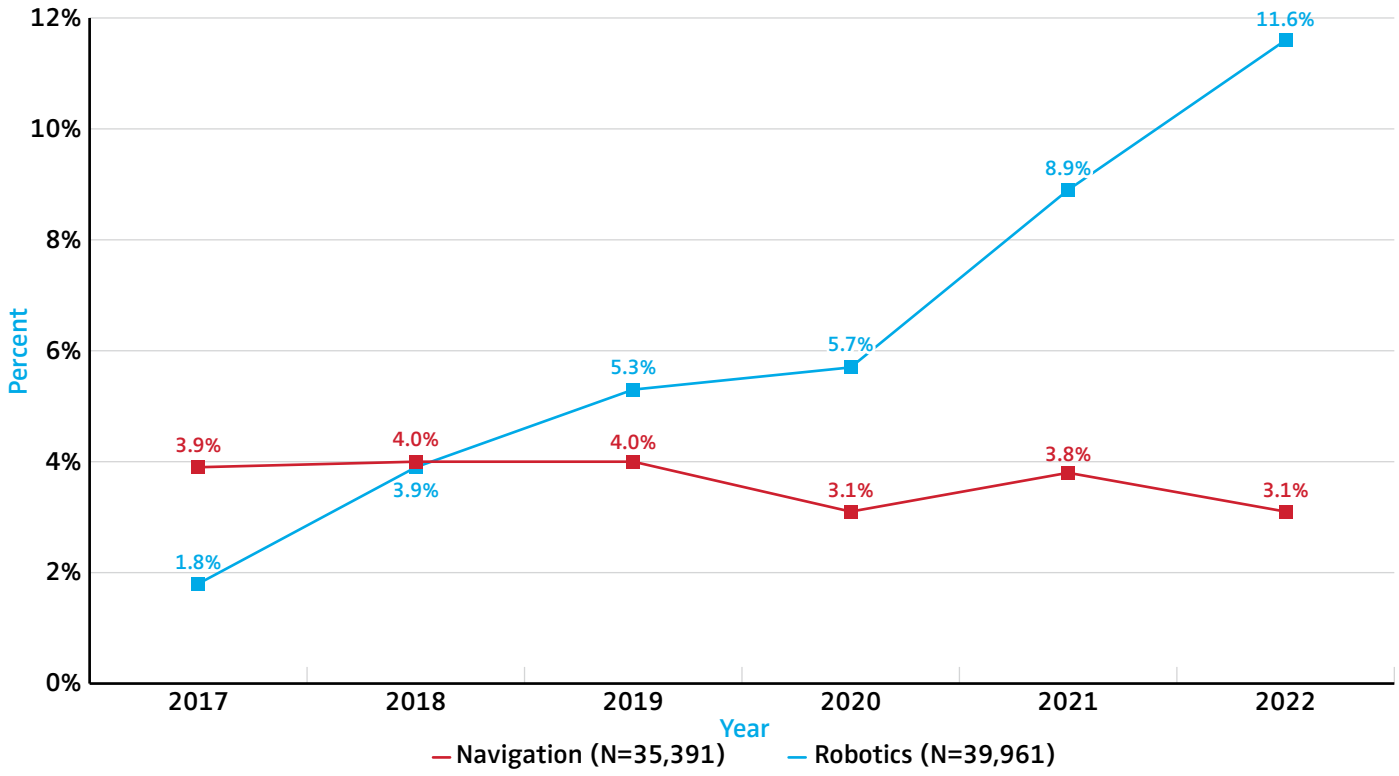


Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Cemented	502,467	453,438	401,696	334,559	262,470	181,152	111,502	61,255	27,207	7,685	4
Cementless	33,890	25,022	18,333	12,764	8,475	5,461	2,753	1,135	380	95	1
Hybrid	14,036	12,859	11,739	10,121	8,461	6,364	4,181	2,575	1,172	278	1
Total	550,393	491,319	431,768	357,444	279,406	192,977	118,436	64,965	28,759	8,058	6

Age/Sex adjusted cause-specific HR (95%CI), p-value
Cementless vs. Cemented: *0.904 (0.757,1.079), p=0.2640*
Hybrid vs. Cemented: *0.854 (0.674,1.081), p=0.1897*

For this year's Annual Report, utilization of technology for surgical assistance in primary total knee arthroplasty was analyzed. The utilization of both computer navigation and robotics has increased substantially over the past few years. The percentage of elective primary total knee arthroplasty cases utilizing robotic assistance is now close to 12% (Figure 3.16). A detailed table comparing procedures performed with technology compared to conventional total knee arthroplasty is also included (Table 3.3).

Figure 3.16 Rate of Technology Use for Assistance in Total Knee Arthroplasty, Jan 2017 - Mar 2022



INSIGHTS

Over the past 5 years, the utilization of robotics in TKA has increased over 6-fold and is now reported in almost 12% of procedures, whereas computer navigation use has remained relatively stable.

Table 3.3 Comparison of Patients Undergoing Total Knee Arthroplasty with or without the Assistance of Technology (Navigation or Robotics)

	Yes (N = 61,637)	No (N = 359,618)	NR (N = 889,917)	Total (N = 1,311,172)
Age				
Mean (SD)	67.53 (9.36)	67.38 (9.31)	67.18 (9.48)	67.25 (9.43)
N (N Missing)	61,637 (0)	359,618 (0)	889,917 (0)	1,311,172 (0)
Patient BMI				
Mean (SD)	32.57 (7.43)	32.50 (6.61)	32.46 (6.54)	32.48 (6.63)
N (N Missing)	47,425 (14212)	240,078 (119540)	378,239 (511678)	665,742 (645430)
Charlson Comorbidity Index (CCI)				
Mean (SD)	2.70 (1.40)	2.61 (1.36)	2.52 (1.30)	2.55 (1.32)
N (N Missing)	61,637 (0)	359,618 (0)	889,917 (0)	1,311,172 (0)
Age Category				
<50	1,839 (2.98%)	10,938 (3.04%)	28,658 (3.22%)	41,435 (3.16%)
50-59	10,228 (16.59%)	60,307 (16.77%)	157,787 (17.73%)	228,322 (17.41%)
60-69	23,066 (37.42%)	137,489 (38.23%)	337,377 (37.91%)	497,932 (37.98%)
70-79	20,518 (33.29%)	116,865 (32.50%)	280,382 (31.51%)	417,765 (31.86%)
80-89	5,724 (9.29%)	32,671 (9.08%)	82,140 (9.23%)	120,535 (9.19%)
>=90	262 (0.43%)	1,348 (0.37%)	3,573 (0.40%)	5,183 (0.40%)
Missing	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Sex				
Female	36,854 (59.79%)	218,458 (60.75%)	542,968 (61.01%)	798,280 (60.88%)
Male	24,733 (40.13%)	141,069 (39.23%)	342,696 (38.51%)	508,498 (38.78%)
NR / Missing	50 (0.08%)	91 (0.03%)	4,253 (0.48%)	4,394 (0.34%)
BMI Category				
Normal	5,179 (10.77%)	24,479 (10.06%)	39,478 (10.37%)	69,136 (10.29%)
Underweight	148 (0.31%)	829 (0.34%)	1,031 (0.27%)	2,008 (0.30%)
Pre-Obesity	13,439 (27.95%)	66,726 (27.42%)	104,823 (27.53%)	184,988 (27.52%)
Obesity Class I	13,760 (28.61%)	71,179 (29.25%)	111,070 (29.17%)	196,009 (29.16%)
Obesity Class II	9,107 (18.94%)	48,409 (19.89%)	76,005 (19.96%)	133,521 (19.87%)
Obesity Class III	6,455 (13.42%)	31,707 (13.03%)	48,314 (12.69%)	86,476 (12.87%)
Missing	13,549 (21.98%)	116,289 (32.34%)	509,196 (57.22%)	639,034 (48.74%)
Region				
Midwest	8,059 (13.14%)	95,449 (26.54%)	299,489 (33.68%)	402,997 (30.76%)
North East	14,746 (24.04%)	51,085 (14.21%)	186,253 (20.94%)	252,084 (19.24%)
South	24,875 (40.56%)	100,234 (27.87%)	229,259 (25.78%)	354,368 (27.05%)
West	13,655 (22.26%)	112,828 (31.38%)	174,252 (19.60%)	300,735 (22.95%)
Missing	302 (0.49%)	22 (0.01%)	664 (0.07%)	988 (0.08%)
Teaching Type				
Major	9,407 (16.37%)	58,250 (17.39%)	190,079 (22.44%)	257,736 (20.79%)
Minor	27,382 (47.66%)	161,938 (48.35%)	465,418 (54.95%)	654,738 (52.83%)
Non Teaching	20,668 (35.97%)	114,732 (34.26%)	191,550 (22.61%)	326,950 (26.38%)
Missing	4,180 (6.78%)	24,698 (6.87%)	42,870 (4.82%)	71,748 (5.47%)
Institution Bed Size				
Between 1-99 Beds	12,651 (22.24%)	84,608 (25.99%)	146,531 (17.37%)	243,790 (19.89%)
Between 100-399 Beds	23,599 (41.48%)	147,141 (45.20%)	401,084 (47.55%)	571,824 (46.65%)
>= 400 Beds	20,645 (36.29%)	93,776 (28.81%)	295,812 (35.07%)	410,233 (33.47%)
Missing	4,742 (7.69%)	34,093 (9.48%)	46,490 (5.22%)	85,325 (6.51%)
Year				
2012	146 (0.55%)	1,634 (6.11%)	24,970 (93.35%)	26,750 (2.04%)
2013	130 (0.21%)	3,409 (5.54%)	58,007 (94.25%)	61,546 (4.69%)
2014	308 (0.30%)	4,794 (4.69%)	97,088 (95.01%)	102,190 (7.79%)
2015	384 (0.29%)	11,272 (8.43%)	122,130 (91.29%)	133,786 (10.20%)
2016	4,470 (2.55%)	59,533 (33.98%)	111,199 (63.47%)	175,202 (13.36%)
2017	9,610 (4.86%)	67,155 (33.97%)	120,906 (61.17%)	197,671 (15.08%)
2018	11,647 (6.43%)	67,010 (36.99%)	102,508 (56.58%)	181,165 (13.82%)
2019	12,607 (7.26%)	61,263 (35.28%)	99,802 (57.47%)	173,672 (13.25%)
2020	10,287 (7.23%)	49,636 (34.88%)	82,383 (57.89%)	142,306 (10.85%)
2021	11,361 (10.19%)	32,528 (29.16%)	67,657 (60.65%)	111,546 (8.51%)
2022	687 (12.87%)	1,384 (25.93%)	3,267 (61.20%)	5,338 (0.41%)

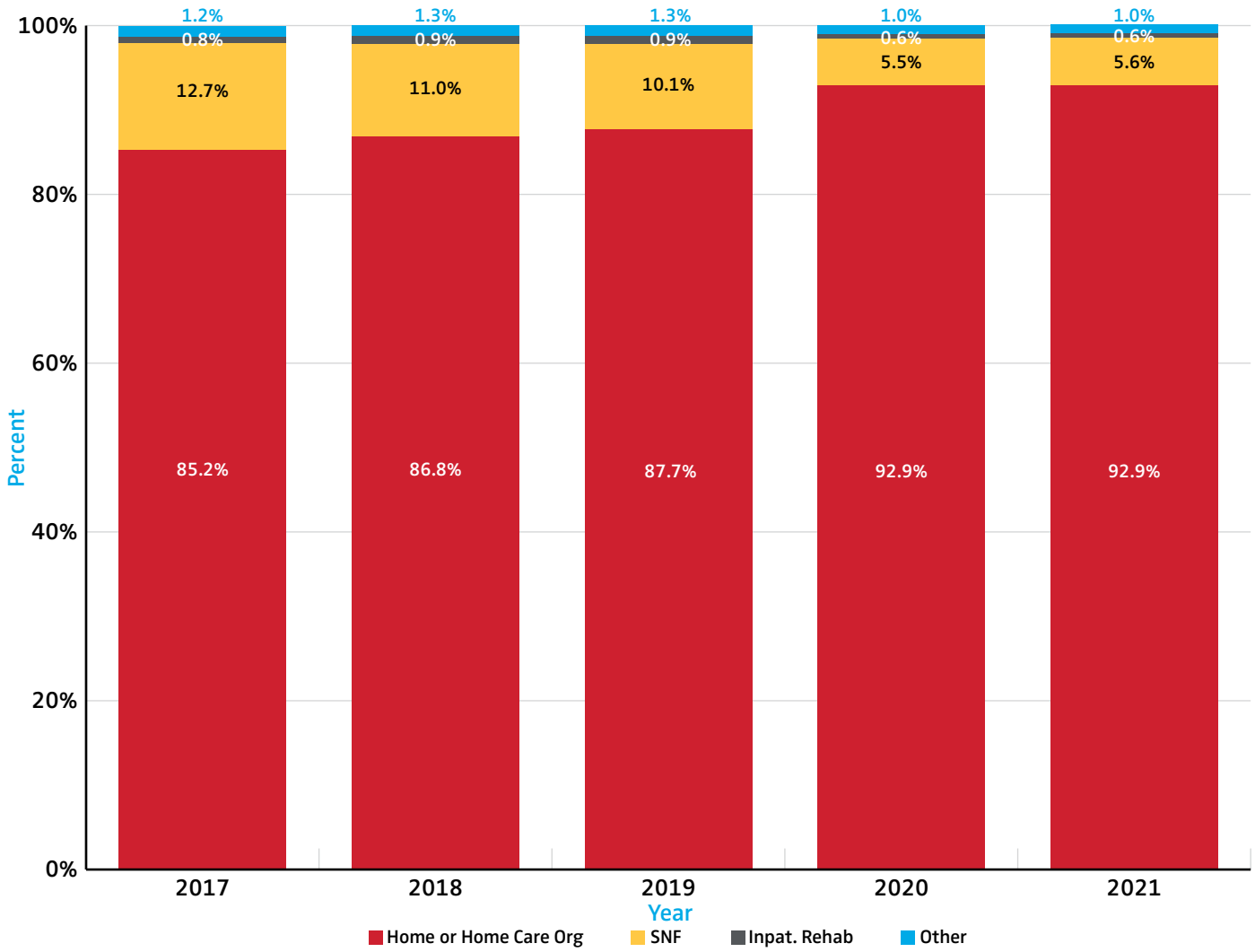
SD=Standard Deviation, NR=Not Reported, BMI=Body Mass Index

Figure 3.17 tabulates the discharge disposition reported for primary total knee arthroplasty procedures by year for the years 2017 through 2021, 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 approximately 93% by 2021. Discharge to a skilled nursing facility (SNF) dropped from 12.7% in 2017 to only 5.6% in 2021. 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 3.17 Total Knee Arthroplasty Discharge Disposition Codes by Year, 2012-2021 (N=641,799)



Code	Code Value
Home	Discharged to home/self-care (routine charge).
Home Care Org.	Discharged/transferred to home care of organized home health service organization.
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.)
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 3.18 shows a tabulation of primary anesthesia techniques chosen for patients undergoing an elective primary total knee arthroplasty. Since 2017, general anesthesia use has decreased 33% while the slightly more commonly used spinal anesthesia has remained relatively steady. Use of combinations such as general and spinal with peripheral nerve block (PNB) have both more than doubled since 2017 each accounting for roughly 10% of 2021 cases with anesthesia data.

Figure 3.18 Primary Total Knee Arthroplasty Anesthesia Type by Year, 2017-2021 (N=430,832)

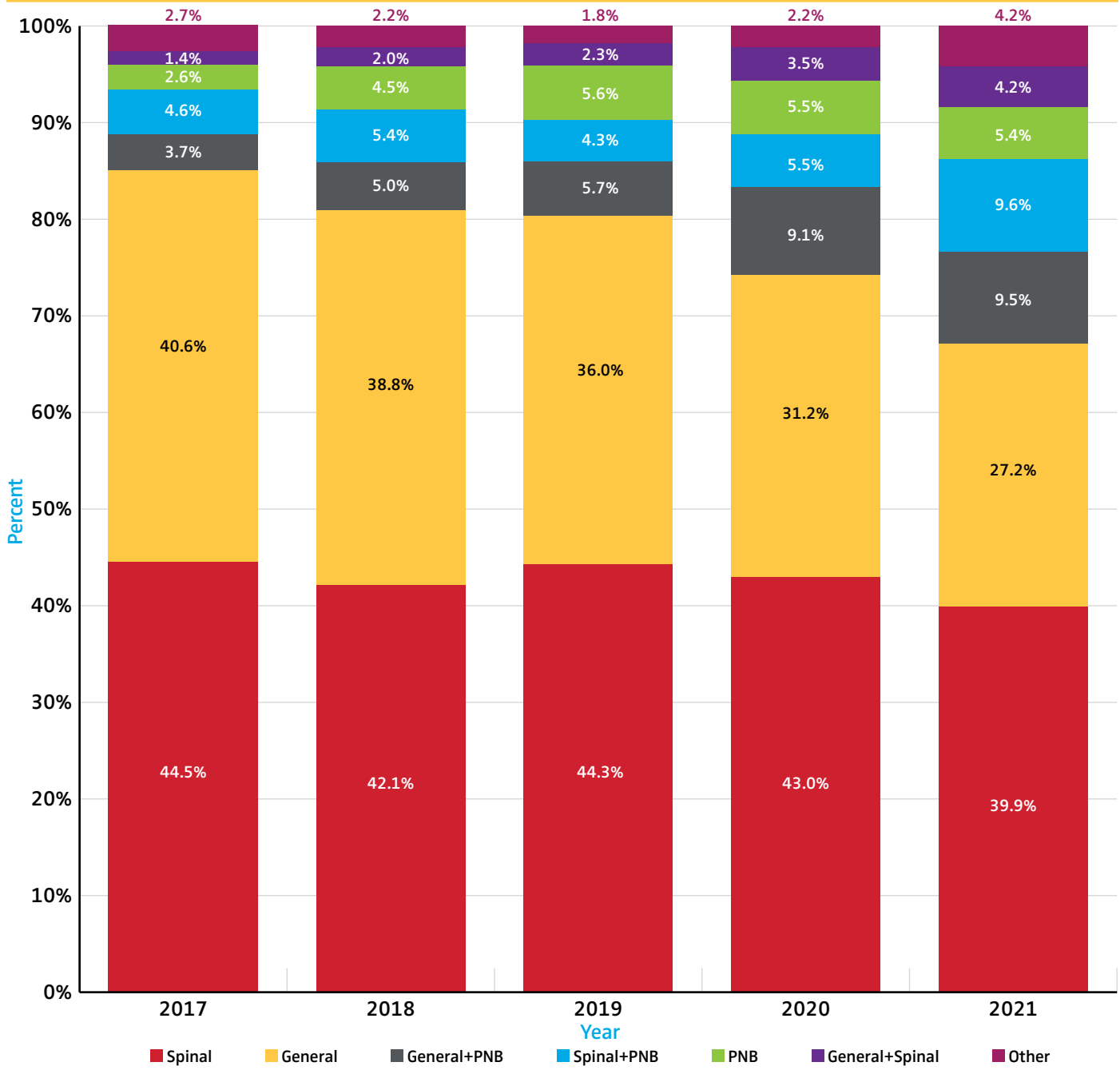
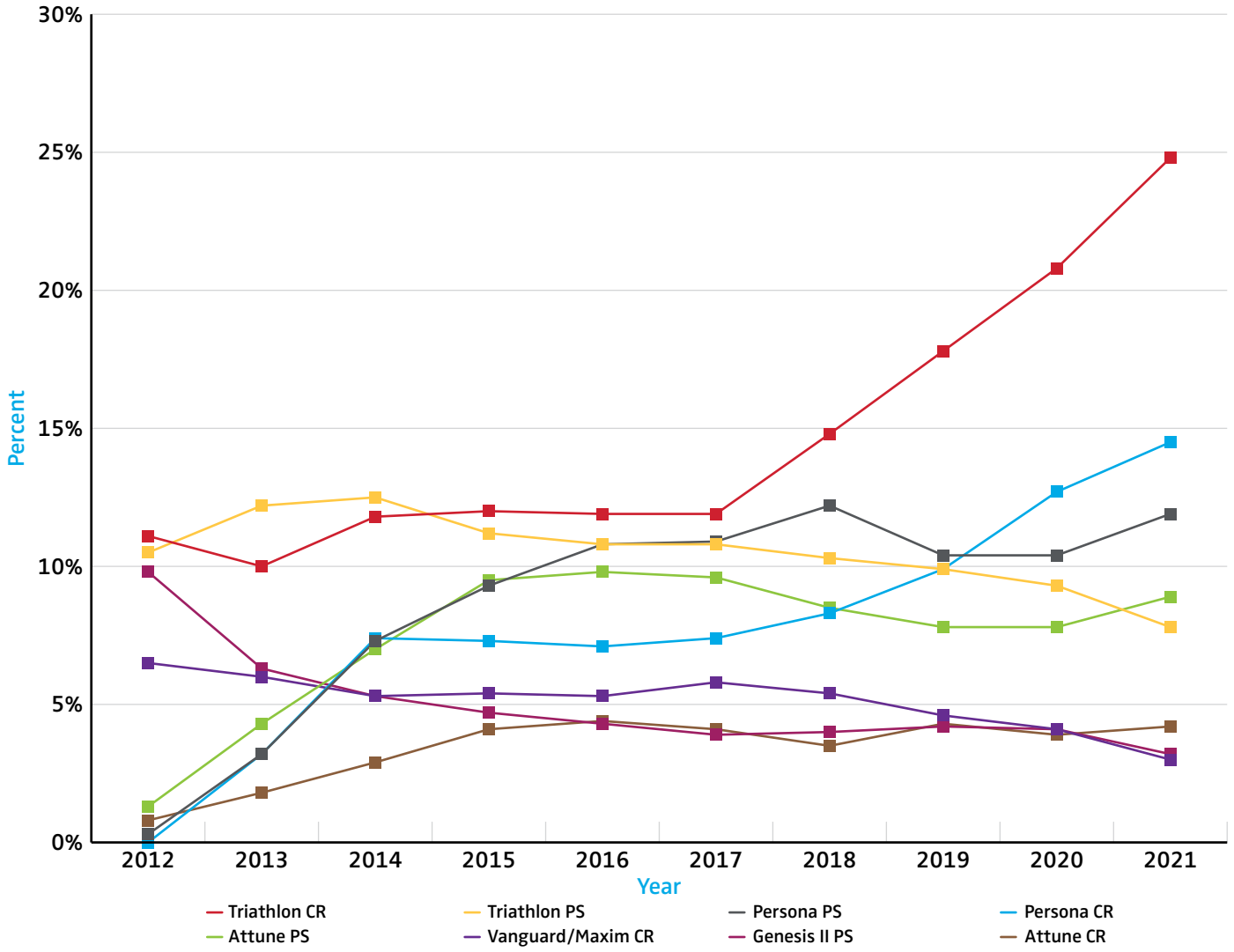


Figure 3.19 provides utilization data of implants used in primary total knee arthroplasty procedures in AJRR by year for the years 2012 through 2021. The eight most commonly implanted femoral and tibial component combinations along with their overall bearing design for TKA by year shows that for the ten-year period, the combinations most frequently implanted have varied. Since 2015, the Triathlon cruciate retaining knee has been the most frequently implanted construct overall in the registry.

Figure 3.19 Primary Total Knee Arthroplasty Femoral/Tibial Component Combinations by Year, 2012-2021 (N=1,025,370)



The ability to look at revision rates for particular implants is one of the great strengths of the AJRR. The tables below (3.4-3.5) display cumulative percent revision stratified by knee constructs as well as bearing and fixation types with 95% confidence intervals. Unlike the hip device-specific survivorship curves 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 2.2% at three years and less than 2.6% at final follow-up for each respective device. The aggregate of included cemented or hybrid devices was 1.7% cumulative percent revision at seven years. 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 2021 AJRR Annual Report Supplement, which can be found at www.aaos.org/AJRRannualreport.

Table 3.4 Unadjusted Cumulative Percent Revision of Cemented Knee Arthroplasty Construct Combinations for Primary Total Knee Arthroplasty in Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020

Femoral Component	Tibial Component	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Triathlon CR	Triathlon	58,334	572	0.55 (0.49, 0.61)	1.01 (0.93, 1.10)	1.25 (1.14, 1.36)	1.42 (1.27, 1.57)
Persona PS	Persona	55,366	706	0.67 (0.60, 0.74)	1.34 (1.23, 1.44)	1.69 (1.56, 1.83)	1.79 (1.64, 1.95)
Triathlon PS	Triathlon	53,782	736	0.73 (0.66, 0.81)	1.35 (1.25, 1.46)	1.67 (1.54, 1.8)	1.78 (1.64, 1.93)
Attune PS	Attune	44,279	621	0.64 (0.57, 0.72)	1.39 (1.27, 1.51)	1.79 (1.64, 1.95)	2.14 (1.87, 2.45)
Persona CR	Persona	42,741	358	0.47 (0.40, 0.54)	0.97 (0.86, 1.08)	1.15 (1.03, 1.28)	1.22 (1.08, 1.38)
Vanguard CR	Maxim	27,481	275	0.52 (0.44, 0.61)	1.00 (0.88, 1.13)	1.21 (1.06, 1.37)	1.36 (1.18, 1.57)
Genesis II PS	Genesis II	24,764	383	0.77 (0.67, 0.89)	1.57 (1.41, 1.75)	1.91 (1.72, 2.12)	2.11 (1.88, 2.36)
Attune CR	Attune	20,532	204	0.51 (0.42, 0.61)	1.06 (0.91, 1.22)	1.30 (1.12, 1.5)	1.34 (1.15, 1.55)
Sigma CR	PFC Sigma	19,407	171	0.42 (0.34, 0.52)	0.75 (0.63, 0.89)	1.04 (0.88, 1.22)	1.23 (1.03, 1.45)
Sigma PS	PFC Sigma	19,014	239	0.64 (0.53, 0.77)	1.20 (1.04, 1.37)	1.47 (1.28, 1.68)	1.68 (1.46, 1.92)
Journey II PS	Journey II	15,573	265	1.03 (0.88, 1.21)	1.96 (1.72, 2.21)	2.27 (1.98, 2.59)	2.34 (2.02, 2.69)
NexGen LPS-Flex PS	NexGen	14,878	218	0.63 (0.51, 0.77)	1.26 (1.09, 1.46)	1.65 (1.43, 1.89)	1.80 (1.56, 2.07)
Vanguard PS	Maxim	14,219	229	0.86 (0.72, 1.03)	1.54 (1.34, 1.77)	1.87 (1.64, 2.14)	2.09 (1.77, 2.46)
Genesis II CR	Genesis II	12,126	137	0.61 (0.48, 0.77)	1.18 (0.99, 1.40)	1.40 (1.17, 1.66)	1.50 (1.24, 1.81)
Legion PS	Genesis II	11,699	156	0.68 (0.54, 0.84)	1.34 (1.12, 1.58)	1.74 (1.46, 2.05)	2.00 (1.54, 2.56)
Sigma PS	MBT	8,293	129	0.50 (0.37, 0.68)	1.18 (0.95, 1.44)	1.83 (1.52, 2.18)	2.13 (1.76, 2.55)
Natural-Knee II GS CR	Natural-Knee II	6,707	60	0.40 (0.27, 0.58)	0.79 (0.59, 1.04)	1.07 (0.81, 1.38)	1.23 (0.91, 1.64)
Legion CR	Genesis II	5,000	56	0.59 (0.40, 0.84)	1.18 (0.88, 1.56)	1.37 (1.03, 1.79)	2.07 (1.25, 3.23)
Evolution MP PS	Evolution MP	4,789	73	0.65 (0.44, 0.92)	1.42 (1.09, 1.83)	2.03 (1.59, 2.57)	2.30 (1.74, 2.98)
NexGen CR-Flex CR	NexGen	4,130	45	0.49 (0.31, 0.75)	0.95 (0.68, 1.30)	1.19 (0.87, 1.60)	1.34 (0.97, 1.8)
EMPOWR 3D CR	EMPOWR	3,557	44	0.74 (0.49, 1.08)	1.37 (0.98, 1.88)	1.93 (1.34, 2.69)	—
Apex Knee CR	Apex Knee	3,539	42	0.69 (0.46, 1.02)	1.23 (0.88, 1.67)	1.53 (1.09, 2.09)	1.53 (1.09, 2.09)
GMK Sphere CR	GMK Primary	2,762	28	0.68 (0.41, 1.06)	1.35 (0.87, 2.02)	1.75 (1.08, 2.68)	1.75 (1.08, 2.68)
Sigma CR	MBT	2,601	43	0.73 (0.46, 1.13)	1.30 (0.92, 1.81)	1.90 (1.38, 2.55)	1.90 (1.38, 2.55)
NexGen CR-Flex CR	NexGen Pegged	1,713	19	0.43 (0.19, 0.86)	1.09 (0.66, 1.71)	1.20 (0.73, 1.87)	1.51 (0.84, 2.52)
EMPOWR PS	EMPOWR	1,420	15	0.87 (0.47, 1.52)	1.36 (0.78, 2.21)	—	—
NexGen LPS-Flex GS PS	NexGen	1,356	26	0.75 (0.39, 1.34)	1.51 (0.94, 2.30)	2.01 (1.32, 2.94)	2.45 (1.59, 3.63)
LCS Complete CR	MBT	1,282	17	0.48 (0.20, 1.01)	1.04 (0.57, 1.76)	1.55 (0.91, 2.47)	1.77 (1.04, 2.84)
Optetrak Logic PS	Optetrak Logic	1,256	18	0.64 (0.31, 1.23)	1.24 (0.73, 2.00)	1.49 (0.90, 2.34)	1.94 (1.03, 3.34)
NexGen CR	NexGen	958	8	0.33 (0.10, 0.93)	0.59 (0.23, 1.31)	0.90 (0.40, 1.79)	1.16 (0.53, 2.26)
3DKnee CR	Foundation	760	14	1.58 (0.87, 2.68)	1.86 (1.07, 3.02)	1.86 (1.07, 3.02)	1.86 (1.07, 3.02)
GMK Primary PS	GMK Primary	655	12	0.77 (0.30, 1.72)	1.29 (0.61, 2.44)	1.95 (1.03, 3.38)	2.31 (1.23, 3.98)
Optetrak Logic CR	Optetrak Logic	641	13	0.79 (0.30, 1.76)	2.07 (1.16, 3.42)	2.07 (1.16, 3.42)	2.07 (1.16, 3.42)
LCS Complete PS	MBT	605	5	—	0.76 (0.26, 1.84)	1.01 (0.38, 2.26)	1.01 (0.38, 2.26)
Apex Knee PS	Apex Knee	525	3	0.38 (0.08, 1.30)	0.38 (0.08, 1.30)	1.27 (0.23, 4.30)	—
Natural-Knee II CR	Natural-Knee II	505	5	1.03 (0.39, 2.28)	1.03 (0.39, 2.28)	1.03 (0.39, 2.28)	1.03 (0.39, 2.28)
NexGen PS	NexGen	447	9	0.68 (0.19, 1.87)	2.10 (1.04, 3.80)	2.10 (1.04, 3.80)	2.10 (1.04, 3.80)
NexGen CR	NexGen Pegged	435	4	0.69 (0.19, 1.89)	0.69 (0.19, 1.89)	1.22 (0.37, 3.12)	1.22 (0.37, 3.12)
Overall	—	488,131	5,958	0.63 (0.61, 0.65)	1.23 (1.19, 1.26)	1.54 (1.50, 1.58)	1.71 (1.66, 1.77)

Table 3.5 Unadjusted Cumulative Percent Revision of Hybrid Knee Arthroplasty Construct Combinations for Primary Total Knee Arthroplasty in Patients ≥65 Years of Age with Primary Osteoarthritis, 2012-2020*

Femoral Component	Tibial Component	N Total	N Revised	1 Yr	3 Yrs	5 Yrs	7 Yrs
Sigma CR	PFC Sigma	2,531	22	0.24 (0.1, 0.51)	0.84 (0.53, 1.3)	1.07 (0.68, 1.61)	1.07 (0.68, 1.61)
Vanguard CR	Maxim	1,801	38	1.41 (0.93, 2.06)	2.09 (1.47, 2.87)	2.53 (1.80, 3.45)	2.53 (1.80, 3.45)
Triathlon CR	Triathlon	1,650	25	0.56 (0.28, 1.04)	1.49 (0.96, 2.21)	1.76 (1.17, 2.56)	1.76 (1.17, 2.56)
Persona CR	Persona	924	14	0.56 (0.22, 1.26)	1.62 (0.91, 2.70)	1.96 (1.07, 3.31)	1.96 (1.07, 3.31)
Apex Knee CR	Apex Knee	731	12	1.10 (0.52, 2.09)	1.67 (0.92, 2.83)	1.67 (0.92, 2.83)	1.67 (0.92, 2.83)
Natural-Knee II GS CR	Natural-Knee II	530	6	0.38 (0.08, 1.29)	1.28 (0.53, 2.65)	1.28 (0.53, 2.65)	1.28 (0.53, 2.65)
Sigma CR	MBT	505	5	0.61 (0.17, 1.69)	0.87 (0.29, 2.12)	1.55 (0.49, 3.83)	1.55 (0.49, 3.83)
Overall	—	8,672	122	0.68 (0.52, 0.87)	1.40 (1.16, 1.68)	1.67 (1.38, 1.99)	1.67 (1.38, 1.99)

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

Partial Knee Arthroplasty

Between 2012 and 2021, AJRR has collected data on 66,394 partial knee arthroplasty procedures.

Medial or lateral unicompartmental knee arthroplasty (UKA) utilization as a percentage of TKA use has fluctuated since the inception of AJRR in 2012. UKA accounted for just 2.9% of all primary knee arthroplasties reported to AJRR for 2017. These numbers have slightly increased to 4.2% by 2021 (Figure 3.20). Since there was a slight increase from the 2.9% 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 Arthroplasty Register noted in 2021 that the use of UKA accounted for almost 11.6% of their primary knee arthroplasty cases (a small increase from the previous year).[17] 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%).[7]

The use of patellofemoral arthroplasty (PFA) in the AJRR remains a small percentage of unicompartmental arthroplasty and has been <1% since 2012 (Figure 3.21). These low numbers are consistent with international registries, where the New Zealand Joint Registry reported from 1999-2020 a total of 142,079 primary knee arthroplasties of which only 746 (0.5%) represented patellofemoral prostheses.[17] The National Joint Registry of England and Wales and the Swedish Arthroplasty Register reported PFA in 2021 at 1.2% and 0.1% respectively.[8,9] Only 4.6% of all surgeons who submitted primary knee arthroplasty procedures to AJRR performed PFAs, and only 20.1% performed medial and/or lateral UKAs in 2021 (Table 3.6).

Figure 3.20 Medial or Lateral Unicompartmental Knee Arthroplasty as a Percentage of All Primary Knee Arthroplasty, 2012-2021 (N=60,931)

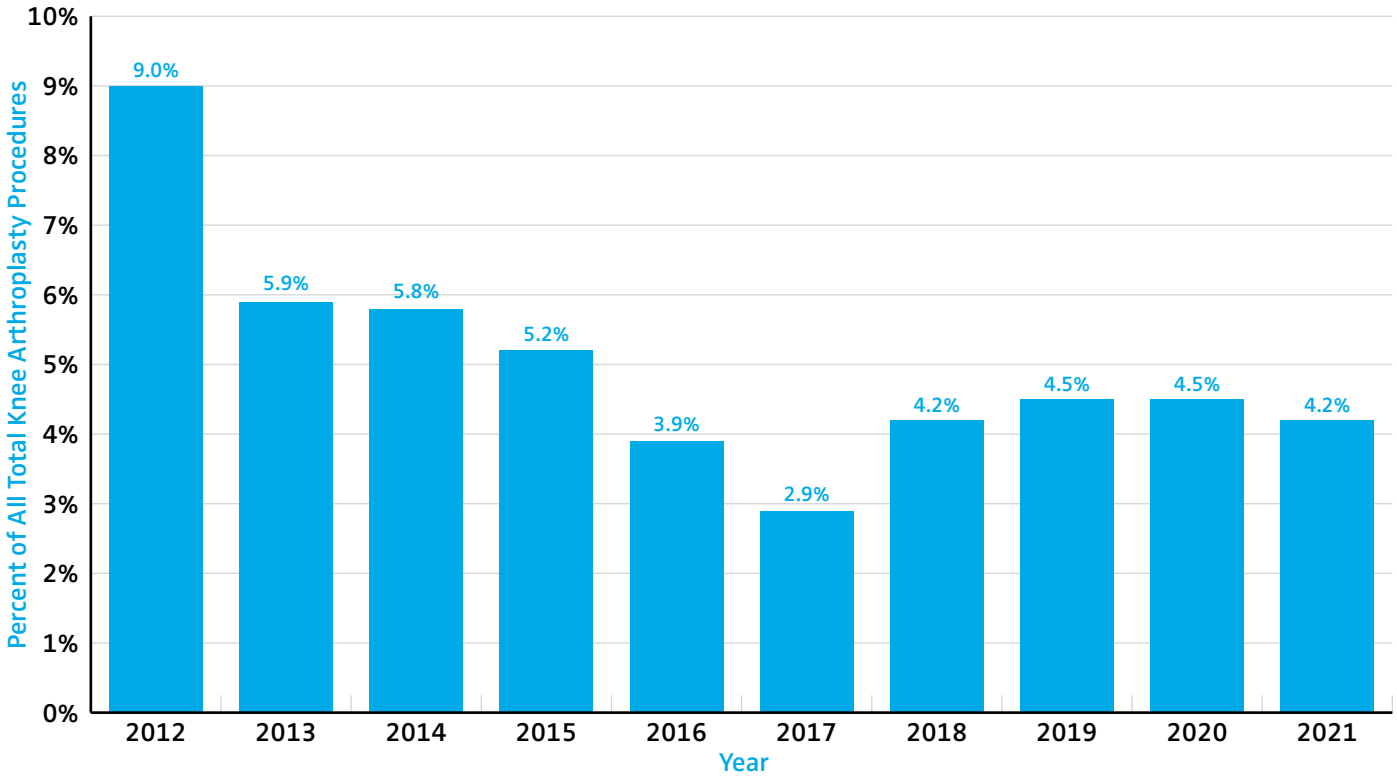


Figure 3.21 Patellofemoral Arthroplasty as a Percentage of All Primary Knee Arthroplasty, 2012-2021 (N=5,463)

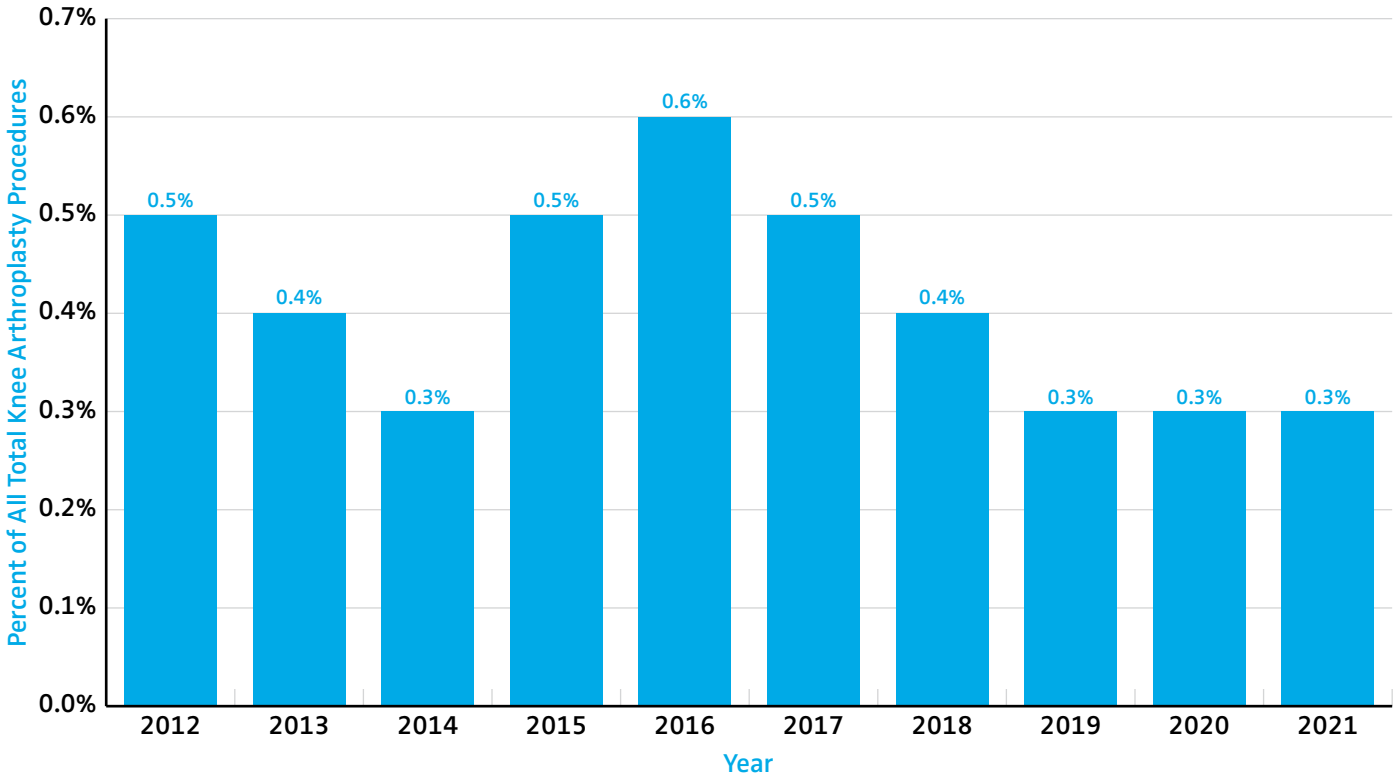


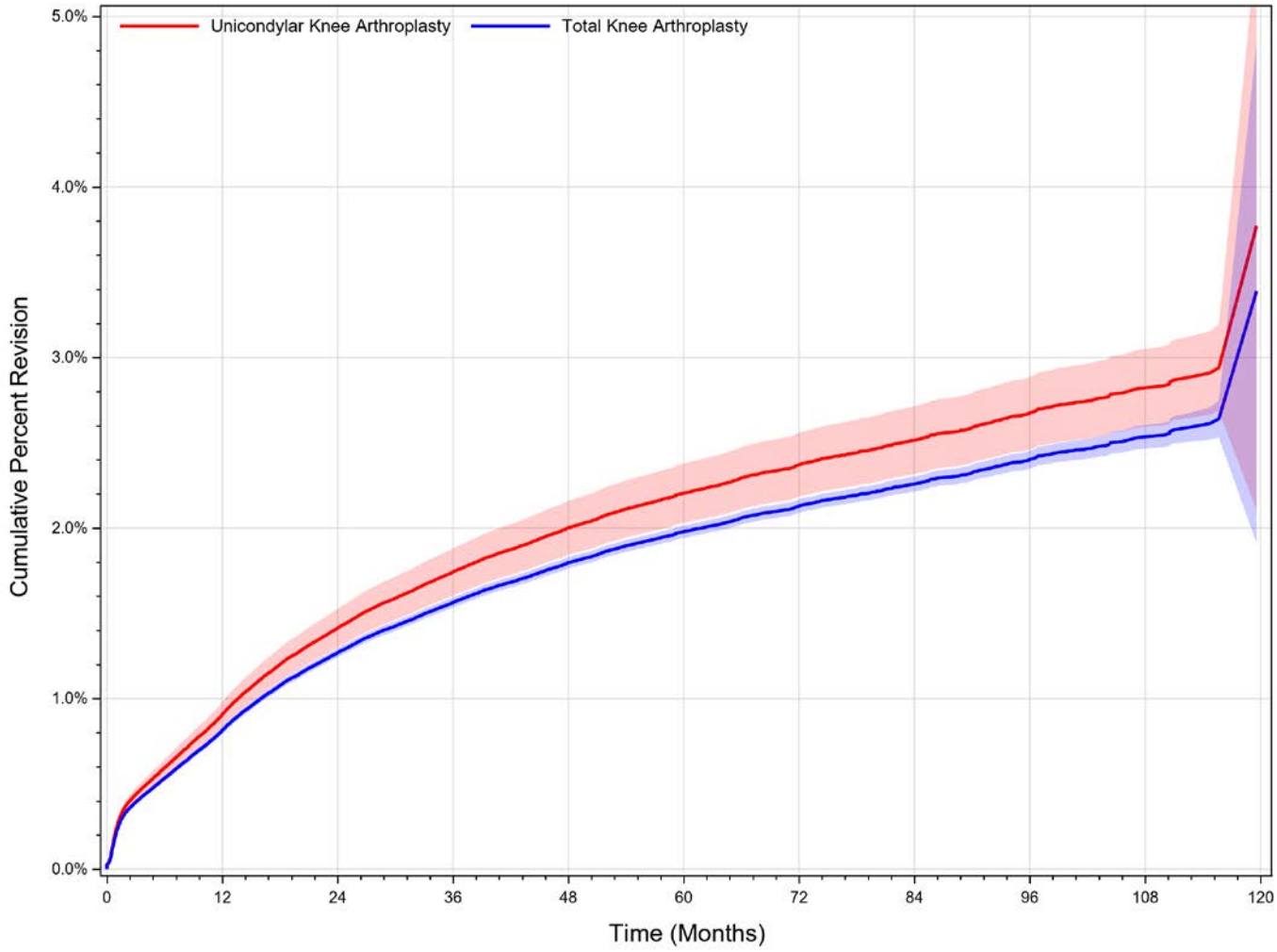
Table 3.6 Surgeons Performing Patellofemoral and Unicompartmental Knee Arthroplasty, 2012-2021

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Surgeons Performing Unicompartmental Knee Arthroplasty	204 (20.71%)	431 (21.51%)	707 (22.85%)	938 (22.27%)	1,057 (19.76%)	973 (18.03%)	1,139 (21.95%)	1,208 (22.51%)	1,132 (21.82%)	838 (20.10%)
Suregeons Performing Patellofemoral Arthroplasty	58 (5.89%)	98 (4.89%)	149 (4.82%)	299 (7.10%)	491 (9.18%)	554 (10.27%)	385 (7.42%)	293 (5.46%)	268 (5.17%)	190 (4.56%)
Total number of Surgeons submitting TKA	723 (73.40%)	1,475 (73.60%)	2,238 (72.33%)	2,974 (70.62%)	3,801 (71.06%)	3,869 (71.70%)	3,666 (70.64%)	3,866 (72.03%)	3,788 (73.01%)	3,141 (75.34%)

In the AJRR or CMS database, total knee arthroplasty procedures demonstrated significantly decreased cumulative percent revision compared to unicondylar knee arthroplasty constructs in patients ≥65 years of age after adjusting for age and sex (HR=1.115, 95% CI, 1.02-1.219, p=0.0164) (Figures 3.22). This finding is aligned with other mature 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.[8]

The cumulative incidence of revision, adjusted for age and sex, is significantly higher with unicompartmental knee arthroplasty when compared with primary total knee arthroplasty.

Figure 3.22 Cumulative Percent Revision of Total Knee Versus Unicondylar Knee Constructs for Femoral Components in Medicare Patients 65 Years of Age and older with Primary Osteoarthritis, 2012-2021



Number at Risk (Months)	0	12	24	36	48	60	72	84	96	108	120
Total Knee Arthroplasty	753,818	669,466	581,711	477,391	372,681	259,109	162,233	92,606	42,564	12,240	6
Unicondylar Knee Arthroplasty	30,423	27,129	23,647	19,420	15,358	12,496	9,194	5,875	2,994	1,257	9
Total	784,241	696,595	605,358	496,811	388,039	271,605	171,427	98,481	45,558	13,497	15

Age/Sex adjusted HR (95%CI), p-value
Unicondylar Knee Arthroplasty vs. Total Knee Arthroplasty: *1.115 (1.02,1.219), p=0.0164*

Figure 3.23 provides utilization data of implants used in partial knee arthroplasty procedures in AJRR. The eight most commonly used femoral and tibial combinations in UKA by year shows that, for the ten-year period, the combinations most frequently implanted have also varied. For 2021, the Restoris MultiCompartmental Knee (MCK) was the most frequently implanted combination with the Oxford Partial Knee System following a similar utilization level since 2012. Over the last four years, the Persona Knee component has seen a steep increase in utilization to become the third most common implant by 2021.

Figure 3.23 Unicondylar Knee Arthroplasty Femoral/Tibial Component Combinations by Year, 2012-2021 (N=46,175)

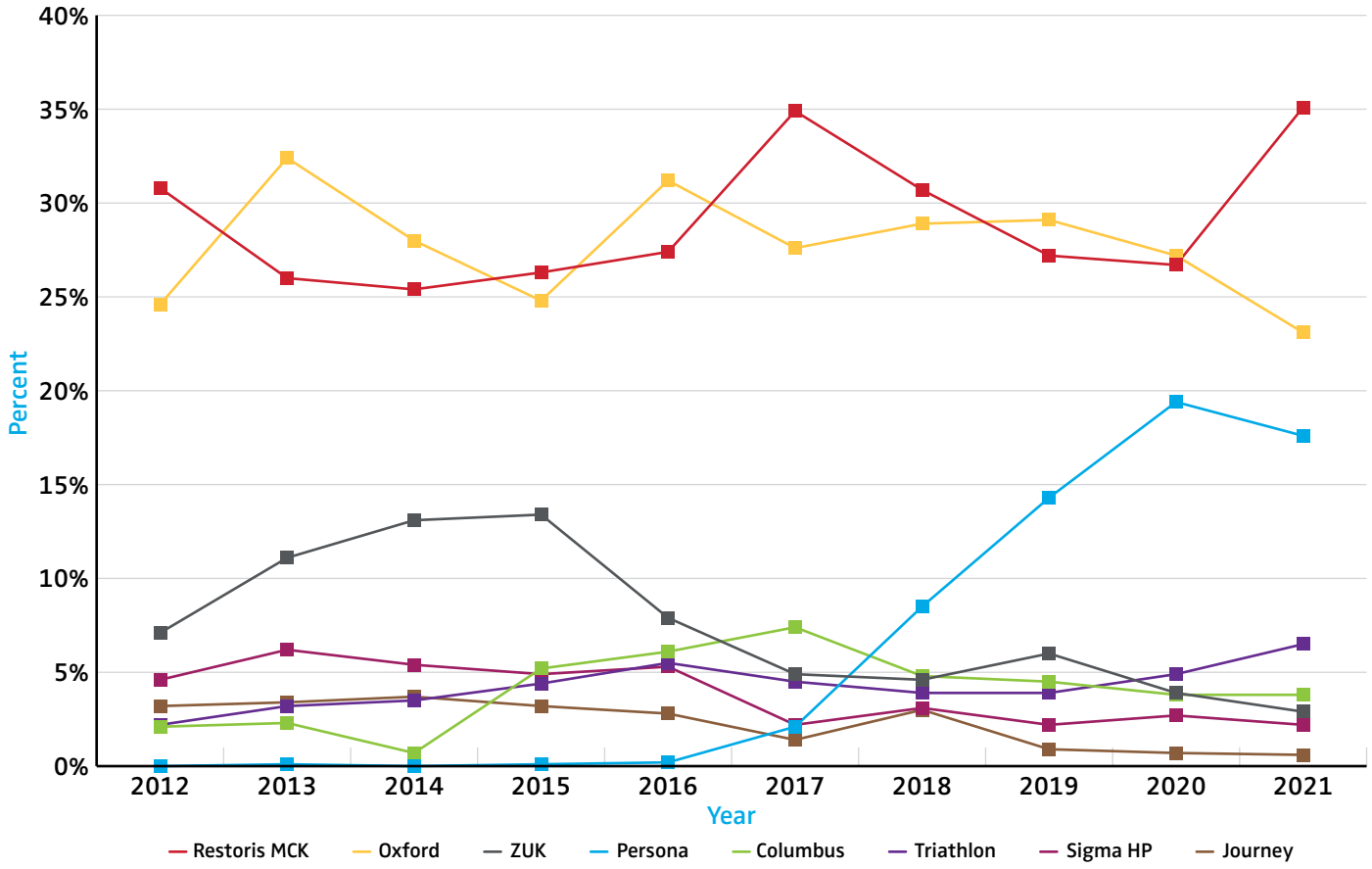
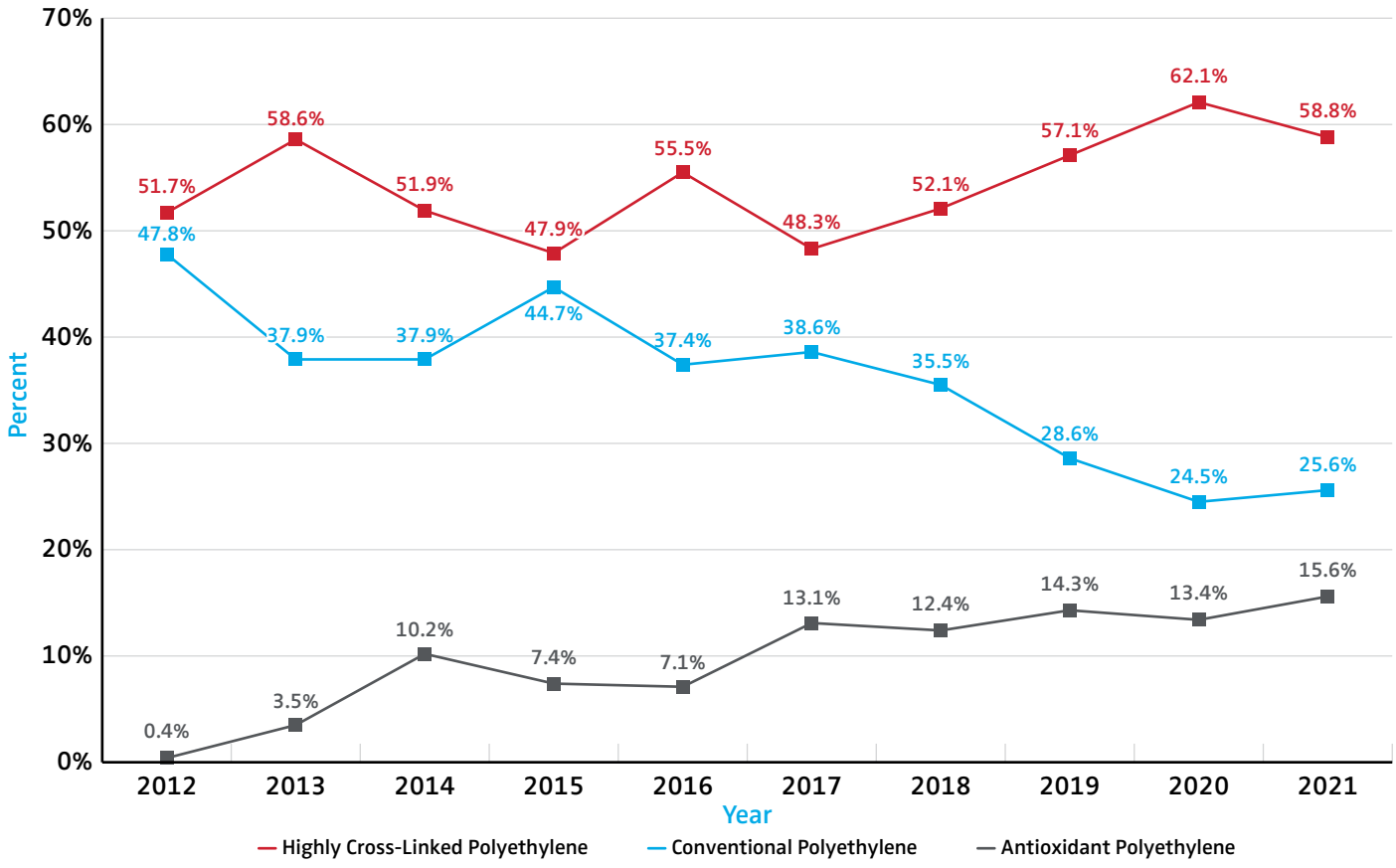


Figure 3.24 shows the polyethylene insert types utilized by year for partial knee arthroplasty. These results show that highly cross-linked polyethylene is the most frequently used material. The use of conventional polyethylene has substantially decreased while the use of antioxidant polyethylene for UKA has increased to account for 15.6% of cases by 2021.

INSIGHTS

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

Figure 3.24 Unicondylar Knee Arthroplasty Insert Polyethylene Material by Year, 2012-2021 (N=41,299)



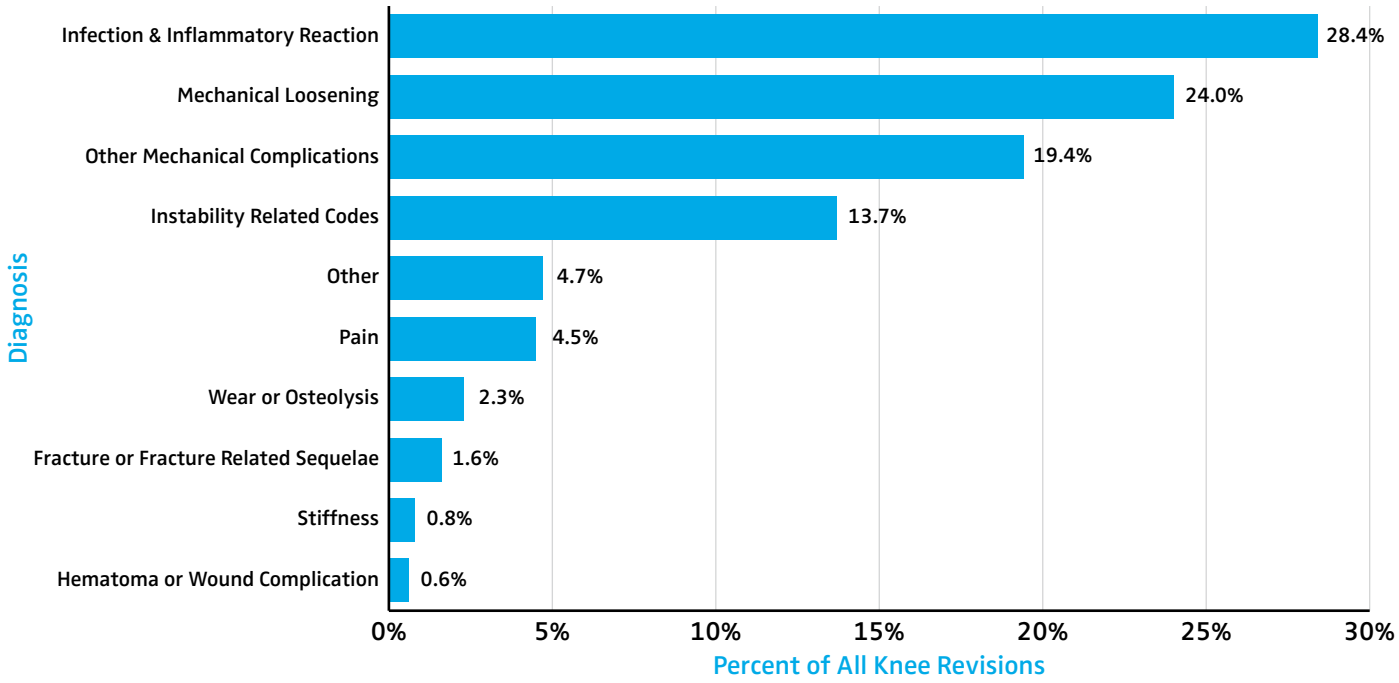
Revision Knee Arthroplasty

Between 2012 and 2021, AJRR has collected data on 122,852 revision knee arthroplasty procedures.

As discussed in the revision hip arthroplasty section, a substantial amount of work is ongoing 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 continue to be 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.

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 28.4% (Figure 3.25).

Figure 3.25 Distribution of Diagnosis Associated with All Knee Revisions, 2012-2021 (N=107,559)



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 3,759 early "linked" revision procedures in AJRR (Table 3.7). 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.[13] 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.[13] Among early revisions, 2,493 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 (59.3%) (Figure 3.26).

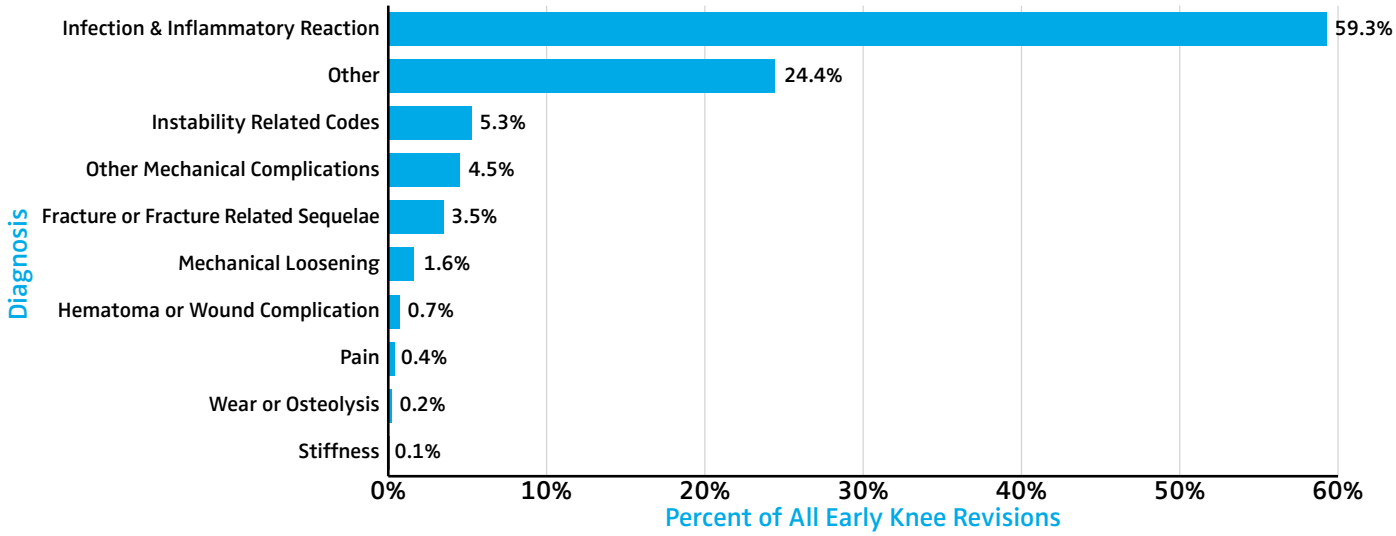
Table 3.7 Distribution of Time Interval Between Primary Total Knee Arthroplasty and Revision Procedures for "Linked" Patients, 2012-2021*

Time	Frequency	Percent
<3 Months	3,759	20.7
3-5 Months	1,538	8.5
6-12 Months	2,992	16.5
>1 Year	9,901	54.4

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

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

Figure 3.26 Distribution of Diagnosis Associated with Early "Linked" Knee Revisions, 2012-2021 (N=2,493)*

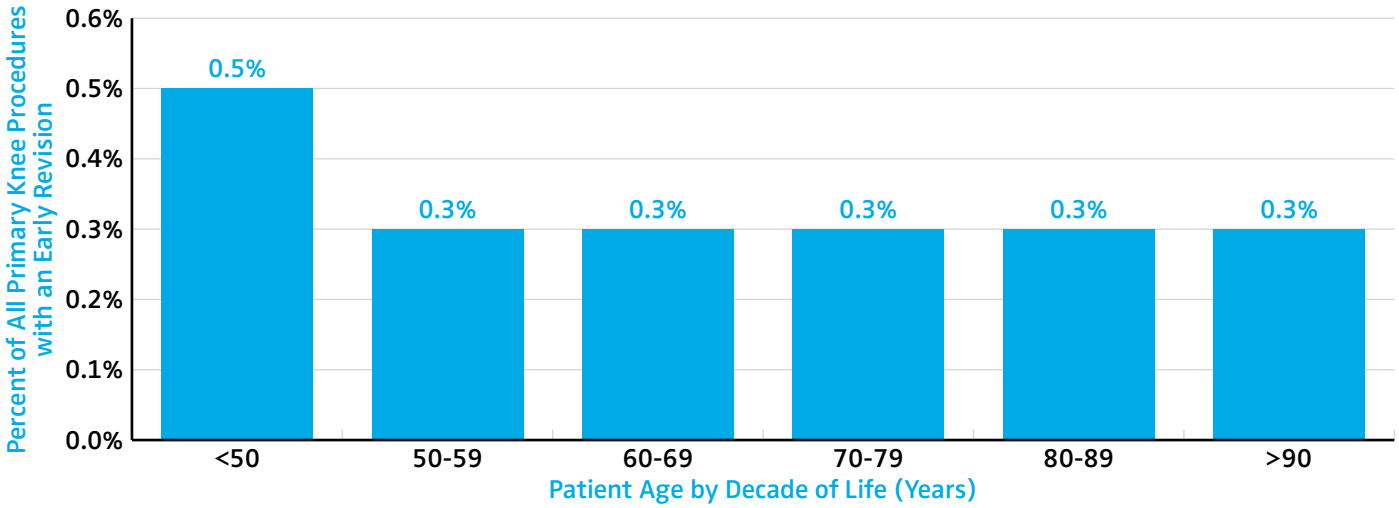


*Linked revisions require matching patient ID, procedure site, and laterality

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

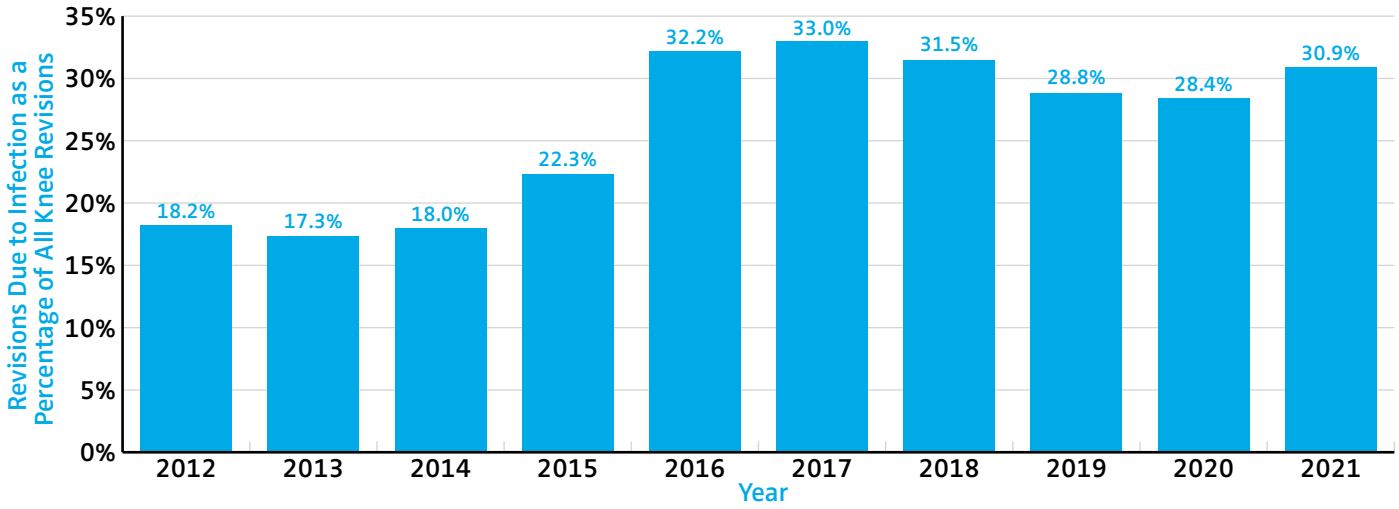
As reported to AJRR, the percentage of primary total knee arthroplasty procedures with an early revision (<3 months from primary procedure) ranged from 0.3% to 0.5% and was most common in the <50 age group (Figure 3.27). When comparing the percentage of revisions for all total knee arthroplasties with a primary diagnosis of infection, there has been an increase from 18.2% in 2012 to 28.4% in 2021 (Figure 3.28).

Figure 3.27 Early "Linked" Revisions as a Percent of All Primary Total Knee Arthroplasty Procedures by Age Group, 2012-2021 (N=3,759)*



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

Figure 3.28 Percent of Revision Total Knee Arthroplasty Procedures Due to Infection, 2012-2021 (N=30,491)



Antioxidant polyethylene usage in revision knee arthroplasties has been significantly increasing since 2012 ($p<0.001$) (Figure 3.29). Non-antioxidant polyethylene inserts include both highly cross-linked polyethylene and conventional polyethylene. Figure 3.30 provides utilization data of implants used in revision total knee arthroplasty procedures in AJRR by year for the years 2012 through 2021. Over the ten-year period, utilization of Triathlon components and the Sigma/MBT system has predominated. In recent years, an increased usage of Attune and Persona 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 3.29 Revision Knee Arthroplasty Insert Polyethylene Material by Year, 2012-2021 (N=84,519)

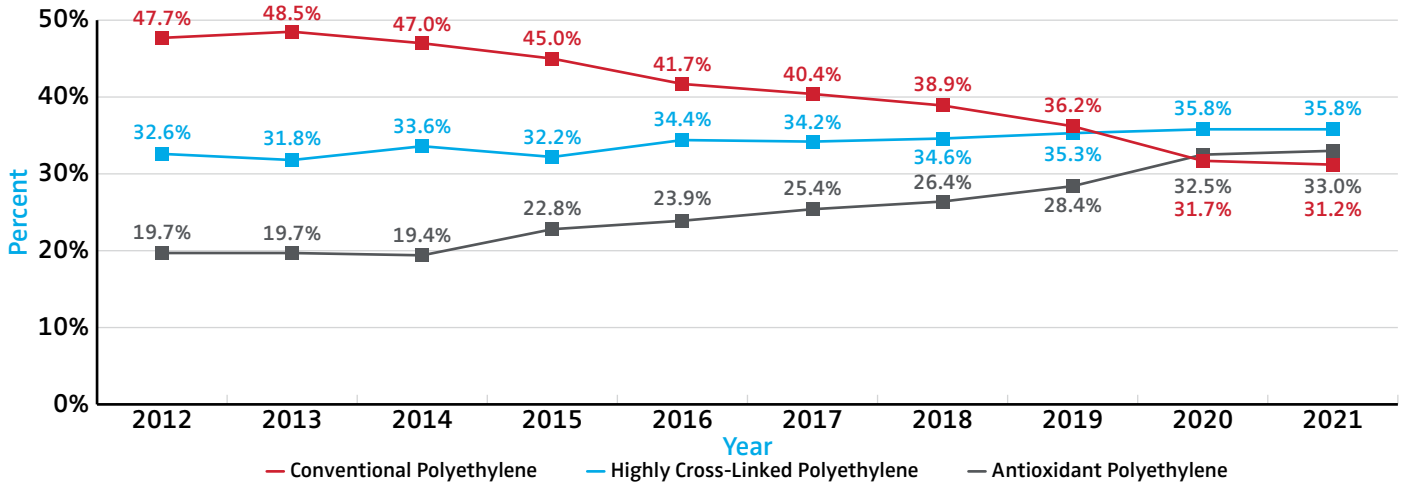
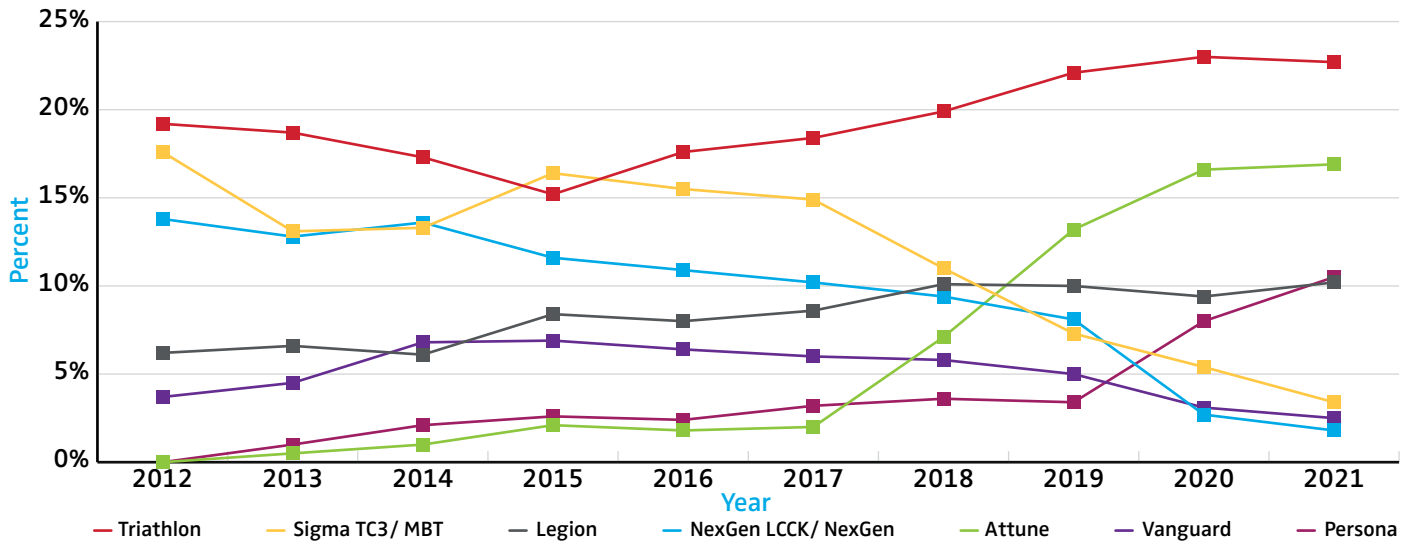


Figure 3.30 Revision Total Knee Arthroplasty Femoral/Tibial Component Combinations by Year, 2012-2021 (N=47,916)



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 2021, AJRR's sample population had a revision burden for all total knee arthroplasty procedures of 9.2%, which has slightly increased from 7.7% in 2012 (Figure 3.31). 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.[14] In 2020, the Australian Orthopaedic Association National Joint Replacement Registry reported a revision burden of 7.3%, an all-time low for the Registry.[7]

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.

Revision burden for all total knee arthroplasty procedures was 9.2% in 2021, which is an increase from a nadir of 7.0% in 2013.

Figure 3.31 Revision Burden of Total Knee Arthroplasty Procedures, 2012-2021 (N=122,852)

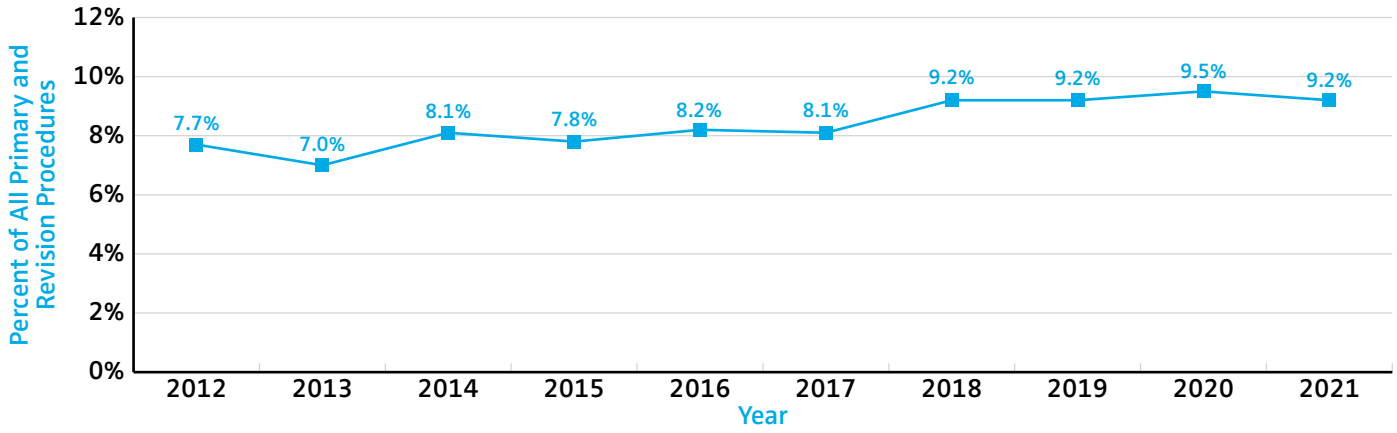
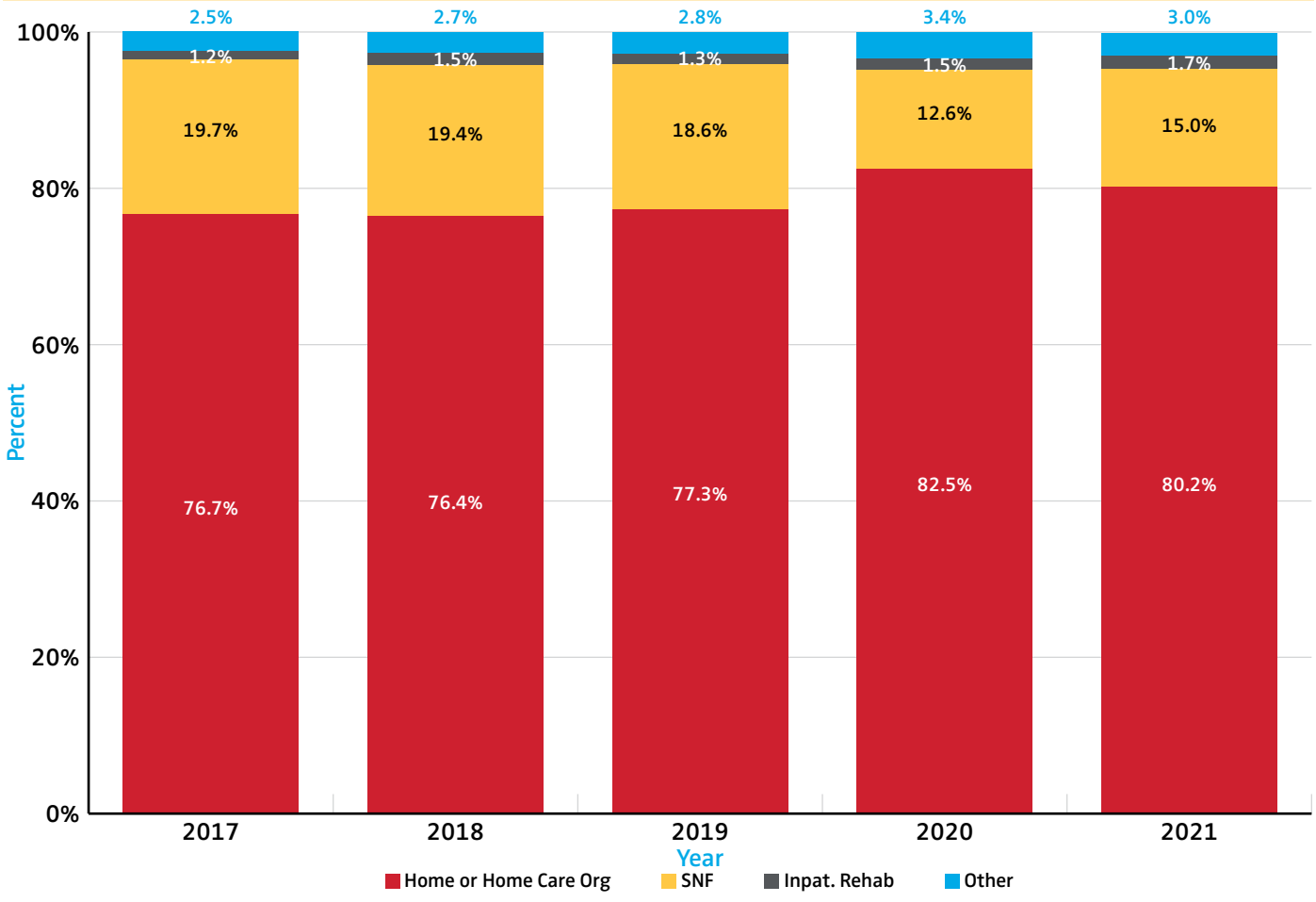


Figure 3.32 tabulates the discharge disposition reported for revision TKA cases for the years 2017 through 2021, when data collection began. AJRR collects the CMS-defined Patient Discharge Status Code values. Discharge to home, represented by discharge codes 1 and 6, occurred following over 80% of revision TKAs in the last two years. Discharge to a skilled nursing facility (SNF) dropped to 15% by 2021. Other discharge codes represent only a small portion of cases.

Figure 3.32 Revision Knee Arthroplasty Discharge Disposition Codes by Year, 2012-2021 (N=68,284)



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.[15]

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.

Based on the KOOS, JR. score, 86% of patients achieved a meaningful improvement after total knee arthroplasty.

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 benchmarking.

•As of December 31, 2021, 401 sites out of 1,251 (32%) have submitted PROMs, which is a 38% increase in sites compared to the previous 2021 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 22-26%.

Similar levels of meaningful improvement in KOOS, JR. scores were seen across all age groups, with patients older than 75 years of age having less improvement compared to younger patients on the PROMIS-10 quality of life assessment tool.

Table 3.8 Preoperative and 1-Year Postoperative PROM Mean Scores After Primary Knee Arthroplasty by PROM, 2012-2021

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	73,847	47.2	14.3
		Postoperative	29,347	76.3	16.3
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	Preoperative	54,520	49.1	9.2
		Postoperative	23,068	51.9	8.6
	Physical T	Preoperative	54,507	40.2	7.3
		Postoperative	23,066	48.2	8.5
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	Preoperative	24,867	52.3	12.5
		Postoperative	10,028	56.2	10
	Physical Health Component	Preoperative	24,665	32	9.8
		Postoperative	10,027	43.4	10.6

Table 3.9 Overall Change Between Preoperative and 1-Year Postoperative PROM Scores after Primary Knee Arthroplasty by PROM, 2012-2021

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	73,847	18,220	24.70%	85.50%
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	54,520	13,904	25.50%	32.60%
	Physical T	54,507	13,903	25.50%	64.80%
VR-12 (The Veterans RAND 12 Item Health Survey)	Mental Health Component	24,867	6,229	25.10%	33.30%
	Physical Health Component	24,665	6,236	25.30%	73.00%

**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.*

Table 3.10 Age-stratified Change Between Preoperative and 1-Year Postoperative PROM Scores after Primary Knee Arthroplasty by PROM for Patients 55 Years and Over, 2012-2021

Patient-Reported Outcome Measure (PROM)	PROM Component	Age Group (Years)	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	55-64	19,438	4,270	22.00%	86.10%
		65-74	31,476	8,487	27.00%	85.40%
		75-84	15,512	3,941	25.40%	84.60%
		>85	1,906	439	23.00%	85.40%
PROMIS-10 (Patient-Reported Outcomes Measurement Information System 10)	Mental T	55-64	13,978	3,092	22.10%	36.50%
		65-74	23,447	6,543	27.90%	32.40%
		75-84	11,582	3,137	27.10%	28.90%
		>85	1,476	338	22.90%	26.60%
	Physical T	55-64	13,969	3,090	22.10%	67.20%
		65-74	23,447	6,544	27.90%	65.60%
		75-84	11,578	3,137	27.10%	61.00%
		>85	1,476	338	22.90%	57.70%

**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 44 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.

Publications:

1. Is American Joint Replacement Registry Data Representative of National Data? A Comparative Analysis. Porter KR, Illgen RL, Springer BD, Bozic KJ, Sporer SM, Huddleston JI, Lewallen DG, Browne JA.J Am Acad Orthop Surg. 2022 Jan 1;30(1):e124-e130. doi: 10.5435/JAAOS-D-21-0053
2. Highlights of the 2021 American Joint Replacement Registry Annual Report. Siddiqui FA, DO, Levine BR, and Springer BD. Arthroplasty Today. 2022 Feb; 13: 205–207. doi: 10.1016/j.artd.2022.01.020
3. Use of Cementless Metaphyseal Fixation in Revision Total Knee Arthroplasty in the United States. Carender CN, An Q, Tetreault MW, De A, Brown TS, Bedard NA.J Arthroplasty. 2022 Mar;37(3):554-558. doi: 10.1016/j.arth.2021.11.027
4. Trends in Polyethylene Design and Manufacturing Characteristics for Total Knee Arthroplasty: An Analysis From the American Joint Replacement Registry. Kendall JA, Pelt CE, Yep PJ, Mullen KJ, Kagan RP. Journal of Arthroplasty. 2022 Apr;37(4):659-667. doi: 10.1016/j.arth.2021.11.012.
5. Revision Risk for Total Knee Arthroplasty Polyethylene Designs in Patients 65 Years of Age or Older: An Analysis from the American Joint Replacement Registry. Kendall JA, Pelt CE, Imlay BJ, Yep PJ, Mullen KJ, Kagan RP. J Bone Joint Surg Am. 2022 Jun 20. doi: 10.2106/JBJS.21.01251
6. Mid-term Performance of the First Mass-Produced 3D-Printed Cementless Tibia in the United States as Reported in the American Joint Replacement Registry (AJRR). Nam D, Bhowmik-Stoker M, Mahoney O, Dunbar M, Barrack RL.J Arthroplasty. 2022 Aug 4:S0883-5403(22)00740-9. doi: 10.1016/j.arth.2022.07.020.
7. Lower Rates of Ceramic Femoral Head Use in Non-White Patients in the United States, a National Registry Study. Upfill-Brown AM 1, Paisner ND 2, Donnelly PC 3, De A 3, Sassoon AA 1 Journal of Arthroplasty. 2022 Aug;37(8S):S919-S924.e2. doi: 10.1016/j.arth.2022.03.050
8. Debridement, Antibiotics and Implant Retention for the Treatment of Periprosthetic Joint Infections: Outcomes from an American Joint Replacement Registry Analysis. Stambough JB, Springer BD, De A, Jaffri H, Browne JA, and Lewallen DG CORR: Conditional acceptance pending final review
9. Spinal vs General Anesthesia in Total Knee Arthroplasty Are There Differences in Complication and Readmission Rates? Heckmann ND, De A, Porter KR, Stambough JB. Journal of Arthroplasty: Conditional acceptance pending final review
10. No Reduction in Revision Risk Associated With Highly Cross-linked Polyethylene With or Without Antioxidants Over Conventional Polyetheylene in TKA: An Analysis From the American Joint Replacement Registry. Kendall J, Pelt CE, Imlay B, Yep P, Mullen K, Kagan R. Clin Orthop Relat Res. 2022. 480:1929-1936. DOI 10.1097/CORR.0000000000002338

Posters and Presentations

1. Increased Risk of Revision with Posterior Stabilized Total Knee Arthroplasty: An Analysis from the American Joint Replacement Registry. Kendall JA, Pelt CE, Imlay B, Yep PJ, Mullen KJ, Kagan RP. Poster Presentation. 2022 AAOS Annual Meeting; March 22-26. Chicago, IL.
2. Polyethylene Crosslinking and Antioxidant Use Not Associated with Risk of Revision after Total Knee Arthroplasty: An Analysis from the American Joint Replacement Registry. Kendall JA, Pelt CE, Imlay B, Yep PJ, Mullen KJ, Kagan RP. Poster Presentation. 2022 AAOS Annual Meeting; March 22-26. Chicago, IL.
3. Spinal vs. General Anesthesia Use in Total Knee Arthroplasty: Are there Differences in Complication and Readmission Rates? Heckmann ND, De A, Porter KR, Stambough JB. Poster Presentation. 2022 AAOS Annual Meeting; March 22-26. Chicago, IL.
4. Trends in Polyethylene Design and Manufacturing Characteristics for Total Knee Arthroplasty: An Analysis from the American Joint Replacement Registry. Kendall JA, Pelt CE, Imlay B, Yep PJ, Mullen KJ, Kagan RP. Poster Presentation. 2022 AAOS Annual Meeting; March 22-26. Chicago, IL.
5. Spinal Anesthesia Use in Total Hip Arthroplasty: Improved Outcomes and Shorter Operative Time in the American Joint Replacement Registry Population. Olsen AS, De A, Porter KR, Stambough JB. Podium Presentation. 2022 AAOS Annual Meeting; March 22-26. Chicago, IL.
6. Dislocation Rates of Primary Total Hip Arthroplasty in Patients with Prior Lumbar Spine Fusion and Lumbar Degenerative Disc Disease with and without Utilization of Dual Mobility Cups: A Joint Registry Study. Malkani AL, Nessler JM, Mullen KJ, MPH; Yep PJ, Illgen RL. Podium Presentation. 2022 Annual Meeting; March 22- 26. Chicago, IL. Podium Presentation. 2022 11th International Congress of Arthroplasty Registries, September 3-5. Dublin, Ireland.
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8. Trends in polyethylene design and manufacturing characteristics for total knee arthroplasty: An analysis from the American Joint Replacement Registry. Kendall JA, Pelt CE, Yep PJ, Mullen KJ, Kagan RP. 2022 Western Orthopaedic Association. Wailea, Maui, HI August 4-6.
9. Lower Revision Risk with All-Polyethylene Tibial Components in Total Knee Arthroplasty. Kagan RP, Mullen KJ, Kelley BV, Kendal JA, De A, Yep PJ, Sassoon AA. Podium Presentation. 2022 11th International Congress of Arthroplasty Registries, September 3-5 in Dublin, Ireland. Poster Presentation. 2022 AAHKS Annual Meeting. November 3-6. Gaylord, Texas.
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12. Cemented femoral fixation for total hip arthroplasty reduces the risk of periprosthetic femur fracture in patients 65 years or older: An analysis from the American Joint Replacement Registry. Kelly M, Sassoon AA, Kelley BV, Kendal JA, Yep PJ Mullen KJ, Kagan RP. Podium Presentation. 2022 11th International Congress of Arthroplasty Registries, September 3-5. Dublin, Ireland.
13. Timing and Factors Associated with Total Knee Arthroplasty Infection. Engh CA, Yep PJ, Donnelly PC, Hopper RH and Mullen KJ. Podium Presentation. 2022 Knee Society Podium Presentation. Sept 8-10. Park City, UT
14. Racial disparities in rates of revision and use of cutting-edge features in total knee arthroplasty. Upfill-Brown AM, Paisner ND, Donnelly PC, De A, Sassoon AA. Poster Presentation. 2022 AAHKS Annual Meeting. November 3-6. Gaylord, Texas.
15. AJRR Registry Data Show Higher Complication Rates in Revision Hip Arthroplasty. Kendal JA, Rollier GL, Porter KR, Mullen KJ, Springer BD, Huddleston JI, Duwelius PJ. Poster Presentation. 2022 AAHKS Annual Meeting. November 3-6. Gaylord Texas.
16. Is Intraoperative Dexamethasone Associated with Increased Rates of Periprosthetic Joint Infection? Heckmann ND, Wang JC, BS, Piple AS, Marshall G, Mills ES, Liu KC, Lieberman JR, Christ AB. Podium Presentation. 2022 AAHKS Annual Meeting. November 3-6. Gaylord, Texas.
17. Dual Mobility Articulation in Revision Total Hip Arthroplasty: An AJRR Analysis. Springer BD, Lieberman JR, Otero JE, Mullen KJ, and Heckmann ND. Podium Presentation. 2022 AAHKS Annual Meeting. November 3-6. Gaylord, Texas.
18. Hospital Teaching Status and Patient-Related Outcomes Following Primary THA—an AJRR Study. Oakley CT, Thomas J, Arraut J, Rozzel JC, Schwarzkopf R, Lalehzarian S, Aggarwal VK. 2022 AAHKS Annual Meeting. November 3-6. Gaylord, Texas.

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

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 D

AJRR Committees

AJRR California State Registry Committee

James I. Huddleston, III, MD, FAAOS–Chair
Stanford University

Stefano Bini, MD, FAAOS
University of California, San Francisco

Christine Brown, MSPT
Methodist Hospital Dignity Health

Bradley Graw, MD, FAAOS
Palo Alto Medical Foundation

Jay Patel, MD, FAAOS
Orthopaedic Specialty Institute

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Manhattan Beach, CA

Nelson F. SooHoo, MD, FAAOS
University of California, Los Angeles

Young Physicians Committee (YPC)

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University of Arkansas

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Los Angeles County Harbor

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Yale School of Medicine

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Loyola University Medical Center

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Indiana University School of Medicine

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University of Florida College of Medicine

Nathanael Heckmann, MD
Keck School of Medicine of USC

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John Hopkins Department of Orthopaedic Surgery

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Penn State Hershey Medical Center

Adam S. Olsen, MD, MS
Brigham and Women's Hospital

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Muir Orthopaedic Specialists

Cody C. Wyles, MD
Mayo Clinic School of Medicine

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Orthopedic and Fracture Specialists

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University of Michigan

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OrthoCarolina Research Institute

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UTHealth

Bryan D. Springer, MD, FAAOS
OrthoCarolina

Jeffrey B. Stambough, MD
University of Arkansas

AJRR Publications Subcommittee

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University of Virginia

John W. Barrington, MD, FAAOS
Plano Orthopaedics and Sports Medicine

Antonia F. Chen, MD, MBA, FAAOS
Brigham and Women's Hospital

Terence J. Gioe, MD, FAAOS
University of Minnesota

William A. Jiranek, MD, FACS, FAAOS
Duke University

Susan M. Odum, PhD
OrthoCarolina Research Institute

Bryan D. Springer, MD, FAAOS
OrthoCarolina

AJRR Research Projects Subcommittee (RPS)

Richard L. Illgen, II, MD, FAAOS–Chair
University of Wisconsin

Antonia F. Chen, MD, MBA, FAAOS
Brigham and Women's Hospital

Elizabeth Gausden, MD, MPH
Hospital for Special Surgery

Alejandro Gonzalez Della Valle, MD, FAAOS
Hospital for Special Surgery

David W. Hennessy, MD
University of Wisconsin

Benjamin A. McArthur, MD, FAAOS
Texas Orthopedics

Brian T. Nickel, MD
University of Wisconsin

Jesse E. Otero, MD, PhD
OrthoCarolina

James Slover MD, MS, FAAOS
NYU Langone Orthopedic Hospital

Timothy Wright, PhD
Hospital for Special Surgery

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Patient/Public Representative
(Louisville, KY)

William (Bill) Mulvihill, M.Ed.
Patient/Public Representative
(Cincinnati, OH)

Kristin Veno
Patient/Public Representative
(Baltimore, MD)

Appendix E

Participating Institutions

Instituitions that joined AJRR by 8/18/22 are included. Those that contributed data for this *Annual Report* by 8/23/22 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
PeaceHealth Orthopedic & Sports Medicine in Ketchikan

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
North Valley Surgery Center
Northwest Medical Center
OASIS Hospital*
Verde Valley Medical Center
Chandler Regional Medical Center
Gateway Surgery Center
Mercy Gilbert Medical 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
Arkansas Specialty Surgery 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

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 8/11/22.*

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Palomar Medical Center Poway
Petaluma Valley Hospital
PIH Health-Whittier
Pomona Valley Hospital Medical Center
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 Santa Monica Medical Center
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
Golden State Orthopedics & Spine
Good Samaritan Hospital
Henry Mayo Newhall Hospital
La Jolla Orthopedic Surgery Center
La Veta Surgery Center
Loma Linda University Health
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
Stanford Health Care Tri-Valley
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

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

Connecticut

Backus Hospital*
Bridgeport Hospital Milford Campus-Milford
Danbury Hospital
Glastonbury Surgery Center
Hartford Hospital*
MidState Medical Center*
Norwalk Hospital*
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*
Johnson Memorial 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 Ocala
AdventHealth Orlando
AdventHealth Waterman
AdventHealth Wesley Chapel
AdventHealth Winter Park
AdventHealth-Zephyrhills Hospital*
Andrews Institute Ambulatory Surgery Center
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
Indian River Medical Center*
JFK Medical Center
Jupiter Medical Center
Kendall Regional Medical Center
Largo Medical Center
Lee Memorial Hospital
Martin Memorial Medical Center

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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
Sarasota Memorial Hospital-Venice
South Bay Hospital
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

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
Florida Medical Center
Lakewood Ranch Medical Center
Manatee Memorial Hospital
Medical Center Clinic
Orlando Orthopaedic Center
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
Coffee Regional Medical Center
Coliseum Northside Hospital
Emory University Orthopaedics & Spine Hospital
Floyd Medical Center
Piedmont Augusta
St. Francis Hospital*
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
Kootenai Outpatient Surgery

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Instituitions that joined AJRR by 8/18/22 are included. Those that contributed data for this *Annual Report* by 8/23/22 are highlighted in blue.

Madison Memorial Hospital
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

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 Resurrection Medical Center Chicago
AMITA Health Saint Joseph Hospital Chicago
AMITA Health Saint Joseph Hospital Elgin
AMITA Health St. Alexius Medical Center Hoffman Estates
AMITA Health St. Mary's Hospital Kankakee
Blessing Health System
Centegra Hospital McHenry
Centegra Hospital Woodstock
DuPage Medical Group
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
Northwestern Medicine Kishwaukee Hospital*
Northwestern Medicine Lake Forest Hospital
Northwestern Memorial Hospital
OrthoIllinois
Orthopedic & Sports Medicine Clinic
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 St. Joseph Medical Center
OSF St. Mary Medical Center
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
Bonutti Orthopedic Clinic
Center For Minimally Invasive Surgery
Decatur Orthopaedic Center
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 Luke Medical Center
OSF Saint Paul 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 Regional Medical Center
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*

Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 8/11/22.

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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*
Parkview Ortho Hospital
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
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
King's Daughters Medical Center
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
Owensboro Health Regional Hospital
South Central Kentucky Orthopedics
UofL Health-UofL Hospital

Louisiana

Doctors Hospital at Deer Creek
East Jefferson General Hospital
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
Lafayette Bone & Joint Clinic
Red River Surgery Center
West Bank Surgery Center
Willis-Knighton Medical Center

Maine

Central Maine Orthopaedics
Falmouth Orthopedic Center
Maine Medical Center*

*Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 8/11/22.

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MaineGeneral Medical Center
OA Centers for Orthopaedics
St. Mary's Regional Medical Center

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
SurgCenter of Western Maryland, LLC
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

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
Lowell General Hospital
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
Emerson Hospital
Longview Orthopaedic Center, LLC
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
OSF St. Francis Hospital & Medical Group
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
St. Joseph Mercy Brighton Health Center

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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*
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*
Pawsat, M.D. & Maeda, M.D. P.C.
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
Total Joint Center of the Northland*
Truman Medical Center-Lakewood*
Missouri Orthopaedic Institute
Orthopedic Associates
Saint Francis Medical Center
Southeast Hospital

Montana

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

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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
Elliot Hospital
Lighthouse Surgical Suites, LLC*
North Atlantic Surgical Suites
Northridge Surgical Suites*
Portsmouth Regional Hospital
Concord Orthopaedics
Southern NH Medical Center

New Jersey

Bayshore Medical Center
Chilton Medical Center
Hackensack University Medical Center*
Holy Name 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
Princeton 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
Virtua Marlton Hospital
Virtua Memorial Hospital
Virtua Voorhees Hospital
Clara Maass Medical Center
Community Medical Center
Eastern Orthopedic Associates
Englewood Hospital
Hudson Crossing Surgery Center
Lourdes Medical Center of Burlington County
Monmouth Medical Center
Monmouth Medical Center Southern Campus
Newark Beth Israel 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

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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
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
Columbus Regional Healthcare System
Duke Ambulatory Surgery Center Arringdon
Viewmont Surgery Center

North Dakota

CHI St. Alexius Health Bismark*
Sanford Medical Center Fargo
Sanford Medical Center-Bismarck*

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
Greater Dayton Surgery Center
Greene Memorial Hospital
Hillcrest Hospital
Indu and Raj Soin Medical Center
Kettering Medical Center
King's Daughters Medical Center Ohio
Licking Memorial Hospital
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*
Ontario Hospital
Selby General Hospital
South Pointe Hospital
Southview Medical Center
Southwest General Health Center

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St. Vincent Medical Center (Sisters of Charity-OH)
Summa Health System-Barberton Campus
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
Cleveland Clinic Mercy Hospital
Firelands Regional Medical Center
First Settlement Orthopaedics
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*
Summa Health Wadsworth-Rittman Medical Center
The Christ Hospital Health Network

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
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*
Bend Surgery Center*
CHI Mercy Health Mercy Medical Center
Oregon Orthopedic & Sports Medicine Clinic
Oregon Surgical Institute
Orthopedic + Fracture Specialists
PeaceHealth Orthopedics at Peace Harbor
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
Bryn Mawr Hospital
Butler Memorial Hospital
Conemaugh Memorial Medical Center*
Doylestown Hospital
Excela Health Latrobe Hospital
Excela Health Westmoreland Hospital
Geisinger Community Medical Center
Geisinger Lewistown Hospital
Geisinger Medical Center
Geisinger Shamokin Area Community Hospital
Geisinger South Wilkes-Barre
Geisinger Wyoming Valley Medical Center*
Heritage Valley Beaver
Indiana Regional Medical Center
Lancaster General Hospital
Lankenau Medical Center
Monongahela Valley Hospital*
Moses Taylor Hospital
Mount Nittany Medical Center
Nazareth Hospital
Orthopaedic & Spine Specialists
OSS Orthopaedic Hospital
Paoli Hospital

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Penn Highlands Healthcare
Penn Presbyterian Medical Center
Penn State Milton S. Hershey Medical Center
Pennsylvania Hospital
Phoenixville Hospital*
Reading Hospital*
Regional Hospital of Scranton
Riddle Hospital
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
Chan Soon-Shion Medical Center at Windber
Doylestown Surgery Center*
Geisinger Jersey Shore Hospital
Geisinger Woodbine Lane
Jefferson Hospital
Mercy Catholic Medical Center-Mercy Philadelphia Campus
Mercy Fitzgerald Hospital
North Pointe Surgery Center
Richards Orthopaedics Center & Sports Medicine
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*
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
Chapin Surgery Center
Conway Medical Center
McLeod Health Cheraw
McLeod Health Clarendon
McLeod Health Dillon
McLeod Health Seacoast
McLeod Regional Medical Center
Novant Health Gaffney Medical Center
Prisma Health Baptist Parkridge Hospital
St. Francis Downtown

South Dakota

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

Tennessee

Baptist Memorial Hospital-Collierville
Baptist Memorial Hospital-Memphis*
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

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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
Vanderbilt University 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

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 Scott & White Surgical Hospital Fort Worth*
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
Houston Methodist Sugar Land Hospital
JPS Health Network
Lake Granbury Medical Center*
Las Palmas Medical Center
Legent Orthopedic Hospital
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 Hospital for Surgery
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 Arlington Memorial Hospital

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Texas Health Harris Methodist Hospital Southwest Fort Worth*
Texas Health Presbyterian Hospital Denton
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 Medical Center of Southeast Texas
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
Inov8 Surgical
Jeff Zhao, D.O.
McAllen Medical Center
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

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

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

**Achieved The Joint Commission Advanced Certification for Total Hip and Total Knee Replacement by 8/11/22.*

Instituitions that joined AJRR by 8/18/22 are included. Those that contributed data for this *Annual Report* by 8/23/22 are highlighted in blue.

University of Virginia Health System University Hospital
VCU Medical Center
Virginia Hospital Center
Centra Health
Inova Fairfax Hospital
The Surgery Center of Lynchburg

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
Cascade Valley Hospital
Dan Downey, MD
Edmonds Center for Outpatient Surgery
MultiCare Covington Medical Center
Olympia Surgery Center
PeaceHealth Orthopedic & Sports Medicine at Medical Office Plaza
PeaceHealth Orthopedics & Sports Medicine in Lynden
Providence Regional Medical Center Everett Pacific Campus
Skagit Valley Hospital
Southwest Seattle Ambulatory Surgery Center
Wenatchee Valley Hospital & Clinics

West Virginia

Cabell Huntington Hospital*
Ruby Memorial Hospital
Thomas Memorial Hospital
West Virginia University 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*
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 Clinic Wasau Center
Marshfield Medical Center-Beaver Dam

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Instituitions that joined AJRR by 8/18/22 are included. Those that contributed data for this *Annual Report* by 8/23/22 are highlighted in blue.

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
Prairie Ridge Health
ProHealth Waukesha Memorial Hospital
Ripon Medical Center
River Falls Area Hospital
Sauk Prairie Hospital
Southwest Health
SSM Health St. Clare Hospital-Janesville
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
Orthopedic & Sports Medicine Specialists of Green Bay
SSM Health St. Clare Hospital-Baraboo
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
Powder River Surgery Center

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Appendix F

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. This is an annual effort, and AJRR continued a contractual relationship with Advent Advisory Group© to serve as the vendor for auditing a sample of 2021 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 Advisory'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 2021 data. The Registry randomly selected 26 actively submitting AJRR sites, both hospitals and ambulatory surgical centers (ASCs), from January 1 to December 31, 2021 to participate. The participating sites included diverse representation of urban and rural locations, and both small practices and large centers. There are two portions of the audit to evaluate Registry data: the first portion was a medical records review, the second was regarding to data completeness. The medical records review was structured to analyze randomly selected hip and knee arthroplasty procedures performed in a specified timeframe in 2021. The audit process ensures data submitted to AJRR correctly represents the data in the facility medical records, and that the data reflected all hip and knee arthroplasty procedures performed at that site within the specified timeframe. The audit was completed in early September 2022.

Three of the randomly selected sites for the 2022 audit were unable to participate due to personnel changes and inability to complete the request by the established timeline. The sites were issued an exclusion waiver and will participate in the 2023 Audit. Per the AJRR contractual agreements, audit participation is required when selected for a given year. Additionally, five institutions were excluded due to repeated erroneous file submission (user error) or incomplete submission of non-required data elements. This resulted in 18 participating sites for inclusion in the aggregate summary.

The overall record completeness assessment rate was 95.3% (Median 96.9%), up from 94.2% in the 2021 Annual Report. 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. 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, which are recommended but can be supplemented beyond raw data submission through registry processing and validation. There were no anomalous observations to suggest any cherry picking or selection of only the best cases being submitted. The medical record audit included 15 selected institutions for a more detailed review of expanded data fields from a random subset of patient cases. Roughly half of these institutions had no discrepancy in data, and the remaining institutions had few cases of discrepancy often related to typographical errors on a small number of cases.

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 G

2022 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 2012-2021. Their follow-up was from time of procedure until 12/31/2021 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 12/31/2021. 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, 2012-2021).

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 percent revision curves were constructed using the Cox proportional hazards model with the endpoint of all-cause revision rate, with patients being censored at death or at the end of the analysis period. These curves can be interpreted as the cumulative risk of revision in patients who are still alive at a specific timepoint. Additionally, a competing-risk proportional sub-distribution hazards model was used to measure overall prognostic risk of revisions, but results from this model were only presented when the hazard ratios or statistical significance were substantially different from the original cox proportional hazards model. These two models have been shown to produce similar results in international joint replacement registries.[18] Patients were tracked for the data set of 2012-2021. Their follow- up was from time of procedure until 12/31/2021 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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AJRR Annual Report Editor:
James A. Browne, MD, FAAOS

AAOS Staff Contributors:
Reagan Bayer, MBA, PMP
Amanda Bagus, MS, ATC
Lori Boukas, MS
Ayushmita De, PhD
Shreyasi Deb, PhD, MBA
Patrick Donnelly, MA
Phil Dwyer
Nathan Glusenkamp, MA
Ben Harkinson
Heena Jaffri, MPH
Emily Jimenez, MPH
Erik Michalesko
Kyle Mullen, MPH
Kimberly Porter, PhD, MPH
Patrick Yep, MS, MPH, MSP
Diane Ziegenhorn, PT, DPT, MHA

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American Academy of Orthopaedic Surgeons (AAOS)
9400 West Higgins Road
Rosemont, IL 60018
Phone: (847) 292-0530
Email: RegistryInfo@aaos.org
www.aaos.org/ajrr

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