Fourth AJRR Annual Report on Hip and Knee Arthroplasty Data
Dedication

This Annual Report is dedicated to two groups: First, the countless individuals at each participating hospital whose efforts are growing the Registry into a powerful tool to improve the care of all hip and knee replacement patients. Second, the phenomenal staff of AJRR who are working tirelessly to actualize the vision the arthroplasty community has for this Registry.

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This year marks an exciting milestone for the American Joint Replacement Registry (AJRR) – we have surpassed the one million mark in number of hip and knee arthroplasty procedures entered into the Registry. This accomplishment has been made possible by the nearly 1,000 hospitals, ambulatory surgery centers (ASCs), and practice groups who are Registry participants.

We are proud to present this 2017 Annual Report which reflects data collected from 2012 through 2016. The report includes data on 860,080 procedures from 654 institutions and 4,755 surgeons, representing a 101% increase in procedures, a 57% increase in reporting institutions, and a 50% increase in surgeons since last year’s report. In addition, this report includes data from the former California Joint Replacement Registry (CJRR), which is now fully integrated into AJRR as the California State Registry.

AJRR has focused on several important activities in the past year. Continued strong efforts to recruit hospitals and ASCs remain a key activity, with a goal of ultimately capturing at least 90% of hip and knee arthroplasty procedures performed in the United States. AJRR is investing heavily in technology platform enhancements and improvements. One benefit of this effort is that we are now able to collect three levels of data, including patient-reported outcome measures (PROMs) as well as comorbidity and operative complication data. As a result, we will be able to risk-adjust our data, greatly enhancing the overall value of the Registry to all of our stakeholders.

The collection of PROMs moves the Registry further towards the twin goals of providing overall procedural “quality” data in addition to implant usage and performance data. Furthermore, with the first two phases now complete, our next-generation RegistryInsights™ platform delivers more functionality, better transparency, and all-around improved performance. Our participants will be able to easily access data to compare against national benchmarks and to support a full range of quality initiatives. The International Society of Arthroplasty Registries has chosen the AJRR as its partner to develop a comprehensive library of hip and knee implants with an associated list of attributes and characteristics. Creation of this comprehensive implant library will allow more efficient and accurate matching of implants with implant characteristics in a single internationally recognized library. Ultimately, it provides an enhanced opportunity to compare “like” data across national registries.

AJRR is well aware that to attain our goals, risk-adjusted longitudinal data will be needed. As the penetrance of the Registry increases and as the Registry is in existence for a longer period of time, these data are becoming available. However, to speed up this process, obtaining “claims” data has the potential to rapidly enhance our ability to collect revision procedure information, regardless of whether the revision was performed at a facility participating in AJRR. We have identified a pathway that will likely give us this capability in the coming year and we look forward to the great benefits these additional data will provide.

The information in this year’s report gives the most comprehensive picture to date of patterns of hip and knee arthroplasty use in the U.S. You will find fascinating information about trends in hip and knee arthroplasty practice over the last five years. Some areas of particular interest include: practice patterns related to hip fracture management, prevalence of use of cemented and uncemented stems in different elective hip arthroplasty populations, the changing patterns of ceramic femoral head use and dual mobility articulation use, and actionable information about the most common reasons for early reoperation or revision after primary hip and knee arthroplasty.

The Board of Directors trusts you will find the information in this report interesting, useful, and in some cases actionable now. With the rapid growth of AJRR capabilities, we look forward to being able to provide the hip and knee arthroplasty community with much more data of value in the coming several years.

Thank you, as always, for your strong and consistent support. We look forward to continuing to grow together.

Daniel J. Berry, MD
Chair, AJRR Board of Directors
Over the course of the past year, AJRR paid substantial attention to enhancing the technological capabilities of the Registry. A multi-million dollar, three-year plan to expand the service offerings to participants and stakeholders is underway with key infrastructure enhancements already in place. RegistryInsights™, AJRR’s new platform, provides better benchmarking and improved data validation and cleansing. This facilitates more transparent and accurate reporting, and increased speed to import participant data to the Registry.

Members of the AJRR Board of Directors and staff continue to participate in several critical initiatives to advance the efforts of the Registry and arthroplasty care overall. AJRR advocated for increased access to Medicare claims data, which will greatly improve reporting data analysis capabilities for the Registry. AJRR was also selected to host the International Society of Arthroplasty Registries’ (ISAR) International Prostheses Library (IPL), which will provide comprehensive detailed device information to arthroplasty registries worldwide.

There was continued growth in 2016, with increased enrollment of participating facilities to 854, and data reporting for 654 or 77% of those entities. As a result of a 101% increase in procedural volume compared to last year’s Annual Report, we report findings from more than 860,000 cumulative procedures between 2012 and 2016. This report reflects approximately 28% of the estimated annual procedural volume in the United States.

Data in AJRR come from institutions across the entire United States, including small community and orthopaedic specialty hospitals, large academic medical centers, and Ambulatory Surgery Centers (ASCs). Indeed, this year’s report includes more than 2,000 cases from ASCs. Data from teaching hospitals reflect 76% of procedures. Findings from an external study of AJRR data compared to national statistics indicate that the demographic profile of AJRR patients is quite similar to those reported in the National Inpatient Sample. While this year’s report reflects increasing national volume captured in the Registry, AJRR is still in an early phase of data collection with longer-term follow-up appropriate for implant survivorship analysis a few years away.

Similar to previous AJRR Annual Reports, the average age of arthroplasty patients was 67 years, and patients were 41.0% male and 59.0% female. Revision hip patients are slightly older than primary hip patients, while revision knee patients are slightly younger than primary knee patients.

The median number of total knee arthroplasty (TKA) and total hip arthroplasty (THA) procedures performed by AJRR surgeons in 2016 was 22 and 12, respectively.

Descriptive data regarding THA included in this report demonstrate a continued significant increase in the number performed for femoral neck fracture. Unlike other national registries, surgeons in the United States overwhelmingly choose cementless stems for such procedures. Hip resurfacing has declined to less than 1% of the THA procedures in our sample. Analysis of femoral head composition indicates consistent and significant increases in the use of ceramic heads overall, and specifically the combined use of antioxidant liners and ceramic heads has increased significantly each year.

For TKA, the use of ultracongruent designs continues to increase steadily over time. While their use in primary arthroplasty remains fairly constant, the use of mobile bearing designs in revision TKA also continues to increase over time. Similar to last year’s report, analyses indicate a continued downward trend in the use of unicompartamental knee implants. While the percentage of institutions performing unicompartamental procedures remains steady at about 25%, in 2016 only 3.2% of all primary TKA were unicompartamental procedures.

Linked revision, where both the primary and revision procedure were performed in an AJRR institution, were recorded in greater numbers in 2016. Early (less than three months) THA revisions indications were led by revisions for dislocation, followed closely by infection and periprosthetic fracture. The majority of early TKA revisions were performed for infection.

Capture of patient-reported outcomes (PROs) remains a challenge for submitting institutions. However, AJRR’s Level III/PRO platform facilitates electronic capture of data and provides national benchmarks for four recommended instruments.

Increased procedural and institutional growth, combined with the financial and resource investment in technology enhancements, has established AJRR as the primary source for pertinent data on total joint arthroplasty in the United States.
About AJRR

AJRR is a not-for-profit 501(c)(3) organization committed to data collection and analysis that drive better outcomes and quality of orthopaedic care. Directed by the Board of Directors to evolve into a “National Orthopaedic Quality Registry,” AJRR has revised its strategic plan to provide the structure necessary to create achievable, actionable, and measurable operating objectives and measures. While the new plan remains rooted in the initial Strategic Recommendations report published by Avalere Health in 2014, it reflects recent changes in the legislative and regulatory environment.

2016: A Year of Progress and Growth

More than 860,000 procedures were submitted to the Registry through 2016. These procedures come from 654 institutions and 4,755 surgeons across the United States. Ambulatory surgery centers (ASCs) and private practice groups are becoming key participants as total joint arthroplasty (TJA) is increasingly performed in the outpatient setting.

Welcome, RegistryInsights™

Following the recruitment of a chief technology officer and a comprehensive assessment of AJRR’s technology platform capacity and capabilities, AJRR’s Board of Directors approved a three-year, multi-million dollar technology enhancement roadmap to upgrade the Registry systems and create a centralized database architecture and independent data warehouse.

The new technology platform, RegistryInsights, offers numerous advantages:

- Enhanced benchmarking. Improved on-demand look-up ability allows Registry participants to compare their health system and individual institution’s procedure data against the Registry national benchmark metrics.
- Improved data validation. A more robust data integration and services environment has improved automated data file validation and record cleansing processes, virtually eliminating a prior data backlog issues and reducing errors.
- Increased speed. The time required to import new procedures into the Registry database has been substantially reduced.

2017 By the Numbers*:

- 28% of the estimated annual procedural volume in the U.S.
- 964 AJRR participants, including 41 ASCs
- 21 of 25 of U.S. News and World Report Best Hospitals for Orthopaedics are participating
- 696 institutions are submitting data
- 24 technology vendors designated Authorized Vendors to facilitate data submission for AJRR participants
- First publication of the Report to the Public About Hip and Knee Replacements created by the AJRR Public Advisory Board

*As of publication

Increase in Institutional Enrollment 2012-2017

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Our Mission

To improve orthopaedic care through the collection, analysis, and reporting of actionable data.
Diving Deeper into Data

The integration of the California Joint Replacement Registry (CJRR) and the national Registry participants into a single technology platform and database has been completed. As AJRR’s database continues to grow exponentially, the harmonization and validation of component definitions, attributes, and related data is an ever-evolving challenge.

However, the work has not been entirely in isolation. Over the years, AJRR has worked on issues of harmonization of attributes and terms with a number of U.S. and international registry colleagues including:

- Advanced Medical Technology Association (AdvaMed) Orthopaedic Sector
- The Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR)
- The International Consortium of Orthopaedic Registries (ICOR)
- The International Society of Arthroplasty Registers (ISAR)
- The National Joint Registry (NJR) for England, Wales, Northern Ireland, and the Isle of Man
- Orthopaedic Network News

Data Reporting and Data Specifications
In 2016, significant effort was placed on updating the data specifications to align with the goal of enhancing the quality and types of data submitted to AJRR. The initial objective was to ensure the Registry would begin receiving enhanced Level I data including surgical approach, surgical technique, computer navigation, robotic assisted surgery, and length of stay.

Data Completeness and Quality Monitoring
Assessment of data elements, completeness, quality of data reporting, and the results of annual data reporting audits of hospitals continues to be the responsibility of the Data committee chaired by Bryan Springer, MD, and the Annual Report Subcommittee, chaired by Terence Gioe MD. After a consensus regarding the topics to be presented in this year’s report was achieved, Dr. Gioe as Annual Report Editor had ongoing discussions with the subcommittee, staff, the Data Committee Chair, and Medical Director about the development of the report with suggestions for additional analyses when warranted.

As with last year’s Annual Report, AJRR collaborated with a statistical consultant, Exponent, Inc., for guidance on appropriate data analysis, proper presentation of findings and correct interpretation of data. Statistical analyses were performed using SAS software v. 9.4 (SAS Institute, Cary, NC).
In March 2017, AJRR achieved a major milestone by adding the millionth arthroplasty procedure to the Registry. Continuing to grow procedural volume is essential and AJRR continually focuses on ways to support institutions’ ability to submit data in a streamlined, automated fashion. In 2017, AJRR efforts included:

- **Reconfigured workflow.** AJRR hired a director of project management and business analysis, who is responsible for introducing structured work approaches and end-to-end business process enhancements.

- **Created a new customer support team.** AJRR merged technology and business development support, and expanded staff roles. A team of three customer support analysts now provides full service onboarding and technical support experience to help participants with the data submission.

- **Streamlined the onboarding process.** The Six Stages to Successful Submission program was created to provide an easy-to-use template to ensure seamless onboarding.

The ability to track operative complications as well as to risk-adjust data for reporting purposes is also critical to the long-term success of the Registry. Several 2017 initiatives have brought AJRR closer to this goal:

- **New data specifications for Level II.** AJRR completed revised data specifications to expand the Registry data specifications to include Level II comorbidities and complications data. The new data specifications were announced in early 2017, with the goal of having all AJRR participants submit both Level I and Level II data by year-end. As of publication, 59 participants have already converted to the new data specifications, and thus are submitting Level II data.

- **Expanded Level III reporting functionality.** In addition, AJRR expanded the Level III patient-reported outcome (PRO) functionality to include data required for the Centers for Medicare & Medicaid Services (CMS) Comprehensive Care for Joint Replacement (CJR) initiative and capability to export data in CMS-required formats.

See Appendix B for AJRR’s data elements.
Strength Through Collaboration

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

**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 receives complimentary advertisements in AAHKS publications and on the website, and the AAHKS journal, Arthroplasty Today, is AJRR’s official journal. The AJRR team has published articles in Arthroplasty Today on infection burden and the early years of AJRR. “Infection burden in total hip and knee arthroplasties: an international registry-based perspective” also won Best Poster presentation at International Congress of Arthroplasty Registers in May 2017.

**Ambulatory Surgery Center Association (ASCA)**
AJRR and ASCA entered into a collaborative relationship to encourage ASCA-member ASCs to register in AJRR. 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 health care costs by groups migrating to this model of practice.

**International Society of Arthroplasty Registries (ISAR)**
ISAR is a global consortium of joint replacement registries established by several of the mature national registries. The society facilitates the development of registry science and observational studies, encourages the development of new national registries around the world, and provides a forum for information sharing to enhance participating countries’ ability to meet their own objectives. AJRR is an active participant and member of ISAR, with regular podium and poster presentations at the ISAR Annual Meeting. Dr. Daniel Berry, chair of AJRR’s Board of Directors, is a member of ISAR’s Steering Committee.

AJRR has contracted with ISAR to develop, house and maintain the International Prostheses Library (IPL) which ISAR is developing to serve as a single source of medical device information for industry partners and ISAR member organizations worldwide.

**Medical Device Manufacturers**
Medical device manufacturers provide ongoing financial support and continue to participate in the governance of AJRR via the Advanced Medical Technology Association (AdvaMed) Orthopedic Sector. This group nominates individuals to serve in the two board positions designated for industry, and has requested names of individuals to serve on various committees where industry expertise or perspective is desired. AdvaMed and its member companies also regularly provide guidance on AJRR efforts to develop the recently completed company specific data access module. This real-time, online portal allows manufacturers to access anonymized, patient-level validated data sets for their own products. AdvaMed’s Orthopedic Sector has played a critical role in designing and implementing standards supporting this access.

**National Quality Registry Network (NQRN)**
NQRN® is a voluntary network consisting primarily of PCPI® member organizations interested in clinical registries. NQRN® continues to be the national force for moving clinical registries forward. The network provides education and tools for AJRR and other registries, including a technical report on HIPAA and the Common Rule, new educational collateral, a public preview version of its registry maturational framework, and a guide to using registries for CMS quality measures submission under the Physician Quality Reporting System (PQRS) as Qualified Clinical Data Registries (QCDRs). AJRR Director of Marketing and Communications Lori Boukas has served on the NQRN® Communications Committee and AJRR Director of Analytics Caryn Etkin is a regular contributor to the NQRN® Annual Meeting.

**Physician Clinical Registry Coalition (PCRC)**
This coalition is a group of 23 medical society-sponsored or physician-led clinical data registries working together to advocate for public policy changes to promote registry development and eliminate barriers. AJRR Executive Director Jeffrey Knezovich, Government Relations Specialist Judi Buckalew and Regulatory Advocacy Coordinator Matthew Snider are active members of the coalition, which regularly submits federal agency public comments on topics such as QCDR measure review, the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA), and Merit-based Incentive Payment System (MIPS).
On the Advocacy, Regulatory, and Quality Improvement Frontlines

AJRR continues to advocate to improve and expand Registry participation and impact, as well as to proactively address potential obstacles. 2016 efforts included:

- Submitting comments on CMS’ proposed rule on the Medicare Program: Merit-Based Incentive Payment System (MIPS) and Alternative Payment Model (APM) Incentive Under the Physician Fee Schedule, and Criteria for Physician-Focused Payment Models. This proposed rule established MIPS, a new program for certain Medicare-enrolled practitioners, and consolidated components of three existing CMS programs. AJRR expressed concerns regarding CMS’ refusal to grant access to Medicare claims data, the data completeness criteria, and the Clinical Practice Improvement Activities (CPIA) category of MIPS.

- Joining with the PCRC to send an email and letter to CMS Acting Administrator Andrew Slavitt expressing concerns about the “quasi-qualified entity” provisions in the Medicare Program: Expanding Uses of Medicare Data by Qualified Entities Final Rule and requesting a meeting with CMS officials.

- Submitting a letter for the record to the House Ways and Means Health Subcommittee highlighting the importance of registries and the unique and prominent role they play in improving the quality and cost-efficiency of care in hospitals.

- As a result of AJRR’s deep concern about CMS’ continued refusal to implement Section 105(b) of MACRA, representatives from AJRR’s Board of Directors and senior staff met with CMS. During the meeting, CMS reiterated support for AJRR access to claims data.

Additional regulatory and quality improvement-related activities and initiatives include:

Supporting CMS Reporting Requirements
Established in 2012, the QCDR program was initially designed to be an additional pathway for eligible professionals to participate in PQRS. Selected by CMS to be a QCDR since 2014, AJRR continues to partner with Premier, Inc., a company that is a leading provider of cloud-based registry platforms for performance improvement and value-based payment – to create the custom platform for data submission to CMS. By partnering with Premier, Inc. for the Orthopaedic Quality Resource Center, AJRR has the ability to fully implement the QCDR program requirements, now consistent with MACRA. The Premier platform ensures that eligible professionals meet all data, scoring, and attestation requirements before they submit their MIPS reports to CMS for payment. Additionally, this platform has been used by individual physicians to meet their Meaningful Use requirements. AJRR is grateful to its orthopaedic partners in the QCDR effort: AAHKS, the American Orthopaedic Association’s Own the Bone initiative, and the Orthopaedic Trauma Association.

AJRR also continued to work with AAHKS to include performance measures for CMS’ MIPS initiative. In 2016 AJRR and AAHKS received approval to add four new total hip performance measures to the Orthopaedic Quality Resource Center. In addition, AJRR continued to modify its platform throughout 2016 to help ensure that institutions mandated to participate in the CMS’ CJR bundled care payment program could utilize Registry participation to meet their requirements.
Developing Device Surveillance Network with Weill Cornell Medicine (WCM)

In 2015, the U.S. Food and Drug Administration (FDA) awarded a U01 cooperative grant to Weill Cornell Medicine (Art Sedrakyan, MD, PhD, Principal Investigator), in which AJRR is a subcontractor. Creating National Surveillance Infrastructure for Priority Medical Devices, also called International Consortium of Orthopaedic Registries, USA (ICOR-USA), aims to develop a national device surveillance network in the orthopedic field, using data from claims and registry sources to create a robust and capable data network.

ICOR-USA partners include AJRR, Functional and Outcomes Research for Comparative Effectiveness in Total Joint Replacement (FORCE-TJR) at the University of Massachusetts, HealthEast Joint Replacement Registry, Kaiser Permanente National Implant Registries, and Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI). Via biweekly planning calls, a governance structure has been developed, advisory committee members have been agreed upon, and opening publications have been discussed.

A data use agreement was established with AJRR, a list of data elements required to test potential linkage strategies was derived, and a full data export was securely transferred to the WCM analytic team. Currently, >99.9% of the 2011-2014 hip and knee procedure records from AJRR can be linked to New York State Department of Health, Statewide Planning, and Research Cooperative System (SPARCS) data.

Developing Preauthorization Process with Blue Shield of California

Through the California State Registry, AJRR began discussions with Blue Shield of California to develop an arthroplasty pre-authorization process for local hospitals participating in AJRR. This program will help to reduce the burden of requiring authorization for AJRR participants.

Improving Patient Safety in Michigan

Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) is a Blue Cross Blue Shield of Michigan and Blue Care Network Collaborative Quality Initiative. This state-based program seeks to improve patient safety and the quality of hip and knee joint replacement procedures by promoting continuous quality improvement activities. AJRR’s collaboration with MARCQI enables rapid recruitment and resultant data acquisition. Twenty-five MARCQI hospitals also participate in AJRR, with data submitted directly on behalf of MARCQI hospitals. AJRR engages in regular dialogue with MARCQI directors and participating hospitals to minimize the burden of data submission and maximize the value of the information collected.

Tracking Safety Issues with ArthroplastyWatch

ArthroplastyWatch is a Swedish-based project designed to collect data on implant recalls or alerts and arthroplasty safety issues from a variety of sources around the world. This information is then disseminated online via a publicly available website. Data are continually collected, updated, and monitored by a team of experts, including AJRR Medical Director David Lewallen, MD, who is a member of the ArthroplastyWatch Advisory Board.

AJRR thanks participating institutions for their continued efforts to ensure accurate data submission.
Governance and Structure

AJRR is a 501(c)3 not-for-profit corporation with a unique multi-stakeholder governance model that includes representation from the entire community involved in the delivery of arthroplasty care, including patients. The contributions and perspectives provided by facilities, surgeons, device manufacturers, commercial health plan payers, and the public have been an important aspect of the success and growth of the organization. Not only do these groups provide financial contributions, but they also provide representation on the Board of Directors and the various committees of AJRR.

Focusing on data collection and quality-improvement initiatives for total hip and knee replacements, AJRR is supported financially by the American Academy of Orthopaedic Surgeons (AAOS), the American Association of Hip and Knee Surgeons (AAHKS), The Hip Society, The Knee Society, hospitals, ASCs, commercial health plans, medical device manufacturers, and contributions from individual orthopaedic surgeons.

The inclusion of members of the public on the Board of Directors has also been key to our success. Through the Public Advisory Board (PAB), direct input is provided from both the patient and public perspective. The members have been integral to AJRR, ensuring that there is a public voice in the Registry’s governance, deliberations, data collection, reporting, and decision making.

2016-2017 AJRR Board of Directors

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Blair Fraser, Industry Observer
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Jeffrey P. Knezovich, CAE, Ex-officio

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American Hospital Association (AHA) Representative:

Kristen Murtos, MBA, NorthShore Skokie Hospital (Skokie, Ill.)

Public Representative:

Margaret VanAmringe, MHS, The Joint Commission (Washington, D.C.)
AJRR Committees
AJRR relies heavily on the contributions and commitment of its volunteers who work unselfishly on assuring that its efforts are achieved with the highest adherence to quality. The work of AJRR’s four standing committees is outlined below. Full membership can be found in Appendix C.

Members of the California State Registry Committee (previously known as the California Data Use Group) conduct clinical affairs and make decisions that support the mission of AJRR and the former CJRR. 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

The Data Management Committee is responsible for recommendations to the Board of Directors concerning data elements to be included in AJRR and the methods by which the selected data are analyzed and reported. The committee is responsible for recommendations concerning yearly areas of interest for the Annual Report along with reviewing proposed research projects, planning for data element expansion, and reviewing other relevant clinical questions.

Chair: Bryan D. Springer, MD

The Finance and Compensation Committee’s responsibility is to review monthly statements and reports in order to keep the Board of Directors abreast of spending and incoming funding and contributions from outside stakeholders and the public. Annually, the committee makes a recommendation to the Board of Directors on all facets of budgeting and investment planning.

Chair: David E. Mino, MD, MBA

The Public Advisory Board provides direct input to the Board of Directors 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.

Chair: Margaret VanAmringe, MHS

The Regulatory Committee is a group of professionals who monitor and respond to the influencers of the socioeconomic and legislative issues. This committee reports to the Board of Directors on governmental opportunities and obstacles affecting the development of AJRR.

Established in 2014, the AJRR Commission is a group of six arthroplasty specialist orthopaedic surgeons without relevant financial conflicts who serve as independent reviewers of the data published in this Annual Report. The Commission made the final recommendation to the Board of Directors regarding the content of the Annual Report. The Commission members are known only to the Board of Directors to ensure members’ independence and allow them to avoid undue outside influence pertaining to the report.

AJRR’s User Group Network, Unet, continues to provide direction and guidance from the participant perspective. AJRR would like to thank the following participants who serve on the Unet Advisory Board and helps to plan useful User webinars and meetings.

Mike B. Anderson, MSc
University of Utah Health

Cecily Froemke, PhD
Providence St. Joseph Health

Christina Kane EdD, MS, OTR
Catholic Health

Amy Ketchum, MS, RN, OCNS-C
Midwest Orthopedic Specialty Hospital

Mark A. Snyder, MD
TriHealth Orthopedic Sports Institute

Cheryl Talamo, PT, MPT
Doylestown Hospital
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David G. Lewallen, MD, Medical Director*
Paul A. Haisman, MBA, Chief Technology Officer
Jillian Bachelor, Customer Support Analyst
Reagan L. Bayer, MBA, PMP, Director of Project Management and Business Analysis
Lori Boukas, MS, Director of Marketing and Communications
Judi Buckalew, RN, BSN, MPH, CAE, Government Relations Specialist*
September R. Cahue, MPH, Senior Registry Analyst
Philip J. Dwyer, Manager of Business Development
Caryn D. Etkin, PhD, MPH, Director of Analytics
Jarrett O. Ferguson, Data Technician
Terence J. Gioe, MD, Annual Report Editor*
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Mariah Matesi, Business Development Representative
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Kristin A. Parisi, MS, Customer Support Analyst
Gordana Sljivar, Office Administrator
Matthew Snider, Esq., Regulatory Advocacy Coordinator*

* Denotes part-time/contract staff

AJRR thanks the following former staff members for their contributions in 2016:
Kristine F. Baldwin, MS, Data Submission Analyst
Savana M. Martin, Program Coordinator
Linda Matos, Program Assistant
Monica T. Moore, Program Assistant
Jason Thomas, Program Assistant

Thank You to AJRR Supporters
AJRR has been an independent, self-sustaining organization since 2015. The AJRR management team annually revises its three-year business plan, continuing to decrease the original sponsors’ financial obligations and to seek funding from various subcontracting agreements, subscriptions, and licensing fees.

Thank you to the organizations that have supported AJRR financially, including the American Academy of Orthopaedic Surgeons (AAOS), the American Association of Hip and Knee Surgeons (AAHKS), The Hip Society, The Knee Society, health plans, medical device manufacturers, and the Advanced Medical Technology Association (AdvaMed). Health plan contributors included Blue Cross Blue Shield Association, United Healthcare Foundation and Anthem. Industry contributors included Aesculap, Consensus Orthopedics, DePuy Synthes, DJO Global, Exactech, MicroPort, Smith & Nephew, Stryker, and ZimmerBiomet.
Overall Results

Facility Enrollment
AJRR maintains institutional enrollment as a major priority. Staff has worked continuously to increase the numbers of hospitals and ASCs that participate in the Registry. In 2016, six dedicated staff members enrolled new facilities and ensured that data were submitted in a timely fashion. As of December 31, 2016, enrollment stood at 844 hospitals and 10 ASCs, representing all 50 states and the District of Columbia (see Figures 1 and 2 and Appendix D). This was an increase of 242 facilities over 2015 and represents 17.4% of the hospitals in the American Hospital Association (AHA) database. However, not all AHA institutions perform joint arthroplasty is performed. More than 80 facilities in California, 60 facilities in Wisconsin, and more than 40 in Ohio, Pennsylvania, and Texas participated, while 8 other states had 30 or more participating facilities.

At the end of 2016, AJRR had enrolled 844 hospitals and 10 ASCs in all 50 states, an increase of 242 facilities over 2015.
Submitting Facilities

By the end of 2016, 654 of the 854 institutions enrolled by that date (77%) were submitting data (Figure 3). This represents a 57% increase in the number of submitting facilities from 2015, due not only to increases in the numbers of facilities enrolled but also to a decrease in the percentage of institutions enrolled but not yet submitting data. There continues to be substantial lag time between facility enrollment and data submission.

As previously noted, AJRR’s Information Technology team implemented new automation technology in 2016 resulting in improved file validation and record cleansing which eliminated an existing data backlog and reduced the duration between data submission and import into the Registry database. By the end of 2016, the time from data submission to entry in the Registry had decreased to only a few days.

Most arthroplasty procedures submitted to AJRR are performed in large or medium-sized hospitals and teaching facilities when compared to smaller community arthroplasty-based non-teaching facilities. Since some small hospitals do not perform elective hip and knee arthroplasty at all, the distribution of hospitals submitting data to AJRR is skewed toward larger academic and teaching facilities when compared to the AHA profile of all hospitals nationally. Hospitals described as major or minor teaching facilities by the AHA make up nearly 64% of the hospitals submitting data to AJRR (Figure 4) but are only 38% of the hospitals in the overall AHA profile (data not shown). These major and minor teaching hospitals accounted for n=653,680 (76%) of the procedures submitted to AJRR in 2016, while the non-teaching community hospitals (representing 36% of the hospitals submitting) accounted for n=160,700 (19%) of the procedures.

Figure 3: Number of Facilities Submitting Data by Year

Figure 4: Teaching Affiliation of Submitting Hospitals* (N=615)

Source: AHA Annual Survey Database Fiscal Year 2015
* Not all participating hospitals had relevant data in the AHA survey

Major Teaching Hospitals: those with Council of Teaching Hospitals designation (COTH)
Minor Teaching Hospitals: those approved to participate in residency and/or internship training by the Accreditation Council for Graduate Medical Education (ACGME) or American Osteopathic Association (AOA), or those with medical school affiliation reported to the American Medical Association
Non-Teaching Hospitals: those without COTH, ACGME, AOA, or Medical School (AMA) affiliation

Figure 5: Hospital Size (Bed Count) of Submitting Hospitals* (N=615)

Source: AHA Annual Survey Database Fiscal Year 2015
* Not all participating hospitals had relevant data in the AHA survey

Major and minor teaching facilities accounted for 76% of the procedures submitted to the AJRR in 2016
Surgeon Participants

By the end of 2016, AJRR had collected data on arthroplasty procedures performed by more than 4,750 surgeons (Figure 6). AJRR hospitals report data for an average of 12 surgeons (range 1-63). These numbers include surgeons conducting only occasional hemiarthroplasty for hip fracture. Participating hospitals are required to submit data from all surgeons performing joint arthroplasty at their facility, and annual audit results over the past five years indicate hospitals consistently do so.

Table 1 demonstrates that in 2016 surgeons conducted an average of 32 primary hip arthroplasties (THA) per year and 46 primary total knee arthroplasties (TKA) per year, with the upper end of the range for both TKA and THA exceeding 600 procedures among contributing surgeons. Numbers from 2016 reveal that mean revision procedures per surgeon were much lower at 5.4 per year for hip revision and 4.9 per year for knee revision with the upper end of the range for revision THA and TKA at 102 and 61 procedures respectively. Median values are much lower, as expected, with the median number of annual primary procedures at 12 THAs and 22 TKAs in 2016. These median values would place the surgeons in our sample between the 1st and 2nd quartiles of surgeon volume as outlined by Bozic et al 3 and quite comparable to the median volumes reported by Wilson et al. 4 In the latter study, median annual primary THA and TKA volumes were eight and 20 respectively, while median revision THA and TKA volumes paralleled the AJRR data with three hip procedures and two knee procedures annually.

This sample includes submissions from facilities that may have submitted less than one year of data based on their AJRR enrollment date. Actual totals may also be higher for some surgeons who operate at both an AJRR participating and non-participating institution during the same year.

Figure 6: Total Number of Surgeons Submitting Data by Year

Table 1: 2016 Average Procedural Volume for Participating Surgeons

<table>
<thead>
<tr>
<th></th>
<th>Total Surgeons</th>
<th>Total Procedures</th>
<th>Per Surgeon Mean</th>
<th>Per Surgeon Median</th>
<th>Interquartile Range (75th percentile – 25th percentile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>2,882</td>
<td>92,780</td>
<td>32.2</td>
<td>12</td>
<td>3-40</td>
</tr>
<tr>
<td>Revision</td>
<td>1,351</td>
<td>7,253</td>
<td>5.4</td>
<td>3</td>
<td>1-6</td>
</tr>
<tr>
<td>KNEE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>3,418</td>
<td>156,656</td>
<td>45.8</td>
<td>22</td>
<td>5-59</td>
</tr>
<tr>
<td>Revision</td>
<td>1,350</td>
<td>6,664</td>
<td>4.9</td>
<td>2</td>
<td>1-5</td>
</tr>
</tbody>
</table>

Procedural Data Metrics

The data included for analysis reflect N=860,080 cumulative procedures submitted between 2012 and 2016 only, unless otherwise noted (Figure 7). This total includes N=2,074 procedures from ASCs. As in previous Annual Report versions, data prior to 2012 was not included in analyses since the small number of facilities and surgeons submitting could skew the data by sampling error. Yearly volumes from prior years are continually updated as AJRR adds participants that submit historical data from 2012 – 2016. For example, the yearly procedural volume for 2015 grew by over 46% compared to last year’s Annual Report.

The cumulative procedural volume continues to grow each year. The 2015 report demonstrated a 102% increase from the previous report. This year’s report demonstrates a 101% increase from last year’s Annual Report.

Actions & Insights

Median number of TKA and THA procedures performed by AJRR surgeons in 2016 was 22 and 12, respectively.

The cumulative procedural volume has grown over 100% per year over the last few years.
Implementation of ICD-10 in October 2015 was an impediment for rapid submission of data. With ICD-10 submission issues more completely addressed by 2016, data submission to AJRR improved. However, the additional granularity of the ICD-10 coding has resulted in challenges for both diagnosis and procedure coding that continue to be addressed. For additional details about ICD-10 coding, please see Appendix E.

**Ambulatory Surgery Centers**

Ambulatory surgical volume has grown, particularly in the last two years, in this limited sample (Figure 9). Larger trends are difficult to assess since both the number of centers enrolled and the arthroplasty procedures per center are increasing. However, it appears that an ever-increasing number of arthroplasties will be performed in ASCs in the future. Although the opportunity for analysis in this small data set is limited, in one preliminary look at ASC procedure mix it appears that a higher proportion of UKAs vs. TKAs are performed in ASCs compared to the hospital setting.

**Demographics**

Data presented in this Annual Report reflect N=860,080 procedures, which includes both primaries and revisions, performed between 2012 and 2016. Patients had a mean age of 67 (SD = 10.9), including 41.0% males and 59.0% females (Figure 10). Females make up n=310,131 (60.8%) of the TKA population and slightly less, n=197,048 (56.3%), of the THA population. Total knee procedures continue to predominate in the Registry, with all primary and revision TKAs representing n=510,084 (59.3%) of the volume compared to n=349,996 (40.7%) for hip procedures. These numbers have been consistent over the past four years of reporting. The majority of patients undergoing arthroplasty in this sample are white, but race was not reported by the submitting hospital nearly 29% of the time (Figure 11).
Revision Burden

Revision burden is the number of revision arthroplasties performed during a year divided by the total number of arthroplasties (revisions plus primaries) performed that same year. Revision burden may be seen as a general measure of arthroplasty success in a joint registry, and though influenced by numerous factors, can be used as a crude comparator between registries. 5

In 2016 alone, AJRR calculated a THA revision burden of 8.6% and a TKA revision burden of 5.1%. This revision burden for both THA and TKA is lower than in previous years (2012-2015) in AJRR (THA mean = 13.9% and TKA mean = 6.5%) (Table 3). The 2016 AJRR results are also substantially lower than the results reported from the AOANJRR where 2015 revision burden for THA was 9.6% and TKA burden was 7.4%. 6 The variation in AJRR reports this year is likely explained by ICD-10 coding issues at the hospital level (including issues with uncaptured revisions, as noted above), changes in the distribution of hospitals performing primary vs. revision procedures as new institutions are added to the registry, large numbers of primary procedures added to the database from newly enrolled institutions, or a combination of these and other unexplained factors. Uncaptured revisions and difficulty interpreting and coding revision procedures for infection have also been problematic for other national registries. 7

As revision burden is a measure of arthroplasty success and may be compared across registries, in 2016 AJRR collaborated with Dr. Brian McGrory on an article entitled “Comparing contemporary revision burden among hip and knee joint replacement registries,” published in Arthroplasty Today. 5 The authors examined revision burden across five national joint registries and found that revision burden has gradually decreased for THA while remaining relatively constant for TKA both in the prior four years and compared to historic controls. Knee revision burden was lower than hip revision burden for each period examined. Numerous factors are undoubtedly responsible, but diminishing revisions for metal-on-metal THA and for dislocation with more widespread use of larger heads would appear to play some role.

A lower revision burden seen for both THA and TKA in the AJRR in 2016 compared to other national registries is likely multifactorial and does not necessarily reflect a lower overall revision rate.
Males predominate in the younger age groups undergoing THA, but females predominate as the population ages, in keeping with life expectancy trends (Figure 13).

* Primary reflects total hip arthroplasty only and does not include hemiarthroplasty or hip resurfacing.
Osteoarthritis was the diagnosis at the time of surgery for approximately 79% of the patients undergoing primary hip arthroplasty (data not shown). Avascular necrosis of the femoral head was the next most common diagnosis, accounting for only 3% of the arthroplasties performed. Rheumatoid arthritis, as noted in prior Annual Reports, accounts for only a very small fraction of the procedures in 2016 as newer medical therapies predominate in the treatment of this disease. (See Appendices F and G for procedure and diagnosis codes). A relatively high percentage (15%) of diagnosis codes under ICD-10 were missing or otherwise invalid.

The categories of hip procedures noted remained relatively constant as a percentage of all hip procedures performed in 2016 (Figure 14).

**Arthroplasty for Femoral Neck Fracture**

Arthroplasty for proximal femoral fracture remains a commonly performed procedure with an aging but active demographic in the United States. Analyses were conducted for hemiarthroplasty in 2012–2016, although the reported incidence of this procedure was small in 2012 (Figure 15). Within our sample, hemiarthroplasty as a percentage of all total hip arthroplasty performed remains at approximately 10%. As additional studies report advantages in pain relief, functional outcomes, and reoperation rates for total hip arthroplasty for femoral neck fractures, our sample shows a significant (p<0.001) increase in the percentage of THAs performed for this diagnosis over the last five years (Figure 16).

Although both cemented and cementless stems remain popular for hemiarthroplasty in the United States, since 2013 a majority of surgeons in our sample continue to favor cementless designs (Figure 17). Our sample reflects a significant trend (p<0.001) toward greater cemented stem usage with each additional decade of life from 50 to >90 years old (Figure 18). However, even in the 80 to 90-year-old group, less than 50% of the hemiarthroplasties performed utilize cemented stems.

In our sample, bipolar heads are used in the majority (>60%) of cases with hemiarthroplasty stems from age 50–90, but with a significant trend (p<0.001) toward a greater proportion of unipolar heads (compared to bipolar heads) with each additional decade of life (Figure 19).

The majority (69.1%) of hemiarthroplasties for femoral neck fracture were performed on females, and the average age of the patients undergoing hemiarthroplasty for proximal femoral fracture is 80 years old.
Figure 15: Hemiarthroplasty as a Percentage of All Hip Arthroplasty in 2012-2016 (N=32,816)

Figure 16: Hemiarthroplasty and Total Hip Arthroplasty Performed for the Diagnosis of Femoral Neck Fracture (N=29,157)

Figure 17: Cemented and Cementless Femoral Stems in Hemiarthroplasty (N=26,394)

Figure 18: Percent of Cemented Stems in Hemiarthroplasty Based on Age (N=10,208)

Figure 19: Unipolar Heads in Hemiarthroplasty Based on Age* (N=10,636)

* Unipolar heads for patients <50 were eliminated from this analysis as there were only 56 patients and a precise fraction of unipolar use for this age group cannot be estimated.

Hip Resurfacing

Hip resurfacing has declined to less than 1% of the total hip arthroplasty procedures in our sample, as surgeons have moved away from metal-on-metal articulations (Figure 20). This procedure remains highly concentrated among a very few number of hospitals and surgeons; in 2016, resurfacing was done in only 109 AJRR hospitals by 165 surgeons (2.9% [165/5642] of all surgeons performing THA). Additionally, in 2016, six surgeons accounted for 71.3% of all hip resurfacing procedures, with two surgeons alone performing n=373 (51.0%) of all hip resurfacing procedures. Over the five-year period from 2012-2016, the majority (87.1%) of the resurfacing procedures were performed on males, and the average age was 53 years old, consistent with the practice in registries worldwide. 6,7
Total Hip Arthroplasty

Femoral head size usage patterns have remained relatively constant between 2012 and 2016, with 36mm heads used in approximately 60% of the procedures performed (Figure 21). The increased stability afforded by larger heads coupled with diminished volumetric wear concerns when these heads are used with highly cross-linked or enhanced polyethylene liners likely explains their sustained popularity. The relative percentage of 28, 32, 36, and >36mm heads used year-to-year has changed significantly between 2012 and 2015 (p <0.001), with the use of 36mm heads increasing significantly and all other head sizes decreasing.

Figure 21: Femoral Head Sizes Implanted by Year (N=251,324)

* Femoral head analyses do not include unipolar or bipolar heads used in hemiarthroplasty.

Ceramic head usage has continued to grow each year, and in our sample of U.S. experience, that growth has been both steady and significant between 2012 and 2016 (p<0.001) (Figure 22). Factors that may have contributed to this growth include the use of ceramic heads as an alternative to metal-on-metal articulations, favorable wear characteristics, and concerns regarding trunnionosis/corrosion with cobalt chrome (CoCr) heads.13,14 These same factors likely play a role in the overall bias of ceramic head usage in younger patients, as does perhaps the cost/value proposition for patients in the later decades of life (Figure 23). Our sample reflects a greater percentage of CoCr heads used in patients in the later decades of life, with the “tipping point” from an even distribution between ceramic and CoCr heads occurring at age 68. However, even in the older age groups, surgeons have increased their ceramic head usage in recent years. The distribution of ceramic heads among popular head sizes (50-60%) likely reflects overall usage and perhaps the aforementioned trunnionosis concerns.

Figure 22: Composition of Femoral Heads (N=315,824)

Figure 23: Ceramic Femoral Head Usage by Patient Decade of Life (N=142,985)

The surgeons in our registry sample overwhelmingly choose to use highly cross-linked polyethylene liners irrespective of ceramic or CoCr head usage (Figure 24). When antioxidant or “enhanced” liners are chosen, ceramic heads are favored the majority of the time (Figure 25). Overall, there is a trend toward increased antioxidant liner use with ceramic heads between 2012-2016 in our sample (p <0.001).
Since both shell diameter and corresponding liner thickness play a role in the surgeon’s decision, it is not surprising that the most common head size (36mm) is chosen once that option is available in most contemporary THA systems (52-54mm acetabular diameters) (Figure 26). Similarly, even larger heads (40mm and greater) are chosen with more frequency once the acetabular diameter and liner thickness permit their use (typically 60mm and larger). As an example, at an acetabular shell diameter of 56mm, a negligible percentage of heads used are less than 28mm or greater than 40mm, 13% are 28mm, 7% are 32mm, 77% are 36mm, and 2% are 40mm.

Use of either highly cross-linked or antioxidant enhanced (vitamin E impregnated) polyethylene has accounted for the majority of hip arthroplasty procedures in the United States since 2012 (Figure 27). Antioxidant enhanced polyethylene has increased significantly (p<0.001) at the expense of highly cross-linked polyethylene, which has decreased during the same period. Most manufacturers offered fewer options in conventional polyethylene in 2016 in response to the increasing longer-term data on the effectiveness of cross-linked polyethylene in reducing clinically evident wear and osteolysis. Very little conventional polyethylene is used at present in the Registry sample, and the mean age of the patients who receive this polyethylene option is 79 years.

The use of conventional Ultra High Molecular Weight Polyethylene (UHMWPE) has decreased each year to a negligible percentage and the mean age of patients who receive this option is 79 years old.
Cemented stems are used very rarely for primary hip arthroplasty in the U.S., and only in the later decades of life is there any meaningful usage, although that usage does increase significantly with age (p<0.001) (Figure 28). In comparison, the proportion of femoral stems that were cemented in 2015 for all age groups was 62.5% in the Swedish Hip Arthroplasty Registry (SHAR), 53.6% in the NJR, and 36.7% in the AOANJRR. 6,7,20

At the time of their introduction, modular neck stems were seen as having the advantage of increased intraoperative flexibility to adjust offset and neck version during primary arthroplasty, as well as potentially easier insertion through less invasive approaches to the hip. However, reports of breakage and corrosion concerns at this additional modular interface have surfaced, and their use has generally declined in this Registry sample between 2012 and 2015 with a slight uptick in 2016 (p<0.001) (Figure 30). 26–29 This increase in 2016 reflects adding additional surgeons to the registry in 2016 who utilized modular neck stems as well as some increased volume among the small number of surgeons utilizing this design concept. In fact, more than 40% of the THAs using a modular neck were performed by a total of 10 surgeons.

Dual mobility articulations continue to grow in use in the United States, presumably due to the claims of enhanced hip stability and reduced risk of dislocation they provide. 21–25 In this Registry cohort sample of the U.S. experience, dual mobility cups were utilized in approximately 8% of all primary hip arthroplasties and more than 28% of revision THA procedures in 2016 (Figure 29).

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Revision Data: Hips

Between 2012 and 2016, data were collected on N=36,091 revision hip arthroplasties. Of these, n=8,245 (22.8%) were “linked revision arthroplasties” where data on the earlier primary THA were also available in the Registry for analysis. Overall, in the larger cohort of n=31,783 revision procedures with confirmed associated diagnosis codes, the predominant isolated cause for revision by diagnosis code was other mechanical, with the codes for aseptic loosening, instability/dislocation infection, and wear and osteolysis (the last two which often co-exist and are interrelated) accounting together for 54% of revisions recorded (Figure 31). Periprosthetic fracture (3.5%) is less common. The large percentage in “other codes” includes codes for “other complications not otherwise classified,” “pain,” and those revisions that may have been miscoded, such as those revision diagnoses for osteoarthritis.

![Figure 31: ICD Diagnosis Codes for All Hip Revisions (N=31,783)](image)

In the 8,245 linked hip arthroplasty revisions where data were also available on the original primary THA, 49% occurred within the first three months post-surgery (Table 4). This may be due to the relatively short period of data collection for this Registry from many of AJRR’s participating hospitals. However, it should also be noted that early revisions have a greater likelihood of returning to the original treating institution (by definition an AJRR reporting hospital) compared to late revision cases that may be more often cared for at a different hospital, which may or may not be reporting to AJRR. In fact, 97% of early hip revisions and 98% of TKA revisions returned to the same hospital or hospital system where the primary procedure was performed. Fewer than 15% of these linked procedures were revisions performed more than one year after primary arthroplasty.

Therefore, the diagnoses that account for revision in this linked subset are clearly biased toward early causes of revision arthroplasty, which often are more related to patient comorbidities and surgical technique than implant performance. Indeed, instability/dislocation is the leading cause of failure in these largely early revisions, accounting for more than 29%, and it is closely followed by infection and periprosthetic fracture (Figure 32). As would be expected, these percentages take on even greater significance when the cohort that is less than three months from surgery is analyzed (Figure 33). When periprosthetic fractures are considered, 98% of the femoral stems identified are cementless, consistent with both their high usage in the Registry and the higher risk of intraoperative fractures associated with cementless stems. 30,31
Table 4: Time interval Between Primary Hip and Revision for “Linked” Patients (N=8,245)

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>&lt;3 Months</th>
<th>3-5 Months</th>
<th>6-12 Months</th>
<th>&gt;1 Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cases</td>
<td>4,008</td>
<td>1,700</td>
<td>1,447</td>
<td>1,090</td>
</tr>
</tbody>
</table>

Figure 32: ICD Diagnosis Codes for “Linked” Hip Revisions (N=8,245)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Percent of All “Linked” Hip Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instability related codes</td>
<td>29.1%</td>
</tr>
<tr>
<td>Infection and inflammatory reaction</td>
<td>25.2%</td>
</tr>
<tr>
<td>All other codes</td>
<td>22.5%</td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>8.8%</td>
</tr>
<tr>
<td>Aseptic loosening</td>
<td>7.9%</td>
</tr>
<tr>
<td>Other mechanical complications</td>
<td>6.4%</td>
</tr>
</tbody>
</table>

Figure 33: Most frequently reported Diagnosis Codes for Hip Revisions (<3 months to Revision)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of Procedures</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instability related codes</td>
<td>n=974</td>
<td>24.3%</td>
</tr>
<tr>
<td>Infection and inflammatory reaction</td>
<td>n=863</td>
<td>21.5%</td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>n=517</td>
<td>12.9%</td>
</tr>
<tr>
<td>Other mechanical complications</td>
<td>n=261</td>
<td>6.5%</td>
</tr>
<tr>
<td>Aseptic loosening</td>
<td>n=125</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
In knee arthroplasty, as with hip arthroplasty, there is a small but significant difference in the average ages between primary and revision patients (p-value <0.001). The mean age of patients having primary knee arthroplasty was 67.0 (SD 9.2), similar to the total hip population in our sample (Figure 34), with the mean age for the revision knee population trending slightly younger at 66.5 (SD 9.9). Between the years 2012 and 2016, there is a significant trend toward an older population for TKA procedures among our contributing hospitals.

**Figure 34: Age Distribution of Knee Arthroplasty Procedures 2012-2016 (N=510,084)**

In contrast to THA, mean age of the revision TKA population is younger than the primary TKA population.
Osteoarthritis was the underlying or original diagnosis for 83% of knee arthroplasties, with rheumatoid arthritis accounting for a fraction of 1% of all arthroplasties performed (similar to the pattern in hip arthroplasty). Revision procedures accounted for 5.8% of knee arthroplasties performed overall, with the rest primary arthroplasties of some type (see Appendices F and H for procedure and diagnosis codes).

Posterior stabilized (PS) type implants continue to be the most common design used in primary knee arthroplasty procedures in our sample (Figure 35), accounting for approximately 50% of the designs used between 2012 and 2016. Cruciate retaining-type (CR) designs were the next most common and made up nearly 39% of the total over the same time frame. Ultracongruent designs, varus/valgus constrained designs, and rotating hinge designs account for the remainder. Among designs, the usage of ultracongruent designs has increased over time with a concomitant decrease in usage of PS and CR designs.

**Figure 35: Primary Knee Implant Design by Year (N=389,355)**

Posterior-stabilized designs are the most common design used in primary TKA in the AJRR, but ultracongruent design use has increased steadily over time.

[Diagram showing primary knee implant design by year (N=389,355)]
Mobile-bearing designs remain a relatively low, but constant, percentage of TKAs implanted in this sample at almost 9% of the cumulative total TKA population between 2012 and 2016 (Figure 36). Their penetration is higher in revision TKA arthroplasty (19% of the cumulative total) where some surgeons may perceive benefits to increased rotational freedom and their use with increasing constraint.

Similarly, patellofemoral arthroplasty remains an even smaller percentage of single compartment arthroplasty in this sample, consistently utilized in less than 1% of knee arthroplasty procedures between 2012 and 2016 (Figure 38). While unicompartamental procedures were performed at a majority of hospitals (72%) participating in AJRR during the five years under review, only roughly 26% of surgeons reported to AJRR that they performed unicompartamental procedures during the same year (Table 5). Relatively few surgeons perform patellofemoral arthroplasty, with less than 6% of all surgeons submitting procedures during the years in question. Two surgeons performing patellofemoral arthroplasty, who accounted for 19% of the total volume of these procedures in 2015, submitted only 4% of the reduced number of procedures recorded in 2016.

Unicompartmental knee arthroplasties (UKA) accounted for 4.9% of all primary knee arthroplasties performed in our sample between 2012 and 2016. There continues to be a downward trend (p=0.03) in their use between 2012 and 2016 (Figure 37). The AOANJRR has reported UKA usage decreased from 15.1% of all knee arthroplasty performed in 2003 to 4.8% in 2015 (cumulative use is at 8.4% of all primary knee arthroplasty). The NJR reports reasonably consistent use of UKA at between 8-9% of the total of all primary knee arthroplasty while the Swedish Knee Arthroplasty Register (SKAR) reports gradually decreasing UKA use over time with UKA representing 5% of their knee arthroplasty procedures in 2015. 7,32

UKA use is approximately 5% of all knee arthroplasty in AJRR and there is a downward trend in its use between 2012-2016.
Polyethylene inserts are categorized as conventional polyethylene (UHMWPE), cross-linked polyethylene, or vitamin E impregnated/antioxidant polyethylene. Although antioxidant polyethylene is also cross-linked, for the purposes of this analysis it has been treated as a separate category to better identify usage trends. For primary knee arthroplasty procedures performed from 2012 to 2016, usage rates of conventional polyethylene and cross-linked polyethylene declined slightly (all \( p<0.001 \)), balanced by a steady increase in the use of antioxidant polyethylene \( (p<0.001) \) over the same time frame from 4% in 2012 to nearly 28% by 2016 (Figure 39).

In contrast, polyethylene usage in revision knee arthroplasty involved conventional polyethylene in more than 50% of revision procedures overall. Nearly one third of revision TKA patients received highly cross-linked polyethylene. While highly cross-linked polyethylene and conventional polyethylene usage have declined (all \( p<0.001 \)) between 2012 and 2016, there has been an increase in the use of antioxidant polyethylene \( (p<0.001) \) (Figure 40).

Unlike other national registries, patellar resurfacing remains the predominant practice in TKA in North America. This is evident in our sample data, with more than 90% of patients receiving a patellar component each year, while patellar resurfacing occurred in 61.5% of primary TKA in Australia in 2015 and only 2.5% of the 2015 procedures performed in Sweden \( (p<0.001) \).

Figure 39: Percentage of Polyethylene Usage by Year in Primary Knee Arthroplasty \( (N=406,670) \)

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional Polyethylene</th>
<th>Highly Cross-Linked Polyethylene</th>
<th>Anti-Oxidant Polyethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>50.6%</td>
<td>35.2%</td>
<td>4.1%</td>
</tr>
<tr>
<td>2013</td>
<td>46.1%</td>
<td>32.3%</td>
<td>4.1%</td>
</tr>
<tr>
<td>2014</td>
<td>42.0%</td>
<td>31.1%</td>
<td>4.1%</td>
</tr>
<tr>
<td>2015</td>
<td>39.5%</td>
<td>29.4%</td>
<td>4.1%</td>
</tr>
<tr>
<td>2016</td>
<td>38.4%</td>
<td>28.1%</td>
<td>4.1%</td>
</tr>
</tbody>
</table>

Figure 40: Percentage of Polyethylene Usage by Year in Revision Knee Arthroplasty \( (N=21,800) \)

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional Polyethylene</th>
<th>Highly Cross-Linked Polyethylene</th>
<th>Anti-Oxidant Polyethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>58.8%</td>
<td>36.8%</td>
<td>3.4%</td>
</tr>
<tr>
<td>2013</td>
<td>58.9%</td>
<td>35.7%</td>
<td>3.4%</td>
</tr>
<tr>
<td>2014</td>
<td>55.6%</td>
<td>35.4%</td>
<td>3.4%</td>
</tr>
<tr>
<td>2015</td>
<td>56.2%</td>
<td>33.6%</td>
<td>3.4%</td>
</tr>
<tr>
<td>2016</td>
<td>53.1%</td>
<td>31.9%</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

Figure 41: Percentage of Knee Arthroplasty with Patellar Resurfacing \( (N=396,171) \)

The AJRR continues to report over 90% patellar resurfacing in primary TKA in contrast to many other national registries.
Revision Data: Knees

The main causes of revision as indicated by diagnosis codes were aseptic loosening, wear, or mechanical causes of failure in the majority of more than 25,000 procedures with confirmed associated diagnosis codes, with infection accounting for 13.1% overall (Figure 42). A total of 6,684 of these revisions were “linked” procedures, which had data in the Registry relating to the original primary procedure as well. Of these linked revision procedures, 25% were performed in the first three months post-surgery and 28% were performed more than a year after the primary procedure (Table 6). In keeping with this bias toward early revision procedures, aseptic problems of wear or mechanical failure were less frequent than infection, which accounted for more than 32% of these relatively early revision procedures (Figure 43). This percentage increases to nearly 44% when only revisions performed within three months of the primary procedure are considered (Figure 44).

Figure 42: ICD Diagnosis Codes for All Knee Revisions (N=25,354)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Percent of All Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other codes</td>
<td>34.5%</td>
</tr>
<tr>
<td>Mechanical loosening of the prosthetic joint</td>
<td>24.5%</td>
</tr>
<tr>
<td>Other mechanical complications</td>
<td>19.1%</td>
</tr>
<tr>
<td>Infection and inflammatory reaction</td>
<td>13.1%</td>
</tr>
<tr>
<td>Instability related codes</td>
<td>6.0%</td>
</tr>
<tr>
<td>Articular bearing surface wear</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

Table 6: Time Interval between Primary Knee and Revision for “Linked” Patients (N=6,683)

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3 Months</td>
<td>1,661</td>
</tr>
<tr>
<td>3-5 Months</td>
<td>1,408</td>
</tr>
<tr>
<td>6-12 Months</td>
<td>1,718</td>
</tr>
<tr>
<td>&gt;1 Year</td>
<td>1,896</td>
</tr>
</tbody>
</table>

Figure 43: ICD Diagnosis Codes for All “Linked” Knee Revisions (N=5,581)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Percent of All “Linked” Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other codes</td>
<td>34.3%</td>
</tr>
<tr>
<td>Infection and inflammatory reaction</td>
<td>32.2%</td>
</tr>
<tr>
<td>Aseptic loosening</td>
<td>11.3%</td>
</tr>
<tr>
<td>Other mechanical complications</td>
<td>10.2%</td>
</tr>
<tr>
<td>Other complications due to device implant</td>
<td>6.1%</td>
</tr>
<tr>
<td>Instability related codes</td>
<td>5.9%</td>
</tr>
</tbody>
</table>
The majority of early linked TKA revisions in the AJRR continue to be for infection.

Figure 44: Most frequently Reported ICD Diagnosis Codes for Early Knee Revisions (<3 Months to Revision)

Patient-Reported Outcomes

In 2016, AJRR launched the Level III – patient-reported outcomes (PRO) platform with the intention of collecting such measures both preoperatively and postoperatively to gain insight into patients’ functional recovery on a large scale. With the April 1, 2016, start date of the CMS CJR bundled payment initiative, there was anticipation that collection of approved measures for quality and outcome assessment (the HOOS, JR, and KOOS, JR, PROMIS-10 Global, VR-12) would expand rapidly. To date, that has not been the case. For this report, 6% (41/654) of sites that submitted data included PRO data. As of this publication, there have not been major improvements in PRO submission rates by institutions. At present, only 11% (74/694) of institutions submitting data to the AJRR have submitted PRO data. The completion rate for “linked” outcomes (those where both a preoperative and postoperative PRO is available on the same patient) varies between 1.4-31%. Higher volume usage and higher completion rates are seen with the VR-12, which is being utilized by sites in the California State Registry. Collection of PROs promises to be a challenging issue for even the most ardent and interested institutions and providers with a mobile populace, unclear responsibility for data collection, and lack of a mandate or clear incentive at present. However, methods of embedding PRO collection into the work flow of patient care has shown promise for improving patient participation and completion rates.

PRO collection remains a challenge for the AJRR, with only small percentage of sites submitting data, and much of the data incomplete. Participants are encouraged to use the PRO platform that is included with their licensing fee.
California State Registry

The California Joint Replacement Registry (CJRR), established in 2009, collected and analyzed data from hip and knee replacement surgeries performed across California. CJRR was the first arthroplasty registry in the United States to introduce public reporting of patient-reported outcomes data related to TJA. In 2015, a transfer of CJRR to AJRR was completed, streamlining business operations under one unit. At that time, oversight of CJRR was conducted by the California Data Use Group. In 2016, all CJRR data was integrated into AJRR and in 2017, the California State Registry was established, overseen by the California State Registry Committee.

Between 2011 and 2017, the time period covered in this report, 30 hospitals contributed data on the hip and knee replacements that were performed. The California State Registry continues to be at the forefront of U.S. registries that routinely collect PROs, as well as clinical information and data about implanted devices. For more information about the California State Registry initiative, see http://www.ajrr.net/state-registries.

Figure 45: California State Registry Cumulative Case Volume (N=32,946)

![Graph showing the cumulative case volume for hips and knees from 2011 to 2016.]

Figure 46: California State Registry Participants by Size (N=30)

![Pie chart showing the distribution of participants by size: Small (n=3, 10%), Medium (n=19, 63.3%), Large (n=8, 26.7%).]

Source: AHA Annual Survey Database Fiscal Year 2015

Small = 1-99 beds; Medium = 100-399 beds; Large = 400+ beds
Collection of patient-reported outcome data continues to be challenging. Despite having more data to analyze, all but two institutions (Hoag Orthopaedic Institute and Eisenhower Medical Center for their UCLA Activity Scores) experienced similar percentages of patients achieving improvement in their risk-adjusted scores. Efforts are underway to improve collection rates.

**Table 7: California State Registry Participants and Cases Reported through June 2017**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Date Joined CJRR</th>
<th>Cases Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alta Bates Summit Medical Center - Alta Bates Campus</td>
<td>9/17/2012</td>
<td>441</td>
</tr>
<tr>
<td>Alta Bates Summit Medical Center - Summit Campus</td>
<td>9/17/2012</td>
<td>725</td>
</tr>
<tr>
<td>California Pacific Medical Center</td>
<td>10/16/2014</td>
<td>624</td>
</tr>
<tr>
<td>Cedars-Sinai Medical Center</td>
<td>5/9/2011</td>
<td>1,143</td>
</tr>
<tr>
<td>Dameron Hospital</td>
<td>11/5/2013</td>
<td>427</td>
</tr>
<tr>
<td>Eisenhower Medical Center</td>
<td>10/28/2013</td>
<td>2,221</td>
</tr>
<tr>
<td>Glendale Adventist Medical Center</td>
<td>10/1/2015</td>
<td>74</td>
</tr>
<tr>
<td>Hoag Orthopedic Institute</td>
<td>4/7/2011</td>
<td>11,134</td>
</tr>
<tr>
<td>John Muir Medical Center, Concord</td>
<td>12/18/2012</td>
<td>1,398</td>
</tr>
<tr>
<td>John Muir Medical Center, Walnut Creek</td>
<td>10/9/2012</td>
<td>2,638</td>
</tr>
<tr>
<td>Lodi Memorial Hospital</td>
<td>3/10/2014</td>
<td>232</td>
</tr>
<tr>
<td>Long Beach Memorial</td>
<td>10/6/2014</td>
<td>799</td>
</tr>
<tr>
<td>Memorial Medical Center</td>
<td>12/8/2014</td>
<td>395</td>
</tr>
<tr>
<td>Mercy General Hospital</td>
<td>4/22/2016</td>
<td>44</td>
</tr>
<tr>
<td>Methodist Hospital of Sacramento</td>
<td>3/18/2014</td>
<td>467</td>
</tr>
<tr>
<td>Mills-Peninsula Medical Center</td>
<td>4/1/2014</td>
<td>1,104</td>
</tr>
<tr>
<td>Novato Community Hospital</td>
<td>12/3/2014</td>
<td>239</td>
</tr>
<tr>
<td>Orange Coast Memorial</td>
<td>9/23/2014</td>
<td>1,022</td>
</tr>
<tr>
<td>PIH Health Hospital - Whittier</td>
<td>3/4/2013</td>
<td>1,713</td>
</tr>
<tr>
<td>Saddleback Memorial</td>
<td>9/30/2014</td>
<td>1,396</td>
</tr>
<tr>
<td>Scripps Green Hospital</td>
<td>8/19/2013</td>
<td>757</td>
</tr>
<tr>
<td>St. Bernardine Medical Center</td>
<td>10/15/2013</td>
<td>14</td>
</tr>
<tr>
<td>St. Helena Hospital Napa Valley</td>
<td>11/24/2015</td>
<td>78</td>
</tr>
<tr>
<td>St. Joseph Hospital</td>
<td>11/12/2012</td>
<td>471</td>
</tr>
<tr>
<td>St. Jude Medical Center</td>
<td>8/12/2013</td>
<td>356</td>
</tr>
<tr>
<td>Stanford Healthcare</td>
<td>9/12/2012</td>
<td>2,892</td>
</tr>
<tr>
<td>Sutter Medical Center, Sacramento</td>
<td>2/13/2013</td>
<td>111</td>
</tr>
<tr>
<td>Tahoe Forest Hospital District</td>
<td>3/10/2015</td>
<td>48</td>
</tr>
<tr>
<td>Tri-City Medical Center</td>
<td>4/15/2014</td>
<td>548</td>
</tr>
<tr>
<td>UCSF Medical Center</td>
<td>3/1/2011</td>
<td>2,287</td>
</tr>
</tbody>
</table>
Table 8: PRO Completion Rates

<table>
<thead>
<tr>
<th>Hospital Name</th>
<th>Patients Completing All 3 Surveys Pre-op [N]</th>
<th>Pre-op and 1 Year Opportunities [N]</th>
<th>Pre-op and 1 Year Completed [N]</th>
<th>Pre-op and 1 Year Completed [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alta Bates Summit Medical Center - Alta Bates Campus</td>
<td>739</td>
<td>556</td>
<td>82</td>
<td>14.7%</td>
</tr>
<tr>
<td>Alta Bates Summit Medical Center - Summit Campus</td>
<td>778</td>
<td>374</td>
<td>91</td>
<td>24.3%</td>
</tr>
<tr>
<td>California Pacific Medical Center</td>
<td>1,029</td>
<td>474</td>
<td>90</td>
<td>19.0%</td>
</tr>
<tr>
<td>Cedars-Sinai Medical Center</td>
<td>421</td>
<td>1,143</td>
<td>130</td>
<td>11.4%</td>
</tr>
<tr>
<td>Dameron Hospital</td>
<td>63</td>
<td>346</td>
<td>23</td>
<td>6.6%</td>
</tr>
<tr>
<td>Eisenhower Medical Center</td>
<td>1,980</td>
<td>1,515</td>
<td>664</td>
<td>43.8%</td>
</tr>
<tr>
<td>Hoag Orthopedic Institute*</td>
<td>0</td>
<td>9,313</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>John Muir Medical Center, Concord</td>
<td>433</td>
<td>1,010</td>
<td>103</td>
<td>10.2%</td>
</tr>
<tr>
<td>John Muir Medical Center, Walnut Creek</td>
<td>917</td>
<td>2,105</td>
<td>215</td>
<td>10.2%</td>
</tr>
<tr>
<td>Lodi Memorial Hospital</td>
<td>334</td>
<td>222</td>
<td>58</td>
<td>26.1%</td>
</tr>
<tr>
<td>Long Beach Memorial</td>
<td>241</td>
<td>555</td>
<td>70</td>
<td>12.6%</td>
</tr>
<tr>
<td>Memorial Medical Center</td>
<td>439</td>
<td>272</td>
<td>110</td>
<td>40.4%</td>
</tr>
<tr>
<td>Methodist Hospital of Sacramento</td>
<td>666</td>
<td>423</td>
<td>102</td>
<td>34.1%</td>
</tr>
<tr>
<td>Mills-Peninsula Medical Center</td>
<td>986</td>
<td>801</td>
<td>234</td>
<td>29.2%</td>
</tr>
<tr>
<td>Novato Community Hospital</td>
<td>282</td>
<td>239</td>
<td>24</td>
<td>10.0%</td>
</tr>
<tr>
<td>Orange Coast Memorial</td>
<td>355</td>
<td>717</td>
<td>44</td>
<td>6.1%</td>
</tr>
<tr>
<td>PIH Health Hospital - Whittier</td>
<td>560</td>
<td>1,299</td>
<td>82</td>
<td>6.3%</td>
</tr>
<tr>
<td>Saddleback Memorial</td>
<td>583</td>
<td>1,008</td>
<td>105</td>
<td>10.4%</td>
</tr>
<tr>
<td>Scripps Green Hospital</td>
<td>790</td>
<td>720</td>
<td>153</td>
<td>21.3%</td>
</tr>
<tr>
<td>St. Bernardine Medical Center</td>
<td>17</td>
<td>14</td>
<td>7</td>
<td>50.0%</td>
</tr>
<tr>
<td>St. Joseph Hospital</td>
<td>303</td>
<td>471</td>
<td>124</td>
<td>26.3%</td>
</tr>
<tr>
<td>St. Jude Medical Center</td>
<td>274</td>
<td>356</td>
<td>96</td>
<td>27.0%</td>
</tr>
<tr>
<td>Stanford Healthcare</td>
<td>1,240</td>
<td>2,292</td>
<td>328</td>
<td>14.3%</td>
</tr>
<tr>
<td>Sutter Medical Center, Sacramento</td>
<td>33</td>
<td>111</td>
<td>10</td>
<td>9.0%</td>
</tr>
<tr>
<td>Tahoe Forest Hospital District</td>
<td>21</td>
<td>48</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Tri-City Medical Center</td>
<td>561</td>
<td>427</td>
<td>174</td>
<td>40.7%</td>
</tr>
<tr>
<td>UCSF Medical Center</td>
<td>2,659</td>
<td>2,204</td>
<td>626</td>
<td>28.4%</td>
</tr>
</tbody>
</table>

* Hoag Orthopaedic Institute collects the 12-Item Short Form Survey (SF-12) instead of the Veterans Rand 12-Item Health Survey (VR-12). They had 30% of their eligible patients complete all three surveys pre-operatively and at one year post-operatively.
As mentioned earlier, the California State Registry collects information directly from patients, using several standardized surveys. These surveys include:

- The Western Ontario & McMaster Universities Osteoarthritis Index (WOMAC), which assesses a patient’s hip and knee pain and function
- The Veterans Rand 12-Item Health Survey (VR-12) which assesses a patient’s general quality of life
- The UCLA Activity Score which surveys a patient’s physical activity.

For participation in the California State Registry, patients can complete their PRO surveys online using a secure web-based interface (on a phone, computer, or tablet). This reduces the administrative burden on surgeons and staff and ensures that PRO collection is uniform and complete. See Appendix I for the methodology for reporting change in risk-adjusted PROs.

**PRO Results**

**Figure 47: WOMAC Hip and Knee Mean Scores Pre-Surgery and One Year Post-Surgery (N=18,764)**
### Table 9: Change in WOMAC Scores Pre-Surgery and One Year Post-Surgery, by Hospital*

<table>
<thead>
<tr>
<th>Hospital Code</th>
<th>Count of Patients That Had Orthopedic Surgery, N</th>
<th>Count of Patients That Had Orthopedic Surgery and Completed a Survey About Their Physical Health Before and After Surgery, N</th>
<th>Response Rate - Percentage of Patients Who Completed Pre-op and 1-Year WOMAC Total Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their WOMAC Total Score after Surgery - Adjusted for Difference in Patient Health, %</th>
<th>Performance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>28,343</td>
<td>4,409</td>
<td>15.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alta Bates Summit Medical Center - Alta Bates Campus</td>
<td>413</td>
<td>82</td>
<td>19.9</td>
<td>80.7</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Alta Bates Summit Medical Center - Summit Campus</td>
<td>654</td>
<td>91</td>
<td>13.9</td>
<td>84.8</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>California Pacific Medical Center</td>
<td>566</td>
<td>90</td>
<td>15.9</td>
<td>94.9</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Cedars-Sinai Medical Center</td>
<td>904</td>
<td>138</td>
<td>15.3</td>
<td>87.9</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Eisenhower Medical Center</td>
<td>1,749</td>
<td>664</td>
<td>38.0</td>
<td>89.4</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Hoag Orthopedic Institute</td>
<td>8,941</td>
<td>620</td>
<td>6.9</td>
<td>90.0</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>John Muir Medical Center, Concord</td>
<td>1,145</td>
<td>106</td>
<td>9.3</td>
<td>91.2</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>John Muir Medical Center, Walnut Creek</td>
<td>2,023</td>
<td>215</td>
<td>10.6</td>
<td>87.5</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Lodi Memorial Hospital</td>
<td>211</td>
<td>58</td>
<td>27.5</td>
<td>81.6</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Long Beach Memorial</td>
<td>706</td>
<td>74</td>
<td>10.5</td>
<td>90.6</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Memorial Medical Center</td>
<td>360</td>
<td>111</td>
<td>30.8</td>
<td>90.6</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Methodist Hospital of Sacramento</td>
<td>438</td>
<td>103</td>
<td>23.5</td>
<td>86.7</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Mills-Peninsula Medical Center</td>
<td>880</td>
<td>238</td>
<td>27.0</td>
<td>79.5</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Orange Coast Memorial</td>
<td>860</td>
<td>45</td>
<td>5.2</td>
<td>85.2</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>PIH Health Hospital - Whittier</td>
<td>1,322</td>
<td>86</td>
<td>6.5</td>
<td>86.9</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Saddleback Memorial</td>
<td>1,158</td>
<td>111</td>
<td>9.6</td>
<td>87.4</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Scripps Green Hospital</td>
<td>634</td>
<td>163</td>
<td>25.7</td>
<td>89.6</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>St. Joseph Hospital</td>
<td>402</td>
<td>125</td>
<td>13.1</td>
<td>89.4</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>St. Jude Medical Center</td>
<td>330</td>
<td>96</td>
<td>29.1</td>
<td>88.3</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Stanford Healthcare</td>
<td>1,844</td>
<td>328</td>
<td>17.8</td>
<td>87.1</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Tri-City Medical Center</td>
<td>455</td>
<td>174</td>
<td>38.2</td>
<td>86.4</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>UCSF Medical Center</td>
<td>1,424</td>
<td>626</td>
<td>44.0</td>
<td>87.7</td>
<td>★★★★★★</td>
</tr>
</tbody>
</table>

*For hospitals with >30 eligible patients who completed both pre-surgical and 1 year post-surgical PROs.
Table 10a: Change in VR-12 Physical Score*

<table>
<thead>
<tr>
<th>Hospital Code</th>
<th>Count of Patients That Had Orthopedic Surgery, N</th>
<th>Count of Patients That Had Orthopedic Surgery and Completed a Survey About Their Physical Health before and After Surgery, N</th>
<th>Response Rate - Percentage of Patients Who Completed Pre-op and 1-Year VR-12 Physical Health Subscale Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Physical Health Score After Surgery - Adjusted for Difference in Patient Health, %</th>
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*For hospitals with >30 eligible patients who completed both pre-surgical and 1 year post-surgical PROs.
### Table 10b: Change in VR-12 Mental Component Score*

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<th>Count of Patients That Had Orthopedic Surgery and Completed a Survey About Their Physical Health before and After Surgery, N</th>
<th>Response Rate - Percentage of Patients Who Completed Pre-op and 1-Year VR-12 Mental Health Subscale, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Mental Health Score After Surgery - Adjusted for Difference in Patient Health, %</th>
<th>Performance Rating</th>
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<tr>
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<td>74.5</td>
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<td>6.2</td>
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<td>376</td>
<td>20.4</td>
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<td>44.7</td>
<td>36.5</td>
<td>★★★★★</td>
</tr>
</tbody>
</table>

*For hospitals with >30 eligible patients who completed both pre-surgical and 1 year post-surgical PROs.

### Figure 49: UCLA Hip and Knee Mean Scores

Pre-Surgery and One Year Post-Surgery (N=16,780)

![UCLA Hip and Knee Mean Scores Chart](chart.png)
Table 11: Change in UCLA Score Pre-Surgery and One Year Post-Surgery, by Hospital*

<table>
<thead>
<tr>
<th>Hospital Code</th>
<th>Count of Patients That Had Orthopedic Surgery, N</th>
<th>Count of Patients That Had Orthopedic Surgery and Completed a Survey about Their Physical Health Before and After Surgery, N</th>
<th>Response Rate - Percentage of Patients Who Completed Pre-op and 1-Year UCLA Activity Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their UCLA Activity Score after Surgery - Adjusted for Difference in Patient Health, %</th>
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<td>UCSF Medical Center</td>
<td>1,424</td>
<td>638</td>
<td>44.8</td>
<td>65.7</td>
<td>★★★★★</td>
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</tbody>
</table>

*For hospitals with >30 eligible patients who completed both pre-surgical and 1 year post-surgical PROs.
Procedural Data Metrics

Figure 50: Age Distribution of Cases in California, and United States, by Procedure

**Figure 51: Mean Body Mass Index (BMI) by Procedure and Gender (N=30,976)**

![Mean BMI by Procedure and Gender](image)

**Figure 52: Principal Diagnoses (N=32,755)**

**Primary Hip (n=12,054)**
- Osteoarthritis: 11,190 (92.8%)
- Avascular Necrosis & Osteonecrosis: 443 (3.7%)
- Other: 316 (2.6%)
- Rheumatoid Arthritis: 67 (0.6%)
- Femoral Neck Fracture: 38 (0.3%)

**Revision Hip (n=1,265)**
- Other Mechanical Complications: 371 (29.3%)
- Loosening/Osteolysis: 317 (25.1%)
- Prosthesis Failure: 171 (13.5%)
- Prosthesis Dislocation: 156 (12.3%)
- Infection: 82 (6.5%)
- Periprosthetic Fracture: 16 (1.3%)

**Primary Knee (n=18,231)**
- Osteoarthritis: 17,683 (97.0%)
- Other: 393 (2.2%)
- Rheumatoid Arthritis: 126 (0.7%)
- Avascular Necrosis & Osteonecrosis: 29 (0.2%)

**Revision Knee (n=1,205)**
- Loosening/Osteolysis: 376 (31.2%)
- Other Mechanical Complications: 219 (18.2%)
- Prosthesis Dislocation: 122 (10.1%)
- Infection: 96 (8.0%)
- Prosthesis Failure: 41 (3.4%)
- Periprosthetic Fracture: 10 (0.8%)
Length of Stay

**Figure 53: Mean Length of Stay (N=35,799)**

![Mean Length of Stay (Days)](chart)

Comorbidities and Adverse Events

**Figure 54: Observed Comorbidities (N=44,041)**

California State Registry observed these major conditions in its population of patients:

- Bilateral Replacement
- Body Mass Index (BMI) >40
- American Society of Anesthesiologists (ASA) Class III/IV
- Diabetes
- Immunocompromised status
- Hypertension
- Myocardial Infarction (MI)
- Coronary Artery Disease (CAD)
- Congestive Heart Failure (CHF)
- Peripheral Artery Disease (PAD)
- Chronic Lung Disease (CLD)
- Venous Thromboembolism (VTE)
- Obesity

![Percent of Cases](chart)
Figure 55: Observed 90-Day Adverse Events (N=44,041)

- Death: 2.5%
- Post-Op Arrhythmia: 1.6%
- Post-Op Renal Failure: 0.8%
- Post-Op DVT: 0.3%
- Post-Op Bleeding: 0.1%
- Post-Op Fracture: 0.1%
- Post-Op MI: 0.0%
- Post-Op Nerve Injury: 0.3%
- Post-Op PE: 0.6%
- Post-Op Wound Infection: 0.2%
- Post-Op Dislocation: 0.5%
- Other Complication: 0.5%

Figure 56: Rates of 90-day Adverse Events, Number of Comorbidities (N=3,384)

- Percent of Cases with Adverse Events:
  - 0 Comorbidities: 15.7%
  - 1 Comorbidities: 20.4%
  - 2 Comorbidities: 21.1%
  - 3 Comorbidities: 21.5%
  - 4 Comorbidities: 12.3%
  - 5 Comorbidities: 9.0%
**Patient Migration**

A key feature of any arthroplasty registry is the ability to monitor implant survivorship by determining when both the primary surgery and any subsequent revision procedure is performed. Until a significantly higher percentage of U.S. hospitals are enrolled in the AJRR, it is unclear what percentage of revision surgery may be performed outside the current AJRR capture area. Unlike other national total joint registries, AJRR must deal with numerous legal and logistical hurdles to identify patients who may undergo revision surgery at an institution other than the one where the primary operation was performed.

AJRR undertook an effort to understand patient migration patterns as they relate to arthroplasty revisions. Medicare hospital claims data (2004-2015) and corresponding beneficiary enrollment data were used to identify patients who received primary or revision TJA, and the enrollment data from subsequent years were compared to evaluate migration and mortality. Surgeon/facility migration was determined using CMS Hospital Provider number and surgeon NPI.

Results of the analysis showed that within the first year after primary arthroplasty, 81.1% of TJA revisions are performed by the primary surgeon. However, at five or more years after primary surgery, this percentage is only 7.3%, though 48.8% of those revisions are performed at the primary hospital. For revisions, only 6% are performed in a different state, but migration out-of-state or out-of-hospital increases from year one to five years and beyond. Movement between hospitals occurs at a much higher rate than between states. Variations in migration patterns based on age groupings between 65 and 80 years are modest. Females migrate more than males during the 10 years following primary surgery.

As a corollary to this analysis, AJRR also sought to determine the correlation between hospital size and revision indication. Since larger tertiary hospitals do a greater percentage of revision surgery, we examined the association between hospital size and where revisions are performed and whether patients are more likely to return to their primary surgeon or hospital within the first year when the indications are more acute (infection, dislocation). Medicare hospital claims data (2004-2015) and beneficiary enrollment data were used, and the facility and surgeon performing the primary and revision procedures were compared using the CMS Hospital Provider number and the surgeon’s NPI. The propensity for returning to the same facility or surgeon was evaluated for revision indications characterized by ICD-9 codes (e.g., infection- or dislocation-related), for different facility size, and as a function of time between primary and revision.

In hospitals of less than 150 beds, 76.1% (95% CI: 75.5-76.7) of revisions within one year were performed at the same institution. This increases with hospital size. In hospitals with more than 450 beds, 87.5% (87.0-88.1) were performed at the same institution. For infection-related revisions within the first year, 82.8% (82.3-83.3) are at the same institution, and 79.5% (79.0-80.1) by the same surgeon. With dislocation-related THA revisions, 86.8% (86.0-87.6) are performed in the same hospital, and 82.7% (95% CI 81.8-83.6) by the same surgeon. Revisions for all causes within the first year are more likely performed in the same institution than all-cause revisions (82.3%; 82.1-82.6), but hip revisions within the first year are more likely to be performed at the same facility by the same surgeon than knee revisions.

Revision TJA surgery is often performed at a larger hospital than the primary procedure, and revisions for infection and dislocation are more likely to return to the same institution than all-cause revisions. Revisions for all causes in the first year are performed in the same hospital by the same surgeon more than 80% of the time in this Medicare population. Again, this information is helpful to understand the practice of revision surgery in the United States as the AJRR moves toward more complete data capture.
Patient Representativeness

It is also incumbent upon AJRR to know whether data collected from approximately 28% of the total joint procedures performed in the United States are representative of the greater population. This remains especially true until AJRR has reached a “critical mass” of hospitals reporting each year. To determine this, AJRR undertook a comparison of their data from 2012-2016 to the data reported to the National (Nationwide) Inpatient Sample (NIS) between 2012-2014. The NIS was developed for the Healthcare Cost and Utilization Project (HCUP), includes all payers, and is the largest publicly available inpatient health care database in the United States, with information on more than seven million hospital stays each year. Since 2012, the NIS approximates a 20% stratified sample of all discharges from U.S. community hospitals that perform joint replacement procedures. This comparison indicates that the demographic profiles of the patients undergoing TKA and THA in the AJRR and NIS databases are quite similar (Tables 12 and 13). Specifically, sex and age distribution are nearly identical. Race is difficult to compare because the AJRR database has a high percentage of missing information for this field. The geographic distribution of the hospitals performing joint replacement surgery is also similar for the Midwest and Northeast regions between the two databases. However, the differences noted for the South and West likely are the result of slower recruitment of southern hospitals to the AJRR, while the rapid inclusion of numerous hospitals in CJRR bolstered the relative percentage seen in western states.
### Table 12: AJRR 2012-2016 and NIS 2012-2014 - Patients with Primary Hip Replacement Surgeries

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<td>185,300</td>
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<td>11,822</td>
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<td>44,790</td>
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<td>0.1%</td>
</tr>
<tr>
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<td>Black</td>
<td>11,285</td>
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<td>72,410</td>
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<tr>
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<td>Other</td>
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<td>44,495</td>
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<td>2.8%</td>
</tr>
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<td>Unknown</td>
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<td>89,495</td>
<td>8.7%</td>
<td>-19.3%</td>
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<td>White</td>
<td>184,234</td>
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<td>826,755</td>
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<td>13.6%</td>
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<td>Midwest</td>
<td>63,392</td>
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<td>-1.0%</td>
</tr>
<tr>
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<td>Northeast</td>
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<td>206,545</td>
<td>20.0%</td>
<td>-0.4%</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>53,937</td>
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<td>344,410</td>
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<td>10.4%</td>
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<tr>
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<td>West</td>
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<td>Sex</td>
<td>Female</td>
<td>153,749</td>
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<td>Male</td>
<td>123,312</td>
<td>44.5%</td>
<td>457,460</td>
<td>44.3%</td>
<td>-0.2%</td>
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</table>

### Table 13: AJRR 2012-2016 and NIS 2012-2014 - Patients with Primary Knee Replacement Surgeries

<table>
<thead>
<tr>
<th>Effect</th>
<th>Level</th>
<th>AJRR Surgeries</th>
<th>AJRR %</th>
<th>NIS Surgeries</th>
<th>NIS %</th>
<th>Diff %</th>
</tr>
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<tr>
<td></td>
<td>Total</td>
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<td>1,972,225</td>
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<td>Age</td>
<td>0-44</td>
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<td>45-54</td>
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<td>9.3%</td>
<td>215,905</td>
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<td>55-64</td>
<td>144,064</td>
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<td>600,475</td>
<td>30.4%</td>
<td>0.5%</td>
</tr>
<tr>
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<td>719,970</td>
<td>36.5%</td>
<td>-1.7%</td>
</tr>
<tr>
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<td>75-84</td>
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<td>18.0%</td>
<td>-0.4%</td>
</tr>
<tr>
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<td>47,830</td>
<td>2.4%</td>
<td>-0.3%</td>
</tr>
<tr>
<td>Race</td>
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<td>21,257</td>
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</tr>
<tr>
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<td>Other</td>
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</tr>
<tr>
<td></td>
<td>Unknown</td>
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<td>177,675</td>
<td>9.0%</td>
<td>-19.6%</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>311,102</td>
<td>64.7%</td>
<td>1,516,495</td>
<td>76.9%</td>
<td>12.2%</td>
</tr>
<tr>
<td>Region</td>
<td>Midwest</td>
<td>118,641</td>
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<td>535,545</td>
<td>27.2%</td>
<td>-1.9%</td>
</tr>
<tr>
<td></td>
<td>Northeast</td>
<td>72,543</td>
<td>17.8%</td>
<td>336,250</td>
<td>17.0%</td>
<td>-0.7%</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>104,139</td>
<td>25.5%</td>
<td>712,016</td>
<td>36.1%</td>
<td>10.6%</td>
</tr>
<tr>
<td></td>
<td>West</td>
<td>112,652</td>
<td>27.6%</td>
<td>388,415</td>
<td>19.7%</td>
<td>-7.9%</td>
</tr>
<tr>
<td>Sex</td>
<td>Female</td>
<td>293,447</td>
<td>61.1%</td>
<td>1,224,515</td>
<td>62.1%</td>
<td>1.0%</td>
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<tr>
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<td>Male</td>
<td>187,027</td>
<td>38.9%</td>
<td>747,640</td>
<td>37.9%</td>
<td>-1.0%</td>
</tr>
</tbody>
</table>
Areas of Future Effort

In addition to overall improvement in the areas of coding accuracy and procedural detail, the Registry has identified certain areas of emphasis for the coming year that will yield improved analysis in the future:

1) Surgical approach—Despite a data element that the Registry considers “mandatory,” only 3% of submitted procedures included data on approach.

2) Use of bone cement—Although details of the use of cement (type of cement, antibiotics in cement, etc.) are submitted to the Registry, it is often difficult to determine which components are cemented unless clearly specified. For example, if total hip components (stem and acetabular components) are submitted along with cement, it may be unclear whether the stem or the cup, or both, were cemented. This may be even more problematic in TKA where any or all of three components (femoral, tibial, patellar) may be cemented.

3) Robotic-assisted surgery—Although the use of robotic-assisted surgery appears to be increasing, the Registry does not routinely collect this data at present.

As mentioned previously, AJRR introduced new data specifications in 2017 to align with the goal of enhancing the quality and types of data submitted. By January 1, 2018, all Registry participants will be required to adhere to the new data specification layout, which includes Level II data, but also requires submission of surgical approach, surgical technique, computer navigation, robotic assisted, and length of stay.
Audit of Registry Data

AJRR is committed to ensuring that data reports are valid and accurate. In addition to internal quality controls, AJRR completes an external audit on an annual basis. As such, AJRR contracted with Quality Insights (formerly West Virginia Medical Institute) to audit a sample of 2016 data.

Quality Insights has a long history of collaboration with nonprofit medical organizations, with a specific focus on validating Registry and health record data.

In the spring of 2017, Quality Insights began an audit of N=18 (3%) randomly selected participants that submitted data to AJRR from January 1 to December 31, 2016. Quality Insights and AJRR undertook an effort to obtain 30 randomly selected procedures files from the 18 audit participants (which reflected at least 80% power). The participants represented urban, rural, small, and large locations. The audit reviewed two aspects of data submission: (1) an accuracy review of the 30 randomly selected procedures, to ensure that data submitted to AJRR correctly reflected the data in the hospital medical records; and (2) a completeness review of data submitted to AJRR for a randomly selected month in 2016, to ensure that AJRR received all procedures performed at that hospital (i.e., review of “cherry picking”). The audit project was completed in early September 2017.

In summary, the overall audit agreement rate for the medical record review was 98.4%, up from 96.9% last year. All 18 selected participants (100%) performed above the 85% “Acceptable” agreement threshold. Of those, 16 participants (88.9%) had agreement rates above 98%, with 2 participants having 100% agreement rate. No data elements were problematic. Compared to previous years, manufacturer name, catalog number, and lot number variables performed extremely well with agreement of 96.1% or higher.

The overall record completeness assessment rate was 91.4%, up from 68.5% last year. Last year’s completeness assessment rate was unusually low due to a corrupted file issue. However, this year’s rate was still an improvement over the 2015 record completeness assessment rate of 85.3%. Of the 18 participants, 13 participants (72.2%) performed above the 85% “Acceptable” agreement threshold. Nine participants (50.0%) had a completeness assessment rate 96.0% or higher, with 2 participants having a 100% completeness assessment rate. The audit participants submitted a total of 1,093 records to Quality Insights. Only 37 records (3.4%) were not in AJRR database. There were no similarities or trends observed to suggest a reason why these records were not submitted to AJRR. Likewise, there were no anomalous observations to suggest any “cherry picking” of records for non-submission on the part of participants. Additionally, 57 records (5.2%) had one or more accuracy issues preventing them from being an exact match with the Registry. Many of the differences were due to mismatches in ICD-10 removal procedure codes. For the most part, the ICD-10 removal procedure codes were present in the AJRR data, but the participants did not submit the ICD-10 removal procedure data to Quality Insights. This may have been due to a misunderstanding of the audit data submission instructions by the participant. AJRR will include additional instruction to rectify this issue for next year’s audit. In general, AJRR and Quality insights were very pleased with the results, and the discussions with hospitals generally led to process improvements.
## Appendix B

### Core Data Elements

#### LEVEL I

**Patient**
- Name (Last, First)
- Date of birth
- Social Security Number
- Diagnosis (ICD-9/10)
- Gender
- Ethnicity

**Hospital**
- Name
- National Provider Identifier (NPI)
- Address

**Surgeon**
- Name
- National Provider Identifier (NPI)

**Procedure**
- Type (ICD-9/10)
- Date of surgery
- Laterality
- Implants

#### LEVEL II

**Patient comorbidities (ICD-9/10)**
- General comorbidities
- Addictions and other mental health comorbidities
- Cardiac-related comorbidities
- Circulatory/Vascular comorbidities
- Charlson and Elixhauser comorbidity indices

**Length of stay**

**Body Mass Index**

**American Society of Anesthesiologists (ASA) classification**

**CJR risk variables**

**Operative and post-operative complications**

#### LEVEL III

**Harris Hip Score**

**Hip disability and Osteoarthritis Outcome Score (HOOS)**

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

**Knee injury and Osteoarthritis Outcome Score (KOOS)**

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

**Knee Society Knee Scoring System**

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

**Oxford Hip and Knee Scores**

**Patient-Reported Outcomes Measurement Information**

**System (PROMIS) 10-item Global Health * **

**Veterans Rand 12-Item Health Survey (VR-12) * **

**Western Ontario and McMaster Universities Arthritis Index (WOMAC)**

* Recommended

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* ICD-9/10: International Classification of Diseases, Ninth/Seventh Revision
* CJR: Center for Medicare and Medicaid Services
* PROMIS: Patient-Reported Outcomes Measurement Information System
* WOMAC: Western Ontario and McMaster Universities Arthritis Index
# Appendix C
AJRR Committee Members

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- James I. Huddleston, III, MD – Chair*
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  University of California, San Francisco
- Kevin J. Bozic, MD, MBA  
  The University of Texas at Austin
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  Dignity Health Methodist Hospital of Sacramento
- Bradley Graw MD, MBA*  
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  Mayo Clinic
- Walter Sujansky, MD, PhD  
  Sujansky & Associates, LLC
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  Hoag Orthopaedic Institute
- Diane Przepiorski  
  California Orthopaedic Association
- Margo Sims  
  Patient Representative
- Nelson SooHoo, MD*  
  UCLA School of Medicine
- Stephanie Teleki, MPH, PhD  
  California Health Care Foundation

* Indicates member of 2017 California State Registry Committee

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  Providence St. Joseph Health
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  Smith & Nephew
- Terence J. Gieo, MD*  
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  Australian Orthopaedic Association National Joint Replacement Registry
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  University of Michigan
- Richard E. Hughes, PhD  
  University of Michigan
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  Stanford University
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  University of Wisconsin
- Robert L. Krebbs  
  Anthem
- David G. Lewallen, MD*  
  Mayo Clinic
- Hilal Maradit-Kremers, MD*  
  Mayo Clinic
- David G. Mekemson  
  Public Advisory Board Representative
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  Medical Device Innovation Consortium

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  Cigna
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  NorthShore University HealthSystem
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  The University of Texas Health Science Center at Houston and Baylor College of Medicine (AAHKS)
- Margaret Van Amringe, MHS

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- Brian S. Parsley, MD  
  The University of Texas Health Science Center at Houston and Baylor College of Medicine (AAHKS)
- Margaret Van Amringe, MHS  
  The Joint Commission
Appendix D
2012-2016 Participating Hospitals, Health Systems, Private Practice Groups, and ASCs

* Institutions that Submitted Data for this Annual Report

**ALABAMA**
- Cullman Regional Medical Center*
- Huntsville Hospital*
- Jack Hughston Memorial Hospital*
- South Baldwin Regional Medical Center
- St. Vincent’s Birmingham

**ALASKA**
- Alpine Surgery Center*
- Central Peninsula Hospital*
- Creekside Surgery Center
- Providence Alaska Medical Center*
- Providence Kodiak Island Medical Center*

**ARIZONA**
- Arizona Spine & Joint Hospital*
- Banner - University Medical Center South*
- Banner University Medical Center Tucson Campus
- Carondelet St. Joseph’s Hospital*
- Chandler Regional Medical Center
- Flagstaff Medical Center*
- Mercy Gilbert Medical Center
- Mountain Vista Medical Center*
- Northwest Medical Center*
- OASIS Health*
- St. Luke’s Medical Center
- Tempe St. Luke’s Hospital
- Verde Valley Medical Center*

**ARKANSAS**
- Arkansas Surgical Hospital
- CHI St. Vincent Infirmary*
- Mercy Hospital Fort Smith*
- Mercy Hospital of Northwest Arkansas
- Mercy Orthopedic Hospital Fort Smith
- National Park Medical Center
- University of Arkansas for Medical Sciences*

**CALIFORNIA**
- Adventist Medical Center - Hanford*
- Alta Bates Summit Medical Center (Summit Campus)*
- Alta Bates Summit Medical Center (Summit Campus)*
- California Pacific Medical Center*
- Cedars-Sinai Medical Center*
- Clovis Community Medical Center*
- Community Hospital of Monterey Peninsula*
- Corona Regional Medical Center
- Dameron Hospital*
- Desert Regional Medical Center
- Doctors Medical Center
- Eisenhower Medical Center*
- El Camino Hospital, Los Gatos Campus
- El Camino Hospital, Mountain View Campus
- Feather River Hospital*
- Fresno Surgical Hospital*
- Glendale Adventist Medical Center*
- Henry Mayo Newhall Hospital
- Hoag Orthopedic Institute*
- Howard Memorial Hospital*
- Huntington Hospital*
- Inland Valley Medical Center
- John Muir Medical Center, Concord*
- John Muir Medical Center, Walnut Creek*
- Keck Medical Center of USC*
- Lodi Memorial Hospital*
- Long Beach Memorial*
- Memorial Medical Center*
- Mercy General Hospital*
- Mercy Hospital of Folsom
- Mercy San Juan Medical Center
- Methodist Hospital of Sacramento*
- Mills-Peninsula Medical Center*
- Monterey Peninsula Surgery Center*
- NorthBay Medical Center
- NorthBay VacaValley Hospital*
- Novato Community Hospital*
- Orange Coast Memorial*
- Palmdale Regional Medical Center
- Palomar Medical Center Escondido*
- Palomar Medical Center Poway*
- PIH Health Hospital - Whittier*
- Pomona Valley Hospital Medical Center*
- Presidio Surgery Center*
- Providence Holy Cross Medical Center*
- Providence Little Company of Mary San Pedro*
- Providence Little Company of Mary Torrance*
- Providence Saint John’s Health Center*
- Providence Saint Joseph Medical Center*
- Providence Tarzana Medical Center*
- Queen of the Valley Medical Center
- Rancho Springs Medical Center
- Ronald Reagan UCLA Medical Center*
- Saddleback Memorial*
- Salinas Valley Memorial Healthcare System*
- San Antonio Regional Hospital*
- San Joaquin Community Hospital*
- Santa Rosa Memorial Hospital
- Scripps Green 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. Agnes Medical Center*
- St. Bernardine Medical Center*
- St. Helena Hospital*
- St. Joseph Hospital*
- St. Joseph's Medical Center
- St. Jude Medical Center*
- St. Mary Medical Center Long Beach
- Stanford Health Care
- Stanford Hospital & Clinics*
- Stanislaus Surgical Hospital
- Sutter Delta Medical Center
Sutter Medical Center, Sacramento*
Sutter Surgical Hospital - North Valley
Tahoe Forest Hospital*
Temecula Valley Hospital
Torrance Memorial Medical Center*
Tri-City Medical Center*
UCLA Medical Center, Santa Monica*
UCSF Medical Center*
Ukiah Valley Medical Center*
Washington Hospital
White Memorial Medical Center*

**COLORADO**

Animas Surgical Hospital*
Avista Adventist Hospital*
Avista Surgery Center
Castle Rock Adventist*
Colorado Joint Replacement
Crown Point Surgery Center*
Denver Health Main Campus*
Littleton Adventist Hospital*
Longmont United Hospital*
Medical Center of the Rockies*
Mercy Regional Medical Center*
OrthoColorado Hospital*
Parker Adventist Hospital*
Penrose Community Urgent Care
Penrose Hospital
Porter Adventist Hospital*
Poudre Valley Hospital*
St. Anthony Hospital*
St. Anthony North Hospital*
St. Anthony Summit Medical Center*
St. Francis Medical Center*
St. Mary-Corwin Medical Center*
St. Mary’s Medical Center*
St. Thomas More Hospital*
University of Colorado Hospital*

**CONNECTICUT**

Bridgeport Hospital*
Greenwich Hospital*
Hartford Hospital*
Hospital of Central Connecticut*
Lawrence + Memorial Hospital
MidState Medical Center*
St. Francis Hartford*
St. Vincent’s Medical Center*
Yale New Haven Hospital Saint Raphael Campus*
Yale New Haven Hospital York Street Campus*

**DELAWARE**

Bayhealth Kent General*
Bayhealth Milford Memorial*
Christiana Hospital*
Wilmington Hospital*

**DISTRICT OF COLUMBIA**

George Washington University Hospital
Providence Hospital
Sibley Memorial Hospital*

**FLORIDA**

Baptist Hospital*
Bartow Regional Medical Center*
Cape Coral Hospital*
Cleveland Clinic Florida - Weston*
Flagler Hospital*
Florida Hospital Waterman
Gulf Breeze Hospital*
Gulf Coast Medical Center*
Health Central Hospital*
Indian River Medical Center*
Jupiter Medical Center
Lakewood Ranch Medical Center
Largo Medical Center
Lee Memorial Hospital*
Manatee Memorial Hospital
Martin Hospital South
Martin Medical Center*
Mease Countryside Hospital*
Mease Dunedin Hospital*
Medical Center Clinic
Memorial Hospital West*
Morton Plant Hospital*
Morton Plant North Bay Hospital*
South Florida Baptist Hospital*
St. Anthony’s Hospital*
St. Joseph’s Hospital - North
St. Joseph’s Hospital - South
St. Joseph’s Hospitals
St. Vincent’s Medical Center Clay County
St. Vincent’s Medical Center Riverside
St. Vincent’s Medical Center Southside
Tallahassee Memorial Healthcare*
The Orthopaedic Institute
 Tradition Medical Center
UF Health Shands Hospital
Wellington Regional Medical Center
Winter Haven Hospital*
Wuesthoff Medical Center - Rockledge

**GEORGIA**

Colquitt Regional Medical Center*
Emory Saint Joseph’s Hospital*
Emory University Orthopaedics & Spine Hospital
Houston Medical Center*
Memorial University Medical Center*
Navicent Health
Northside Medical Center*
Optim Medical Center - Tattnall*
Redmond Regional Medical Center*
Southeast Georgia Health System*
WellStar Cobb Hospital*
WellStar Douglas Hospital*
WellStar Kennestone Hospital*
WellStar Paulding Hospital*
West Georgia Medical Center*
HAWAII
Castle Medical Center*
Pali Momi Medical Center*
Straub Clinic and Hospital*
Wilcox Memorial Hospital*

IDAHO
Cassia Regional Medical Center*
Northwest Specialty Hospital*
Saint Alphonsus Medical Center - Nampa*
Saint Alphonsus Regional Medical Center*
St. Luke's Boise Medical Center*
St. Luke's Meridian Medical Center*

ILLINOIS
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 Lutheran General Hospital
Advocate Sherman Hospital
Advocate South Suburban Hospital
Advocate Trinity Hospital
Blessing Health System*
Centegra Hospital McHenry*
Centegra Hospital Woodstock*
Genesis Medical Center, Silvis*
HSHS St. John's Hospital
Memorial Medical Center - Springfield*
NorthShore University HealthSystem Evanston Hospital*
NorthShore University HealthSystem Glenbrook Hospital*
NorthShore University HealthSystem Highland Park Hospital*
NorthShore University HealthSystem Skokie Hospital*
Northwestern Medicine Central DuPage Hospital*
Northwestern Medicine Delnor Hospital*
Northwestern Memorial Hospital*
OrthoIllinois
Palos Community Hospital*
Rockford Memorial Hospital*
Rush University Medical Center*
SwedishAmerican Hospital
UnityPoint Health - Methodist*
UnityPoint Health - Proctor*
UnityPoint Health - Trinity Rock Island*
Valley Ambulatory Surgery Center
Weiss Memorial Hospital*

INDIANA
Allied Physicians Surgery Center
Bluffton Regional Medical Center
Community Hospital Anderson
Dukes Memorial Hospital
Dupont Hospital
Franciscan Health Carmel
Franciscan Health Indianapolis
Franciscan St. Francis Health
Hancock Regional Hospital*
IU Health Arnett Hospital
IU Health Ball Memorial Hospital*
IU Health Bedford Hospital
IU Health Beltway Surgery Centers
IU Health Blackford Hospital
IU Health Bloomington Hospital
IU Health Eagle Highlands Surgery Center
IU Health Indiana Hand to Shoulder Center
IU Health Jay County Hospital
IU Health Meridian South Surgery Center
IU Health Methodist Hospital
IU Health Morgan
IU Health North Hospital
IU Health Paoli Hospital
IU Health Saxony Hospital
IU Health Saxony Hospital Adult Outpatient Services
IU Health Senate Street Surgery Center
IU Health Tipton Hospital
IU Health University Hospital
IU Health West Hospital
IU Health White Memorial Hospital
Kosciusko Community Hospital
Lutheran Hospital
Major Hospital*
Memorial Hospital and Health Care Center*
OrthoIndy*
Riley Hospital for Children at IU Health
Schneck Medical Center*
St. Joseph Hospital
St. Joseph Plymouth Medical Center*
St. Joseph Regional Medical Center*
The Orthopedic Hospital

IOWA
Allen Hospital*
Buena Vista Regional Medical Center*
Central Iowa Healthcare Clinic - Marshalltown*
CHI Health Mercy Coralville
CHI Health Mercy Council Bluffs*
Finley Hospital*
Genesis Medical Center, Davenport*
Great River Medical Center
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 - Des Moines*
Mercy Medical Center - Dubuque*
Mercy Medical Center - North Iowa*
Mercy Medical Center - Sioux City*
Mercy Medical Center - West Des Moines*
Methodist West Hospital*
Spencer Hospital*
St. Luke's Hospital*
St. Luke's Regional Medical Center*
Trinity Bettendorf*
Trinity Muscatine*
Trinity Regional Medical Center*
University of Iowa Hospitals and Clinics*

KANSAS
Hutchinson Regional Medical Center*
Kansas City Orthopaedic Institute*
Newton Medical Center*
Ransom Memorial Hospital
St. Catherine Hospital*
St. Rose Ambulatory & Surgery Center
Stormont Vail Health*
The University of Kansas Hospital*
Wesley Medical Center*

KENTUCKY
Jewish Hospital
Methodist Hospital
Saint Joseph Hospital
St. Elizabeth Edgewood*
St. Joseph East*

LOUISIANA
Doctors Hospital at Deer Creek*
Lafayette Surgical Specialty Hospital*
Ochsner Baptist - A Campus of Ochsner Medical Center*
Ochsner Medical Center*
Ochsner Medical Center - Kenner*
Ochsner Medical Center - West Bank Campus*
Our Lady of Lourdes Regional Medical Center*
Specialists Hospital Shreveport*
Thibodaux Regional Medical Center

MAINE
Falmouth Orthopaedic Center*
Maine Medical Center Joint Replacement Center*
MaineGeneral Medical Center*

MARYLAND
Anne Arundel Medical Center*
Atlantic General Hospital*
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
Sinai Hospital
Suburban Hospital
The Johns Hopkins Hospital
The 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 and Orthopaedic Institute
University of Maryland Shore Medical Center at Easton*
University of Maryland St. Joseph Medical Center*
University of Maryland Upper Chesapeake Medical Center*
Western Maryland Health System*

MASSACHUSETTS
Berkshire Medical Center*
Beth Israel Deaconess Hospital - Plymouth*
Beth Israel Deaconess Medical Center*
Beverly Hospital*
Boston Medical Center*
Good Samaritan Medical Center*
Holy Family Hospital at Methuen
Lahey Hospital & Medical Center*
Massachusetts General Hospital
New England Baptist Hospital
Quincy Medical Center*
Saint Anne's Hospital*
Signature Healthcare Brockton Hospital
South Shore Hospital*

MICHIGAN
Beaumont Hospital, Royal Oak campus*
Borgess Medical Center*
Bronson Methodist Hospital*
Genesys Regional Medical Center
Henry Ford Hospital*
Henry Ford Macomb Hospital*
Henry Ford West Bloomfield Hospital*
Henry Ford Wyandotte Hospital*
Holland Hospital*
Hurley Medical Center*
Lakeland Health*
McLaren Flint*
McLaren Greater Lansing*
Mercy Health Muskegon*
Mercy Health Saint Mary's*
Michigan Surgical Hospital*
MidMichigan Medical Center - Midland*
Munson Healthcare Cadillac Hospital*
Munson Medical Center*
Providence - Providence Park Hospital, Novi Campus
Providence - Providence Park Hospital, Southfield Campus*
Sparrow Hospital*
Spectrum Health Ludington Hospital*
St. Joseph Mercy Ann Arbor*
St. Joseph Mercy Chelsea*
St. Joseph Mercy Livingston Hospital*
St. Joseph Mercy Oakland*
St. Mary Mercy Livonia*
University of Michigan Health System*
UP Health System - Marquette*

MINNESOTA
Abbott Northwestern - WestHealth
Abbott Northwestern Hospital*
Buffalo Hospital*
Cambridge Medical Center*
CHI St. Gabriel's Health*
Crosstown Surgery Center*
Cuyuna Regional Medical Center*
Douglas County Hospital*
Essentia Health-St. Mary’s Medical Center*
Fairview Lakes Medical Center
Fairview Ridges Hospital
Fairview Southdale Hospital
Hennepin County Medical Center*
High Pointe Surgery Center*
Lakeview Hospital*
Mercy Hospital*
Mercy Hospital - Unity Campus*
New Ulm Medical Center*
Owatonna Hospital*
Park Nicollet Methodist Hospital*
Regina Hospital*
Ridgeview Medical Center*
Riverwood Healthcare Center*
St. Francis Regional Medical Center*
St. John’s Hospital*
St. Joseph’s Hospital - HealthEast*
Two Twelve Surgery Center*
United Hospital*
Vadnais Heights Surgery Center*
WestHealth Surgery Center*
Woodwinds Health Campus*

**MISSISSIPPI**
Baptist Medical Center*
Merit Health River Oaks*
North Mississippi Medical Center
Ocean Springs Hospital
Singing River Hospital*
St. Dominic Hospital*
University of Mississippi Medical Center*

**MISSOURI**
Mercy Hospital Jefferson
Mercy Hospital Joplin
Mercy Hospital Lebanon
Mercy Hospital St. Louis
Mercy Hospital Washington
Mercy Springfield Hospital*
Meyer Orthopedic & Rehabilitation Hospital*
North Kansas City Hospital
Phelps County Regional Medical Center*
St. Luke’s Hospital*

**MONTANA**
Benefis Health System*
Providence St. Joseph Medical Center*
St. Patrick Hospital*

**NEBRASKA**
Bergan Mercy Medical Center*
CHI Health Good Samaritan
Creighton University Medical Center
Immanuel Medical Center*
Lakeside Hospital*
Lincoln Surgical Hospital*
Midlands Hospital*
Midwest Surgical Hospital
Nebraska Medicine*
Nebraska Orthopaedic Hospital*
St. Elizabeth Regional Medical Center

**NEVADA**
Centennial Hills
Desert Springs Hospital
Henderson Hospital
Northern Nevada Medical Center
Renown Regional Medical Center*
Saint Mary’s Regional Medical Center
Spring Valley Hospital Medical Center
Summerlin Hospital Medical Center
Valley Hospital Medical Center

**NEW HAMPSHIRE**
Concord Hospital*
Dartmouth-Hitchcock Medical Center*

**NEW JERSEY**
Chilton Medical Center*
Hackensack University Medical Center*
Morristown Medical Center*
Newton Medical Center*

**NEW YORK**
Crouse Hospital*
Faxton St. Luke’s Healthcare
Glens Falls Hospital*
Hospital for Special Surgery*
Kenmore Mercy Hospital*
Mercy Hospital of Buffalo
Montefiore Medical Center*
Mount Sinai Brooklyn
Mount Sinai Hospital
Mount Sinai Queens
Mount Sinai St. Luke’s
Mount Sinai West
New York Methodist Hospital*
New York-Presbyterian/Queens
NewYork-Presbyterian/Columbia University Medical Center*
NewYork-Presbyterian/Lower Manhattan Hospital
NewYork-Presbyterian/Weill Cornell Medical Center
Oswego Hospital
Sisters of Charity Hospital
Sisters of Charity Hospital - St. Joseph Campus
St. Charles Hospital*
St. Elizabeth Medical Center*
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<td>Oregon Health &amp; Science University Hospital</td>
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<td>Providence Hood River Memorial Hospital*</td>
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<td>Providence Medford Medical Center*</td>
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<td>Providence Milwaukie Hospital*</td>
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<td>Providence Portland Medical Center*</td>
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Providence St. Vincent Medical Center*
Providence Willamette Falls Medical Center*
Saint Alphonsus Medical Center - Baker City*
Saint Alphonsus Medical Center - Ontario*
Salem Health Hospital*
Samaritan Albany General Hospital*
St. Charles Health System*
Tillamook Regional Medical Center*
Willamette Surgery Center
Willamette Valley Medical Center*

**PENNSYLVANIA**
Advanced Surgical Hospital
Allegheny General Hospital
Chan Soon-Shiong Medical Center at Windber
Children’s Hospital of Pittsburgh of UPMC
Doylestown Hospital*
Hanover Hospital*
Hospital of the University of Pennsylvania
Indiana Regional Medical Center*
Lancaster General Hospital*
Magee-Womens Hospital of UPMC*
Mercy Fitzgerald Hospital
Mercy Philadelphia Hospital
Moses Taylor Hospital
Mount Nittany Medical Center*
Nazareth Hospital*
Orthopaedic & Spine Specialists*
Penn Highlands DuBois
Penn Presbyterian Medical Center*
Penn State Milton S. Hershey Medical Center*
Pennsylvania Hospital*
PinnacleHealth Community General
Osteopathic Hospital*
PinnacleHealth Harrisburg Hospital*
PinnacleHealth West Shore Hospital*
Reading Hospital*
Regional Hospital of Scranton DBA Scranton Hospital Company LLC
Rothman Institute
St. Mary’s Medical Center - Langhorne*
Thomas Jefferson University Hospital
UPMC Altoona*
UPMC Bedford Memorial
UPMC East*
UPMC Hamot*
UPMC Horizon*
UPMC Jameson
UPMC McKeesport*
UPMC Mercy*
UPMC Northwest*
UPMC Passavant-McCandless*
UPMC Presbyterian
UPMC Shadyside*
UPMC St. Margaret*
WellSpan Gettysburg Hospital*
WellSpan Surgery and Rehabilitation Hospital*
WellSpan York Hospital*

**RHODE ISLAND**
South County Hospital*
Westerly Hospital

**SOUTH CAROLINA**
Aiken Regional Medical Center
Baptist Erasley Hospital
Bon Secours St. Francis Hospital*
Carolina Coast Surgery Center
Carolina Pines Regional Medical Center
Conway Medical Center
East Cooper Medical Center*
Medical University of South Carolina*
Novant Health Gaffney Medical Center
Palmetto Health Baptist*
Palmetto Health Baptist Parkridge
Palmetto Health Richland*
Palmetto Health Tuomey
Providence Orthopaedic Hospital*
Roper Hospital*
Roper St. Francis Mount Pleasant Hospital*
Tidelands Waccamaw Community Hospital*

**SOUTH DAKOTA**
Sanford USD Medical Center*
Sioux Falls Specialty Hospital

** TENNESSEE**
Baptist Memorial Hospital-Collierville*
CHI Memorial Hospital Chattanooga*
CHI Memorial Hospital Hixson
Henry County Medical Center*
Indian Path Medical Center*
Johnson City Medical Center*
Knoxville Orthopaedic Clinic
Maryville Orthopaedic Clinic
Maury Regional Medical Center*
Orthopaedic Surgeons of Oak Ridge
Physicians Regional Medical Center*
Saint Thomas Midtown Hospital
Saint Thomas Rutherford Hospital
Saint Thomas West Hospital
Turkey Creek Medical Center
University of Orthopaedic Surgeons
University of Tennessee Medical Center*

**TEXAS**
Baptist Beaumont Hospital of Southeast Texas*
Baylor Medical Center at Uptown
Baylor Scott & White - 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 - Waxahachie*
Baylor University Medical Center*
CHRISTUS Good Shepherd Medical Center - Longview*
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<td>CHRISTUS Good Shepherd Medical Center - Marshall*</td>
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<td>CHRISTUS Mother Frances Hospital - Tyler</td>
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<td>CHRISTUS Southeast Texas St. Elizabeth*</td>
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<tr>
<td>Cornerstone Regional Hospital</td>
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<tr>
<td>Doctors Hospital at Renaissance*</td>
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<tr>
<td>Doctors Hospital of Laredo</td>
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<tr>
<td>Edinburg Regional Medical Center</td>
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<tr>
<td>El Paso Specialty Hospital*</td>
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<td>Houston Methodist Hospital*</td>
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<td>JPS Health Network*</td>
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<td>Memorial Hermann Memorial City Medical Center*</td>
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<tr>
<td>Midland Memorial Hospital*</td>
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<td>Nix Health*</td>
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<tr>
<td>North Central Surgical Center Hospital</td>
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<td>Northwest Texas Hospital</td>
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<tr>
<td>Scott &amp; White Memorial Hospital - Temple*</td>
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<td>South Texas Spine &amp; Surgical Hospital*</td>
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<td>St. Joseph Health System*</td>
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<tr>
<td>Texas Health Harris Methodist Hospital South Texas Fort Worth*</td>
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<td>Texas Spine &amp; Joint Hospital</td>
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<td>University Medical Center - Brackenridge*</td>
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<td>Dixie Regional Medical Center*</td>
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<td>Proliance Highlands Surgery Center</td>
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Implementation of ICD-10 in October 2015 was an impediment for rapid submission of data. With ICD-10 submission issues more completely addressed by 2016, data submission to AJRR improved. However, the additional granularity of the ICD-10 coding has resulted in challenges for both diagnosis and procedure coding that continue to be addressed. For example, a joint replacement revision in ICD-10 must be coded with a "removal" procedure followed by a "replacement" procedure. If AJRR only receives a replacement with no removal, we are to assume the procedure is a primary arthroplasty. If AJRR receives a removal only, we are unable to utilize the procedure. Specifically, for this Annual Report, there were nearly 11,000 procedures eliminated from analysis because the "removal" primary code was followed by secondary code of "supplement." With this data, we were not always able to determine if the procedure was indeed a revision. With new data specifications released in 2017, AJRR will accept multiple procedure codes, which hopefully will allow for more complete identification of revisions. For diagnosis codes, AJRR participants may inadvertently submit secondary diagnosis codes for the patient, rather than the primary diagnosis code. AJRR thus receives "primary" diagnosis codes for BMI status, allergies, and presence of other comorbid conditions.
### Primary Hip Replacement

**ICD-9**

- 81.51 Total Hip Replacement

**ICD-10**

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<th>Description</th>
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Revision Hip Replacement

ICD-9

00.7 Other Hip Procedures
00.70 Revision of Hip Replacement, both Acetabular and Femoral Components
00.71 Revision of Hip Replacement, Acetabular Component
00.72 Revision of Hip Replacement, Femoral Component
00.74 Hip Bearing Surface, Metal-on-Polyethylene
81.53 Revision of Hip Replacement, Not Otherwise Specified

ICD-10 Removal Trigger Codes

0QP204Z Removal of Internal Fixation Device from Right Pelvic Bone, Open Approach
0QP304Z Removal of Internal Fixation Device from Left Pelvic Bone, Open Approach
0QP604Z Removal of Internal Fixation Device from Right Upper Femur, Open Approach
0QP704Z Removal of Internal Fixation Device from Left Upper Femur, Open Approach
0SP904Z Removal of Internal Fixation Device from Right Hip Joint, Open Approach
0SPB04Z Removal of Internal Fixation Device from Left Hip Joint, Open Approach
0SP908Z Removal of Spacer from Right Hip Joint, Open Approach
0SPB08Z Removal of Spacer from Left Hip Joint, Open Approach
0SP909Z Removal of Liner from Right Hip Joint, Open Approach
0SPB09Z Removal of Liner from Left Hip Joint, Open Approach
0SP90BZ Removal of Resurfacing Device from Right Hip Joint, Open Approach
0SPB0BZ Removal of Resurfacing Device from Left Hip Joint, Open Approach
0SUA0BZ Supplement Right Hip Joint, Acetabular Surface with Resurfacing Device, Open Approach
0SPAOBZ Supplement Left Hip Joint, Acetabular Surface, Open Approach
0SUR0BZ Supplement Right Hip Joint, Femoral Surface with Resurfacing Device, Open Approach
0SUP0BZ Supplement Left Hip Joint, Femoral Surface, Open Approach

Hip Resurfacing

ICD-9

00.85 Resurfacing Hip, Total, Acetabulum, and Femoral Head
00.86 Resurfacing Hip, Partial, Femoral Head
00.87 Resurfacing Hip, Partial, Acetabulum

ICD-10

0ZU90BZ Supplement Right Hip Joint with Resurfacing Device, Open Approach
0SUB0BZ Supplement Left Hip Joint with Resurfacing Device, Open Approach
0SUA0BZ Supplement Right Hip Joint, Acetabular Surface with Resurfacing Device, Open Approach
0SUE0BZ Supplement Left Hip Joint, Acetabular Surface with Resurfacing Device, Open Approach
0SUR0BZ Supplement Right Hip Joint, Femoral Surface with Resurfacing Device, Open Approach
0SUS0BZ Supplement Left Hip Joint, Femoral Surface with Resurfacing Device, Open Approach
Hemiarthroplasty (Partial Hip Replacement)

ICD-9

81.52  Partial Hip Replacement

ICD-10

0SRRO19  Replacement of Right Hip Joint, Femoral Surface with Metal Synthetic Substitute, Cemented, Open Approach
0SRRO1A  Replacement of Right Hip Joint, Femoral Surface with Metal Synthetic Substitute, Uncemented, Open Approach
0SRSO19  Replacement of Left Hip Joint, Femoral Surface with Metal Synthetic Substitute, Cemented, Open Approach
0SRSO1A  Replacement of Left Hip Joint, Femoral Surface with Metal Synthetic Substitute, Uncemented, Open Approach
0SRR039  Replacement of Right Hip Joint, Femoral Surface with Ceramic Synthetic Substitute, Cemented, Open Approach
0SRR03A  Replacement of Right Hip Joint, Femoral Surface with Ceramic Synthetic Substitute, Uncemented, Open Approach
0SRS039  Replacement of Left Hip Joint, Femoral Surface with Ceramic Synthetic Substitute, Cemented, Open Approach
0SRS03A  Replacement of Left Hip Joint, Femoral Surface with Ceramic Synthetic Substitute, Uncemented, Open Approach
0SRROJ9  Replacement of Right Hip Joint, Femoral Surface with Synthetic Substitute, Cemented, Open Approach
0SRROJA  Replacement of Right Hip Joint, Femoral Surface with Synthetic Substitute, Uncemented, Open Approach
0SRSOJ9  Replacement of Left Hip Joint, Femoral Surface with Synthetic Substitute, Cemented, Open Approach
0SRSOJA  Replacement of Left Hip Joint, Femoral Surface with Synthetic Substitute, Uncemented, Open Approach
0SRA019  Replacement of Right Hip Joint, Acetabular Surface with Metal Synthetic Substitute, Cemented, Open Approach
0SRA01A  Replacement of Right Hip Joint, Acetabular Surface with Metal Synthetic Substitute, Uncemented, Open Approach
0SRE019  Replacement of Left Hip Joint, Acetabular Surface with Metal Synthetic Substitute, Cemented, Open Approach
0SRE01A  Replacement of Left Hip Joint, Acetabular Surface with Metal Synthetic Substitute, Uncemented, Open Approach
0SRA039  Replacement of Right Hip Joint, Acetabular Surface with Ceramic Synthetic Substitute, Cemented, Open Approach
0SRA03A  Replacement of Right Hip Joint, Acetabular Surface with Ceramic Synthetic Substitute, Uncemented, Open Approach
0SRE039  Replacement of Left Hip Joint, Acetabular Surface with Ceramic Synthetic Substitute, Cemented, Open Approach
0SRE03A  Replacement of Left Hip Joint, Acetabular Surface with Ceramic Synthetic Substitute, Uncemented, Open Approach
0SRAOJ9  Replacement of Right Hip Joint, Acetabular Surface with Synthetic Substitute, Cemented, Open Approach
0SRAOJA  Replacement of Right Hip Joint, Acetabular Surface with Synthetic Substitute, Uncemented, Open Approach
0SREOJ9  Replacement of Left Hip Joint, Acetabular Surface with Synthetic Substitute, Cemented, Open Approach
0SREOJA  Replacement of Left Hip Joint, Acetabular Surface with Synthetic Substitute, Uncemented, Open Approach

Primary Knee Replacement

ICD-9

81.54  Total Knee Replacement

ICD-10

0SRCOJ9  Replacement of Right Knee Joint with Synthetic Substitute, Open Approach, Cemented
0SRCOJA  Replacement of Right Knee Joint with Synthetic Substitute, Open Approach, Uncemented
0SRCOJZ  Replacement of Right Knee Joint with Synthetic Substitute, Open Approach
0SRDOJ9  Replacement of Left Knee Joint with Synthetic Substitute, Open Approach, Cemented
0SRDOJA  Replacement of Left Knee Joint with Synthetic Substitute, Open Approach, Uncemented
0SRDOJZ  Replacement of Left Knee Joint with Synthetic Substitute, Open Approach
Revision Knee Replacement

ICD-9

00.80 Revision of Knee Replacement, Total (all components)
0.81 Revision of Knee Replacement, Tibial Component
0.82 Revision of Knee Replacement, Femoral Component
0.83 Revision of Knee Replacement, Patellar Component
0.84 Revision of Total Knee Replacement, Tibial Insert (liner)
81.47 Other Repair of Knee
81.55 Revision of Knee Replacement, Not Otherwise Specified

ICD-10 Removal Trigger Codes

0QPB04Z Removal of Internal Fixation Device from Right Lower Femur, Open Approach
0QPC04Z Removal of Internal Fixation Device from Left Lower Femur, Open Approach
0QPD04Z Removal of Internal Fixation Device from Right Patella, Open Approach
0QPF04Z Removal of Internal Fixation Device from Left Patella, Open Approach
0QPD0JZ Removal of Synthetic Substitute from Right Patella, Open Approach
0QPF0JZ Removal of Synthetic Substitute from Left Patella, Open Approach
0QPG0JZ Removal of Synthetic Substitute from Right Tibia, Open Approach
0QPGO4Z Removal of Synthetic Substitute from Right Tibia, Open Approach
0QPH04Z Removal of Internal Fixation Device from Left Tibia, Open Approach
0QPG04Z Removal of Internal Fixation Device from Right Tibia, Open Approach
0QPH04Z Removal of Internal Fixation Device from Left Tibia, Open Approach
0SPC04Z Removal of Internal Fixation Device from Right Knee Joint, Open Approach
0SPD04Z Removal of Internal Fixation Device from Left Knee Joint, Open Approach
0SPC08Z Removal of Spacer from Right Knee Joint, Open Approach
0SPD08Z Removal of Spacer from Left Knee Joint, Open Approach
0SPC09Z Removal of Liner from Right Knee Joint, Open Approach
0SPD09Z Removal of Liner from Left Knee Joint, Open Approach
0SPC0JZ Removal of Synthetic Substitute from Right Knee Joint, Open Approach
0SPD0JZ Removal of Synthetic Substitute from Right Knee Joint, Open Approach
0SPC0KZ Removal of Nonautologous Tissue Substitute from Right Knee Joint, Open Approach
0SPD0KZ Removal of Nonautologous Tissue Substitute from Left Knee Joint, Open Approach
0SPC4JZ Removal of Synthetic Substitute from Right Knee Joint, Percutaneous Endoscopic Approach
0SPD4JZ Removal of Synthetic Substitute from Left Knee Joint, Percutaneous Endoscopic Approach
0SPTOJZ Removal of Synthetic Substitute from Right Knee Joint, Femoral Surface, Open Approach
0SPU0JZ Removal of Synthetic Substitute from Left Knee Joint, Femoral Surface, Open Approach
0SPV0JZ Removal of Synthetic Substitute from Right Knee Joint, Tibial Surface, Open Approach
0SPWOJZ Removal of Synthetic Substitute from Left Knee Joint, Tibial Surface, Open Approach
Appendix H  ICD-9 & ICD-10 Diagnosis Code Categories included for Knees

ICD-9

714  Rheumatoid Arthritis
715  Osteoarthritis of Knee
716  Other and Unspecified Arthropathies
719  Other and Unspecified Disorders of Joint; Other Joint Disorder, Not Elsewhere Classified
733  Other Disorders of Bone and Cartilage; Disorder of Continuity of Bone
820  Fracture of Neck of Femur; Fracture of Femur
996  Complications Peculiar to Certain Specified Procedures; Complications of Internal Orthopedic Prosthetic Devices, Implants, and Grafts; Complications of Other Internal Prosthetic Devices, Implants, and Grafts

ICD-10

M06  Rheumatoid Arthritis
M16  Osteoarthritis of Hip
M12  Other and Unspecified Arthropathies
M25  Other and Unspecified Disorders of Joint; Other Joint Disorder, Not Elsewhere Classified
M84  Other Disorders of Bone and Cartilage; Disorder of Continuity of Bone
S72  Fracture of Neck of Femur; Fracture of Femur
T84-T85 Complications Peculiar to Certain Specified Procedures; Complications of Internal Orthopedic Prosthetic Devices, Implants, and Grafts; Complications of Other Internal Prosthetic Devices, Implants, and Grafts

Appendix G  ICD-9 & ICD-10 Diagnosis Code Categories included for Hips

ICD-9

714  Rheumatoid Arthritis
715  Osteoarthritis of Hip
716  Other and Unspecified Arthropathies
719  Other and Unspecified Disorders of Joint; Other Joint Disorder, Not Elsewhere Classified
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ICD-10

M06  Rheumatoid Arthritis
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T84-T85 Complications Peculiar to Certain Specified Procedures; Complications of Internal Orthopedic Prosthetic Devices, Implants, and Grafts; Complications of Other Internal Prosthetic Devices, Implants, and Grafts
Appendix I
Methodology for Reporting Meaningful Change in Risk-Adjusted Patient-Reported Outcomes

Risk-Adjustment for Patient-Reported Outcomes of Total Joint Replacement Surgeries
From the Former California Joint Replacement Registry
February 4, 2015

Background
The former California Joint Replacement Registry (CJRR) has been publicly reporting risk-adjusted patient reported outcomes (PRO) for joint replacement surgeries in CJRR-participating hospitals. Risk-adjustment controls for diseases and conditions and other patient characteristics that vary from hospital to hospital and may cause PROs to vary because of circumstances outside of a provider’s control. These PRO results are based on data collected in CJRR about surgeries that occurred from April 1, 2011, through November 6, 2014. The calculations are current as of December 31, 2014.

Model Development
Patient Sample
Patients undergoing primary total hip or primary total knee replacement (unilateral or bilateral) were included in the risk adjustment modeling and subsequent public reporting. Patients with pathological fractures or malignant neoplasms (primary or metastatic cancer) were excluded. See Table 1 in the Appendix for a list of excluded codes. A total of 5,780 eligible patients were registered by CJRR during the study period beginning April 1, 2011, through November 6, 2014, at 14 participating hospital sites. Cases are eligible if at least one year has elapsed since the procedure occurred. Cases are complete if the patient has finished a pre-procedure PRO survey and also a one-year post-procedure PRO survey. There were 1,155 completed cases. The hospital response rate is the number of complete cases divided by the number of eligible cases. These PRO scores and performance outcome results are based on data collected in CJRR about surgeries that occurred from April 1, 2011, to November 6, 2014. The calculations are current as of December 31, 2014.

PRO Measure
CJRR collects PRO data using three distinct surveys: VR-12, Western Ontario and McMaster Universities Arthritis Index (WOMAC), and the UCLA Activity Index. The PRO measure that CJRR will report publicly at this time is the WOMAC, which is a condition-specific survey that asks patients about symptoms, pain, stiffness, and the patient’s ability to perform various routine activities of daily life that are progressively more physically demanding.

From the WOMAC data, the specific outcome measure to be reported is the percentage of WOMAC respondents that had Minimal Clinically Important Differences between pre- and post- WOMAC scores (MCID). Survey responses sometimes have statistically significant differences that are associated with small clinical changes. The MCID accounts for this, making sure that all patients who are counted as having positive post-procedure change have meaningful changes in their WOMAC scores.

Risk Adjustment Methods
The risk-adjustment approach used in CJRR compares the 95% confidence interval of each hospital’s risk-adjusted PRO MCID rate (RAR) to all participating hospitals’ overall PRO MCID rate to identify hospital performance “Better” or “Worse” outliers. The risk-adjusted PRO results represent what a hospital’s PRO MCID rate would have been if the hospital had a patient case mix identical to the reference population. For CJRR, the reference population is the patient population of all CJRR participating hospitals. A hospital’s RAR is calculated by dividing the hospital’s observed PRO MCID rate by the hospital’s expected PRO MCID rate (obtained from the risk model calculation) to get the observed/expected (O/E) ratio. If the O/E ratio is greater than one, the hospital has a higher PRO MCID rate than expected given its patient mix. If the O/E ratio is less than one, the hospital has a lower PRO MCID rate than expected. The O/E ratio is then multiplied by the overall PRO MCID rate of all participating hospitals to obtain the hospital’s risk-adjusted PRO MCID rate.
Statistical Analysis

All candidate risk factors were entered into a stepwise, backward-selection logistic regression model. Candidate risk factors included age, gender, race (Caucasian), ASA Class, ASA Class grouped, hip vs. knee procedure, multiple simultaneous procedures, diabetes, immunocompromised status, obese, hypertension history, MI history, CAD History, CLD history, VTE history, count of risk factors, surgery year, and median household income. These variables were collected from patient records where available and reported by participating hospitals. Patients with missing data for these variables were assigned a value not associated with MCIDs. For example, a patient with missing BMI would be assigned an obese score of “No.”

The variable selection method required an individual predictor to be associated with PRO MCID at the 0.05 level of significance to be retained. Predictor variables that did not meet this level of significance were dropped. A final risk model was specified by keeping all predictor variables that met the 0.05 level of significance in the automated selection method, and by adding additional variables that were not statistically significant but were clinically meaningful.

The CJRR Reporting Subcommittee determined that the resulting risk adjustment model had adequate fit (Hosmer-Lemeshow lack-of-fit chi-square = 0.299, n.s.), and that it was adequately predictive (c=0.78).

Final Risk Adjustment Variables

The final risk adjustment regression model included several patient-level variables known to be associated with improved patient-reported outcomes:

- Pre-operative WOMAC score
- Age: Patient age in years at the time of surgery
- Gender: Male/Female
- Race: Caucasian/Other
- ASA Physical Status Classification System score: (3 or 4)/(1 or 2)
- Obese: Body Mass Index (BMI) score of 30 greater
- Diabetes: Yes/No
- Hypertension History: Yes/No
- Chronic Lung Disease History: Yes/No
- Hip vs. Knee Procedure

Calculation of Hospital Risk-Adjusted MCID Outcome

The risk-adjustment regression model was used to calculate expected MCIDs for each hospital using patient-level data. The expected PRO MCID rate was the number of expected MCIDs as predicted by the risk-adjustment model, divided by the total number of actual, eligible joint replacement surgery cases, multiplied by 100. The expected event rate is adjusted for the severity of the hospital’s case mix. The observed PRO MCID rate was the number of observed MCIDs divided by the total number of eligible joint replacement surgery cases, multiplied by 100.

The risk-adjusted MCID rate (RAR) was obtained by multiplying the population-observed MCID rate (87.1%) by the hospital’s Observed/Expected ratio. The risk-adjusted event rate reflects the best estimate of what a provider’s MCID rate would have been if the provider had a patient case mix identical to the overall CJRR average. This rate is comparable among providers because it accounts for the differences in patient severity-of-illness.

Each provider’s performance rating was based on a comparison of the 95% confidence interval (CI) of each provider’s RAR to the population average MCID rate (87.1%). The Poisson exact probability method was used for computing the 95% CI for the RAR.

1Partial procedures, resurfacings, and revisions were excluded.
2http://www.womac.org/womac/index.htm
3Change in WOMAC Score between Pre-Op and 1-year Post-Op ≥ the Minimal Clinically Important Difference (0.5*standard deviation of mean change in scores).
References


We gratefully acknowledge the assistance of Bryan Springer, MD, current chair of the Data Management Committee; the members of the Annual Report Subcommittee, Kevin Fleming, Blair Fraser, and James Huddleston, III, MD; and the rest of the 2017 Data Committee for their guidance pertaining to the contents of this Annual Report. Thank you to Edmund Lau and Heather Watson, PhD, from Exponent for their statistical expertise. And, we are appreciative of Deborah Render for her editing of this document.

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