Dedication

The 2018 Annual Report is dedicated to David Lewallen, MD, inaugural Chair and current Medical Director of the AJRR, for his unwavering support of the AJRR and the countless hours he has spent helping us develop the premier patient outcomes registry in orthopaedics.

– Kevin Bozic, MD, MBA,
Chair of the AJRR Steering Committee.
Foreword

This year marks an exciting year for the American Academy of Orthopaedic Surgeons (AAOS) and our cornerstone registry for hip and knee arthroplasty, the American Joint Replacement Registry (AJRR). With over 1 million patients and over 1.4 million hip and knee arthroplasty procedures entered into the Registry, the AJRR is the largest orthopaedic registry in the world by annual procedural count.

We are proud to present this 2018 Annual Report which reflects data collected from 2012 through 2017. The report includes data on 1,186,955 procedures from 1,067 institutions. 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 been able to move forward with analysis of new data elements and data sources this year. This information has led to new sections in this Annual Report to include an overview of data completeness, patient-reported outcome measures, and implant survivorship curves. These survivorship curves were made possible by the successful integration of Medicare claims data into the AJRR, which provides a more complete picture of our patient population and their associated outcomes, including revision procedures done at non-AJRR participating hospitals. The information in this year’s report gives the most comprehensive picture to date of patterns of hip and knee arthroplasty use and outcomes in the United States.

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

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

Kevin J. Bozic, MD, MBA
Chair, AJRR Steering Committee
In 2017, AJRR became part of AAOS, as well as the inaugural registry of the AAOS Registry Program. Directed by the AAOS Registry Oversight Committee (ROC) and the AJRR Steering Committee, their aligned goals and resources increase the Registry’s capabilities and reach. Based on the number of procedures submitted per year, AJRR is the largest orthopaedic registry in the world. It serves as the cornerstone of the AAOS Registry Program, which has begun to incorporate other anatomic sites and areas of interest, such as the Shoulder & Elbow Registry (SER) and the Musculoskeletal Tumor Registry (MsT). The AAOS Registry Program’s goal is to improve patient outcomes through the development of a national family of clinical data registries reporting on a broad range of orthopaedic conditions, procedures, and outcomes.

It has been an eventful year for AJRR. New subscriber growth, innovative initiatives, and collaborations (none more significant than rejoining AAOS) have all contributed to the momentum the Registry experienced in 2017. Enrollment of participating facilities increased to 1,067, data were reported for 796 (75%) of those entities, and there was a 38% increase in procedural volume compared to last year’s Annual Report. This report, based on 2017 AJRR data submissions, reflects approximately 32.3% (based on Healthcare Cost and Utilization Project [H-CUP] data 2012-2014) of the estimated annual procedural volume in the United States.

In 2017-2018 AAOS and AJRR, united through the AAOS Registry Program, successfully delivered on a significant number of promises to Registry stakeholders:

- For several years, both AAOS and AJRR advocated for increased access to Medicare claims data to improve the data reporting and analysis capabilities of the Registry. Beginning in 2018, AJRR has obtained patient records for all Medicare patients represented in the Registry from 2012-2018 provided through an agreement between the Centers for Medicare & Medicaid Services (CMS) and AAOS. These patient files were matched with existing Registry records to allow for improved longitudinal analysis of patient care. Furthermore, this data supports objective risk adjustment. Along with the CMS data, AJRR’s new post-op (Level II) data requirements will help ensure that Registry subscribers can conduct risk-adjusted case analysis and benchmarking for the first time.

- In 2016, AJRR was selected to develop and host the International Society of Arthroplasty Registries’ (ISAR) International Prostheses Library (IPL), which contains comprehensive and detailed device information. In 2018, AJRR completed three related pilots and launched the Library worldwide, per its ISAR contractual commitment. These development efforts were aided by expertise and funding from industry, including AdvaMed’s Orthopedic Sector. The IPL is housed and maintained by AJRR and owned by ISAR. ISAR’s IPL goal is to have the Library serve as a single source of medical device information and safety alerts for industry partners and ISAR member organizations throughout the world. Currently, the IPL is the only data repository of its kind.
• AdvaMed’s Orthopedic Sector also provided guidance on Registry efforts to develop the recently completed company-specific data access module. This real-time, online portal allows manufacturers to access anonymized, procedure-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.

• AJRR Data Specifications and Data Dictionary were updated in early 2018 to provide more clarity around data capture. AJRR also went through a multi-month process to help participants transition to the updated specifications with a series of group webinars and one-on-one support by Registry Support Specialists. As of September 30, 2018, AJRR sunset specification Version 2.01.2017, Version 4.1, and the CJRR format and now supports only Version 7.13.2017 and Version 7.13.2017. Revision 1. Moving forward, the AJRR will provide annual updates to ensure the most accurate and relevant data specifications, ensure a transition period that sunsets the oldest specification, and support the two most recent specification versions. The current data specifications include submission of procedural (Level I) and post-op (Level II) data requirements, as well as the continued reporting of patient-reported outcomes (Level III). This robust data capture can enable Registry subscribers to conduct risk-adjusted case analysis and participate in pay-for-performance programs.

• The Registry values relationships with state registries so states can benefit from state-level reporting and benchmarking. The California State Registry became part of AJRR, the Virginia Joint Registry sites were enabled to join AJRR, and AJRR collaborates with the Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) to allow MARCQI sites to join AJRR while leveraging their data abstraction for MARCQI. Each state relationship increases the breadth (more procedures, hospitals, ambulatory surgery centers (ASCs), surgeons) and depth of the Registry’s hip and knee procedural database.

• AJRR disseminates Registry participant success stories in a variety of ways. Published case studies from AJRR subscribing institutions including Providence St. Joseph Health (Washington State), TriHealth Good Samaritan Hospital (Ohio), and MountainView Regional Medical Center (New Mexico) demonstrate how they leverage their Registry participation into successful quality-improvement initiatives. Annual conferences/meetings, a weekly blog, User Group meetings, webinars, video presentations, and website posts are other real-time channels for information sharing.

• Research findings by AJRR staff on such topics as Correlation Between Hospital Size and Revision Indication and Where TJA Revision Surgery is Performed, National Trends in the Treatment of Femoral Neck Fracture, and Early Linked THA and TKA Revisions Tied to Higher Infection Rates are shared via peer-reviewed journals, posters, and podium presentations and demonstrate the value of Registry data and its analysis.

The demographics of the AJRR overall patient population have remained unchanged: the average patient age is 66.8 years, 41% are male and 59% female, and nearly 70% self-describe as white

This year’s report is based on the findings from over 1,186,955 cumulative procedures between 2012 and 2017. Major and minor teaching hospitals still supply the majority of procedural data to AJRR but ASCs will undoubtedly figure more prominently in future years.

AJRR surgeons performed a mean of 26 primary hip arthroplasties (THA) per year and 46 primary total knee arthroplasties (TKA), which represents an increase in TKAs and a decrease in THAs compared to 2016. The upper range among surgeons for either procedure is over 600 procedures annually.

Some trends noted in hip arthroplasty over the last few years have continued. There was increasing use of ceramic heads, enhanced polyethylene liners, dual-mobility constructs for both primary and revision THA, and an increase in THA for the indication of femoral neck fracture. The use of cementless stems over cemented stems in both primary THA and arthroplasty for femoral neck fracture is still favored in the sample for every age group. Resurfacing procedures decreased in 2017 and are rarely reported. The revision burden for THA continues to decrease, although numerous factors may contribute to this finding.

In total knee arthroplasty, posterior-stabilized fixed-bearing designs remain most popular, but mobile-bearing designs show slow and steady growth in the revision TKA setting. Unicompartmental knee arthroplasty (UKA) continues to decrease in our database, now representing less than 2% of the knee arthroplasties performed.
When considering linked revisions, where both the primary and revision procedures were performed in an AJRR contributor institution, early revisions (less than three months) predominate. As in prior years, these early revisions for THA were primarily for the indications of periprosthetic fracture, dislocation, and infection, while those for TKA were primarily performed for a diagnosis of infection.

Data completeness was analyzed in greater detail for the first time this year, and as expected Level I data elements generally have a high level of completeness. Many of these data elements can be populated from the Electronic Health Record (EHR). The launch of Level II data elements collection in 2017 proved difficult for many sites during the past year, with less than 10% of sites submitting this information by calendar year-end. Again, those elements included in the EHR system, such as discharge disposition and length of stay, are collected more readily than those relating to the perioperative period, such as surgical approach or use of robotics.

Patient-reported outcome measures (PROMs) have also seen increased emphasis following the pioneering work of the CJRR, and beginning for the larger population of the AJRR in April 2016. With the development of a PROM platform within our RegistryInsights™ system, the AJRR has actively promoted the collection of four validated PROMs (HOOS/HOOS, Jr., KOOS/KOOS, Jr., PROMIS-10, and VR-12). However, PROM collection and reporting remain a work in progress, with 6% (41/654) of sites that submitted data including PROM data for this report, and a relatively low completion rate of linked preoperative and postoperative PROMs. Nevertheless, methods to improve the collection of PROMs by embedding the process into the workflow of patient care show promise and should increase these rates.

Finally, this report includes the first results of successful acquisition and linkage of claims data from CMS with the AJRR database to obtain more complete information on comorbidities, revisions performed on AJRR patients in non-AJRR institutions, and other factors pertinent to analysis of the arthroplasty experience in the Medicare population. Over 500,000 knee and hip arthroplasty procedures within AJRR were identified from the CMS inpatient files, and were available for early survival analysis of primary arthroplasty with consideration of indication for surgery, sex, and age. Preliminary results are presented for analyzed factors such as mode of fixation in THA (cemented vs. cementless), ceramic vs. metal heads in THA, cruciate-retaining vs. posterior-stabilized TKA designs, and TKA designs vs. UKA designs, among others.

“Physicians struggle with outcome measures, but they need them because reimbursement is tied to outcomes and there is potential for significant industry research that improves patient care. One of the main reasons AJRR is successful is because of its alignment with and support from industry.”

Paul Duwelius, MD
Providence St. Vincent Medical Center
(Orthopaedic Surgeon)
About AJRR

After nearly three years as an independent 501(c)3 not-for-profit corporation, AJRR rejoined AAOS, becoming the cornerstone of the AAOS Registries Program in October 2017. AJRR transitioned from an independent organization with a Board of Directors to a department within AAOS while maintaining its multistakeholder governance model. As part of the Academy, AJRR will contribute to the AAOS Registry Program mission to improve orthopaedic care through the collection, analysis, and reporting of actionable data to effect better outcomes and quality.

2017: A Year of Progress and Growth

More than 300,000 procedures have been submitted to AJRR as 2017 procedures. These procedures come from 796 institutions and over 4,900 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.

2018: A Year of Accelerated Growth

- Largest total hip and knee arthroplasty Registry in the world by annual procedural count with 1,432,491 procedures
- 25-30% of the estimated annual procedural volume in the United States
- 1,166 contracted participants
- 8,603 surgeons contributed cases
- 146 sites submitted PRO data
- 51,186 completed PRO patient surveys

*As of publication deadline, August 31, 2018

Increase in Institutional Enrollment 2010-2018

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OUR MISSION

To improve orthopaedic care through the collection, analysis, and reporting of actionable data.
Investing in RegistryInsights™ and the User Experience

In 2017 the initial phase of a three-year, multi-million dollar technology enhancement roadmap was completed. It upgraded the Registry systems, platform, and the visual functionality and appeal of the dashboards while creating a centralized database architecture and independent data warehouse.

The new technology platform, RegistryInsights™, offers an improved user-experience:

- **Enhanced benchmarking.** Improved on-demand search ability allows Registry participants to compare their health system and individual institution’s procedure data against the Registry national benchmark metrics. This is especially important as risk-adjusted comparisons are enabled for the first time in early 2019.
- **Improved data validation.** A more robust data integration and services environment has improved automated data file validation and record cleansing processes, virtually eliminating prior data backlog issues and reducing errors.
- **More transparency in the data submission process.** The new portal design provides a window into the technical aspects of the data submission process. It allows users access to error reports, accepted procedure reports, and other data submission performance measures.

The next phase will emphasize dashboard security, introduction of performance measures, and enhanced benchmarking capabilities. It will also offer enhanced research request capabilities and self-service analytics.

Data Reporting and Data Specifications

In early 2017, the Registry introduced new data specifications, the first significant enhancement in its history. It was initially anticipated that sites would adopt these new data specification standards by January 1, 2018. However, based on user feedback, the decision was made to give participants more time to adhere to the requirements. Subsequently, a number of new data specification adjustments were made and the specification standards implementation deadline was moved to September 30, 2018. Moving forward, data specifications will be updated on an annual basis on a published schedule.

A 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 procedural data including surgical approach, surgical technique, procedure duration, computer navigation, robotic assisted surgery, and length of stay. However, the enhanced data specifications also included requirements for patient comorbidities, Body Mass Index, American Society of Anesthesiologists physical status classification, and discharge disposition. These additional data elements enable the Registry to track operative complications, as well as to risk-adjust data for reporting purposes (Appendix A). These new capabilities are critical to the long-term success of the Registry to deliver more comprehensive and informative feedback to participants.
Data Completeness and Quality Monitoring
Under the direction of the AJRR Data Committee, chaired by Bryan Springer, MD, and the Annual Report Subcommittee, chaired by Terence Gioe, MD, it was decided to include a comprehensive analysis on data completeness and quality monitoring. AAOS Registry and Statistical teams engaged in an effort to understand completeness of Level I (implant and demographic data), Level II (enhanced patient and procedural information), and Level III (PROMs) data. Reporting on completeness of these data elements can be seen in their associated sections.

With the integration of AJRR into AAOS, analyses were conducted by AAOS statistical staff. They provided guidance on additional AJRR data analytics, proper presentation of findings, and correct interpretation of data. Statistical analyses were performed using SAS software v. 9.4 (SAS Institute, Cary, NC).

ICD-10 Procedure and Diagnosis Coding
Additional granularity of the ICD-10 coding continues to result in challenges for both diagnosis and procedure codes received by AJRR. Coordinated and consistent guidance among the orthopaedic community is essential for improving coding errors and discrepancies across institutions. Furthermore, correctly coding procedures is inherent to the success of the Registry. As AJRR receives data from Electronic Health Records (EHR) and not through direct data input during or after procedures, codes are the only way the Registry can gain a detailed understanding of the procedure performed. These data are the backbone of reporting back to participants who seek comparative benchmarking on their TJA outcomes and the development of this Annual Report. Thus, a major effort was undertaken in 2017 to identify and categorize procedure codes submitted to the Registry. Registry staff, in conjunction with representatives from the AAOS Coding & Reimbursement Committee, American Association of Hip and Knee Surgeons (AAHKS), and industry coding experts, convened a series of conference calls to address this issue. The final procedure code list will be disseminated to all Registry participants to use in their continued efforts to submit data to the Registry. It will also be the foundation by which participants will see their data in reports and dashboards on the RegistryInsights™ platform. Similar efforts will also be undertaken as the AAOS Registry Program adds new anatomical site and interest-based registries in the future.

Audit of Registry Data
AJRR contracted with Quality Insights to audit a sample of 2017 data in the spring of 2018. Quality Insights intended to audit N=18 (2%) randomly selected AJRR participants from January 1 to December 31, 2017, to analyze 30 randomly selected procedures. The participants represented urban, rural, small, and large hospital locations. The audit ensured that data submitted to AJRR correctly reflected the data in the hospital medical records, and that the data submitted to AJRR for a randomly selected month in 2017 reflected all procedures performed at that hospital. One hospital site was unable to comply with the requirements of the audit process given their own staffing changes and was removed from the effort. That site will be included in the audit in 2019. Hence, this year’s audit included 17 participants.

The overall audit agreement rate for the medical record review was 94.5%, down from 98.4% last year, and the overall record completeness assessment rate was 75.0%, down from 91.4% last year. Seventy-five percent agreement completeness is comparable to previous years and the lower agreement rate is primarily due to formatting issues with the reports participants submitted to Quality Insights causing mismatches. There are no concerns of cherry picking, i.e. selecting the best cases. It is important to understand this reflects agreement between the information in the hospital record and the information as reported to AJRR. The audit does not reflect whether data and resulting codes assigned in the hospital record were the most appropriate or accurate for the procedure performed. Efforts to address accuracy and appropriateness of the submitted data, especially at the point of data entry, will continue in collaboration with the participating hospitals. For more details about the audit of Registry data, please see Appendix B.
2018 and Beyond: Building the Foundation for the Future

AAOS leadership enthusiastically supports the Registry Program and continues to provide resources to ensure its success. Many of the building blocks needed to reach the vision to be the National Registry for orthopaedics have already been captured in whole or in part in 2018:

- **AJRR is the largest orthopaedic registry in the world.** Size matters. AJRR is the global leader based on the number of hip and knee procedures submitted per year.

- **Integration into AAOS.** A shared commitment matters. AAOS has devoted significant resources, experienced leadership from within the Registry Oversight Committee, and AAOS staff with additional expertise. Together they create new opportunities for AJRR and future members of the AAOS Registry Program.

- **Part of AAOS Registry Program.** Ability to scale matters. Because AJRR is part of the AAOS Registry Program, it can offer its subscribers the ability to easily access other AAOS Registry Program anatomic and procedure areas.

- **CMS access to Medicare Claims data.** Ability to share data matters. This year’s AAOS and CMS claims data agreement allows AJRR to enter a new level of outcomes analysis. Other leading organizational partners, beyond CMS, can and will be sought to securely share data and further the research needs of all parties.

- **Performance measures.** Collaboration matters. One of the AAOS 2018 strategic initiatives is integrating one or more performance measures in AJRR to enhance participant value. This cross-department initiative will continue for years to come to ensure alignment between Registry data collection and measurement development moving forward. In the summer of 2018, AJRR collaborated with the AAOS Clinical Quality & Value (CQV) group to identify an appropriate AAOS approved measure for integration this year. The initial measure chosen for integration was the AAOS process measure, Osteoarthritis: Pain and Function Assessment (measure #109), into AJRR. Measure #109 was developed to calculate percentage of Pain and Function assessments administered to osteoarthritis patients at non-surgical office consultations. Given that the AJRR data base is structured around defined surgical events, the decision was made to develop a modified version of measure #109 as a proof of concept measure to accommodate AJRR data structure. AJRR re-defined the measure’s denominator and numerator to align with AJRR data structure, and CQV tested it with a mock dataset. Further validation of modified measure #109 is in process and an implementation plan is being developed.

- **Accelerated number of published research papers, subscriber case studies, and interactive blog posts.** Communication matters. The value of registries is described through the stories and experiences of the Registry’s institutional subscribers. As the data becomes more robust, more research papers will be published.

- **User survey.** Feedback matters. The first Registry User Survey was deployed to identify institutional needs and satisfaction levels with current Registry offerings. The results will be used to provide more comprehensive offerings for its users.

- **New and expanded RegistryInsights™ dashboard experience.** A better user experience matters. New AJRR dashboard offerings are being created so a wider variety of users can see data that brings value to them. Surgeons have different needs than hospital administrators and different dashboard choices will soon become available. Additionally, refreshing and enhancing user interfaces for multiple queries and self-directed queries will improve the user experience beginning in 2019.

**OUR VISION**

To be the National Registry for orthopaedics through comprehensive data and technology resulting in optimal patient outcomes.
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 is given complimentary advertisements in AAHKS publications as well as on their website, and the AAHKS journal, *Arthroplasty Today*, is AJRR’s official journal.

**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 proud to be an associate member of ISAR and a partner in the IPL development. In 2018, AJRR was well represented with presentations at the ISAR international congress.

**National Association of Orthopaedic Nurses (NAON)**
NAON was incorporated in 1980 to advance the specialty of orthopaedic nursing through excellence in research, education, and nursing practice. Registry staff participated in the 2018 NAON national conference.

**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 Steering Committee positions designated for industry, and as requested names individuals to serve on various committees where industry expertise or perspective is desired.

**Physician Clinical Registry Coalition (PCRC)**
This coalition is a group of 25 medical society-sponsored or physician-led clinical data registries working together to advocate for public policy changes to promote registry development and eliminate barriers. The coalition members work collaboratively to advocate for changes in legal and policy issues that are impeding the development and operations of clinical data registries or that could help facilitate and promote the growth of such repositories. AJRR has been an active member of this group since its inception.

**Insights**
The number of outpatient total joint procedures are increasing.
On the Advocacy, Regulatory, and Quality Improvement Frontlines

AAOS and AJRR continue to advocate to improve and expand Registry participation and impact. 2017 – 2018 advocacy accomplishments and proactive activities include:

- AJRR succeeded in obtaining access to Medicare claims data by utilizing the CMS-recommended Research Data Assistance Center Program (ResDAC). AJRR is the first, and currently the only, Qualified Clinical Data Registry (QCDR) to gain access to Medicare claims data, which was accomplished in the second quarter of 2018. AJRR held numerous calls and meetings with CMS officials in late 2017 and early 2018 to approve AJRR access to claims data.

- AJRR successfully obtained report language in the FY 2018 Health and Human Services (HHS) Appropriations bill clarifying that the Center for Medicare and Medicaid Innovation (CMMI) may use their funds to support research and demonstrations that involve QCDRs.

- AJRR was represented in over 20 meetings with CMS and HHS officials to discuss QCDR provisions related to the implementation of the new Quality Payment Program (QPP).

- Comment letters were submitted to HHS on CY2017 and 2018 Quality Payment Program rule, CY2017 and 2018 Physician Fee Schedule Rule, and CY2017–2018 Medicare Hospital In-Patient Prospective Payment System Rule (IPPS).

- Comment letters were submitted to House Ways & Means Committee, Senate Finance, and HELP Committees on topics of price transparency, quality program improvements, and innovation topics.

- AJRR was invited to attend a meeting with a lead CMS Administrator to discuss new Meaningful Measures program roll-out.

- AJRR was invited to attend a meeting with high-level officials from the HHS Office of Inspector General (OIG) and Office of the National Coordinator to discuss data interoperability concerns.

Additional Regulatory and Quality Improvement-related Activities

- Arranged meetings with American Hospital Association (AHA) executives and attended AHA Health Leadership Summit.

- AJRR was featured in presentations at AAOS Council on Advocacy and National Orthopaedic Leadership Conference.

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

After nearly three years as an independent 501(c)3 not-for-profit corporation, AJRR became the cornerstone of the AAOS Registry Program in October 2017. AJRR transitioned from an independent organization with a Board of Directors, to a department within AAOS with an AJRR Steering Committee. The Steering Committee continues to function 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 Registry.

The inclusion of members of the public on the Steering Committee continues to be key to the success of the Registry. Through the Public Advisory Board (PAB), direct input is provided from the patient 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.

2018 AAOS Registry Oversight Committee
After AAOS decided to develop a Registry Program for all areas of orthopaedics, a Registry Oversight Committee (ROC) reporting to the AAOS Board of Directors was created and launched. AJRR’s Steering Committee reports into the ROC. Many of the surgeon leaders who have been involved with AJRR since its inception were asked to serve on this committee to ensure a smooth transition and preserve previous Registry knowledge. ROC has the primary responsibility of overseeing all AAOS registry activities. Specific activities of the ROC include: 

- a) Develop strategy for adding additional registries, 
- b) Develop policy and procedures for registry operations, 
- c) Approve business plans/annual budget for individual registries, 
- d) Review individual registry performance biannually, 
- e) Set subscription rates for individual registries, and 
- f) Set rates for data reports.

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

Daniel J. Berry, MD, Chair, Mayo Clinic (Rochester, Minn.)
William J. Maloney, MD, Vice Chair, Stanford University (Stanford, Calif.)
Kevin J. Bozic, MD, MBA, Dell Medical School at The University of Texas at Austin (Austin, Texas)
Michael J. Gardner, MD, Stanford University (Redwood City, Calif.)
Steven D. Glassman, MD, Norton Leatherman Spine Center (Louisville, Ky.)
Joseph P. Ianotti, MD, PhD, Cleveland Clinic (Cleveland, Ohio)
David S. Jevsevar, MD, MBA, Dartmouth-Hitchcock Medical Center (Lebanon, N.H.)
Ronald A. Navarro, MD, Kaiser Permanente (Harbor City, Calif.)
Kurt P. Spindler, MD, Cleveland Clinic (Cleveland, Ohio)
2018 AJRR Steering Committee

Kevin J. Bozic, MD, MBA, Chair,
Dell Medical School at The University of Texas at Austin
(Austin, Texas)

Bryan D. Springer, MD, Vice Chair,
OrthoCarolina (AAHKS) (Charlotte, N.C.)

Scott M. Sporer, MD, Secretary,
Midwest Orthopaedics at Rush (Chicago, Ill.)

David E. Mino, MD, MBA, Treasurer,
Cigna, Inc. (Blue Bell, Pa.)

Yvonne Bokelman, MBA, FACHE, Industry Observer,
ZimmerBiomet, Inc. (Warsaw, Ind.)

David D. Lewallen, MD, AJRR Medical Director, Ex-Officio,
Mayo Clinic (Rochester, Minn.)

Daniel J. Berry, MD,
Mayo Clinic (The Hip Society) (Rochester, Minn.)

James A. Browne, MD,
University of Virginia (The Knee Society)
(Charlottesville, Va.)

Robert L. Krebbs,
Anthem, Inc. (Richmond, Va.)

Gregory B. Krivchenia, II, MD,
First Settlement Orthopaedics (Marietta, Ohio)

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

Douglas E. Padgett, MD,
Hospital for Special Surgery (New York, N.Y.)

Brian S. Parsley, MD,
University of Texas Health Science Center at
Houston and Baylor College of Medicine (AAHKS)
(Houston, Texas)

Margaret VanAmringe, MHS,
The Joint Commission (Washington, D.C.)

Paul Voorhorst,
DePuy Synthes Inc. (Warsaw, Ind.)

James I. Huddleston, III, MD, Ex-Officio,
Stanford Medicine Outpatient Center
(Redwood City, Calif.)

Outgoing 2017 Volunteers

The success of the AJRR could not be achieved
without the contributions and countless work hours
of its board and committee members. The following
volunteers’ terms concluded at the end of 2017:

AJRR Board of Directors:
Michael R. Dayton, MD,
AAOS Representative, University of Colorado
(Aurora, Colo.)

Blair Fraser,
Industry Observer and Representative, Smith &
Nephew (Cordova, Tenn.)

Craig J. Della Valle, MD,
Ortho Specialty Society Representative, Midwest
Orthopaedics at Rush (The Knee Society) (Chicago, Ill.)

PAB Committee:
David G. Mekemson
(Chicago, Ill.)

AJRR Committees

AJRR relies heavily on the contributions and
commitment of its volunteers who work unselfishly on
ensuring 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
conduct clinical affairs and make decisions that
support the mission of AJRR and California state-
related activities. Activities include data collection and
review, public reporting of its findings, coordinating
programs with third-party payers, and presentations
at national and international meetings.

Chair: James I. Huddleston III, MD

The Data Management (Central) Committee is
responsible for recommendations to the Steering
Committee concerning data elements to be included
in the Registry and the methods by which the selected
data are analyzed and reported. The committee is also
responsible for recommendations concerning proposed
research projects. Annually, the committee will submit
a report to the AJRR Commission to validate the
findings of the Data Management Committee.

Chair: Bryan D. Springer, MD
The three Data Management Subcommittees are:

**Annual Report Subcommittee** takes the lead on the development of the content of AJRR’s Annual Report, including final determination of Yearly Areas of Interest (YAI) and directions for the additional content. The subcommittee reviews preliminary analyses and drafts of the Annual Report as they are completed during the development process. They are the final sign-off on the completed Annual Report prior to the document being sent to the Commission and subsequently AJRR’s Steering Committee for their review.

*Chair: Terence Gioe, MD*

**Data Elements and Analysis Subcommittee** monitors, receive requests, and makes recommendations for additions or deletions to data elements or assessment tools collected by AJRR. The subcommittee makes recommendations to the Data Committee for review prior to discussion and final approval by the AJRR Steering Committee. This subcommittee works with staff and statisticians to determine, develop, and oversee the implementation of appropriate data analysis methodology and algorithms. The subcommittee’s purview includes risk adjustment, scientific integrity of data, rigor of conclusions drawn from Registry data, and consideration of optimal reporting and data analysis to provide actionable data for the benefit of patients and which is useful to AJRR stakeholders.

*Chair: Scott Sporer, MD*

**Research Projects Subcommittee** reviews incoming external research proposals and requests. Members review incoming external research proposals and requests, and make recommendations for project approvals.

*Chair: Richard L. Ilgen II, MD*

*University of Wisconsin*

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

*Chair: Margaret VanAmringe, MHS*

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

**User Group Network**
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 help plan user-specific webinars and meetings:

- **Patrice Hallak**, 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

AJRR is thankful for the insight and input that these two outgoing Unet Advisory members have contributed through the years:

- **Mike B. Anderson, MSc**, University of Utah Health
- **Cecily Froemke, PhD**, Providence St. Joseph Health
Thank You to AJRR Supporters

Thank you to the organizations that have supported AJRR financially since inception, including 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, Conformis, Consensus Orthopedics, DePuy Synthes, DJO Surgical, Exactech, MicroPort, Smith & Nephew, Stryker, and ZimmerBiomet.
Overall Results

Data Completeness

One of the new areas considered for this year's Annual Report was to analyze and present findings on data completeness for the elements included at all Levels of data.

Level I data elements, as seen in Table 1, generally have a high level of completeness. The Registry platform will not accept cases missing the following elements: account ID, hospital name and National Provider Identifier (NPI), patient name, Social Security number, date of birth, sex, zip code, procedure date, procedure code, diagnosis code, joint and laterality, implant catalog number, and manufacturer name.

Hence these elements show nearly 100% completion. Those data elements that can be populated from the Electronic Health Record (EHR) are by their nature more likely to be completed. Many sites do not collect race/ethnicity information in their EHR, and this data element was not required by the AJRR in our early years. Additionally, some patients decline to answer this question when surveyed.

As seen here, submission of the Unique Device Identifier continues to be a challenge for Registry participants, with a number of invalid codes submitted. Lack of uniformity in identifying implant components between manufacturers and across countries has focused awareness on the need for an International Prosthesis Library to update device information and maintain global standards. These issues, as well as simple miscoding or missing fields results in some degree of incomplete identification of even the most basic implant identifiers (Table 2).

<table>
<thead>
<tr>
<th>Institution/Hospital/ASC Name</th>
<th>% of Cases with Accepted Value</th>
<th>% of Cases with Not Reported</th>
<th>% of Cases with Invalid Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Birth</td>
<td>100.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Sex</td>
<td>100.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Race</td>
<td>76.9%</td>
<td>22.8%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>69.7%</td>
<td>30.0%</td>
<td>0.3%</td>
</tr>
<tr>
<td>City</td>
<td>83.6%</td>
<td>0.0%</td>
<td>16.4%</td>
</tr>
<tr>
<td>State</td>
<td>100.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>First Implant Catalog # Listed</td>
<td>98.4%</td>
<td>0.0%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Implant Lot #</td>
<td>94.0%</td>
<td>0.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>UDI</td>
<td>35.2%</td>
<td>0.0%</td>
<td>64.8%</td>
</tr>
<tr>
<td>Procedure Date</td>
<td>100.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Principal Diagnosis Code</td>
<td>96.4%</td>
<td>0.0%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Laterality</td>
<td>99.7%</td>
<td>0.2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Procedure Site</td>
<td>99.2%</td>
<td>0.0%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component Attribute</th>
<th>% of Cases with Accepted Value</th>
<th>% of Cases with Attribute Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Viscosity</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>44%</td>
<td>56%</td>
</tr>
<tr>
<td>Acetabular Liners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composition of the polyethylene</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>Inside diameter</td>
<td>92%</td>
<td>8%</td>
</tr>
<tr>
<td>Outside diameter</td>
<td>66%</td>
<td>34%</td>
</tr>
<tr>
<td>Acetabular Shells</td>
<td>Outside diameter</td>
<td>87%</td>
</tr>
<tr>
<td>Femoral Stem</td>
<td>Cement vs. cementless fixation</td>
<td>95%</td>
</tr>
<tr>
<td>Size of component specified</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>Component length specified</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>Femoral Head</td>
<td>Metal vs. ceramic composition</td>
<td>90%</td>
</tr>
<tr>
<td>Head diameter</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>Femoral Component (Knee)</td>
<td>Cemented vs. cementless fixation</td>
<td>72%</td>
</tr>
</tbody>
</table>
Level II Completeness

As discussed earlier, in 2017 AJRR launched the collection of Level II data elements. Level II data elements include expanded procedural data, patient risk factors and comorbidities, and operative and perioperative complications. Revised data specifications were released February 20, 2017. Participants were expected to transition to the new specifications throughout the calendar year, with the directive that all participants would be required to submit in the new specification layout by January 1, 2018.

Unfortunately, this timeframe for transition proved challenging for many participating sites. By the end of 2017, 76/796 (9.5%) sites were submitting Level II data in the new format (Table 3).

Completeness of Level II data submitted by those sites using the new specifications (not ALL historical data) can be seen in Table 4. Results indicate that those elements included in standard EHR systems such as discharge disposition, length of stay, and body mass index (BMI) are more readily transmitted to the Registry, while variables related to the perioperative time period (surgical technique, use of robotics, periarticular injection) are more challenging for data submission.

Facility Enrollment

AJRR consistently maintains institutional enrollment as a major priority. Staff has worked continuously each year to increase the number of institutions participating in the Registry, including hospitals, ASCs, and private practice groups. In 2017, the Engagement team included three dedicated staff members who focus on enrollment of new facilities and ensure that data are submitted in a timely fashion. As of December 31, 2017, enrollment stood at 1,006 hospitals/ASCs and 61 private practice groups, representing all 50 states and the District of Columbia (see Figure 1 and Appendix D & E). This was an increase of 213 facilities over 2016 and represents 17.0% of the hospitals in the American Hospital Association (AHA) database, although not all AHA institutions perform joint arthroplasty. More than 95 facilities in California, 62 facilities in Wisconsin, 55 in Texas, and more than 40 in Florida, Indiana, Ohio, Pennsylvania, and Washington participated, while 5 other states had 30 or more participating facilities.

Table 3: Hospitals Submitting Level II Data

<table>
<thead>
<tr>
<th>N=73 (removed ASC)</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>12</td>
<td>16.4</td>
</tr>
<tr>
<td>Minor</td>
<td>26</td>
<td>35.6</td>
</tr>
<tr>
<td>Nonteaching</td>
<td>32</td>
<td>43.8</td>
</tr>
<tr>
<td>Unknown</td>
<td>3</td>
<td>4.1</td>
</tr>
<tr>
<td>N=73 (removed ASC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 1-99 Beds</td>
<td>15</td>
<td>20.5</td>
</tr>
<tr>
<td>Between 100-399 Beds</td>
<td>39</td>
<td>53.4</td>
</tr>
<tr>
<td>&gt;= 400 Beds</td>
<td>17</td>
<td>23.3</td>
</tr>
<tr>
<td>Unknown Bed Count</td>
<td>2</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Table 4: Completeness of Level II Data Elements (N=84,804)

<table>
<thead>
<tr>
<th>Data Element</th>
<th># of Cases with Accepted Value (%)</th>
<th># of Cases with Not Reported (%)</th>
<th># of Cases with Invalid Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia Type</td>
<td>59,335 (70.0)</td>
<td>24,174 (28.5)</td>
<td>1,295 (1.5)</td>
</tr>
<tr>
<td>Body Mass Index (BMI)</td>
<td>78,948 (93.1)</td>
<td>5,845 (6.9)</td>
<td>11 (0.0)</td>
</tr>
<tr>
<td>Comorbidity – at least one comorbidity code reported</td>
<td>59,078 (69.7)</td>
<td>25,726 (30.3)</td>
<td>0</td>
</tr>
<tr>
<td>Computer Navigation</td>
<td>46,605 (55.0)</td>
<td>38,199 (45.0)</td>
<td>0</td>
</tr>
<tr>
<td>Discharge Disposition</td>
<td>68,922 (81.3)</td>
<td>5,927 (7.0)</td>
<td>9,955 (11.7)</td>
</tr>
<tr>
<td>Length of Stay</td>
<td>79,746 (94.0)</td>
<td>5,046 (6.0)</td>
<td>12 (0.0)</td>
</tr>
<tr>
<td>Periarticular Injection</td>
<td>6,484 (7.6)</td>
<td>78,320 (92.4)</td>
<td>0</td>
</tr>
<tr>
<td>Procedure Duration</td>
<td>79,567 (93.8)</td>
<td>2,059 (2.4)</td>
<td>3,178 (3.7)</td>
</tr>
<tr>
<td>Robotic Assisted</td>
<td>36,408 (42.9)</td>
<td>48,385 (57.1)</td>
<td>0</td>
</tr>
<tr>
<td>Surgical Approach</td>
<td>13,863 (16.4)</td>
<td>62,604 (73.8)</td>
<td>8,337 (9.8)</td>
</tr>
<tr>
<td>Surgical Technique Hip</td>
<td>3 (0.0)</td>
<td>84,506 (99.6)</td>
<td>295 (0.3)</td>
</tr>
<tr>
<td>Surgical Technique Knee</td>
<td>5 (0.0)</td>
<td>84,194 (99.3)</td>
<td>605 (0.7)</td>
</tr>
</tbody>
</table>
At the end of 2017, AJRR had enrolled 1,006 hospitals and ASCs along with 61 private practice groups in all 50 states, an increase of 213 facilities over 2016.

Submitting Facilities

By the end of 2017, 796/1,067 (75%) of institutions enrolled by that date were submitting data (Figure 2). This represents a 22% increase in the number of submitting facilities from 2016, 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 a lag time of 3–6 months between facility enrollment and data submission which is site dependent. To address these issues, in 2017 the Registry created a Registry Support team where Registry Support Specialists are assigned to each participating site to help walk them through the onboarding process. AJRR also created a position of Registry Optimization Analyst in 2018 to focus on working with sites that have suspended data submission or delayed their original submission.

As in prior years, the majority of arthroplasty procedures submitted to the Registry were performed in medium-sized hospitals and teaching facilities compared to smaller community-based non-teaching facilities (Figures 3 & 4). Since many small hospitals do not perform any elective hip and knee arthroplasty, the distribution of hospitals submitting data to AJRR continues to skew toward larger academic and teaching facilities compared to the AHA national profile. Hospitals described by AHA as major or minor teaching facilities make up nearly 52% 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=793,809 (67.4%) of the procedures submitted to AJRR in 2017, while the non-teaching community hospitals (representing 41.9% of the hospitals submitting) accounted for n=341,481 (29%) of the procedures.

Figure 2: Number of Facilities Submitting Data by Year

- Small (1-99 beds) n=183 (24.9%)
- Medium (100-399 beds) n=336 (45.7%)
- Large (400+ beds) n=147 (20.0%)
- Unknown Bed Count n=69 (9.4%)

Figure 3: Hospital Size (Bed Count) of Submitting Hospitals* (N=735)

- Non-Teaching n=308 (41.9%)
- Minor Teaching n=297 (40.4%)
- Major Teaching n=83 (11.3%)
- Unknown n=47 (6.4%)

Figure 4: Teaching Affiliation of Submitting Hospitals (N=735)

* 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 51.7% of the procedures submitted to the AJRR in 2017.
Surgeon Participants

By the end of 2017, AJRR had collected data on arthroplasty procedures performed by more than 4,900 surgeons (Figure 5). AJRR hospitals report data for an average of 11 surgeons (range 1-54), which include those conducting only the 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.

Figure 5: Total Number of Surgeons Submitting Data by Year

Table 5 demonstrates that in 2017, surgeons conducted a mean of 26 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 2017 reveal that mean revision procedures per surgeon were much lower at 4.0 per year for hip revision and 4.6 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 8 THAs and 23 TKAs in 2017. These median values would continue to place surgeons in our sample between the 1st and 2nd quartiles of surgeon volume as outlined by Bozic et al1 and quite comparable to the median volumes reported by Wilson et al.2 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. Actual totals may of course be higher for some surgeons who operate at both an AJRR participating and non-participating institution during the same year.

Insights

Median number of TKA and THA procedures performed by AJRR surgeons in 2017 was 23 and 8, respectively.

Table 5: 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><strong>HIP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>3,914</td>
<td>102,901</td>
<td>26.3</td>
<td>8</td>
<td>2-30</td>
</tr>
<tr>
<td>Revision</td>
<td>1,252</td>
<td>5,056</td>
<td>4.0</td>
<td>2</td>
<td>1-5</td>
</tr>
<tr>
<td>Other</td>
<td>549</td>
<td>3,353</td>
<td>6.1</td>
<td>1</td>
<td>1-4</td>
</tr>
<tr>
<td><strong>KNEE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>3,280</td>
<td>150,455</td>
<td>45.9</td>
<td>23</td>
<td>6-61</td>
</tr>
<tr>
<td>Revision</td>
<td>1,766</td>
<td>8,047</td>
<td>4.6</td>
<td>2</td>
<td>1-5</td>
</tr>
<tr>
<td>Other</td>
<td>1,166</td>
<td>7,674</td>
<td>6.6</td>
<td>2</td>
<td>1-3</td>
</tr>
</tbody>
</table>
Procedural Data Metrics

The data included for analysis reflect N=1,186,955 cumulative procedures submitted between 2012 and 2017 only, unless otherwise noted (Figure 6). This total includes N=2,074 procedures from ASCs. As AJRR adds participants that submit historical data, yearly volumes from prior years are continually updated. For example, the yearly procedural volume for 2016 grew by over 7% compared to last year’s Annual Report. This year’s report demonstrates a 38% increase in procedural volume over last year’s Annual Report. The 1,164,814 procedures through 2017 span knee and hip arthroplasty to include 55.9% primary knee arthroplasty, 32.2% primary hip arthroplasty, 4.3% hemiarthroplasty, 3.8% knee revisions, 3.2% hip revisions, and 0.7% hip resurfacing (Figure 7).

Figure 6: Cumulative Procedural Volume

Number of Procedures (In Thousands)

<table>
<thead>
<tr>
<th>Year</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>47,361</td>
</tr>
<tr>
<td>2013</td>
<td>161,958</td>
</tr>
<tr>
<td>2014</td>
<td>357,030</td>
</tr>
<tr>
<td>2015</td>
<td>603,801</td>
</tr>
<tr>
<td>2016</td>
<td>907,526</td>
</tr>
<tr>
<td>2017</td>
<td>1,186,955</td>
</tr>
</tbody>
</table>

Figure 7: Distribution of Procedures (N=1,164,814)

- Primary Knee: n=650,674 (55.9%)
- Primary Hip: n=374,873 (32.2%)
- Hemiarthroplasty: n=50,340 (4.3%)
- Revision Knee: n=43,693 (3.8%)
- Revision Hip: n=37,672 (3.2%)
- Hip Resurfacing: n=7,562 (0.7%)

Overall Results

Data presented in this Annual Report reflect N=1,186,955 procedures, which includes both primaries and revisions, performed between 2012 and 2017. Patients had a mean age of 66.8 (SD = 11.2), including n=487,265 (41.1%) males and n=699,159 (58.9%) females (Figure 9). Females make up 61% of the primary TKA population and 55.5% of the primary THA population. Total knee procedures continue to predominate in the Registry, with all primary and revision TKAs representing 694,367 (59.6%) of the volume compared to n=470,447 (40.4%) for hip procedures. These numbers have remained relatively consistent over the past five years of reporting. The majority of patients undergoing arthroplasty in this sample are white (69.5%), but race was not reported by the submitting hospital nearly 23% of the time (Figure 10).
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.

For the 2017 sample population, AJRR calculated a THA revision burden of 4% and a TKA revision burden of 5%. This revision burden for both THA and TKA is lower than in previous years (2012-2016) in AJRR (Table 6). The 2017 AJRR results are also substantially lower than the results reported from the AOANJRR where 2016 revision burden for THA was 8.9% and TKA burden was 7.4%.

The AJRR results should be interpreted with caution and are likely explained by ongoing 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.

In a prior AJRR collaboration with Dr. Brian McGrory published in Arthroplasty Today entitled “Comparing contemporary revision burden among hip and knee joint replacement registries,” it was noted that revision burden has gradually decreased for THA while remaining relatively constant for TKA among the international registries studied. Knee revision burden was also lower than hip revision burden for each period examined. Numerous factors are undoubtedly responsible, but diminishing revisions for metal-on-metal THA, where peak primary use worldwide was seen between 2007-2009, and for dislocation, with more widespread use of larger heads and other surgical approaches, undoubtedly play some role.

<table>
<thead>
<tr>
<th>Year</th>
<th>Hip Revision Burden</th>
<th>Knee Revision Burden</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>12%</td>
<td>8%</td>
</tr>
<tr>
<td>2013</td>
<td>13%</td>
<td>7%</td>
</tr>
<tr>
<td>2014</td>
<td>13%</td>
<td>8%</td>
</tr>
<tr>
<td>2015</td>
<td>10%</td>
<td>7%</td>
</tr>
<tr>
<td>2016</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>2017</td>
<td>4%</td>
<td>5%</td>
</tr>
</tbody>
</table>

A lower revision burden seen for both THA and TKA in the AJRR in 2017 compared to other national registries is likely multifactorial and does not necessarily reflect a lower overall revision rate.

Revision burden seems to be decreasing for THA across all national registries while remaining constant for TKA.
Procedural Data: Hips

In hip arthroplasty, there is a significant difference in the average age between primary and revision patients (p<0.001). The mean age of primary total hip arthroplasty patients in 2017 was 65.5 years (SD=11.6) with the mean age of revision hip arthroplasty patients slightly higher at 67.4 (SD=12.6) (Figure 11). As might be expected, the majority of patients undergoing primary THA at ages <59 are male, but females predominate as the population ages, in keeping with general life expectancy trends (Figure 12). The age at which 50% of the primary THA population is represented by each sex is 59. The age distribution of patients across hip arthroplasty procedures shows a mean age ranging from 81.2 (SD=11) for hemiarthroplasty to 53.4 (SD=9.2) for resurfacing (Table 7).

Table 7: Age Distribution of Hip Arthroplasty Procedures (years)

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemiarthroplasty</td>
<td>81.2</td>
<td>11.0</td>
</tr>
<tr>
<td>Others</td>
<td>64.8</td>
<td>13.3</td>
</tr>
<tr>
<td>Replacement</td>
<td>65.5</td>
<td>11.6</td>
</tr>
<tr>
<td>Resurfacing</td>
<td>53.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Revision</td>
<td>67.4</td>
<td>12.6</td>
</tr>
</tbody>
</table>

Figure 11: Age Distribution of Hip Arthroplasty Procedures 2012-2017 (N=443,014)
Arthroplasty for Femoral Neck Fracture

With an aging but active demographic in the United States, arthroplasty for proximal femoral fracture remains an attractive surgical option. Analyses were conducted for hemiarthroplasty between 2012-2017, although relatively few procedures were reported in 2012 (Figure 14). Within our sample, hemiarthroplasty as a percentage of all total hip arthroplasty performed is at 11.8% (all hemis/(all hemis + all THA)), but continues to grow annually as a percentage of all hip arthroplasty procedures.

Reported advantages in pain relief, functional outcomes, and reoperation rates for total hip arthroplasty for femoral neck fractures have resulted in a significant (p<0.001) increase in the percentage of THAs performed for this diagnosis over the last six years (Figure 15).6-11 THA represents approximately 24% of the arthroplasties performed for femoral neck fracture over each of the last two years in the Registry. However, THA predominates as the arthroplasty option of choice in our sample for patients <59 years old, with the “tipping point” in age between the THA and hemiarthroplasty option at 60; beyond this age surgeons overwhelmingly choose the hemiarthroplasty option.
Although both cemented and cementless stems remain popular for hemiarthroplasty in the United States, since 2013 a majority of surgeons in our sample (60% in 2017) continue to favor cementless designs (Figure 16). However, we have observed a significant trend (p< 0.001) toward greater cemented stem usage with each additional decade of life from 50 to >90 years old (Figure 17). Cemented stems are only used approximately 25% of the time in the 50-59 year-old age group, but in approximately 42% of the procedures occurring in the 80-89 year-old age range. Nevertheless, even in the 90 plus-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 18).

The majority (69.1%) of hemiarthroplasties for femoral neck fracture were performed on females, and the mean age of the patients undergoing hemiarthroplasty for proximal femoral fracture is 80 years old.

Figure 14: Hemiarthroplasty as a Percentage of All Hip Arthroplasty in 2012-2017 (N=50,388)

Figure 15: Hemiarthroplasty and Total Hip Arthroplasty Performed for the Diagnosis of Femoral Neck Fracture (N=43,692)

Figure 16: Cemented and Cementless Femoral Stems in Hemiarthroplasty (N=41,881)

Figure 17: Percent of Cemented Stems in Hemiarthroplasty Based on Age (N=16,973)

Figure 18: Unipolar Heads in Hemiarthroplasty Based on Age (N=16,039)
Hip Resurfacing

Hip resurfacing has declined to less than 0.5% (Figure 19) of the total hip arthroplasty procedures in our sample, as surgeons in the AJRR have nearly abandoned metal-on-metal articulations. This procedure remains highly concentrated among a small number of hospitals and surgeons. A total of 50 surgeons conducted the 380 hip resurfacing procedures completed in 2017, while 67% of this total were performed by six surgeons. Almost 1/3 of these total procedures (n=118) were performed by a single surgeon.

**Figure 19: Hip Resurfacing as a Percentage of All Hip Arthroplasty by Year (N=4,181)**

Total Hip Arthroplasty

Femoral head size usage patterns have remained relatively constant between 2012 and 2017, with 36 mm heads used in approximately 58% of the primary THA procedures performed (Figure 20). 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 generally explains their sustained popularity. Over the last two years, the use of 36 mm heads and 40 mm heads and larger has remained relatively static, while the use of 32 mm heads has decreased and 28 mm or less heads has increased. While the percent change is modest, the increased use of smaller heads may be related to increasing use of dual mobility acetabular constructs in primary arthroplasty. These constructs typically use 22 mm or 28 mm heads inside a larger polyethylene bearing articulating against a polished acetabular shell or liner.

**Figure 21: Femoral Head Sizes Implanted by Year for Revisions (N=28,228)**

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 2017 (p<0.001) (Figure 22). 2017 represents the first year that the use of ceramic heads outpaced cobalt chrome (CoCr) heads in the AJRR database. 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 CoCr heads.12-15 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, similar to findings from previous years. However, even in

Larger heads (≥ 40 mm) are used more frequently in revision arthroplasty for the purpose of enhanced stability, and the increase in use of 28 mm heads here likely also is related to the increasing use of dual mobility constructs to achieve the same goal (Figure 21).

**Figure 22: Femoral Head Sizes Implanted in Primary Hip Arthroplasty by Year (N=318,207)**

**Figure 23: Femoral Head Sizes Implanted in Revision Arthroplasty by Year (N=28,228)**
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=361,498)**

The use of antioxidant liners with ceramic heads in the AJRR has increased significantly each year.

**Figure 23: Ceramic Femoral Head Usage by Patient Decade of Life (N=394,836)**

Ceramic head use is increasing each year, with the “tipping point” from an even distribution between ceramic and CoCr heads occurring at age 68.

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 vast majority (71.4% in 2017) of the time. When conventional polyethylene (ultra-high molecular weight polyethylene – UHMWPE) liners are chosen, CoCr heads are typically chosen (Figure 25). However, there is a trend toward increased antioxidant liner use with ceramic heads between 2012-2017 in our sample ($p <0.001$).

**Figure 24: Percentage of Cobalt Chrome (CoCr) and Ceramic Heads Used with Cross-Linked Polyethylene (XLPE) and Antioxidant Polyethylene Acetabular Liners (N=332,203)**

The use of antioxidant liners with ceramic heads in the AJRR has increased significantly each year.

**Figure 25: Enhanced Liner Use and Head Composition (N=40,910)**
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 26). Antioxidant enhanced polyethylene use 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 2017 in response to the increasing longer-term data on the effectiveness of cross-linked polyethylene in reducing clinically evident wear and osteolysis.16–20 Very little conventional polyethylene is used at present in the Registry sample, and the mean age of the patients who received this polyethylene option in 2017 was 77.6.

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 27). 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.4,5,21

The use of conventional UHMWPE has decreased each year to a negligible percentage and the mean age of patients who receive this option is 76 years old.
Dual mobility articulations continue to grow in use in the United States, likely due to the claims of enhanced hip stability and reduced risk of dislocation they provide.\textsuperscript{22–27} In this Registry cohort sample of the U.S. experience, dual mobility cups were utilized in approximately 9.7\% of all primary hip arthroplasties and more than 28\% of revision THA procedures in 2017 (Figure 28).

**Figure 28: Frequency and Percentage of Dual Mobility Cups Implanted in Hip Arthroplasty by Year (N=35,063)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Primary</th>
<th>Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>n=936</td>
<td>6% (153%)</td>
</tr>
<tr>
<td>2013</td>
<td>n=3,692</td>
<td>6% (174%)</td>
</tr>
<tr>
<td>2014</td>
<td>n=3,725</td>
<td>6% (179%)</td>
</tr>
<tr>
<td>2015</td>
<td>n=5,556</td>
<td>7% (27%)</td>
</tr>
<tr>
<td>2016</td>
<td>n=8,012</td>
<td>8% (28%)</td>
</tr>
<tr>
<td>2017</td>
<td>n=8,030</td>
<td>9% (28%)</td>
</tr>
</tbody>
</table>

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 and 2017 (p<0.001) (Figure 29).\textsuperscript{28–31} This increase in 2016 and 2017 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 total primary THAs using a modular neck were performed by a total of 10 surgeons.

**Figure 29: Frequency of Modular Neck Stems Implanted in Primary Hip Arthroplasty by Year (N=6,618)**

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 and 2017 (p<0.001) (Figure 29).\textsuperscript{28–31} This increase in 2016 and 2017 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 total primary THAs using a modular neck were performed by a total of 10 surgeons.

"As a national registry, AJRR is able to provide the most accurate and complete picture of the arthroplasty experience in the United States. By [AJRR] providing benchmarking and monitoring outcomes of arthroplasty, we can further advance the efforts of patient safety and quality of care."

Edward Sweetser, MD  
MountainView Regional Medical Center  
(Orthopaedic Surgeon)
Revision Data: Hips

Between 2012 and 2017, data were collected on N=47,378 revision hip arthroplasties. Of these, n=10,188 (21.5%) were “linked revision arthroplasties” where data on the earlier primary THA were also available in the Registry for analysis. Overall, in the cumulative revision cohort, 25,607 of the 47,378 have confirmed associated diagnosis codes. The remaining 46% in the “other category” have diagnosis codes that do not align with usual ICD revision codes or are clearly miscoded. In the sample with a confirmed diagnosis, the predominant isolated cause for revision based on diagnosis code was instability/dislocation, with the codes for instability/dislocation, aseptic loosening, infection, wear and osteolysis accounting for over 70% of the revisions recorded. Other mechanical complications are noted as the indication for 20.1% of the confirmed revision diagnoses, while periprosthetic fracture (6.9%) is less common. (Figure 30)*

In the 10,188 linked hip arthroplasty revisions where data were also available on the original primary THA, 53% occurred within the first three months post-surgery (Table 8). 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, 96% of early hip revisions and 97% of TKA revisions returned to the same hospital or hospital system where the primary procedure was performed. Approximately 10.7% (1093/10,188) of the linked hip revision procedures were performed more than one year after primary arthroplasty.

Table 8: Time Interval Between Primary Hip and Revision for “Linked” Patients (N=10,188)

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3 Months</td>
<td>5,434</td>
</tr>
<tr>
<td>3-5 Months</td>
<td>1,846</td>
</tr>
<tr>
<td>6-12 Months</td>
<td>1,815</td>
</tr>
<tr>
<td>&gt;1 Year</td>
<td>1,093</td>
</tr>
</tbody>
</table>

Figure 30: ICD Diagnosis Codes for All Hip Revisions (N=47,378)

For revision (N=10,188) in the linked subset with confirmed diagnosis codes includes 4,531 are biased toward early causes of revision arthroplasty, which often are more related to patient comorbidities and surgical technique than implant performance. Indeed, periprosthetic fracture is a leading cause of failure in these largely early revisions, accounting for 27.6%, and it is closely followed by infection and instability/dislocation (Figure 31). 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 32). When periprosthetic fractures are considered, 94.3% 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.32,33
“Our Joint Commission Advanced Orthopaedic Certification is, in part, dependent on registry participation. Without AJRR, we would not have the proof we need for the ICP initiatives, nor the health system push to support initiatives like mobile compression devices purchased for every TJR case. We view [this] program and Registry participation as cornerstones of our current and future quality care delivery efforts.”

Mark A. Snyder, MD
TriHealth Good Samaritan Hospital
(Orthopaedic Surgeon)
Knee Arthroplasty

Procedural Data: Knees

The mean age of patients undergoing primary knee arthroplasty in our sample was 66.8 (SD 9.6), with the mean age for the revision knee population trending slightly younger at 66.1 (SD 10.7), with a small but significant difference (p <0.001) in the average ages between primary and revision patients (Figure 33). Among our contributing hospitals, the mean age for both primary and revision knee surgery has increased by over one year between 2012-2017.

Figure 33: Age Distribution of Knee Arthroplasty Procedures 2012-2016 (N=680,238)
Revision procedures accounted for 6.0% of knee arthroplasties performed overall (with a peak of 7.3% in 2014 and a low of 4.6% in 2017) with the rest primary arthroplasties of some type. Although it appears that the percentage of revision arthroplasties performed is steadily decreasing in our samples, numerous factors such as increasing hospital enrollment and batch processing of prior years’ data may impact this analysis.

Posterior stabilized type implants remain the most common design used in primary knee arthroplasty procedures in this sample (Figure 34), accounting for approximately 50% of the designs used between 2012 and 2017. Cruciate retaining-type designs are the next most common and make up approximately 40% of the total during the same time. Ultracongruent designs, varus/valgus constrained designs, and rotating hinge designs account for the remainder. The use of ultracongruent designs has increased over time in our sample, while more accurate coding has diminished those designs previously classified as “other.” Ultracongruent designs, characterized by a higher anterior wall on the tibial insert and a more congruent articulating surface, may offer some advantages in decreasing the cam-post wear of traditional posterior stabilized designs, while limiting bone sacrifice in the intercondylar notch.

Mobile-bearing designs continue to represent a small but relatively constant percentage of primary TKAs (7-9%) performed in this sample between 2012 and 2017 (Figure 35). Their use remains higher in revision TKA arthroplasty (19.3% of the cumulative total) where surgeons may perceive benefits to increased rotational freedom, especially when used with increasing constraint.

**Insights**

Posterior-stabilized designs are the most common design used in primary TKA in the AJRR, but ultracongruent design use has increased steadily over time.
Unicompartmental knee arthroplasties (UKA) accounted for 3.2% of all primary knee arthroplasties performed in our sample between 2012 and 2017. There continues to be a downward trend (p=0.0032) in their use between 2012 and 2017 (Figure 36). The AOANJRR has reported UKA usage decreased from 14.5% of all knee arthroplasty performed in 2003 to 5.1% in 2016, although there has been a slight increase in usage over the last two years (cumulative use is at 7.5% of all primary knee arthroplasty). The NJR reports 8.7% cumulative use of UKA between 2003-2016 while the Swedish Knee Arthroplasty Register (SKAR) reports gradually decreasing UKA use over time with UKA representing 7% of their knee arthroplasty procedures in 2016. Both of the latter registries have also recorded slight increases in UKA usage over the last one to two years.

Similarly patellofemoral arthroplasty (PFA) remains an even smaller percentage of single compartment arthroplasty in the sample, consistently utilized in less than 0.5% of knee arthroplasty procedures between 2012 and 2017 (Figure 37). The AOANJRR reported that PFA represented 0.5% of the knee arthroplasty procedures performed in 2016, while the percentages performed in the NJR and SKAR were 1.2% and 0.4%, respectively. While unicompartmental procedures were not performed at a majority of hospitals (74%) participating in AJRR during the six years under review, only roughly 20% of surgeons reported to AJRR that they performed unicompartmental procedures during the same year, with that percentage dropping to 15% in 2017 (Table 9). As might be expected, fewer surgeons perform patellofemoral arthroplasty, with less than 5% of all surgeons submitting procedures during the years in question. The highest volume surgeon performing PFA in this sample performed five such procedures in 2017. 17 surgeons out of 70 performed more than 1 of these procedures in 2017 accounting for 43% of these procedures.

![Figure 36: Unicompartmental Knee Arthroplasty as a Percentage of All Primary Knee Arthroplasty (N=21,209)](image)

![Figure 37: Patellofemoral Arthroplasty as a Percentage of All Primary Knee Arthroplasty (N=2,115)](image)

### Table 9: Unicompartmental Knee Arthroplasty and Patellofemoral Arthroplasty Utilization

<table>
<thead>
<tr>
<th>Year</th>
<th>Unicompartmental Knee Arthroplasty</th>
<th>Patellofemoral Arthroplasty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surgeons performing</td>
<td>Total number of surgeons</td>
</tr>
<tr>
<td></td>
<td>procedures</td>
<td>submitting TKA</td>
</tr>
<tr>
<td></td>
<td>n (%), n (%)</td>
<td>n (%), n (%)</td>
</tr>
<tr>
<td>2012</td>
<td>180 - (20.5%)</td>
<td>878 - (100%)</td>
</tr>
<tr>
<td>2013</td>
<td>392 - (21.3%)</td>
<td>1,840 - (100%)</td>
</tr>
<tr>
<td>2014</td>
<td>627 - (22.0%)</td>
<td>2,845 - (100%)</td>
</tr>
<tr>
<td>2015</td>
<td>827 - (21.8%)</td>
<td>3,803 - (100%)</td>
</tr>
<tr>
<td>2016</td>
<td>855 - (19.8%)</td>
<td>4,316 - (100%)</td>
</tr>
<tr>
<td>2017</td>
<td>575 - (14.9%)</td>
<td>3,861 - (100%)</td>
</tr>
</tbody>
</table>

Insights: Few surgeons in the AJRR perform patellofemoral arthroplasty and it remains less than 1% of the knee arthroplasties recorded in AJRR.
In the AJRR, polyethylene tibial 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 annual analysis it has been treated as a separate category. For primary knee arthroplasty procedures performed from 2012 to 2017, usage rates of conventional polyethylene continued to decline, balanced by a steady increase in the use of antioxidant polyethylene over the same time frame from 2.5% in 2012 to over 25% by 2017 (Figure 38).

**Figure 38: Percentage of Polyethylene Usage by Year in Primary Knee Arthroplasty (N=540,176)**

In contrast, polyethylene usage in revision knee arthroplasty involved conventional polyethylene in more than 50% of revision procedures overall, despite declining usage over this time period. Over one third of revision TKA patients received highly cross-linked polyethylene. While conventional polyethylene usage has declined between 2012 and 2017, there has been a corresponding increase in the use of antioxidant polyethylene similar to that seen in primary TKA (Figure 39).

**Figure 39: Percentage of Polyethylene Usage by Year in Revision Knee Arthroplasty (N=29,827)**

Patellar resurfacing remains the predominant practice in TKA in North America, unlike that seen in many other national registries. This is evident in our sample data, with more than 90% of patients receiving a patellar component each year, while patellar resurfacing occurred in 64.4% of primary TKA in Australia in 2016 and only 2.4% of the 2016 procedures performed in Sweden (Figure 40).

**Figure 40: Percentage of Knee Arthroplasty with Patellar Resurfacing (N=505,709)**

Although highly cross-linked polyethylene is used in the majority of primary TKA procedures, its usage and that of conventional UHMWPE is decreasing while that of antioxidant polyethylene is growing.
Revision Data: Knees

The main causes of revision were other mechanical complications, aseptic loosening, and infection in the majority (25,268; 68%) of more than 40,000 procedures with confirmed associated diagnosis codes, where “other” again reflects diagnosis codes that do not align with usual ICD revision codes or are clearly miscoded. (Figure 41). A total of 9,175 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, 20.5% were performed in the first three months post-surgery and 28.2% were performed more than a year after the primary procedure (Table 10). In keeping with this bias toward early revision procedures, aseptic problems of wear or mechanical failure were less frequent than infection, which accounted for approximately 27% of these relatively early revision procedures (Figure 42). This percentage increases to over 50% when only revisions performed within three months of the primary procedure are considered (Figure 43).

### Table 10: Time Interval between Primary and Revision for “Linked” Patients

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3 Months</td>
<td>1877</td>
</tr>
<tr>
<td>3-5 Months</td>
<td>1658</td>
</tr>
<tr>
<td>6-12 Months</td>
<td>3044</td>
</tr>
<tr>
<td>&gt;1 Year</td>
<td>2596</td>
</tr>
</tbody>
</table>

### Figure 43: Most Frequently Reported ICD Diagnosis Codes for Early Knee Revisions (<3 Months to Revision) (N=1,877)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Percent</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection and inflammatory reaction</td>
<td>50.6%</td>
<td>981</td>
</tr>
<tr>
<td>Other complications</td>
<td>36.8%</td>
<td>717</td>
</tr>
<tr>
<td>Instability related codes</td>
<td>5.9%</td>
<td>93</td>
</tr>
<tr>
<td>Other mechanical complications</td>
<td>4%</td>
<td>77</td>
</tr>
<tr>
<td>Mechanical loosening</td>
<td>0.3%</td>
<td>5</td>
</tr>
<tr>
<td>Articular bearing surface wear</td>
<td>0.1%</td>
<td>5</td>
</tr>
</tbody>
</table>

### Figure 41: ICD Diagnosis Codes for All Knee Revisions (N=40,488)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Percent</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other codes</td>
<td>37.6%</td>
<td>15,220</td>
</tr>
<tr>
<td>Other mechanical complications</td>
<td>23.7%</td>
<td>9,576</td>
</tr>
<tr>
<td>Mechanical loosening of the prosthetic joint</td>
<td>21.0%</td>
<td>8,519</td>
</tr>
<tr>
<td>Infection and inflammatory reaction</td>
<td>7.9%</td>
<td>3,177</td>
</tr>
<tr>
<td>Instability related codes</td>
<td>7.7%</td>
<td>3,108</td>
</tr>
<tr>
<td>Articular bearing surface wear</td>
<td>2.2%</td>
<td>888</td>
</tr>
</tbody>
</table>

### Figure 42: ICD Diagnosis Codes for All “Linked” Knee Revisions (N=9,175)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Percent</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other codes</td>
<td>44.6%</td>
<td>3,601</td>
</tr>
<tr>
<td>Infection and inflammatory reaction</td>
<td>27.0%</td>
<td>2,175</td>
</tr>
<tr>
<td>Mechanical loosening</td>
<td>11.0%</td>
<td>889</td>
</tr>
<tr>
<td>Other mechanical complications</td>
<td>8.8%</td>
<td>708</td>
</tr>
<tr>
<td>Instability related codes</td>
<td>8.2%</td>
<td>664</td>
</tr>
<tr>
<td>Articular bearing surface wear</td>
<td>0.4%</td>
<td>34</td>
</tr>
</tbody>
</table>
The Importance of PROMs

Patient-reported outcome measures (PROMs) have been an increasing focus of large national registries and in 2014 the ISAR steering committee established a working group in this area to advise on best practices. PROMs have the advantage of largely eliminating clinician bias and objectively measuring the patient’s own perception of their health status. Their increasing use by registries and elsewhere reflects an improved understanding that healthcare decisions should be based on factors that can be shown to add value for the patient. As of September of 2014, 8/41 ISAR member registries collected PROMs on all elective hip and knee arthroplasty patients while 6 additional registries collected them on select sample populations. In the AJRR, collection of PROMs was initiated in the CJRR in early 2011 and following incorporation of CJRR within AJRR began for the larger U.S. population in April 2016.

One of AJRR’s goals is to provide the orthopaedic community with national comparative PROM data. To assist AJRR institutions in PROM data capture and deliver a service to both store and facilitate on-demand access to clinical and PROM data, AJRR developed a PROM platform within its RegistryInsights™ system. The platform has many features for clinical staff to access their patient data, while having the ability to manage and assign PROM surveys electronically via a secure application. AJRR’s secure application also allows patients to access their surveys by means of the Internet at home or in the clinic to complete the surveys in a convenient and timely manner.

AJRR has actively promoted the collection of 4 validated PROMs (HOOS/HOOS, JR., KOOS/KOOS, JR., PROMIS-10, and VR-12). In addition to these measures, other common PROMs collected by international registries include the EQ-5D, Oxford Hip and Knee Scores, the WOMAC, and the UCLA Activity Score. It is important to understand that PROM submission for participating institutions is entirely voluntary, and institutions may choose to not collect PROMs, collect only some of the suggested PROMS, or collect different PROMs of their own choosing. When the CMS CJR bundled payment initiative began on April 1, 2016, it was anticipated that collection of the suggested PROMs would expand rapidly. However, PROM collection and reporting remain a work in progress. For this report, 6% (41/654) of sites that submitted data included PROM data, which does not represent an improvement over the previous year.

In addition, the completion rate for “linked” outcomes (those where both a preoperative and 1 year-postoperative PROM is available on the same patient) varies between 10.2-33.8%. Higher volume usage and higher completion rates are seen with the PROMs utilized by sites in the former California State Registry such as the VR-12 and PROMIS-10. With neither a clear mandate nor clear incentive to collect PROMs, and with unclear responsibility for their collection, PROM completion remains a challenging issue, especially with a mobile populace. However, methods of embedding PROM collection into the work flow of patient care has shown promise for improving patient participation and completion rates.

As would be expected, the majority of patients who undergo elective total joint replacement report meaningful improvement in both joint-specific PROMs and more global measures (Tables 11–18).
### Table 11: AJRR PROM Preoperative and 1 Year Postoperative Mean Scores and Rate of Completion

<table>
<thead>
<tr>
<th>Patient-Reported Outcome Measure (PROM)</th>
<th>PROM Component</th>
<th>IntervalKey</th>
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### Patient-Reported Outcome Measure (PROM)

#### SF-36

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#### VR-12

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### Table 12: Change in HOOS from Preoperative State to 1 Year Postoperative

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<th>Component</th>
<th>Patients with Documented Procedure</th>
<th>Patients with Linked Preoperative and Postoperative Measure</th>
<th>Response Rate (%)</th>
<th>Patients with Meaningful Improvement* (%)</th>
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<td>177</td>
<td>21.9%</td>
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</tr>
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<td>Pain</td>
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<td>177</td>
<td>21.8%</td>
<td>92.1%</td>
</tr>
<tr>
<td>QOL</td>
<td>809</td>
<td>177</td>
<td>21.9%</td>
<td>93.8%</td>
</tr>
<tr>
<td>Sport</td>
<td>807</td>
<td>177</td>
<td>21.9%</td>
<td>87.6%</td>
</tr>
<tr>
<td>Symptoms</td>
<td>811</td>
<td>177</td>
<td>21.8%</td>
<td>93.2%</td>
</tr>
<tr>
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<td>82.7%</td>
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<tr>
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<td>1,268</td>
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<td>86.2%</td>
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<td>1,268</td>
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<td>79.6%</td>
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*Meaningful improvement was calculated by minimal clinical important difference (MCID). MCID was determined to be a positive change score of half the pooled standard deviation.
### Table 13: Change in HOOS JR Pre-surgery and One Year Post Surgery

<table>
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<tr>
<th>Component</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 Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Score after Surgery – Adjusted for Difference in Patient Demographic, %</th>
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</thead>
<tbody>
<tr>
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<td>980</td>
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### Table 14: Change in KOOS Pre-surgery and One Year Post Surgery

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<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 Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Score after Surgery – Adjusted for Difference in Patient Demographic, %</th>
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### Table 15: Change in KOOS JR Pre-surgery and One Year Post Surgery

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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 Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Score after Surgery – Adjusted for Difference in Patient Demographic, %</th>
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### Table 16: Change in KOOS Pre-surgery and One Year Post Surgery

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<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 Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Score after Surgery – Adjusted for Difference in Patient Demographic, %</th>
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<td>Physical Raw</td>
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<td>74.7%</td>
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<td>Physical Standard Error</td>
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<td>1697</td>
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<td>67.4%</td>
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### Table 17: Change in SF-36 Pre-surgery and One Year Post Surgery

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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 Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Score after Surgery – Adjusted for Difference in Patient Demographic, %</th>
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</table>

### Table 18: Change in VR-12 Pre-surgery and One Year Post Surgery

<table>
<thead>
<tr>
<th>Component</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 Score, %</th>
<th>Percent of Patients That Reported Meaningful Improvement in Their Score after Surgery – Adjusted for Difference in Patient Demographic, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Health Component</td>
<td>17597</td>
<td>5941</td>
<td>33.8%</td>
<td>39.0%</td>
</tr>
<tr>
<td>Physical Health Component</td>
<td>17597</td>
<td>5941</td>
<td>33.8%</td>
<td>77.0%</td>
</tr>
</tbody>
</table>
California State Registry

The California State Registry was previously integrated into the AJRR. Beginning in 2009, the CJRR introduced public reporting of PROMs related to joint arthroplasty to the U.S. registry community. Of the 110 sites who joined AJRR from the California State Registry, 18 (16.4%) are hospitals with 1-99 beds, 60 (54.5%) are hospitals with 100-399 beds, 25 (22.7%) are 400 or more beds, and 7 (6.4%) are unknown. Additionally, 11 (10%) are major teaching institutions, 51 (46.4%) are minor teaching institutions, 42 (38.2%) are non-teaching, and 6 (5.4%) are unknown. The California State Registry continues to lead registries that routinely collect PROMs, and has generated both valuable risk-adjusted data and the pathway for other AJRR institutions to follow. The standardized surveys used by the CJRR include the Western Ontario & McMaster Universities Osteoarthritis Index (WOMAC), the VR-12, and the UCLA Activity Score.

The methodology employed by the CJRR model for risk-adjustment includes several patient-level variables including age, sex, race, ASA classification, BMI and presence of diabetes, hypertension, or chronic lung disease. Performance measures are generated by comparison of minimal clinically important difference (MCID) in PROM scores after adjusting for differences in patient health to the population average.

Details of the CJRR cumulative experience with PROMs includes hospital participants, cases reported, PROM completion rates and PROM results for the WOMAC, VR-12 and UCLA score, with performance ratings, and is provided in a digital supplement. Additional information regarding the methodology behind reporting meaningful change in risk-adjusted PROMs and the risk-adjustment model is also noted there.

California State Registry PROM data has been collected for a longer period of time than AJRR PROM data and is available by hospital in electronic supplement.

“This year’s Annual Report foreshadows the Registry’s transition to analytic capabilities that were simply not possible before. Access to over one million Medicare patient records, new data specifications that will support risk-adjusted analysis, and emphasis on data completeness will contribute to future arthroplasty research and findings that may prove or dispel commonly held arthroplasty performance impressions from the past.”

Terence J. Gioe, MD
AJRR Annual Report editor
A long-term priority for the American Joint Replacement Registry (AJRR) has been to obtain claims data from CMS to facilitate linkages between AJRR and Medicare to support AJRR’s quality improvement and patient safety efforts. These linkages allow AJRR to obtain information that is presently lacking in the AJRR database (more complete comorbidity information, knowledge of revisions performed in non-AJRR institutions, etc.). Following a detailed application process, this data was received from CMS on June 19, 2018.

In summary, AJRR submitted a finder file of 1,058,936 patient data files to CMS (the AJRR database from 2012-2017) and received 690,281 matching Medicare files. The remainder of AJRR files represented patients who were not Medicare eligible and would be covered by other payers. The analyses that were performed for this report were based on the 422,531 matching inpatient files between CMS and AJRR databases. Within the AJRR patient population, a total of 525,591 hip or knee arthroplasty procedures were identified from those inpatient files. The dataset was then further restricted to primary arthroplasties performed for OA, and metal-on-metal THAs were excluded for the hip analysis sections since as a class they have shown a higher than average revision rate.

Methodology

From the 2012-2017 ResDAC dataset all primary and revision THA and TKA procedures were identified using ICD-9/ICD-10 coding. Since ICD-9 does not identify laterality, but ICD-10 does, when laterality was in question it was cross-referenced with AJRR data. For ICD-9 codes the assumption was made that a revision code postdating a primary procedure was a “linked” revision, which was later validated in the AJRR database. ICD-10 coding allows for (but does not require) both removal and replacement codes, but has the advantage of including laterality, and the same postdating assumptions were made with either acceptable single codes for revision or with the dual code permutations. In short, appropriate laterality was used to identify revisions and primaries when ICD-10 coding was used and, when ICD-9 was used, subsequent revisions were linked to previous primary procedures with laterality verified at a later step.

Data was not censored for mortality because that information is not reliably available in the AJRR at this time, and the time frame for survival analysis in the registry is relatively short. Patients who had not undergone revision or where revision status was unclear were censored. Linked revisions and unlinked primaries were tracked for up to six years when applicable and the unit of analysis was “months to revision.”

The ResDAC/CMS data team provided AJRR with a unique identifier that matches an AJRR case record to a CMS claim file. Observations from ICD-9 codes where patients were noted to have mismatched laterality for primary and revision or revisions without a previous record of a primary in the AJRR database were excluded. Kaplan Meier survival curves were constructed and stratified by age and sex where appropriate. An open source macro provided by the SAS institute was used for proper scaling and graphical depiction of the information.39
Limitations of Dataset and Data Interpretation

Administrative databases such as the Medicare claims data can add great value to our analyses of the core data collected directly by the AJRR by extending and making more comprehensive the follow-up information available. Claims are very reliably submitted across the entire health care system by all health care providers whether they participate in a registry or not. Two of the major advantages of such databases include their increasing availability and the large nationwide sample sizes they provide that are by definition demographically diverse and generally unselected.

However, there are some important limitations and potential problems with these administrative data sources that must be understood when interpreting the information that results in the reports presented herein. First, as noted above, the data are derived from either ICD-9 or ICD-10 codes on administrative billing claims data submitted by institutions and providers. Coding may be inconsistent, inaccurate, or change over time and may also be influenced by reimbursement policies as they exist and as they change. Of note, the use of procedural codes in addition to diagnosis codes appears to improve accuracy and detail compared to diagnosis codes alone.40-42

This is of importance for a procedure-based registry such as the AJRR. In this section of the AJRR Annual Report, the CMS dataset has been linked to AJRR data to derive implant survivorship estimates on THA or THA procedures recorded in the AJRR performed on patients who also appear subsequently in the CMS database. By using administrative claims submitted to CMS for any reoperations after the index procedure, it is possible to capture all revisions including those performed outside of AJRR-participating institutions that otherwise would have been missed and unavailable for survival analysis. The validity of this approach depends on the relatively safe assumption that institutions are billing CMS for services that they provide to Medicare patients. But because a substantial number of past revision procedures submitted to CMS do not have the side or laterality of the procedure coded, those procedures cannot be used to estimate implant survivorship. This problem is much reduced under the now required reporting of laterality under ICD-10, but it means that any survivorship estimates using historical CMS data including that shown below potentially overestimates the true survivorship, and is a best-case representation.

When interpreting the graphs that follow, several other important issues should be considered. As this represents retrospective observational data from a large registry and administrative database, causation cannot be established, and only associations are offered. Often further in-depth analysis is needed, perhaps with different methods, to determine the root cause behind observed associations. As the AJRR only has recorded its own data from 2012 onwards (and the 2012 data is limited), the differential follow-up from primary procedures performed in 2017 and 2012 may have implications. Procedures in 2017 could be censored due to a patient revision at any time between 0-9 months. For these procedures follow-up ends in 9 months until the next round of CMS data is uploaded into the AJRR system. Procedures performed in 2012 are right censored at 72 months when the follow-up for procedures concludes. This would indicate that the survival functions are most robust at 0-12 months where the least censoring has occurred. Finally, the graphs show 95% confidence bands used for graphical representation of the non-parametric Kaplan Meier curves. Confidence bands are more conservative estimates of the variance than confidence intervals and are used to reduce the occurrence of Type 1 error. As a result, confidence bands are always wider than confidence intervals as the latter underestimates true variability when evaluating survival function as a whole.

Finally, these selected graphs were provided to furnish a broad overview of some of the more common areas of interest in arthroplasty design and application available in the AJRR. Additional survival curves evaluating these areas of interest and others with differing variables and stratification measures are available in the electronic appendix.
**Femoral Stem Fixation in THA:**

Overall implant survivorship was similar for both cemented and cementless stem fixation for patients with osteoarthritis but appears slightly better for cementless femoral stems in the time frame analyzed (Figure 44). When analyzed separately by sex and age (65-69, 70-79, 80 and above) this pattern is more defined for males and for all patients aged 65-69 yrs. (Figure 45). The pattern is less clear for females, and as age increases cemented implants show better survivorship than cementless in females over age 80 years (Figure 46). The actual difference in survival is very small, and the reasons behind this difference is unclear, with other potential confounders not considered in this analysis. It should also be noted that the proportion of cemented stems compared to cementless stems is quite small (< 10%), as described elsewhere in this report, and we cannot account for the selection of stem fixation method based on individual surgeons’ indications.

![Figure 44: Fixation of the Femoral Stem: Cemented vs Cementless Designs in Patients Diagnosed with Primary OA (2012-2017)](image)

* Total possible patient population: 108,002; after accounting for missing data and exclusions as noted, the number analyzed = 93,095 (85% of total population)

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Cement Fixation</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cemented</td>
<td>7.7%</td>
<td>7,190</td>
<td>219</td>
<td>6,971</td>
<td>96.0%</td>
</tr>
<tr>
<td>2</td>
<td>Cementless</td>
<td>92.3%</td>
<td>85,905</td>
<td>2,175</td>
<td>83,730</td>
<td>97.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>93,095</td>
<td>2,394</td>
<td>90,701</td>
<td>97.4%</td>
</tr>
</tbody>
</table>

![Figure 45: Fixation of Hip Construct Femoral Component: Cemented vs Non-Cemented For Ages 65-69 Diagnosed with Primary OA (2012-2017)](image)

* Total possible patient population: 32,282; after accounting for missing data and exclusions as noted, the number analyzed = 28,288 (88% of total population)

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Cement Fixation</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cemented</td>
<td>4.8%</td>
<td>1,361</td>
<td>50</td>
<td>1,311</td>
<td>96.3%</td>
</tr>
<tr>
<td>2</td>
<td>Cementless</td>
<td>95.2%</td>
<td>26,927</td>
<td>576</td>
<td>26,351</td>
<td>97.9%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>28,288</td>
<td>626</td>
<td>27,662</td>
<td>97.8%</td>
</tr>
</tbody>
</table>
“At Holland Hospital we are motivated to use data to improve quality care. Our surgeons are passionate about supporting the developing national registry (AJRR) with data submissions that help the medical community understand orthopaedic treatment in the United States.”

Kristie Dennett, RN, MSN, ONC
Holland Hospital
(Program Manager, Spine & Orthopedics)

Figure 46: Fixation of Hip Construct Femoral Component: Cemented vs Non-Cemented For Females Ages 80+ Diagnosed with Primary OA (2012-2017)

Summary of the Number of Censored and Uncensored Values

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Cement Fixation</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cemented</td>
<td>15.9%</td>
<td>1,963</td>
<td>37</td>
<td>1,926</td>
<td>98.1%</td>
</tr>
<tr>
<td>2</td>
<td>Cementless</td>
<td>84.1%</td>
<td>10,401</td>
<td>290</td>
<td>10,111</td>
<td>97.2%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>12,364</td>
<td>327</td>
<td>12,037</td>
<td>97.4%</td>
</tr>
</tbody>
</table>
**Femoral Head Diameter in THA:**

Implant survivorship is also associated with femoral head diameter in Medicare-age patients with primary osteoarthritis, with 32 and 36 mm diameter heads showing better overall survivorship than both the larger (≥40 mm) and smaller (≤28 mm) heads (Figure 47). These differences were similar between males and females but the differences diminish somewhat with increasing age. There appears to be an inter-play between composition and diameter of the femoral head that is most apparent in patients receiving a 36 mm diameter head, with better survivorship seen with the ceramic 36 mm diameter head combination (Figure 48). The interplay of head diameter, age, sex, and other factors such as patient comorbidities, and indication for revision surgery (especially dislocation) will be of interest in future analyses of these data. The small number of patients overall receiving 40 mm or larger heads raises the possibility that these implants were used selectively (rather than routinely) by surgeons in certain patients or clinical situations not accounted for in these data, which may therefore affect the results (Figure 49).

"The exceptional utility of AJRR’s RegistryInsights™ platform capabilities and the size of our participating hospital network were both deciding factors in choosing AJRR as our national registry partner."

Andrew N. Pollak, MD
The James Lawrence Kernan Professor and Chairman
Department of Orthopaedics
University of Maryland School of Medicine
Senior Vice President for Clinical Transformation and Chief of Orthopaedics
University of Maryland Medical System
Figure 48: 36mm Head by Composition of Femoral Heads Diagnosed with Primary OA (2012-2017)

* Total possible patient population: 30,534; after accounting for missing data and exclusions as noted, the number analyzed = 27,219 (89% of total population)

Summary of the Number of Censored and Uncensored Values

<table>
<thead>
<tr>
<th>Head Composition</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic</td>
<td>44.7%</td>
<td>24,345</td>
<td>615</td>
<td>23,730</td>
<td>97.5%</td>
</tr>
<tr>
<td>Cobalt Chrome</td>
<td>55.3%</td>
<td>30,149</td>
<td>898</td>
<td>29,251</td>
<td>97.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>54,494</strong></td>
<td><strong>1,513</strong></td>
<td><strong>52,981</strong></td>
<td><strong>97.2%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Figure 49: 40 mm Head by Composition of Femoral Heads Diagnosed with Primary OA (2012-2017)

* Total possible patient population: 101,192; after accounting for missing data and exclusions as noted, the number analyzed = 95,627 (95% of total population)

Summary of the Number of Censored and Uncensored Values

<table>
<thead>
<tr>
<th>Head Composition</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic</td>
<td>39.8%</td>
<td>1,847</td>
<td>42</td>
<td>1,805</td>
<td>97.7%</td>
</tr>
<tr>
<td>Cobalt Chrome</td>
<td>60.2%</td>
<td>2,794</td>
<td>144</td>
<td>2,650</td>
<td>94.9%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,641</strong></td>
<td><strong>186</strong></td>
<td><strong>4,455</strong></td>
<td><strong>96.0%</strong></td>
<td></td>
</tr>
</tbody>
</table>
Femoral Head Composition in THA:

In Medicare-age patients with osteoarthritis implant survivorship was associated with femoral head composition, with ceramic heads showing slightly better survivorship than CoCr heads (Figure 50). This appears related to an early difference followed by survivorship curves of similar slope beyond 1-2 years. This effect was more defined in the younger age group (65 to 69 yrs.) (Figure 51). Again, the actual difference in rates is very small and reasons behind this observed early difference are unclear from these data alone. The interplay between other factors such as head size, specific implant design, indication for surgery, and any association with early complications of THA will be of interest as these observations are extended over time.

**Figure 50: Composition of Femoral Heads For Patients 65-69 Years of Age Diagnosed with Primary OA (2012-2017) (Metal on Metal Removed)**

* Total possible patient population: 59,864; after accounting for missing data and exclusions as noted, the number analyzed = 54,494 (91% of total population)

**Summary of the Number of Censored and Uncensored Values**

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Head Composition</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ceramic</td>
<td>57.3%</td>
<td>38,793</td>
<td>329</td>
<td>15,256</td>
<td>97.9%</td>
</tr>
<tr>
<td>2</td>
<td>Cobalt Chrome</td>
<td>42.7%</td>
<td>11,634</td>
<td>364</td>
<td>11,270</td>
<td>96.9%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>27,219</td>
<td>693</td>
<td>26,526</td>
<td>97.5%</td>
</tr>
</tbody>
</table>

**Figure 51: Composition of Femoral Heads for Patients Diagnosed with Primary OA (2012-2017) (Metal on Metal Removed)**

* Total possible patient population: 5,528; after accounting for missing data and exclusions as noted, the number analyzed = 4,461 (84% of total population)

**Summary of the Number of Censored and Uncensored Values**

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Head Composition</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ceramic</td>
<td>42.7%</td>
<td>38,793</td>
<td>1,000</td>
<td>37,793</td>
<td>97.4%</td>
</tr>
<tr>
<td>2</td>
<td>Cobalt Chrome</td>
<td>57.3%</td>
<td>51,955</td>
<td>1,721</td>
<td>50,234</td>
<td>96.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>90,748</td>
<td>2,721</td>
<td>88,027</td>
<td>97.0%</td>
</tr>
</tbody>
</table>
Cruciate Retaining vs. Cruciate Stabilizing (Posterior Stabilized) TKA Designs:

In patients over 65 years of age, CR designs were associated with slightly better survivorship overall than PS designs when used in patients with primary OA (Figure 52). With the aforementioned caveats, the difference was statistically significant when comparing these large cohorts. The influence of specific implant system, mode of fixation, and interplay with materials used for the articulation will be topics of interest for future evaluation. Selection bias may play a role as well, if PS designs are used selectively by some surgeons in more problematic patient populations.

Composition of Tibial Inserts IN TKA:

In patients over the age of 65 years, polyethylene composition was associated with an observed difference in implant survivorship with antioxidant polyethylene showing the highest survivorship, UHMWPE the lowest, and highly-cross linked polyethylene intermediate between the two (Figure 53). The observed differences persisted when stratified by sex and age for the Medicare population with primary OA. Nevertheless, survivorship associated with all three polyethylene types was over 96% at five years post-TKA.
UKA vs. TKA Designs:

In this sample of Medicare-age patients, unicompartmental knee arthroplasty was associated with lower survivorship than TKA (Figure 54). However, this effect was somewhat less defined in males than in females (Figures 55 and 56). Again, design differences between implants, surgical indications for the primary procedure, and indications for revision surgery remain confounders that are not addressed in the database at present.

* Total possible patient population: 231,792; After accounting for missing data and exclusions as noted, the number analyzed = 202,764 (87% of total population).

Summary of the Number of Censored and Uncensored Values

<table>
<thead>
<tr>
<th>Stratum</th>
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<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TKA</td>
<td>97.5%</td>
<td>197,791</td>
<td>1,990</td>
<td>195,801</td>
<td>99.0%</td>
</tr>
<tr>
<td>2</td>
<td>UNI</td>
<td>2.5%</td>
<td>4,973</td>
<td>77</td>
<td>4,896</td>
<td>98.5%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>202,764</td>
<td>2,067</td>
<td>200,697</td>
<td>99.0%</td>
</tr>
</tbody>
</table>

* Total possible patient population: 87,964; after accounting for missing data and exclusions as noted, the number analyzed = 77,293 (88% of total population).

Summary of the Number of Censored and Uncensored Values

<table>
<thead>
<tr>
<th>Stratum</th>
<th>construct</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TKA</td>
<td>96.9%</td>
<td>74,872</td>
<td>863</td>
<td>74,009</td>
<td>98.9%</td>
</tr>
<tr>
<td>2</td>
<td>UNI</td>
<td>3.1%</td>
<td>2,421</td>
<td>38</td>
<td>2,383</td>
<td>98.4%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>77,293</td>
<td>901</td>
<td>76,392</td>
<td>98.8%</td>
</tr>
</tbody>
</table>
**Figure 56: Knee Constructs Femoral Component (Total Knee and Uni-condylar) For Females Diagnosed with Primary OA (2012-2017)**

* Total possible patient population: 143,828; after accounting for missing data and exclusions as noted, the number analyzed = 125,471 (87% of total population)

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Construct</th>
<th>% of the Total</th>
<th>Total</th>
<th>Failed</th>
<th>Censored</th>
<th>Percent Censored</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TKA</td>
<td>98.0%</td>
<td>122,919</td>
<td>1,127</td>
<td>121,792</td>
<td>99.1%</td>
</tr>
<tr>
<td>2</td>
<td>UNI</td>
<td>2.0%</td>
<td>2,552</td>
<td>39</td>
<td>2,513</td>
<td>98.5%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>125,471</td>
<td>1,166</td>
<td>124,305</td>
<td>99.1%</td>
</tr>
</tbody>
</table>

*With one of our hospitals having been certified for several years by the Joint Commission for Hip and Knee Joint Replacement, I am pleased that AAOS and TJC have collaborated to require national registry participation in the Total Hip and Total Knee Replacement Advanced Certification. We can only truly evaluate our performance when we are using standardized metrics and comparing ourselves to other hospitals. As the AJRR database evolves to include more outcomes data, that will really help us as we strive to provide the very best care to our patients."

Suzy Beeler, MHA, CPHQ
Ascension Texas
(Network Director Quality, Effectiveness, and Value)
### Data Elements

#### Procedural (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)
  - Date of surgery
  - Laterality
  - Implants

#### Post-Operative, Complications (Level II)
- **Patient risk factors/comorbidities**
  *below are focus comorbidities but any are accepted (ICD-9/10)*
  - Chronic lung disease
  - Congestive heart failure
  - Coronary artery disease
  - Diabetes mellitus
  - Dialysis
  - History of venous thrombosis and embolism
  - Hypertension
  - Obesity
  - Peripheral artery disease
  - Previous cardiac condition (past myocardial infarction)

#### Patient Reported Outcome Measures, PROMs (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*
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 2017 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 2018, Quality Insights began an audit of N=18 (3%) randomly selected participants that submitted data to AJRR from January 1 to December 31, 2017. 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). One hospital received an exclusion waiver for this year’s audit due to personnel changes. However, the hospital will be automatically included for next year’s audit. 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 2017, 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 2018.

In summary, the overall audit agreement rate for the medical record review was 94.5%, down from 98.4% last year. Fifteen of the 17 selected participants (88.2%) performed above the 85% “Acceptable” agreement threshold. Two hospitals performed at slightly less than 85% agreement. Both hospitals’ agreements rates were impacted by component catalog numbers not being submitted as part of the medical records to Quality Insights. However, catalog numbers were submitted to AJRR. Eleven participants (64.7%) had agreement rates above 95%. Of those, 7 participants having agreement rates above 98%. No data elements were problematic.

The overall record completeness assessment rate was 75.0%, down from 91.4% last year. Last year’s score was much higher than previous years, whereas this year’s score is more consistent with the previous years. The lower score for the completeness assessment can be contributed formatting issues with the reports submitted to QI or a consistent error for one or two data elements (e.g., submitted wrong surgeon NPI or not submitting laterality) causing mismatches. Of the 17 participants, 11 participants (64.7%) performed above the 85% “Acceptable” agreement threshold. Ten participants (58.9%) had a completeness assessment rate 95.0% or higher, with 6 participants having a 100% completeness assessment rate. The audit participants submitted a total of 988 records to Quality Insights. Only 21 records (2.1%) 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. In general, AJRR and Quality insights were very pleased with the results, and the discussions with hospitals generally led to process improvements.
Appendix C  AJRR Committees

California State Registry Committee
James I. Huddleston, III, MD – Chair
Stanford University
Stefano Bini, MD
University of California, San Francisco
Christine Brown, MSPT
Methodist Hospital Dignity Health
Bradley Graw, MD
Palo Alto Medical Foundation
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Orthopaedic Specialty Institute
Richard Seiden, Esq.
Los Angeles, Calif.
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University of California Los Angeles

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Plano Orthopaedics and Sports Medicine
Antonia F. Chen, MD, MBA
Rothman Institute at Jefferson
Kevin Fleming, MBA
Providence St. Joseph Health
Terence J. Goe, MD
University of California, San Francisco and San Francisco VA Health Care System
Brian R. Hallstrom, MD
University of Michigan
James I. Huddleston, III, MD
Stanford University
Richard L. Illgen II, MD
University of Wisconsin
David G. Lewallen, MD
Mayo Clinic
Hilal Maradit-Kremers, MD
Mayo Clinic
Susan M. Odum, PhD
OrthoCarolina Research Institute
Scott M. Sporer, MD
Midwest Orthopaedics at Rush and Central DuPage Hospital
Timothy Wright, PhD
Hospital for Special Surgery

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Industry Representative
Kevin Fleming, MBA
Providence St. Joseph Health
James I. Huddleston, III, MD
Stanford University
Bryan D. Springer, MD
OrthoCarolina
Diana Stilwell, MPH
Sharon, Mass.

Data Elements and Analysis Subcommittee (DEAS)
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John W. Barrington, MD
Plano Orthopaedics and Sports Medicine
Brian R. Hallstrom, MD
University of Michigan
Timothy M. Mojonnier
River Forest, Ill.
Susan M. Odum, PhD
OrthoCarolina Research Institute
Bryan D. Springer, MD
OrthoCarolina

Research Projects Subcommittee (RPS)
Richard L. Illgen II, MD – Chair
University of Wisconsin
Antonia F. Chen, MD, MBA
Rothman Institute at Jefferson
Hilal Maradit-Kremers, MD
Mayo Clinic
Bryan D. Springer, MD
OrthoCarolina
Timothy Wright, PhD
Hospital for Special Surgery

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Aquebogue, NY
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River Forest, Ill.
Diana Stilwell, MPH
Sharon, Mass.
Appendix D 2017 Participating Hospitals, Health Systems, and ASCs

Institutions that Submitted Data for this Annual Report are highlighted in blue.

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

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

California
Adventist Medical Center - Hanford
California Pacific Medical Center
Cedars-Sinai Medical Center
Clovis Community Medical Center
Community Hospital of Monterey Peninsula
Dameron Hospital
Doctors Medical Center
Eisenhower Medical Center
El Camino Hospital, Los Gatos Campus
Feather River Hospital
Fresno Surgical Hospital
Glendale Adventist Medical Center
Hoag Orthopedic Institute
Howard Memorial Hospital
Huntington Hospital
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
Methodist Hospital of Sacramento
Mills-Peninsula Medical Center
Monterey Peninsula Surgery Center
NorthBay Vacaville Hospital
Novato Community Hospital
Orange Coast Memorial
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
Ronald Reagan UCLA Medical Center
Saddleback Memorial
Saint Agnes Medical Center
Salinas Valley Memorial Healthcare System
San Antonio Regional Hospital
San Joaquin Community 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. Bernardine Medical Center
St. Helena Hospital
St. Joseph Hospital
St. Jude Medical Center
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Institutions that Submitted Data for this Annual Report are highlighted in blue.

**Georgia**
- Colquitt Regional Medical Center
- Houston Medical Center
- Memorial University Medical Center
- Navicent Health
- Northside Medical Center
- Optim Medical Center – Tattnall
- Redmond Regional Medical Center
- Southeast Georgia Health System Brunswick Campus
- Southeast Georgia Health System Camden Campus
- WellStar Cobb Hospital
- WellStar Douglas Hospital
- WellStar Kennestone Hospital
- WellStar Paulding Hospital
- West Georgia Medical Center
- Emory University Orthopaedics & Spine Hospital
- Premier Orthopedic Surgery 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**
- Blessing Health System
- Genesis Medical Center, Silvis
- Gibson Area Hospital & Health Services
- 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
  - UnityPoint Health - Methodist
  - UnityPoint Health - Proctor
  - UnityPoint Health - Trinity Rock Island
  - Valley Ambulatory Surgery Center
- Weiss Memorial Hospital
  - Advocate BroMenn Medical Center
  - Advocate Christ Medical Center
  - Advocate Condell Medical Center
  - Advocate Eureka Hospital
  - Advocate Good Samaritan Hospital
  - Advocate Good Shepherd Hospital
  - Advocate Illinois Masonic Medical Center
  - Advocate Lutheran General Hospital
  - Advocate Sherman Hospital
  - Advocate South Suburban Hospital
  - Advocate Trinity Hospital
  - Herrin Hospital
  - HSHS St. John’s Hospital
  - Memorial Hospital of Carbondale
  - OSF Heart of Mary Medical Center
  - OSF Holy Family Medical Center
  - OSF Sacred Heart Medical Center
  - OSF Saint Anthony Medical Center
  - OSF Saint Anthony’s Health Center
  - OSF Saint Elizabeth Medical Center
  - OSF Saint Francis Medical Center
  - OSF Saint James – John W. Albrecht Medical Center
  - OSF Saint Luke Medical Center
  - OSF Saint Paul Medical Center
  - OSF St. Joseph Medical Center
  - OSF St. Mary Medical Center
- SwedishAmerican Hospital

**Indiana**
- Allied Physicians Surgery Center
- Franciscan Health Carmel
- Franciscan Health Indianapolis
- Franciscan Health Mooresville
- IU Health Ball Memorial Hospital
- Major Hospital
- Memorial Hospital and Health Care Center
- OrthoIndy Hospital
- Plymouth Medical Center

**Schneck Medical Center**
- St. Joseph Regional Medical Center
- Bluffton Regional Medical Center
- Columbus Regional Hospital
- Community Hospital Anderson
- Dukes Memorial Hospital
- Dupont Hospital
- IU Health Arnett Hospital
- IU Health Bedford Hospital
- IU Health Beltway Surgery Centers
- IU Health Blackford Hospital
- IU Health Bloomington Hospital
- IU Health Eagle Highlands Outpatient 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 Surgery Center
- 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
- Riley Hospital for Children at IU Health
- Riverview Health Main Hospital
- Riverview Health Westfield Hospital
- St. Joseph Hospital
- The Orthopedic Hospital

**Iowa**
- Allen Hospital
- Buena Vista Regional Medical Center
- 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
Appendix D continued

Mercy Medical Center - Des Moines
Mercy Medical Center - Dubuque
Mercy Medical Center - West Lakes
Methodist West Hospital
Mississippi Valley Surgery Center
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
CHI Health Mercy Corning

Kansas
Hutchinson Regional Medical Center
Kansas City Orthopaedic Institute
Newton Medical Center
St. Catherine Hospital
Stormont Vail Health
The University of Kansas Hospital
Wesley Medical Center
Bob Wilson Memorial Grant County Hospital
Menorah Medical Center
Ransom Memorial Hospital
St. Rose Ambulatory & Surgery Center

Kentucky
St. Elizabeth Edgewood
St. Joseph East
Jewish Hospital
Methodist Hospital
Saint Joseph Hospital

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
Red River Surgery Center
Tulane Medical Center
West Bank Surgery 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
Saint Agnes Healthcare
Suburban Hospital
The Surgery Center of Easton
University of Maryland Baltimore Washington 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
Peninsula Regional Medical Center
Sinai Hospital
The Johns Hopkins Hospital
University of Maryland Charles Regional Medical Center

Massachusetts
Berkshire Medical Center
Beth Israel Deaconess Hospital - Plymouth
Beth Israel Deaconess Medical Center
Beverly Hospital
Boston Medical Center
Good Samaritan Medical Center
Lahey Hospital & Medical Center
Quincy Medical Center
Saint Anne’s Hospital

Signature Healthcare Brockton Hospital
South Shore Hospital
Boston Out-Patient Surgical Suites, LLC
Holy Family Hospital
Massachusetts General Hospital
New England Baptist Hospital

Michigan
Borgess Medical Center
Bronson Methodist Hospital
Henry Ford Hospital
Henry Ford Macomb Hospital
Henry Ford West Bloomfield Hospital
Henry Ford Wyandotte Hospital
Holland Hospital
Lakeland Health
McLaren Flint
McLaren Greater Lansing
Mercy Health Muskegon
Mercy Health Saint Mary’s
MidMichigan Medical Center - Midland
Monson Healthcare Cadillac Hospital
Monson Medical Center
Providence-Providence Park Hospital-Southfield
Sparrow Hospital
Spectrum Health Hospitals Blodgett 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
William Beaumont Hospital
Bronson Battle Creek Hospital
Bronson LakeView Hospital
Bronson South Haven Hospital
Genesys Regional Medical Center
Memorial Healthcare
OSF St. Francis Hospital & Medical Group
Providence-Providence Park Hospital-Novi
St. John Macomb-Oakland Hospital, Madison Heights
St. John Macomb-Oakland Hospital, Warren
Institutions that Submitted Data for this Annual Report are highlighted in blue.

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<td>Owatonna Hospital</td>
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<td>University of Minnesota Medical Center</td>
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<td>Baptist Medical Center</td>
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<td>Newark-Wayne Community Hospital</td>
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<td>St. Joseph’s Hospital Health Center</td>
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Appendix D continued

St. Peter’s Hospital
The Hospital for Joint Diseases
The Mount Sinai Hospital
UHS Binghamton General Hospital
UHS Wilson Medical Center
Unity Hospital
Upstate University Hospital - Downtown Campus
Winthrop - University Hospital
Faxton St. Luke’s Healthcare
Highland Hospital
Mercy Hospital of Buffalo
NewYork-Presbyterian/Lower Manhattan Hospital
NewYork-Presbyterian/Weill Cornell Medical Center
Oswego Hospital
Sisters of Charity Hospital
Sisters of Charity Hospital - St. Joseph Campus

North Carolina
Blue Ridge Surgery Center - SCA - Surgical Care Affiliates
Davie Medical Center
FirstHealth Moore Regional Hospital
Lexington Medical Center
Mission Hospital
New Hanover Regional Medical Center
North Carolina Specialty Hospital
Northern Hospital of Surry County
Novant Health Brunswick Medical Center
Novant Health Charlotte Orthopaedic Hospital
Novant Health Forsyth Medical Center
Novant Health Huntersville Medical Center
Novant Health Matthews Medical Center
Novant Health Rowan Medical Center
Novant Health Thomasville Medical Center
Surgical Center of Greensboro
The Moses H. Cone Memorial Hospital
Wake Forest Baptist Medical Center
Wesley Long Hospital
Annie Penn Hospital
CarolinaS HealthCare System Lincoln
CarolinaS Medical Center
Novant Health Clemmons Medical Center
Novant Health Kernersville Medical Center
OrthoCarolina
Park Ridge Health
Sentara Albemarle Medical Center
The Surgical Center of Morehead City
WakeMed Cary Hospital
WakeMed North Family Health & Women’s Hospital
WakeMed Raleigh Campus

North Dakota
Sanford Medical Center
CHI St. Alexius Health

Ohio
Bethesda Butler Hospital
Bethesda North Hospital
Blanchard Valley Hospital
Cleveland Clinic Lakewood
Cleveland Clinic Main Campus
Crystal Clinic Orthopaedic Center
Euclid Hospital
Genesis Healthcare System
Good Samaritan Hospital
Grant Medical Center
Hillcrest Hospital
Lutheran Hospital
Marymount Hospital
McCullough-Hyde Memorial Hospital
Medina Hospital
Mount Carmel East
Mount Carmel New Albany
Mount Carmel St. Ann’s
Mount Carmel West
OhioHealth Mansfield Hospital
Selby General Hospital
South Pointe Hospital
St. John Medical Center
St. Vincent Charity Medical Center
The Ohio State University Wexner Medical Center
TriHealth Evendale Hospital
University Hospitals Ahuja Medical Center
University Hospitals Cleveland Medical Center
University Hospitals Conneaut Medical Center
University Hospitals Elyria Medical Center
University Hospitals Geauga Medical Center
University Hospitals Geneva Medical Center
University Hospitals Parma Medical Center
University Hospitals Portage Medical Center
University Hospitals Regional Hospitals Bedford Campus
University Hospitals Regional Hospitals Richmond Campus
Amherst Family Health Center
Ashtabula County Medical Center
Cleveland Clinic Children’s Hospital for Rehabilitation
Fairview Hospital
Fort Hamilton Hospital
Grandview Medical Center
Greene Memorial Hospital
Kettering Medical Center
Mercy Health - Anderson Hospital
Mercy Health - Clermont Hospital
Mercy Health - Fairfield Hospital
Mercy Health - West Hospital
MetroHealth Main Campus
Soin Medical Center
Southview Medical Center
Southwest General Health Center
Sycamore Medical Center
The Jewish Hospital - Mercy Health
Trumbull Regional Medical Center

Oklahoma
Community Hospital North Campus
Community Hospital South Campus
Duncan Regional Hospital
Mercy Hospital Ada
Mercy Hospital Ardmore
Mercy Hospital Oklahoma City
Northwest Surgical Hospital
Southwestern Medical Center
St. John Broken Arrow
Stillwater Medical Center
St. Mary’s Regional Medical Center
Institutions that Submitted Data for this Annual Report are highlighted in blue.

Oregon
Adventist Medical Center - Portland
Good Samaritan Regional Medical Center
Legacy Silverton Medical Center
Oregon Health & Science University Hospital
Providence Hood River Memorial Hospital
Providence Medford Medical Center
Providence Milwaukie Hospital
Providence Newberg Medical Center
Providence Portland Medical Center
Providence Seaside Hospital
Providence St. Vincent Medical Center
Providence Willamette Falls Medical Center
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
Bend Surgery Center
Legacy Emanuel Medical Center
Legacy Good Samaritan Medical Center
Legacy Meridian Park Medical Center
Legacy Mount Hood Medical Center
Oregon Orthopedic & Sports Medicine Clinic
South Portland Surgical Center

Pennsylvania
Advanced Surgical Hospital
Doylestown Hospital
Hanover Hospital
Indiana Regional Medical Center
Lancaster General Hospital
Magee-Womens Hospital of UPMC
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
St. Mary Medical Center
UPMC Altoona
UPMC East
UPMC Hamot
UPMC Horizon
UPMC Jameson
UPMC McKeensport
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
Allegheny General Hospital
Chan Soon-Shiong Medical Center at Windber
Children’s Hospital of Pittsburgh of UPMC
Hospital of the University of Pennsylvania
Mercy Fitzgerald Hospital
Mercy Philadelphia Hospital
Rothman Institute
Surgery Center of Allentown
Thomas Jefferson University Hospital
UPMC Bedford Memorial

Rhode Island
South County Hospital
Westerly Hospital

South Dakota
Sanford USD Medical Center
Sioux Falls Specialty Hospital

Tennessee
Baptist Memorial Hospital-Collierville
Baronesse Hospital
CHI Memorial Hospital Chattanooga
Erlanger East Hospital
Henry County Medical Center
Indian Path Medical Center
Johnson City Medical Center
Maury Regional Medical Center
Physicians Regional Medical Center
Saint Thomas Midtown Hospital
Saint Thomas West Hospital
University of Tennessee Medical Center

South Carolina
Bon Secours St. Francis Hospital
Carolina Pines Regional Medical Center
East Cooper Medical Center
Medical University of South Carolina
Palmetto Health Baptist
Palmetto Health Richland
Providence Orthopaedic Hospital
Roper Hospital
Roper St. Francis Mount Pleasant Hospital
Aiken Regional Medical Center
Baptist Easley Hospital
Carolina Coast Surgery Center
Conway Medical Center
Novant Health Gaffney Medical Center
Oconee Memorial Hospital
Palmetto Health Baptist Parkridge
Palmetto Health Tuomey
Patelwood Memorial Hospital
Self Regional Healthcare

Pennsylvania
Advanced Surgical Hospital
Doylestown Hospital
Hanover Hospital
Indiana Regional Medical Center
Lancaster General Hospital
Magee-Womens Hospital of UPMC
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
St. Mary Medical Center
UPMC Altoona
UPMC East
UPMC Hamot
UPMC Horizon
UPMC Jameson
UPMC McKeensport
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
Allegheny General Hospital
Chan Soon-Shiong Medical Center at Windber
Children’s Hospital of Pittsburgh of UPMC
Hospital of the University of Pennsylvania
Mercy Fitzgerald Hospital
Mercy Philadelphia Hospital
Rothman Institute
Surgery Center of Allentown
Thomas Jefferson University Hospital
UPMC Bedford Memorial

Rhode Island
South County Hospital
Westerly Hospital

South Dakota
Sanford USD Medical Center
Sioux Falls Specialty Hospital

Tennessee
Baptist Memorial Hospital-Collierville
Baronesse Hospital
CHI Memorial Hospital Chattanooga
Erlanger East Hospital
Henry County Medical Center
Indian Path Medical Center
Johnson City Medical Center
Maury Regional Medical Center
Physicians Regional Medical Center
Saint Thomas Midtown Hospital
Saint Thomas West Hospital
University of Tennessee Medical Center

South Carolina
Bon Secours St. Francis Hospital
Carolina Pines Regional Medical Center
East Cooper Medical Center
Medical University of South Carolina
Palmetto Health Baptist
Palmetto Health Richland
Providence Orthopaedic Hospital
Roper Hospital
Roper St. Francis Mount Pleasant Hospital
Aiken Regional Medical Center
Baptist Easley Hospital
Carolina Coast Surgery Center
Conway Medical Center
Novant Health Gaffney Medical Center
Oconee Memorial Hospital
Palmetto Health Baptist Parkridge
Palmetto Health Tuomey
Patelwood Memorial Hospital
Self Regional Healthcare
### Appendix D continued

#### Texas
- Baptist Beaumont Hospital
- 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
- CHRISTUS Good Shepherd Medical Center - Marshall
- CHRISTUS Mother Frances Hospital - Tyler
- CHRISTUS Southeast Texas St. Elizabeth
- Dell Seton Medical Center at the University of Texas
- Doctors Hospital at Renaissance
- El Paso Specialty Hospital
- Harlingen Medical Center
- Houston Methodist Hospital
- JPS Health Network
- Memorial Hermann Memorial City Medical Center
- Memorial Hermann Southwest Hospital
- Midland Memorial Hospital
- Nix Health
- North Central Surgical Center Hospital
- Scott & White Memorial Hospital - Temple
- Seton Highland Lakes Hospital
- Seton Medical Center - Austin
- Seton Medical Center - Hays
- Seton Medical Center - Williamson
- Seton Northwest Hospital
- South Texas Spine & Surgical Hospital
- South Texas Surgical Hospital
- St. Joseph Health System
- Texas Health Harris Methodist Hospital
- Southwest Fort Worth
- Texas Health Presbyterian Hospital Flower Mound
- Texas Health Presbyterian Hospital Plano
- Texas Health Presbyterian Hospital Rockwall
- Texas Institute for Surgery
- United Regional Health Care System
- University of Texas Southwestern Medical Center
- Baylor Medical Center at Uptown
- CHRISTUS Southeast Texas St. Mary Cornerstone Regional Hospital
- Doctors Hospital of Laredo
- Edinburg Regional Medical Center
- Fort Duncan Regional Medical Center
- McAllen Medical Center
- Northwest Texas Hospital
- Texas Spine & Joint Hospital
- Texoma Medical Center
- The Physicians Centre Hospital
- College Station Medical Center
- Hill Country Memorial Hospital

#### Utah
- Alta View Hospital
- American Fork Hospital
- Bear River Valley Hospital
- Cedar City Hospital
- Dixie Regional Medical Center
- Heber Valley Medical Center
- Intermountain Medical Center
- LDS Hospital
- Logan Regional Hospital
- Maple Grove Hospital
- McKay-Dee Hospital
- North Memorial Health Hospital
- Park City Hospital
- Primary Children's Hospital
- Riverton Hospital
- Sevier Valley Hospital
- TOSH - The Orthopedic Specialty Hospital
- University of Utah Health Care
- Utah Valley Hospital
- Cedar Orthopaedic Surgery Center
- McKay-Dee Surgical Center
- Orem Community Hospital

#### Vermont
- Central Vermont Medical Center
- Rutland Regional Medical Center
- University of Vermont Medical Center
- Northwestern Medical Center

#### Virginia
- Carilion New River Valley Medical Center
- Carilion Roanoke Memorial Hospital
- Inova Mount Vernon Hospital
- Johnston Memorial Hospital
- Mary Washington Hospital
- Novant Health Prince William Medical Center
- Novant Health UVA Health System
- Haymarket Medical Center
- Reston Hospital Center
- Sentara CarePlex Hospital
- Sentara Leigh Hospital
- Sentara Martha Jefferson Hospital
- Sentara Norfolk General Hospital
- Sentara Northern Virginia Medical Center
- Sentara Obici Hospital
- Sentara Princess Anne Hospital
- Sentara RMH Medical Center
- Sentara Virginia Beach General Hospital
- Sentara Williamsburg Regional Medical Center
- University of Virginia Medical Center
- Virginia Hospital Center
- Chippenham Hospital
- Inova Fair Oaks Hospital
- Inova Fairfax Hospital
- Inova Loudoun Hospital and Surgery Center - Countryside
Institutions that Submitted Data for this Annual Report are highlighted in blue.

**Washington**
- Capital Medical Center
- Central Washington Hospital & Clinics
- EvergreenHealth Medical Center
- Harrison Medical Center
- Highline Medical Center
- Kadlec Regional Medical Center
- Northwest Hospital & Medical Center
- Overlake Medical Center
- Proliance Eastside Surgery Center
- Proliance Highlands Surgery Center
- Providence Centralia Hospital
- Providence Holy Family Hospital
- Providence Mount Carmel Hospital
- Providence Regional Medical Center Everett - Colby
- Providence Sacred Heart Medical Center
- Providence St. Joseph’s Hospital
- Providence St. Mary Medical Center
- Providence St. Peter Hospital
- St. Anthony Hospital
- St. Clare Hospital
- St. Elizabeth Hospital
- St. Francis Hospital
- St. Joseph Medical Center
- Swedish Ballard Campus
- Swedish Edmonds Campus
- Swedish First Hill Campus
- Swedish Issaquah Campus
- Trios Health
- Valley Medical Center
- Virginia Mason Medical Center
- Walla Walla General Hospital
- Yakima Valley Memorial Hospital
- Edmonds Center for Outpatient Surgery
- Everett Bone & Joint Surgery Center
- Lakewood Surgery Center
- Legacy Salmon Creek Medical Center
- Olympia Surgery Center
- Overlake Surgery Center
- Proliance Orthopaedics & Sports Medicine Redmond
- Providence Regional Medical Center Everett - Pacific
- Seattle Orthopedic Center Surgery
- Seattle Surgery Center

**West Virginia**
- Cabell Huntington Hospital
- Ruby Memorial Hospital
- Marshall Orthopaedics

**Wisconsin**
- Amery Hospital & Clinic
- Ascension St. Michael’s Hospital
- Aurora BayCare Medical Center
- Aurora Lakeland Medical Center
- Aurora Medical Center Grafton
- Aurora Medical Center in Kenosha
- Aurora Medical Center in Manitowoc County
- Aurora Medical Center in Oshkosh
- Aurora Medical Center in Summit
- Aurora Medical Center in Washington County
- Aurora Memorial Hospital of Burlington
- Aurora Sheboygan Memorial Medical Center
- Aurora Sinai Medical Center
- Aurora St. Luke’s Medical Center
- Aurora St. Luke’s South Shore Medical Center
- Aurora West Allis Medical Center
- Beaver Dam Community Hospitals, Inc.
- Beloit Health System
- Berlin Memorial Hospital
- Columbus Community Hospital
- Community Memorial Hospital
- Fort Healthcare
- Froedtert Hospital
- Gundersen Health System
- HSHS St. Mary’s Hospital Medical Center
- HSHS St. Nicholas Hospital
- HSHS St. Vincent Hospital
- Hudson Hospital & Clinic
- Lakeview Medical Center
- Memorial Medical Center - Neillsville
- Mercy Hospital and Trauma Center
- Mercy Walworth Hospital and Medical Center
- Midwest Orthopedic Specialty Hospital
- Monroe Clinic
- OakLeaf Surgical Hospital
- Oconomowoc Memorial Hospital
- Orthopaedic Hospital of Wisconsin
- Osceola Medical Center
- Ripon Medical Center
- River Falls Area Hospital
- Saint Mary’s Hospital
- Sauk Prairie Hospital
- Southwest Health
- St. Agnes Hospital
- St. Croix Regional Medical Center
- St. Joseph’s Hospital, West Bend
- The Orthopedic and Sports Surgery Center
- ThedaCare Medical Center-New London
- ThedaCare Medical Center-Shawano
- ThedaCare Medical Center-Waupaca
- ThedaCare Regional Medical Center-Appleton
- ThedaCare Regional Medical Center-Neenah
- Tomah Memorial Hospital
- UnityPoint Health - Meriter
- University of Wisconsin Hospitals and Clinics
- Vernon Memorial Healthcare
- Waukesha Memorial Hospital
- Waupun Memorial Hospital
- Westfields Hospital & Clinic
- Aspirus Wausau Hospital
- Aurora Medical Center in Milwaukee
- Divine Savior Healthcare
- SSM Health St. Clare Hospital - Baraboo
- SSM Health St. Mary’s Hospital - Janesville
- SSM Health St. Mary’s Hospital - Madison
- Wheaton Franciscan Healthcare - All Saints (Spring Street Campus)
- Wheaton Franciscan Healthcare - All Saints (Wisconsin Avenue Campus)

**Wyoming**
- Cheyenne Regional Medical Center
- Mountain View Regional Hospital
- St. John’s Medical Center
Appendix E  Private Practice Names

Institutions that Submitted Data for this Annual Report are highlighted in blue.

Arizona
Shane Martin, MD of Greater Phoenix Orthopedics
Sonoran Orthopaedic Trauma Surgeons
University Orthopedic Specialists

Arkansas
Martin Knee & Sports Medicine Center OrthoSurgeons

California
North Tahoe Orthopedics

Colorado
Pueblo Bone & Joint Clinic, LLC
Panorama Orthopedics and Spine Center

Connecticut
Valley Orthopaedic Specialists, LLC

Delaware
First State Orthopaedics
Orthopaedic Associates of Southern Delaware, P.A.

Florida
Andrews Institute Orthopaedics & Sports Medicine
Florida Joint & Spine Institute
OrthoCare Florida
Orthopedic Center of Palm Beach County, Inc.
Orthopedic Special Surgery of Palm Beach
Pensacola Orthopaedics & Sports Medicine
Toman Orthopedics & Sports Medicine

Georgia
Summit Sports Medicine & Orthopedic Surgery

Illinois
Adult & Pediatric Orthopedics
Orthopedic & Sports Medicine Clinic
Bonutti Orthopedic Clinic
Decatur Orthopaedic Center
Raycroft & Jones Orthopaedics

Iowa
Steindler Orthopedic Clinic

Kentucky
Bluegrass Orthopaedics
South Central Kentucky Orthopedics

Louisiana
Lafayette Bone and Joint Clinic

Maryland
Capital Orthopaedics and Rehabilitation, LLC

Massachusetts
Sports Medicine North Orthopedic Surgery
Longview Orthopaedic Center, LLC

Minnesota
The Orthopaedic & Fracture Clinic, P.A.

Missouri
Signature Medical Group
Pawsat, M.D. & Maeda, M.D. P.C.
Orthopedic Associates

Nevada
Orthopaedic Institute of Henderson

New Hampshire
Concord Orthopaedics

New Jersey
Eastern Orthopedic Associates

New York
Excelsior Orthopaedics

North Carolina
Greensboro Orthopaedics
Carolina Sports Medicine & Orthopaedic Specialists P.A.
Cary Orthopaedic & Sports Medicine Specialists, P.A.

Oregon
Hope Orthopedics
Portland Knee Clinic

Pennsylvania
Barry A. Ruht MD PC
Richards Orthopaedics Center & Sports Medicine

South Carolina
Carolina Orthopaedics

Tennessee
Tennessee Orthopaedic Alliance
Mid-Tennessee Bone & Joint Clinic, P.C.
OrthoTennessee

Texas
Collom & Carney Clinic Association
Dallas Orthopedic & Shoulder Institute
Paris Orthopedic Clinic, PA
The Carrell Clinic
Advent Orthopaedics
Cross Timbers Orthopedics
Jeff Zhao, D.O
Stefan Kreuzer
Texas Orthopaedic Associates
Texas Orthopedics, Sports & Rehabilitation Associates

Wisconsin
Orthopedic & Sports Medicine Specialists of Green Bay

Private Practice Names
Appendix E


We gratefully acknowledge the assistance of Bryan Springer, MD, current chair of the Data Management Committee, the members of the Annual Report Subcommittee, Terence J. Goe, MD, Kevin Fleming, MBA, James I. Huddleston, III, MD, Bryan Springer, MD, Yvonne Bokelman, MBA, Diana Stilwell, MPH; and the rest of the 2018 Data Committee for their guidance pertaining to the content of this Annual Report. And, we are appreciative of Deborah Render for her editing of this document.

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