THE ORTHOPAEDIC FORUM

# The Michigan Arthroplasty Registry Collaborative Quality Initiative Experience: Improving the Quality of Care in Michigan

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**Abstract:** The Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) is a regional quality improvement effort that is focused on hip and knee arthroplasty. From its inception in 2012, MARCQI has grown to include data from 66 hospitals and surgery centers, and contains over 209,000 fully abstracted cases in its database. Using high-quality risk-standardized outcomes data, MARCQI drives quality improvement through a collaborative and nonpunitive structure. Quality improvement initiatives have included transfusion reduction, infection prevention, venous thromboembolism reduction, and reduction of discharge to nursing homes. In addition, MARCQI focuses on postmarket surveillance of implants by computing revision-risk estimates based on the cases that were registered prior to the end of 2016. This paper describes the impact of MARCQI on the quality of hip and knee arthroplasty care in the state of Michigan since its inception in 2012, and it briefly summarizes the recently released 5-year report.

Improvement in health-care quality is a key element of value enhancement, and patient registries are central to the reporting and assessment of quality improvement activities. For hip and knee arthroplasty procedures, national registries began in 1975 with the launch of the Swedish Knee Arthroplasty Register[1], followed by the Swedish Hip Arthroplasty Register in 1979[2]. Both have been successful, and Herberts and Malchau reported on the impressive reduction of the number of hip revisions in Sweden since the inception of the hip registry[3]. Since that time, other national registries also have had notable successes. One example is the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR), which identified the ASR metal-on-metal implant (DePuy Orthopaedics) as an outlier device, leading to its worldwide recall[4]. In the United States, registries include the Kaiser Permanente National Joint Replacement Registry[5], the Function and Outcomes Research for Comparative Effectiveness in Total Joint Replacement (FORCE-TJR) research program, the HealthEast Joint Replacement Registry[6], and the American Joint Replacement Registry (AJRR). Many national registries issue annual reports that provide revision-risk data by individual implant type. The primary vehicles for the dissemination of improvement data from large national

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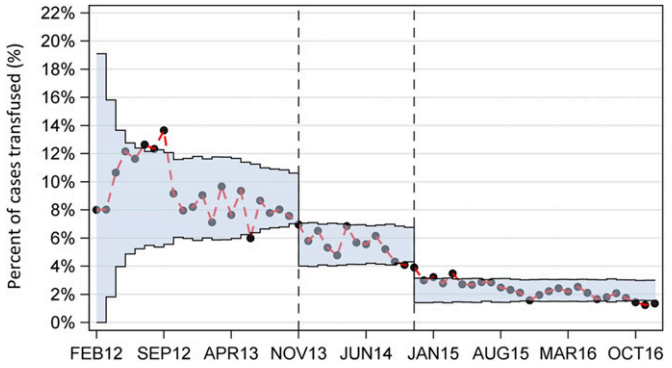


Fig. 1

The combined percent of primary THA, TKA, and UKA cases with blood transfusions represented in a statistical process control chart. The dashed red line and dots represent point estimates; the blue band represents the region between the upper and lower control limits.

registries are publication of such reports, notifications to federal and state regulatory bodies, articles in peer-reviewed publications, and presentations. While the primary focus of these efforts has been on implants, registries like the Kaiser Permanente National Joint Replacement Registry include nonimplant quality improvement activities as well[7-10].

In parallel with the proliferation of device-oriented arthroplasty registries around the world, other models for healthcare quality improvement initiatives have been developed. For example, in 1996, O'Connor et al. showed that a regional quality improvement collaborative could reduce mortality following coronary artery bypass graft procedures by 24%[11]. In the 1990s, Blue Cross Blue Shield of Michigan/Blue Care Network's (BCBSM/BCN) Value Partnerships program began applying the quality improvement collaborative model to a range of specialties and procedures, from general surgery to interventional cardiology[12]. The Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI), a part of the BCBSM/BCN Collaborative Quality Initiative (CQI) program, was started in 2012[13]. It has grown to include 66 hospitals and surgery centers and has over 209,000 cases in its registry. It is built on nonpunitive and collaborative principles. MARCQI combines the device postmarket surveillance activities of traditional arthroplasty registries with the collaborative quality improvement processes of CQIs. For more information about the structure of MARCQI, see Hughes et al.[13,14] and the Appendix.

The purpose of this paper is to describe the growth of MARCQI and its successes in improving the quality of care for patients who undergo hip or knee arthroplasty in the state of Michigan.

## Quality Improvement Initiatives

MARCQI began by focusing on reducing the risks of negative patient-care processes and adverse events associated with total hip arthroplasty (THA), total knee arthroplasty (TKA), and unicondylar knee arthroplasty (UKA) procedures. Reducing blood transfusion was selected as the first project, and subsequent quality improvement initiatives involved prevention of venous thromboembolism (VTE) and appropriateness of discharge to an extended-care facility (ECF).

### *Blood Transfusions*

In 2013, the MARCQI coordinating center observed large variations among hospitals regarding the percentage of patients having transfusions, suggesting an opportunity for improvement. Because unnecessary transfusions present risks to patients[15,16], in November 2013, MARCQI initiated a quality improvement initiative to reduce transfusions. The initiative included (1) presenting raw and risk-standardized risks at the hospital level in the Collaborative reports that are distributed to participating hospitals, (2) presenting raw and risk-standardized outcomes at Collaborative meetings, and (3) presenting the American Red Cross transfusion guidelines at Collaborative meetings. The percentage of patients undergoing TKA who received transfusions varied widely in 2013, ranging from 1% to 25%; for THA cases, the range was 7% to 39%. Hospitals with higher rates were especially motivated to examine transfusion practices; a report of 1 site's experience was published by Markel et al.[17]. By 2017, the range among hospitals had been reduced to 0% to 10% for TKA procedures, and 0% to 16% for THA.

In addition to transfusion risk in primary elective THA and TKA, MARCQI staff analyzed data on tranexamic acid (TXA) use and hemoglobin levels, and found smaller drops in hemoglobin and less risk of transfusion when TXA was used. Moreover, there was no significant increase in risk of readmission, cardiovascular events, or VTE events or increased length of stay in patients undergoing THA or TKA with use of TXA[18]. Therefore, MARCQI recommended administering TXA, recognizing this as off-label use in TKA and THA procedures.

As a result, there has been a dramatic drop in the number of transfusions throughout Michigan (Fig. 1). The percentage of primary unilateral THA cases with transfusions decreased

**TABLE I The Three Most Common Reasons for First Revision by Procedure***

| Procedure | Top 3 Reasons for Revision in First 3 Yr |
|---|---|
| THA | Instability/dislocation (24.4%) |
| | Periprosthetic fracture of the femur (21.1%) |
| | Infection (18.1%) |
| TKA | Instability (27.1%) |
| | Infection (23.1%) |
| | Pain (21.4%) |
| UKA | Pain (26.5%) |
| | Conversion of UKA (25.6%) |
| | Aseptic loosening (16.2%) |

*THA = total hip arthroplasty, TKA = total knee arthroplasty, and UKA = unicondylar knee arthroplasty.

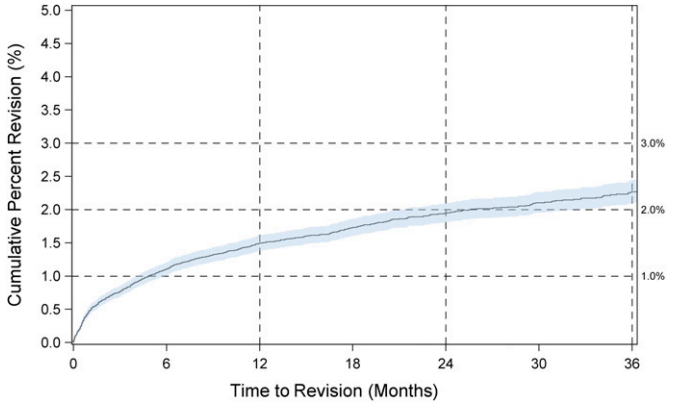


Fig. 2

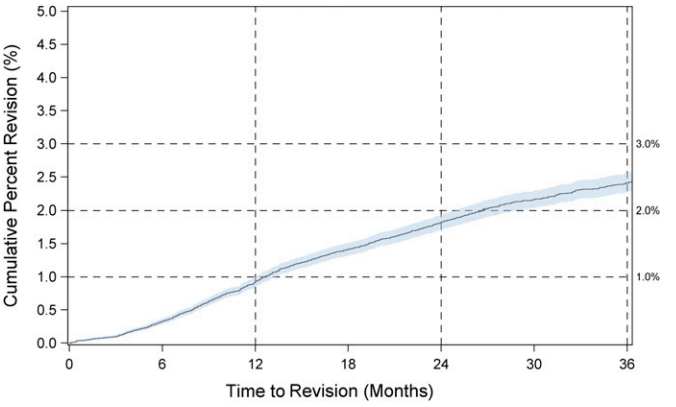


Fig. 3

**Fig. 2** The CPR for primary THA up to 3 years. The solid line represents the Kaplan-Meier estimate of time to first revision, and the blue band is the 95% confidence interval. **Fig. 3** The CPR for primary TKA up to 3 years. The solid line represents the Kaplan-Meier estimate of time to first revision, and the blue band is the 95% confidence interval.

from 12.6% before November 2013 to 3.6% for the 12 months between July 2016 and June 2017. For TKA, the rate decreased from 6.3% to 1.1% during the same period. There was no increase in length of stay, readmission, emergency department visits, or deep infections during this period. Markel et al. have described the MARCQI experience in reducing transfusions[17,19].

### *Infections*

From the start, infection prevention has been a priority for MARCQI (MARCQI's definition of infection is described in the Appendix, Part B). Raw and risk-standardized risks are reported to sites, and the Collaborative has recommended *Staphylococcus aureus* (SA) screening for all patients, with decolonizing in those who test positive. SA screening has increased from 40% of patients in 2012 to 74% in 2016, and an additional 14% were decolonized without screening. In May 2014, a 10-step infection-prevention protocol was recommended to all sites. The protocol includes preoperative, intraoperative, and postoperative elements. There are 4 preoperative elements: (1) patient education, (2) use of a chlorohexidine gluconate (CHG) wash prior to the day of surgery, (3) nasal screening for SA and decolonizing, if necessary, and (4) not removing hair unless necessary (and if needed, using clippers). There are 4 intraoperative components: (1) use of alcohol-based skin preparation agents, (2) selection of appropriate antibiotics, (3) giving antibiotics within 1 hour of making the incision, and (4) minimizing operating room traffic. Finally, there are 2 postoperative elements: (1) using sterile dressings and (2) discontinuing the antibiotics within 24 hours. While meaningful trends have been difficult to identify because of the infrequent nature of infections, the 90-day infection incidence of primary TKA and THA cases in 2017 was 0.33% and 0.53%, respectively. For comparison, the reported corresponding national values were 1.0% and 1.4%, respectively[20].

### *Discharge to an ECF*

The variation in discharge to nursing homes, also referred to as ECFs, ranged from 9% to 35% across sites. We found that patients going to an ECF had a 50% higher chance of readmission following TKA and a 30% higher chance of admission following THA. These results were still valid after patients had been divided into risk strata. Assessment of contributing factors using median odds ratios[21] found that the vast majority of variation could be explained at the surgeon and hospital levels rather than by patient factors. In the spring of 2014, hospitals were encouraged to begin quality improvement activities to discharge patients to ECFs more judiciously. Hospitals with especially high rates responded very quickly, and Charles et al. described a reduction at 3 MARCQI hospitals[22]. The overall MARCQI rate has decreased from 23% to 11.7%.

### *Future Initiatives*

MARCQI has launched 2 initiatives in 2018: (1) reducing early revisions (within 1 year), and (2) reducing overprescribing of opioids. The opioid project is being conducted in collaboration with the Michigan-Opioid Prescribing Engagement Network (M-OPEN).

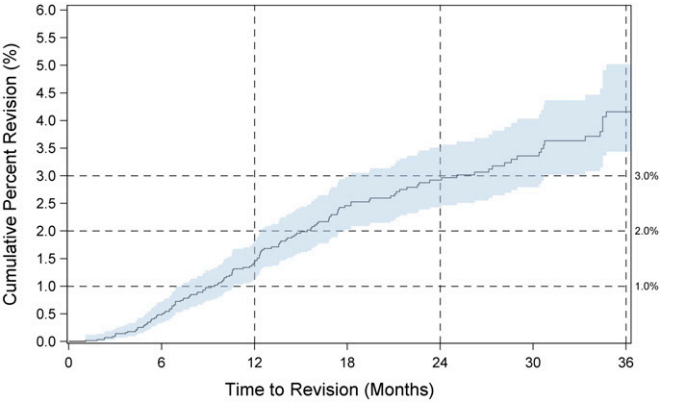


Fig. 4

The CPR for primary UKA up to 3 years. The solid line represents the Kaplan-Meier estimate of time to first revision, and the blue band is the 95% confidence interval.

**TABLE II Cumulative Percent Revision for Total Hip Arthroplasty Stem-Cup Combinations Having ≥500 Cases, Sorted Alphabetically***

| Stem | Cup | Manufacturer | No. of Cases | CPR at 3 Yr (95% CI) |
|---|---|---|---|---|
| Accolade II | Trident | Stryker | 9,929 | 2.27 (1.84, 2.81) |
| Accolade TMZF | Trident | Stryker | 860 | 1.87 (1.06, 3.31) |
| Anthology | Reflection 3 | Smith & Nephew | 1,452 | 3.26 (2.36, 4.50) |
| Corail | Pinnacle | DePuy Synthes | 1,182 | 1.48 (0.83, 2.63) |
| Fitmore | Continuum | Zimmer Biomet | 1,888 | 1.75 (1.20, 2.54) |
| M/L Taper† | Continuum | Zimmer Biomet | 4,983 | 2.42 (1.96, 2.97) |
| M/L Taper† | Trilogy | Zimmer Biomet | 1,180 | 2.67 (1.76, 4.04) |
| S-ROM | Pinnacle | S-ROM | 794 | 1.23 (0.61, 2.48) |
| Secur-Fit | Trident | Stryker | 696 | 3.63 (2.35, 5.60) |
| Secur-Fit Max | Trident | Stryker | 1,498 | 2.85 (2.00, 4.07) |
| Secur-Fit Plus Max | Trident | Stryker | 1,679 | 2.15 (1.47, 3.15) |
| Summit | Pinnacle | DePuy Synthes | 3,779 | 1.57 (1.19, 2.08) |
| Synergy | Reflection 3 | Smith & Nephew | 579 | 2.93 (1.77, 4.84) |
| Taperloc 133 | G7 | Zimmer Biomet | 1,779 | 2.28 (1.41, 3.69) |
| Taperloc 133 | RingLoc+ | Zimmer Biomet | 1,262 | 2.10 (1.41, 3.12) |
| Trabecular Metal | Continuum | Zimmer Biomet | 522 | 4.29 (2.15, 8.47) |
| Tri-Lock Bone Preservation Stem | Pinnacle | DePuy Synthes | 1,201 | 0.57 (0.25, 1.26) |

*CPR = cumulative percent revision, and CI = confidence interval. †The M/L Taper combinations exclude the M/L Taper Kinectiv implants.

## Implant Surveillance

MARCQI conducts postmarket surveillance of TKA, UKA, and THA implants through its device committee. Barcode data are collected from all of the implanted devices and are stored in the database, and a device library developed and maintained by *Orthopaedic Network News* is used to convert catalog numbers to product names and device characteristics. The 3 most common reasons for first revision for THA, TKA, and UKA are listed in Table I. Following the lead of the AOANJRR, MARCQI computes the cumulative percent revision (CPR) from the Kaplan-Meier estimate of time to first revision (if S[t] is the Kaplan-Meier estimate at time t, the CPR is $100 \times [1\text{-}S(t)]$)[23]. A revision is defined as a procedure that involves removing and replacing some or all of the hip or knee replacement components. Competing risks are not modeled[24]. The CPR is calculated for each implant combination that has ≥500 cases in the database that were registered through December 31, 2016. Figures 2, 3, and 4 summarize CPR data for 3 years postoperatively for THA, TKA, and UKA, respectively. Implant-specific revision risks for THA, TKA, and UKA implants also are computed (Tables II, III, and IV); to our knowledge, this is the first time that a regional or national registry in the United States has publicly released revision risk data by implant. Full details on these implants are available in MARCQI's 5-year report, which is available online[14]. Data on patient demographics are provided, along with information on approaches, bearing surfaces (for THA), and head size (for THA) for each implant combination. The numbers of surgeons and hospitals using each implant are reported.

## Patient-Reported Outcomes

From its inception, MARCQI intended to collect patient-reported outcome survey (PROS) data. Early experience showed the importance of physician engagement and survey brevity, resulting in modifications to our data collection methods. MARCQI now collects the Patient-Reported Outcomes Measurement Information System 10 Global Health (PROMIS-10)[25] as well as the Hip disability and Osteoarthritis Outcome Score for Joint Reconstruction (HOOS JR)[26] and Knee injury and Osteoarthritis Outcome Score for Joint Reconstruction (KOOS JR)[27] survey instruments. Collection of the PROMIS-10, KOOS JR, and HOOS JR data began in February 2013, September 2014, and July 2015, respectively. The database vendor (Ortech) has implemented e-mail and other web-based methods for patients to respond to surveys. Sites also may collect the PROS in other ways and/or use other vendors and upload the PROS data. The following time windows for PROS collection are recommended: preoperatively; 5 to 13 weeks postoperatively; 5 to 13 months postoperatively; and 2, 5, and 10 years postoperatively. The percentage of patients (THA and TKA combined) completing the PROMIS-10, the HOOS JR, and the KOOS JR surveys preoperatively, at 4 to 19 weeks postoperatively, and at 9 to 13 months postoperatively is 33.1%, 25.8%, and 15.0%, respectively. The plan for improving the PROS collection rate focuses on including it in BCBSM's hospital pay-for-performance program.

## Conclusions

Quality improvement projects have led to improved value through decreased utilization of expensive therapies such as transfusions or costly pathways such as ECF discharges.

**TABLE III Cumulative Percent Revision for Total Knee Arthroplasty Femoral-Tibial Combinations Having ≥500 Cases, Sorted Alphabetically***

| Femoral | Tibial | Manufacturer | No. of Cases | CPR at 3 Yr (95% CI) |
|---|---|---|---|---|
| Attune | Attune | DePuy Synthes | 4,870 | 2.42 (1.60, 3.66) |
| Evolution MP | Evolution MP | MicroPort Orthopedics | 548 | 2.16 (1.01, 4.58) |
| Genesis II | Genesis II | Smith & Nephew | 4,944 | 3.99 (3.26, 4.87) |
| Journey II | Journey | Smith & Nephew | 1,581 | 5.07 (3.30, 7.73) |
| LCS complete | MBT | DePuy Synthes | 665 | 5.42 (3.19, 9.13) |
| Legion | Genesis II | Smith & Nephew | 747 | 2.92 (1.54, 5.50) |
| NexGen LPS GS | NexGen Precoat | Zimmer Biomet | 505 | 2.08 (1.12, 3.83) |
| NexGen LPS option | NexGen Precoat | Zimmer Biomet | 583 | 1.65 (0.83, 3.29) |
| NexGen LPS option | NexGen TM | Zimmer Biomet | 983 | 0.84 (0.40, 1.77) |
| NexGen option | NexGen option | Zimmer Biomet | 860 | 1.23 (0.57, 2.64) |
| NexGen option | NexGen Pegged | Zimmer Biomet | 527 | 2.25 (1.15, 4.39) |
| NK II | NK II | Zimmer Biomet | 903 | 0.87 (0.36, 2.10) |
| NK II GS | NK II | Zimmer Biomet | 1,574 | 1.43 (0.78, 2.64) |
| Persona | Persona | Zimmer Biomet | 18,633 | 2.29 (2.00, 2.63) |
| Sigma | MBT | DePuy Synthes | 600 | 3.54 (2.20, 5.67) |
| Sigma | Sigma | DePuy Synthes | 1,249 | 3.17 (2.23, 4.51) |
| Sigma PFC | Sigma | DePuy Synthes | 2,377 | 1.38 (0.93, 2.04) |
| Triathlon | Triathlon | Stryker | 10,536 | 2.02 (1.64, 2.49) |
| Triathlon | Triathlon TS | Stryker | 10,261 | 2.22 (1.85, 2.66) |
| Vanguard | Maxim | Zimmer Biomet | 12,110 | 2.41 (2.06, 2.82) |
| Vanguard | Maxim Mono-Lock | Zimmer Biomet | 576 | 3.09 (1.70, 5.56) |

*CPR = cumulative percent revision, CI = confidence interval, and MBT = mobile bearing tibial.

Through annual savings determinations, MARCQI has consistently demonstrated savings to its sponsor (BCBSM/BCN), financially justifying support for the program. In 2016, MARCQI estimated an annual cost savings from transfusion, ECF utilization, and readmission reductions to be approximately 4, 20, and 1 million dollars per year, respectively[14]. Cost savings estimates are based on changes in rates of events (transfusions, discharges to an ECF, and readmissions) and costs that are estimated from BCBSM/BCN claims and published data. Because the United States faces an imperative to improve health-care value, efforts like MARCQI that increase quality while reducing cost may play a very important part in solving the health-care financing crisis.

The MARCQI experience has shown that a collaborative quality improvement model can be applied successfully on the scale of 60 to 70 hospitals. This is important because mergers and acquisitions of hospitals have created many health systems of this approximate size. Health systems could develop and operate MARCQI-like quality improvement efforts to reduce 90-day adverse events. Moreover, MARCQI is a model for other states of similar size. For larger states such as California, Texas, and New York, it may be necessary to break the states into several collaboratives in order to manage the size of the collaborative meetings and to facilitate interaction.

Although MARCQI has improved the quality of care in Michigan, a comprehensive United States registry is

**TABLE IV Cumulative Percent Revision for Unicondylar Knee Arthroplasty Femoral-Tibial Combinations Having ≥500 Cases, Sorted Alphabetically***

| Femoral | Tibial | Manufacturer | No. of Cases | CPR at 3 Yr (95% CI) |
|---|---|---|---|---|
| Oxford | Oxford | Zimmer Biomet | 1,664 | 4.33 (3.11, 6.02) |
| Restoris MCK | Restoris MCK | Stryker | 1,721 | 4.04 (2.26, 7.16) |
| Zimmer High Flex | Zimmer High Flex | Originally Zimmer Biomet, but sold to Smith & Nephew in 2015 and marketed as ZUK Unicompartmental Knee | 1,970 | 2.95 (2.12, 4.11) |

*CPR = cumulative percent revision, and CI = confidence interval.

needed in order to have adequate capture of the number of revisions for the nationwide postmarket surveillance of implants. When the AJRR has achieved its goal of full national coverage, it will accrue cases fast enough to identify outlier devices much faster than regional registries, resulting in a reduced number of failures and improved public health.

## Appendix

eA Data showing the structure and function of MARCQI, the definition of infection that is used by MARCQI, and MARCQI's risk-standardization methodology are available with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/E968). ■

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