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ORIGINAL RESEARCH

Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) as a model for regional registries in the United States

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Background: The United States has been a difficult environment in which to develop arthroplasty registries, largely because of the absence of a national health system. The purpose of this paper is to describe the development of a statewide registry-based quality improvement collaborative in Michigan.

Methods: The Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) was started in 2011 to improve the quality of care for total hip and knee replacement patients in Michigan. It is funded by Blue Cross and Blue Shield of Michigan/Blue Care Network as part of their Collaborative Quality Initiative (CQI) program. The CQI concept depends on capturing high-quality data (clinical status, process, and outcome), rigorously developing risk-adjustment models, and presenting risk-adjusted data to collaborative members at four face-to-face meetings a year.

Results: MARCQI has grown to include 44 hospitals and 377 orthopedic surgeons. The registry contains 54,848 cases (18,421 hips and 36,427 knees). Four collaborative-wide quality improvement activities have been initiated: 1) transfusion reduction, 2) deep vein thrombosis and pulmonary emboli prevention, 3) infection prevention, and 4) readmission prevention.

Conclusion: The CQI model developed by Blue Cross and Blue Shield of Michigan/Blue Care Network can be adapted to hip and knee arthroplasty, which demonstrates that private payers can play a role in the development and promotion of arthroplasty registries in the United States.

Keywords: registry, arthroplasty, hip, knee, quality, collaboration

Introduction

Arthroplasty registries have been shown to be powerful tools for hip and knee replacement quality improvement.[1] Despite the development of successful institutional registries,[2,3] the United States has been a difficult environment in which to develop regional and national registries. Two efforts to develop nationwide registries failed[4] prior to the start of the American Joint Replacement Registry (AJRR) in 2009. Only one health network registry (Kaiser Permanente)[5] has been operating for more than 10 years, and a community registry (HealthEast Joint Replacement Registry)[6] has been in operation for over 20 years. Registry development has been hindered by financial, legal, and privacy factors. Private payers have been reluctant to support a large registry that will benefit their competitors, legal impediments include ambiguous federal regulation regarding consent requirements, and privacy issues include reluctance of individuals and institutions to share Social Security Numbers.

Despite these challenges, we have developed the Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI), a statewide consortium of 44 hospitals

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representing more than 377 surgeons, which includes active, structured inter-institutional collaboration for quality and process/outcome improvement. The purpose of this paper is to describe the origin, structure, and progress of MARCQI in light of the challenges described.

MARCQI overview

MARCQI has three goals: 1) improve patient safety and the quality of care for patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures in Michigan, 2) improve quality of total joint replacement procedures by rapidly identifying poorly performing new orthopedic technologies through the analysis of registry outcome data, and 3) demonstrate to patients and purchasers that MARCQI institutions are improving the value of arthroplasty services by utilizing available resources responsibly and efficiently.

MARCQI is part of the Collaborative Quality Initiative (CQI) program developed and funded by the Value Partnerships program of Blue Cross and Blue Shield of Michigan/Blue Care Network (BCBSM/BCN). Financial support from BCBSM/BCN for the operation of the MARCQI coordinating and data management centers is $1.48 million annually. BCBSM/BCN's first CQI, which was started in 1997, focused on percutaneous coronary interventions. In 2004, BCBSM/BCN expanded the program to 13 other areas.[7–9] The CQI model includes rigorously validated collection of data on patient risk factors, processes of care, and outcomes. These data are entered into a registry. Risk-adjusted outcomes are shared at face-to-face quarterly meetings in a non-punitive, confidential framework for orchestrated quality improvement. The CQI model has been shown to reduce complications. The Michigan Bariatric Surgery Collaborative has reduced complications from 8.7% to 6.6%. The Percutaneous Cardiology Intervention CQI reduced in-hospital death by a relative 27%.[10]

Quarterly meetings are a critical part of the CQI model because they provide a forum for disseminating hospital-specific data, sharing best practices, and developing consortium-wide quality improvement. Each site designates an orthopedic surgeon as their MARCQI clinical champion to attend quarterly meetings and promote quality improvement activities within their institution. Sites also send their clinical data abstractors, and quality administrator to each quarterly meeting. A hospital information technology specialist from each hospital is required to attend one quarterly meeting a year to receive information on updates to the registry and requirements for file-based upload of administrative data. The quarterly meeting, which is a half-day in length, has three components: 1) a device committee meeting, 2) general assembly, and 3) break-out sessions. The device committee reviews data on implant performance using methods similar to those developed by the Australian Orthopaedic Association National Joint Replacement Registry. The committee consists of orthopedic surgeons, biostatistician, quality improvement expert, and two biomedical engineers. The general assembly is the focus of the meeting where collaborative-wide and hospital-specific risk-adjusted adverse event data are presented. Ample time is provided for discussion. Presentations on national guidelines are presented sometimes. Panel discussions are also included to share best practices. Hospitals with especially low risks are asked beforehand to provide representatives to serve on the panels. Extensive panel and audience interaction occurs. Following the general assembly there are break-out sessions for the clinical data abstractors and clinical champions. The clinical champion session, which forms the medical advisory committee, serves to prioritize quality improvement initiatives and provide input to the executive committee. It is important to note that the overall management and direction are guided by participating physicians through the medical advisory committee.

MARCQI consists of the participating sites, a coordinating center, a database vendor (Ortech, London, ON, Canada), and a data management center. The coordinating center, housed at the University of Michigan, oversees data quality, data use agreements, training of data abstractors, collaborative-wide quality improvement initiatives, budgeting, contracting for information technology, organization of quarterly meetings of collaborative members, and interfacing with BCBSM/BCN. It employs a project manager, three full-time data auditors, and an administrative assistant. Ortech, which is the information technology vendor, is responsible for developing and maintaining the registry database according to industry and regulatory security standards. It produces "dashboard" reports for sites and physicians that are available via the web. The data management center, which receives raw data from Ortech, cleans and validates the data, computes metrics of data completeness, prepares quarterly reports, conducts analyses for presentation at the quarterly meetings, and develops risk-adjustment models. Day-to-day leadership of the coordinating center and data management center is provided, respectively, by a project manager and the Director of the Quality Institute at St Joseph Mercy Hospital – Ann Arbor.

To be eligible to participate in MARCQI, a hospital must satisfy two fundamental criteria: 1) be located in Michigan, and 2) perform at least 200 elective total hip

or knee procedures (combined) annually. Conditions of participation are clearly stated at the time of site recruitment, and they also include: identify all eligible patients presenting at the facility, contribute data to MARCQI database on a weekly basis, provide adequate computer resources, have an active quality improvement committee, identify an onsite clinical champion, identify an administrative lead, identify an information technology administrative lead, hire clinical data abstractor(s), collaborate with the coordinating center, and collaborate with other MARCQI sites.

Each participating site contributes data on 100% of total hip and knee replacement procedures performed. Thus, all physicians performing these procedures at MARCQI sites contribute data to the registry. Annual audits of each site are performed to ensure that all eligible cases are entered into the database. The operating room log is compared to the database to ensure that all eligible cases are abstracted. At the end of the 150-day period the data record is locked. Thus, it is possible to have incomplete data. However, the annual audits also address data completeness.

Data are owned by the collaborative rather than BCBSM/BCN. BCBSM/BCN has found through the development of its CQI program that it is important to have a firewall between itself and the database to assure the integrity of the data and maintain participants' confidentiality and the collaborative, statewide quality improvement process. The focus on measurement to improve rather than to judge facilitates open sharing of best practices. BCBSM/BCN does not request identifiable patient, physician, or hospital data from MARCQI; however, it does receive aggregate data on the performance of the consortium and the range of performance of participants in a de-identified format.

Governance of MARCQI is organized around co-directors, an executive board, and a medical advisory committee. The MARCQI executive board consists of the co-directors, project manager, director of the data management center, committee chairs (patient-reported outcome measures, device, and data abstractor), and five orthopedic surgeons from participating sites. There is a larger medical advisory committee that consists of all site clinical champions, co-directors, project manager, and the data management center director. The executive committee and medical advisory committee meet quarterly. Also supporting the collaborative are a data and publications committee, a device committee that guides the analysis of implant data, and a patient reported outcome survey committee to develop methods for collecting patient reported outcome surveys in clinical practices and a clinical data abstractor committee.

Conflict of interest and confidentiality are carefully managed. MARCQI requires annual disclosure by all physicians and other personnel having access to collaborative data.

Data organization

MARCQI collects level I, II, and III data (defined later) on qualifying procedures (Table 1). It plans to collect level IV data starting in 2015. Level I data consist of data elements that define the operative intervention, including implant model and manufacturer, and includes protected health information such as name and Social Security Number. Level II has elements relating to adverse events, additional demographic information, and comorbidities. Level III consists of patient-reported outcomes surveys. Table 2 lists the data elements. The process for selecting data elements began in 2009, with the philosophy to minimize the number of data elements as much as possible so that there would be sufficient time to properly identify and follow-up patients,

Table 1 ICD-9-CM codes used to define inclusion criteria for cases

Procedure name	ICD-9-CM code	Description
Total knee replacement	81.54	Total knee replacement
Revision knee replacement	81.55	Revision total knee replacement, not otherwise specified
	00.80	Revision of knee replacement, total (all components)
	00.81	Revision of knee replacement, tibial component including tibial insert
	00.82	Revision of knee replacement, femoral component
	00.83	Revision of knee replacement, patellar component
	00.84	Revision of knee replacement, isolated revision of tibial insert
Total hip replacement	81.51	Total hip replacement, the femoral head is excised, osteophytes are removed, and acetabulum is reamed out before replacement is inserted in the femoral shaft.
Revision hip replacement	81.53	Revision of hip replacement, not otherwise specified
	00.70	Revision of hip replacement, both acetabular and femoral components
	00.71	Revision of hip replacement, acetabular component
	00.72	Revision of hip replacement, femoral component
	00.73	Revision of hip replacement, acetabular liner and/or femoral head only
Hip resurfacing	00.85	Resurfacing hip, total, acetabulum and femoral head

Abbreviation: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

Table 2 Data elements

Data element number	Data element name
1	Hospital – MARCQI Registered No
2	Hospital – Full Name
3	Hospital – Short Name
4	Hospital – Street Address
5	Hospital – City
6	Hospital – State
7	Hospital – Zip
8	Hospital – Phone number
9	Hospital – National Provider Identifier
10	Hospital – Patient Social Security Number Hash Preference
11	Hospital – Patient Social Security Number Hash Preference Decision Date
12	Hospital – Pre/Postoperative PRO Email Method Preference
13	Hospital – Pre/Postoperative PRO Email Method Preference Decision Date
14	Surgeon – Registered Surgeon ID
15	Surgeon – First Name
16	Surgeon – Last Name
17	Surgeon – Middle Name/Initial
18	Surgeon – National Provider Identifier (NPI)
19	Surgeon – Hospital Privileges
20	First Name – Patient
21	Last Name – Patient
22	Middle Name/Initial – Patient
23	Suffix – Patient
24	Date of Birth – Patient
25	Year of Birth – Patient
26	Sex – Patient
27	Home Street Address – Patient
28	Home City – Patient
29	Home State – Patient
30	Home Zip Code – Patient
31	Home Phone Number – Patient
32	Cell Phone Number – Patient
33	Email Address – Patient
34	Email Address – Not Available – Patient
35	Social Security Number Hashed – Patient
36	Education Level – Patient
37	Employment Status – Patient
38	Ethnicity – Patient
39	Race – Patient
40	Marital Status – Patient
41	Profession – Patient
42	PRO Security Question – Patient
43	Security Answer – Patient
44	Smoking Status
45	Smoking Years – Patient History
46	Smoking Packs Per Day – Patient History
47	Bleeding Disorder or Contraindication to Anticoagulation – Patient History
48	Postoperative Events
49	Question not answered
50	Death
51	Date of Death
52	Withdrawn from MARCQI (withdrawn from the registry)
53	Deep Venous Thrombosis (DVT)
54	Pulmonary Embolism (PE)
55	Deep Venous Thrombosis or Pulmonary Embolism
56	DVT or PE During Index Hospitalization
57	DVT or PE Postdischarge
58	Urinary Tract Infection (UTI)
59	Hematoma
60	Date of Hematoma
61	Hematoma Requiring Irrigation and Debridement
62	Date of Hematoma
63	Deep Infection
64	Readmission
65	Emergency Room Visit without Readmission
66	Dislocation
67	Fracture (related to the total joint)
68	Hardware (mechanical) failure
69	Other Return to OR
70	No 90-Day Postoperative Events
71	Postoperative Event Date
72	Postoperative Event Relationship
73	Event – Action Taken – Related to Case, within 90 days – Patient
74	Planned Hospital
75	Hospital Medical Record Number (MRN)
76	Encounter Number
77	Joint
78	Side
79	Planned Surgeon
80	Planned Date of Surgery
81	Actual Date of Surgery
82	Time of Surgery
83	Principal Procedure (ICD-9-CM)
84	Principal Procedure (CPT)
85	Principal Procedure Performed (Descriptive)
86	Is Primary Procedure?
87	Principal Diagnosis (ICD-9-CM)
88	Principal Diagnosis POA
89	Insurer Type
90	Age at Date of Surgery – Patient
91	PRO Method
92	Preoperative Albumin
93	Preoperative Albumin Date
94	Preoperative Creatinine
95	Preoperative Creatinine Date
96	Preoperative Hemoglobin
97	Preoperative Hemoglobin Date
98	Preoperative Platelet Levels
99	Preoperative Platelet Levels Date
100	Preoperative INR
101	Preoperative INR Date
102	MRSA/MSSA Screening
103	MRSA/MSSA Screening Date
104	MRSA/MSSA Screening Result
105	MRSA Decolonized?

Table 2 (*Continued*)

Data element number	Data element name
106	Preoperative Surgical Checklist
107	Preoperative Anticoagulation Medications
108	Preoperative Antimicrobial Medications
109	Preoperative Antiplatelet Medications
110	Preoperative Diabetic Treatment
111	Preoperative Diabetic Treatment – Diet
112	Preoperative Diabetic Treatment – Insulin
113	Preoperative Diabetic Treatment – Oral
114	Preoperative Diabetic Treatment – Both
115	Preoperative Diabetic Treatment – Other
116	Preoperative Diabetic Treatment – None
117	Preoperative Diabetic Treatment – Unknown
118	Preoperative Steroids
119	Preoperative Narcotics
120	Assistive Devices
121	Height – Patient
122	Weight – Patient
123	BMI at Date of Surgery – Patient
124	Admission Date
125	Admission Type
126	Discharge Date
127	Discharge Disposition
128	Length of Stay in Days
129	Blood Transfusion During Stay
130	Date of Blood Transfusion
131	Number of Units of Red Blood Cells (RBCs)
132	Date of Action Taken for Event
133	American Society of Anesthesiologists (ASA) Classification
134	Intraoperative Complication – Fracture
135	Intraoperative Complication – Nerve Injury
136	Intraoperative Complication – Tendon/ Ligament Injury
137	Intraoperative Complication – Vascular Injury
138	Intraoperative Complication – Other
139	Intraoperative Complication – None
140	Anesthesia – Spinal
141	Anesthesia – Epidural
142	Anesthesia – General
143	Anesthesia – Block
144	Anesthesia – Local
145	Anesthesia – Other
146	Surgical Approach
147	Social Security Number Declined – Patient
148	Optional Techniques – ETO (hip only)
149	Optional Techniques – Computer Assisted
150	Optional Techniques – Robotic Surgery
151	Optional Techniques – Custom Implants
152	Optional Techniques – Prefabricated Blocks (Knees Only)
153	Surgical Incision Open Time
154	Time from Incision to Closure
155	Device Manufacturer
156	Device Catalog Number
157	Device Lot Number
158	Postoperative Hemoglobin
159	HGB Post, Patient with Nadir HGB<7
160	HGB Delta, postoperative minus preoperative levels
161	Postoperative Hemoglobin Date
162	Postoperative INR
163	Postoperative INR Date
164	Previous DVT/PE – Patient History
165	Previous Anterior Cruciate Ligament (ACL) Surgery on Surgical Knee
166	Previous Arthroscopy on the Surgical Joint – Patient History
167	Previous Infection on the Surgical (knee/hip) Joint – Patient History
168	Email Address – Opt Out – Patient
169	Smoking, Pack Years (if Applicable) Patient History
170	Preoperative HbA_{1c} Level
171	Preoperative HbA_{1c} Date
172	Preoperative Diabetes Mellitus
173	Intraoperative Tranexamic Acid
174	VTE Prophylaxis Type
175	VTE Prophylaxis Date of Initiation
176	VTE Prophylaxis Stop Date
177	VTE Prophylaxis Duration
178	VTE Prophylaxis – Chronic Treatment
179	VTE Diagnostic Testing Performed
180	VTE Diagnostic Testing Date
181	VTE Diagnostic Testing Positive Result
182	Unable to Access Surgeon Notes
183	Complete Data Flag
184	PROMIS-10 (10 questions)
185	HOOS-PS (5 questions)
186	KOOS-PS (7 questions)

Abbreviations: MARCQI, Michigan Arthroplasty Registry Collaborative Quality Initiative; ID, identification; PRO, patient reported outcome; HGB, hemoglobin; OR, operating room; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; CPT, current procedural terminology; POA, present on admission; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*; BMI, body mass index; INR, international normalized ratio; ETO, extended trochanteric osteotomy; HBA1c, hemoglobin A1c; VTE, venous thromboembolism; PROMIS, Patient Reported Outcome Measurement Information System; HOOS-PS, Hip Osteoarthritis Outcome Score-Physical Function Short form; KOOS-PS, Knee Osteoarthritis Outcome Score-Physical Function Short form.

collect key data elements, identify relevant complications in a consistent fashion, risk-adjust based on comorbidities, and assess technical aspects of the procedure. Changes to data elements are allowed only once per year.

MARCQI is an all-payer registry that uses manual abstraction from the medical record, administrative data uploads, medical device file uploads, and access to a statewide database of billing records. Each site has at least one clinical data abstractor, trained by the coordinating center, who is responsible for submitting all site-generated data into the registry. BCBSM/BCN funds 80% of the cost

of each data abstractor, according to an assumption that each abstractor can abstract 700 cases per year. Hospitals performing more than 700 cases annually are eligible for multiple abstractors. Data abstractors perform the manual medical record review for their hospitals, enter the corresponding data elements into an online interface, and ensure their sites upload administrative and device data to the registry. Data abstractors utilize the medical records systems of their institutions. They extract select data elements and enter them in an online form for the Ortech database. There is a 90-day post-operative time window for almost all events (the exception being revision, which can be captured indefinitely into the future). An incomplete data record is flagged by the system, and each abstractor can see a list of incomplete records. The abstractor is given 60 days past the 90-day window to complete the record, which creates a 150-day delay in providing complete data to the database for analysis. Device data included consist of device manufacturer catalog number, and lot number. Sites are given flexibility in how these data are captured. Some upload files generated by their supply chain data; others scan bar codes on packaging.

When a new site joins MARCQI, coordinating center staff perform an initial introductory visit and then an initial audit. Feedback for improvement is provided during the audits. Annual site audits are conducted to assure consistency and accuracy of data element interpretation across participating sites and to validate completeness and accuracy of data entered. Data abstractors are also required to attend quarterly meetings, during which there is a special break-out session for them to discuss data issues. The coordinating center also conducts periodic in-services to update and clarify data specifications, and distributes updated specifications and other correspondence.

Institutions are incentivized to participate in MARCQI through a variety of mechanisms. The first is the value of the data itself, which are provided back to the hospitals to facilitate quality improvement and allows benchmarking with others across the state. The second benefit is financial support to offset the salary for the data abstractor, who is encouraged to work on local quality improvement projects. The third is recognition as a participant in quality improvement and maintenance of "Blue Distinction Center" of BCBS/BCN. Finally, the hospitals are incentivized through a pay-for-performance program rewarding participation, attendance at collaborative meetings, and quality improvement gains. MARCQI advocates strongly for consortium-wide improvement goals rather than mere site-level progress to maintain the benefits of the collaborative effort and avoid counterproductive activity between sites.

The Michigan Inpatient Database (MIDB), which is managed and operated by the Michigan Health and Hospital Association Service Corporation, is used to track subsequent hospitalizations of the total joint cohort at any of the participating sites (regardless of where the index surgery was performed) over an open-ended follow-up period. The MIDB contains encounter-level inpatient hospital discharge (all payer) data that include the hospital medical record number, principal diagnosis and procedure, secondary diagnoses and procedures, diagnostic related group, discharge disposition, and basic demographic information. Michigan Health and Hospital Association Service Corporation technical staff create a unique patient identifier within their database using protected health information identifiers supplied by its member hospitals, and are able to match records of the index and subsequent hospitalizations at the patient level across participating hospitals. An extract of the MIDB data is submitted to the information technology vendor on a quarterly basis, contingent on the conditions specified in the data use and business associate agreements. For example, subject level data may not be shared with any payer organization, nor can the MIDB data be used to contact individual patients. Ortech then uses the hospital medical record number and other available patient identifiers to link the MIDB records to the corresponding patient data submitted by the MARCQI data abstractors. A summary of the data flow model is provided in Figure 1.

Privacy issues are paramount in MARCQI operations, and compliance activities require a significant amount of staff effort. MARCQI adheres to Health Insurance Portability and Accountability Act and Health Information Technology for Economic and Clinical Health privacy rules. Business associate and data use agreements are required for all sites. Additional agreements are required for those sites that request MARCQI to share their data with the AJRR. Because MARCQI is a quality improvement initiative rather than a research enterprise, it operates under the "not regulated" status defined by federal statutes for human subject research (45 Code of Federal Regulations 46) as advised by the University of Michigan's Institutional Review Board.

Progress

MARCQI grew in planned stages from two hospitals in 2011 to 12 in 2012, 29 in 2013, and 44 in 2014 (there are a total of 115 hospitals in Michigan, of which 55 perform more than 200 hip and knee replacements annually). In 2015 the

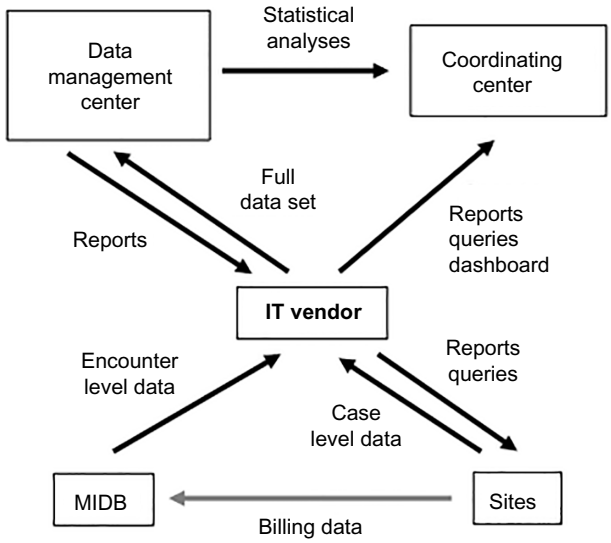

Figure 1 Data flow schematic illustrating elements of MARCQI and data flows between them.
Notes: Key activities include: 1) participating sites submit case-level data along with protected health information (PHI) to the secure website of the information technology (IT) vendor (Ortech); 2) the Michigan Inpatient Data Base (MIDB) submits encounter-level data on elective total joint replacement surgeries performed at participating hospitals as well as the subsequent hospitalizations for these patients to the registry along with available PHI for linkage purposes only; 3) the IT vendor assigns a registry identification number for each unique patient as well as an identification number for each qualifying surgical event, and uses the available PHI to assign the applicable registry identification numbers to MIDB data; 4) the IT vendor provides the data management center with registry data (full data set) that has patient names, medical record numbers, and social security numbers removed; 5) the data management center prepares reports of aggregated data to the coordinating center and to the IT vendor that the sites access through the IT website; case-level data sets are also submitted to the IT vendor so that sites can access these and perform analyses of their own cases through an online query system; 6) the IT vendor provides reports, queries, and dashboard to the coordinating center. The link from sites to MIDB is represented in gray because this transfer of data is done outside of the MARCQI framework; all hospitals in Michigan submit their billing data for all inpatient discharges to MIDB independent of MARCQI.
Abbreviation: MARCQI, Michigan Arthroplasty Registry Collaborative Quality Initiative.

Figure 2 MARCQI sites across Michigan.
Notes: Dots indicate locations of participating hospitals. Both the lower and upper peninsulas of Michigan are represented.
Abbreviation: MARCQI, Michigan Arthroplasty Registry Collaborative Quality Initiative.

final cohort of hospitals will join to bring the total to 50. The phased implementation contributed to systematic growth in database functionality, data definitions, staff growth, and development of operational policies and procedures. MARCQI hospitals range from community hospitals to large academic medical centers, and they are spread across the state (Figure 2). Growth in the number of registered cases has been rapid (Figure 3). As of October 27, 2014, a total of 54,848 cases had been registered (18,421 THA and 36,427 TKA). Full data collection lags because there is a 150-day window (90-days follow-up and 60 additional days allocated to complete data collection) for data to be fully abstracted. Thus, the number of cases that have completed the data abstraction period is 8,045 THA and 15,535 TKA. Eleven quarterly meetings have been held.

Completeness of level I and II data is 98.5%. A case is defined as a scheduled qualifying procedure that matches with an actual surgical procedure performed and contained in the hospital's operating room log. Eight key categories of data are required per case: 1) patient demographics, 2) laboratory values, 3) evidence that the surgery actually occurred (operating room file), 4) data about the operation itself, 5) information about the device implanted, 6) perioperative information, 7) information on whether or not venous thromboembolism prophylaxis was given, and 8) evidence

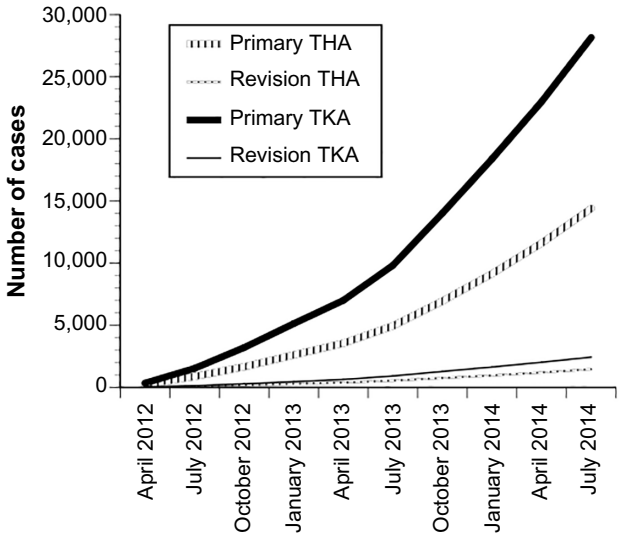

Figure 3 Growth of case registrations since inception (sum of primary and revision total hip and total knee arthroplasties).
Abbreviations: THA, total hip arthroplasty; TKA, total knee arthroplasty.

Table 3 Collaborative-wide procedure and event statistics

Measure	Unilateral TKA		Bilateral TKA		THA	
	N	Mean (SD) or frequency (%)	N	Mean (SD) or frequency (%)	N	Mean (SD) or frequency (%)
Length of stay (days)	15,532	2.6 (1.2)	447	3.6 (1.6)	8,042	2.6 (1.4)
Age (years)	15,535	66.0 (9.8)	450	62.1 (8.0)	8,045	65.0 (11.6)
BMI (kg/m^2)	15,456	33.1 (7.0)	447	32.8 (6.7)	8,023	30.4 (6.3)
Sex	15,504		450		8,035	
Female		9,593 (61.9)		229 (50.9)		4,352 (54.2)
Male		5,909 (38.1)		221 (49.1)		3,683 (45.8)
Race					8,034	
Caucasian	15,504	13,562 (87.5)	450	418 (92.9)		7,066 (88.0)
Non-Caucasian		1942 (12.5)		32 (7.1)		968 (12.0)
Approach	15,530		896		8,042	
Medial parapatellar, quad-splitting		12,668 (81.6)		695 (77.6)		N/A
Lateral parapatellar		53 (0.3)		5 (0.6)		N/A
Mid-vastus		2,237 (14.4)		180 (20.1)		N/A
Sub-vastus		438 (2.8)		5 (0.6)		N/A
Posterior		N/A		N/A		4,445 (55.3)
Anterior		N/A		N/A		1,236 (15.4)
Transtrochanteric		N/A		N/A		76 (0.9)
Anterolateral		N/A		N/A		2,232 (27.8)
Other/unknown		134 (0.9)		11 (1.2)		53 (0.6)
Operative complications	15,526		896		8,040	
Intraoperative fracture		33 (0.2)		0 (0.0)		109 (1.4)
Intraoperative nerve injury		2 (0.0)[c]		2 (0.2)		5 (0.1)
Intraoperative tendon injury		13 (0.1)		1 (0.1)		6 (0.1)
Intraoperative vascular injury		8 (0.1)		0 (0.0)		3 (0.1)[c]
Other		20 (0.1)		1 (0.1)		16 (0.2)
90-day events	15,535				8,045	
Dislocation[a]		6 (0.0)[c]	900	0 (0.0)		73 (0.9)
Deep infection[a]		56 (0.4)	900	3 (0.3)		49 (0.6)
Fracture[a]		25 (0.2)	900	1 (0.1)		84 (1.0)
Hardware failure[a]		3 (0.0)[c]	900	0 (0.0)		4 (0.0)[c]
Other return to OR[a]		625 (4.0)	900	35 (3.9)		45 (0.6)
Missing (not abstracted)[a]		150 (1.0)	900	16 (1.8)		83 (1.0)
ED visit[b]		1,449 (9.3)	450	32 (7.1)		659 (8.2)
Death[b]		24 (0.2)	450	0 (0.0)		17 (0.2)
Readmission[b]		833 (5.4)	450	14 (3.1)		468 (5.8)
UTI[b]		174 (1.1)	450	8 (1.8)		108 (1.3)

Notes: [a]Computed per procedure; [b]computed per hospitalization; [c]a small number of events occurred, but the percentage was less than 0.05% and is rounded to 0.0%.
Abbreviations: TKA, total knee arthroplasty; THA, total hip arthroplasty; SD, standard deviation; BMI, body mass index; N/A, not applicable; ED, emergency department; OR, operating room; UTI, urinary tract infection.

that postoperative surveillance occurred and events recorded. MARCQI considers data submission "complete" if the site submits at least some data elements per key category per case. If no information is provided for any of the above eight categories of data, then the information is considered incomplete for the given case. Collection of level III data, however, lags far behind at only approximately 25%. Overall collaborative performance is illustrated in Table 3.

Because there is variability in case mix between providers (hospitals or surgeons), it is necessary to adjust or standardize the risk estimates for patient-level variables that may contribute to an unwanted outcome. We do this using methodology developed by Yale New Haven for the Centers for Medicare and Medicaid Services.[11] This entails fitting a logistic regression model to determine patient-level predictors for each outcome and then fitting these predictors in a hierarchical logistic regression model to estimate the risk of the outcome in patients cared for by that provider compared to what would be expected if the average provider cared for that same case mix. We initially calculated these metrics for all cases in the database, but as quality improvement initiatives have matured we are reporting the standardized ratios and risks as rolling estimates to capture changes in outcomes over time.

MARCQI has initiated four collaborative-wide quality improvement projects: 1) red blood cell transfusion reduction, 2) deep venous thrombosis/pulmonary embolism prevention, 3) infection prevention, and 4) readmission prevention. Hospital-specific rates for each of these have been presented to the collaborative at quarterly meetings, with risk adjustment. The transfusion initiative focuses on reducing the percentage of cases in which a transfusion is given to patients with hemoglobin greater than 8 g/dL. It grew out of an initial investigation of bleeding rates and is in response to a growing body of literature that demonstrates increased risk of complications and mortality associated with use of transfusions during the same hospitalization. Data suggest a change in transfusion practices has occurred since initiation of this quality improvement project. The deep venous thrombosis/pulmonary embolism initiative has focused on highlighting the inter-site variability in prophylaxis regimens while MARCQI accrues a sufficient sample to compare the effectiveness of these practices. The infection prevention work includes achieving consensus on evidence-based prophylactic measures. The readmission project includes analysis of length of stay in the hospital as well as disposition at discharge (extended care facility, home care, home). This project is driven in part by the Center for Medicare and Medicaid Services Readmission Measure, which bases hospital reimbursement adjustments on readmission rates. MARCQI plans to better define the risk adjustment techniques and variables that influence readmission rates between patients and institutions and use that information to reduce readmissions and variability across institutions.

MARCQI encourages sites to participate in the AJRR. MARCQI uploads level I data to AJRR for hospitals that elect to have data submitted to AJRR. Twelve hospitals have chosen to do this.

Limitations and future directions

While MARCQI is an innovative approach to quality improvement and registries in the United States, it has limitations. Most notably, it is a regional effort contained within a single mid-sized state. Patient care events outside of Michigan following the primary procedure are not captured. However, MARCQI is able to capture events that require hospital admissions at other hospitals within Michigan other than the hospital where the arthroplasty procedure was performed. This is done through linking data with the MIDB, which contains the billing data for all hospital discharges in Michigan. The inability to capture revisions occurring outside of Michigan emphasizes the critical need for the development and success of the AJRR.

Future directions for MARCQI include medical device post-marketing surveillance and assisting others develop similar collaboratives. National registries such as the Swedish Hip Arthroplasty Register, Swedish Knee Arthroplasty Register, Australian Orthopaedic Association National Joint Replacement Registry, and the National Joint Registry of England, Wales and Northern Ireland have demonstrated the power of analyzing revision risk associated with individual implants and classes of implants. MARCQI seeks to conduct similar analyses in the future. Additionally, MARCQI leadership is interested in teaching others about the collaborative quality improvement model. Despite the limitations described earlier, there has been significant interest in the MARCQI model from others. MARCQI has received inquiries from hospitals, hospital systems, and payers in other states.

Conclusion

Michigan, similar in population size to Sweden, has developed a statewide hip and knee arthroplasty registry, which exists in the context of a structured, collaborative improvement consortium. Key functions include the collection of high-quality clinical data, rigorously developing risk-adjustment models, and presenting risk-adjusted performance analysis to collaborative members at a face-to-face meeting four times a year. It has been shown to be effective by virtue of the high data capture rate within only a few years' time. This model had been refined by BCBSM/BCN and its physician/hospital partners during the development of other registries prior to the MARCQI launch. Consequently, the arthroplasty registry had the benefit of learning from others. An essential factor in the success of MARCQI has been the non-punitive nature of the endeavor in which the registry serves to inform and improve. While a payer is supporting MARCQI, it does not receive identified hospital, physician, or patient-level data. In fact, BCBSM/BCN supports MARCQI through a pay-for-performance incentive system for hospitals that emphasizes participation and improvement in collaborative-wide performance. Establishing the registry as a quality improvement activity also allows MARCQI to operate under federal regulations without requiring individual patient consent.

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Disclosure

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