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FEATURE ARTICLE

# Quality Improvement Tools in Total Joint Arthroplasty: A Systematic Review

**Henry V. Bonner, BS; James R. Jones, BS; Alexandra M. Arguello, MD; Jun Kit He, MD; Brent A. Ponce, MD; Amit M. Momaya, MD; Elie S. Ghanem MD; and Eugene W. Brabston, MD**

*Systems review and quality improvement (QI) is a significant need within orthopaedic surgery. The focus of this paper is to systematically review QI principles utilized in total joint arthroplasty to determine most successful QI tools. A systematic search on MEDLINE/Pubmed, Embase, Cochrane Library and other sources was conducted from September 1991 through October 2018. The three primary improved outcomes from each article were recorded along with the date, author and subspecialty. Thirty-four eligible studies related to joint arthroplasty were identified for inclusion in the systematic review. The most common outcomes that were improved in these publications were: length of stay (LOS), cost, medication management, and patient education. Lean, clinical care pathways (CCP), plan-do-check-act (PDCA), and shared decision-making improved those metrics. Four metrics were found that were consistently improved by certain quality improvement tools: LOS, cost, medication management, and patient education. Further research is warranted to continue to build a framework for quality improvement in orthopaedic surgery.* (Journal of Surgical Orthopaedic Advances 30(3):125–130, 2021)

Key words: quality improvement, process optimization, arthroplasty, clinical care pathways (CCP), plan-do-check-act (PDCA), lean

Publicly reported institutional outcomes of hip and knee arthroplasty are among the most significant measurable quality variables utilized in rating and differentiating hospitals in the United States. Recent healthcare reimbursement models have aimed to prioritize delivery of high-quality care over quantity, especially in the instance of bundled care payments for hip and knee arthroplasty.[1,2] Additionally, hip and knee arthroplasty are two of the nine procedures and conditions used by U.S. News & World Report to determine hospital rankings.[3] The quality variables frequently measured for joint replacement include: length of stay (LOS), surgical site infection rate, 30-day and 90-day readmission rate, cost value for patients, and patient experiences.[4] In order to improve these tracked variables, several studies have rigorously applied quality improvement tools and reported on their impact at their individual institutions.[5-8] The number of quality improvement publications within orthopaedics is increasing along with the variety of measured outcomes across subspecialties.[9-40]

Systems review and quality structure implementation continues to be a significant need within healthcare.[12] According to Institute of Medicine's definition of health care quality, quality improvement is defined as "safe, effective, patient-centered, timely, efficient and equitable."[41] Despite the growing recognition of the importance of quality improvement activities in medicine, the prevailing mentality by many physicians is that this activity is not the responsibility of clinicians. Additionally, many clinicians believe that quality efforts implemented by administrators focuses upon managing physicians instead of improving outcomes, which is a potential source of frustration.[42] Quality improvement in healthcare must focus on managing the process of care instead of managing healthcare providers. Quality improvement is in the domain of both physicians and hospital administration.

The focus of this paper is to provide a systematic review of quality improvement principles within total joint arthroplasty. Hip and knee arthroplasty has been selected for several reasons including its widespread utilization, significant impact on patient functional improvement, structured and reproducible technique and protocols, and significant impact on healthcare expenditures for the present and foreseeable future.[13-18] The goals of this review are to identify the most common quality improvement tools used in arthroplasty and to determine which variables were impacted the most by these tools.

## Materials and Methods

The systematic review was performed following Preferred Reporting Items for Systematic Reviews and Meta–Analyses (PRISMA) guidelines.[43] Studies were included if the articles mentioned quality improvement in orthopaedic surgery or if they mentioned lean, six sigma, lean six sigma, statistical quality control, plan-do-check-act (PDCA), clinical practice guidelines, clinical care pathways (CCP), checklists, root cause analysis, failure modes and effect analysis, or total quality management (Fig. 1).

From Department of Orthopaedic Surgery, University of Alabama at Birmingham Hospital, Birmingham, Alabama. Address correspondence to Henry V. Bonner, Department of Orthopaedic Surgery, University of Alabama at Birmingham, 1313 13th St. S, Suite 207, Birmingham, AL 35205; email: vbonner@uab.edu.

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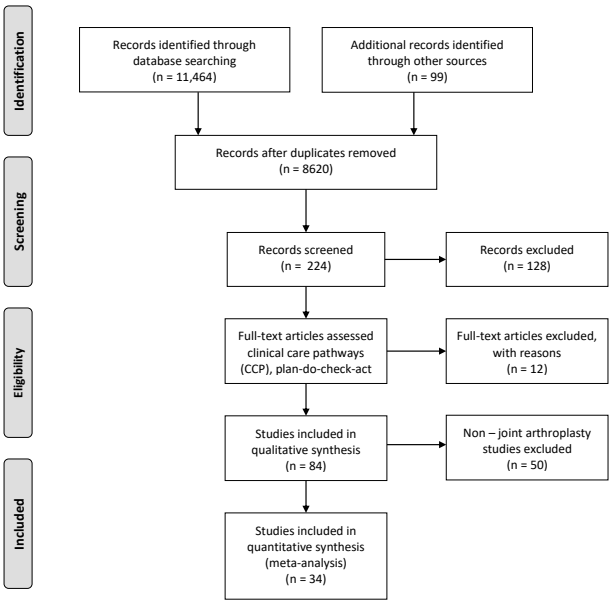


**FIGURE 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and methods for quality improvements (QI).

MEDLINE/PubMed, Embase, the Cochrane Library and other non-database sources were searched for relevant publications. This online search was conducted from September 1991 through October 2018. The following terms were used in the search strategy for the PubMed, Embase, and Cochrane databases: orthopedic OR orthopaedics AND (plan do check act) or (PDCA) OR (statistical quality control) OR (SQC) OR (lean process) OR (six sigma) or (lean six sigma) OR (lean) OR (quality improvement). The combined database search produced a total of 11,563 publications. After duplicates were removed, 8,620 publications remained. Study titles and abstracts were reviewed to determine study eligibility. Study selection were performed independently by two investigators. After nonrelevant papers were excluded, the full text of each of the remaining studies were reviewed by a single investigator. Articles were assessed for eligibility if they were noted to include principles of quality improvement, were specific to orthopaedic surgery, and were in the English language. After screening titles for study relevance, 224 abstracts remained for review. Articles were excluded if they reported medical effectiveness without description of a process tool or quality improvement, if it was an editorial, or if it was unrelated to orthopaedics. From these abstracts, 84 articles were reviewed and were categorized into a subspecialty of orthopaedic surgery: Hip and Knee Arthroplasty, Trauma, Spine, Pediatrics, Hand, or General Orthopaedics (Fig. 2).

The articles were also assessed for which quality improvement tool (QPIT) that Pinney et al. described in 2016 was used.[44] Pinney et al. detailed 14 QPITs that are commonly used in healthcare. For example, lean process improvement is a QPIT that is defined as a multidisciplinary, team-based process for improving value and flow in the provision of services.[44] Different tools were categorized based on whether they could be applied to a specific event (i.e., checklists) versus the entire episode of care (i.e., clinical care pathways, patient-and family-centered care); whether they continuously adjust the process (lean and PDCA) versus work statically (checklists and clinical practice guidelines) or whether they focused more on standardizing an existing process versus redesigning a process. This framework was useful when thinking about which QPITs should be applied to certain clinical situations. Three primary measured outcomes were extracted from each study, which were determined based upon which outcomes were most improved across all studies. From these 84 studies, 34 articles related to joint arthroplasty were identified for inclusion in the systematic review (see Fig. 1) (Table 1).[9-11,13-29,31-40,45-48]

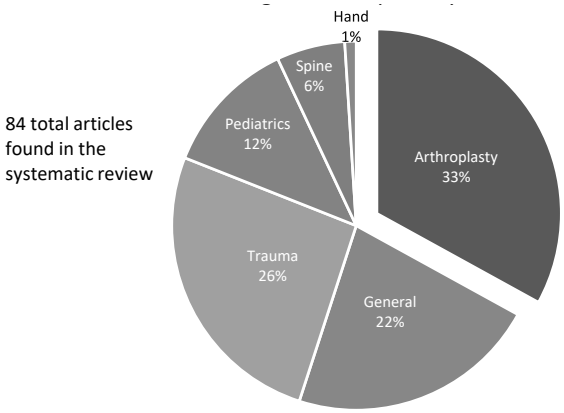


**FIGURE 2.** Percentages of subspecialty articles.

## Results

The most common variables that were improved in these publications were: LOS – 35%, cost – 26% (Table 2); medication management – 17%; and patient education 11%. Out of the 34 joint arthroplasty articles found in our systematic review, clinical care pathways (CCP), lean, plan-do-check-act (PDCA), shared decision-making (SDM) and clinical practice guidelines (CPG) were among the most commonly used tools. The most common tools for improving LOS[11,14-16,18-21,24] and cost[11,13,14,18,19,21,23,24,34] were CCP and lean process improvement; the most common tools for improving patient communication and patient satisfaction were shared decision-making (SDM); the most common tools for improving venous thromboembolism (VTE) prophylaxis were plan-do-check-act, care pathways and checklists (Table 3) (Fig. 3).

## Discussion

In this systematic review, it is reported that the literature in the area of quality improvement in orthopaedic surgery is presently under investigated with only a handful of high-quality studies. With the recent advances in medical knowledge and innovative therapies in the past two decades, there has not been a proportionate improvement in quality, outcomes, costs and equity.[12] Orthopaedic surgery specifically has been under scrutiny to optimize quality and cost efficiency. Unfortunately, limited knowledge of continuous quality improvement tools that may be used within orthopaedic surgery has hampered implementation and published outcomes of quality improvement success within the field of orthopaedic surgery. Despite this, through this systematic review, the research team has identified that total joint arthroplasty is the leading area in orthopaedics where quality improvement tools have been used to provide better outcomes (Fig. 2).

**TABLE 1. Quality and process improvement tools (QPITs) used in arthroplasty literature with definitions**

| QPIT in Arthroplasty | # of Studies | Studies (Author, Year) | Definition according to Piney et al.[44] |
|---|---|---|---|
| Care Pathways/ CCP | 8 | Gregor, 1996[20]; Bragato, 2003[22]; Walter, 2007[19]; Munoz, 2006[15]; Metcalf, 2009[10]; McCann-Spry, 2016[14]; Featherall, 2018[21]; Kaye, 2019[11] | "formal pathway that outlnes how care for a specific condition is to be delivered throughout the entire EOC" |
| Checklist | 3 | Tillman, 2013[36]; Talia, 2017[35]; Atkinson, 2015[40] | "standardizes and improves team communication around a specific event by formally reviewing a preset checklist" |
| CPG | 3 | Sax, 2014[33]; Douglas, 2001[31]; Bautista, 2016[32] | "formal guidelines for diagnosis or management of a clinical situation: generated in an evidence-based manner" |
| FMEA | 1 | Auset, 2010[37] | "proactive approach to preventing adverse events by identifying potential failure models within the existing system" |
| Lean | 3 | Audet, 1998[23]; Arana, 2017[24]; Gould, 2012[48] | "eliminating waste and improving workflow" |
| Lean Six Sigma | 3 | Gayed, 2013; Improta, 2015; Guo, 2016. | "amalgamation of principles of lean (eliminating waste and improving workflow) and six sigma (decreasing rate of errors and reducing process variation)" |
| PDCA/PDSA | 3 | Gillaspie, 2010[17]; Lesselroth, 2011[25]; Mazaleski, 2011[26]; | "four-step, iterative continuous improvement cycle. Plan, Do, Check, Act." |
| PFCC/SDM | 3 | Braddock, 2008[29]; Klifto, 2017[28]; Norgaard, 2012[27] | "a six-step, continuous improvement process developed specifically for health care based on TQM principles" |
| RCA | 2 | Schilling, 2010[38]; Molina, 2015[9] | "formalized approach to evaluating cause of an adverse event" |
| Six Sigma | 3 | Frings, 2005[47]; Stiehl, 2007[45]; Heck, 2009[46] | "process improvement strategy…that focuses on 1) decreasing the rate that errors occur, and 2) reducing variation in the production process" |
| TQM | 2 | Morgan, 2015[39]; Barratt, 2017[34] | "comprehensive approach to continuous quality improvement of the entire process involving all members of the healthcare team including patients" |

CCP, clinical care pathways; EOC, episode of care; CPG, clinical practice guidelines; FMEA, failure models and effect analysis; PDCA, plan-do-check-act; PDSA, plan-do-study-act; PFCC, patient and family centered care; SDM, shared decision-making; RCA, root cause analysis; TQM, total quality management

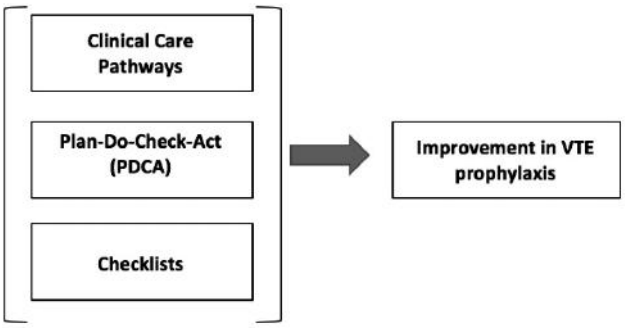


**FIGURE 3.** Tools for improvement in venous thromboembolism (VTE) prophylaxis.

CCPs (26%) are most useful for standardizing the care for a specific condition by reducing the variation in a process.[10,11,14,15,19-22] CCPs are specifically useful in joint arthroplasty due to the reproducible nature of the surgery. The entire surgical team should be able to anticipate and prepare for sequential steps in the episode of care of a joint patient. CCPs give the team a framework to follow for different steps in the episode of care. Lean (18%), like CCPs, can be used in standardization of an entire episode of care, but according to Pinney at al.,[44] it is also iterative in nature because the process is adjusted in real time based on the results that are obtained.[13,16,18,23,24] This is especially useful in joint arthroplasty when it comes to improving variables such as operating room (OR) time and hospital stay. PDCA (8%) is useful because it is constantly improving the process with each "cycle" of implementation.[17,25,26] Like lean, PDCA is iterative because it does not have to be measured against a control but can be continuously updated. This allows for timely implementation of quality and process improvement. Shared decision-making (SDM) (12%) is useful for promoting better communication and patient satisfaction about decisions in their own episode of care.[27-29] SDM is defined as a collaborative process that allows patients and their providers to make health care decisions together, taking into account the best scientific evidence available, as well as the patient's values and preferences.[30] Clinical practice guidelines (CPGs) (8%) are evidenced based guidelines to standardize treatment of specific conditions.[31-33] CPGs unlike CCPs, lean and PDCA are used for a specific event in the episode of care instead of the entire episode of care.

Length of stay (LOS) (35%)[11,14-16,18-21,24] and cost (26%)[11,13,14,18,19,21,23,24,34] were the two most commonly improved outcomes reported. Reducing LOS in joint replacement patients is vital not only to reduce the likelihood of inpatient complications and to begin the rehabilitation process at home, but also from a cost standpoint. It is no surprise that cost improvements should parallel LOS reduction due to decreased hospital costs. It is reported that CCPs and lean process improvement are the best QPITs for improving LOS and cost. Of the 34 joint arthroplasty articles, nine of the LOS improvement articles were either CCP or lean, and five of them also reported cost improvements. Like previously stated, CCPs and lean by nature focus on reducing variation and eliminating waste. This is advantageous for shortening the LOS and cost of patients undergoing joint replacement. One hypothesis was that the successful implementation of a quality initiative process would be associated with a concurrent decrease in complication rates; however, it was found that the majority of these articles found the complication rate to be unchanged.

Medication management was another commonly improved outcome in the review (17%).[10,17,25,32,35,36] More specifi-

**TABLE 2. Articles utilizing QPIT to reduce LOS and lower costs associated with total joint arthroplasty**

| Title | Author | Year | Joint | LOS (days) | | Cost Change | Complication/ Readmission Rate | QPIT |
|---|---|---|---|---|---|---|---|---|
| | | | | *Before* | *After* | | | |
| *Success of clinical pathways for total joint arthroplasty in a community hospital* | Walter[19] | 2007 | THA | 4.41 | 3.24 | 3.24 % increase | Remained stable | *Care Pathway* |
| | | | TKA | 3.92 | 2.98 | (was less than proportionate increase in cost of healthcare) | | |
| *Clinical pathway for hip arthroplasty six years after introduction* | Munoz[15] | 2006 | THA | 4.5 | 1.08 | | Remained stable | *Care Pathway* |
| *Reduced length of stay and improved appropriateness of care with a clinical path for total knee or hip arthroplasty* | Gregor[20] | 1996 | Both | 12 | 9 | | Remained stable | *Care Pathway* |
| *Redesigning a joint replacement program using Lean Six Sigma in a Veterans Affairs hospital* | Gayed[18] | 2013 | Both | 5.3 | 3.4 | $1 million annually (for the hospital system) | Remained stable | *Lean Six Sigma* |
| *Lean Six Sigma: a new approach to the management of patients undergoing prosthetic hip replacement surgery* | Improta[16] | 2015 | THA | 18.9 | 10.6 | | | *Lean Six Sigma* |
| | | | | ***LOS Reduction*** | | | | |
| *Implementation of a total hip arthroplasty care pathway at a high-volume health system: effect on length of stay, discharge disposition, and 90-day complications* | Featherall[21] | 2018 | THA | 0.747 | | $1,203 per patient | Remained stable | *Care Pathway* |
| *An interdisciplinary approach to reducing length of stay in joint replacement patients* | McCann-Spry[14] | 2016 | Both | 0.5 | | $400 per patient | | *Care Pathway* |
| *Reducing length of stay, direct cost, and readmissions in total joint arthroplasty patients with an outcome manager-led interprofessional team* | Arana[24] | 2017 | THA | 0.4 | | $1,020 per patient | Remained stable | *Lean* |
| | | | TKA | 0.6 | | $539 per patient | Remained stable | |
| *Enhanced recovery pathways in orthopedic surgery* | Kaye[11] | 2019 | Both | Used ERAS to improve LOS (no data in the article) | | | | *Care Pathway* |

QPIT, quality improvement tool; LOS, length of stay; TKA, total knee arthroplasty; THA, total hip arthoplasty

**TABLE 3. Articles utilizing QPIT's for VTE prophylaxis and antibiotic management processes**

| Article Titles | Author | Year | Variable Improved | | QPIT |
|---|---|---|---|---|---|
| *Communication skills training for health care professionals improves the adult orthopaedic patient's experience of quality of care* | Talia[35] | 2017 | Physician Documentation | | Checklist |
| | | | ***Before*** | ***After*** | |
| | Surgical details | | 38.6% | 85.3% | |
| | VTE discussion | | 9.8% | 45.6% | |
| | Weight bearing status | | 11.4% | 83.8% | |
| *Thromboprophylaxis after major orthopedic surgery: Improving compliance with clinical practice guidelines.* | Bautista[32] | 2016 | Barriers of compliance | | CPG/ PDSA |
| | | | ***Before*** | ***After*** | |
| | Medical order of VTE prophylaxis | | 60% | 100% | |
| | VTE prophylaxis – timely administration | | 60% | 95.7% | |
| *Timely administration of VTE prophylaxis after surgery* | Lesselroth[25] | 2011 | VTE prophylaxis – EHR | | PDSA |
| | | | ***Before*** | ***After*** | |
| | VTE orders for eligible surgeries | | 18% | 78% | |
| *Surgical care improvement project and the orthopaedic patient* | Metcalf[10] | 2009 | SCIP | | CCP |
| | | | ***Before*** | ***After*** | |
| | VTE prophylaxis | | 91% | 100% | |
| | Proper antibiotic use | | 87% | 97.7% | |

QPIT, quality improvement tool; VTE, venous thromboembolism; EHR, electronic health records; PDSA, plan-do-study-act ; CPG, clinical practice guidelines; SCIP, surgical care improvement project; CCP, clinical care pathways

cally, improvement in venous thromboembolism (VTE) prophylaxis was reported in four of these articles.[10,25,32,35] This was found to be especially relevant for total joint arthroplasty due to the increased risk of developing deep vein thrombosis in the postoperative period. The tools for improving VTE prophylaxis were more diverse than improving LOS and cost. In this review, PDCA,[10,25] checklists[35] and CCPs[10] were found to have been used in standardizing VTE prophylaxis. Since there was not a strong correlation for a specific QPIT to be used for improving medication management, we are not suggesting one tool is superior to another. But in summary, we can report that quality improvement efforts have been successful in improving the VTE prophylaxis of total joint patients and recommend each institution determine the best method internally.

Improved patient education was another area of improvement (11%).[26-29] A strong emphasis on improving the process at which providers educate patients on decisions regarding their care was also found. Patients that reported feeling more included in the decision-making process regarding joint replacement typically had better outcomes after surgery. Shared decision-making was the primary tool used to improve communication, education and satisfaction among patients. Klifto et al. used the SDM model that resulted in marked improvements in the patients' decision certainty, decision quality, and decision consistent with patient values.[28] It is suggested that all orthopaedic surgeons use a form of shared decision-making when speaking to patients about undergoing total joint arthroplasty.

## Conclusion

Data is limited in orthopaedic surgery quality improvement. There is a lack of clarity due to the inconsistent definitions of quality improvement tools. This systematic review identifies the most common QI tools used in joint arthroplasty based upon 14 major quality process and improvement tools. In this review, three metrics were found that were consistently improved by certain QPITs: (1) Lean used in conjunction with Clinical Care Pathways were most commonly used for improving length of stay and cost. (2) Plan-Do-Check-Act (PDCA) was most commonly used for improving medication management such as VTE prophylaxis. (3) The Shared Decision-Making Model (SDM) was most commonly used for improving patient education and satisfaction. Further research is warranted to continue to build a framework for quality improvement in orthopaedic surgery. Orthopaedic surgeons should champion principles similar to the ones highlighted here to improve the patient's episode of care and to further the field of orthopaedics.

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