



Joint Replacement Medical Mission Trips Can Provide High Quality Care in Developing Countries: Assessing Quality Using the Structure, Process, and Outcomes Paradigm

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Joint Replacement Medical Mission Trips Can Provide High Quality Care in Developing Countries: Assessing Quality Using the Structure, Process, and Outcomes Paradigm

by

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Abstract:

Background

Medical mission trips that go to developing countries are becoming more popular worldwide and there is need for rigorous quality assessment of the care that these trips provide. Current scrutiny of these trips stems from the lack of established metrics to assess these programs' quality and from the dearth of literature that attempts to evaluate these trips' care quality. In developed countries, however, the structure, process, and outcomes paradigm is commonly used to comprehensively assess care quality and many tools exist to evaluate each of these respective quality categories. In this study, we apply these assessment tools to evaluate the structure, processes, and outcomes of Operation Walk (Op-Walk) Boston's medical mission joint replacement trips to the Dominican Republic (D.R.).

Methods

For Op-Walk Boston's medical mission trip to the D.R., the structure and process elements of care quality were assessed using the Blue Cross/Blue Shield's (BCBS) Blue Distinction criteria. Full points were given for criteria that the program replicates entirely and zero points were given for criteria that are not replicated entirely. For non-replicated criteria, Op-Walk Boston's clinical and administrative teams were asked if they compensate for failure to meet the criterion, and they were also asked to identify barriers that prevent them from meeting the criterion.

To assess the outcomes quality category, Op-Walk Boston's patients completed Western Ontario and McMaster Universities' Arthritis Indexes (WOMAC) and Short Form (36) Health Surveys (SF-36) preoperatively and at 12-month follow-up. Patients were stratified into low, medium, and high scoring preoperative groups based on their preoperative WOMAC function scores. We then examined the associations between these groups' baseline functional status and two outcomes—improvement in functional status over 12 months and absolute functional status at 12 months—using ANOVA with multivariable linear regression.

Results

The structure and process assessment revealed that Op-Walk Boston's program scored 71 out of 100 possible points, exceeding the 60-point threshold needed to qualify for Blue Distinction.

The program met five out of eight “required” criteria and 11 out of 19 “informational” criteria. It scored 14/27 in the “general” category, 30/36 in the “structure” category, 17/20 in the “process” category, and 10/17 in the “outcomes and volume” category.

The outcomes assessment revealed that patients’ functional status and pain levels improved greatly after surgery and that those with the lowest WOMAC functional scores preoperatively made the greatest gains in function and pain relief following their joint replacement.

Conclusion

Our analysis shows that Op-Walk Boston’s medical mission trip provides high quality care across all care quality categories. An analysis of the program’s structure and processes reveals that Op-Walk Boston scores well on the Blue Distinction criteria’s structure and process categories. In addition to demonstrating high quality structure and processes, the Blue Distinction analysis identifies areas of programmatic improvement and identifies targets for future quality improvement initiatives. Furthermore, the analysis shows that many Blue Distinction criteria can only be met by hospitals operating in the United States (U.S.), so future work should focus on creating criteria that are applicable to total joint replacement (TJR) mission trips in the context of developing countries.

Our analysis of the program’s outcomes shows that all tertiles in the Dominican cohort exhibited substantial improvements and high absolute scores at one-year follow-up, demonstrating that the program achieves high quality outcomes. Similar to cohorts from developed countries, Op-Walk patients with poorer preoperative functional statuses improve more than patients who had a higher preoperative level of function. Contrasting developed country cohorts, however, all Dominican tertiles had similar one-year follow-up outcomes regardless of their baseline WOMAC function status, suggesting that poor preoperative function may not limit absolute scores at one-year follow-up. Additional research is needed to confirm these findings in other developing countries and to understand why these associations vary between patients in the D.R. and patients from developed countries.

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Listing of Abbreviations:

ANOVA- Analysis of Variance

ASA- American Society of Anesthesiologists

BCBS- Blue Cross/Blue Shield

BMI- Body Mass Index

CMS- Centers for Medicare and Medicaid Services

D.R.- Dominican Republic

EMR- Electronic Medical Record

FDA- Food and Drug Administration

HCAHPS- Hospital Consumer Assessment of Healthcare Providers and Systems

HGPS- Hospital General de la Plaza de la Salud

IHI- Institute for Healthcare Improvement

INF- Infection

IRB- Institutional Review Board

Op-Walk- Operation Walk

PCP- Primary Care Physician

PT- Physical Therapist

SCIP- Surgical Care Improvement Project

SD- Standard Deviation

SF-36- Short Form (36) Health Survey

TJR- Total Joint Replacement

U.S.- United States

VTE- Venous Thromboembolism

WHO- World Health Organization

WOMAC- Western Ontario and McMaster Universities Arthritis

Introduction:

Improved longevity in developing countries has led to the rise of chronic diseases, including osteoarthritis and other joint diseases.[1,2,3] In developed countries, total joint replacement (TJR) is often used to address symptomatic advanced arthritis. Total hip and knee replacements have been shown to enhance quality of life and satisfaction by improving function[4] and by decreasing pain.[5,6] Although TJRs are cost effective in developed countries,[7,8,9] these procedures' high costs has made financing them difficult in developing countries. Despite the high costs of most surgical interventions, the World Health Organization (WHO) and other health organizations have called for renewed focus on building developing countries' surgical capacities.[10,11,12] Some developing countries are therefore currently establishing and evaluating their own TJR programs.[13,14] Additionally, organizations such as Operation Walk (Op-Walk) Boston have started annual mission trips to provide pro-bono total knee and total hip replacements to people in developing countries while concurrently building surgical capacity by educating local physicians and surgical teams about TJRs.[15,16]

The organizations that provide surgical care in developing countries aspire to provide the highest quality care possible, although the effectiveness of these short-term medical mission programs has been debated.[17,18] Ideally, all medical mission trips would offer services with quality that is equal to the quality provided in developed countries. Although some attempts have been made to standardize surgical processes and procedures during medical mission trips[19, 20] and to assess these trips' outcomes,[21,22,23] quality criteria have not been specifically established for TJR medical mission trips. Following traditional paradigms for assessing care quality, however, reveals that three categories should be considered: program structure, processes, and outcomes (Figure 1).[24] In developed countries, assessments for each of these categories have been created and are widely used for assessing quality and may therefore provide valuable starting points for evaluating care quality in the context of TJR medical mission programs.

To assess the structure and processes categories of quality, the Blue Cross/Blue Shield's (BCBS) "Blue Distinction Center for Knee and Hip Replacement" criteria[25] are used in the U.S. as a benchmark of TJR quality, assessing programs' structural elements, processes, and reporting mechanisms. Because BCBS believes these metrics are tied to end outcomes, these criteria are used for determining TJR reimbursement eligibility and rates at high-performing U.S. hospitals. Although the Blue Distinction criteria were developed to assess TJR program quality in developed

countries, these criteria might also help medical mission groups to evaluate and to improve the care they provide in developing countries.

To assess the outcomes category of TJR quality in developed countries, pain and functional status are typically recorded before and after surgery with validated patient surveys,[26,27] such as the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and the Short Form (36) Health Survey (SF-36). These instruments measure pain and functional limitations related to lower extremity arthritis (WOMAC) and to overall health status (SF-36). In developed countries, people with worse functional status scores prior to surgery make the greatest gains in these scores following TJR, but their final scores (at one or two years after surgery) are worse than those of individuals who had better preoperative scores. Thus, operating earlier in the course of functional decline appears to result in better outcomes.[28] These findings have led to a gradual reappraisal of optimal TJR timing in developed countries, with TJRs offered earlier in the process of functional decline to reduce the period of disability and to improve the functional outcome.[29] In previously reported research from the Dominican Republic (D.R.), the Op-Walk Boston team demonstrated that patients' WOMAC and SF-36 scores improve dramatically following their TJRs,[30] preliminarily suggesting that this medical mission trip's TJR program excels in the outcomes category of quality assessment. Associations between preoperative WOMAC/SF-36 surveys and ultimate TJR outcomes in the D.R., however, have not been studied, so it is unclear if medical mission trips' improvement patterns in the D.R. match improvement patterns observed in developed countries – understanding these associations is critical in evaluating the outcomes category of quality assessment and to understanding optimal TJR timing for medical mission trips in the D.R.

This report provides the first known attempt to evaluate a TJR medical mission trip's care quality using assessment tools from developed countries that span all three care quality categories. First, we¹ evaluate the mission trip's program-level quality metrics (structure and process categories) using the BCBS's Blue Distinction criteria and demonstrate that this kind of evaluation can help medical mission organizations identify areas of programmatic improvement. Then, we focus on patient-level quality outcomes metrics using data from WOMAC and SF-36 scores taken preoperatively and at one-year follow-up to evaluate the improvement patterns of 97 low-income patients from the D.R. who received total knee and hip replacements during Op-Walk Boston's

¹ Note: Throughout this honors thesis, I use the term “we” instead of “I” since several people contributed to data collection and also provided input throughout the manuscript drafting process.

2009, 2010, and 2011 trips to the D.R. By assessing associations between patients' preoperative WOMAC and SF-36 scores and their one-year TJR outcomes, we evaluate if score improvement patterns in developing countries match patterns observed in developed countries. Insight into the associations between preoperative WOMAC and SF-36 scores and TJR outcomes may help leaders of TJR programs in developing countries better assess outcomes quality and to understand the optimal point to operate during the process of functional decline, informing the allocation of these programs' limited resources.

Methods:

Setting

The D.R. is a small country (population 10,478,756) in the Caribbean Sea that shares the island of Hispaniola with Haiti. As of 2014, the country's per capita income was approximately \$14,000.[31] Citizens have access to a free state health care plan, which provides basic primary care coverage, and private clinics provide most specialty care. The nation's capital, Santo Domingo, is home to several private hospitals, including the Hospital General de la Plaza de la Salud (HGPS). In 2008, when the Op-Walk Boston team made their first trip to the D.R., the hospital performed fewer than 20 TJRs annually, though this number has grown to more than 100 cases annually.

Operation Walk Boston Team

Op-Walk Boston is part of the national Operation Walk organization.[32] The Boston team has made annual service trips to the D.R. since 2008. The team consists of approximately 50 individuals, including orthopedic surgeons, anesthesiologists, internists, physical therapists, physician assistants, surgical and medical nurses, operating room personnel, medical students, and other staff. The Op-Walk Boston team works closely with its Dominican colleagues at HGPS in Santo Domingo to identify low-income Dominican patients with severe joint disease; the team provides pro-bono knee and hip replacements for these patients during its annual trips.

Program-Level Evaluation (Quality Category Emphases: Structure and Processes)

Using the BCBS's selection criteria for "Blue Distinction Centers for Knee and Hip Replacements", we determined if Op-Walk Boston's joint replacement program meets the Blue Distinction criteria (scores at least 60 out of 100 possible points).[33] Op-Walk Boston's clinical and administrative directors from the U.S. and the D.R. (five total people) were independently surveyed with binary questions for all Blue Distinction criteria. In total, there were three answer discrepancies between the respondents, so the data collector individually reconciled these items with the involved parties to understand sources of disagreement. Following the reconciliation, full points were awarded for criteria that the program replicates exactly and zero points were given for criteria that are not replicated. If a criterion was not applicable outside of the U.S., zero points were awarded and the criterion was labeled "not applicable." For all criteria that are not replicated, we asked clinical and administrative teams if they compensate for failing to meet the criterion by introducing an

alternative strategy or process to enhance quality. We also asked team members if there are barriers that prevent them from adopting certain criteria.

We classified the criteria as “General/Administrative”, “Process”, “Structure”, and “Outcomes and Volume” categories to follow widely-used frameworks for quality assessment[34] and to match the subcategories established in the Blue Distinction criteria. The scores from each category were graphed to represent visually the relative weighting of each category and the percentages of points that were met, not met, or somehow compensated for in each category.

Patient-Level Evaluation (Quality Category Emphasis: Outcomes)

Participant Selection

From 2008-2011, physicians from the Orthopedic Department at the HGPS have assembled groups of low-income patients who have advanced, symptomatic, functionally limiting hip or knee arthritis and joint destruction. Prior to the Op-Walk team’s departure from Boston, Op-Walk Boston’s surgical team reviews patients’ radiographs and medical records to confirm appropriateness for total hip or knee replacement. When the Op-Walk Boston team arrives in the D.R., Op-Walk Boston’s surgical team performs a detailed preoperative assessment of all patients to finalize surgical plans and to obtain informed consent for surgery.

Survey Information

The pre- and post-operative surveys incorporated Spanish versions[35,36] of the SF-36[37] physical activity and mental health subscales and the WOMAC index.[38,39] These instruments have been validated previously and are widely-used for evaluating TJR outcomes.[40,41] To aid in interpretation and for consistency with other literature in this field,[29] we similarly inverted the WOMAC score scales and transformed the SF-36 and the WOMAC scores to a 0 to 100 point scale, with 100 representing the best outcomes. Cronbach’s alpha coefficients were previously reported to exceed 0.75 in the Dominican cohort for each of the WOMAC and SF-36 subscales included in the surveys.[30] This level of reliability exceeds the commonly accepted threshold of 0.70, supporting the internal consistency of these scales in the Dominican cohort.[42]

In addition to the WOMAC and SF-36 instruments, the preoperative surveys also requested patients’ demographic information (age, education level, gender, employment, and living arrangements) as well as their perception that a TJR would relieve their pain or lead to operative

complications. The post-operative survey also asked questions related to surgical outcome satisfaction and quality of life improvements.

Preoperative and Postoperative Data Collection

During the preoperative evaluation, the research team provided patient fact sheets about the study and patients were offered the opportunity to opt out. Research associates then administered the surveys to consenting participants. Patients who underwent TJR in 2009, 2010, and 2011 were asked each year to return to the hospital for annual follow-up appointments. During this appointment, the patients filled out WOMAC/SF-36 follow-up forms. All surveys are written in Spanish and research associates provided assistance with reading and interpreting the survey, when necessary.

Statistical Analysis

The association between baseline WOMAC function score and one-year follow-up score was similar in the total knee and the total hip replacement cohorts, so we combined the cohorts in our analyses (Supplementary Tables 1 and 2). To determine whether patients who started with lower function improved more than those who started at a higher level of function, patients were stratified into tertiles using their preoperative WOMAC functional status scores. For each tertile, we investigated the association between preoperative functional status and both the absolute 12-month score and the total score improvement. We calculated each group's mean and used a one-way ANOVA to test for overall group differences. Tukey's studentized range test was used to perform pairwise comparisons when the overall ANOVA was statistically significant.

We used multivariable linear regression models to adjust for sex, procedure (bilateral vs. unilateral), joint (knee vs. hip), and education. Separate models of hip and knee replacement yielded similar results, so we provide data on the combined hip and knee replacement cohorts to achieve more stable estimates.

IRB Approval

This study was approved by the IRBs at both the Brigham and Women's Hospital in Boston and the HGPS in Santo Domingo.

Results:

Program-Level Evaluation (Quality Category Emphases: Structure and Processes)

General Criteria for All Blue Distinction Centers

In the general criteria section, the program received 14 out of a possible 27 points (Table 1). The program lost four points because it lacks formal conflict of interest policies and it lost seven points because it does not collaborate with several U.S.-based quality improvement organizations. Two points were lost because it does not participate in the Surgical Care Improvement Project, although the program does compensate by following best practice surgical care guidelines.

There are two “required” and three “informational” general criteria; the Op-Walk Boston program meets one of the required criteria and one of the informational criteria. The program did not meet one of the required criteria because HGPS is not accredited by a CMS-regulated national accreditation organization. The two unmet informational criteria relate to using a Surgical Care Improvement Project (SCIP) database to produce procedure-specific performance reports and to tracking FDA-recalled prostheses and contacting patients with these prostheses. The hospital does not have a SCIP database and it also has difficulty tracking patients, which makes it difficult to contact patients whose prostheses are recalled.

Structure

In the structure category, the program was awarded 30 out of 36 possible points (Table 1). The only criterion that the program did not fully meet involved reporting to surgical quality improvement registries and databases. The program also lost three points because it lacks three out of eight required multi-disciplinary team members: psychiatrists and psychologists, pain management specialists, and dedicated case managers. Despite lacking psychiatrists and psychologists and formally trained pain management specialists, the program compensates by having doctors and nurses work directly with patients to address their mental health needs and by having well-trained anesthesiologists who commonly provide pain management services.

Aside from the scorable criteria, there were also two criteria listed as “required” and seven listed as “informational.” The program met both of the required criteria and six of the informational criteria. It did not meet one informational criterion because it lacks pain management specialists who have subspecialty certifications in pain management.

Process

The program received 17 out of 20 possible points in the process category (Table 2). The program lost one point because it lacks standardized practices for case management and discharge planning. It lost an additional point because the program does not monitor care transitions for patients who are discharged to other care settings, although it does compensate by having an electronic medical record system that helps to track patients over time. It also lost a point because it lacks formal protocols that ensure patients' operative notes and discharge summaries are made available to their primary care physicians (PCPs) upon discharge.

There are six informational criteria in the process category, and the program met three of them. One unmet criterion involved using shared decision making processes with patients. Another unmet criterion involved tracking operative notes and discharge forms to ensure the patient's PCP receives the documents. The final unmet informational criterion involved using BCBS's case management team to track transitions of care.

Outcomes and Volume

In the outcomes and volume category, the program received 10 out of 17 possible points (Table 2). The program lost three points because the host facility does fewer than 250 TJRs annually, and it lost an additional two points because the host facility does fewer than 500 TJRs annually. It lost two additional points because the host hospital does fewer than 50 TJR revisions annually.

There are two required and two informational criteria in the outcomes and volume category. The program met both of the required criteria and did not meet either of the informational criteria. One missed informational criterion requests that the program publicly report average lengths of stay for patients who need hip and knee revisions and the other criterion involves tracking selection, administration, and discontinuation of prophylactic antibiotics for knee replacements.

Overall Evaluation

The Op-Walk Boston program met enough criteria to score 71 of 100 possible points (Figure 2), exceeding the 60-point threshold needed to qualify for Blue Distinction. The program met five of the possible eight "required" criteria and 11 out of the possible 19 "informational" criteria.

Patient-Level Evaluation (Quality Category Emphasis: Outcomes)

Recruitment

In 2009, 2010, and 2011, a total of 130 patients were invited to participate in this study. 123 patients agreed to participate and subsequently completed baseline forms. Of the patients who completed baseline forms, 97 attended their one-year follow-up visit and completed a follow-up form. There were no differences in demographic or baseline clinical characteristics between patients who attended follow-up and patients who did not attend follow-up.

Demographic Data

The majority of patients were female (81.4%) and the mean age was 60.9 (SD=11.8). 72.9% of patients received total knee replacements and the remainder received total hip replacements (one patient received both a total knee and a total hip replacement). 61.5% of cases were unilateral. 75% of patients had less than a high school education, 19.6% were working at the time of the survey, and 92.7% lived with friends or family members. The mean American Society of Anesthesiologists (ASA) score was 2.2 (SD=0.5) and the average body mass index (BMI) was 28.9 (SD=5.7). 76.6% believed that the surgery had a greater than 90% chance of relieving their pain and 58.7% of patients believed that there was less than a 1% chance that they would experience some kind of complication (Table 3).

Pain and Function Scores

Prior to undergoing TJR, patients had, on average, poor baseline WOMAC function (mean=33.6, SD=23.3) and SF-36 physical function (mean=15.5, SD=17.4) scores.[29] The cohort also had poor baseline WOMAC stiffness scores (mean=35.3, SD=26.2). In contrast, the cohort had good SF-36 mental health scores (mean=75.0, SD= 16.6).

Following surgery, patients improved substantially from their baseline WOMAC function (cohort mean improvement=53.3, SD=26.0), SF-36 physical function (cohort mean improvement=56.7, SD=24.3), WOMAC pain (cohort mean improvement=47.8, SD31.0), and WOMAC stiffness (cohort mean improvement=47.9, SD=33.9) scores. SF-36 mental health scores also improved modestly (cohort mean=6.5, SD=21.3) (Table 4).

Association Between Preoperative Function and End Outcomes, Unadjusted Analysis

When broken into tertiles based on preoperative WOMAC function scores, the highest functioning tertile had a mean score of 60.5 (range: 43–94), the middle tertile had a mean score of 29.2 (range: 19–42), and the lowest tertile had a mean score of 10.1 (range: 0–18). When each tertiles'

one-year follow-up scores were compared to their corresponding preoperative scores, the lowest functioning tertile made the greatest WOMAC function gains (mean improvement=76.2, SD=14.9) when compared to the middle (mean=54.5, SD=17.5) and highest functioning tertiles (mean=29.2, SD=19.5) ($p<0.001$). Significant pairwise differences were found between all groups (data not shown, only the adjusted pairwise comparisons are displayed in Table 4). SF-36 function scores ($p=0.047$), WOMAC pain ($p<0.001$), and WOMAC stiffness ($p<0.001$) all show similar patterns in which the lowest tertile groups improved more than the highest tertile groups. There was no significant difference in improvement patterns in SF-36 mental health scores between the tertiles ($p=0.973$) (Table 4).

There was no difference in one-year follow-up WOMAC function scores between the patients in the lowest tertile of preoperative function scores and those in the highest tertile ($p=0.089$, Figure 3A). Similarly, the three groups did not differ in 12-month SF-36 physical function score ($p=0.053$, Figure 3B), WOMAC pain score ($p=0.114$, Figure 3C), WOMAC stiffness score ($p=0.472$, Figure 3D), or SF-36 mental health ($p=0.456$, Figure 3E).

Multivariable Analysis

There was little change in the statistical significance observed between the tertiles in the univariate analyses and in multivariate analyses that adjusted for sex, education, procedure (unilateral vs bilateral), and joint (knee vs hip; Table 4).

Discussion, Conclusions, and Suggestions for Future Work

Discussion

In this research, we comprehensively evaluated a medical mission joint replacement program's care quality using the structure, process, and outcomes paradigm for quality assessment. To assess the program's structure and processes, we used the BCBS's Blue Distinction Criteria for Knee and Hip Replacement Centers. Overall, this analysis showed that the program scored 71/100 (Figure 2), which exceeds the 60-point threshold for Blue Distinction designation and demonstrates that the program scores excellently on the structure and process elements of quality. We then evaluated patient-level outcomes using preoperative and 12-month post-operative WOMAC and SF-36 survey scores and observed that all tertiles in the Dominican cohort exhibited substantial improvements and high absolute scores at one-year follow-up (Figure 3). A comparison to a cohort study that examined joint replacement outcome patterns in patients from developed countries[29] shows that Op-Walk achieved similar or better post-operative outcomes for each tertile, indicating outstanding performance in the outcomes element of quality (Figure 4). Taken together, our research shows that Op-Walk Boston provides high quality care across all elements of the structure, process, and outcomes paradigm.

Although there is a growing body of quality assessment literature for medical mission trips in other fields,[19,20] our inquiry is the first to evaluate the structure, process, and outcomes aspects of quality in the context of an international TJR medical mission trip. Inquiry into each of these aspects of care quality revealed important and unique insights. For example, our evaluation of Op-Walk Boston's structure and processes highlighted the importance of having dedicated research teams that monitor outcomes and provide data to improve clinical care, an essential structural element that other international joint replacement programs should integrate into their ongoing programs in order to achieve higher-quality care.[43] The relative importance of having dedicated research teams is illustrated by the fact that Op-Walk Boston's research team's operations accounted for eight out of the 71 points received in the structure and process categories, and it also helped the program to meet three informational criteria (Tables 1 and 2).

The structure and processes aspect of our analysis also illustrated areas for program improvement. For example, the program lost a point because it does not use patient navigators. Since Op-Walk Boston's patients often have complex social needs and may have difficulties navigating the health care system, initiating a patient navigation program may help patients with

the hospital experience and subsequent recovery. The program also lost a point because it does not evaluate patients' discharge needs prior to their hospital admission. This is another area Op-Walk Boston has now identified for improvement. The Op-Walk Boston team plans to discuss these findings with their medical, nursing, and rehabilitation colleagues in the D.R. to find culturally acceptable and financially feasible ways of addressing these deficiencies, which will ultimately lead to higher care quality. Leaders of other international joint replacement medical mission programs can similarly use the Blue Distinction criteria and follow similar steps to improve their program's structure and processes.

The outcomes portions of our care quality analysis, in addition to demonstrating Op-Walk Boston's ability to achieve high quality outcomes, illustrated an insight that has never been observed in research performed in developed countries[28,29]— each tertile in our outcomes analysis had similar outcomes at 12-month follow-up. In developed countries, studies have consistently shown that patients with lower preoperative WOMAC function scores have worse functional outcomes at 12-month follow-up than patients who start at a higher baseline functional levels.[28,29] The reason(s) for why Dominican patients with very low preoperative WOMAC scores nevertheless attain good postoperative scores is not yet clear.

Conclusion

Although the Blue Distinction criteria for joint replacement centers were created as quality standards for U.S. hospitals, using these criteria as a benchmark for evaluating TJR medical mission trips can help demonstrate care quality and identify areas of quality improvement—other international joint replacement programs should therefore undertake similar analyses to examine their programs' care quality and to improve their programs.

Additionally, other medical mission joint replacement program administrators should integrate our study's finding that observed improvement patterns in developed countries vary from improvement patterns witnessed in the D.R. This finding suggests that operating on patients of lower preoperative functional status may not compromise their end result. More broadly, this information may be especially important to policy makers from developing countries, as it will allow them to more thoughtfully allocate their countries' limited resources.

Limitations

The data used for the Blue Distinction criteria analysis were potentially subject to observer bias, as data were collected by an investigator rather than a research assistant blinded to the study's hypotheses and objectives. Anticipating this bias, we used data elements from the BCBS's Blue Distinction Criteria for Knee and Hip Replacement Centers that were objective, binary, and subject to little interpretation. Furthermore, the data for this study were collected from a small number of respondents who provided key information to evaluate if the program meets or does not meet the criteria; it is therefore possible that responses would have been more heterogeneous if more people were surveyed but this variability should be limited by the objective and binary nature of the BCBS's criteria.

The outcomes evaluation portion of our study is limited because it only examines patient outcomes from the D.R. Additional work is needed to assess if the observed improvement patterns occur in other developing countries. The small sample size (97) and low proportion of subjects that received hip replacements also limit the scope of inferences permitted by our data. For example, a larger sample would have supported analyses of quartiles instead of tertiles, providing a richer comparison. Our work suggests, however, that surgical patterns observed in developed countries vary from patterns observed in developing countries. With medical mission trips' growing prevalence, it will become increasingly important for mission groups to track their outcomes and to have dedicated research teams that analyze outcomes data to determine if country or region-specific variations in patients' surgical indicators and surgical outcomes exist. Better understanding these differences may have important policy implications for developing health care systems and the mission groups that work in these countries.

Suggestions for Future Work

Since some aspects of the Blue Distinction criteria require organizations to report to U.S.-based quality improvement organizations, future work should alter the existing criteria so that these organizations can earn points for reporting to equivalent international quality improvement organizations, such as Joint Commission International[44] or the International Board of Medicine and Surgery,[45] or provide waivers for organizations that operate in countries without equivalent quality improvement organizations. Furthermore, some Blue Distinction criteria require investment in patient navigators or expensive health care infrastructure, which is difficult because cost is a common barrier for international medical missions. The criteria should therefore be

redesigned so that they can be implemented with a level of investment more congruent with the resource capacity in the country being evaluated. Having a revised set of criteria could help medical mission trips better evaluate their programs and allow them to enhance the care they provide.

Since the reasons for the differences in improvement patterns between patients in developed countries and Dominican patients is not clear, future work should also focus on better understanding the many potential explanations for these differences. One hypothesis relates to patients' demographic status, as it is known that living alone leads to worse functional outcomes [27] and a relatively high percentage of Op-Walk Boston's patients live with friends or family members (Table 3), so this demographic difference may explain the Dominican patients' ability to achieve high functional scores, regardless of the preoperative functional status. A second hypothesis relates to differences in the cohorts' health status, as the Dominican patients are screened carefully before being accepted into the program, so there may be selection bias for patients who have better overall health, leading to greater improvements following surgery. A third hypothesis involves the cohorts' age differences. The Dominican patients' average age (60.9) is almost ten years less than the average age (70.7) of the combined cohorts used in the literature from developed countries. Although age did not seem to be a confounder in our study, it has been noted that higher age predicts lower SF-36 functional scores at two-year follow-up[29] and worse post-operative function,[27] so it is possible that our patients' younger age helps them to achieve better outcomes, regardless of their baseline status. A final hypothesis is that patients' motivation to improve post-surgery may be an important driver of these differences, as the Dominican patients are notably enthusiastic and highly motivated to regain function following surgery. Additional research is required to more rigorously test these hypotheses.

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The author of this honors thesis reports no financial interests that would be relevant to this research.

Summary:

This work uses the structure, process, and outcomes paradigm of care quality to comprehensively evaluate a medical mission that provides total knee and hip replacements in the D.R. This analysis yielded several key insights:

- 1) Op-Walk Boston, a joint replacement medical mission trip, provides high care quality across all quality categories,
- 2) Using tools from developed countries that are designed to measure the structure and process elements of quality can lead to useful insights into how to improve medical mission trips and can identify unique ways in which these programs compensate while operating in resource-constrained environments,
- 3) Structure and process scoring rubrics from the U.S. and other developed countries need to be adapted to reflect the unique contexts of developing countries, as many scoring elements on currently-available scoring rubrics are not applicable in developing countries, and
- 4) Patterns of improvement following joint replacement in the D.R. do not match improvement patterns observed in developed countries, which could have major policy implications for the optimal timing of joint replacements and for the allocation of these scarce resources in the D.R. and potentially in other developing countries.

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Table 1. Blue Distinction Criteria, Points Awarded, Accommodations Made to Meet the Criteria, and Barriers to Criteria’s Implementation for General and Structure Criteria.[46]²

Criteria	Points Earned Out of Total	Explanation	Accommodation	Barrier
General Criteria for all Blue Distinction Centers				
Facility must be an inpatient acute care hospital that provides comprehensive inpatient care (e.g., Emergency Room, Intensive Care and other specified services)	Required	Criterion met.	N/A	N/A
Full facility accreditation by a CMS-deemed national accreditation organization	Required	Criterion not met.	Hospital is working to meet the Joint Commission's accreditation criteria.	N/A
Facility participation in Institute for Healthcare Improvement (IHI) with a commitment to patient safety, including formal commitment to at least 6 improvement campaigns (i.e., initiatives)	0/2	Criterion not applicable because IHI does not work in the Caribbean.	Program has engaged in quality improvement measures from IHI's list of QI initiatives.	IHI does not currently operate in the D.R.
Facility publicly reports on the Leapfrog Web site via the Leapfrog Group Quality and Safety Hospital Survey	0/1	Criterion not applicable because Leapfrog does not work in D.R.	N/A	The Leapfrog Group does not evaluate international hospitals.
If facility does not report to Leapfrog, facility participates in other initiatives that encourage the sharing of best practices, incorporates data feedback for objective analysis, and promotes collaborative improvement *Alternate initiatives will be reviewed on a case-by-case basis	0/0	Criterion met.	N/A	N/A
Facility accepts the Association of American Medical Colleges (AAMC) principles for all clinical trials	1/1	Criterion met. Hospital participates in three multicenter trials, follows AAMC principles.	N/A	N/A

² This table was previously published in a peer-reviewed journal by the author of this thesis.[46]

Facility uses a certified electronic medical record (EMR) certified by the Certification Commission for Healthcare Information Technology (CCHIT)	0/1	Criterion not met.	The hospital uses the LOLCLI 9000 EMR by LOLIMSA.	N/A
Facility uses an e-prescribing program to facilitate communication that meets the standards set forth in the 2003 Medicare Modernization Act (MMA)	0/1	Criterion not applicable.	Physicians e-prescribe using an electronic medical order sent directly to the hospital's pharmacy. Prescriptions for outpatients must be made manually.	Medicare Modernization Act's specifications relate to specific formularies that are not relevant in D.R.
Facility has a formal process of medication reconciliation that includes: --Verification --Clarification --Reconciliation	1/1	Criterion met.	N/A	N/A
Facility is currently active in one of the following quality nursing excellence initiatives: --Has earned the Magnet Recognition Award of the American Nurses Credentialing Center --Reports to the American Nurses Association's National Database of Nursing Quality Indicators (NDNQI)	0/1	Criterion not applicable.	Hospital currently improving nursing quality, including evaluation of nurse performance, patient quality and safety education, and CME meetings.	Magnet Award from ANCC requires compliance with U.S. Department of Labor and the Department of Health and Human Services (not applicable in the D.R.).
Facility participates in Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey and makes data publicly available on the Hospital Compare Web site for the most recent public reporting date	0/1	Criterion not applicable.	Op-Walk Boston's research team collects patient satisfaction surveys, and it uses this information to improve patient care.	HCAHPS is specific to U.S. hospitals.

Facility utilizes one of the following national quality improvement initiatives focused on surgical safety: --Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery --World Health Organization Surgical Safety Checklist	1/1	Criterion met. Op-Walk Boston uses WHO Surgical Safety Checklists.	N/A	N/A
Facility participates in the Surgical Care Improvement Project (SCIP)	0/2	Criterion not met.	Hospital follows best practice guidelines but does not specifically follow SCIP. Working toward Joint Commission International (JCI) accreditation.	N/A
SCIP INF 1a: Prophylactic antibiotic received within one hour prior to surgical incision	1/1	Criterion met.	N/A	N/A
SCIP INF 2a: Prophylactic antibiotic selection for surgical patients	1/1	Criterion met. Medications and allergies are reviewed before selecting a prophylactic antibiotic.	N/A	N/A
SCIP INF 5: Postoperative wound infection diagnosed during index hospitalization (OUTCOME – facility tracks & internally reports data)	1/1	Criterion met.	N/A	N/A
SCIP VTE 1: Surgery patients with recommended venous thromboembolism prophylaxis ordered	1/1	Criterion met.	N/A	N/A
SCIP VTE 2: Surgery patients who received appropriate venous thromboembolism prophylaxis within 24 hours prior to surgery to 24 hours after surgery	1/1	Criterion met.	N/A	N/A
SCIP VTE 3: Intra- or postoperative pulmonary embolism (PE) diagnosed during index hospitalization and within 30 days of surgery (OUTCOME – facility tracks & internally reports data)	1/1	Criterion met.	N/A	N/A

SCIP VTE 4: Intra- or postoperative deep vein thrombosis (DVT) diagnosed during index hospitalization and within 30 days of surgery (OUTCOME – facility tracks & internally reports data)	1/1	Criterion met.	N/A	N/A
Facility's SCIP database is able to produce procedure-specific performance reports	Informational	Criterion not met.	Op-Walk Boston's research team evaluates each trip's outcomes.	N/A
Facility has a policy on physician/surgeon conflict of interest	0/1	Criterion not met.	N/A	N/A
Facility publicly reports physician/surgeon conflict of interest related to financial relationships with pharmaceutical companies or device manufacturers	0/1	Criterion not met.	N/A	N/A
Facility discloses to patients prior to surgery exclusive relationships the facility has with device manufacturers or pharmaceutical companies	0/1	Criterion not met.	N/A	N/A
Facility has a written policy or process for selecting devices in the device formulary	0/1	Criterion not met.	N/A	N/A
Facility's policy includes a mechanism for tracking FDA-recalled prosthesis and notifying patients who have received them	Informational	Criterion not met.	N/A	N/A
Facility reports incidences of device malfunction to the device manufacturer	Informational	Criterion met.	N/A	N/A
Facility has protocols for acute pain management in peri-operative surgical patients	1/1	Criterion met.	N/A	N/A
Pain management protocols are based on national guidelines: --American Society of Anesthesiologists' Practice Guidelines for Acute Pain Management in the Peri-operative Setting --Pain Management Standards of the facility's accrediting agency (identified in question #8)	1/1	Criterion met. Pain management protocols modeled after protocols followed in Boston-area teaching hospitals.	N/A.	N/A

Facility has an interdisciplinary workgroup/committee/team in place for implementing pain management protocols and monitoring their effectiveness	2/2	Criterion met. Team of anesthesiologists, internists, nurses, physical therapist's (PT), and orthopedists reviews pain management needs.	N/A	N/A
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Structure

Program is currently and has been actively performing knee and hip replacement surgery since July 1, 2009 or for at least the immediately previous 12 uninterrupted months	Required	Criterion met.	N/A	N/A
Program has formal care quality initiatives for knee and hip replacement services with the following components: --Collection of quality indicator data --Analysis of collected data --Identification of issues --Development of improvement goals --Implementation of changes --Demonstration that the implemented changes improve the quality of clinical care that patients receive --Ongoing requirements for physician/surgeon learning and improvement and/or regularly scheduled educational conferences	2/2	All sub-categories of this criterion are met.	N/A	N/A
Program maintains an internal registry or database to track knee and hip replacement patients' treatment and outcome data	5/5	Criterion met. Research team tracks outcomes with standardized surveys.	N/A	N/A
Program has a process in place to track complications in the context of a program-wide quality improvement process	2/2	Criterion met. Complications reviewed at the end of each trip and corrective actions are taken to	N/A	N/A

		minimize future complications		
Program has a process in place to track primary knee and hip replacement patients who return to the facility for revision of their primary procedure	1/1	Criterion met. Op-Walk Boston's colleagues in the D.R. monitor patients' ongoing needs (including revision).	N/A	N/A
Program obtains and evaluates patient satisfaction specific to knee and hip replacement services with results reported back to program staff	Informational	Criterion met.	N/A	N/A
Program has a protocol in place to contact patients (or primary physicians) for follow-up and status information post-discharge	0/1	Criterion not met.	The hospital lacks a protocol for contacting patients. Follow-up consultations are scheduled by the individual doctors.	Able to contact patients, but communicating with PCPs is challenging.
Program reports to a multi-center registry or database that tracks knee and hip replacement surgery	Informational	Criterion met. Op-Walk Boston keeps a database that is shared between HGPS and the Brigham and Women's Hospital.	N/A	N/A
Program reports to at least one of the following registries or database: --National Surgical Quality Improvement Program (NSQIP) --University HealthSystem Consortium (UHC) --Premier Clinical Advisor	0/2	Criterion not applicable.	Op-Walk Boston's research team tracks surgical quality.	Organizations are primarily focused on U.S. hospitals. Require expensive membership fees or purchasing other goods.

Program plans to participate in a comprehensive national knee and hip replacement registry once one is developed	Informational	Criterion met.	Op-Walk Boston uses a database to track all knee and hip replacement outcomes.	No TJR registries exist in the D.R. and there are no ongoing plans to establish one.
Facility has an inpatient unit dedicated to the care of orthopedic patients	2/2	Criterion met. During the mission trip, Op-Walk Boston has an entire hospital ward dedicated exclusively to its patients and team members.	N/A	N/A
Program utilizes multi-disciplinary clinical pathways/protocols for the care of knee and hip replacement patients that include the following features: --Treatment goals --Sequence and timing of interventions --Active participation of a multi-disciplinary team --Daily milestones --Coordination of discharge, patient education and other patient needs	4/4	Criteria met for all sub-categories.	N/A	N/A
Multi-disciplinary pathways/protocols address the full continuum of care across inpatient and outpatient settings	1/1	Criterion met.	N/A	N/A
Multi-disciplinary pathways/protocols generate standardized pre- and post-operative order sets	1/1	Criterion met. Clinical teams follow pre- and post-operative standardized work flows.	N/A	Electronic medical systems within the host hospital do not allow for automated, electronic order sets.
Program has standing orders that are utilized for the care of knee and hip replacement patients	1/1	Criterion met.	Each procedure has defined protocols. These procedures are documented in the patients' chart.	N/A

Pathways/protocols or standing orders are placed in the medical record for daily use by all care providers	1/1	Criterion met.	N/A	N/A
Specific physician orders are required to deviate from the pathways/protocols or standing order set	1/1	Criterion met. Deviations discussed in the context of an interdisciplinary team.	N/A	N/A
Program consults resources to develop facility's pathways/protocols or standing orders (e.g., clinical guidelines, national standards)	Informational	Criterion met. Op-Walk Boston strives to replicate the TJR process followed by Mass General Hospital and Brigham and Women's Hospital.	N/A	N/A
In addition to orthopedic surgery and/or neurosurgery, other dedicated members of the multi-disciplinary care team for knee and hip replacement include: -- Anesthesiology -- Psychiatry/Psychology -- Pain Management Specialist -- Clinician focused on peri-operative medical management -- Nursing -- PT/Occupational Therapy -- Physiatrist/Physical Medicine and Rehabilitation -- Dedicated case managers as care coordinators for complex patients	5/8	Most criteria met. Op-Walk Boston lacks psychiatrists and psychologists, pain management specialists, and dedicated case managers.	Anesthesia team has experience in pain management, so they function as pain management specialists.	Case managers would require additional resources.
Program identifies departments that have at least one identified clinician who provides as-needed consultation to the knee and hip replacement team: -- Cardiology -- Endocrinology -- Pulmonology -- Nutrition -- Social Services	Informational	Criterion met.	N/A	N/A
Program has pain management specialist(s) with subspecialty certification in Pain Medicine	Informational	Criterion not met.	Op-Walk Boston's anesthesiologists provide all needed pain care.	N/A

Program identifies subspecialty certification(s) held by nurses on the care team: -- Surgical nursing -- Orthopedic nursing -- Rehabilitation nursing	1/1	Criterion met, although not all nurses have one of these certifications.	N/A	N/A
Physical therapists on the care team maintain the American Physical Therapy Association (APTA) certification in orthopedic care	1/1	Criterion met.	N/A	N/A
Knee and hip replacement team holds multi-disciplinary team meetings or case management conferences at least monthly	1/1	Criterion met.	N/A	N/A
Surgeons performing knee and hip replacement surgery are certified or eligible for certification by the American Board of Medical Specialties, the Royal College of Physicians and Surgeons Board, or the American Osteopathic Board of Orthopedic Surgery	Required	Requirement met.	N/A	N/A
50% of knee and hip replacement surgeons have Accreditation Council for Graduate Medical Education (ACGME) fellowship training in Adult Reconstructive Orthopedics	1/1	All surgeons are fellowship trained in Reconstructive Orthopedics.	N/A	N/A
Surgeon participation in American Board of Medical Specialties (ABMS) Maintenance of Certification (MOC)	Informational	Criterion met.	N/A	N/A

Table 2. Blue Distinction Criteria, Points Awarded, Accommodations Made to Meet the Criteria, and Barriers to Criteria’s Implementation for Process and Outcomes and Volume criteria.[46]³

Criteria	Points Earned Out of Total	Explanation	Accommodation	Barrier
Process				
Structured functional assessments that are routinely performed and tracked for all knee and hip replacement patients include: --Preoperative functional assessments --Functional assessments four or more weeks post-operatively	3/3	Criterion met.	N/A	N/A
Program identifies routine pre- and post-op assessment of functional status that are used for standardized indexes (e.g., Knee Society Score or Harris Hip Score, Western Ontario and McMaster Osteoarthritis Index, SF-36, EuroQol 5-D)	Informational	Criterion met.	N/A	N/A
Program has written patient selection criteria that are applied to all adult patients referred for knee or hip replacement	1/1	Criterion met.	N/A	N/A
Patient selection criteria are developed by a multi-disciplinary team of physicians and staff	1/1	Criterion met.	N/A	N/A
Program screens knee and hip patients preoperatively for the presence of anxiety or depression	1/1	Criterion met.	N/A	N/A
Program uses formal measures to screen preoperatively for anxiety or depression: --Beck Depression Inventory --The Hospital Anxiety and Depression Scale --The nine-item depression scale of the Patient Health Questionnaire --The mental health subscale of the Health status Questionnaire Short Form-36 (SF-36) --Euro QOL 5-D	1/1	Criterion met. Op-Walk Boston uses the mental health subscale of the SF-36.	N/A	N/A

³ This table was previously published in a peer-reviewed journal by the author of this thesis.[46]

Program employs or is willing to implement SDM processes with patients considering knee or hip replacement surgery	Informational	Criterion not met.	N/A	Dominican patients are accustomed to agreeing with Doctors' recommendations.
Program provides standardized preoperative patient education	1/1	Criterion met.	N/A	N/A
Preoperative patient education activities include: Educational group session or class Interactive electronic media program Materials provided to the patient (print, video) Written questionnaire completed by the patient	2/2	Criterion met. Educational sessions, classes, and print material provided.	Hospital's staff offers reading help for all print material.	N/A
Percentage of patients participating in preoperative patient education process greater than or equal to 90%	1/1	Criterion met.	N/A	N/A
Protocol informing patients with relevant comorbidities (e.g., BMI > 40 kg/m ² , diabetes mellitus) of the increased risks associated with knee and hip replacement surgery	1/1	Criterion met.	N/A	N/A
Program utilizes established practice standards/recommendations for the perioperative care of knee and hip replacement patients: --American Society of Anesthesiologists (ASA) Practice Advisory for Pre-anesthesia Evaluation --American College of Cardiology/American Heart Association (ACC/AHA) Guideline for the Perioperative Cardiovascular Evaluation for Non-cardiac Surgery --American Diabetes Association (ADA) Standards of Diabetes Care in the Hospital --AHA recommendations for Smoking Cessation - Making Hospital-Wide System Level Changes That Succeed	2/2	Criteria met. ASA, ACC, and ADA requirements met.	N/A	Following AHA guidelines requires prolonged and repeated contact with patients.
Program has a thromboprophylaxis protocol in place that is specific for knee and hip replacement patients and incorporates the American Academy of Orthopedic Surgeons (AAOS) Clinical Guideline on the Prevention of Symptomatic Pulmonary Embolism in Patients Undergoing Total Hip or Total Knee Arthroplasty	1/1	Criterion met.	N/A	N/A

<p>Program implements the following anesthesia practices: --Knee and hip replacement patients are routinely evaluated for the use of regional anesthesia --The program has a protocol in place for monitoring and maintaining intraoperative normothermia for appropriate knee and hip replacement patients</p>	1/1	Criterion met.	N/A	N/A
<p>Program has protocols for the assessment and treatment of physical therapy needs in the post-operative knee and hip replacement surgery patients</p>	1/1	Criterion met.	N/A	N/A
<p>Program identifies aspects of PT/OT care that are provided routinely (e.g., preoperative and post-operative education, home assessment, functional assessment, readiness-for-discharge assessment)</p>	Informational	Criterion met.	N/A	N/A
<p>Standard practices for case management and discharge planning for knee and hip replacement patients include: --Evaluation for discharge needs occurs prior to the hospital admission --Written criteria for hospital discharge and readmission --Coordination of post-discharge needs (e.g., physical therapy, home care services) --Written protocol for emergency evaluation and treatment post discharge</p>	0/1	Criteria not met. Does not evaluate discharge needs before admission and lacks protocols for emergency evaluations and treatment post discharge.	N/A	N/A
<p>Percentage of patients admitted from home who return to home</p>	Informational	100% return home.	N/A	N/A
<p>Program monitors transitions of care for patients discharged to another setting (e.g., home, rehab facility) using a formal method</p>	0/1	Criterion not met.	Patient stored in hospital's EHR, so patient information could be tracked.	Formal tracking protocol not followed.
<p>Program has an established protocol ensuring the operation note and discharge summary of each patient are made available to the primary care physician upon discharge</p>	0/1	Criterion not met.	Op-Walk Boston's colleagues follow-up with their patients for any needed	Most patients lack PCPs and there is no care coordination infrastructure.

			post-op care.	
Program tracks receipt of the operation note and discharge summary by primary care physician	Informational	Criterion not met.	N/A	Most patients lack PCPs and there is no care coordination infrastructure.
Program utilizes services of the local Blue Cross Blue Shield case management care team to coordinate transitions of care	Informational	Criterion not met.	N/A	Blue Cross/ Shield does not operate in the D.R.

Outcomes and Volume

Average and median surgeon volumes (across all surgeons actively performing TKA or THA) are at least 50 primary or revision TKA or THA procedures during reported 12-month period. Surgeons may include cases done at any facility.	Required	Criteria met.	N/A	N/A
Facility performs at least 100 total knee and total hip replacement surgeries (primary and revisions) during reported 12-month period, with at least 25 each of total knee and total hip replacements	Required	Requirement met.	N/A	N/A
Facility volume \geq 250 surgeries during reported 12-month period	0/3	Criterion not met.	N/A	N/A
Facility volume \geq 500 surgeries during reported 12-month period	0/2	Criterion not met.	N/A	N/A
Facility performs 50 net revisions for Total Knee and Total Hip Arthroplasty (Net Volume = total reported TKA/THA revisions minus revisions performed < 6 months following a primary procedure where both procedures were done at the facility)	0/2	Criterion not applicable.	N/A	N/A
Average LOS for primary Total Knee Arthroplasty (TKA) less than or equal to 3.5 days	3/3	Criterion met.	N/A	N/A
Average LOS for primary Total Hip Arthroplasty (THA) less than or equal to 4.0 days	3/3	Criterion met.	N/A	N/A

Average LOS for Revision Hip Replacement, Hip Resurfacing and Revision Knee Replacement	Informational	Revisions rare. Inadequate data to access criterion.	N/A	N/A
Average 30-day readmission rate for primary Total Knee Arthroplasty (TKA) less than or equal to 10%	2/2	Criterion met.	N/A	N/A
Average 30-day readmission rate for primary Total Hip Arthroplasty (THA) less than or equal to 10%	2/2	Criterion met.	N/A	N/A
Program tracks the selection, administration and discontinuation of prophylactic antibiotics for total knee replacement patients: SCIP INF 1e, INF 2e, and INF 3e	Informational	Criterion not met.	Each surgeon tracks their patients, but no programmatic level tracking.	N/A

Table 3. Patient Demographics for All Op-Walk Patients.[47]⁴

Demographic	Overall (n=97)	Highest (best) Tertile (n=33)	Medium Tertile (n=32)	Lowest (worst) Tertile (n=32)
Sex – Female	79 (81.4%)	21 (63.6%)	28 (87.5%)	30 (93.8%)
Age (n, Mean (SD))	97 60.9 (11.8)	33 62.0 (8.8)	32 58.0 (13.4)	32 62.8 (12.6)
Education – completed secondary school or higher	24 (25.3%)	11 (33.3%)	8 (25.8%)	5 (16.1%)
Currently Working	19 (19.6%)	12 (36.4%)	5 (15.6%)	2 (6.3%)
Lives with Friends or Family Members	89 (92.7%)	29 (87.9%)	31 (100.0%)	29 (90.6%)
ASA (n, Mean (SD))	90 2.2 (0.5)	30 2.1 (0.5)	29 2.1 (0.5)	31 2.2 (0.4)
BMI (n, Mean (SD))	79 28.9 (5.7)	28 28.6 (5.6)	24 29.2 (6.3)	27 29.0 (5.4)
BMI > 35	10 (12.7%)	4 (14.3%)	2 (8.3%)	4 (14.8%)
Health >= GOOD	47 (50.5%)	17 (54.8%)	15 (50.0%)	15 (46.9%)
Surgery > 90 percent Chance of relieving pain	72 (76.6%)	23 (71.9%)	22 (71.0%)	27 (87.1%)
Chance of major surgical complication < 1 percent	54 (58.7%)	15 (48.4%)	16 (53.3%)	23 (74.2%)
Procedure - Knee	70 (72.9%)	24 (72.7%)	20 (62.5%)	26 (83.9%)
Procedure - Hip	26 (27.1%)	9 (27.3%)	12 (37.5%)	5 (16.1%)
Procedure - Unilateral	59 (61.5%)	28 (84.8%)	18 (56.3%)	13 (41.9%)
Procedure - Bilateral	37 (38.5%)	5 (15.2%)	14 (43.8%)	18 (58.1%)

⁴ This table was previously published in a peer-reviewed journal by the author of this thesis.[47]

Table 4. Baseline and 12-Month WOMAC and SF-36 Scores Stratified by Baseline WOMAC Function Score.[47]⁵

	Overall	Highest (Best) Tertile	Medium Tertile	Lowest (Worst) Tertile	Unadjusted p-value	Adjusted p-value*
<u>WOMAC Function Scores</u>						
Baseline WOMAC Function	N=97 Mean (S.D.)=33.6 (23.3)	33 60.5 (15.0)	32 29.2 (7.4)	32 10.1 (5.9)		
Follow-Up WOMAC Function	N=94 Mean (S.D.)=86.5 (13.1)	32 90.0 (11.8)	30 83.0 (14.8)	32 86.2 (11.9)	0.089	0.051
Change in WOMAC Function	N=94 Mean (S.D.)=53.3 (26.0)	32 29.2 (19.5)	30 54.5 (17.5)	32 76.2 (14.9)	<0.001	<0.001
<u>SF-36 Physical Function Scores</u>						
Baseline SF-36 Physical Function	N=94 Mean (S.D.)=15.5 (17.4)	32 27.2 (22.8)	30 11.2 (10.8)	32 7.7 (7.4)		
Follow-Up SF-36 Physical Function	N=91 Mean (S.D.)=72.1 (20.4)	32 77.7 (17.0)	29 65.0 (21.4)	30 73.1 (21.2)	0.053	0.043
Change in SF-36 Physical Function	N=88 Mean (S.D.)=56.7 (24.3)	31 49.3 (22.5)	27 55.9 (24.6)	30 65.1 (23.9)	0.047	0.108
<u>WOMAC Pain Score</u>						
Baseline WOMAC Pain	N=91 Mean (S.D.)=37.0 (22.0)	30 55.2 (19.6)	30 37.0 (14.4)	31 19.5 (15.4)		
Follow-Up WOMAC Pain	N=93 Mean (S.D.)=85.0 (17.5)	32 88.9 (12.9)	30 80.2 (22.3)	31 85.6 (15.8)	0.114	0.150
Change in WOMAC Pain	N=87 Mean (S.D.)=47.8 (31.0)	29 33.4 (24.8)	28 42.6 (33.2)	30 66.7 (25.0)	<0.001	0.001
<u>WOMAC Stiffness Scores</u>						
Baseline WOMAC Stiffness	N=92 Mean (S.D.)=35.3 (26.2)	31 55.2 (20.6)	31 35.1 (24.5)	30 15.0 (15.5)		

⁵ This table was previously published in a peer-reviewed journal by the author of this thesis.[47]

Follow-Up WOMAC Stiffness	N=94 Mean (S.D.)=83.8 (19.9)	33 85.6 (16.6)	29 80.2 (25.3)	32 85.2 (17.5)	0.472	0.374
Change in WOMAC Stiffness	N=89 Mean (S.D.)=47.9 (33.9)	31 30.6 (26.0)	28 42.9 (35.9)	30 70.4 (26.8)	<0.001	<0.001
<u>SF-36 Mental Health Scores</u>						
Baseline SF-36 Mental Health	N=97 Mean (S.D.)=75.0 (16.6)	33 74.7 (15.2)	32 72.0 (15.0)	32 78.3 (19.2)		
Follow-Up SF-36 Mental Health	N=93 Mean (S.D.)=81.5 (18.8)	31 81.3 (17.8)	32 78.5 (21.2)	30 85.1 (17.1)	0.456	0.165
Change in SF-36 Mental Health	N=93 Mean (S.D.)=6.5 (21.3)	31 7.4 (25.2)	32 6.5 (19.5)	30 5.7 (19.3)	0.973	0.753

Significant pairwise comparisons from adjusted analysis were found in Change in WOMAC Function (all comparisons); change in WOMAC Pain (H vs L; M vs L); change in WOMAC Stiffness (H vs L; M vs L).

*Adjusted for sex, education, procedure (unilateral vs. bilateral), and joint (hip vs. knee)

Figure 1. Explanation and examples of structure, process, and outcomes categories.[24]

Care quality category	Explanation
Structure	Focus on physical place where outcomes produced. Examples: facility conditions, provider qualifications, facility certifications, administrative structure
Process	Focus on how the care is provided . Examples: appropriateness of patient selection, coordination and continuity, progression to home
Outcomes	Focus on patient's health after the intervention . Examples: time to recovery, restoration of function, reduction of pain, survival

Figure 2. Weighted Score Breakdowns for Blue Cross/Blue Shield’s Joint Replacement Center of Excellence Criteria that are Met or not Met in Each of the Four Quality Categories.

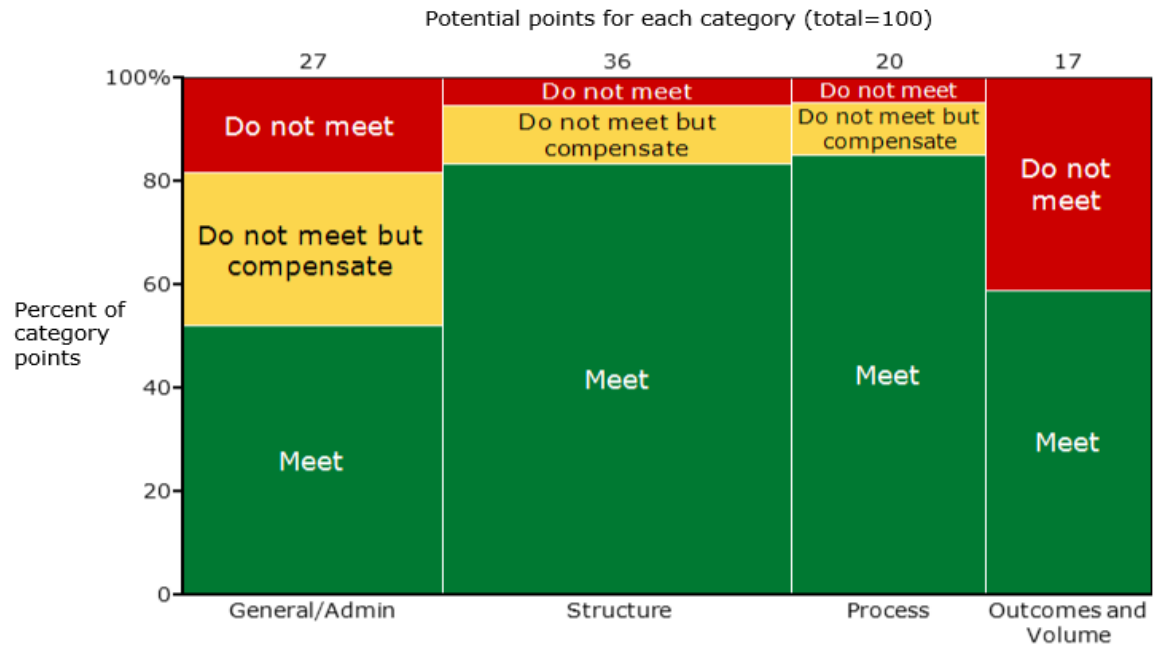
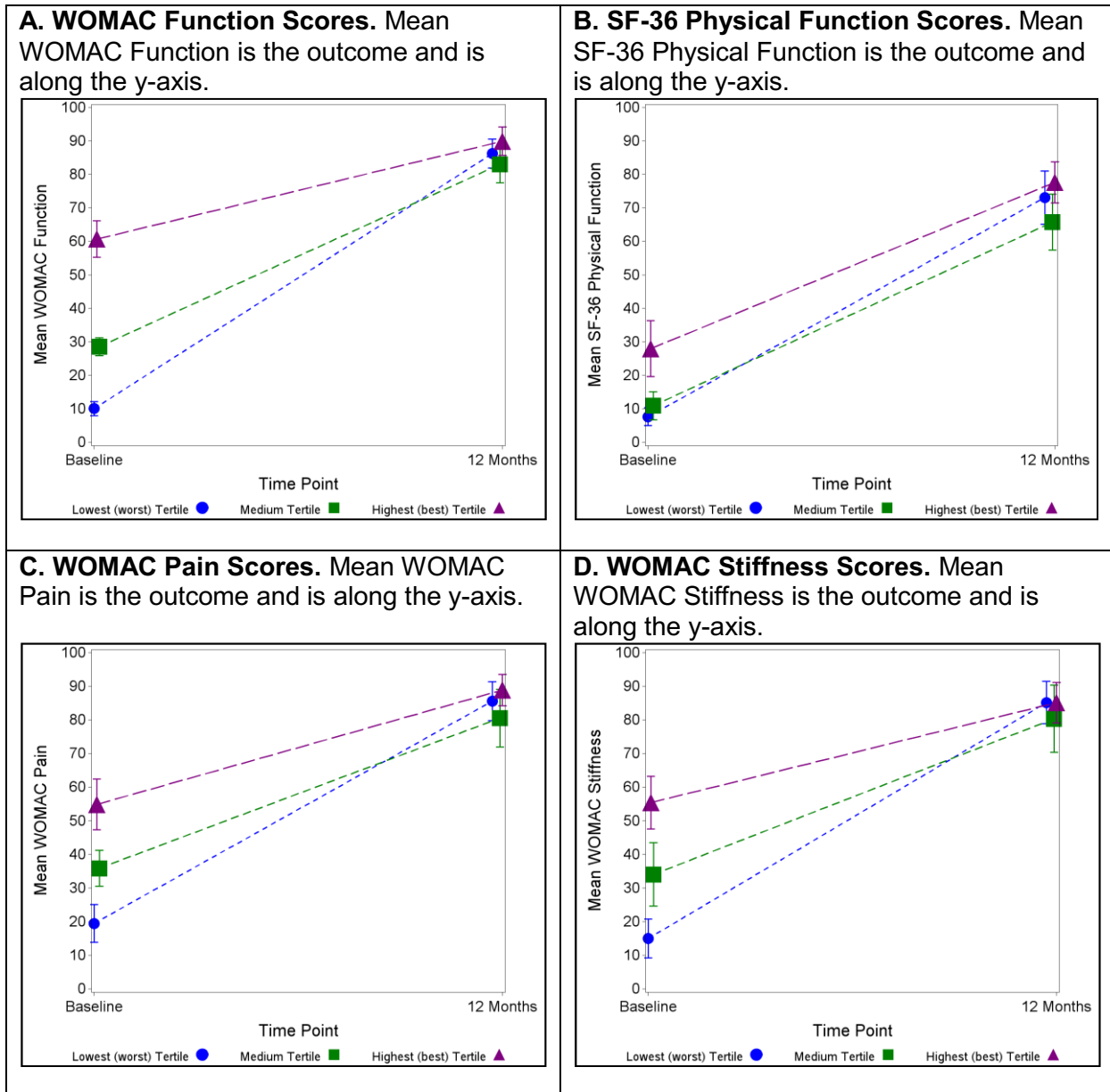


Figure 3. Baseline and 12-Month WOMAC and SF-36 Scores with 95% CI, Stratified by Baseline WOMAC Function Score.[47]⁶

Each line represents a different group: blue dots are patients in the lowest (worst) baseline WOMAC Function tertile; green squares are patients in the medium baseline WOMAC Function tertile; purple triangles are patients in the highest (best) baseline WOMAC Function tertile. The X-axis has the two timepoints: baseline and 12-month. The y-axis has the mean outcome measured at each timepoint. Each symbol represents the mean outcome score for that particular group at that timepoint, with a 95% confidence interval.



⁶ These figures were previously published in a peer-reviewed journal by the author of this thesis.[47]

E. SF-36 Mental Health Scores. Mean SF-36 Mental Health is the outcome and is along the y-axis.

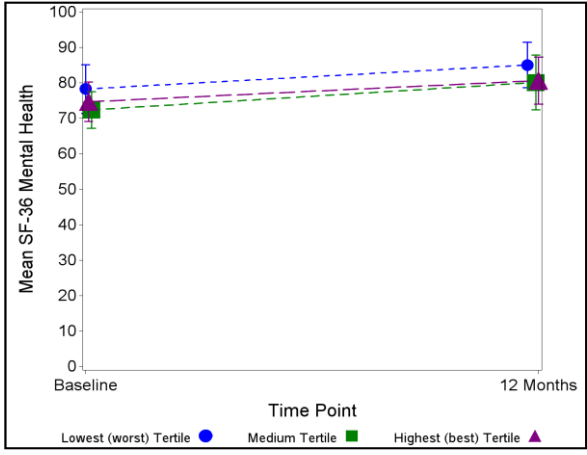
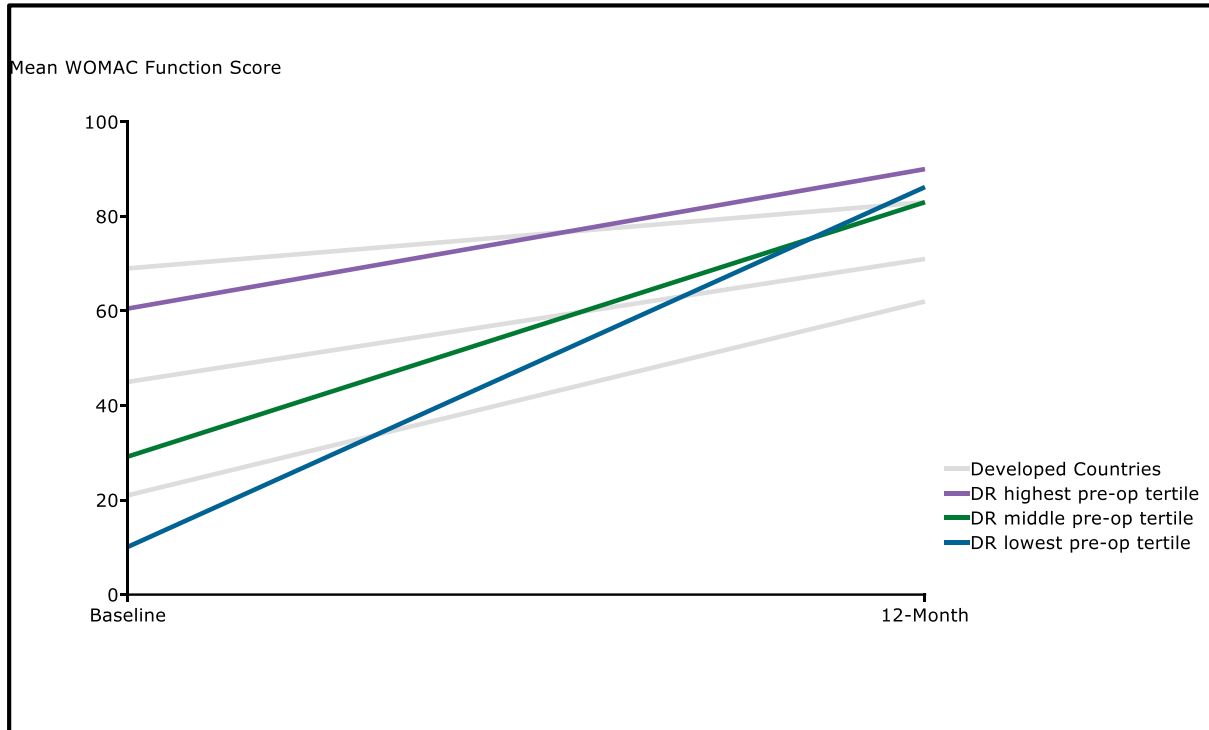


Figure 4. Merged Improvement Pattern Tertile Data at Baseline and 12-month Follow-up from Developed Countries'[29] and Op-Walk Boston's D.R. Program.*



*Data for developed countries' tertiles were extracted and extrapolated from Lingard et al.'s original paper[29] by assigning Lingard's quartile one to developed countries' lowest tertile, the average of Lingard's quartiles two and three to developed countries' middle tertile, and Lingard's quartile four to developed countries' third tertile. The grouping of Lingard's quartiles two and three into developed countries' middle tertile was based on pairing the Lingard quartiles to best mimic the baseline scores of the D.R. tertiles.

Supplementary Table 1. Baseline and 12-Month WOMAC and SF-36 Scores in Knee Replacement Patients Stratified by Baseline WOMAC Function Scores.[47]⁷

	Overall	Highest (Best) Tertile	Medium Tertile	Lowest (Worst) Tertile
<u>WOMAC Function Scores</u>				
Baseline WOMAC Function	N=70 Mean (S.D.)=32.3 (23.2)	24 58.7 (15.5)	20 29.5 (7.3)	26 10.1 (5.9)
Follow-Up WOMAC Function	N=68 Mean (S.D.)=84.9 (13.9)	23 88.3 (13.0)	19 81.1 (16.7)	26 84.7 (12.2)
Change in WOMAC Function	N=68 Mean (S.D.)=53.0 (26.5)	23 29.4 (20.6)	19 52.0 (19.7)	26 74.6 (15.2)
<u>SF-36 Physical Function Scores</u>				
Baseline SF-36 Physical Function	N=67 Mean (S.D.)=14.6 (17.2)	23 25.4 (22.9)	18 12.0 (11.4)	26 6.8 (7.7)
Follow-Up SF-36 Physical Function	N=67 Mean (S.D.)=69.4 (20.6)	23 76.2 (18.1)	19 59.9 (19.7)	25 70.3 (21.3)
Change in SF-36 Physical Function	N=64 Mean (S.D.)=54.7 (25.1)	22 49.3 (24.2)	17 49.2 (24.0)	25 63.3 (25.1)
<u>WOMAC Pain Scores</u>				
Baseline WOMAC Pain	N=64 Mean (S.D.)=35.4 (20.2)	21 50.0 (18.2)	18 38.3 (13.8)	25 21.2 (16.0)
Follow-Up WOMAC Pain	N=67 Mean (S.D.)=84.2 (17.3)	23 88.5 (13.3)	19 78.0 (21.5)	25 85.0 (16.2)
Change in WOMAC Pain	N=61 Mean (S.D.)=48.5 (29.0)	20 38.3 (25.1)	17 38.2 (29.7)	24 64.4 (25.1)
<u>WOMAC Stiffness Scores</u>				
Baseline WOMAC Stiffness	N=66 Mean (S.D.)=33.1 (26.6)	22 51.1 (21.8)	19 35.5 (28.6)	25 15.5 (16.3)
Follow-Up WOMAC Stiffness	N=68 Mean (S.D.)=82.0 (19.4)	24 83.3 (17.9)	18 79.2 (23.5)	26 82.7 (18.1)
Change in WOMAC Stiffness	N=64 Mean (S.D.)=48.2 (34.3)	22 32.4 (28.8)	17 39.7 (37.0)	25 68.0 (27.5)
<u>SF-36 Mental Health Scores</u>				

⁷ This table was previously published in a peer-reviewed journal by the author of this thesis.[47]

Baseline SF-36 Mental Health	N=70 Mean (S.D.)=74.2 (15.6)	24 74.1 (11.8)	20 71.6 (16.2)	26 76.2 (18.2)
Follow-Up SF-36 Mental Health	N=66 Mean (S.D.)=81.3 (17.7)	22 80.9 (16.9)	20 79.8 (19.2)	24 83.0 (17.6)
Change in SF-36 Mental Health	N=66 Mean (S.D.)=7.2 (20.2)	22 8.1 (20.6)	20 8.2 (19.9)	24 5.6 (21.0)

Supplementary Table 2. Baseline and 12-Month WOMAC and SF-36 Scores in Hip Replacement Patients Stratified by WOMAC Function Scores.[47]⁸

	Overall	Highest (Best) Tertile	Medium Tertile	Lowest (Worst) Tertile
<u>WOMAC Function Scores</u>				
Baseline WOMAC Function	N=26 Mean (S.D.)=37.6 (23.9)	9 65.3 (13.2)	12 28.8 (7.7)	5 8.5 (6.4)
Follow-Up WOMAC Function	N=25 Mean (S.D.)=90.3 (9.6)	9 94.3 (7.1)	11 86.5 (11.0)	5 91.4 (9.0)
Change in WOMAC Function	N=25 Mean (S.D.)=52.9 (24.8)	9 28.9 (17.4)	11 58.8 (12.5)	5 82.9 (13.4)
<u>SF-36 Physical Function Scores</u>				
Baseline SF-36 Physical Function	N=26 Mean (S.D.)=17.8 (18.2)	9 31.9 (23.2)	12 10.0 (10.2)	5 11.0 (4.2)
Follow-Up SF-36 Physical Function	N=23 Mean (S.D.)=79.1 (18.2)	9 81.3 (14.1)	10 74.8 (22.1)	4 85.0 (17.3)
Change in SF-36 Physical Function	N=23 Mean (S.D.)=61.2 (21.8)	9 49.4 (19.2)	10 67.3 (22.1)	4 72.5 (17.6)
<u>WOMAC Pain Scores</u>				
Baseline WOMAC Pain	N=26 Mean (S.D.)=42.0 (25.7)	9 67.4 (18.2)	12 35.0 (15.7)	5 13.0 (12.0)
Follow-Up WOMAC Pain	N=25 Mean (S.D.)=86.5 (18.5)	9 90.0 (12.5)	11 83.9 (24.1)	5 86.0 (15.6)
Change in WOMAC Pain	N=25 Mean (S.D.)=44.5 (35.3)	9 22.6 (21.6)	11 49.3 (38.4)	5 73.0 (26.6)
<u>WOMAC Stiffness Scores</u>				
Baseline WOMAC Stiffness	N=25 Mean (S.D.)=42.0 (24.4)	9 65.3 (13.7)	12 34.4 (17.0)	4 12.5 (14.4)
Follow-Up WOMAC Stiffness	N=25 Mean (S.D.)=88.0 (21.2)	9 91.7 (10.8)	11 81.8 (29.2)	5 95.0 (11.2)
Change in WOMAC Stiffness	N=24 Mean (S.D.)=45.3 (33.1)	9 26.4 (18.2)	11 47.7 (35.3)	4 81.3 (23.9)

⁸ This table was previously published in a peer-reviewed journal by the author of this thesis.[47]

SF-36 Mental Health Scores				
Baseline SF-36 Mental Health	N=26 Mean (S.D.)=76.5 (19.0)	9 76.4 (22.7)	12 72.7 (13.4)	5 85.6 (24.3)
Follow-Up SF-36 Mental Health	N=26 Mean (S.D.)=81.4 (21.8)	9 82.2 (20.7)	12 76.3 (24.9)	5 92.0 (13.9)
Change in SF-36 Mental Health	N=26 Mean (S.D.)=4.9 (24.4)	9 5.8 (35.5)	12 3.7 (19.3)	5 6.4 (13.1)