Title
Collaborative Learning Among Health Care Practices and Systems to Improve Patient-Centered Care

Author
Hurley, Vanessa Beth

Publication Date
2018

Peer reviewed|Thesis/dissertation

Collaborative Learning Among Health Care Practices and Systems to Improve Patient-Centered Care

by

Vanessa Beth Hurley

A dissertation submitted in partial satisfaction of the
requirements for the degree of
Doctor of Philosophy

in

Health Policy
in the
Graduate Division
of the
University of California, Berkeley

Committee in charge:
Professor Hector P. Rodriguez, Chair
Professor Stephen M. Shortell
Professor Ming D. Leung

Spring 2018

ABSTRACT

Collaborative Learning Among Health Care Practices and Systems
to Improve Patient-Centered Care

By

Vanessa Beth Hurley

Doctor of Philosophy in Health Policy

University of California, Berkeley

Professor Hector P. Rodriguez, Chair

Despite a rich literature examining the application of organizational learning to engineering and management contexts, learning in the health care sector has received far less empirical attention. These papers collectively address which organizational factors are precursors to learning within quality improvement collaboratives (QICs) and how participation in QICs impacts patient-centered outcomes. The first paper examines the organizational attributes associated with physician practices' propensity to participate in QICs. The second paper explores the implementation of a shared decision making intervention within the High Value Healthcare Collaborative (HVHC) and investigates its impact upon hip and knee osteoarthritis patients' treatment preferences and decision certainty. Finally, the third paper interrogates whether surgical utilization varies across patients engaged in shared decision making compared with patients receiving usual care within HVHC.

DEDICATION

I dedicate this dissertation to my Mom, without whose unwavering encouragement and endless love I could never have imagined completing this degree, and to my Dad, who continues to light the way ahead.

TABLE OF CONTENTS

LIST OF FIGURES AND TBLES

ACKNOWLEDGEMENTS

My first acknowledgement necessarily goes to my advisors, Drs. Hector Rodriguez and Stephen Shortell. Their guidance across the past four years has enabled me to grow both as a student and a practitioner of health services research, and in doing so has affirmed my passion for this field. Dr. Shortell's patience and wisdom helped me to learn what it means (and what it takes) to be a wonderful instructor to students of health policy. The tireless mentoring over many courses and many manuscripts provided by Dr. Rodriguez is only matched by his extraordinary commitment to helping me grow into this profession and find my way through the darker moments of the past six months. I am indebted to others including Dr. Ming Leung at the Haas School of Business, who served alongside Drs. Rodriguez and Shortell as my dissertation committee members. He too sat through many hours in his office patiently offering new ways of tackling challenging methodological and theoretical questions that arose along the path to completing this dissertation. Dr. Lucy Savitz as well as the analytical team at the High Value Healthcare Collaborative (and especially Stephen Kearing, Chris Weiss, Jay Knowlton and Ronald Russell) have played invaluable roles in helping me carry out work that fascinates and motivates me as a scholar. CHOIR staff including Salma Bibi, Dora Mairena, Patty Ramsay, Zosha Kandel, Janet Blodgett and especially Yue (Emily) Wang have been instrumental in guiding me through the highs and lows of my research and the doctoral student experience. I have been fortunate to be supported by an AHRQ T32 training grant as well as by the Health Assessment Lab's Alvin R. Tarlov & John E. Ware Jr. Doctoral Dissertation Award in Patient-Centered Outcomes. Leeann Comfort, Thomas Huber, Kathy McDonald, Jung Kim, Neil Sehgal, Sarah Lewis and James Cho have each played important roles in seeing me through the adventure that is a doctoral program, and I know they will continue to do so as I take my next steps.

CURRICULUM VITAE
Vanessa B. Hurley

1. Biographical Information

University of California, Berkeley
School of Public Health
PhD Candidate in Health Policy (Organizations and Management)
50 University Hall, Room 590J
Berkeley, CA 94720
Phone: (707) 217-8917
Email: vbhurley@berkeley.edu

Dissertation Title: *Collaborative Learning Among Health Care Organizations and Systems to Improve Patient-Centered Care*
Committee Members: Hector Rodriguez, PhD (UC Berkeley School of Public Health); Stephen Shortell, PhD (UC Berkeley School of Public Health); Ming Leung, PhD (UC Berkeley Haas School of Business); Lucy Savitz, PhD (Discovery and Dissemination Board Member, High Value Healthcare Collaborative & Vice President for Research, Kaiser Permanente)

Cumulative GPA: 3.926

Date of Birth: February 28, 1987
Birthplace: Santa Rosa, CA

2. Education

MS, Biomedical Sciences
Tufts University School of Medicine
December 2012

MPH, Health Policy and Clinical Practice
Dartmouth College
June 2010

AB, English
Dartmouth College
June 2009

3. Research Interests

Organizational learning and quality improvement in health care; role of learning in the adoption of patient-centered care processes; external and internal organizational characteristics associated with the propensity to engage in inter-organizational quality improvement; innovations in patient-centered care and chronic disease management

4. Professional Positions

Community Outreach Director, Tufts University School of Medicine Sharewood Clinic, Malden, MA (2013-2014)
Case Manager, Tufts University School of Medicine Sharewood Clinic, Malden, MA (2012-2014)
Policy Analyst, Health Policy Program, New America Foundation, Washington, D.C. (2010-2011)
Project Associate, Ottauquechee Health Foundation, Woodstock, VT (2009-2010)
Quality Improvement Consultant, Mt. Ascutney Hospital, Windsor, VT (2009-2010)

5. Fellowships and Awards

Alvin R. Tarlov & John E. Ware Jr. Doctoral Dissertation Award in Patient-Reported Outcomes (2017-2018)
Trainee Scholarship, Patient-Centered Outcomes Research Institute Annual Meeting (2017)
Agency for Health Care Research and Quality (AHRQ) Pre-Doctoral (T32) Fellowship (2014-2016)

6. Professional Activities

Member, AcademyHealth (2014-present)
Member, Academy of Management (2017-present)
Abstract Reviewer, "Effects of Innovations in Payment and Delivery" podium session, AcademyHealth Annual Research Meeting, New Orleans, LA, Jun. 25, 2017

7. Bibliography

Rodriguez, H.P., Knox, M., **Hurley, V**., Rittenhouse, D.R., Shortell, S.M. 2016. The Use of Enhanced Appointment Access Strategies by Medical Practices. *Medical Care* 54(6): 632-8.

Hurley, V.B., Rodriguez, H.P., Shortell, S.M. 2017. The Role of Accountable Care Organization Affiliation and Ownership in Promoting Physician Practice Participation in Quality Improvement Collaboratives. *Health Care Management Review* (In Press).

8. Graduate Teaching and Research Positions

Graduate Student Instructor, UC Berkeley School of Public Health, *Strategic Management and the Health Sector* (Jan-May 2017)

Graduate Student Researcher, Berkeley Center for Health Care Organizational and Innovation Research

Current Work:
(2016-present) Agency for Healthcare Research and Quality (AHRQ) U19 Grant, P.I. Elliott Fisher, M.D.

Provide analytic and writing support to projects assessing the role of high-performing healthcare systems in advancing implementation and dissemination of patient-centered, evidence-based care processes. Works in progress examine the association between patient exposure to a shared decision making (SDM) intervention and subsequent treatment preferences and surgical utilization, as well as an investigation into the role of practice and system-level volume of SDM upon patient treatment choices.

Past Projects:
(2015-2016) Centers for Disease Control and Prevention/National Institute for Diabetes, Digestive, and Kidney Diseases-funded Evaluation of the State Innovation Model (SIM) Grant Program, P.I. Hector P. Rodriguez, PhD

Aided in coordination of advisory board meetings as part of a broader project to examine the evolution of diabetes care management processes and effects of state participation in SIM upon avoidable readmissions for diabetes patients between 2013-2017. Collaborated with Dr. Diane Rittenhouse on a commentary regarding heterogeneity in state and county-level implementation of SIM. Contributed to drafting and editing of grant application submitted to CDC/NIDDKD.

(2014-2015) University of California Center for Health Quality and Innovation (CHQI), P.I. Sheldon Greenfield, M.D.

Conducted qualitative interviews within physician-researchers and drafted report summarizing current progress and barriers to implementation of over 40 quality improvement projects throughout the UC Health System.

9. Conferences and Symposia

AcademyHealth Annual Research Conference, Seattle, WA. Jun. 25, 2018. (Scheduled) Poster Presentation, "Improving Treatment Certainty for Hip and Knee Osteoarthritis Patients Through Shared Decision Making within the High Value Healthcare Collaborative."

AcademyHealth Annual Research Conference, Boston, MA, Jun. 25, 2016. Podium Presentation, "The Role of Accountable Care Organization Affiliation and Ownership in Promoting Physician Practice Participation in Quality Improvement Collaboratives."

UCSF Joint Medical Program (JMP) Seminar Series, Nov. 1, 2016. Ibid.

10. Academic References

Hector P. Rodriguez
Professor, Division of Health Policy and Management
School of Public Health
50 University Hall, Room 245
University of California, Berkeley
Berkeley, CA 94720
(510) 642-4578
hrod@berkeley.edu

Stephen M. Shortell
Professor of the Graduate School, School of Public Health
School of Public Health
50 University Hall, Room 247-H
University of California, Berkeley
Berkeley, CA 94720
(510) 643-5346
shortell@berkeley.edu

Ming D. Leung
Assistant Professor, Management of Organizations Group
Haas School of Business
University of California, Berkeley
Berkeley, CA 94720
(510) 642-4952
mingdleung@berkeley.edu

INTRODUCTION

Organizational learning is often highlighted as one of the most critical capacities among knowledge-intensive industries (Argote and Ingram 2000; Garvin 1988). Learning is often associated with productivity and knowledge creation, and as such increasingly serves as "currency for competitive success" in organizational settings (Argote and Ingram 2000; Egan, Yang, and Bartlett 2004, p. 279). Empirical examinations of organizational learning in industrial contexts abound (Irwin and Klenow 1993; Udayagiri and Baladrishnan 1993), but the application of learning to health care is far less common (Tucker, Nembhard, and Edmondson 2007). Yet the imperative for organizational learning in the health care sector is significant, especially in light of the ever-evolving body of medical knowledge and increasing incentives at the federal level for health care organizations to achieve specific quality benchmarks (Nembhard, Cherian, and Bradley 2014).

Definitions of organizational learning differ according to the context in which they are being utilized, but there is general consensus that learning implies a change in knowledge that results as the organization acquires experience. Learning impacts organizational processes and routines through the creation, retention or transference of new knowledge (Argote, Fiol and Lyles 1985). Changes to processes or policies that result from collective learning may in turn become "encoded" as formal policies at the organizational level. Learning is often referred to as a social process in which organizational members "interact to construct meaning and knowledge about action-outcome relationships and about effects of the organization's context (learning environment) on those relationships" (Berta et al. 2015, p.2). Just as organizational changes may prompt engagement in learning, so too may learning lead to the application of new knowledge to inspire new organizational practices (Ratnapalan and Uleryk 2014a).

Among the primary motivations for studying organizational learning is its association with performance improvements, which have been demonstrated across diverse settings including electronic, automotive and marketing industries (Garvin 1993; Senge 1990; Slater and Narver 1995). Organizational learning has also been linked to organizational effectiveness when assessed by institutional commitment and job satisfaction (Egan et al. 2004; Rose, Kumar, and Pak 2009). Berta notes that performance improvements were demonstrated both for experiential learning (from repetition of standardized routines) as well as for adaptive learning (when cumulative experience enables adaptation of work routines) (Berta et al. 2015). The health care system itself has been identified as a complex adaptive system requiring adaptive learning as a means "of facilitating incremental innovation" (Baker and Sinkula 1999, p.412; Institute of Medicine 2001).

One of the principal avenues by which health care organizations engage in learning is through quality improvement. Examples of intra-organizational learning through quality improvement are numerous; for example, Tucker et al leveraged organizational learning, best practice transfer and process change theories to understand how and under which conditions hospital teams embedded within intensive care units implement best practices (Tucker et al. 2007). This work underscores the importance of activities that help teams "learn how" in order to successfully integrate new behaviors into clinical practice. Nembhard examined U.S. hospitals' efforts to reduce door-to-balloon time for ST-segment elevation myocardial infection (STEMI) patients. In the early stages of their improvement efforts, hospitals learned most from imported (external) best practices while internal problem solving proved more effective in later stages (Nembhard et al. 2014) Pisano et al's study highlights the importance of learning by doing

in intra-organizational quality improvement but also finds important differences in learning curves across a sample of 16 hospitals implementing a minimally invasive cardiac procedure, suggesting a critical role for organizational capacity and motivation in successful learning (Pisano, Bohmer, and Edmondson 2001).

Just as organizations may acquire knowledge through internal quality improvement activities, they may also learn through the improvement activities of outside organizations (Argote 1993). Quality improvement collaboratives (QICs) are an increasingly popular means of fostering inter-organizational learning. They have been employed to address a variety of improvement topics and traverse international contexts (Ovretveit et al. 2002). They are most commonly defined as a gathering of multidisciplinary groups from multiple organizations who participate in organized "group learning initiatives" centered on improving the provision of care within a shared clinical arena, such as quality of life among diabetics or the incidence of asthma attacks among adolescents (Nadeem et al. 2013; Shaw et al. 2012). Best practices as well as quality improvement techniques and progress are shared between members through regularly scheduled in-person meetings or conference calls (Crites et al. 2009). Facilitation of QICs by experts in quality improvement and organizational learning is another hallmark of QICs (Nadeem et al. 2013). Collaboratives can range in length from a few weeks to over a year; regardless of the timeline, "practice changes are made and evaluated rapidly through frequent reporting of data with analysis and dissemination of results throughout the collaborative. This cycle of intervention, evaluation and adjustment allows for an accelerated process of quality improvement" (Finks 2014; Ovretveit et al. 2002). Two systematic reviews have examined the impact of QICs on improvements in quality of care and practice patterns (Nadeem et al. 2013; Schouten et al. 2008a). These and subsequent papers suggest that QICs are capable of altering care practices and exerting positive impacts on clinical outcomes (Clarke et al. 2015; Strating et al. 2012; Young et al. 2006).

One axis along which intra- and inter-organizational quality improvement varies concerns the intervention focus; improvement activities span the continuum from technical (medical treatments or surgical procedures) to interpersonal (involving communication between physicians and patients) (Donabedian 1988). The challenges associated with implementation of new clinical treatments or best practices has been well-documented, with growing attention afforded to the idea that successful attempts to integrate new practices require cooperation at individual, team, unit and organizational levels (Kitson et al. 2008). Instituting interpersonal inventions also implies unique implementation challenges. Whereas improvement in technical interventions requires the mastery of specific techniques relating to a new surgical or interventional practice, improvement relating to interpersonal interventions often necessitates a shift in the relationship between physicians and patients away from paternalism to an embrace of more equitable and participant decision-making (Elwyn and Fisher 2014).

This dissertation addresses several gaps in the empirical literature on learning through quality improvement collaboratives. The first paper utilizes a national sample of health care organization to explore the organizational characteristics associated with the propensity for physician practices to engage in inter-organizational learning through quality improvement collaboratives. The second and third papers explore the intersection of organizational learning and the implementation of one interpersonal intervention – shared decision making (SDM) – within practices affiliated with the High Value Healthcare Collaborative (HVHC). These papers represent a unique opportunity to explore learning among practices embedded within high-performing health care systems affiliated with a single collaborative. Additionally, few studies

have examined the routine implementation of SDM within system-affiliated practices. The work comprising the latter two papers of this dissertation provides a novel opportunity to examine quality improvement within the context of an increasingly evidence-based and patient-centered intervention (Institute of Medicine 2013).

References

Argote, L. 1993. “Group and Organizational Learning Curves: Individual, System and Environmental Components.” *British J Soc Psych* 32: 31-51.
Argote, L. and P. Ingram. 2000. “Knowledge Transfer: A Basis for Competitive Advantage in Firms.” *Organizational Behavior and Human Decision Processes* 82(1): 150-69.
Baker, W. E. and J. M. Sinkula. 1999. “The Synergistic Effect of Market Orientation and Learning Orientation on Organizational Performance.” *Academy of Marketing Science* 27(4): 411-27.
Berta, W., L. Cranley, J. W. Dearing, E. J. Dogherty, and J. E. Squires. 2015. “Why (We Think) Facilitation Works: Insights from Organizational Learning Theory.” *Implementation Science* 10(141).
Clarke, C. M., T. Cheng, K. G. Reims, and C. M. Steinbock. 2015. “Implementation of HIV Treatment as Prevention Strategy in 17 Canadian Sites: Immediate and Sustained Outcomes from a 35-month Quality Improvement Collaborative.” *BMJ Quality and Safety*: 1-10.
Crites, G. E., M. C. McNamara, E. A. Akl, W. S. Richardson, C. A. Umscheid, and J. Nishikawa. 2009. “Evidence in the Learning Organization.” *Health Research Policy and Systems* 7(4): 1-13.
Donabedian, A. 1988. “The Quality of Care: How Can It Be Assessed?” *JAMA* 260: 1743-48.
Egan, T. M., B. Yang, and K. R. Bartlett. 2004. “The Effects of Organizational Learning Culture and Job Satisfaction on Motivation to Transfer Learning and Turnover Intention.” *Human Resource Development Quarterly* 15(3): 279-301.
Elwyn, G. and E. Fisher. 2014. “Higher Integrity Health Care: Evidence-Based Shared Decision Making.” *Circulation* 7: 975-80.
Finks, J. 2014. “Collaborative Quality Improvement.” In *Success in Academic Surgery: Health Services Research*, edited by J. Dimick. London: Springer-Verlag.
Garvin, D. A. 1988. *Managing Quality: The Strategic and Competitive Edge*. New York: Free Press.
Garvin, D. A. 1993. “Building a Learning Organization.” *Harvard Business Review* 71: 78-91.
Institute of Medicine. 2001. “Crossing the Quality Chasm: A New Health System for the 21st Century.” N. A. Press. Washington, D.C.: Committee on Quality of Health Care in America.
Institute of Medicine. 2013. “Partnering with Patients to Drive Shared Decisions, Better Value, and Care Improvement.” *Roundtable on Value & Science-Driven Health Care.* Washington, D.C.
Irwin, D. A. and P. J. Klenow. 1993. “Learning-by-doing Spillovers in the Semiconductor Industry.” *Journal of Political Economy* 102: 1200-26.
Kitson, A. L., J. Rycroft-Malone, G. Harvey, and B. McCormack. 2008. “Evaluating the Successful Implementation of Evidence into Practice Using the PARiHS Framework: Theoretical and Practical Challenges.” *Implementation Science* 3(1).
Nadeem, E., S. S. Olin, L. C. Hill, K. E. Hoagwood, and S. M. Horowitz. 2013. “Understanding the Components of Quality Improvement Collaboratives: A Systematic Literature Review.” *Milbank Quarterly* 91(2): 354-94.
Nembhard, I. M., P. Cherian, and E. H. Bradley. 2014. “Deliberate Learning in Health Care: The Effect of Importing Best Practices and Creative Problem Solving on Hospital Performance Improvement.” *Medical Care Research and Review* 71(5): 450-71.
Ovretveit, J., P. Bate, P. Cleary, S. Cretin, D. Gustafson, K. McInnes, and H. McLeod. 2002. “Quality Collaboratives: Lessons from Research.” *Quality and Safety in Health Care* 11: 345-51.

Pisano, G. P., R. M. J. Bohmer, and A. C. Edmondson. 2001. "Organizational Differences in Rates of Learning: Evidence from the Adoption of Minimally Invasive Cardiac Surgery." *Management Science* 47(6): 752-68.
Ratnapalan, S. and E. Uleryk. 2014. "Organizational Learning and Health Care Organizations." *Systems* 2: 24-33.
Rose, R. C., N. Kumar, and O. G. Pak. 2009. "The Effect of Organizational Learning on Orgaizational Commitment, Job Satisfaction and Work Performance." *Journal of Applied Business Research* 25(6).
Schouten, L. M., M. E. Hulscher, J. J. van Everdingen, R. Huijsman, and R. P. Grol. 2008. "Evidence for the Impact of Quality Improvement Collaboratives: Systematic Review." *British Medical Journal*: 1-9.
Senge, P. M. 1990. *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York, NY: Doubleday.
Shaw, E. K., S. M. Chase, J. Howard, P. A. Nutting, and B. F. Crabtree. 2012. "More Black Box to Explore: How Quality Improvement Collaboratives Shape Practice Change." *Journal of the American Board of Family Medicine* 25: 149-57.
Slater, S. F. and J. C. Narver. 1995. "Market Orientation and the Learning Organization." *Journal of Marketing* 59(3): 63-74.
Strating, M. M., T. Broer, S. Van Rooijen, R. A. Bal, and A. P. Nieboer. 2012. "Quality Improvement in Long-Term Mental Health: Results from Four Collaboratives." *Journal of Psychiatric Mental Health Nursing* 19(5): 379-88.
Tucker, A. L., I. M. Nembhard, and A. C. Edmondson. 2007. "Implementing New Practices: An Empirical Study of Organizational Learning in Hospital Intensive Care Units." *Management Science* 53(6): 894-907.
Udayagiri, N. D. and S. Baladrishnan. 1993. "Learning Curves and Knowledge Spillovers: The Case of Semiconductor Memories." Philadelphia, PA: The Wharton School, University of Pennsylvania.
Young, P. C., G. B. Glade, G. J. Stoddard, and C. Norlin. 2006. "Evaluation of a Learning Collaborative to Improve the Delivery of Preventive Services by Pediatric Practices." *Pediatrics* 117(5): 1469-76.

I. The Role of Accountable Care Organization Affiliation and Ownership in Promoting Physician Practice Participation in Quality Improvement Collaboratives

ABSTRACT

Background: Quality Improvement Collaboratives (QICs) have emerged as an important strategy to improve processes and outcomes of clinical care through interorganizational learning. Little is known about the organizational factors that support or deter physician practice participation in QICs.

Purpose: This study examined organizational influences on physician practices' propensity to participate in QICs. We hypothesized that practice affiliation with an Accountable Care Organization (ACO) and practice ownership by a system or community health center (CHC) would increase the propensity of physician practices to participate in a QIC.

Methodology: Data from the third wave of the National Survey of Physician Organizations (NSPO3), a nationally representative sample of medical practices (n=1,359) were analyzed. Weighted multivariate regression analyses were estimated to examine the association of ACO affiliation, ownership, and QIC participation, controlling for practice size, health information technology (HIT) capacity, public reporting participation and practice revenue from Medicaid and uninsured patients. The Sobel-Goodman test was used to explore the extent to which practice use of quality improvement (QI) methods such as Lean, Six Sigma, and use of Plan-Do-Study-Act cycles mediates the relationship between ACO affiliation and QIC participation.

Findings: Only 13.6% of practices surveyed in 2012-2013 participated in a QIC. In adjusted analyses, Accountable Care Organization (ACO) affiliation (Odds Ratio (OR) = 1.51, $p< 0.01$), CHC ownership (OR = 6.57, $p<0.001$), larger practice size (OR=14.72, $p<0.001$), HIT functionality (OR= 1.15, $p<0.001$) were positively associated with QIC participation. Practice use of QI methods partially mediated (13.1-46.7%) the association of ACO affiliation with QIC participation.

Practice Implications: ACO-affiliated practices are more likely than non-ACO practices to participate in QICs; practice size rather than system ownership appears to influence QIC participation. Quality improvement methods often promoted and used by health care systems, CHCs and ACOs may promote QIC participation.

Introduction

Quality improvement collaboratives (QICs) have emerged as an important strategy to systematically improve processes and outcomes of care through interorganizational learning. QICs are most commonly characterized as organized "group learning initiatives" in which clinicians – often from different departmental units or organizations – come together at regular intervals to learn how to improve the provision of care for focal clinical conditions (Nadeem et al. 2013, p.359) (Ovretveit et al. 2002). Members of these collaboratives develop measurable targets, gather data at regular intervals as a means of assessing their progress toward those targets, and initiate process changes on a small scale "to advance reinvention and learning by doing" (Schouten et al. 2008b, p.2). Project leaders or experts in QI and the clinical topic of interest often guide team members in these pursuits (Shaw et al. 2012). QICs are conceptualized as a means by which to integrate quality improvement efforts into the heart of systemic organizational transformation (Shaw et al. 2013).

Two systematic reviews evaluated the impact of QICs on improvements in quality of care and found mixed results in regards to participation in collaboratives and the attainment of clinical and quality improvement goals (Nadeem et al. 2013; Schouten et al. 2008b). Other work examining specific QICs suggests that they are capable of improving processes of care and exert positive influence on clinical outcomes (Clarke et al. 2015; Strating et al. 2012; Young et al. 2006). Evidence also suggests that internal organizational capabilities may enable participation in interorganizational learning activities such as collaboratives, yet few studies have identified the organizational factors that support physician practice engagement in QICs (Deo et al. 2009). Such engagement typically requires substantial time and resources on the part of practices, both in terms of formal participation of clinicians in collaboratives as well as the effort needed to apply lessons from collaboratives to improving processes of care within the practice setting (Ovretveit et al. 2002). In one study, Nembhard found that use of interorganizational learning activities, such as conference calls and monthly reports, had positive impacts on performance improvement for participants across four Institute for Healthcare Improvement-sponsored collaboratives. Use of intraorganizational activities, such as Plan-Do-Study-Act (PDSA) cycles in which organizations plan, test and evaluate new interventions, was also shown to increase the odds of performance improvement (Institute for Health Care Improvement 2016; Nembhard 2012). These results suggest that internal practice capabilities in addition to interorganizational learning play a central role in QI team engagement in QICs and the success of these efforts.

Past work has tended to focus upon interorganizational learning among hospitals or large health systems (Mills 2003; Nembhard 2012; Ratnapalan and Uleryk 2014b; Versteeg 2012), but there has been a dearth of research examining QIC participation among physician practices. Recent initiatives such as the Centers for Medicare and Medicaid Services' State Innovation Model Initiative, Transforming Clinical Practice Initiative, the Medicaid Program, and the Child Health Insurance Program (CHIP) promote QICs for improving quality of patient care (Centers for Medicare and Medicaid Services 2016a, 2016b; Maine Department of Health and Human Services 2015; Minnesota Department of Health 2015; Oregon Health Authority 2015). As more physician practices align with ACOs, an exploration of how ACO affiliation is associated with physician practice participation in QICs is especially timely (Muhlestein 2015). Previous research indicates that structural attributes can have profound impacts on organizational capacity to engage in QI initiatives (Alexander and Hearld 2011), we also examine the role of ownership in practices' propensity to take part in collaborative. Finally, we explore the extent to which

practice use of QI methods such as Lean, Six Sigma, and use of Plan-Do-Study-Act cycles mediates the relationship between ACO affiliation and QIC participation, as QI methods may provide a foundation for the activities practices take part in when taking part in when engaging in QICs. The relation of use of these practice capabilities and QIC participation remains unexplored in the literature.

Framework

The Consolidated Framework for Implementation Research (CFIR) highlights the organizational factors that influence the effectiveness of QI interventions in health care delivery organizations (Damschroder, Aron, and Keith 2009). The CFIR emphasizes that both the inner and outer settings relevant to a given intervention play significant roles in implementation effectiveness. The outer setting encompasses externally imposed incentives or policies and competitive pressures stemming from the organizational field, while the inner setting includes such characteristics as structure, leadership and culture (Damschroder et al. 2009). We conceptualize the inner components as those existing at the organization level, while the outer component represents an aspect of the regulatory environment. In the case of QIC participation among physician practices, the inner setting includes practice ownership, practice size, ACO affiliation, health information technology (HIT) functionality, percent of practice revenue derived from Medicaid and uninsured patients, and use of various quality improvement methods, while the outer setting includes public reporting of quality metrics by external entities. Appendix 1 depicts the conceptual model guiding our inquiry.

Theory

Engaging in QI initiatives necessitates both the proper infrastructure and adequate resources within the organizational setting. Past empirical work suggests that capital is more readily accessed by practices belonging to systems (Robinson and Casalino 1996; Rodriguez et al. 2016b). Such a conclusion aligns well with a resource dependence perspective, as ownership represents one basis for power among organizations, which in turn affects an organization's ability to satisfy external environmental pressures (Aldrich and Pfeffer 1976). Practices owned by systems may also benefit from "greater managerial and resource planning expertise" (Shortell et al. 2005, p.417). In turn, system-owned practices may find it easier to absorb the time and resource requirements necessary to send teams of clinicians to participate in QICs. Additionally, the structural alignment of multiple practices owned by a system is expected to contribute to greater uniformity both from a management and operational perspective. For example, the integration of physician practices into a large health system in Pennsylvania facilitated strong programmatic support of new clinical programs and initiatives (Levin and Gustave 2013). Thus, practices within a system may have more support to engage in QICs, in contrast with independent practices that are physician-owned which may lack the slack resources (Nohria and Gulati 1996) to participate in QICs.

Hypothesis 1: Practices that are owned by health care systems are more likely than physician-owned practices to take part in QICs.

Since 1998, the Health Resources and Services Administration's (HRSA) Bureau of Primary Health Care (BPHC) has sponsored Health Disparities Collaboratives (HDCs). These collaboratives are often comprised of 20 or more community health centers (CHCs) engaged in

learning sessions in which best practices to more effectively manage chronic conditions are shared and formal instruction in quality improvement techniques such as PDSA cycles is provided (Landon et al. 2007). Past HDCs have addressed topics that are of greatest relevance to the patient population served by CDCs, such as diabetes prevention and care, depression, asthma, cardiovascular disease and cancer (Health Resources and Services Administration 2008). Other health disparities related topics, such as infant mortality, have also been a focus of QICs (Health Resources and Services Administration 2013), as these health disparities are especially challenging for CHCs to address due to the vulnerable populations they serve.

HDCs differ from other types of QICs in that they are specifically designed for CHCs and they provide additional infrastructure in the form of regional coordinators and health information technology support (Chin et al. 2007). Grossman et al reported that as of 2008, over 90% of CHCs funded by HRSA had taken part in at least one HDC (Grossman et al. 2008), but more current data are not available. Such high participation rates in HDCs may be influenced by normative pressures experienced by CHCs as they strive to meet the needs of their patient populations and are subject to a shared set of quality metrics set by HRSA. Coupled with HRSA's direct oversight of CHCs and the direct support provided for CHCs to engage in collaborative learning through HDCs we expect that such factors will encourage CHCs' participation in these types of QICs.

Hypothesis 2: Community Health Centers are more likely than physician-owned practices to participate in QICs.

The rise of new organizational forms such as ACOs and the subsequent affiliation of physician practices with systems and networks are also expected to influence practices' decisions to participate in QICs. The defining characteristics of ACOs include a distinct emphasis on primary care and preventive medicine, accountability for the achievement of quality and cost benchmarks, and the use of payment strategies such as global budgets and shared savings in lieu of fee-for-service (McClellan, McKethan, and Lewis 2010). ACOs are held accountable for quality and continuity of care at the same time that they are charged with generating shared savings through their relationships with large payer groups such as Medicare. An explicit emphasis is placed upon reducing care that does not add value to patients as well as reducing readmissions and unnecessary emergency department visits within a broader environment of advancing quality while constraining costs.

While market forces serve as one stimulus for organizations to achieve efficiency, institutional forces such as the requirements placed on ACOs prompt conformity to environmental expectations and norms (D'Aunno 1991). In addition to securing material and technical resources, attaining institutional credibility is equally critical to organizational survival. Influential organizations establish norms that lay the foundation for other legitimacy-seeking organizations within the field (Scott 2000). Isomorphism, which can act through coercive, mimetic, or normative channels, describes the adoption of these norms as organizations vie for legitimacy (DiMaggio and Powell 1983). Legitimacy functions as an outward signal to other organizations of alignment with shared values and norms, which in turn enables access to critical resources and support.

Researchers have previously highlighted the strong normative pressures to which ACOs

are subject by virtue of their mission to deliver high quality, cost effective care (Shortell et al. 2014). These same normative pressures may create the conditions under which ACOs enable practices to maintain legitimacy. QIC participation can signal a quality improvement orientation to key stakeholders and all the physician organization to remain abreast of best practices simultaneously, enabling the delivery of high quality care for which ACOs are financially accountable.

Hypothesis 3: ACO-affiliated practices are more likely to participate in QICs than practices not affiliated with ACOs.

Methods

Study Design and Sample

We utilize data from the third wave of the National Study of Physician Organizations (NSPO3) (2012-2013) for this analysis. NSPO3 is a national survey of physician organizations that includes information regarding size, ownership, specialty mix and patient demographics of these practices. Internal organizational capabilities such as health information technology (HIT) functionality and use of care management processes to care for patients with chronic diseases such as asthma, congestive heart failure, depression and diabetes are also included. This 40-minute phone or website survey was fielded to physician leaders or practice managers, achieving overall response rate of 50% (n=1,398 organizations). Following exclusion of 39 practices for which data were missing, our analytic sample includes 1,359 practices (97% of respondents). A paper by Wiley et al, which includes details about the administration of NSPO3, found only small differences between respondents and non-respondents to NSPO3 (Wiley, Rittenhouse, and Shortell 2015).

Measures

QIC Participation

QIC participation among our sample of practices was determined through a binary (yes vs. no) response to the following question, "Does your practice use the following formal and systematic quality improvement system: quality improvement learning collaboratives?" Participation in a QIC was assessed separately from use of other common quality improvement methods, such as Plan-Do-Study-Act (PDSA) cycles, Lean production techniques, and Six Sigma.

Practice Ownership

Practice ownership was determined based on a response to the following question: "Who owns the equipment and employs the non-physician staff of your practice?" Practices are classified as system-owned when the response to the above question is a "hospital", "hospital system", "health care system that is not an academic medical center", or an "HMO or other insurance entity". Practices are categorized as physician-owned if the answer to the above question is "physicians in the practice" or "non-physician managers". To ensure that we

classified CHCs correctly, we examined survey responses to three questions: where respondents reported their organization's name, the ownership of their organization, and whether their organization identified as a "community clinic." Respondents were able to provide open-ended answers for each of the three questions. Responses for each question were searched for the terms "community," "health center," "non-profit," and similar derivatives of those terms. Extensive research, including online searches, was conducted for all practices flagged on any of the search terms. Specifically, organizations were considered CHCs when: (1) they identified as a federally-qualified health center (FQHC) or FQHC look-a-like; (2) they were found in a national listing of "Health Centers and look-a-like Sites" published by the Health Resources and Services Administration; or (3) an online search demonstrated that practices held values consistent with being community health centers (offered financial assistance, serve patients "regardless of ability to pay," or provide comprehensive care "for the community").

ACO Affiliation

ACO affiliation is a binary variable indicating whether a practice had joined a public or private ACO by 2012.

Control Variables

We include four control variables in our models, three at the organizational level and one at the environmental level. First, we include practice size, which is categorized according to the number of physicians across all practice locations (1-2 physicians, 3-9 physicians, 10-19 physicians, and 20 or more physicians). HIT functionality measured on a scale from 1 to 14 comprises such measures as the use of an electronic medical record with progress notes, medication lists, problem lists, and alerts for drug interactions and abnormal test results. Other capabilities included in this measure are the ability to communicate with patients via e-mail, e-prescribing and registries for chronic diseases (Rodriguez et al. 2016a). HIT functionality is included as a control because HIT can impact health care organizations' ability to continuously monitor progress toward quality improvement goals (Li 1997). Practices with a greater proportion of revenue from commercially ensured patients are expected to have relatively more resources to invest in activities such as quality improvement when compared with practices serving more Medicaid or uninsured patients. For this reason, we also include percent of a practice's revenue derived from Medicaid and uninsured patients as a control variable. At the external environmental level, we control for public reporting of quality metrics by external entities. Practices may be incentivized to participate in QICs to the extent that it contributes to reporting higher quality scores on reported measures as part of these external initiatives.

Statistical Analyses

Unweighted chi-squared tests were used to examine differences in QIC participation across categories of ownership, ACO participation, and all key variables used in the study. Then, multivariate logistic regression with survey weights were estimated to explore the association of ownership, ACO participation and physician practice propensity to participate in QICs, controlling for practice size, HIT functionality, percentage of practice revenue from Medicaid and uninsured patients, and public reporting of quality metrics by external entities. Alternative

specifications of the regression model were examined to assess the sensitivity of our main results to consideration of other quality improvement (QI) methods used by physician practices, including Lean, Six Sigma, and plan-do-study-at (PDSA). We used the Sobel-Goodman Test to explore the mediating influence of these QI methods on the relationship between ACO affiliation and QIC participation. We calculated the mediating effects of Lean, Six Sigma and PDSA cycle use, both independently and when one or more of the QI methods were used. We specified two mediation models to compare estimates that incorporated vs. excluded control variables. We also computed the Variance Inflation Factor for each independent variable to determine whether multicollinearity was present. All statistical analyses were completed using STATA 14.0 The research protocol was approved by the Institutional Review Board of the University of California, Berkeley.

Results

Table 1 includes the survey weighted means and standard deviations for all variables in this analysis. Among the 1,359 physician practices, 13% (n= 185) participated in a QIC. Nearly 20% of all practices were affiliated with an ACO in 2012. The majority of practices (82%) were physician-owned, while nearly 14% were hospital or health system-owned and the remaining practices (4%) were CHCs. Approximately 38% of QIC participating practices were affiliated with an ACO. Thirty two percent (32%) of system-owned practices participate in QICs. Approximately 37% of CHCs took part in QICs. Tests examining the association of ACO affiliation and QIC participation and the association of ownership categories and QIC participation were both statistically significant ($p<0.05$): $X(1, N=1359) = 28.61$, $p<0.01$ and $X(2, N=1359) = 114.19$, $p<0.01$.

As reported in Table 2, Model 1, system-owned practices had three times the odds of QIC participation compared to physician-owned practices. This result did not, however, reach statistical significance (OR = 3.05, p=0.08). Thus, we found partial support for Hypothesis 1, which suggested that system-owned practices would be more likely to participate in a QIC relative to physician-owned practices. CHCs had six and a half times the odds (OR = 6.57, $p<0.001$) of QIC participation compared to physician-owned practices, providing strong support for Hypothesis 2. We posited that ACO affiliation would be associated with practice propensity to participate in a QIC (Hypothesis 3). Model 1 results indicate that ACO-affiliated practices had greater odds of QIC participation compared to practices not affiliated with an ACO (OR=1.51, $p<0.05$), thus providing support for Hypothesis 3.

Results of multivariate analyses indicate statistically significant relationships between several control variables and practice participation in QICs (Table 2). Larger practice size was associated with greater odds of participation in QICs, where practices composed of 20 or more physicians had 14 times the odds (OR=14.72, $p<0.005$) of participating in a QIC relative to practices with 1-2 physicians. For each unit increase in the HIT capability of a practice, the likelihood of engaging in a QIC increased by 15% (OR=1.15, $p<0.01$). Finally, those practices whose clinical quality data was publicly reported by external entities had nearly three times the odds of QIC participation (OR=2.90, $p<0.01$) compared to practices not publicly reporting such information.

Other quality improvement methods such as use of Six Sigma, Lean, and PDSA cycles appear to partially explain the association between ACO affiliation and QIC participation (Table 3). Results of the Sobel Goodman tests of mediation that excluded control variables indicate that

use of PDSA cycles and Lean mediates 35.2% and 36.0% of the effect of ACO affiliation upon QIC participation, respectively. Use of Six Sigma also mediates the effect of ACO affiliation upon QIC participation, but to a lesser degree (by approximately 28.6%). Use of one or more of the QI methods accounts for just over 58.2% of the ACO affiliation and QIC participation relationship. When control variables are included in the mediation analyses, use of one or more of the three QI methods still mediated a substantial proportion of the ACO affiliation–QIC participation relationship (46.7%).

Variance Inflation factor results indicate that no variables attained a VIF value above 3.9. Based on a conservative threshold of 5.0 (Acock 2014), we conclude that multicollinearity was not a concern for our analyses.

Discussion

This study aimed to better understand the relation of ACO affiliation and practice ownership on the propensity of physician practices to participate in QICs. Our findings provide important insights into the organizational and contextual factors associated with physician practice engagement in QICs. Our first hypothesis concerning the influence of system ownership on QIC participation was partially supported. Larger practice size, rather than system-ownership, appears to have a greater influence on practice participation in QICs. Given that larger practices were more likely than small practices to participate in QICs, it may be that larger physician organizations, irrespective of ownership, have the scale and slack resources to participate in QICs. The ability to spread costs over a large number of practice sites and to disseminate best practices from one site to other sites may make QIC participation a more worthwhile investment for large physician organizations compared to small physician organizations.

Our second hypothesis posited that CHCs would be more likely than physician-owned practices to take part in QICs. Our results indicate that HRSA's administrative and financial support to many CHCs as well as their role in organizing QICs may enable CHCs to participate in QICs. In support of our third hypothesis, ACO affiliation was positively associated with practice participation in QICs. For example, Oregon's Coordinated Care Organizations (CCOs), which provide care to the state's Medicaid population, participate in a statewide quality improvement collaborative. The Oregon Transformation Center integrates data and analytic tools for the entire community of CCOs while facilitating collaborative learning activities to advance evidence-based care and to reduce unnecessary utilization (McConnell, Chang, and Cohen 2014). To the extent that normative and financial pressures encourage practices affiliated with ACOs to achieve quality benchmarks, the sharing of best practices via participation in QICs may serve as one important avenue by which ACOs support the provision of high quality care to their patient populations. Whether normative institutional pressures underlie ACO-affiliated practices' greater propensity to participate in a QIC deserves further empirical attention, especially in light of the growing number of practices joining ACOs (Muhlestein 2015).

The Sobel-Goodman Test results (Table 3) suggest that practice use of other QI methods, such as PDSA cycles, Lean, and Six Sigma, partially mediates the effect of ACO affiliation upon QIC participation. Use of PDSA and Lean have the strongest mediating effects, with each method mediating over one-third of the total effect of ACO affiliation on increased odds of practice participation in QICs. Since the use of any of the three QI methods has a sizable

mediating effect, the promotion of QI methods by ACOs may enable practices be better positioned to take advantage of inter-organizational quality improvement opportunities.

Limitations

A number of limitations should be noted. For example, the 50% response rate to the NSPO3 survey suggests that we cannot rule out the possibility of differential nonresponse. Also, the NSPO3 data are based on a single respondent and, therefore, subject to potential single informant bias. But this is mitigated to some extent by identifying the most knowledgeable physician or administrative leader to respond to the factual questions. Further, while NSPO3 provides information about whether or not a physician organization participated in a QIC, it does not include specific details such as whether practices participated in multiple QICs, when QIC participation occurred, the clinical foci of QICs, or whether QIC participation resulted in improved quality performance metrics. Also, since NSPO3 is a cross-sectional survey, we cannot establish causal relationships between ACO participation, ownership, and QI methods. Additionally, these analyses cannot rule out the possibility that participation in a QIC might have preceded use of other internal organizational tools such as Lean and PDSA. The use of longitudinal data could help clarify the temporal ordering of these factors on practice participation in QICs. It will be important to revisit these relationships when such data are available. Finally, although the findings provide evidence that practices affiliated with ACOs are more likely to participate in QICs, the processes that underlie such engagement remain unclear. Qualitative research of frontline clinicians, staff, and managers in ACO-affiliated practices could lend further insight into how and why QI methods and QIC participation are used by ACOs.

Practice Implications

Organizational and contextual influences are critical to understanding the participation of physician practices in inter-organizational learning activities such as QICs (Kaplan 2012; Versteeg 2012).. Internal practice capabilities, such as HIT functionality and use of quality improvement methods are often promoted by health care systems, CHCs and ACOs to stimulate improved organizational outcomes, also appear to foster interorganizational learning through QIC participation. Our findings suggest a strong mediating role of practice use of quality improvement methods such as use of PDSA cycles and Lean in explaining the greater propensity of ACO-affiliated practices to participate in QICs (Hung, Gray, and Martinez 2016). To support systematic improvement in processes and outcomes of care through QICs, organizational leaders should focus attention upon improving internal practice capabilities that are often emphasized by systems and ACOs. For example, practices that intend to engage in interorganizational learning activities such as QICs may benefit from expanding HIT capabilities to support the continuous monitoring and improvement activities that accompany such participation. As Nembhard and Tucker point out, the process of organizational learning that underlies engagement in a QIC requires both the "processes and infrastructure that enable the creation, storage, and dissemination of information that helps the organization perform better" (Nembhard and Tucker 2016, p.6).

QICs are one strategy physician practices can use to learn about best practices for managing chronic care and other conditions, so continued exploration of how to engage small, rural and physician-owned practices in collaboratives and other QI activities should be a high

priority for research and policy, as their internal capabilities currently limit their ability to effectively participate (Kilo 1998). More specifically, clarifying the role of organizational and legitimacy factors in influencing QIC participation may inform the development of policies and interventions that enable small and medium sized practices to participate in QICs and other collaborative learning activities. Various initiatives currently occurring across the country such as the Clinical Practice Transformation Initiative provide important opportunities to gain insight into strategies to improve engagement in QICs by small practices and organizations. The perspectives of frontline clinical and administrative staff and leaders may also provide insights as to how internal learning orientation impacts participation in QICs and, ultimately, improved quality performance. Future research clarifying the cultural, organizational, and contextual influences on practice engagement in interoganizational learning activities would be especially valuable for practices affiliated with ACOs and related networks with the triple aim goals of high quality of care, improved population health, and lower costs of care.

Appendix 1. The Role of QI Methods in Explaining the Relation of ACO-affiliation, ownership, and Practice Participation in QICs

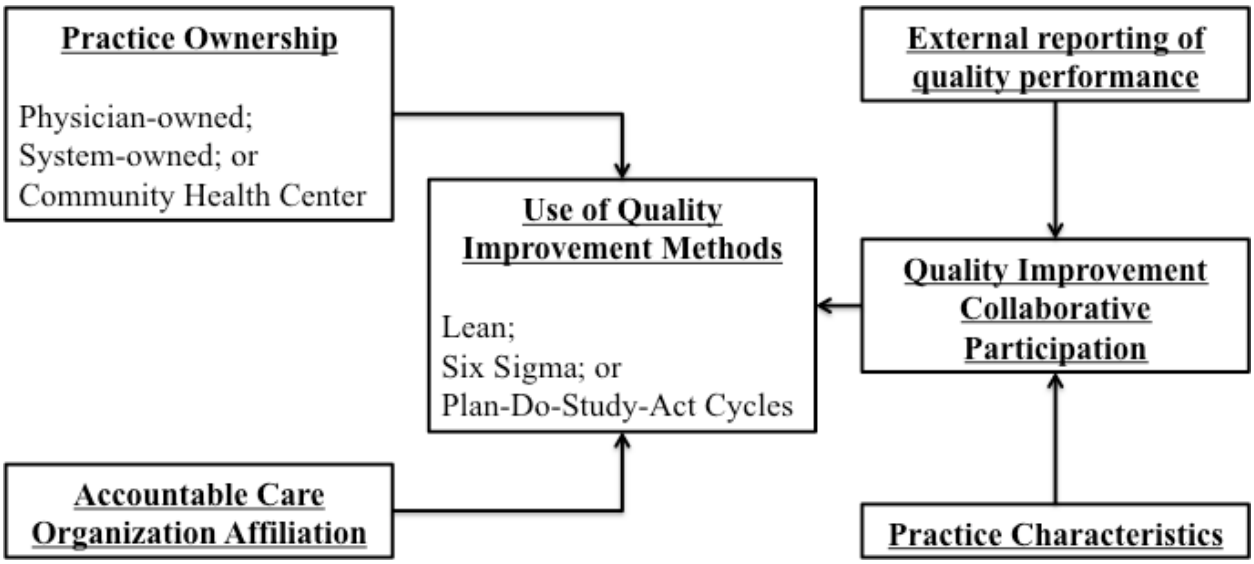

Table 1. Descriptive Statistics: Quality Improvement Collaborative (QIC) Participation, Quality Improvement Methods, and Organizational Characteristics

Variable		Frequency (N)	Percent
Quality Improvement Collaborative (**QIC**) Participation	No	1,174	86.4
	Yes	185	13.6
Accountable Care Organization (ACO) Affiliation	Non-ACO affiliated	1,093	80.47
	ACO affiliated	265	19.53
Practice Ownership	Physician-owned	1,118	82.3
	Hospital/Health System-owned	184	13.51
	Community Health Center	57	4.18
Practice Size	1-2 physicians	750	55.17
	3–7 physicians	431	31.68
	8–12 physicians	50	3.7
	13-19 physicians	18	1.32
	20-99+ physicians	111	8.14
Public Reporting of Quality Metrics by External Entities	No	746	59.92
	Yes	613	45.08
Quality Improvement Methods			
Plan-Do-Study-Act (PDSA) Cycle Use	No	1,203	88.53
	Yes	156	11.47
Six Sigma	No	1,273	93.67
	Yes	86	6.33
Lean	No	1,230	90.54
	Yes	129	9.46
Any Quality Improvement (QI) Method	No	993	73.07
	Yes	366	26.93

Table 2. The Relationship Between ACO Participation, Ownership, and Practice Participation in Quality Improvement Collaboratives, Multivariate Analyses

	Adjusted Odds Ratio				
	Model 1	Model 2	Model 3	Model 4	Model 5
Organizational Characteristics					
ACO Affiliation					
Non-ACO affiliated (reference)					
ACO affiliated	1.51**	1.64*	1.27**	0.93	1.12
Practice Ownership					
Physician Owned (reference)					
System-Owned	3.05	3.13	2.45	3.04	2.45
Community Health Center Owned	6.57***	6.48***	7.61***	4.99***	4.99***
Practice Size					
1-2 physicians (reference)					
3–7 physicians	1.35	1.33	1.58*	2.05***	1.65*
8–12 physicians	1.63	1.6	1.72	1.5	1.44
13-19 physicians	3.79	3.86	2.7	2.61	2.55
20-99+ physicians	14.72***	18.76**	10.41**	8.16***	8.08***
Health Information Technology Index	1.15***	1.16***	1.10***	1.13***	1.11***
%Medicaid/Uninsured Revenue	1.04	1.03	1.04	1.02	1.03
Public Reporting of Quality Metrics by External Entities					
No (reference)					
Yes	2.9***	2.92***	4.08***	4.07***	3.89***
Six Sigma Use		0.54			
Lean Use			5.47***		
Plan-Do-Study-Act (PDSA) Cycle Use				6.45***	
Any QI Method					4.77***

* p<0.05, ** p<0.01, *** p< 0.001

Table 3. Mediating Role of Quality Improvement (QI) Methods on the Accountable Care Organization (ACO) and QI Collaborative Participation Relationship

	Percent of total effect of ACO on QIC that is mediated	
Mediator	Unadjusted	Adjusted*
Plan-Do-Study-Act Cycle Use	35.2%	13.1%
Lean Use	36.0%	27.7%
Six Sigma Use	28.6%	32.3%
Any QI Method	58.2%	46.7%

*Adjusted analyses control for the following variables: practice ownership, practice size, Health Information Technology index, percent Medicaid/uninsured revenue, and public reporting of quality metrics by external entities

References

Acock, A. C. (2014). A Gentle Introduction to Stata. College Station, TX, Stata Press.
Aldrich, H. E. and J. Pfeffer (1976). "Environments of Organizations." Annual Review of Sociology **2**: 79-105.
Alexander, J. A. and L. R. Hearld (2011). "The Science of Quality Improvement Implementation: Developing Capacity to Make a Difference." Medical Care **49**: S6-S20.
Chin, M. H., M. L. Drum, M. Guillen and A. Rimington (2007). "Improving and Sustaining Diabetes Care in Community Health Centers with the Health Disparities Collaboratives." Medical Care **45**(12): 1135-1143.
Clarke, C. M., T. Cheng, K. G. Reims and C. M. Steinbock (2015). "Implementation of HIV Treatment as Prevention Strategy in 17 Canadian Sites: Immediate and Sustained Outcomes from a 35-month Quality Improvement Collaborative." BMJ Quality and Safety: 1-10.
CMS. (2016). "Transforming Clinical Practice Initiative." Retrieved May 28 2016, from https://innovation.cms.gov/initiatives/Transforming-Clinical-Practices/.
D'Aunno, T. (1991). "Isomorphism and External Support in Conflicting Institutional Environments: A Study of Drug Abuse Treatment Centers." Academy of Management Journal **34**(3).
Damschroder, L. J., D. C. Aron and R. E. Keith (2009). "Fostering Implementation of Health Services Research Findings into Practice: A Consolidated Framework for Advancing Implementation Science." Implementation Science **4**(50): 1-15.
Deo, S., K. McInnes and C. J. Corbett (2009). "Associations Between Organizational Characteristics and Quality Improvement Activities of Clinics Participating in a Quality Improvement Collaborative." Medical Care **47**(9): 1026-1030.
DiMaggio, P. and W. W. Powell (1983). "The Iron Cage Revisited: Istitutional Isomorphism and Collective Rationality in Organizational Fields." American Sociological Review **48**: 147-160.
Grossman, E., T. Keegan, A. L. Lessler and M. H. Ly (2008). "Inside the Health Disparities Collaboratives: A Detailed Exploration of Quality Improvement at Community Health Centers." Medical Care **46**(5): 489-496.
HRSA. (2008). "Health Disparities Collaboratives." Retrieved Jun. 1, 2016, from http://www.ihi.org/resources/pages/improvementstories/healthdisparitiescollaboratives.aspx.
HRSA. (2013). "Collaborative Improvement & Innovation Network (CoIIN) to Reduce Infant Mortality: Public Health Regions IV and VI." from http://mchb.hrsa.gov/infantmortalitysummit/coiintoreduceinfantmortality.pdf.
Hung, D., C. Gray and M. Martinez (2016). "Acceptance of Lean Redesigns in Primary Care: A Contextual Analysis." Health Care Management Review: In Press.
IHI. (2016). "Plan-Do-Study-Act Work Sheet." Retrieved Sept. 7, 2016, from http://www.ihi.org/resources/pages/tools/plandostudyactworksheet.aspx.
Kaplan, H. C. (2012). "The Influence of Context on Quality Improvement Success in Health Care: A Systematic Review of the Literature." Milbank Quarterly **88**(4): 500-559.
Kilo, C. (1998). "A Framwork for Collaborative Improvement: Lessons from the Institute for Healthcare Improvement's Breakthrough Series." Quality Management in Healthcare **6**: 1-13.
Landon, B. E., L. S. Hicks, J. A. O'Malley and T. A. Lieu (2007). "Improving the Management of Chronic Disease at Community Health Centers." New England Journal of Medicine **356**: 921-934.

Levin, L. S. and L. Gustave (2013). "Aligning Incentives in Health Care: Physician Practice and Health System Partnership." Clinical Orthopaedics and Related Research **471**(6): 1824-1831.
Li, L. X. (1997). "Relationships between Determinants of Hospital Quality Management and Service Quality Performance - A Path Analytic Model." Omega **25**(5): 535-545.
McClellan, M., A. McKethan and J. L. Lewis (2010). "A National Strategy to Put Accountable Care into Practice." Health Affairs **29**(5): 982-990.
McConnell, K. J., A. M. Chang and D. J. Cohen (2014). "Oregon's Medicaid Transformation: An Innovative Approach to Holding a Health System Accountable for Spending Growth." Healthcare **2**(3): 163-167.
MDH. (2015). "Health Reform Minnesota: Learning Collaboratives." Retrieved May 28, 2016, from http://www.health.state.mn.us/healthreform/homes/collaborative/lcindex.html.
MDHHS. (2015). "Maine State Innovation Model (SIM): Quality Counts (QC) Role." Retrieved May 28, 2016, from https://www.mainequalitycounts.org/page/2-960/maine-state-innovation-model-sim.
Medicaid. (2016). "Medicaid and CHIP (MAC) Learning Collaboratives." Retrieved May 28, 2016, from https://www.medicaid.gov/state-resource-center/mac-learning-collaboratives/medicaid-and-chip-learning-collab.html.
Mills, P. D. (2003). "A Multihospital Safety Improvement Effort and the Dissemination of New Knowledge." Joint Commission Journal on Quality and Safety **29**: 124-133.
Muhlestein, D. (2015). "Growth and Dispersion of Accountable Care Organizations in 2015." Following the ACA 2016.
Nadeem, E., S. S. Olin, L. C. Hill, K. E. Hoagwood and S. M. Horowitz (2013). "Understanding the Components of Quality Improvement Collaboratives: A Systematic Literature Review." Milbank Quarterly **91**(2): 354-394.
Nembhard, I. M. (2012). "All teach, all learn, all improve?: The role of interorganizational learning in quality improvement collaboratives." Health Care Management Review **37**(2): 154-164.
Nembhard, I. M. and A. L. Tucker (2016). "Applying Organizational Learning Research to Accountable Care Organizations." Medical Care Research and Review: 1-12.
Nohria, N. and R. Gulati (1996). "Is slack good or bad for innovation?" Academy of Management Journal **39**(5): 1245-1264.
OHA. (2015). "Oregon's State Innovation Model Project Progress Report." Retrieved May 28, 2016, from https://www.oregon.gov/oha/OHPR/SIM/docs/Oregon-SIM-Quarterly-Program-Progress-Report-Oct-Dec-2015.pdf.
Ovretveit, J., P. Bate, P. Cleary, S. Cretin, D. Gustafson, K. McInnes and H. McLeod (2002). "Quality Collaboratives: Lessons from Research." Quality and Safety in Health Care **11**: 345-351.
Ratnapalan, S. and E. Uleryk (2014). "Organizational Learning in Health Care Organizations." Systems **2**: 24-33.
Robinson, J. C. and L. P. Casalino (1996). "Vertical Integration and Organizational Networks in Health Care." Health Affairs **15**(1): 7-22.
Rodriguez, H. P., R. M. Henke, S. Bibi, P. R. Ramsay and S. M. Shortell (2016). Organizational and Market Influences on the Exnovation of Chronic Care Management Processes by Physician Organizations.
Rodriguez, H. P., S. R. McClellan, S. Bibi, L. P. Casalino, P. Ramsay and S. M. Shortell (2016). "Increased Use of Care Management Processes and Expanded Health Information Technology

Functions by Practice Ownership and Medicaid Revenue." Medical Care Research and Review **73**(3): 308-328.
Schouten, L. M., M. E. Hulscher, J. J. van Everdingen, R. Huijsman and R. P. Grol (2008). "Evidence for the Impact of Quality Improvement Collaboratives: Systematic Review." British Medical Journal: 2.
Scott, W. R. (2000). Institutional Change and Health Care Organizations. Chicago, IL, University of Chicago Press.
Shaw, E. K., S. M. Chase, J. Howard, P. A. Nutting and B. F. Crabtree (2012). "More Black Box to Explore: How Quality Improvement Collaboratives Shape Practice Change." Journal of the American Board of Family Medicine **25**: 149-157.
Shaw, E. K., P. A. Ohman-Strickland, A. Piasecki and S. V. Hudson (2013). "Effects of Facilitated Team Meetings and Learning Collaboratives on Colorectal Cancer Screening Rates in Primary Care Practices: A Cluster Randomized Trial." Annals of Family Medicine **11**(3): 220-228.
Shortell, S. M., J. Schmittdiel, M. C. Wang, R. Li, R. R. Gillies and L. P. Casalino (2005). "An Empirical Assessment of High-Performing Medical Groups: Results from a National Study." Medical Care Research and Review **62**(4): 407-434.
Shortell, S. M., F. M. Wu, V. A. Lewis, C. H. Colla and E. S. Fisher (2014). "A Taxonomy of Accountable Care Organizations for Policy and Practice." Health Services Research **49**(6): 1883-1899.
Strating, M. M., T. Broer, S. Van Rooijen, R. A. Bal and A. P. Nieboer (2012). "Quality Improvement in Long-Term Mental Health: Results from Four Collaboratives." Journal of Psychiatric Mental Health Nursing **19**(5): 379-388.
Versteeg, M. (2012). "Factors Associated with the Impact of Quality Improvement Collaboratives in Mental Healthcare: An Exploratory Study." Implementation Science **7**(1): 1-11.
Wiley, J. A., D. R. Rittenhouse and S. M. Shortell (2015). "Managing Chronic Illness: Physician Practices Increased the Use of Care Management and Medical Home Processes." Health Affairs (Millwood) **34**: 78-86.
Young, P. C., G. B. Glade, G. J. Stoddard and C. Norlin (2006). "Evaluation of a Learning Collaborative to Improve the Delivery of Preventive Services by Pediatric Practices." Pediatrics **117**(5): 1469-1476.

II. Improving Treatment Certainty for Hip and Knee Osteoarthritis Patients within the High Value Healthcare Collaborative

ABSTRACT

Research Objective: Shared decision making (SDM) is acknowledged as important to engage patients in treatment decisions, but few large-scale efforts have integrated SDM into routine clinical practice. As part of a Centers for Medicare and Medicaid Innovation project, 10 health systems collaboratively implemented SDM using decision aids (DAs) among adult hip and knee osteoarthritis patients. We examine the impact of DAs on these patients' treatment preferences and decision certainty.

Study Design: As part of usual care, patients completed self-report web-based surveys and viewed online DAs for their orthopedic surgical decision. Pre-DA and post-DA surveys were integrated to assess shifts in 1) treatment preferences among patients without preferences at baseline and 2) decision certainty among patients with baseline treatment preferences. Separately for hip and knee patients, logistic regression estimated the extent to which age, sex, marital status, race/ethnicity, and pain levels were associated with greater propensity for uncertain patients to indicate a treatment preference post-DA. Ordinal logistic regression models estimated which patient characteristics were associated with increased treatment certainty post-DA exposure among patients with a baseline treatment preference. Health system fixed effects accounted for patient clustering within systems.

Population Studied: 495 hip and 1,343 knee osteoarthritis patients exposed to DAs within HVHC systems across the 2.5 years of the SDM intervention (Jan 2013 to Jun 2015).

Principal Findings: Use of DAs by eligible patients was low and varied considerably across the 10 systems (median: 184, range: 8-794 patients). Among knee patients, 28.6% reported decision uncertainty at baseline; after DA exposure, 14.3% of these patients preferred surgery, 18.5% preferred non-surgical treatment, and 67.2% continued to be uncertain. Among hip patients, 23.6% reported decision uncertainty at baseline; after DA exposure, 18.8% preferred surgery, 9.4% preferred non-surgical treatment, and 71.8% continued to be uncertain. DA exposure increased decision certainty among 25% of hip and 33% of knee patients with baseline surgical or non-surgical preferences. In adjusted analyses, Hispanic knee patients had higher odds of switching from an uncertain to a non-surgical treatment preference post-DA compared with white patients (OR = 3.78, $p < 0.05$). Uncertain college-educated and unmarried hip patients had lower odds of choosing a non-surgical intervention post-DA. Knee patients having at least one comorbidity in addition to osteoarthritis had lower odds of indicating increased decision certainty for non-surgical intervention post-DA (OR = 0.44, $p < 0.05$). Among hip patients, comorbidity increased certainty for surgery post-DA (OR = 5.07, $p<0.05$).

Introduction

There is growing momentum toward engaging patients to be more participative in their own care through the process of shared decision making (SDM), a collaborative approach to clinical decisions in which both physicians and patients contribute equally to conversations about treatment choices. These choices are in turn more likely to be aligned with patients' preferences and values (Elwyn, Edwards, and Kinnersley 1999). Many studies suggest that when patients are engaged in SDM, they not only become more knowledgeable about their conditions but they also experience less decisional conflict or uncertainty about their treatment choices (Gionfriddo et al. 2014; Stacey, Bennett, and Barry 2011). Moreover, patients who adopt active roles in their own medical care experience improved clinical outcomes and are more likely to adhere to treatment plans (Stewart et al. 1999; Towle and Godolphin 1999).

Although past work has emphasized the role of SDM as important to helping patients arrive at treatment decisions reflective of their preferences, there have been few large-scale efforts to integrate SDM into routine clinical practice. As a result, there is a dearth of evidence about patient-level outcomes associated with the routine implementation of SDM, especially across diverse health systems (Hsu et al. 2013). This study explores the impact of one element of SDM – exposure to decision aids (DAs) - upon hip and knee osteoarthritis patients' expressed treatment preferences for surgery versus medical management (non-surgical intervention) and decision certainty before and after the SDM intervention.

The use of patient decision aids (DAs) to facilitate SDM has been a topic of growing empirical interest amidst ongoing policy initiatives that seek to advance the role of patients in medical decision-making. The International Patient Decision Aids Standards (IPDAS) collaboration defines DAs as "tools designed to help people participate in decision making about two or more health care options...[they] provide information about the options and help patients clarify and communicate the personal values they associate with different features of the options" (The International Patient Decision Aids Standards 2012). They most often take the form of pamphlets, videos or web-based programs (O'Connor et al. 2007). DAs have been demonstrated to be effective resources for improving patients' knowledge of their health conditions and enabling them to engage as equal decision makers alongside clinicians in treatment choices (Stacey et al. 2011). Although SDM can appropriately be utilized in the context of most health conditions, it has been acknowledged as a particularly valuable tool in the treatment of preference-sensitive conditions, or those conditions for "which there is a lack of clear evidence showing superiority of one treatment, and treatment choices vary in ways that may matter to patients" (Boss, Mehta, and Nagarajan 2016).

Knee and hip replacements are among the most commonly performed orthopedic procedures in the U.S., and increasingly appear among lists of the most prevalent and costly procedures for both commercially and publicly insured patients (Pasquale et al. 2014). A robust body of empirical literature has explored the varied benefits and risks of both surgical and non-surgical interventions for these conditions, with the latter encompassing weight loss, physical therapy, and non-steroidal anti-inflammatory medications (Bozic et al. 2013). For conditions such as hip or knee osteoarthritis, DAs represent an important tool in helping patients weigh important tradeoffs between surgical and non-surgical treatment options.

Although total joint arthroplasty or replacement for hip or knee osteoarthritis can reduce long-term pain and improve mobility, the procedure has not been shown to prolong

life and post-operative complications in up to 17% of patients have been recorded (Bohl et al. 2017; Hamel, Toth, and Legedza 2008). Thus the possible benefits of a surgical intervention should be considered along with the potential increased risk of mortality or possible complications and discomfort during recovery. Non-surgical interventions such as weight reduction and strengthening exercises have been shown to significantly reduce pain among osteoarthritis patients (Zhang et al. 2010). Notably, recent research suggests that some patients undergo arthroplasty even when clinical indicators suggest they should not; one study found that up to 34% of knee arthroplasties were medically inappropriate (Riddle, Jiranek, and Hayes 2014). These factors underlie the importance of incorporating decision aids into the treatment trajectories for these patients.

Theory

One prominent stream of SDM research points to the importance of patient-level characteristics in understanding their impact upon patient preferences. For example, patient age, ethnicity, educational attainment as well as the patient's overall health status are hypothesized to influence treatment decisions when exposed to DAs as part of the SDM process (Tariman et al. 2012). Some studies suggest a sharp decline in preference for surgical interventions with increasing patient age (Hurria et al. 2003; Schrag et al. 2001). Patient concerns about serious complications of surgeries, long recovery periods and the need to rely upon others to help with post-operative care are commonly cited explanations for older patients to choose more conservative treatment modalities (Hamel et al. 2008). Hip and knee arthroplasty carry similar risks of perioperative complications, but higher rates of 30-day readmissions and rehospitalizations have been reported with hip arthroplasty. This has been attributed to greater risk of medical and surgical complications such as sepsis following hip arthroplasty (George et al. 2017). Elsewhere, it has been reported that hip arthroplasty patients age 65-79 have over twice the odds of experiencing an adverse surgical event compared with patients under the age of 65 (Koenig et al. 2012). Older patients undergoing hip arthroplasty have been shown to exhibit worse physical functioning scores over time, but such an outcome was not as frequently reported among older patients undergoing knee arthroplasty (Santaguida et al. 2007). In light of these differing risks, we hypothesize that:

Hypothesis 1: Older hip patients will be less likely to express a preference for surgical treatment following exposure to DAs when compared with middle-aged (51-64 years old) hip patients.

Hypothesis 2: Older knee patients will be more likely to express a preference for surgical treatment following exposure to DAs when compared with middle-aged knee patients.

Studies across clinical settings from orthopedic surgery (Lurie et al. 2011) to mental health (Metz et al. 2015) underscore the role of DAs in facilitating decisional certainty, or confidence for a given patient to choose the most appropriate treatment choice (O'Connor 1995). Patients are less likely to experience regret or dissatisfaction when they feel supported and confident in their chosen treatment paths (Stacey et al. 2014). A randomized controlled trial (RCT) evaluating a video DA for herniated disc patients found that, compared to control group patients, intervention patients were more likely to express stronger treatment certainty

after intervention relative to the control group (Lurie et al. 2011). Video DAs have also been demonstrated to improve certainty for end-of-life care decisions among both high and low literacy patient groups (Volandes et al. 2010). Taken together, prior work suggests that the use of DAs as part of the SDM intervention can aid patients in expressing greater certainty for a preferred treatment route.

The relationship between self-reported pain and patient treatment certainty post-DA intervention is poorly understood. Recent papers have reported that patients reporting worse scores on an assessment of osteoarthritis severity and pain were more likely to have chosen surgery over medical management (Hawker 2006), and that knee osteoarthritis patients were more likely to choose surgical interventions when they reported more severe pain and greater functional limitations when compared with patients reporting fewer impediments to activity and less pain (Moorman et al. 2017).

Hypothesis 3: Patients who report worse pain scores will be more likely to express decisional certainty for surgery post-DA intervention.

Although the association between comorbidity status and outcomes of arthroplasty (i.e. improvements in pain, mobility) are well-studied (Vina et al. 2017), there have been fewer attempts to understand how comorbidity impacts patients' preferences or decisional certainty. Longitudinal studies of hip and knee patients who underwent joint arthroplasties have noted a trend toward greater comorbidity burden among this group; between 1991-2008, arthroplasty patients had, on average, two comorbidities, with cardiovascular disease and diabetes among the most commonly reported conditions (Cram et al. 2011; Krones et al. 2008) Previous work has highlighted associations between SDM exposure and higher knowledge scores as well as decisional certainty among patients with other chronic conditions (Krones et al. 2008; Lin et al. 2009). In light of increasing comorbidity among hip and knee patients, we hypothesize that:

Hypothesis 4: Co-morbid patients with stable surgical preferences will be more likely to express decisional certainty for surgery post-DA intervention when compared with patients reporting less comorbidity.

Methods

Data

This paper leverages data collected from 10 systems belonging to the High Value Healthcare Collaborative between 2012-2015, when HVHC was awarded a Centers for Medicare and Medicaid Innovation (CMMI) grant to implement SDM for patients considering surgery for hip or knee osteoarthritis (High Value Healthcare Collaborative 2012). This SDM intervention was carried out within the context of orthopedic specialty practices and was in most cases "triggered" by patients calling to make an appointment to discuss treatment options for hip or knee osteoarthritis.

The DAs included a 15-minute video addressing the risks and benefits of surgery or medical management for hip or knee osteoarthritis, and featured real patients as they discussed their experiences and satisfaction with their treatment choices. Patients completed

post-DA surveys either immediately after viewing or shortly thereafter (usually within 1-2 weeks). Together, the patient surveys assessed demographic information, pain scores, expectations for health outcomes and treatment preferences (surgical vs. non-surgical vs. unsure). Health coaches, who were often trained nurses or physician assistants, assisted patients in-office or online as they completed these surveys and were able to address questions (electronically or in-person) as they arose.

Although most systems implemented the intervention such that patients viewed the DAs before their orthopedic consultation, some sites carried out the intervention post-consultation. Notably, some systems moved this process upstream into other clinical settings such as primary care practices. The overarching goals of this CMMI-funded project were to improve the health status (as measured by pain and functioning) of patients considering hip and knee interventions, to increase the number of patients engaged in SDM, and to reduce total costs of hip and knee surgeries across participant sites (Hawke 2016). Beyond the scope of the data collected for the CMMI-funded SDM intervention, HVHC maintains a virtual database of member submitted data known as the Unified Data Extract. This repository enables longitudinal comparative analyses of outcomes for hip and knee osteoarthritis patients as well as patients with low back pain, diabetes, and congestive heart failure in order to identify areas of progress as well as those processes requiring additional attention to narrow the gap between delivered and optimal care (Savitz and Weiss 2017).

Additional data was collected from the HVHC Unified Data Extract, which includes organizational information for each health system including inpatient and outpatient encounter visits, and patient and provider descriptive data. The Patient Data Specifications includes patient responses to questions assessing preferred treatment choices (before and after DA viewing) and decisional certainty (before and after DA) for expressed treatment choices and Hip Disability and Osteoarthritis Outcome Score (HOOS) and Knee Disability and Osteoarthritis Outcome Score (KOOS) pain scores.

In order to maximize the inclusion of patients in the analytic sample, we utilized likelihood-based imputation to derive values for patients with missing pain scores. For these analyses, the patient cohort is restricted to those with a diagnosis of either knee osteoarthritis (ICD-9 CM diagnostic codes 715.09, 715.16, 715.26, 715.36 or 715.96) or hip osteoarthritis (ICD-9 CM diagnostic codes 715.09, 715.15, 715.25, 715.35 or 715.95) (Hawke 2016). All analyses were conducted in parallel for the hip and knee cohorts.

Outcome Measures

Treatment Preferences Among Uncertain Patients: Patients expressing shifts in preferences from uncertainty to surgery or uncertainty to non-surgery are compared with those patients with continuously uncertain preferences (both pre- and post-DA exposure). Patient responses are based upon the following question, asked before and after DA viewing: "At this time [before or after viewing the DA], what treatment are you leaning toward doing for your [hip/knee] pain?" The three possible response categories are: [hip/knee] surgery, non-surgical treatment, or not sure.

Decision Certainty Among Patients with Stable Preferences: Among patients expressing stable surgical or non-surgical preferences, we explore decision certainty as an outcome of exposure to DAs. To assess decision certainty, we leverage the following

question - asked before and after DA viewing - from the patient survey: "How far along are you with this decision?" Patient responses fall into one of four categories: [1] "Not yet thought about all the options," [2] "Considering the different options," [3] "Close to choosing an option," or [4] "Already chose an option." We construct an ordinal outcome, where shifts in decisional certainty could take the form of a decrease (moving down in the numbered response, i.e. from [3] to [2]), a stable response (the same numbered response reported before and after DA viewing), or an increase (moving up in numbered response). We focus the analysis on changes in patient decision certainty, so exclude those patients reporting they had already arrived at a treatment option before and after the DA (i.e. patients reporting [4] in the pre- and post-DA surveys). Among our sample of patients with stable treatment preferences (n = 551), 170 hip and knee patients expressed increased decision certainty after DA viewing.

Independent Variables

The patient surveys assessed patient age, co-morbidity information, and the Hip Disability and Osteoarthritis Outcome Score (HOOS) and Knee Disability and Osteoarthritis Outcome Score (KOOS). These batteries are 40 and 42 questions in length (respectively), and include 5 individually scored subscales assessing symptomology, pain, and the extent to which osteoarthritis impacts daily activities, recreation, and quality of life. The pain sub-scale is utilized for these analyses. We normalized pain scores on a 0-100 scale, where 0 indicates no pain and 100 indicates extreme hip or knee pain. The HOOS and KOOS surveys have been well-validated and demonstrated to be reliable in assessing both short- and long-term pain relating to osteoarthritis (Weeks et al. 2016). The co-morbidity score is constructed from patient-reported data capturing whether osteoarthritis patients also report diabetes and/or congestive heart failure (CHF). Patients only reporting hip and/or knee osteoarthritis received a score of "1" while those reporting osteoarthritis plus diabetes and/or CHF received a score of "2".

Control Variables

We explore independent variables of interest (age, pain score, and co-morbidity) while controlling for sex, race/ethnicity, marital status, and, in adjusted models, education level. Prior literature exploring the association between patient characteristics and treatment decisions after SDM suggests that patient preferences for surgical interventions are influenced by patient sex, with females slightly more likely to express a tendency toward conservative (non-surgical) treatment options when compared with males (Nilsdotter et al. 2003; Roos and Lohmander 2003). A patient's social support system - in particular having a spouse – also plays a notable role in patient decision-making. Spouses contribute another voice to the dialogue concerning treatment benefits and disadvantages at the same time that they often assume some responsibility for the patient's ongoing care (Karlson, Daltroy, and Liang 1997). Patient race has also been hypothesized to influence patient treatment choices in shared decision making settings (Cram et al. 2011; Krones et al. 2008). There is also evidence to suggest that patients with higher educational attainment may be more likely to actively engage in SDM than less well education patients (Hudak et al. 2008). To the extent that education serves as a marker of socio-economic (as well as insurance) status, these

patients may also experience fewer financial impediments should they decide to pursue surgery.

Statistical Analyses

Differences in patient-level covariates relative to the dependent variable of post-DA preference (uncertain to surgical or non-surgical preference) compared with continuously uncertain patients are analyzed by chi-square analysis for dichotomous variables or analysis of variance (ANOVA) for continuous outcomes using robust standard errors due to the clustering of patients within systems. Due to small cell sizes among hip patients, some independent variable categories are collapsed differently than for knee patients (i.e. age categories for hip patients are Under 64 and 65+, while age categories for knee patients are Under 50, 50-64, and 65+). We assessed the relationship between DA exposure and change in treatment preferences through logistic regression models with adjustments for patient-level control variables and with health system fixed effects to account for clustering of patients within systems. Likelihood-based multiple imputation is employed to address missing data from HOOS and KOOS pain scores across health systems. Sensitivity analyses are conducted to examine the differential impact of increasing age upon the propensity to express a treatment preference post-DA exposure.

Results

Descriptive Statistics

Descriptive statistics for the knee and hip patients are reported in Tables 1 and 2, respectively. A total of 1,343 knee patients and 495 hip patients received the DA intervention and completed the patient survey questions assessing pre- and post-DA treatment preferences, resulting in a total exposed population of 1,838 patients (Figure 1). The mean age among knee patients was 59.3 years (SD = 9.6); among hip patients it was 58.5 years (SD = 10.1). The majority of patients were female (64.5% among knee patients and 56.2% among hip patients) and Caucasian (82% of both knee and hip patients). Nearly 12% of hip patients and 16% of knee patients had at least one co-morbidity other than osteoarthritis.

A greater percentage of both knee and hip patients expressed stable surgical preferences (43.6% and 58.2%, respectively). 21.7% of knee patients had stable preferences for non-surgical treatment, and 13.3% of hip patients similarly had stable non-surgical preferences. Across condition and preference categories, patients under the age of 65 comprised a larger segment of the study population compared with older patients. Among knee patients expressing stable surgical preferences (n = 586), 60.2% were between the ages of 50 and 64, while 22.5% were 65 or older. Just over 5% (n=71) of knee patients shifted from uncertainty toward a non-surgical preference; among these, 64.5% were between 50-64 and 26.8% were 65 or older. Among hip patients, 288 expressed stable surgical preferences, with a majority (71.9%) of these patients 64 or younger. Among those shifting from uncertainty to a non-surgical preference (n=11), 72.7% were 64 or younger while the remaining 27.3% were 65 or older.

28.6% of knee patients reported decision uncertainty at baseline; after DA exposure, 14.3% of these patients preferred surgery, 18.5% preferred non-surgical treatment, and

67.2% continued to be uncertain. Among hip patients, 23.6% reported decision uncertainty at baseline; after DA exposure, 18.8% of these patients preferred surgery, 9.4% preferred non-surgical treatment, and 71.8% continued to be uncertain.

Multivariate Logistic Regression Analyses

Results of multivariate logistic regressions assessing treatment preferences among patients with baseline uncertainty are reported in Table 3 for both knee and hip patients. Among knee patients, those 65 and older had higher odds of choosing surgery when compared with patients aged 50-64 (OR = 1.33, $p > 0.05$). Hip patients age 65 and older had 42% higher odds of choosing non-surgical intervention compared with younger patients (OR = 1.42, $p > 0.05$). Due to the modest sample sizes for these subgroups, neither of these results attained statistical significance at the $p < 0.05$ level; the magnitude of these effects, however, were relatively large. Thus, we find partial support for our first and second hypotheses. In adjusted models, Hispanic knee patients had over three times the odds of switching from an uncertain to a non-surgical preference post-DA when compared with white patients and controlling for all other covariates (OR = 3.78, $p<0.05$). Unmarried hip patients had lower odds of switching from uncertainty to a non-surgical preference compared with married hip patients (OR = 0.11, $p<0.05$). Conversely, hip patients with worse pain scores had nearly twice the odds of switching from uncertainty to a surgical preference relative to hip patients reporting less pain (OR = 1.85, $p<0.05$).

Ordinal logistic regression findings for decision certainty are reported in Tables 4 and 5. DA exposure increased decision certainty among 33% of knee patients and 25% of hip patients with baseline surgical or non-surgical preferences. For knee patients with stable surgical preferences, being co-morbid was associated with greater odds of expressing decisional certainty post-DA, although this finding did not achieve statistical significance (OR = 1.78, $p>0.05$). Having at least one co-morbidity in addition to osteoarthritis was associated with 56% lower odds of knee patients indicating increased decision certainty for non-surgical intervention post-DA (OR = 0.44, $p < 0.05$); co-morbid knee patients with stable surgical preferences, however, had greater odds of expressing increased certainty for surgery (OR = 1.78, $p>0.05$). Among hip patients, co-morbidity was associated with increased certainty for surgery post-DA (OR = 5.07, $p < 0.05$). These findings lend support to our fourth hypothesis. Notably, unmarried knee patients had greater odds of expressing certainty for surgery relative to married patients (OR = 1.90, $p< 0.05$). Conversely, more educated hip patients (with some college education or a college degree) had 78% lower odds of expressing certainty for surgery post-DA compared with patients with a high school education only (OR = 0.22, $p < 0.05$).

Discussion

Although not all uncertain patients arrived at a treatment decision, DA use increased certainty among hip and knee patients with baseline treatment preferences. Compared with hip patients, a greater proportion of knee patients expressed increased certainty after exposure to DAs (25% vs. 33%). These findings echo what has been reported in other pragmatic clinical settings evaluating the impact of DAs upon treatment choices and decision certainty (Durand et al. 2014).

To understand which patient characteristics were associated with shifts toward post-DA treatment preferences, the sample for these treatment preference regressions was limited to patients who initially expressed treatment uncertainty. Our sample size provided us with enough power to detect large coefficients for the associations between patient age and post-DA treatment preferences, despite not reaching statistical significance. Although older knee patients had greater odds of switching from an uncertain to a surgical preference compared with older hip patients, we saw older hip patients shift away from uncertainty toward both treatment choices. These findings suggest important differences across treatment choices for hip and knee osteoarthritis according to patient age, while highlighting the role of DAs in clarifying treatment preferences for older patients. Given the growing number of aging patients within the U.S., future work should explore whether such shifts continue to manifest across diverse system contexts.

Our analyses highlight important associations between other patient-level predictors of treatment choice after the SDM intervention. For example, our finding that Hispanic knee patients had greater odds of switching toward a non-surgical preference is aligned with previous research suggesting that non-white patients may perceive the relative balance of risks and benefits associated with surgery more negatively than white patients (Lurie et al. 2011). Although we do not investigate the reasons underlying this association in this paper, others have demonstrated that these perceptions may in part be explained by poorer baseline knowledge and familiarity with orthopedic procedures such as arthroplasty (Hawker et al. 2004). Providing patients across ethnic and socio-demographic groups with tools such as DAs to help them consider treatment options is an important means to facilitate conversations about expectations while it provides patients with a knowledge base to accurately weigh treatment tradeoffs.

We also found that unmarried hip patients had lower odds of preferring non-surgical intervention compared with married patients. This finding diverges from other work suggesting that unmarried patients may be more likely than married patients to consider and pursue non-surgical interventions (Ibrahim et al. 2002). For patients without the immediate social support of a spouse with whom they could discuss treatment options, DAs may play a particularly important role in helping these patients weigh the relative benefits and risks associated with each choice.

Our findings should be considered with the following limitations. First, this study leveraged a before and after comparison, but the associations identified may not represent causal relationships. The data for this paper was collected from a CMMI project, thus precluding the possibility of constructing a “pure” unexposed control group. There was also heterogeneity of the SDM intervention across practice sites within systems; some patients were prompted to view a Health Dialog DVD DA or an online DA in advance of their appointments, while other practices invited patients to view the DA on an iPad in the

orthopedist's office. Because these variations were not consistently documented within and across the HVHC systems, these measures of implementation variation could not be incorporated into our regression analyses. More nuanced quantitative implementation data as well as qualitative key informant interviews could clarify the associations we found.

In conclusion, this study highlights an important role for SDM in supporting the treatment trajectories of patients with preference-sensitive conditions such as hip or knee osteoarthritis, in particular patients with limited social support and/or complex clinical conditions. At the same time, the study results underscore how implementation of SDM in routine practice settings may not shift patient preferences and certainty to the same extent as has been reported in RCTs or non-pragmatic trials (Hamel et al. 2008). For example, nearly 20% of knee patients and 17% of hip patients in our study remained uncertain about their treatment preferences both before and after exposure to DAs. To our knowledge, far less empirical work has taken up the topic of how best to facilitate shared conversations with continuously uncertain patients. Future research that clarifies the mechanisms through which SDM facilitates treatment choices could inform how to use DAs are helpful tools to support SDM within patient-clinician encounters. Such insights are priorities for ongoing efforts by entities such as the Patient-Centered Outcomes Research Institute to bring patient-centered care to the forefront of funding and research priorities. As health care systems seek to integrate SDM into routine practice, identifying patients who will be most responsive to DAs can direct resources and training to better align patient preferences and treatment decisions.

Figure 1: HVHC Hip and Knee Patient Study Population

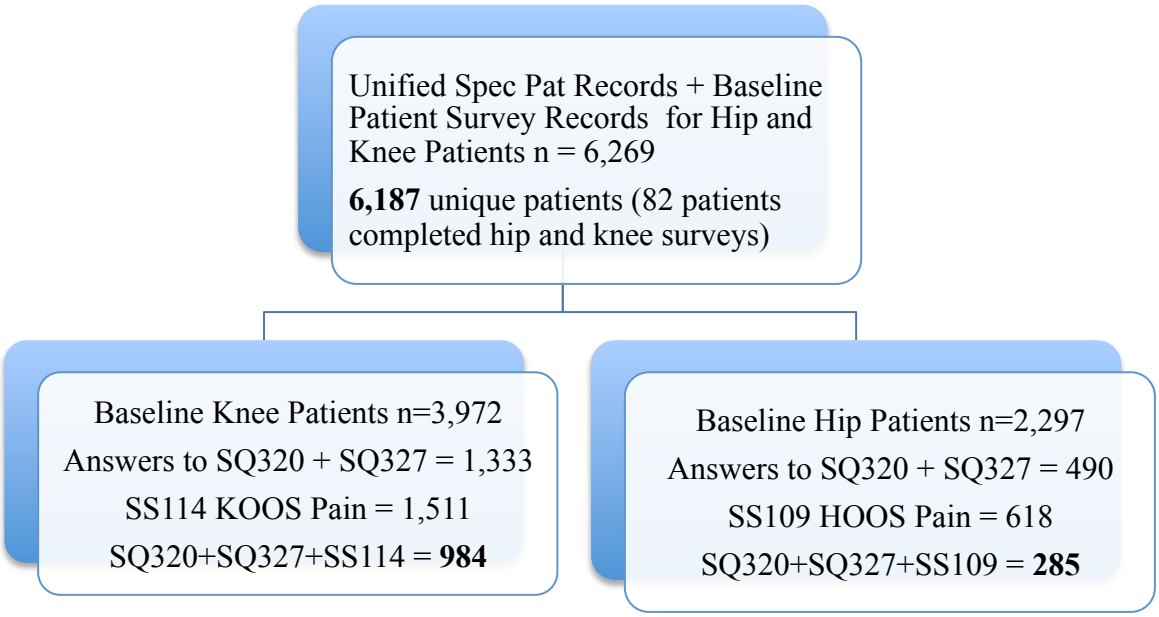

Table 1: Descriptive Statistics for Knee Patients Exposed to Shared Decision Making

	Stable Surgical Preference	Stable Non-Surgical	Uncertain to Surgical	Uncertain to Non-Surgical	Continuously Uncertain	Other*	p-value
n (total n=1,343)	586 (43.6%)	291 (21.7%)	55 (4.1%)	71 (5.3%)	258 (19.2%)	82 (6.1%)	
Patient Characteristics							
Age (Mean, SD)							0.41
Under 50 (Column %)	101 (17.2%)	23 (7.9%)	6 (10.9%)	6 (8.5%)	34 (13.2%)	17 (20.7%)	
50-64	353 (60.2%)	154 (52.9%)	46 (64.8%)	46 (64.5%)	147 (57.0%)	47 (57.3%)	
65+	132 (22.5%)	114 (39.2%)	16 (29.1%)	19 (26.8%)	77 (29.8%)	18 (22%)	
Gender							0.72
Female (%)	344 (58.7%)	213 (73.2%)	41 (74.6%)	43 (60.6%)	171 (66.3%)	57 (69.5%)	
Race							0.12
Hispanic	62 (10.6%)	15 (5.2%)	9 (16.4%)	14 (19.7%)	19 (7.4%)	11 (13.4%)	
White	422 (72.0%)	230 (79.0%)	30 (54.6%)	47 (66.2%)	199 (77.3%)	57 (69.5%)	
Other/Unknown	102 (17.4%)	46 (15.8%)	16 (29.1%)	10 (14.1%)	40 (15.5%)	14 (17.1%)	
Marital Status							0.36
Married/Life Partner (%)	323 (55.1%)	164 (56.4%)	28 (50.9%)	36 (50.7%)	156 (60.5%)	45 (54.9%)	
Not Married (%)	263 (44.9%)	127 (43.6%)	27 (49.1%)	35 (49.3%)	102 (39.5%)	37 (45.1%)	
Co-Morbidities Score							0.27
Hip or Knee OA Only	506 (86.4%)	237 (81.4%)	42 (76.4%)	54 (76.1%)	220 (85.3%)	64 (78.1%)	
Hip or Knee OA + Diabetes and/or CHF	80 (13.7%)	54 (18.6%)	13 (23.6%)	17 (23.9%)	38 (14.8%)	18 (21.9%)	
HOOS or KOOS Pain Score (Mean, Std. Dev.)	58.86 (17.33)	42.56 (17.81)	59.44 (18.68)	49.72 (19.90)	50.93 (18.23)	54.63 (19.19)	0.33
Education							0.16
Less than High School	169 (28.8%)	62 (21.3%)	23 (41.8%)	24 (33.8%)	79 (30.6%)	32 (39%)	
Some College/College Graduate	318 (23.7%)	158 (54.3%)	22 (40%)	28 (39.4%)	134 (51.9%)	39 (47.6%)	
Postgraduate	99 (16.9%)	71	10 (18.2%)	19 (26.8%)	45 (17.4%)	11	

School or Degree		(24.4%)				(13.4%)	

Note: * Other includes patients switching from a surgical or non-surgical preference to uncertain (n=63), patients switching from a surgical preference to non-surgical preference post-DA expsoure (n=12), and patients switching from a non-surgical preference to surgical preference post-DA expsoure (n=7).

Table 2: Descriptive Statistics for Hip Patients Exposed to Shared Decision Making

	Stable Surgical Preference	Stable Non-Surgical	Uncertain to Surgical	Uncertain to Non-Surgical	Continuously Uncertain	Other*	p-value
n (total n=495)	288 (58.2%)	66 (13.3%)	22 (4.4%)	11 (2.2%)	84 (17.0%)	24 (4.9%)	
Patient Characteristics							
Age (Mean, SD)							0.79
64 and Under	207 (71.9%)	40 (60.6%)	18 (81.8%)	8 (72.7%)	66 (78.6%)	17 (70.8%)	
65+	81 (23.1%)	26 (39.4%)	4 (18.2%)	3 (27.3%)	18 (21.4%)	7 (29.2%)	
Gender							0.38
Female (%)	149 (51.7%)	40 (60.6%)	16 (72.7%)	8 (72.7%)	53 (63.1%)	12 (50%)	
Race							0.79
White	248 (86.1%)	56 (84.9%)	15 (68.2%)	8 (72.7%)	67 (79.8%)	16 (66.7%)	
Other/Unknown	40 (13.9%)	10 (15.2%)	7 (31.8%)	3 (27.3%)	17 (20.2%)	8 (33.3%)	
Marital Status							0.05
Married/Life Partner (%)	181 (62.3%)	41 (62.1%)	13 (59.1%)	8 (72.7%)	45 (53.6%)	7 (29.2%)	
Not Married (%)	107 (37.2%)	25 (37.9%)	9 (40.9%)	3 (27.3%)	39 (46.4%)	17 (70.8%)	
Co-Morbidities Score							0.60
Hip or Knee OA Only	260 (90.3%)	55 (83.3%)	19 (86.4%)	10 (90.9%)	70 (83.3%)	23 (95.8%)	
Hip or Knee OA + Diabetes and/or CHF	28 (9.7%)	11 (16.7%)	3 (13.6%)	1 (9.1%)	14 (16.7%)	1 (4.2%)	
HOOS or KOOS Pain Score (Mean, Std. Dev.)	60.14 (17.76)	40.04 (18.64)	62.73 (20.93)	57.78 (27.48)	53.46 (16.15)	54.79 (17.61)	0.10
Education							0.32
Less than High School/Graduated from High School/GED	50 (17.4%)	16 (24.2%)	9 (40.9%)	8 (72.7%)	23 (27.4%)	4 (16.7%)	
Some College/College Graduate	238 (82.6%)	50 (75.8%)	13 (59.1%)	3 (27.3%)	61 (72.6%)	20 (83.3%)	

Note: * Other includes patients switching from a surgical or non-surgical preference to uncertain (n=20), patients switching from a surgical preference to non-surgical preference post-DA exposure (n=3), and patients switching from a non-surgical preference to surgical preference post-DA exposure (n=1).

Table 3: Multivariate Logistic Regression Results Table: Treatment Preferences among Knee and Hip Patients

	Patients Switching from Uncertain to Non Surgical (vs. Continuously Uncertain)				**Patients Switching from Uncertain to Surgical (vs. Continuously Uncertain)**			
	KNEE (n = 71)		**HIP (n = 11)**		**KNEE (n = 55)**		**HIP (n = 22)**	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
Age	Age (vs. 51-64)		Age (vs. 64 and under)		Age (vs. 51-64)		Age (vs. 64 and under)	
Under 50	0.59	0.57	N/A	N/A	0.49	0.47	N/A	N/A
65+	0.60	0.63	1.61	1.42	1.28	1.33	1.13	1.11
Female (vs. Male)	0.70	0.73	1.50	0.87	1.54	1.63	1.54	1.48
Race (vs. White)								
Hispanic	3.82**	3.78**	N/A	N/A	1.34	1.30	N/A	N/A
Non-White/Other/Unknown	0.95	0.92	2.15	2.29	1.69	1.64	1.98	1.79
Marital Status (vs. Married)								
Unmarried	1.23	1.23	0.27	0.11**	0.98	0.99	0.45	0.42
Co-Morbidities (vs. Hip or Knee OA only)								
Hip or Knee OA + Diabetes and/or CHF	1.40	1.46	0.59	0.55	1.36	1.49	0.69	0.77
Pain Score (HOOS or KOOS)	0.88	0.93	1.64	1.45	1.36	1.42	2.02**	1.85*
Education Level (vs. Less than or Graduated from High School /GED)								
Some College/Graduated from College	N/A	1.05	N/A	0.08	N/A	0.98	N/A	0.68
Postgraduate Education	N/A	1.97			N/A	2.05		
Intercept	0.31	0.45	0.12**	0.90**	0.33	0.46	0.22**	0.31*
AIC	309.5	310.2	78.2	68.7	264.7	266.3	112.9	116.8

**** p<0.05; *p<0.10**

Table 4: Decision Certainty Among Knee Patients with Baseline Treatment Preferences

	Knee Patients with Stable Non Surgical Preference			**Knee Patients with Stable Surgical Preference**		
	Model 1	Model 2	CI	Model 1	Model 2	CI
Patient Characteristics						
Age						
Under 50	2.55	2.30	0.64 – 8.23	1.68	1.72	0.78 – 3.81
51-64						
65+	1.57	1.57	0.85 – 2.90	1.19	1.22	0.62 – 2.41
Female	1.53	1.41	0.71 – 2.80	0.82	0.80	0.46 – 1.39
Race						
Hispanic	1.60	1.59	0.44 – 5.72	1.69	1.79	0.64 – 5.02
White (ref)						
Other/Unknown	1.05	1.13	0.49 – 2.62	2.32	2.43	1.00 – 5.91
Marital Status						
Married/Life Partner (ref)						
Unmarried	1.24	1.29	0.69 – 2.43	2.05	1.90**	1.06 – 3.38
Co-Morbidities						
(Hip or Knee OA + Diabetes and/or CHF vs. Hip or Knee OA only)	0.45**	0.44**	0.20 – 0.94	2.07	1.78	0.80 – 4.00
Pain Score (HOOS or KOOS)	0.76*	0.79	0.58 – 1.07	0.87	0.83	0.62 – 1.13
Education Level						
High School/GED/Other (ref)						
Some College/Graduated		1.08	0.48 – 2.43		0.95	0.50 – 1.98

from College						
Postgraduate Education		0.99	0.40 – 2.44		0.89	0.46 – 1.98
Intercept (Increase)	0.27**	0.41		0.19**	0.20**	
Intercept (Stable)	6.05**	6.64**		6.79**	7.13**	
AIC	331.8	322.6		393.2	397.2	

**** p<0.05; *p<0.10**

Table 5: Decision Certainty Among Hip Patients with Baseline Treatment Preferences

	Hip Patients with Stable Non Surgical Preference			**Hip Patients with Stable Surgical Preference**		
	Model 1	Model 2	CI	Model 1	Model 2	CI
Patient Characteristics						
Age						
64 and under						
65+	0.43	0.36	0.05 – 2.41	1.11	1.28	0.49 – 3.35
Female	0.43	0.37	0.07 – 1.89	2.22	2.31	0.96 – 5.60
Race						
White (ref)						
Non-white/ Other/Unknown	1.57	1.50	0.19 – 12.07	1.20	0.72	0.21 – 2.48
Marital Status						
Married/Life Partner (ref)						
Unmarried	0.38	0.34	0.05 – 2.10	0.79	0.78	0.29 – 2.11
Co-Morbidities						
(Hip or Knee OA + Diabetes and/or CHF vs. Hip or Knee OA only)	2.49	3.72	0.40 – 34.71	2.68*	5.07**	1.05 – 24.43
Pain Score (HOOS or KOOS)	1.14	1.09	0.44 – 2.70	1.01	0.72	0.41 – 1.29
Education Level						
High School/GED/Other (ref)						
Some College/Graduated from College/Postgraduate Education		2.9	0.32 – 26.27		0.22	0.06 – 0.87
Intercept (Increase)		0.32			0.60	
Intercept (Stable)		71.45**			19.1**	
AIC	66.3	67.4		179.5	177.1	

**** p<0.05; *p<0.10**

References

Bohl, D. D., N. T. Ondeck, B. A. Basques, and B. R. Levine. 2017. "What is the Timing of General Adverse Health Events That Occur After Total Joint Arthroplasty?" *Clin Orthopedic Relat Res*.

Boss, E. F., N. Mehta, and N. Nagarajan. 2016. "Shared Decision Making and Choice for Elective Surgical Care: A Systematic Review." *Otolaryngology - Head and Neck Surgery* 154(3): 405-20.

Bozic, K. J., J. Belkora, V. Chan, J. Youm, and T. Zhou. 2013. "Shared Decision Making in Patients with Osteoarthritis of the Hip and Knee." *Journal of Bone and Joint Surgery* 95: 1633-39.

Cram, P., X. Lu, P. J. Kaboli, M. S. Vaughan-Serrazin, X. Cai, and B. R. Wolf. 2011. "Clinical Characteristics and Outcomes of Medicare Patients Undergoing Total Hip Arthroplasty, 1991-2008." *JAMA* 305(15): 1560-67.

Durand, M. A., L. Carpenter, H. Dolan, P. Bravo, and M. Mann. 2014. "Do Interventions Designed to Support Shared Decision-Making Reduce Health Inequalities? A Systematic Review and Meta-Analysis." *Plos One* 9.

Elwyn, G., A. Edwards, and P. Kinnersley. 1999. "Shared Decision Making in Primary Care: The Neglected Second Half of the Consultation." *The British Journal of General Practice* 49(443): 477-82.

George, J., M. Chughtai, A. Khlopas, A. K. Klika, and W. K. Barsoum. 2017. "Readmission, Reoperation, and Complications: Total Hip vs. Total Knee Arthroplasty." *The Journal of Arthroplasty*.

Gionfriddo, M. R., A. L. Leppin, J. P. Brito, A. LeBlanc, and K. R. Boehmer. 2014. "A Systematic Review of Shared Decision Making Interventions in Chronic Conditions: A Review Protocol." *Systematic Reviews* 3(38).

Hamel, M., M. Toth, and A. Legedza. 2008. "Joint Replacement Surgery in Elderly Patients with Severe Osteoarthritis of the Hip or Knee Decision Making, Postoperative Recovery, and Clinical Outcomes." *Archives of Internal Medicine* 168(13).

Hawke, A. 2016. "Final Narrative Report: High Value Healthcare Collaborative Engaging Patients to Meet the Triple Aimed." Dartmouth Medical School.

Hawker, G. A. 2006. "Who, When and Why Total Joint Replacement Surgery? The Patient's Perspective." *Curr Opinion Rheumatol* 18: 526-30.

Hawker, G. A., J. G. Wright, E. M. Bradley, and P. C. Coyte. 2004. "Perceptions of, and Willingness to Consider, Total Joint Arthroplasty in a Population-Based Cohort of Individuals with Disabling Hip and Knee Arthritis." *Arthritis & Rheumatism* 51(4): 635-41.

High Value Healthcare Collaborative. 2012. Department of Health and Human Services, Centers for Medicare and Medicaid Services.

Hsu, C., D. T. Liss, E. Westbrook, and D. Arterburn. 2013. "Incorporating Patient Decision Aids into Standard Clinical Practice in an Integrated Delivery System." *Medical Decision Making* 33: 85-97.

Hudak, P. L., K. Armstrong, C. Braddock, and R. M. Frankel. 2008. "Older Patients' Unexpressed Concerns About Orthopedic Surgery." *Joural of Bone and Joint Surgery* 90: 1427-35.

Hurria, A., D. Leung, K. Trainor, and P. Borgen. 2003. “Factors Influencing Treatment Patterns of Breast Cancer Patients Age 75 and Older.” *Critical Review of Oncology & Hematology* 46(2): 121-26.
Ibrahim, S. A., L. A. Siminoff, C. J. Burant, and C. K. Kwoh. 2002. “Differences in Expectations of Outcome Mediate African American/White Patient Differences in "Willingness" to Consider Joint Replacement.” *Arthritis & Rheumatism* 46(9): 2429-35.
Karlson, E. W., L. H. Daltroy, and M. H. Liang. 1997. “Gender Differences in Patient Preferences May Underlie Differential Utilization of Elective Surgery.” *American Journal of Medicine* 102: 524-30.
Koenig, K., J. I. Huddleston, H. Huddleston, W. J. Maloney, and S. B. Goodman. 2012. “Advanced Age and Comorbidity Increase the Risk for Adverse Events After Revision Total Hip Arthroplasty.” *The Journal of Arthroplasty* 27(7): 1402-07.
Krones, T., H. Keller, A. Sonnichsen, E. Sadowski, and E. Baum. 2008. “Absolute Cardiovascular Disease Risk and Shared Decision Making in Primary Care: A Randomized Controlled Trial.” *Annals of Family Medicine* 6(3): 218-27.
Lin, G. A., D. S. Aaronson, S. J. Knight, P. R. Carroll, and R. A. Dudley. 2009. “Patient Decision Aids for Prostate Cancer Treatment: A Systematic Review of the Literature.” *CA Cancer J Clin* 59(6): 379-90.
Lurie, J. D., K. F. Spratt, E. A. Blood, T. D. Tosteson, A. N. Tosteson, and J. N. Weinstein. 2011. “Effects of Viewing an Evidence-Based Video Decision Aid on Patients' Treatment Preferences for Spinal Surgery.” *Spine* 36(18): 1501-04.
Metz, M. J., G. C. Franx, M. A. Veerbeek, E. de Beurs, C. M. van der Feltz-Cornelis, and A. T. F. Beekman. 2015. “Shared Decision Making in Mental Health Care Using Routine Outcome Monitoring as a Source of Information: A Cluster Randomised Controlled Trial.” *BMC Psychiatry* 313(15): 1-10.
Moorman, C. T., T. Kirwan, J. Share, and C. Vannabouathong. 2017. “Patient Preferences Regarding Surgical Interventions for Knee Osteoarthritis.” *Clin Med Insights Arthritis Musculoskeletal Disorders* 10: 1-12.
Nilsdotter, A. K., L. S. Lohmander, M. Klassbo, and E. M. Roos. 2003. “Hip Disability and Osteoarthritis Outcome Score (HOOS) - Validity and Responsiveness in Total Hip Replacement.” *BMC Musculoskeletal Disorders* 4(10).
O'Connor, A. M. 1995. “Validation of a Decisional Conflict Scale.” *Medical Decision Making* 15: 25-30.
O'Connor, A. M., J. E. Wennberg, F. Legare, H. A. Llewellyn-Thomas, and B. W. Moulton. 2007. “Toward the 'Tipping Point': Decision Aids and Informed Patient Choice.” *Health Affairs* 26(3): 716-25.
Pasquale, M. K., R. Dufour, D. Schaaf, A. T. Reiners, J. Mardekian, A. V. Joshi, and N. C. Patel. 2014. “Pain Conditions Ranked by Healthcare Costs for Members of a National Health Plan.” *Pain Practice* 14(2): 117-31.
Riddle, D. L., W. A. Jiranek, and C. Hayes. 2014. “Using a Validated Algorithm to Judge the Appropriateness of Total Knee Arthroplasty in the United States: A Multi-Center Longitudinal Cohort Study.” *Arthritis & Rheumatology* 66: 2134-43.
Roos, E. M. and L. S. Lohmander. 2003. “The Knee Injury and Osteoarthritis Score (KOOS): From Joint Injury to Osteoarthritis.” *Health and Quality of Life Outcomes* 1(64).

Santaguida, P. L., G. Hawker, P. L. Hudak, R. H. Glazier, N. Mahomed, and H. J. Kreder. 2007. "Patient Characteristics Affecting the Prognosis of Total Hip and Knee Joint Arthroplasty: A Systematic Review." *Journal of Canadian Chiropracty* 51(6).
Savitz, L. A. and L. T. Weiss. 2017. "A Data Driven Approach to Achieving High Value Healthcare." *eGEMs (The Journal for Electronic Health Data and Methods)* 5(3).
Schrag, G., L. D. Cramer, P. B. Bach, and C. B. Begg. 2001. "Age and adjuvant chemotherapy use after surgery for stage III colon cancer." *J Natl Cancer Inst* 93(11): 850-57.
Stacey, D., C. L. Bennett, and M. J. Barry. 2011. "Decision Aids for People Facing Health Treatment or Screening Decisions." *Cochrane Database of Systematic Reviews* 10.
Stacey, D., G. A. Hawker, G. Dervin, P. Tugwell, and L. Boland. 2014. "Decision Aid for Patients Considering Total Knee Arthroplasty with Preference Report for Surgeons: A Pilot Randomized Controlled Trial." *BMC Musculoskeletal Disorders* 15(54).
Stewart, M., J. B. Brown, H. Boon, and J. Galajda. 1999. "Evidence on Patient-Doctor Communication." *Cancer Prevention and Control* 3(1): 25-30.
Tariman, J. D., D. L. Berry, B. Cochrane, A. Z. Doorenbos, and K. G. Schepp. 2012. "Physician, Patient, and Contextual Factors Affecting Treatment Decisions in Older Adults with Cancer and Models of Decision Making: A Literature Review." *Oncology Nursing Forum* 39(1): E70-83.
The International Patient Decision Aids Standards. 2012. "The 2012 IPDAS Background Document" [accessed on Nov. 7, 2012]. Available at: http://ipdas.ohri.ca/IPDAS-Introduction.pdf.
Towle, A. and W. Godolphin. 1999. "Framework for Teaching and Learning Informed Shared Decision Making." *BMJ* 319: 766-71.
Vina, E. R., D. Ran, E. L. Ashbeck, M. Kaur, and C. K. Kwoh. 2017. "Relationship Between Knee Pain and Patient Preferences for Joint Replacement: Health Care Access Matters." *Arthritis Care Res* 69(1): 95-103.
Volandes, A. E., M. J. Barry, Y. C. Chang, and M. K. Paasche-Orlow. 2010. "Improving Decision Making at the End of Life with Video Images." *Medical Decision Making* 30: 29-34.
Weeks, W. B., W. J. Schoellkopf, L. Sorensen, and A. L. Masica. 2016. "The High Value Healthcare Collaborative: Observational Analyses of Care Episodes for Hip and Knee Replacement Surgery." *Journal of Arthroplasty* 32(3): 702-08.
Zhang, W., G. Nuki, R. W. Moskowitz, and S. Abramson. 2010. "OARSI Recommendations for the Management of Hip and Knee Osteoarthritis: Changes in Evidence Following Systematic Cumulative Update of Research Published through January 2009." *Osteoarthritis Cartilage* 18(4): 476-99.

III. The Impact of Shared Decision Making on Surgical Utilization among Patients with Hip and Knee Osteoarthritis in the High Value Healthcare Collaborative

ABSTRACT

Objective: To examine the impact of decision aids (DAs) for shared decision-making (SDM) among adult patients with hip and/or knee osteoarthritis on surgical utilization.

Study Setting: Patients with hip and/or knee osteoarthritis who had orthopedic specialty consultations within High Value Healthcare Collaborative (HVHC) systems between July 2012 to June 2015.

Study Design: Propensity-score weighted analyses were employed to examine differences in surgical utilization after 6 months of their specialty consultation among patients completing a DA intervention and those who did not receive DAs. Multivariate logistic regression estimated the relationship between DA exposure and surgical utilization, controlling for patient age, sex, race/ethnicity, and payer type.

Data Collection Methods: Analysis of HVHC administrative data.

Principal Findings: In adjusted analyses, hip and knee patients exposed to DAs had greater odds of undergoing surgery within six months compared with hip and knee patients who did not receive DAs. DA exposed hip patients had nearly three times the odds of undergoing surgery compared with unexposed patients (OR = 2.78, $p<0.001$). Female hip and knee patients had slightly lower odds of undergoing surgery compared with male hip and knee patients (OR = 0.65, $p<0.001$ and OR = 0.89, $p<0.001$, respectively). Hip and knee patients with depression had twice the odds of having surgery (OR = 2.36, $p<0.001$ and OR = 2.12, $p<0.001$, respectively).

Conclusions: In contrast to randomized clinical trials of SDM interventions using DAs, DA use in routine practice settings may not sway hip and knee patients toward more conservative treatment modalities, on average. Discussions between clinicians and patients that clarify treatment preferences, particularly for depressed patients, should be a priority for SDM research.

Introduction

Hip and knee osteoarthritis are among the most prevalent and quickly growing chronic conditions within the United States, with estimates that these as well as other forms of musculoskeletal arthritis affect nearly 30 million Americans nationwide. Projections from the Centers for Disease Control and Prevention indicate that the number of adults age 65 and over living with osteoarthritis is expected to double from 21.4 million in 2005 to 41.1 million by the year 2030 (Centers for Disease Control and Prevention 2003). In 2014, Medicare spent approximately $50,000 per arthroplasty hospitalization, with total costs nearing $7 billion (Bert, Hooper, and Moen 2017).

Alongside the rise in the number of cases and arthroplasties performed to address hip and knee osteoarthritis, there is also a growing body of scholarship exploring the role of shared decision making (SDM) to help patients make informed decisions about elective surgeries (Coylewright et al. 2016; Elwyn, Edwards, and Thompson 2016). This study examines the extent to which the use of Decision Aids (DAs) in the context of SDM is associated with lower propensity for hip or knee osteoarthritis patients to receive surgery within 6 months compared with an unexposed comparison group of patients receiving care in the same health care systems. Drawing upon data from the High Value Healthcare Collaborative (HVHC), we compare arthroplasty rates across practices that did not implement an SDM intervention with those that did in order to understand relative differences in arthroplasty rates.

There is a robust evidence base suggesting that patient exposure to DAs is associated with a tendency toward less surgery across a suite of preference-sensitive conditions including hip and knee osteoarthritis. A prospective study of patients at Group Health Cooperative demonstrated that exposure to DAs was associated with 26% fewer hip replacement surgeries and 38% fewer knee replacements relative to a cohort of matched patients who received usual care (Arterburn et al. 2012). Veroff et al found that patients with preference-sensitive conditions who received “enhanced” SDM (DAs plus consultations with health coaches via telephone, mail and email) experienced, on average, 12.5% fewer hospital admissions and 9.9% fewer preference-sensitive surgeries relative to control groups, with the greatest reduction in surgeries observed for patients with preference-sensitive heart conditions (Veroff, Marr, and Wennberg 2013). Although 15 studies (11 of which were randomized controlled studies) included in a systematic review found that the introduction of decision aids increased patients’ tendency to choose less invasive treatment options, only 5 studies reported results reaching statistical significance (Reames, Shubeck, and Birkmeyer 2014). Given this evidence, we hypothesize that patients with hip and knee osteoarthritis exposed to DAs are less likely to have arthroplasty after 6 months post-DA exposure compared to patients with hip and knee osteoarthritis consultations not supported by DAs during the implementation period.

Methods

Study Sample

Founded in 2009, HVHC is a consortium of health care systems with a shared goal of studying and disseminating promising interventions with one another in order to improve the quality of care for their patient populations while reducing overall health care costs. Member systems collect and analyze information on the impact of evidence-based interventions upon clinical outcomes across their patient populations in real time such that this data can be rapidly shared between member systems. Such an approach is intended to accelerate rapid evaluation and testing the effectiveness of implementing innovative care processes on healthcare value and dissemination of best practices (Tomek et al. 2012).

In 2012, the Centers for Medicare and Medicaid Innovation (CMMI) granted HVHC a Health Care Innovation Award. The three-year grant (which ended in June 2015) supported HVHC's efforts to, among other projects, implement Shared Decision Making (SDM) as part of the processes of care for patients considering hip and knee surgery (Weeks et al. 2016). The SDM intervention for this study made use of DAs as well as consultations with health coaches to enable patients to be more participant in decisions about their own care. The goals of the CMMI project were to improve the health status (as measured by pain and functioning) of patients considering hip or knee arthroplasty, to increase the number of these patients engaged in SDM, and to reduce total costs of hip and knee surgeries across participant sites. A table listing the 10 member health care systems with hip and knee cohorts can be found in Table 1.

Data

Clinical and administrative data from HVHC's Unified Data Extract was used for the analyses. Encounter data from eligible patients to HVHC system sites from 2012-2015 were analyzed. Patients with diagnoses of hip (International Classification of Diseases, Clinical Modification codes (ICD-9 CM) diagnostic codes 715.09, 715.15, 715.25, 715.35 or 715.95) or knee osteoarthritis (ICD-9 CM diagnostic codes 715.09, 715.16, 715.26, 715.36 or 715.96) were analyzed. Patients were excluded if they had missing data for age, sex or comorbidity status or if they were under 18 years old. The intervention group consisted of patients exposed to the SDM intervention and for whom surveys assessing experiences with DAs were completed prior to the end of the CMMI grant on June 30, 2015 (n = 1,670). Our control group comprises 201,825 hip and knee patients with visits to HVHC system sites who were not exposed to DAs. Control group patients were selected if their records indicated appropriate ICD-9 codes for hip or knee osteoarthritis and if they had a consultation within the CMMI grant (between July 1, 2012 and June 30, 2015). Control group patients are first matched within health system, then are stratified by appointment date and matched to intervention group patients with post-DA survey completion dates within a corresponding 6 month timeframe. Finally, we incorporate standardized inverse propensity score weights using age-, sex-, and co-morbidity status to reduce potential selection effects when assessing the relationship between DA exposure and surgical utilization.

Measures

Outcome Variable

Surgical utilization is the primary outcome variable of interest and is assessed using procedure codes for hip or knee arthroplasty. SDM-exposed and unexposed patient records were assessed to examine whether they had undergone surgery within 6 months of DA exposure between July 2012 and June 2015. The encounter data included ICD-9 procedure codes 81.54 (knee arthroplasty) or 81.51 (hip arthroplasty) and these were used to classify patients as having surgery vs. not within 6 months of their consultation.

Independent Variable

The primary independent variable of interest is exposure to DAs as part of the SDM intervention implemented by HVHC as part of the CMMI grant. The SDM intervention consisted of patients viewing either condition-specific DVD DAs, an online DA, or watching the DA on a tablet in the physician's office either prior to or following orthopedic consultations. Patients were asked to complete surveys before and after viewing the DAs that assessed their treatment preferences, decision certainty, as well as a variety of demographic questions ranging from education and employment history to self-assessed pain and physical activity scores. Nurses, medical assistants, or care managers who had been trained as health coaches were available to answer questions about the DAs or the surveys.

Control Variables

This analysis explores the association between exposure to the DA intervention and surgical utilization, controlling for relevant patient level characteristics. Past work investigating patient propensity to undergo orthopedic procedures such as arthroplasty within the context of SDM suggests that patient age, sex, race, marital status, and health insurance payer type play important roles in influencing treatment trajectories. Multiple studies note that patients 65 years of age and older are less likely to pursue surgical intervention for preference sensitive conditions such as hip or knee osteoarthritis (Hudak et al. 2008; Hurria et al. 2003) because providers may be less likely to engage older patients in discussions about the benefits and tradeoffs of surgery compared with younger patients (Hamel, Toth, and Legedza 2008). Female patients have been shown to be somewhat less likely than males to choose surgery across a range of preference sensitive conditions including joint arthroplasty (Nilsdotter et al. 2003; Roos and Lohmander 2003). More recent studies have highlighted a tendency for non-white patients to undergo surgery less frequently than white patients (Kwoh et al. 2015), a finding that has in part been attributed to minority patients' perceptions of greater risk-to-benefit ratios for surgery (Lurie et al. 2011). Patients living with a spouse or partner may feel better supported in the decision to pursue surgery and subsequently in the recovery period compared with unmarried patients (Ibrahim et al. 2002). Finally, a patient's health insurance payer type may impact perceptions of access to and cost-sharing for surgical interventions (Wiznia et al. 2017).

Statistical Analyses

We employ stratification by health system and exposure date (DA exposure date for the intervention group, specialty consultation for the comparison group) followed by propensity score weighting in order to understand differences in surgical utilization between patients who received the DA intervention for hip or knee osteoarthritis and hip or knee patients who did not receive DAs. Stratifying patients prior to propensity score analyses is a method that has been demonstrated to further reduce bias in non-randomized study settings (Cochran 1968). We calculated stabilized inverse propensity score weights using age, sex, and comorbidity status (e.g. whether patients had been diagnosed with diabetes, depression, or congestive heart failure).

Finally, multivariable logistic regression was used to examine the relationship of DA exposure and surgical utilization. The regression models were propensity score weighted and controlled for patient age, sex, comorbidity, race/ethnicity, marital status, and health insurance payer type. Regression models also include system level fixed effects to account for patient clustering within systems.

Results

Descriptive Statistics

Descriptive statistics comparing unadjusted and propensity score weighted samples for the knee and hip patient cohorts are reported in Tables 1 and 2, respectively. The unadjusted statistics (before propensity score weighting) reveal important differences across the DA intervention and control patient pools. For example, there is a larger relative percentage of female knee patients in the intervention group compared with the control group (64.2% vs. 60.7%). Knee patients who are Medicaid beneficiaries comprise a larger relative percentage within the SDM exposed group as well (11.1% vs. 3%). Among the hip patients, there is a similarly larger relative percentage of SDM exposed patients who are Medicaid beneficiaries in relation to the unexposed patients (9.5% vs. 2.2%); commercially insured patients also comprise a larger segment of the exposed population of hip patients compared with the unexposed population (45% vs. 24.8%). Among hip patients, the unadjusted surgery rate for the control group is 29.1% versus 53.9% for the intervention group. Among knee patients, the unadjusted surgery rate for the control group is 24.4% compared with 32.4% for the intervention group. The differences across group for both the hip and the knee cohorts are statistically significant ($p < 0.0001$).

After propensity score weighting incorporating age, sex and comorbidity status variables, the differences across SDM exposed and unexposed patients are narrowed across both the hip and knee cohorts. The relative proportion of Latino knee patients across intervention and control cohorts is narrowed to less than 1% difference, while dual eligible hip patients are matched within 0.2 percentage points across intervention and control patients.

Multivariate Logistic Regression Analyses

In final propensity score weighted regression models, knee patients who were exposed to the SDM intervention had greater odds of undergoing surgery compared with unexposed knee patients (OR = 1.24, $p<0.001$). Although knee patients with congestive heart failure (CHF) had lower odds of undergoing arthroplasty compared to patients not living with CHF (OR = 0.61, $p<0.001$), knee patients with depression had one and a half times the odds of having surgery compared to patients not affected by depression (OR = 1.59, $p<0.001$). African American and Latino knee patients both had lower odds of having surgery when compared with white patients (OR = 0.49, $p<0.001$ and OR = 0.51, $p<0.001$, respectively). Payer status revealed varied associations with the likelihood of surgery; for example, while dual eligible (Medicare and Medicaid) patients had almost 1.2 times the odds of receiving arthroplasty compared with commercially insured patients, Medicare-only and Medicaid-only patients had lower odds of receiving arthroplasty (OR = 0.92, $p<0.001$ and OR = 0.66, $p<0.001$).

Adjusted models indicate that hip patients exposed to DAs had over three times the odds of undergoing arthroplasty compared with unexposed patients (OR = 3.15, $p<0.001$). Female hip patients had lower odds of undergoing arthroplasty compared with male hip patients (OR = 0.87, $p<0.001$). In accordance with our findings for the knee cohort, hip patients with depression also had greater odds of undergoing arthroplasty when compared with hip patients without depression (OR = 1.36, $p<0.001$), but hip patients with congestive heart failure or diabetes had lower odds of undergoing arthroplasty (OR = 0.65, $p<0.001$ and OR = 0.78, $p<0.001$, respectively). Hip patients insured through Medicare had lower odds of having undergone arthroplasty relative to privately insurance patients (OR = 0.89, $p<0.001$).

Discussion

Adult patients with hip and/or knee osteoarthritis within HVHC who received a SDM intervention had greater propensity toward undergoing arthroplasty within 6 months of their exposure when compared with patients receiving standard specialty consultations within the same period. These findings are notable in light of an existing literature from controlled intervention studies which suggest that patients exposed to SDM and DAs are more likely to choose more conservative treatment modalities in the context of preference-sensitive conditions (Arterburn et al. 2012; Phelan et al. 2001). Studying the impact of a collaborative-wide effort to integrate SDM into routine practice on arthroplasty utilization expands the frame of reference to a much larger sample of hip and knee patients than has been previously reported. One possible contributor to our findings concerns the implementation of the SDM intervention within a routine care setting. In contrast with randomized controlled trial studies of surgical use after SDM interventions, the translation of such interventions under real world conditions often differ as a result of implementation heterogeneity, organizational culture, time constraints, and the presence or lack of feedback loops (Rohrbach et al. 2006). Additionally, the clinical setting for this SDM intervention may have also contributed to our finding; initiating conversations upstream within a primary care rather than specialty context may enable patients to more fully consider and weigh treatment options.

Important associations between patient-level characteristics and the propensity to undergo arthroplasty for hip or knee osteoarthritis were found. In addition to decreased quality of life, individuals with depression also have a high likelihood of physical morbidity as well as mortality (Ghoneim and O'Hara 2016; Guerini et al. 2010), which may make it more difficult for depressed patients to pursue non-surgical treatment options such as physical therapy as an alternative to surgery. It has also been demonstrated that clinically depressed patients experience poor post-operative outcomes; depressed patients who undergo coronary artery bypass surgery have a higher incidence of readmissions and serious cardiac events such as arrhythmias as well as postoperative delirium (Tully and Baker 2012). Such findings underscore the importance of decision aids initiating informed conversations with depressed patients about the tradeoffs of surgery and non-surgery in light of unique risks and benefits.

Our results should be considered in light of important limitations. First, our finding that African American and Latino patients had lower odds of undergoing arthroplasty compared with white patients may be reflective of selection effects as white patients represented a far greater percentage of our overall unadjusted patient population (>70% across hip and knee cohorts). Second, the SDM intervention was carried out heterogeneously across the HVHC member systems; some patients were prompted to view a Health Dialog DVD DA or an online DA in advance of their appointments, while other practices invited patients to view the DA on an iPad in the orthopedist's office. These variations may have impacted our findings in ways that we were not able to measure in regression analyses. HVHC membership is not random and one contingency of membership is that systems pay fees to support data collection and reporting. Thus, the generalizability of our findings to health systems with fewer resources may be limited. Nevertheless, few studies examining surgical utilization post-SDM have made use of a study sample that crossed diverse geographic regions and health systems, underscoring the novelty of the research. Finally, although the use of propensity score weighting has been shown to help balance intervention and control groups, it cannot account for unobserved differences across these groups (Stukel et al. 2007). We attain good balance across exposed and unexposed hip and knee patients after the use of propensity score weights.

DA use in routine practice settings may not sway hip and knee patients toward more conservative treatment modalities. Our finding that hip patients exposed to DAs have three times the odds of undergoing arthroplasty compared with unexposed hip patients merits further research. Sensitivity analyses to determine whether certain systems within HVHC may be driving these results could clarify whether such a finding is attributable to specific methods employed within those systems to disseminate and implement this SDM intervention. This work points to the importance of acknowledging differences in patient-level outcomes between controlled studies and routine clinical practice settings. Exploring the reasons underlying differing results across these settings will contribute to broader efforts to bridge the translational divide and to facilitate and sustain innovations in patient-centered care.

Table 1: Hip and Knee Patient Cohort Distribution by High Value Healthcare Collaborative (HVHC) Member System, July 1, 2012 - June 30, 2015

	Hip Patients		**Knee Patients**	
HVHC System	Count	% of overall	Count	% of overall
Baylor Health System	8,644	17.3%	27,131	17.7%
Beth Israel Deaconess Medical Center	929	1.9%	2,593	1.7%
Denver Health	860	1.7%	5,467	3.6%
Eastern Maine Healthcare Systems	2,958	5.9%	9,357	6.1%
Intermountain Healthcare	10,806	21.6%	45,962	30%
MaineHealth	N/A*	N/A*	3,661	2.4%
Mayo Clinic	15,252	30.5%	25,386	16.5%
Scott & White Health	5,062	10.1%	19,670	12.8%
UCLA Health System	2,906	5.8%	7,345	4.8%
Virginia Mason Medical Center	2,623	5.2%	6,883	4.5%
Total	50,040	100%	153,455	100%

***N/A= MaineHealth did not report any complete patient survey records for hip patients exposed to Decision Aids via the Shared Decision Making intervention.**

Table 2. Distribution of Knee Patient Characteristics Across Intervention and Control Cohorts Before and After Propensity Score Weighting

	Unadjusted			**Weighted**		
	SDM Intervention	**Control**	**P value**	**SDM Intervention**	**Control**	**P value**
n	1,219	152,236		1,313	140,085	
Age (Mean, SD)	59.2 (9.7)	61.2 (13.1)	***	61.8 (9.7)	61.2 (13.1)	*
Female	782 (64.2%)	92,415 (60.2%)	*	835 (63.6%)	85,116 (60.8%)	*
Co-Morbidities						
Congestive Heart Failure	27 (2.3%)	5,682 (4.1%)	**	47 (3.6%)	5,364 (3.8%)	
Depression	238 (19.5%)	30,637 (20.1%)		248 (18.9%)	27,859 (19.9%)	
Diabetes	181 (15.1%)	24,554 (17.3%)	*	181 (13.8%)	22,628 (16.2%)	*
Race			***			***
White	877 (71.9%)	118,570 (77.9%)		1,076 (81.9%)	107,558 (76.8%)	
Hispanic/Latino	125 (10.3%)	6,524 (4.3%)		70 (5.3%)	6,372 (4.6%)	
Black/African American	99 (8.1%)	10,167 (6.7%)		82 (6.2%)	9,797 (7.0%)	
Non-white/Other	118 (9.7%)	16,975 (11.2%)		86 (6.5%)	16,358 (11.7%)	
Married/Life Partner	679 (55.7%)	91,269 (60.0 %)	**	919 (70%)	84,335 (60.2%)	***
Payer			***			***
Medicare		55,750 (36.6%)		738 (56.2%)	52,298 (37.3%)	

	454 (37.2%)					
Medicaid	135 (11.1%)	4,403 (2.9%)		42 (3.2%)	4,152 (3.0%)	
Medicare/ Medicaid	52 (4.3%)	1,610 (1.1%)		18 (1.4%)	1,457 (1.0%)	
Private	424 (34.8%)	41,460 (27.2%)		376 (28.5%)	38,179 (27.3%)	
Other	154 (12.6%)	49,013 (32.2%)		141 (10.7%)	43,999 (31.4%)	

Note: After stratifying by system and exposure date, propensity score weights incorporate condition, age, sex, and co-morbidities to construct a weighted control group; * $p<0.05$, ** $p<0.01$, *** $p<0.001$ for difference between SDM intervention vs. comparison group

Table 3. Distribution of Hip Patient Characteristics Across Intervention and Control Cohorts Before and After Propensity Score Weighting

	Unadjusted			**Weighted**		
	SDM Intervention	**Control**	**P value**	**SDM Intervention**	**Control**	**P value**
n	451	49,589		481	46,219	
Age (Mean, SD)	58.2 (10.1)	62.2 (14.0)	***	62.7 (9.1)	62.1 (14.1)	
Female	246 (54.6%)	27,573 (55.6%)		306 (63.5%)	27,633 (55.5%)	**
Co-Morbidities						
Congestive Heart Failure	8 (1.8%)	1,763 (3.8%)	*	11 (2.4%)	1,638 (3.5%)	
Depression	73 (16.2%)	8,628 (17.4%)		101 (21.1%)	7,853 (17%)	*
Diabetes	44 (9.9%)	5,929 (12.7%)		56 (11.7%)	5,410 (11.7%)	
Race			**			***
White	356 (78.9%)	42,416 (85.5%)		445 (92.5%)	39,221 (84.9%)	
Hispanic/Latino	13 (2.9%)	1,156 (2.3%)		4 (0.8%)	1,129 (2.4%)	
Black/African American	33 (7.3%)	2,510 (5.1%)		5 (1.1%)	2,476 (5.4%)	
Non-white/Other	49 (10.9%)	3,507 (7.1%)		27 (5.6%)	3,393 (7.3%)	
Married/Life Partner	267 (59.2%)	30,760 (62.0%)		329 (68.4%)	28,791 (62.3%)	**
Payer			***			***
Medicare	167 (37.0%)	19,587 (39.5%)		252 (52.4%)	18,609 (40.3%)	
Medicaid	43 (9.5%)	1,110 (2.2%)		6 (1.2%)	1,058 (2.3%)	
Medicare/	10 (2.2%)	328 (0.7%)		4 (0.8%)	292 (0.6%)	

Medicaid						
Private	203 (45.0%)	13,389 (27.0%)		188 (39.1%)	12,615 (27.3%)	
Other	28 (6.2%)	15,175 (30.6%)		32 (29.5%)	13,645 (29.5%)	

Note: After stratifying by system and exposure date, propensity score weights incorporate condition, age, sex, and co-morbidities to construct a weighted control group; * $p<0.05$, ** $p<0.01$, *** $p<0.001$ for difference between SDM intervention vs. comparison group

Table 4. Multivariate Logistic Regression - Impact of SDM Exposure on Surgical Utilization Among SDM-Exposed Hip and Knee Osteoarthritis Patients†

	Surgical Intervention-Hip		**Surgical Intervention-Knee**	
	Model 1	Model 2	Model 1	Model 2
SDM Intervention vs. Comparison	3.17***	3.15***	1.20**	1.24**
Age	1.00**	1.00**	1.02***	1.02***
Female	0.83***	0.87***	0.90***	1.01
Co-Morbidities				
Congestive Heart Failure	0.65***	0.68***	0.57***	0.61***
Depression	1.36***	1.37***	1.51***	1.59***
Diabetes	0.78***	0.79***	0.86***	1.01
Race				
White (reference)				
Hispanic		0.43***		0.51***
Black/African American		0.44***		0.49***
Non-white/Other		0.63***		1.01***
Married/Life Partner		1.25***		1.48***
Payer				
Commercial/Private (reference)				
Medicare		0.89***		0.92***
Medicaid		0.94		0.66***
Medicare/Medicaid		0.98		1.18*
Other		1.16***		1.36***
Intercept	0.57***	0.52***	0.11***	0.08**
Adjusted R2	0.014	0.034	0.020	0.061

*** p<0.05, **p<0.01, ***p<0.001 for difference between SDM intervention vs. comparison group;** †Regression results are propensity score weighted.

References

Arterburn, D., R. Wellman, E. Westbrook, and C. Rutter. 2012. “Introducing Decision Aids at Group Health Was Linked to Sharply Lower Hip and Knee Surgery Rates and Costs.” *Health Affairs* 31(9): 2094-104.

Bert, J. M., J. Hooper, and S. Moen. 2017. “Outpatients Total Joint Arthroplasty.” *Curr Rev Musculoskelet Med* 10(4): 567-74.

Centers for Disease Control and Prevention. 2003. “Public Health and Aging: Projected Prevalence of Self-Reported Arthritis or Chronic Joint Symptoms Among Persons Aged >65 years. United States, 2005-2030.” *MMWR Morb Mortal Wkly Rep.* pp. 489-91.

Cochran, W. G. 1968. “The Effectiveness of Adjustment by Subclassification in Removing Bias in Observational Studies.” *Biometrics* 24: 295-313.

Coylewright, M., S. Dick, B. Zmolek, J. Askelin, and E. Hawkins. 2016. “PCI Choice Decision Aid for Stable Coronary Artery Disease: A Randomized Trial.” *Circ Cardiovasc Qual Outcomes* 9: 767-76.

Elwyn, G., A. Edwards, and R. Thompson. 2016. *Shared Decision Making in Health Care: Achieving Evidence-Based Patient Choice*. Oxford, UK: Oxford University Press.

Ghoneim, M. M. and M. W. O'Hara. 2016. “Depression and Postoperative Complications: An Overview.” *BMC Surgery* 16(5).

Guerini, F., S. Morghen, E. Lucchi, G. Bellelli, and M. Trabucchi. 2010. “Depressive Symptoms and One Year Mortality Among Elderly Patients Discharged from a Rehabilitation Ward after Orthopedic Surgery of the Lower Limbs.” *Behav Neurol* 23: 117-21.

Hamel, M., M. Toth, and A. Legedza. 2008. “Joint Replacement Surgery in Elderly Patients with Severe Osteoarthritis of the Hip or Knee Decision Making, Postoperative Recovery, and Clinical Outcomes.” *Archives of Internal Medicine* 168(13).

Hudak, P. L., K. Armstrong, C. Braddock, and R. M. Frankel. 2008. “Older Patients' Unexpressed Concerns About Orthopedic Surgery.” *Journal of Bone and Joint Surgery* 90: 1427-35.

Hurria, A., D. Leung, K. Trainor, and P. Borgen. 2003. “Factors Influencing Treatment Patterns of Breast Cancer Patients Age 75 and Older.” *Critical Review of Oncology & Hematology* 46(2): 121-26.

Ibrahim, S. A., L. A. Siminoff, C. J. Burant, and C. K. Kwoh. 2002. “Differences in Expectations of Outcome Mediate African American/White Patient Differences in "Willingness" to Consider Joint Replacement.” *Arthritis & Rheumatism* 46(9): 2429-35.

Kwoh, C. K., E. R. Vina, Y. K. Cloonan, M. J. Hannon, R. M. Boudreau, and S. A. Ibrahim. 2015. “Determinants of Patient Preferences for Total Knee Replacement: African-Americans and Whites.” *Arthritis Research & Therapy* 17(348).

Lurie, J. D., K. F. Spratt, E. A. Blood, T. D. Tosteson, A. N. Tosteson, and J. N. Weinstein. 2011. “Effects of Viewing an Evidence-Based Video Decision Aid on Patients' Treatment Preferences for Spinal Surgery.” *Spine* 36(18): 1501-04.

Nilsdotter, A. K., L. S. Lohmander, M. Klassbo, and E. M. Roos. 2003. “Hip Disability and Osteoarthritis Outcome Score (HOOS) - Validity and Responsiveness in Total Hip Replacement.” *BMC Musculoskeletal Disorders* 4(10).

Phelan, E. A., R. A. Deyo, D. C. Cherkin, and J. N. Weinstein. 2001. "Helping Patients Decide About Back Surgery: A Randomized Trial of an Interactive Video Program." *Spine* 26: 206-11.
Reames, B. N., S. P. Shubeck, and J. D. Birkmeyer. 2014. "Strategies for Reducing Regional Variation in the Use of Surgery: A Systematic Review." *Annals of Surgery* 259(4): 616-27.
Rohrbach, L. A., R. Grana, S. Sussman, and T. W. Valente. 2006. "Type II Translation: Transporting Prevention Interventions From Research to Real-World Settings." *Evaluation and the Health Professions* 29(3): 302-33.
Roos, E. M. and L. S. Lohmander. 2003. "The Knee Injury and Osteoarthritis Score (KOOS): From Joint Injury to Osteoarthritis." *Health and Quality of Life Outcomes* 1(64).
Stukel, T. A., E. Fisher, D. E. Wennberg, D. A. Alter, D. J. Gottlieb, and M. J. Vermeulen. 2007. "Analysis of Observational Studies in the Presence of Treatment Selection Bias." *JAMA* 297(3): 278-85.
Tomek, I. M., A. L. Sabel, M. I. Froimson, and G. Muschler. 2012. "A Collaborative of Leading Health Systems Finds Wide Variations in Total Knee Replacement Delivery and Takes Steps to Improve Value." *Health Affairs* 31(6): 1329-38.
Tully, P. J. and R. A. Baker. 2012. "Depression, Anxiety, and Cardiac Morbidity Outcomes After Coronary Artery Bypass Surgery: A Contemporary and Practical Review." *J Geriatr Cardiol* 9: 197-208.
Veroff, D., A. Marr, and D. E. Wennberg. 2013. "Enhanced Support for Shared Decision Making Reduced Costs of Care for Patients with Preference-Sensitive Conditions." *Health Affairs* 32(2): 285-93.
Weeks, W. B., W. J. Schoellkopf, L. Sorensen, and A. L. Masica. 2016. "The High Value Healthcare Collaborative: Observational Analyses of Care Episodes for Hip and Knee Replacement Surgery." *Journal of Arthroplasty* 32(3): 702-08.
Wiznia, D. H., E. Nwachuku, A. Roth, C. Kim, and A. Save. 2017. "The Influence of Medical Insurance on Patient Access to Orthopedic Surgery Sports Medicine Appointments Under the Affordable Care Act." *Orthopedic Journal of Sports Medicine* 5(7).

CONCLUSION

Organizational learning has been highlighted as critical to addressing the "knowledge-doing gap" such that organizational members incorporate innovative practices into their work in an expedient manner (Argyris 1978; Crites et al. 2009). Health care must contend with precisely such a gap, as "barriers to improvement (even for relatively "simple" quality problems) remain extensive and pervasive" (Mittman 2004). Quality improvement collaboratives (QICs) represent one such response to these pervasive challenges. Organizations that take part in QICs often exhibit high levels of learning include "tolerance, experimentation, open discussion of errors, and systemic thinking" (Singer et al. 2012), and these characteristics in turn provide a foundation for engagement toward innovation and improvement among organizational participants. Such learning may be read as a lens for elucidating how improvement activities evolve, and how knowledge is perpetuated through the organizational structure (and its participants) over time.

A recent paper notes three imperatives for organizational learning in the health care context: the rise of new organizational forms in the wake of national health reform (and thus new competition to provide quality care) such as in the form of Accountable Care Organizations (ACOs), the ongoing prevalence of errors or gaps in quality resulting in patient injuries and deaths, and the constantly evolving evidence base underlying the practice of modern medicine (Nembhard, Cherian, and Bradley 2014). Current streams of research on organizational learning in health care have principally focused upon which aspects of an organization permit or prevent learning (Tucker, Nembhard, and Edmondson 2007) or how specific training of clinical staff impacts their learning capabilities (McAlearney 2012). Identifying factors that influence participation in collaborative learning initiatives such as QICs represents an important inquiry to the extent that such participation impacts practices' sharing and learning of best clinical practices. Participation in QICs may in turn have implications for innovations in clinical outcomes and quality of care. Elucidating collaborative learning's role in advancing quality improvement may enable health care managers to make better informed decisions about where to concentrate both resources and effort such that the greatest impact on collective organizational knowledge - and positive patient-centered outcomes - can be achieved.

References

Argyris, C. 1978. *Organizational Learning: A Theory of Action Perspective*. San Francisco: Jossey-Bass.

Crites, G. E., M. C. McNamara, E. A. Akl, W. S. Richardson, C. A. Umscheid, and J. Nishikawa. 2009. "Evidence in the Learning Organization." *Health Research Policy and Systems* 7(4): 1-13.

McAlearney, A. 2012. "The Role of Cognitive and Learning Theories in Supporting Successful EHR System Implementation Training: A Qualitative Study." *Medical Care Research and Review* 69(3): 294-315.

Mittman, B. S. 2004. "Creating the Evidence Base for Quality Improvement Collaboratives." *Annals of Internal Medicine* 140(11): 897-901.

Nembhard, I. M., P. Cherian, and E. H. Bradley. 2014. "Deliberate Learning in Health Care: The Effect of Importing Best Practices and Creative Problem Solving on Hospital Performance Improvement." *Medical Care Research and Review* 71(5): 450-71.

Singer, S. J., S. C. Moore, M. Meterko, and S. Williams. 2012. "Development of a Short-Form Learning Organization Survey: The LOS-27." *Medical Care Research and Review* 69(4): 432-59.

Tucker, A. L., I. M. Nembhard, and A. C. Edmondson. 2007. "Implementing New Practices: An Empirical Study of Organizational Learning in Hospital Intensive Care Units." *Management Science* 53(6): 894-907.