

Quality Measurement in Orthopaedics

The Purchasers' View

David Lansky PhD, Arnold Milstein MD, MPH

© The Author(s) 2009. This article is published with open access at Springerlink.com

Abstract While all of medicine is under pressure to increase transparency and accountability, joint replacement subspecialists will face special scrutiny. Disclosures of questionable consulting fees, a demographic shift to younger patients, and uncertainty about the marginal benefits of product innovation in a time of great cost pressure invite a serious and progressive response from the profession. Current efforts to standardize measures by the National Quality Forum and PQRI will not address the concerns of purchasers, payors, or policy makers. Instead, they will ask the profession to document its commitment to appropriateness, stewardship of resources, coordination of care, and patient-centeredness. One mechanism for addressing these expectations is voluntary development of a uniform national registry for joint replacements that includes capture of preoperative appropriateness indicators, device monitoring information, revision rates, and structured postoperative patient followup. A national registry should support performance feedback and quality improvement activity, but it must also be designed to satisfy payor, purchaser, policymaker, and patient needs for information. Professional societies in orthopaedics should lead a collaborative process to develop metrics,

infrastructure, and reporting formats that support continuous improvement and public accountability.

Introduction

American employers provide healthcare benefits to 158 million Americans and pay an average of over \$8,000 per employee per year in healthcare costs [13, 24]. For many years, they operated in the belief that qualified professionals will make sound judgments, do only what is medically indicated, and act in the best interests of patients. Health insurance plans are expected to screen unqualified practitioners from the network, provide a moderate level of utilization review and oversight to avert abuses and fraud, and establish modest incentives to encourage clinical improvement. Employers write checks to the health plans, and the plans write checks to the providers, with some confidence that their employees and their family members will harvest the benefits of a skilled and largely self-regulating professional enterprise. However, due to an enormous escalation of costs and the onslaught of data describing the safety, quality, and service failures of U.S. healthcare, employers today feel compelled to take on a more direct oversight role and abandon the model they used in the past.

Most employers are capitalists and expect market forces of competition to drive continuous improvement and efficiency rather than external, let alone governmental, regulation. Perhaps naively, employers imagine that health plans will include high-performing physicians in their preferred networks, will reward them with increased compensation, and that greater use of these high-performing physicians will both lower total costs and motivate other physicians to adopt similarly efficient clinical

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

This work was performed at Pacific Business Group on Health, San Francisco, CA.

D. Lansky (✉), A. Milstein
Pacific Business Group on Health (PBGH), 221 Main St.,
Ste 1500, San Francisco, CA 94105, USA
e-mail: dlansky@pbgh.org

practices. The underpinning of this market theory is the availability of standardized information on the cost and quality of care delivered by individual physicians and other business units. Many studies show that variations in quality and cost can ultimately be attributed to individual physician behavior rather than to organizational factors [25]. For this reason—and particularly in specialties where critical decisions and techniques are literally in the hands of one person—employers have recently emphasized the importance of acquiring standardized performance information at the individual practitioner level.

Orthopaedics has not, historically, been a priority focus area for employers concerned about the cost and quality of healthcare services. Most of the expensive procedures, particularly total joint replacement, have been concentrated among older patients covered by the Medicare program. Since the mid-1990s, however, the frequency of knee replacement procedures, in particular, has increased dramatically among patients under age 65 (Fig. 1). Recent studies suggest orthopaedic surgeons vary widely in both quality performance and efficiency of resource use. One recent consulting analysis of quality and cost suggests an opportunity to raise both quality and affordability by > 20% by closing the gap between average and best-performing orthopaedic surgeons (Fig. 2) (personal communication: Daniel Dunn, Senior Vice President of Research and Development, Ingenix, 11/20/08).

Employers are now paying attention to the full range of issues in healthcare decision making and management: cost, appropriateness, quality, and safety. This paper reviews purchasers' concerns about contemporary orthopaedic practice and suggests that a new relationship is needed between providers and purchasers. This new relationship will be built upon greater transparency and a

commitment to disciplined self-examination of orthopaedic practice, health outcomes, and appropriate use of resources. We summarize purchasers' information expectations in support of orthopaedic contracting, and likely uses of performance information to affect payment and consumer benefit designs.

Purchaser Concerns Regarding Orthopaedic Practice

Cost

By 2006, over 550,000 knee replacements were being performed in the United States at an aggregate cost of about \$21 billion, with about \$8 billion of that being paid by U.S. employers through commercial insurance plans. In 2006, employers spent an additional \$4.6 billion (of the \$16 billion national total) on hip replacements for commercially insured patients. The proportion of total hip replacements being performed on patients under age 65 has also increased, now accounting for 45% of procedures. And all of these rates continue to increase at 10% to 15% per year [3, 14]. Many other orthopaedic procedures are also of interest to employers, of course, including arthroscopies and back surgeries.

Appropriateness

Beyond the escalation in absolute costs, the apparent shift in utilization to a younger population raises questions about changes in indications for these procedures. Has the prevalence of knee disorders increased? Are employees experiencing more joint-related pain and disability than ten years ago? Or has the professional threshold for joint replacement surgery been lowered? Are all of these “new” procedures indicated? With widespread evidence of supply-sensitive care in other disciplines, do we need to examine the appropriateness of orthopaedic procedures too [21, 22]?

Quality

Orthopaedists have participated in the considerable recent activity around quality measurement, largely focused on the National Quality Forum and Physicians Quality Reporting Initiative sponsored by CMS. The 2008 PQRI measures (Fig. 3) are notably deficient in addressing the concerns or expectations of employers or the value proposition that these procedures offer to patients: improved functioning and reduced pain.

Certainly, there is substantial evidence that total joint replacements effectively relieve symptoms and improve

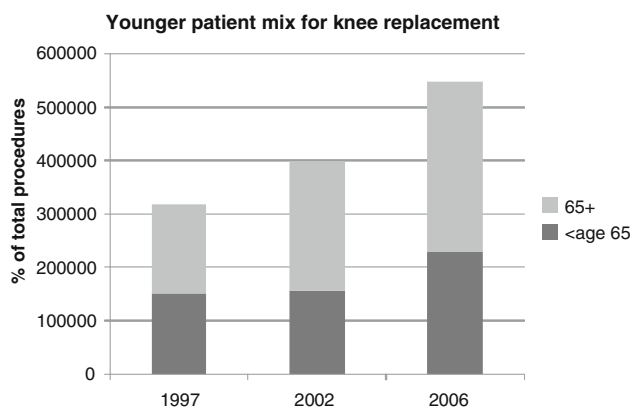
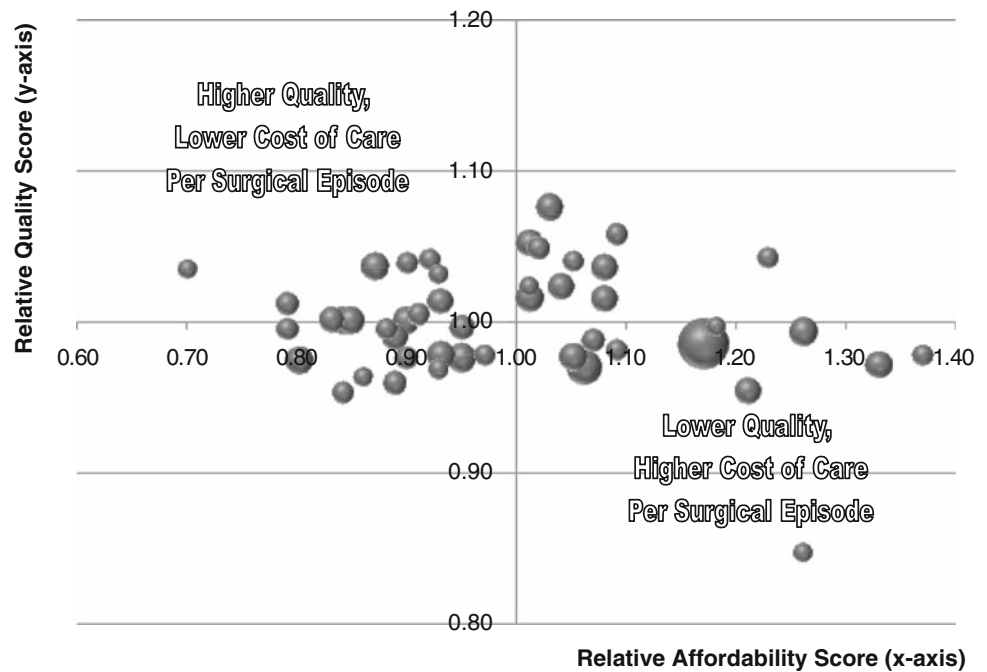


Fig. 1 Frequency of knee replacement procedures, by age: 1997 to 2006. (Source: DeFrances CJ, Lucas CA, Buie VC, Golosinskiy A. 2006 national hospital discharge survey. *Natl Health Stat Report*. 2008;5:1–20. Available at: <http://hcupnet.ahrq.gov>. Accessed Nov. 1, 2008.)

Fig. 2 Distribution of an insurer's quality and total case-mix adjusted cost of care composite results for spine and orthopaedic surgeons in a U.S. metro area; each sphere represents one surgeon. Larger sphere connotes higher insurer volume/surgeon. (Graph prepared by Ingenix using representative data.)



2008 PQRI Measures Applicable to Orthopaedics (from AAOS)

Clinical Measures

- 4. Screening for Future Fall Risk
- 20. Perioperative Care: Timing of Antibiotic Prophylaxis - Ordering Physician
- 21. Perioperative Care: Selection of Prophylactic Antibiotic - First OR Second Generation Cephalosporin
- 22. Perioperative Care: Discontinuation of Prophylactic Antibiotics (Non-Cardiac Procedures)
- 23. Perioperative Care: Venous Thromboembolism (VTE) Prophylaxis (When Indicated in ALL Patients)
- 24. Osteoporosis: Communication with the Physician Managing Ongoing Care Post Fracture
- 39. Screening or Therapy for Osteoporosis for Women Aged 65 Years and Older
- 40. Osteoporosis: Management Following Fracture
- 41. Osteoporosis: Pharmacologic Therapy
- 126. Diabetic Foot and Ankle Care, Peripheral Neuropathy: Neurological Evaluation
- 127. Diabetic Foot and Ankle Care, Ulcer Prevention: Evaluation of Footwear

Administrative Measures

- 124. HIT – Adoption/Use of Health Information Technology (Electronic Health Records)
- 125. HIT – Adoption/Use of e-Prescribing

Fig. 3 The 2008 PQRI measures applicable to orthopaedics are shown. (Available at: http://www.aaos.org/research/committee/evidence/pqri_measures.asp; accessed June 20, 2009. Reprinted with permission and ©American Academy of Orthopaedic Surgeons. AAOS has an updated list and Measure 4 (Screening for Future Fall Risk) was discontinued in 2009, but replaced by Measures 154 & 155 Falls—Risk Assessment (Measure 154) and Plan of Care (Measure 155). Measure 125—HIT Adoption/Use of E-Prescribing has been removed from the PQRI list and is now a separate reporting mechanism.)

function. But international comparisons invite questions from the employer community now paying a larger share of these costs. A 2006 study by the Australian Centre for Health Research found a rapid increase in the use of cementless fixation for THR in the first half of this decade (from 40% to 58% between 2001 and 2005) coupled with wide regional variation (90% in Tasmania versus 36% in Queensland in 2005, for example) [9]. The Canadian national rate in 2007 was 70% in 2006 [1]. In Sweden, however, only 3.4% of hip replacements use cementless fixation and national practice is to limit prosthesis selection to a few devices. Remarkably, the AAOS statistical staff is not able to make public any estimates of fixation practice in the United States (personal communication with Kristin Hitchcock, Medical Librarian, 11/7/08). The Australian analysts observe: “The reason for these differences relates to the influence of the long established hip and knee registries in Sweden. The identification of the best performing prostheses and techniques is known to significantly influence prosthesis selection and the practice of joint surgery in that country. ... An important observation is that the Swedish experience has not influenced the practice of joint replacement worldwide” [9, 15].

The key quality indicator for the employer is patient outcome: are patients able to resume high levels of functioning and is this functioning sustained over time? Two simple outcome measures appeal to us: functional improvement as measured by a patient-reported self-assessment (eg, Oxford Hip Score, EQ-5, etc) and revision rate. In Sweden, for example, the national registry is able to

report very favorable outcomes showing that patients age 75 to 79 years achieve comparable EQ5D scores to the general population at 6 years postoperation. These data are not routinely available in the United States, which makes the value proposition for employers difficult to assess.

Similarly, the only published information on revision rates in the United States provides the proportion of annual procedures performed as revisions, rather than a Kaplan-Meier estimate of cumulative revision rates. In the absence of cumulative revision rates and rigorous, continuous analysis, it is difficult to understand the value of new device models and processes. The absence of such data for joint prostheses can be contrasted with the rich history of survival modeling for heart valves which has led both to relative product stability and well-defined indications for product selection [7, 20].

Safety

Perioperative complications are generally infrequent for total joint replacement, but the considerable attention given to deep-vein thrombosis prevention is not fully reflected in current practice. One recent study reported that most patients receive DVT prophylaxis, but that only 47% of THA and 61% of TKA patients in the United States receive prophylaxis services consistent with the recent ACCP guidelines—in terms of type, duration, start time, and dose [6]. Compliance may be greater with the AAOS guidelines on pulmonary embolism prevention, but no data on practice conformity are available [4]. Such evidence suggests broad variations in orthopaedic safety and quality performance across hospitals. A Pennsylvania study of 3769 knee replacement procedures found wide variations in complication and readmission rates and concluded “the hospital in which the procedure was performed was the most powerful predictor of risk adjusted in-hospital complications (n = 400). Thirty-day readmission (n = 170) rates ranged between 0 and 8.8%” [23].

Strategies to Address Purchaser Concerns

As U.S. healthcare purchasers become alert to the growing cost and significance of orthopaedic services in the employed population, and start to explore these dimensions of quality and value, they see a mixed picture. They observe a generally effective and desirable service that lacks transparency in the four key areas of their concern. They see steadily escalating utilization and costs, rapid adoption of new technologies without evidence of incremental value, and wide variations in practice and outcomes. These concerns are compounded by recent press

attention to the dangers of a system lacking transparency and strong professional self-regulation. In late 2007, the Department of Justice entered into deferred prosecution agreements based on evidence of inappropriate marketing and incentive practices among the large device manufacturers [5]. The resulting publication of extraordinary consulting fees further raised questions regarding the commitment of participating surgeons to exercising independent medical judgment.

The trend over the past decade of continued price escalation for devices, and the primary technology focus on cementless devices without evident incremental benefit for most patients, compounds the concern that manufacturers are excessively influencing the choice of therapies. The Australian review of 103 recently introduced devices found that “new prostheses were almost universally at the top end of the market with respect to cost; in particular almost all were cementless components. It appears that sponsors and manufacturers are not developing prostheses for cement fixation despite evidence from the Swedish registries and now more recently the Australian registry that they have better outcomes” [9].

Finally, the recent press attention to the recognition of the design flaws of the Durom cup and the particularly slow response by U.S. surgeons to data available internationally highlights purchasers’ concerns [16].

Faced with these challenges, contemporary healthcare purchasers are seeking ways to assure that their employees and dependents receive appropriate and effective care and achieve the best possible outcomes. Given the wide variability we observe in the clinical and cost performance of hospitals and physicians, one mechanism of quality improvement is to identify high-performing providers, processes, and products and encourage patients to seek them out. The presumption is that this “market signal” will encourage all providers to try to achieve comparable or superior clinical and cost outcomes, which will in turn encourage greater use of quality improvement support systems, best practice protocols, and care coordination strategies.

Examination of low-cost, high-quality physician exemplars suggest that they do not differ in their mindset from leaders in any other sector of the economy. One foundation-funded study of primary care practices that excelled on low total cost of care for chronic illness patients found two overarching foci of their clinical work: (1) frequent “tinkering” with their care methods in order to continuously reduce wasteful resource use and costly treatment complications; and (2) selecting referral resources (specialists, hospitals, drug, and equipment suppliers) who similarly deliver superior clinical outcomes for a lower total cost [17]. These exemplars illustrate the central point that whether motivated internally or by public release of

physician performance comparisons, continuous striving to migrate towards the “northwest quadrant” (Fig. 2) is the only path by which the U.S. healthcare system can remain affordable to nonwealthy Americans if we also wish to maintain the rate of technology-enabled clinical outcome gains.

Today, employers, health plans, and patients, as well as referring physicians, are all unable to identify high-performing orthopaedic surgeons from any systematic data, public or private. If such data were available, we would see a variety of methods deployed to encourage (1) selection of high-performing physicians; (2) greater engagement of patients in care decisions; and (3) greater professional adoption of practice standards and quality improvement techniques. Such data would be used by doctors to improve, by patients to choose, and by purchasers to reward.

For example, clinical and cost performance data could support several patient-facing techniques, such as reduced co-pays for selecting better-performing surgeons; shared decision making prior to knee replacement surgery; workplace education on musculoskeletal issues, prevention techniques, etc. [2]; and patient ratings networks (eg, HealthCareScoop.com). Employers would also encourage adoption of several provider-facing techniques—largely administered by health plans—such as recognition of high-performing physicians in provider directories, referral systems, etc; bonus payment for outcomes reporting and attainment of superior performance; incentives for involving patients in shared decision-making protocols; incentives for participation in uniform clinical registries with public reporting; disincentives for care without adequate documentation of indications, failure to comply with ACCP prophylaxis guidelines, etc.; and bundled payment for episodes of care (to include rehabilitation, potential DVT or other complications). These market-oriented incentives for appropriate, cost-effective care all depend upon a robust and reliable information base, which is unavailable today. In the absence of clinically sound information, payor and regulatory concerns could be expressed in blunt-instrument techniques of cost control and network design. Instead, a constructive approach to value-based orthopaedic practice would build upon an enhanced clinical registry approach, with several important components, including (1) a uniform, national and universal total joint replacement registry, including standard specifications for patient, procedure, and device characteristics and indications for the procedure; (2) a uniform battery of outcomes measures, including standard specifications for preoperative functional and symptom assessment and corresponding postoperative outcomes (including complications, revisions, functioning, patient experience with care, and total costs); and (3) interfaces to

related data systems, including payor claims data for acquisition of both cost and late outcomes information.

A number of regional or enterprise joint replacement registries are already in place, including those in the Kaiser Permanente system and at Massachusetts General Hospital, for example [10, 12, 15, 19]. These systems were often built upon the experience of the established national registries in Norway, Sweden, and Australia as well as the GLORY global registry [8].

Challenges Ahead

Certainly there are no substantial scientific or intellectual barriers to creating a flow of information that would support continuous improvement, patient safety, patient decision making, and market-based incentives. Existing registries have developed many of the data definition and coding requirements, there are numerous validated instruments for assessing disability and outcome, and other systems are implementing routine patient followup including the Swedish national registry and the National Health Service launch of patient-reported outcomes measures in 2009 [18]. But there are marked cultural, economic, political, and technical challenges.

Purchasers are pleased to see growing professional interest in clinical registries but also view such programs as insufficient. They often reflect a well-intended but inadequately responsive view of accountability and improvement—one rooted in professional aspirations of clinical excellence but tone-deaf to the realities of the contemporary healthcare system described above. Purchasers are not convinced that feedback of performance information, by itself, leads to adjustments in clinical behavior sufficient to balance the financial incentives favoring high utilization, rapid adoption of unproven technologies, and uncoordinated care across the continuum. Instead, we encourage development of a database of registry, outcomes, and cost information as a reliable resource for supporting performance-based payment, public recognition, and professional improvement efforts.

These purchaser expectations suggest the value of a dialogue between orthopaedic professionals and those who pay for and consume their services. Clearly, orthopaedic surgeons will be reluctant to participate in a voluntary data gathering activity which may expose unfavorable aspects of their performance. As Henrik Malchau noted in a recent interview, “orthopaedic surgeons are also concerned that data from the registry will be used to monitor their performance as surgeons. They are afraid of being excluded from doing certain procedures. We need to address this problem and assure surgeons that this will not be the case” [11]. Purchasers do not share this view, of course. They and

the patients they represent believe strongly that poor performing physicians should be excluded or disincented from performing some procedures. Patients certainly have a right to know how skilled their surgeon is, how many cases he or she performs, and what short- and long-term outcomes are achieved. It would be understandable, even desirable, for this level of transparency to reduce the flow of patients to low-performing surgeons.

The introduction and evolution of a national joint registry could be structured to address these concerns. It could begin by asking payors to offer financial incentives for surgeons' participation, with an agreement not to disclose individual performance information for 2 years; commission a balanced panel of surgeons, referring physicians, payors, and patients to identify a subset of indicators to be reported to the public at Year 3; depending upon participation levels, consider mandatory contribution to the registry; the sponsor of the Virginia state registry believes this essential [12].

A second set of challenges involves the mechanics of data acquisition and processing. Today, most registry data are collected through chart abstraction or management of a parallel set of forms by nurses and other personnel. Collection of data from patients is equally burdensome and expensive, often requiring frequent callbacks and management of voluminous paper forms. Advocates of an enhanced national registry should undertake an information systems analysis, optimized to take advantage of continuing developments in information technology. Key elements would include standardization of coding and terminology for a core set of items; identification of electronic interfaces from hospital, practice management, and payor systems for as much data as possible; capture of patient e-mail addresses preoperatively and maximal use of online reminders and forms to gather followup data; use of multidisciplinary data systems wherever appropriate, such as the NIH PROMIS Surgical Outcomes Module and the ACS SCIP measures; longitudinal interface to health plan and vital statistics data systems to capture readmissions, revisions, deaths, and full-episode costs of care.

Discussion

Employers want their employees to receive necessary and effective medical care, and they want to encourage providers to deliver care with the most efficient use of resources. They believe there are wide variations in the performance of orthopaedic surgeons, in terms of quality, appropriateness, and careful stewardship of resources. Health care purchasers and payors are prepared to support joint replacement registries and other systems for providing clinically rich feedback to surgeons while also bringing

new information into the hands of referring physicians and patients so that they, too, can make better decisions about when and where to seek care.

This paper has reviewed both the data systems and administrative mechanisms that could support a new and more transparent relationship between surgeons and the larger community of purchasers, payors, and patients. Many dimensions of this new arrangement have not been broadly tested in this country. Some large systems—such as Kaiser Permanente and the Veterans Health Administration—have implemented registries with clinical feedback, but these have generally not included transparency to the public. Other disciplines, such as cardiology, have moved further in building links between the registry technology and the ability to provide feedback on conformity to professionally defined appropriateness criteria. Other countries, including Australia, Norway, and the United Kingdom, have operated national joint replacement registries and systematic patient outcomes reporting. We have ample evidence that these approaches provide value and lead to both care improvements and greater efficiency, but they have not yet been applied to the broad community practice of orthopaedic surgery.

Employers generally do not like centralized and regulatory approaches to controlling prices or limiting the availability of services. Instead, they would like to recognize and reward providers who deliver safe, high-quality, and efficient care—and who are committed to continuous improvement across these dimensions. They believe that such recognition will stimulate a widespread commitment to measurable improvement and innovation. But this “market-based” approach to purchasing requires a shared understanding of accountability and a shared commitment to transparency.

The idea of accountability needs to reflect orthopaedic surgeons' participation in a large and complex ecosystem, one which entails an enormous and growing transfer of wealth from America's workers to its health professionals. Orthopaedic surgeons occupy an important space along the care continuum, alongside and interacting with primary care physicians, other specialists, rehabilitation services, pharmacists, and many community resources. Perhaps training and economics focus the orthopaedist's attention on the immediate requirements of the procedure, but the employer sees that procedure in a broad context, and looks for opportunities to reduce the need for those procedures and, when indicated, to maximize the likelihood of a good outcome. For employers, the key ingredients of the information infrastructure will be evidence that procedures are undertaken appropriately, that the least costly, effective devices and related services (eg, imaging) were used, and that patients ultimately achieved the intended functional gains.

Transparency does not require embarrassment, disclosure of proprietary information, or violation of patient privacy. Instead, it is based upon society's understanding that evidence of variation in safety, quality, and cost exposes patients to risk and uncertainty. And it reflects the recognition that physicians cannot identify opportunities for improvement without a view of patient experience outside of their own practice.

Our national healthcare industry needs to discover mechanisms for achieving a 2% to 2.5% annual reduction in total cost of care if we are to continuously offset the cost-additive impact of valuable biomedical advances. Compared to other specialties, the clinical and cost consequences of orthopaedic surgery are more greatly influenced by the surgeon's skill and choice of resources, such as orthopaedic implants. Because orthopaedic implants comprise such a major component of total episode cost, more value-sensitive selection by orthopaedic surgeons offers substantial opportunity for shared savings arrangements with patients and payors. Ultimately, orthopaedists will also need to master more nuanced methods of continuous process improvement used routinely in other complex service industries—which will in turn depend upon a rich flow of clinical and outcomes information. As evidenced by the early successes of Medicare's physician-focused demonstrations, the most plausible scenario for a "win-win" translation of performance transparency into health and financial benefit for nonwealthy Americans will involve continuous improvement leading to "shared savings" between payors and providers. Orthopaedists are uniquely positioned to "do good and do well" in an era of increasing clinical performance transparency and accountability for long-term outcomes and lower total cost of care.

Acknowledgments We thank Kevin Bozic, MD for his encouragement to us to formalize our many conversations on this topic and Emily London for her assistance in drafting this manuscript.

Open Access This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

References

- Canadian Institute for Health Information, *Canadian Joint Replacement Registry (CJRR) 2007 Annual Report—Hip and Knee Replacements in Canada*. Ottawa, Ontario, Canada: CIHI; 2008:59.
- Connelly LB, Woolf A, Brooks P. Cost-effectiveness of interventions for musculoskeletal conditions. In: Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB, Jha P, Mills A, Musgrove P, eds. *Disease Control Priorities in Developing Countries*. 2nd ed. New York, NY: Oxford University Press; 2006: 963–980. Available at: <http://files.dcp2.org/pdf/DCP/DCP51.pdf>. Accessed July 21, 2009.
- DeFrances CJ, Lucas CA, Buie VC, Golosinskiy A. 2006 national hospital discharge survey. *Natl Health Stat Report*. 2008;5:1–20. Available at: <http://hcupnet.ahrq.gov>. Accessed Nov. 1, 2008.
- Eikelboom JW, Karthikeyan G, Fagel N, Hirsh J. American Association of Orthopedic Surgeons and American College of Chest Physicians guidelines for venous thromboembolism prevention in hip and knee arthroplasty differ: what are the implications for clinicians and patients? *Chest*. 2009;135:513–520.
- Feder BJ. U.S. settles with hip and knee makers. *New York Times*. September 27, 2007; Available at: http://www.nytimes.com/2007/09/27/business/27cnd-device.html?_r=1. Accessed July 21, 2009.
- Friedman RJ, Gallus AS, Cushner FD, Fitzgerald G, Anderson FA Jr, Global Orthopaedic Registry Investigators. Physician compliance with guidelines for deep-vein thrombosis prevention in total hip and knee arthroplasty. *Curr Med Res Opin*. 2008;24:87–97.
- Gaudiani VA, Grunkemeier GL, Castro LJ, Fisher AL, Wu Y. The risks and benefits of reoperative aortic valve replacement. *Heart Surg Forum*. 2004;7:E170–E173.
- Global Orthopaedic Registry. Available at: <http://www.outcomes-umassmed.org/GLORY/index.cfm>. Accessed June 20, 2009.
- Graves SE, Wells V. A review of joint replacement surgery and its outcomes: appropriateness of prostheses and patient selection. Australian Centre for Health Research Ltd. October 2006, p. 52. Available at: <http://www.achr.com.au/pdfs/Graves.pdf>. Accessed July 21, 2009.
- Hauser DL, Wessinger SJ, Condon RT, Golladay GJ, Hoeffel DP, Gillis DJ, Merrill DR, Chaisson D, Freiberg AA, Estok DM, Rubash HE, Malchau H, Harris WH. An electronic database for outcome studies that includes digital radiographs. *J Arthroplasty*. 2001;16(8 Suppl 1):71–75.
- Hayashi A. Building a national joint replacement registry. *AAOS Now*. March 2008; Available at: <http://www.aaos.org/news/aaosnow/mar08/cover2.asp>. Accessed July 21, 2009.
- Jiranek W. Building a statewide registry to monitor joint implantations." XM Radio Reach MD Podcast. Hill MN, host. Focus on Public Health Policy Series. Available at: <http://www.reachmd.com/xmsegment.aspx?sid=3607>. Accessed June 20, 2009.
- Kaiser Family Foundation and Health Research and Educational Trust. *Employer Health Benefits 2007 Annual Survey*. Available at: <http://www.kff.org/insurance/7672/upload/76723.pdf>. Accessed June 20, 2009.
- Kim S. Changes in surgical loads and economic burden of hip and knee replacements in the US: 1997–2004. *Arthritis Rheum*. 2008;59:481–488.
- Malchau H, Garellick G, Eisler T, Kärrholm J, Herberts P. Presidential guest address: the Swedish Hip Registry: increasing the sensitivity by patient outcome data. *Clin Orthop Relat Res*. 2005;441:19–29.
- Meier B. A call for a warning system on artificial joints. *New York Times*. July 29, 2008.
- Milstein, A. Medical homes — and medical "home runs"? *Health Affairs Blog*. September 10th, 2008; Available at: <http://healthaffairs.org/blog/2008/09/10/medical-homes-and-medical-home-runs/?source=promo>. Accessed July 21, 2009.
- National Health Service Guidance on the Routine Collection of Patient Reported Outcome Measures (PROMs). Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_092647. Accessed July 21, 2009.
- Paxton EW, Inacio M, Slipchenko T, Fithian DC. The Kaiser Permanente National Total Joint Replacement Registry. *The Permanente Journal*. 2008;12:3.

20. Puvimanasinghe JP, Takkenberg JJ, Edwards MB, Eijkemans MJ, Steyerberg EW, Van Herwerden LA, Taylor KM, Grunkemeier GL, Habbema JD, Bogers AJ. Comparison of outcomes after aortic valve replacement with a mechanical valve or a bioprosthesis using microsimulation. *Heart*. 2004;90:1172–1178.
21. Quintana JM, Arostegui I, Escobar A, Azkarate J, Goenaga JI, Lafuente I. Prevalence of knee and hip osteoarthritis and the appropriateness of joint replacement in an older population. *Arch Intern Med*. 2008;168:1576–1584.
22. Quintana JM, Escobar A, Azkarate J, Goenaga JI, Bilbao A. Appropriateness of total hip joint replacement. *Int J Qual Health Care*. 2005;17:315–321.
23. Sirio CA, Jones J, Pei Y, Meacock K, Roberts MS; Academy for Health Services Research and Health Policy. Total knee replacement in Southwest Pennsylvania—assessing utilization, post-operative complications and hospital readmission using a statewide database. *Abstr Acad Health Serv Res Health Policy Meet*. 2000; 17. Available at: <http://gateway.nlm.nih.gov/MeetingAbstracts/ma?f=102272675.html>. Accessed July 21, 2009.
24. U.S. employers' health benefit cost continues to rise at twice inflation rate, Mercer survey finds. 2007. Mercer LLC website. Available at: <http://www.mercer.com/referencecontent.htm?idContent=1287790>; Accessed June 20, 2009.
25. Wennberg DE. Variation in the delivery of health care: the stakes are high. *Ann Intern Med*. 1998;128:866–868.