The Future of Quality Measurement in the United States

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Abstract

The need to practice cost efficient medicine and provide it in the safest way possible is paving the way for quality improvement (QI) programs to take off. American College of Surgeons National Surgical QI Project and Surgical Care and Outcomes Assessment Program are some of the leading examples and have provided useful data to evaluate our systems and decrease morbidity and mortality. With proven outcomes driving morbidity and mortality rates down, we have to wonder how to refine these measures to make them more relevant to specialty surgeries such as colorectal. On the contrary, participation in programs like these has placed extended requirements on hospitals and physicians. In addition, some of the quality measures may be inaccurately identifying low and high performing hospitals and individuals because of inherent flaws in the database. This could potentially be in conflict with the mission of these programs. What will be presented are some alternatives and different directions QI is moving toward.

Keywords

- ACS NSQIP
- quality improvement
- process measures
- colorectal surgery

CME Objective: On completion of this article, the reader should be able to summarize the benefits, shortcomings, and future direction of quality improvement.

Standardization of perioperative care of the surgical patient is becoming widely recognized for its benefits on overall morbidity and mortality. Institution of the Surgical Care Improvement Project (SCIP) guidelines, preoperative order sets and/or bundles are just some of the things that are becoming a part of our surgical practice. Many of the articles discussed in this issue have laid out important data showing these benefits, such as decreased surgical site infections (SSI), which are becoming the measuring sticks by which we judge how well we are performing as physicians and hospitals. With the continued economic strain on the health care system, it is becoming imperative that we routinely self-assess how well we are doing to provide the evidence-based driven data necessary to deliver the best and most efficient form of health care to the patient. This has been demonstrated in programs such as Surgical Care and Outcomes Assessment Program (SCOAP) and National Surgical Quality Improvement Project (NSQIP).

Therefore, this begs the question of “Where do we go from here?” Now that the programs have been in place for several years and the data collected are being used to improve the system of care to surgical patients, is there something more to be done? On the contrary, is the concept of doing things for the “greater good” not allowing independent thought and taking away the autonomy of the physician? Can this be dangerous to the patient when we allow things to just go on autopilot?

SCOAP versus NSQIP

When looking at the future of NSQIP, some of the things that can be used to improve it could be seen in smaller regional programs such as SCOAP. The Washington State SCOAP is a statewide initiative that is unique in many ways, to include its participants. SCOAP brings together a clinical community of practitioners whose work touches on procedures or surgery (including radiology, pathology, and interventional radiology). This multidisciplinary approach is a distinct departure from a “surgeon-only” report card-oriented QI approach.

Building off the fellowship of the clinical community at large, it aims to drive improvement by changing behavior.¹ Instead of focusing on an observed-to-expected (O/E) ratio, the collaborators of SCOAP recognize that although a hospital may not be an outlier, it does not mean that things cannot be improved. This grassroots, continual process improvement speaks to SCOAP's success. Within 5 years, they have seen their negative appendectomy rates drop significantly, in addition to the cost of postoperative complications from colorectal surgery decrease, etc. Much of the energy behind SCOAP focused not just on tracking variability, but in creating an active response to reduce that variability leading to the aforementioned examples of their success. This continually evolving system is something unique that is viewed as being more "realistic" in the eyes of groups performing comparative effectiveness research. SCOAP is inclusive of all types of hospitals, with members of "priority populations" for research funding agencies (e.g., pediatrics, geriatric, minorities, and those of lower socioeconomic standing that live far away from larger medical centers) supporting this idea of being "realistic."

The other unique part of SCOAP is that it is a purely volunteer physician-led collaborative effort, with data that is not reported for medicolegal purposes. In this way, there is no punitive element involved for those hospitals that are underperforming. This fosters a community of positively influenced changes in surgical quality and safety. Unfortunately, because there is no financial incentive for volunteered time, team building, and development work, some smaller hospitals may not feel it beneficial to participate. This may turn the altruistic QI approach of SCOAP into a pay-for-performance model, if a large payor does step in. Altruism is one thing that SCOAP prides itself on, but it is also striving to adapt so that smaller hospitals do continue or start to participate.

One thing missing in the SCOAP program that can be a focus of improvement going forward is better patient-reported outcomes. This is an exclusively subjective component for measuring quality of care but is central in terms of patient satisfaction. This is of particular importance after major operations but is probably appropriate for all interventions (e.g., postoperative hernia pain).¹ In addition to collecting static data, the SCOAP collaborative has also noted that it is looking to move toward dynamic data feedback and intervention that can provide real-time feedback to the physician. This involves creating a long-term follow-up plan that may be difficult and resource intensive to maintain.

SCOAP is just one example of a regional QI program that takes into account local influences on patient care. However, there may be certain factors that are regional and cannot be delineated when examining national data. The impact of regional data is obviously more relevant to the practitioners involved in that region. Sometimes, it is difficult to glean lessons learned when the outcomes are influenced by factors that may not be relevant to local practitioners. QI in medicine may be better served on a regional level with some oversight at the national level. As stated before, most of the participants in the American College of Surgeons (ACS) NSQIP project are

large, academic medical centers, which serve a different population than the small community hospital 100 miles away. Nevertheless, regional differences should not be used as an excuse or a reason why we can not strive toward better outcomes overall. Programs such as ACS NSQIP have built in to their analysis the ability to account for differences such as interrater reliability and data quality (especially in this time when the electronic health record [EHR] is becoming a mandate).

One of the main goals of the ACS NSQIP data collection is to create statistical models that describe the O/E ratio for mortality and morbidity outcomes for each participating hospital, adjusting for differences in patient risk factors between hospitals.² The reliability of the data requires a large start up in resources to train individuals to effectively collect, examine, and check the data. Some have criticized the high cost involved in starting a NSQIP program which involves, on average, \$90,000 for salary and benefits for an experienced nurse reviewer, \$10,000 for travel to the annual NSQIP meeting and internal information technology support, and \$35,000 for data entry software, nurse training, and data management.³ These costs may not seem as substantial for a major hospital system when it compares this to the costs of patient complications. Examples include \$18,310 for thromboembolic complications, \$7,789 for cardiovascular complications, and anywhere from \$1,398 to \$4,901 for infectious complications.^{4,5} Mitigating costs for smaller hospital systems will be something to consider in moving forward with standardization nationwide. This could potentially be accomplished through federal support to improve the quality of these hospitals, which in the end may pay out considering the avoidance of costly complications. Reform of the health care system is already a hotly debated topic, and part of that discussion should be federal support for mandated QI. If hospitals and physicians are to be subjected to penalties in reimbursement, there should be a system in place (preferably governed by physicians) that would support the implementation of QI programs such as NSQIP until the hospitals see improvement. This is an idea in its infancy, but should be considered, moving forward, as there is a growing set of literature demonstrating the benefits of utilizing programs such as ACS NSQIP. Hall et al looked at whether surgical quality improved in 118 institutions enrolled in NSQIP between 2006 and 2007. What they found was that the mean absolute change in the O/E ratio was highly significant for both morbidity and mortality.⁶

Data Collection

Another matter that needs to be addressed in the future of NSQIP is the collection of data, as the EHR becomes more ubiquitous. The Health Information Technology for Economic and Clinical Health Act was created and passed with the intent to convert medical records into an EHR format that would provide "meaningful use" of health information to serve as a platform for information exchange, e-prescribing, and collecting data to submit for quality measurement.⁷ Physicians will be penalized 1% increasing to 3% over 3 years

if they do not utilize and demonstrate a “meaningful use” EHR. The integrity of the data is directly related to highly trained and audited data abstractors (surgical clinical reviewers or SCRs). SCRs undergo an intensive initial training period, as well as ongoing learning with regular interrater reliability audits and frequent telephone conferences. Site reviewers examine operative logs and charts to identify any potential reporting errors. A disagreement rate greater than 5% for the individual site’s audit of variables collected or an individual variable within the overall program generates corrective action. Overall, the interrater variability and disagreement rates have declined over the years since the inception of ACS NSQIP.⁸ Maintaining the integrity of the database is time and money intensive. Depending on the size of the hospital, the costs of maintaining an SCR can be as minimal as the aforementioned estimate of \$135,000/year, or much more for larger hospital systems. In addition, maintenance of the database is dependent on how efficient the SCRs are at reviewing patient charts and operative reports.

A few solutions have been presented for the problem of having a select group of people going through a large amount of information, expecting to maintain data integrity. Just as there are preoperative checklists for items such as antibiotics and venous thromboembolic prophylaxis, a similar dedicated checklist can be created electronically for the circulating nurse, physician, or anesthesiologist. This checklist can include key words that would automatically populate into the database. A similar electronic form can be used as part of the daily progress note. Creating a program to run this can be complicated as these terms will have to be tied to a “language” that can crosstalk with other systems. Currently, that language is International Classification of Diseases, Ninth Revision or Current Procedural Terminology codes, which much of the research in publication today uses. This problem of crosstalking between systems is born out of the data that are collected from charts for either clinical or administrative purposes. The different information abstracted then falls into disparate databases with nonstandardized terms. This leads to repetitive, manual abstraction from the required documentation of care.³ The process is costly, slow, and unreliable, and it makes up a significant proportion of the 31% of total administrative health care expenditures in the United States.⁹ Hammermeister suggested that the problem of different languages in the system not be solved all at once. As the mapping of terms is laborious, the approach could be piecemeal, such as using the < 200 ACS NSQIP patient-related risk terms and outcomes (e.g., albumin, American Society of Anesthesiologists score, cancer, emergent operation, etc.). These terms must also be clinician friendly so that the eventual mapping can be done to familiar language. Hopefully, this could alleviate the burden of data combing and entry by the SCRs.

The Electronic Health Record

The data in the ACS NSQIP and other QI programs also encompass the data related to patient outcomes within the 30-day postoperative period. Patients are often seen and

evaluated by several different providers or in several different environments (e.g., preoperative clinic visit or postoperative, outpatient follow-up) and this leads to disjointed episodes in the medical record with less than optimal communication. In particular, as patients are followed up in the outpatient setting, a provider’s EHR may not necessarily communicate with the hospital’s system and data points can be lost. The simple solution would be to provide physicians with the same EHR that the hospital uses, but providers are often at several different hospitals. A more reasonable solution would be to mandate that the various EHR systems operate on a platform, which would highlight the various key terms being extracted for QI databases such as NSQIP. A platform like this exists in the form of open source software (OSS). Open source EHRs enable individual regions to adapt information technology to their own special needs and not be pigeonholed into various commercial software vendors. This would allow the establishment of regional health care networks.^{10,11} An adjunct to a formal EHR can include the use of mobile health records. Currently, there are mobile programs that are primarily used in the home health care realm where home health care providers are able to input data into the records of patients.¹¹ This is an interesting application that may actually benefit surgical patients during their postoperative home recuperative phase. Valuable patient feedback can be inputted through this mobile-based software. This is an evolving technology that has the potential to fill in the blanks of gathering patient outcomes outside of the office/hospital setting.

As current EHRs are trying to create systems that can store and collect data efficiently, there is also a movement toward intelligent analysis. This involves operating software that can determine and perform tasks like “prefetching.” Prefetching enables access to relevant prior studies across multiple disparate picture archiving and communications systems (radiology viewers) and moves them to the appropriate viewing station.¹² In a similar fashion, this software could be developed to integrate data points from different EHR systems. This may be a possible solution to the problem of having different EHR vendors (similar to the problem of having different radiology viewing software). Finally, the financial cost of purchasing and maintaining OSS is cheaper than your standard desktop-based EHR. Some of the offset of the cost is due to reduced security of the software, but it still falls within the Health Insurance Portability and Accountability Act (HIPAA) regulations. OSS could, therefore, be offered as an EHR for more impoverished countries as globalization of QI occurs, and the need for databases to communicate between countries grows.¹¹

The technological evolution and focus on improving data integrity has led to the expansion of data. With this, there is a stricter requirement to comb through the data to give the most honest picture of hospital morbidity and mortality. The ACS NSQIP has traditionally instituted a systematic sampling strategy for the selection of procedures.⁸ Although this has its distinct advantages, many hospitals have discovered that many procedures, particularly those in the outpatient setting, tend not to be associated with a high incidence of complications. The problem comes about as many hospitals report

most of their procedures as being outpatient. If hospitals are interested in QI, it would be more advantageous for them to include cases that tend to be associated with complications. For these hospitals, a targeted case selection affords a greater opportunity to identify areas for QI and the ability to collect all (or nearly all) cases, thus providing more robust statistical analyses based on larger sample sizes.⁸ Larger hospitals can continue to expand on their case selections as improvements in their original case selections reach a plateau in performance.

The Move toward Specialty Driven Quality Improvement

As ACS NSQIP expands, there is a need to not duplicate these efforts by working closely with the different surgical societies. ACS NSQIP follows patients for 30 days after operations, which provides a framework for societies interested in outcomes beyond the 30-day period.⁸ Raval et al completed a study on the initiation of a specialty-specific ACS NSQIP among pediatric surgical subspecialties.¹³ This study represents the first multi-institutional prospective assessment of specialty-specific surgical outcomes in children. What they established was the feasibility of implementing a QI program in specialty-specific surgery. They did this by demonstrating similar outcomes in variability as well as overall improvement in complication rates for a set of cases. Overall, interrater reliability showed less than 2% discordance between hospital data abstractors and expert audit.¹³ The need for specialty-specific data are shown in the composition of cases that were evaluated in study. One-third of the cases and complications were considered general pediatric surgery. Some of the specialties, such as pediatric otolaryngology and urology, represented a relatively high proportion of cases but a paucity of the complications.¹³ The need to reach out to these specialties is thus demonstrated, and can assist with tailoring QI to meet their specific goals. This would include the development of specific risk-adjusted models for the different surgical specialties.

Research is starting to evaluate the effects of subspecialty reporting, comparing it to the ACS NSQIP to see if there are specialty-specific measures that could lead to QI. Lawson et al looked at the ACS case log system for physician reported patient risk factors and outcomes to see if there was any entry bias.¹⁴ Although there may be obvious entry bias on the end of the surgeon entering his/her cases, the option of self-entry is relatively easy and inexpensive to use, and allows a surgeon to collect data on all his/her patients in one place, even if he/she practices at multiple hospitals.

One unique aspect of subspecialty-specific QI is the formulation of a colorectal surgical risk calculator. This could be an important tool, which could be used to counsel patients, giving them a complete picture of their surgical risk. This would allow a much more thought out decision-making process when deciding between an operative or nonoperative approach to an elective problem. Cohen et al used data from the ACS NSQIP for patients who underwent colorectal surgery in 2006 to 2007, and then generated logistic prediction

models for serious 30-day morbidity and mortality. Results were then used to construct a universal multivariable model to predict risk for all three outcomes.¹⁵ The basis behind the creation of this statistical risk model is to construct a "patient-centered" consent process where a more accurate picture of morbidity and mortality could be presented to patients. It should be stressed that this is just an adjunct and not a basis for decision making. Ultimately, the surgeon's expert opinion should not be swayed if the procedure is obviously beneficial to the patient. The eventual vision for this tool is for a password-protected program at a given hospital. The variables would be entered, and the colorectal surgical risk for overall morbidity, and serious morbidity and mortality would be reported, based on specific risk factors for the patient. They also argue to quote the patient's risk within the tercile ranking for that treating hospital (which would be based on the O/E ratio).

Another of the weaknesses of programs such as ACS NSQIP is that data do not take into account surgeon specialty, and specific outcomes that are important to specialty-specific surgeons (i.e., time to first bowel movement or stoma function, time to oral diet, etc.). It also does not show cancer staging or early readmission data. For specialties such as surgical oncology, the limitation of the ACS NSQIP data up to 30 days after operation prohibits the ability to assess long-term oncologic outcomes. As a result, specialties such as colorectal surgery are beginning to critically look at these database deficiencies in an effort to move forward to higher fidelity data.^{16,17} Combining this effort with improvements in evaluating the variable factors that go into morbidity and mortality outcomes may hopefully result in accurate risk assessments for surgical patients. In their article, Greenblatt et al identified some of the shortcomings with strictly using the ACS NSQIP database for morbidity outcome in colorectal surgery.¹⁶ Their group compared morbidity between laparoscopic-assisted and open proctectomy for rectal cancer. Although the ACS NSQIP is excellent as a source for the study of early outcomes and the maintenance of > 200 variables related to patient outcomes, still it is lacking, since some of these variables may not be relevant to patients in colorectal surgery. By moving toward specialty-specific data, then, we can potentially use composite measures to better define the weight of variables that would be pertinent to risk-adjusted calculators.

Patient Centered Quality Improvement Processes

Earlier, we had seen how using an O/E ratio strictly can be misleading to hospitals, especially if their case load is predominantly associated with lower risk surgeries. A more recent publication uses what is called a composite measure to better validate a hospital's morbidity ranking.¹⁸ The weakness of this study was the fact that it used data from ACS NSQIP hospitals, which may not translate well to non-ACS NSQIP hospitals. This may be a starting point to consider, however, in developing a hospital's own individual risk calculator based off of a similar database such as the NSQIP.

Looking at more patient centered processes and outcomes measures may be ideal way to use large databases such as ACS NSQIP. The SCIP was developed as one of the first set of process measures to assess quality of care. The aim was to reduce preventable surgical mortality and morbidity by 25% by 2010.¹⁹ It has become ubiquitous in practice and is a clear marker to use in QI. However, the association between process measures and patient outcomes in surgical patients has not been well defined. Understanding the relationship could help identify process measures that are highly correlated with outcomes and can guide the use of QI resources. Ingraham et al examined this in their article published in the *Journal of the American College of Surgeons*.²⁰ They looked at the four publicly reported process measures related to SSI. SSI were used because it is one of the most common surgical complications (in addition to venous thromboembolism and cardiac events) evaluated in the ACS NSQIP database. Overall, their analysis demonstrated little to no association between compliance with most SCIP infection-related process measures and ACS NSQIP risk-adjusted outcomes. The only exception of statistical significance was compliance with administration of the appropriate antibiotic when compared with risk-adjusted SSI.²⁰ Their findings that most of the comparisons examined did not reach significance were consistent with other recent studies that have failed to demonstrate that process measures explain a substantial amount of the hospital-level variation in outcomes for nonsurgical patients.^{21,22} These findings have important implications on the monitoring of surgical quality. Outcomes are multifactorial and one simple process measure may not be sufficient to explain it. Therefore, it may be appropriate to do away with some of the surgically related process measures that have fundamentally weak relations to outcomes. As a result, Ingraham et al suggest moving toward risk-adjusted outcomes as quality measures instead.²⁰ This comes with its own unintended consequences, including “cherry-picking” healthy patients or even nontreatment of patients with serious morbidity. However, an approach like this might reveal the most important quality measure for the physician and patient alike—the outcome.²³ Using a continued data-driven approach could lead to concurrently retiring less-effective measures, whatever they may prove to be. The same idea of moving away from process measures such as SCIP was endorsed in the article by Hawn et al.²⁴ Although these process measures are best practices and should continue, they might be too simplistic in the long run to delineate hospital quality.²³

In a more recent publication, Dimick et al talk about using composite measures as a more accurate way of relating hospital morbidity and mortality.²⁵ Although clinically intuitive for surgeons, simple rates of risk-adjusted morbidity may not reliably reflect hospital performance because of either low event rates or caseloads. This may incorrectly identify high and low performing hospitals.^{26,27} Composite measures combine multiple quality indicators for a single operation (e.g., morbidity, length of stay, reoperation). This strengthens the quality and reliability of risk-adjusted morbidity rates. Prior studies have demonstrated the superiority of these

techniques for profiling hospitals on mortality, but it is unclear whether it will also be useful for risk-adjusted morbidity.²⁵ The composite measure was created out of statistical methods published in an earlier article by Staiger et al.²⁸ As a brief overview, they first determined the extent to which each individual quality indicator predicted risk-adjusted morbidity for the index operation. To evaluate the importance of each potential input, an estimate of the proportion of systematic variation (nonvariable) in risk-adjusted morbidity by each quality indicator was performed. They included any quality indicator in the composite measure that explained more than 10% of hospital variation in risk-adjusted morbidity. Weights were then calculated for each quality indicator. This was based on two factors. First was the hospital-level correlation of each quality indicator, with the morbidity rate for the index operation. The strength of these correlations indicates the extent to which other quality indicators can be used to help predict morbidity for the index operation. The second factor was the reliability with which each indicator was measured. This could range from 0 (no reliability) to 1 (perfect reliability). Reliability of each quality indicator refers to the proportion of the overall variance that is attributable to true hospital-level variation in performance, as opposed to estimation error.¹⁸ The value of their composite measure was then determined by how well it predicted risk-adjusted morbidity the following year (2009). For example, with ventral hernia repair, historical risk-adjusted morbidity predicted a smaller difference between the best and worst hospitals (8%) when compared with the composite measure (58%). This was the case when they evaluated the four other procedures looked at in their study (colon resection, abdominal aortic aneurysm repair, and lower extremity bypass surgery). Ultimately, what they demonstrated was that these composite measures address the problem of misclassifying surgeons and hospitals because of the unreliability of outcomes measurement secondary to small sample size and low event rates. Composite measures are increasingly being used in several quality measurement activities such as the Center for Medicare and Medicaid Services/Premier (in orthopedic and cardiac surgery) and the Society of Thoracic Surgeons (for coronary artery bypass surgery). Going forward in ACS NSQIP, it may be beneficial to consider composite measures to decrease the amount of false positives and false negatives that can degrade data when looking at hospital morbidity and mortality.

Conclusion

Improving outcomes is a goal for hospitals, surgeons, and patients. The advent of programs such as ACS NSQIP and SCOAP are manifestations of this goal. In examining the variable factors related to patient outcomes, we have seen the enormity of the database and where QI measures can sometimes fall short. The exciting part of moving forward is the direction QI is taking. Surgical specialties are beginning to form their own specialty-specific QI programs based on the ACS NSQIP model. This should help to better identify specific variables for outcomes that are relevant for each specialty.

As we move forward to providing a safer, more cost-efficient health care system, it will help to continually self-evaluate using QI programs. Universal acceptance will require some refinement in the costs of implementing the programs, refinements in the software to make it more physician friendly for daily utilization in clinical practice, and coordination between regions to use collection software that will crosstalk. Ultimately, these activities could provide global tools which could communicate with hospitals and physicians from other countries, in the hopes of improving health care worldwide.

References

- 1 Kwon S, Florence M, Grigas P, et al; SCOAP Collaborative, Writing Group for the SCOAP Collaborative. Creating a learning healthcare system in surgery: Washington State's Surgical Care and Outcomes Assessment Program (SCOAP) at 5 years. *Surgery* 2012;151(2):146–152
- 2 Shiloach M, Frencher SK Jr, Steeger JE, et al. Toward robust information: data quality and inter-rater reliability in the American College of Surgeons National Surgical Quality Improvement Program. *J Am Coll Surg* 2010;210(1):6–16
- 3 Hammermeister K. The National Surgical Quality Improvement Program: learning from the past and moving to the future. *Am J Surg* 2009;198(5, Suppl):S69–S73
- 4 Dimick JB, Weeks WB, Karia RJ, Das S, Campbell DA Jr. Who pays for poor surgical quality? Building a business case for quality improvement. *J Am Coll Surg* 2006;202(6):933–937
- 5 Olsen MA, Chu-Ongsakul S, Brandt KE, Dietz JR, Mayfield J, Fraser VJ. Hospital-associated costs due to surgical site infection after breast surgery. *Arch Surg* 2008;143(1):53–60, discussion 61
- 6 Hall BL, Hamilton BH, Richards K, Bilimoria KY, Cohen ME, Ko CY. Does surgical quality improve in the American College of Surgeons National Surgical Quality Improvement Program: an evaluation of all participating hospitals. *Ann Surg* 2009;250(3):363–376
- 7 Habib JL. EHRs, meaningful use, and a model EMR. *Drug Benefit Trends* 2010;22(4):99–101
- 8 Ingraham AM, Richards KE, Hall BL, Ko CY. Quality improvement in surgery: the American College of Surgeons National Surgical Quality Improvement Program approach. *Adv Surg* 2010;44:251–267
- 9 Hogarth MA, Turner S. A study of clinically related open source software projects. *AMIA Annu Symp Proc* 2005;•••:330–334
- 10 Janamanchi B, Katsamakos E, Raghupathi W, Gao W. The state and profile of open source software projects in health and medical informatics. *Int J Med Inform* 2009;78(7):457–472
- 11 Maglogiannis I. Towards the adoption of open source and open access electronic health record systems. *J Healthc Eng* 2012;3(1):141–162
- 12 Weathermon A, Tsui J, Rohling R. iScout: an intelligent scout for accessing and navigating large image sets in a PACS. *J Digit Imaging* 2004;17(2):109–119
- 13 Raval MV, Dillon PW, Bruny JL, et al; ACS NSQIP Pediatric Steering Committee. Pediatric American College of Surgeons National Surgical Quality Improvement Program: feasibility of a novel, prospective assessment of surgical outcomes. *J Pediatr Surg* 2011;46(1):115–121
- 14 Lawson EH, Wang X, Cohen ME, Hall BL, Tanzman H, Ko CY. Morbidity and mortality after colorectal procedures: comparison of data from the American College of Surgeons case log system and the ACS NSQIP. *J Am Coll Surg* 2011;212(6):1077–1085
- 15 Cohen ME, Bilimoria KY, Ko CY, Hall BL. Development of an American College of Surgeons National Surgery Quality Improvement Program: morbidity and mortality risk calculator for colorectal surgery. *J Am Coll Surg* 2009;208(6):1009–1016
- 16 Greenblatt DY, Rajamanickam V, Pugely AJ, Heise CP, Foley EF, Kennedy GD. Short-term outcomes after laparoscopic-assisted proctectomy for rectal cancer: results from the ACS NSQIP. *J Am Coll Surg* 2011;212(5):844–854
- 17 Greenblatt DY, Weber SM, O'Connor ES, LoConte NK, Liou JI, Smith MA. Readmission after colectomy for cancer predicts one-year mortality. *Ann Surg* 2010;251(4):659–669
- 18 Dimick JB, Staiger DO, Hall BL, Ko CY, Birkmeyer JD. Composite measures for profiling hospitals on surgical morbidity. *Ann Surg* 2013;257(1):67–72
- 19 Bratzler DW. The Surgical Infection Prevention and Surgical Care Improvement Projects: promises and pitfalls. *Am Surg* 2006;72(11):1010–1016, discussion 1021–1030, 1133–1148
- 20 Ingraham AM, Cohen ME, Bilimoria KY, et al. Association of surgical care improvement project infection-related process measure compliance with risk-adjusted outcomes: implications for quality measurement. *J Am Coll Surg* 2010;211(6):705–714
- 21 Bradley EH, Herrin J, Elbel B, et al. Hospital quality for acute myocardial infarction: correlation among process measures and relationship with short-term mortality. *JAMA* 2006;296(1):72–78
- 22 Werner RM, Bradlow ET. Relationship between Medicare's hospital compare performance measures and mortality rates. *JAMA* 2006;296(22):2694–2702
- 23 Werner RM, Asch DA. The unintended consequences of publicly reporting quality information. *JAMA* 2005;293(10):1239–1244
- 24 Hawn MT, Vick CC, Richman J, et al. Surgical site infection prevention: time to move beyond the surgical care improvement program. *Ann Surg* 2011;254(3):494–499, discussion 499–501
- 25 Dimick JB, Staiger DO, Baser O, Birkmeyer JD. Composite measures for predicting surgical mortality in the hospital. *Health Aff (Millwood)* 2009;28(4):1189–1198
- 26 Kao LS, Ghaferi AA, Ko CY, Dimick JB. Reliability of superficial surgical site infections as a hospital quality measure. *J Am Coll Surg* 2011;213(2):231–235
- 27 Dimick JB, Welch HG, Birkmeyer JD. Surgical mortality as an indicator of hospital quality: the problem with small sample size. *JAMA* 2004;292(7):847–851
- 28 Staiger DO, Dimick JB, Baser O, Fan Z, Birkmeyer JD. Empirically derived composite measures of surgical performance. *Med Care* 2009;47(2):226–233