Integrating Hospital Administrative Data to Improve Health Care Efficiency and Outcomes: “The Socrates Story”

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Clin Colon Rectal Surg 2013;26:56–62.

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Abstract

Evaluation of health care outcomes has become increasingly important as we strive to improve quality and efficiency while controlling cost. Many groups feel that analysis of large datasets will be useful in optimizing resource utilization; however, the ideal blend of clinical and administrative data points has not been developed. Hospitals and health care systems have several tools to measure cost and resource utilization, but the data are often housed in disparate systems that are not integrated and do not permit multisystem analysis. Systems Outcomes and Clinical Resources Administrative Efficiency Software (SOCRATES) is a novel data merging, warehousing, analysis, and reporting technology, which brings together disparate hospital administrative systems generating automated or customizable risk-adjusted reports. Used in combination with standardized enhanced care pathways, SOCRATES offers a mechanism to improve the quality and efficiency of care, with the ability to measure real-time changes in outcomes.

Keywords

- ▶ costs
- ▶ performance
- ▶ technology

Objectives: On completion of this article, the reader should be able to appreciate the need for information technology and sophisticated data analysis in health care to assess performance and optimize patient care and outcomes.

Innovation can be defined as “the intentional introduction and application within a role, group, or organization, of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, or wider society.”¹ Innovation can be fully realized using sustainable technology, or specialized software that organizes data; however, few software systems exist that can truly integrate hospital clinical and financial information in a way that can facilitate the quality and efficiency of provision of care.^{2,3} This is critical in a time when both hospitals and private practice groups are facing mounting financial pressures.⁴ Outside evaluations of the health care system in the United States continue to show that current rates of growth in cost are unsustainable. Improvements may be attained by the analysis of large datasets such as the National Surgery Quality Improvement Program (NSQIP) and the Agency for Health-

care Research and Quality (AHRQ).⁵ Specifically, reports estimate that up to \$300 billion of new health care value can be attained through analysis of “big data.”⁶

An analysis by McKinsey described how data exist in four separate pools: pharmaceutical R&D data, clinical data, activity (claims) and cost data, and patient behavior and sentiment data. With the Systems Outcomes and Clinical Resources Administrative Efficiency Software (SOCRATES) project, we have linked activity and claims data and clinical data in a manner that permits real-time assessment of endpoints to permit improvement and adjustment of care-pathways, and continued improvements in utilization of resources. Traditionally, hospital databases have been completely disparate systems that do not communicate (▶Fig. 1a), resulting in a truly vast amount of valuable information lacking synergism and making useful analysis impossible.⁷

We believe that if hospitals merged their complex existing data such that they could be altered into a collection of simple readable reports, objective cost and care decisions could be made, improving understanding both qualitatively and quantitatively. To facilitate this process, we initially proposed and

Fig. 1 (a) Image depicting examples of disparate data systems with no congruity or backward compatibility. (b) Organization and integration of our software as a filtration and analysis system.

developed the General Surgical Outcomes Quality Improvement Database (GSOD), subsequently renamed SOCRATES. This is a novel software system, which tracks all surgical, medical, and radiological encounters occurring across the University Hospitals Case Medical Center (UHCMC) system of hospitals. Having completed software development and validation, and integrated feedback from several user groups in administration and different medical and surgical departments, SOCRATES has now been in use at UHCMC for 5 years, with plans to implement this software at other local, regional, and national hospitals.

Integration with Care Pathways

Clinical pathways, standardized care pathways, or enhanced recovery pathways are names for methods to standardize care for patients undergoing treatment for certain medical or surgical diagnoses. For the purpose of this discussion, we will use the term enhanced recovery pathway (ERP) for all these care paths. ERP tend to reduce the cost of care with similar or improved clinical outcomes.⁸ They have been investigated in many areas of medicine and surgery, including cardiac, orthopedic, bariatric, and colorectal surgery.^{9–14} However, in a recent national survey⁹ only 30% of surgeons were shown to be using these care pathways.

ERP are simple applications of fundamental perioperative standards of care, delivered in a multidisciplinary manner

throughout the course of a surgical patients encounter. Components of patient information and preparation, clinical assessments, methods of care delivery, and postoperative support that traditionally were delivered on an “as needed” basis, often by the senior clinician in charge are consolidated and effected in a standardized way in ERP. Particularly in colorectal surgery, elements of care include written patient information, flow diagrams with standards of care for certain procedures such as hemicolectomy or total colectomy. Provision of stoma support and postoperative pain control regimens aim to maintain patient comfort and safety, deliver superior care with consistency and identify problems early and follow an organized approach to deal with complications. The net result of evidence-based practices in colorectal ERP such as avoidance of fluid excess, early ambulation, opioid-sparing analgesia, and select use of nasogastric tubes have been the safe and early discharge of patients with an improved quality of life and a similar rate of readmission to that of traditional postoperative care.^{9,15–17}

It has been shown that disparate information technology (IT) and billing systems as well as multiple different payment methods and administrative systems make it difficult for hospitals to identify areas of poor economics, or commercial weakness and to compare themselves with geometric averages. Software such as SOCRATES will provide those statistics. We have demonstrated the low instances of readmission associated with patients discharged quickly as compared with traditional postoperative recovery pathways with longer hospital stay.^{18–20} SOCRATES appears to be a unique and valuable data management system: We believe that it will “trim the administrative complexity associated with poorly defined IT and data transfer standards.”⁷

Colorectal surgery can offer significant challenges with multiple patient, disease, and surgical factors interplaying, which can sometimes create an unexpectedly complex case. However, postoperative management is a domain with which a surgeon can have a certain degree of control, and if standardized, can produce predictable results. In turn, outcomes become more comparable and quality can be better evaluated. Unfortunately, physicians are frequently given no information on how their outcomes differ from those of their peers, and therefore lack the appropriate tools or insight to changing their processes of care. This becomes even more important as hospitals struggle to maintain a profitable status, or break even, as health care reimbursement is reduced.²¹

Background Work

Hospitals use a variety of software programs for professional billing, administration (such as operating room scheduling), and technical charge assessment. Each of these systems is coded in a different way, making comparisons between databases and datasets challenging. For instance, many billing systems code by CPT (current procedural terminology) code, whereas administrative systems code by ICD (International Classification of Diseases) or DRG (diagnosis-related group) codes, and operating room scheduling systems may code by

Outcomes by Physician for ALL - (Inpatient)

Date Range: 1/1/2006 - 11/30/2011

Department: ALL

Patient Type: Inpatient

Division: ALL

Operating Room Data

	Volume	Entry to Incision mean (median)	Incision To Close mean (median)	Total OR Time mean (median)	Total OR Time Outliers >mean + stdev
Surgeon 'A'					
Surgeon 'B'					
Surgeon 'C' etc					

Post Operative Data

	Volume	LOS mean (median)	Mean APR-DRG	Adjusted LOS	LOS outliers >mean + stdev	Readmits
Surgeon 'A'						
Surgeon 'B'						
Surgeon 'C' etc						

Financial Data

	Volume	Net Revenue/ Admit	Hospital Costs/Admit	Hospital Cost Outliers	Contribution Margin	CM/Admit	CM/Day	Total Margin	Total Margin/ Admit	Total Margin / Day	Total Margin / OR Minute
Surgeon 'A'											
Surgeon 'B'											
Surgeon 'C' etc											

Fig. 2 Report generated by Systems Outcomes and Clinical Resources Administrative Efficiency Software (SOCRATES) when queried for General Surgery between specific dates, which can be modified for any CPT code or group of codes, any providers, and any date range.

free text. In 2006, our institution defined a need for reporting technology, which could integrate disparate hospital administrative information systems. Using an initial philanthropic grant, we hired a software engineer, and initial code was written to merge hospital data (►Fig. 1b). This code has now been upgraded and functions as a data warehouse, which cleans and sorts automatically downloaded data, and performs sophisticated reporting.

Programs such as the National Surgical Quality Improvement Project (NSQIP) have been brought from the Veteran's Administration Medical Center (VAMC) system into private and academic health care systems to sample surgical outcomes and provide hospitals with benchmarks that can be achieved, as well as informing them where they rank in the overall results.²² Unfortunately, systems such as NSQIP are based on sampling a percentage of cases performed each week and do not track all cases or all providers. Many cases are therefore not tracked in any way. Our software differs in that it tracks all cases and all providers, making it possible to evaluate all cases in an institution.

Like many health care systems nationwide, University Hospitals Health System collects clinical and administrative information during the course of a patient's treatment and stores this information in multiple databases across different areas of the hospitals. For example, when a patient undergoes a surgery, information relating to the procedure and outcomes is stored in multiple databases including those for operating room information, hospital billing information, physician billing information, hospital administrative information, and physician order entry.

SOCRATES is capable of producing patient and physician-level, procedure-specific reports aggregating information on

operative times, length of stay, certain postoperative complications, and financial outcomes of care across the institution. These automated and fully customizable reports empower physicians and hospital administrators to accelerate improvements in quality and efficiency by identifying positive and negative outliers and helping to implement best care practices.

Reporting Structure

There are three fundamental work environments within the software: development, testing, and training, making use of SQL server analysis services that delivers online analytical processing (OLAP) and data mining functionality. The database currently houses over 1.7 million encounters for more than 500,000 patients for over 250 physicians across multiple disciplines. SOCRATES outcome and resource utility reports present quantifiable information such as operating room (OR) time analyses including outliers, cost per admission or operating room time unit, volume-based data per operating surgeon and length of stay (LOS). Reports can be risk adjusted by all patient refined diagnosis related groups (APR-DRG) and Charlson comorbidity score. Standardized reports have been developed of which there are two main types: The first evaluates overall financial, operative, and clinical outcomes (►Fig. 2); the second details resources necessary to provide care in surgery (►Fig. 3) or overall for all departments (►Fig. 4).

These reports evaluate costs during the hospital stay, or within the operating room, and evaluate specific cost areas by type of expense, such as biologic, implantable, or fixed costs. Any other reports can be customized to support the needs of

Resource Utilization by Physician for General Surgery

Department: General Surgery

Division: ALL

Utilization Data

[illegible]

Fig. 3 Resource Utilization Report outlining implant and equipment use costs, risk-adjusted length of stay versus geometric mean, outliers, and readmissions, comparing results to geometric mean length of stay based on the Federal Register.

the user group in the hospital, whether looking at length of stay outliers, or readmissions for certain diagnoses or procedures. In each case, reports can be linked to aggregate data for a time period, physician, or group of physicians, with the ability to drill down to specific patient-level data.

Much of the ability of SOCRATES comes from its data warehousing and mining capabilities. Any encounter or procedure can be identified using a variety of queries specific to a department's reporting needs, such as CPT code, date range, or physician. Once a report is developed, information regarding the mean and median LOS with APR-DRG adjusted evaluations and geometric values for comparison, operative time, readmissions, hospital costs, total and contribution margins per admission or unit of time, as well as the outliers pertaining to any of the above can be provided. Outliers by length of stay, cost operative time, or morbidity can be further evaluated directly to identify the source of the anomaly,

which can then be addressed using case-specific process-control methodology. Resource utilization reports have the added advantage of evaluating specific baseline costs for an encounter such as implantable and biological costs. It is possible to either query by admission or discharge disposition or to identify these parameters in a given subset based on another specific query. These reports provide the means to monitor and analyze outliers and performance. They can then be further evaluated using industrial-style statistical process control methods, a key tool in the functioning of industry when determining where there is poor performance, service provision, consumer satisfaction, and margins.^{3,23-26}

Discussion

Currently, all U.S. hospitals are required to provide statistics (such as volumes of CPT and DRG codes) on all Medicare

Non-Surgical Resource Utilization by Physician for ALL

Department: ALL

Division: ALL

Utilization Data

[illegible]

ICD-9 Codes: 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.42, 428.43, 428.9

Fig. 4 Report generated by ICD-9 code specific for medical code groups, demonstrating similarities with outcome metrics for surgical outcomes sheets including volume, costs, length of stay, and readmission rate.

Resource Utilization by Physician for Colorectal

Date Range: 1/1/2011 - 6/30/2011

Department: General Surgery

Patient Type: Inpatient

Division: Colorectal

Utilization Data

	Volume	OR Time mean (median)	Chargeable Cost mean	Non Chrgble Cost mean	Implantable Cost mean	Biological Cost mean	Cost mean (median)	PICIS Cost mean (median)	LOS mean (median)	LOS w/o Outliers mean (median)
									5.6 (5.0)	4.3 (4.0)
									3.9 (3.0)	3.4 (3.0)
									5.2 (4.0)	4.1 (4.0)
									3.9 (3.0)	3.6 (3.0)
Total									4.5 (4.0)	3.7 (4.0)

a**Resource Utilization by Physician for Colorectal**

Date Range: 9/1/2011 - 2/12/2012

Department: General Surgery

Patient Type: Inpatient

Division: Colorectal

Utilization Data

	Volume	OR Time mean (median)	Chargeable Cost mean	Non Chrgble Cost mean	Implantable Cost mean	Biological Cost mean	Cost mean (median)	PICIS Cost mean (median)	LOS mean (median)	LOS w/o Outliers mean (median)
									4.0 (3.5)	4.0 (3.5)
									6.5 (2.0)	2.1 (2.0)
									5.4 (6.0)	5.4 (6.0)
									6.4 (4.0)	3.8 (3.0)
Total									5.7 (3.0)	3.4 (3.0)

b

Fig. 5 (a) Report of outcome/utilization data for sample 6 months without the use of transversus abdominal plane (TAP) block. (b) Report generated for 6 months with the use of the TAP block demonstrating reduction in length of stay.

patients. SOCRATES can facilitate the comparison of detailed demographics about a patients' entire encounter. This makes transparency of results easier, and allows for greater public awareness of performance and competence of local health care institutions. SOCRATES is able to generate details regarding LOS and comparisons with the geometric averages, which can be modified in a risk-adjusted manner. It can offer prospective analysis of operative times, recovery period time frames, and overall volume of cases and outcomes for the institution and health care systems. The data can easily be transformed into a weekly, annual, or biannual report with simplified terminology to act as a patient information booklet.

Departmental conferences such as morbidity and mortality meetings not only provide the means to utilize and evaluate the data that SOCRATES can provide, but they are also dependent on accurate, detailed information to evaluate particular cases and provide structured reports of any adverse incidents or failures in a process. SOCRATES can provide this type of information, structured in a variety of ways to suit the needs of any user group in the institution. Specifically, process control with SOCRATES has allowed evaluation of the use of transversus abdominal plane blocks (TAP) as an adjunct to our previously optimized ERP for colorectal surgery. Figures from sample-generated reports for 6 months

without the use of the TAP block and a subsequent 6-month period with its adoption demonstrate its effectiveness (**►Fig. 5**). We have been able to demonstrate a reduction in mean hospital stay from 3.7 days to less than 2.5 days.²⁷

Of course, not all institutions have the means to redesign their infrastructure, with meaningful modifications for most institutions being likely to involve expensive hardware and software, dedicated teams for setup, maintenance, and support and a change in the practice of information collection and management. Sweden has determined the need for coherent clinical and administrative data with accurate referencing and high-level semantic interoperability.²⁸ Quality metric data and IT assessment remains imperfect; it is fundamental for an institution or department to establish a benchmark of operations and provide the means for ongoing quality control and analysis.²⁹ Another institution in Cleveland, OH this year examined administrative and clinical data and two clinical data sources in four surgical morbidity outcomes. The disharmony between data due to mismatched definitions and data collection and management strategies again highlighted the need for concordance and standardization of information.⁵

We believe that with SOCRATES we have achieved the ability to focus on reproducible outcome measures such as LOS, costs and readmission rates, over which there can be some control.³⁰ These results can confer quality standards

against which similar departments and institutions can be compared. It is natural to draw comparisons in health care between a variety of other industries; it is therefore acceptable to expect to be able to adopt some of those industry control standards and achieve much greater efficiency in health care provision and limit errors and outliers.

The increasing computing hardware and database power available permits the review, management, and transfer of information with incredible ease and speed. To achieve this industry-standard quality requires the use of information technology to process large amounts of data quickly and accurately. Large corporations understand the need for good quality data to measure performance and optimize cost efficiency or profit. The company Apple Inc. has made such hardware available to the general public so that we now can personally organize and review all of our data, referencing our personal, media, or lifestyle information from one source (the "Cloud") to multiple devices. It would seem reasonable to expect the same abilities in an institution such as a large health care system, though it remains paramount to secure the data and ensure confidentiality.

Summary

"By their data, we shall know them"—with the steady adoption of ERP³¹ and minimally invasive surgery, the availability of the Internet, patient-centered care, and the financial implications of costly health care, it has never been more important to quantify performance. ERP can improve efficiency and effectiveness, which in turn can reduce costs associated with colorectal surgery. In one study, evaluating surgical warranties for better hospitals in colorectal surgery suggested a total cost reduction of 6%.³²

SOCRATES is a novel software solution that we have used to permit rapid evaluation of modifications in care for patients, with evaluation of quality parameters and health care efficiency metrics. Systems such as SOCRATES offer significant potential to positively impact the efficiency and quality of delivery of care across multiple health care systems, and for all medical and surgical specialties.

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