Integrating Six Sigma with Total Quality Management: A Case Example for Measuring Medication Errors

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EXECUTIVE SUMMARY

Six Sigma is a new management philosophy that seeks a nonexistent error rate. It is ripe for healthcare because many healthcare processes require a near-zero tolerance for mistakes. For most organizations, establishing a Six Sigma program requires significant resources and produces considerable stress. However, in healthcare, management can piggyback Six Sigma onto current total quality management (TQM) efforts so that minimal disruption occurs in the organization. Six Sigma is an extension of the Failure Mode and Effects Analysis that is required by JCAHO; it can easily be integrated into existing quality management efforts. Integrating Six Sigma into the existing TQM program facilitates process improvement through detailed data analysis. A drilled-down approach to root-cause analysis greatly enhances the existing TQM approach. Using the Six Sigma metrics, internal project comparisons facilitate resource allocation while external project comparisons allow for benchmarking. Thus, the application of Six Sigma makes TQM efforts more successful.

This article presents a framework for including Six Sigma in an organization's TQM plan while providing a concrete example using medication errors. Using the process defined in this article, healthcare executives can integrate Six Sigma into all of their TQM projects.

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Healthcare organizations are continuously challenged by both private and public sectors to reduce medical errors. The Institute of Medicine (IOM 2002) estimated that between 44,000 and 98,000 deaths occur each year as a result of medical errors. Medical errors cost an excess of between $17 and $29 billion. GE Medical Systems reported that over 69 percent of individuals are misdiagnosed or mistreated for low-back pain, while 31 percent of post-heart-attack patients receive improper medications and 30 percent of mammograms are incorrect (Ettinger 2001). The state of Missouri found that over 80 percent of pneumonia inpatients in the state do not receive the appropriate initial empiric antibiotic selection, that almost 90 percent of the state's atrial fibrillation inpatients do not receive antithrombotic at discharge, and that 76 percent of Missourians admitted for acute myocardial infarction do not receive early administration of aspirin (Grim 2001). To reduce the widespread trend of medical errors, the Department of Health and Human Services created the Agency for Healthcare Research and Quality; this organization has dedicated $165 million to patient safety research since its inception in 2001 (DHHS 2002; Clancy 2003). In addition, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO 2002a) has identified medical errors as a major issue.

MEDICATION ERRORS

An important class of medical errors that is receiving a lot of attention is medication errors. Medication errors often result in serious patient harm or death. A 1999 IOM report estimated that medication errors accounted for 7,000 deaths per year (Phillips et al. 2001). In 1995, JCAHO reviewed 1,541 adverse events, of which 178 were directly related to medication errors. Eighty-one percent of the adverse events (excluding patient suicide) resulted in death or loss of function to the patient (JCAHO 2002b). The Federal Drug and Alcohol Administration collected data on 5,366 medication errors during 1993 through 1998; of these, 78 percent resulted in serious patient outcome or death.

Existing TQM Efforts Fall Short

For more than a decade, U.S. hospitals have been adopting and implementing various total quality management (TQM) programs that have the potential for reducing medication errors. In fact, 89 percent of hospital organizations claim to have organizationwide efforts for improving the medication-use process (ISMP 2002). Despite such efforts, medication errors continue to be a serious and costly problem for hospitals and have become a leading area of concern in ongoing dialogs about healthcare safety. As Buck (1998) states, "Despite having the best physicians, hospitals, and medical equipment in the world, our health care system produces more errors than any of us think is acceptable."

The reason many medical-error reduction initiatives fall short may be, in part, the result of the focus of TQM programs. Although TQM encourages

data collection and analysis, it is often not implemented so as to produce the level of detail required to understand process variation. As a result, the development of sustainable improvement plans is difficult. For example, the staff at Aultman Hospital in Canton, Ohio, were generating over 75 graphs to analyze their operations. This exhaustive analysis allowed hospital administrators to answer most questions as they arose; however, the analyses were retrospective and slow at addressing potential problems (*Receivables Report for America's Health Care Financial Managers* 2000). Like most hospitals, Aultman's TQM efforts were not focused on concurrently understanding process variation and implementing change. The end result of such analysis for many hospitals is suboptimal quality improvement initiatives, as evidenced by the continued number of medical errors.

One quality movement that offers hope for significant improvement in the delivery of quality healthcare and in the reduction of errors is Six Sigma. Six Sigma is a relatively new quality approach that complements, embellishes, and expands TQM. The work of Six Sigma is not unlike TQM; however, its goals are more aggressive and its methods are better defined.

STUDY PURPOSE

The purpose of this research is to demonstrate the ease of integrating Six Sigma with existing TQM efforts and to provide a concrete example of Six Sigma's measurement scheme. Six Sigma does not have to replace existing hospital quality improvement plans, but it can be inserted into the infrastructure. The result is an approach to quality that includes traditional TQM methods as well as Six Sigma's deep-level data measurement, collection, and analysis, extensive employee training, and quality philosophy. In essence, Six Sigma can take TQM to the next level, a level with reduced medical errors and increased profitability.

Using medication errors as a case example, Six Sigma's measurement orientation is shown. The detailed example demonstrates the Six Sigma process, calculation of the Six Sigma levels, and the utility of such knowledge. It shows Six Sigma can be an excellent managerial tool for reducing medication errors because of its focus on identifying, analyzing, and monitoring errors.

SIX SIGMA

Six Sigma began in the 1980s as the in-house quality improvement plan for Motorola; it was implemented to accelerate the rate of change in the competitive marketplace. The approach has since grown into a multibillion-dollar effort adopted by many world-class companies. Both a methodology and a measurement, Six Sigma evaluates the capability of a process to perform defect free, where a defect is defined as anything that results in customer dissatisfaction. Six Sigma's breakthrough strategy combines improved metrics and a new management philosophy to significantly reduce defects, thereby strengthening a company's market position and improving the profit line (Harry and Schroeder 2000).

Six Sigma was greatly expanded and developed in the 1990s at General Electric and Allied Signal/Honeywell and has had a dramatic effect on the TQM programs of many companies in the business world. It involves designing, improving, and monitoring business activities to minimize or eliminate waste while optimizing customer satisfaction and increasing financial stability (Pande, Newman, and Cavanagh 2000). Six Sigma is customer focused and has the potential to achieve exponential quality improvement through the reduction of variation in system processes. Its early and ongoing focus on the customer aids in the acceptance of new processes (Thompson and Lewis 2002).

The notion of Six Sigma is derived from previous quality schemes in which a process was considered to produce quality results if 99.74 percent ($\pm 3\sigma$) of the products or attributes were within specification. This standard assumed that to have 0.26 percent or 2,600 out of 1 million attributes or products out of specification was acceptable. Although this standard is acceptable for many business processes, such as turnaround time and billing errors, it is unacceptable in most medical industries.

Six Sigma in Healthcare

Six Sigma's potential for reducing medical errors in the healthcare industry is great, but few healthcare organizations have implemented Six Sigma. Mount Carmel Health in Columbus, Ohio, was one of the first healthcare organizations to implement Six Sigma organizationwide. By end of 2001, more than 52 Six Sigma projects were in some phase of implementation at Mount Carmel. Its first project focused on timely and accurate Medicare+ Choice claims reimbursement. Process improvements attained through Six Sigma resulted in an $857,000 gain in net income (Lazarus and Butler 2001).

Virtua Health, a four-hospital system servicing southern New Jersey and Philadelphia, is a nonprofit integrated delivery system that began Six Sigma implementation in September 2000 to improve patient satisfaction and financial performance. Virtua Health has undertaken projects in nearly every aspect of its business. A Six Sigma congestive heart failure (CHF) team found that outcomes, lengths of stay, and treatment pathways were highly variable. Six Sigma was used to define the causes of variation, allowing the team to develop solutions that involved patients and families in the delivery of care. The CHF team was also able to streamline the process, resulting in a significant decrease in length of stay from 6.2 days to 4.6 days (Ettinger 2001). Virtua Health's Six Sigma projects also include improving patient satisfaction, operating room throughput, nurse retention, and reducing medication errors.

Other successful attempts at implementing Six Sigma in healthcare include those at Charleston Area Medical Center, Froedtert Memorial Lutheran Hospital, North American Medical Management–California (NAMM–Cal), Scottsdale Healthcare, and Wellmark, Inc. (see Table 1). Charleston Area Medical Center in Charleston, West Virginia, used Six Sigma to reduce the inventory of surgical equipment and related costs.

TABLE 1
Healthcare Organizations with Successful Six Sigma Projects

Organization	Project(s)	Outcomes	Achievements
Charleston Area Medical Center	Supply chain management for surgical supplies	Reduced inventory levels, improved supplier relationships	Savings: $163,410 immediate, $841,540 future
Commonwealth Health Corporation	Radiology	Decreased time between dictation and signature, reduced patient wait times, improved staff scheduling	Savings: $800,000 Additional savings: 14 positions eliminated, 25 percent increase in throughput
Froedtert Memorial Lutheran Hospital	Medication errors	Reduced clinically significant discrepancies for IV infusion	Savings: Discrepancies decreased from 15.8 to 2.9 percent
	Intensive care unit lab turnaround time	Reduced turnaround time on intensive care unit lab resets	Decreased time from 52 minutes to 23 minutes
Mount Carmel Health	Medicare+Choice Plan reimbursement	Redefined coding of working-aged Medicare recipients.	Profits: $857,000
NAMM-Cal	Identification of Medicare members admitted to a facility for over 30 days	Increased accuracy in identification for increased billing	Profits: In excess of $100,00 per year projected
Scottsdale Healthcare	Overcrowded emergency department	Reduced time to transfer a patient from the ER to an inpatient hospital bed	Profits: $600,000
Virtua Health	Congestive Heart Failure outcomes	Reduced variations in outcomes, length of stay, and treatments; improved quality and reduced length of stay from 6.2 to 4.6 days	In process
	Patient satisfaction	Improved satisfaction in the emergency room and medical/ surgical units	In process
	Operating room	Increased the number of cases per day	In process
	Nursing retention	Improved employee retention	In process

continued

Organization	Project(s)	Outcomes	Achievements
	Medication errors	Reduced number of errors in the use of high-risk medications	In process
Wellmark, Inc. (BC&BS Medical Plans)	Physician additions to managed care networks	Reduced amount of time for adding a physician to the BC&BS medical plans	Savings: $3 million/ year

Sources: Arndt 2002; Ettinger 2001; Lazarus and Butler 2001; Lazarus and Stamps 2002; *Managed Care Outlook* 2002; Simmons 2002

Through Six Sigma, more rapid turnover of inventory was made possible by negotiating with principal vendors. At Froedtert Memorial Lutheran Hospital in Milwaukee, Wisconsin, Six Sigma resulted in a tremendous decrease of clinically significant IV-infusion discrepancies. NAMM–Cal cut costs and increased revenue by undertaking almost a dozen Six Sigma projects. Scottsdale Healthcare in Scottsdale, Arizona, was able to reduce the amount of time its staff spent on finding a bed and transfering a patient out of the emergency room, creating increased capacity for the emergency department. Wellmark, Inc. in Des Moines, Iowa, used Six Sigma to shave administrative expenses by $3 million per year. All of the healthcare organizations implementing Six Sigma have noticed improvements in their profitability, either directly or indirectly, through a reduction in length of stay.

INTEGRATING SIX SIGMA WITH EXISTING TQM EFFORTS

One roadblock for implementing Six Sigma in healthcare organizations is their current use of TQM. Organizations have invested many years and dollars in establishing and promoting their current TQM efforts. TQM can serve as a significant deterrent to beginning anew with Six Sigma. Fortunately, many of the Six Sigma tenets and models can be integrated with existing TQM infrastructures, thereby allowing healthcare organizations to seamlessly adopt and use Six Sigma ideas, techniques, and philosophies more rapidly and effectively for process improvement. Thus, Six Sigma does not have to replace other TQM efforts but can be used to complement, embellish, and strengthen such programs.

TQM is an approach to quality management that focuses on processes, recognizes both the internal and external customers, and promotes the need for objective data to analyze and improve processes. One of the difficulties surrounding TQM initiatives is measurement. TQM teams must establish criteria for assessment, develop a means for surveillance to identify deviations, and minimize the occurrence of deviations (Longest, Rakich, and Darr 2000). Although doing this appears easy in theory, it is difficult to

practice for many projects. However, one of the strengths of Six Sigma is its focus on measurement, so Six Sigma can provide the needed metrics often lacking from TQM projects.

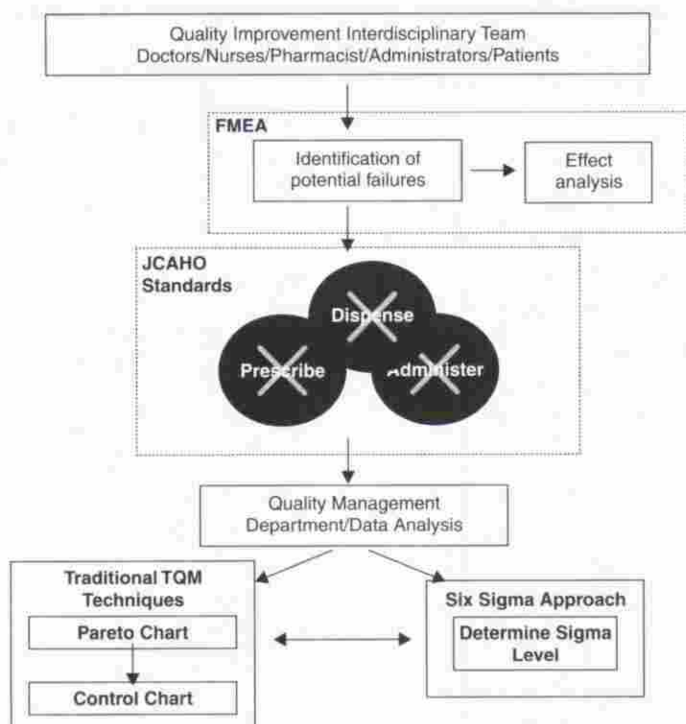
Six Sigma's focus on measurable and sustainable methods and rigorous statistical techniques complements existing TQM projects that are based on unproven assumptions or questionable data. Six Sigma's evidence-based approach to improvement often provides TQM teams with tremendous insight. For example, quality teams at both the University of Virgina Health System (UVa) and Virtua Health found surprising results when they used a Six Sigma data-driven approach. UVa found that "one of the most interesting aspects of this endeavor [Six Sigma] is the fact that initial assumptions about problem causes can be wrong. Using the Six Sigma model, the team identified the root cause of problems through data collection and analysis that were a surprise" (Thompson and Lewis 2002). The Six Sigma team of Virtua Health was able to demonstrate that "the use of an injectable form of heparin, which was more expensive than the IV medication, was actually less expensive and safer to use in the long run because less nursing time and fewer tests were needed" (Simmons 2002).

Six Sigma's defined metrics, deep-level data collection, and statistical training are beneficial to TQM. The metric system provides measures that can be used to develop improvement initiatives, compare projects, and allocate resources. Deep-level data collection expands process understanding, identifies the root cause of system failures, and targets areas for improvement. Statistical training encourages TQM teams to think about processes and process variation, with the goal of minimizing opportunities for process failures. Together, Six Sigma and TQM can make huge strides in reducing medical errors.

Framework

Integrating Six Sigma into the existing TQM infrastructure should be easy for most hospitals. Many of the tenets of Six Sigma are integral parts of TQM (see Figure 1). Quality improvement interdisciplinary teams are commonly used for TQM initiatives. Using the existing teams, opportunities for failure can be identified through the Failure Mode and Effects Analysis (FMEA) process. The FMEA process allows the team to work together to determine all potential failures that may occur and their effect on the patient, staff, and system. Those failure opportunities that are realistic and cause problems should be used in the Six Sigma computations (as demonstrated in the case example presented below). Appropriate failure opportunities can be grouped using JCAHO standards. This provides documentation of improvement initiatives during a JCAHO site visit. Typically, the quality management department assumes responsibility for creating the necessary system (computer or paper) to document failures. At a defined interval, the failure data are compiled and analyzed using both traditional TQM techniques (e.g., Pareto charts, control charts) and Six Sigma. Thus, determination of the Six Sigma level

FIGURE 1
Integrating Six Sigma with Existing Quality Improvement Efforts



little time and limited additional data collection. It requires little time and limited additional data collection.

MEDICATION ERROR CASE EXAMPLE

A case example using the average number of medication errors in a typical hospital demonstrates both the ease of TQM and Six Sigma integration and the utility of the Six Sigma measurement scheme. Medication errors that result in patient harm or death are the focus because this is an issue for most hospitals. Annualized data were obtained on the average number of inpatient medication errors, filled prescriptions, and medication administration. These values were applied to a typical hospital by determining both the average number of inpatients annually and their average length of stay. The case example demonstrates Six Sigma's expansion of existing TQM efforts.

Methodology

Medication errors and opportunities for medication errors must be defined for the purpose of computing Six Sigma levels. Errors and opportunities can be classified into three categories: prescription errors, dispensing errors, and administering errors. Prescribing errors include, but are not limited to, the following four opportunities for error: drug-knowledge deficit, miscalculation of dosage, poor oral commu-

nication, and poor written communication. Dispensing errors include, but are not limited to, the following four opportunities for error: misinterpretation of order, name confusion, poor labeling, and poor packaging and design. Administering errors include, but are not limited to, the following five opportunities for error: wrong time, inappropriate dosage (including omission), incorrect drug, improper route of administration, and wrong patient (Phillips et al. 2001; Mullins 2002). Table 2 summarizes the various potential opportunities for error in hospital medication.

Previous studies have determined that, on average, a hospital has 225 medication errors per year that result in patient harm (Pallarito 2002). Of these, less than 1 percent result in death (Pallarito 2002; Mullins 2002). It is highly likely that the number of medication errors that occur but do not result in patient harm or death is much larger; however, most of these near misses are unreported. This study focuses solely on errors resulting in direct harm or death to the patient.

Six Sigma uses a ratio of the number of realized errors to the number of opportunities that exist for error. For medication errors the ratio is as follows:

$$\text{Medication Error Ratio} = \frac{\textit{Number of Medication Errors}}{\textit{Number of Opportunities for Error}}$$

This ratio is used to compute the percentage of items "in compliance," which, in turn, is used to determine the sigma level.

Medication Errors Data

Approximately, 35 percent of all medication errors are the result of prescribing errors, 30 percent are caused by dispensing errors, and 35 percent are due to administering errors (Phillips et al. 2001; Mullins 2002). If a typical hospital has 225 total medication errors per year, the application of these percentages results in 79 medication errors in the area of prescribing, 67 errors in dispensing, and 79 in administrating medications. These values—79, 67, and 79—represent the numerator in the Six Sigma level calculation (shown above) for each of the three types of medication errors.

Six Sigma levels can also be calculated for medication errors resulting in patient death. Conservatively, it can be assumed that of the medication errors causing patient harm, one-half of 1 percent result in patient death. Therefore, 1.125 patient deaths occur annually per hospital (225 errors × 0.5 percent). These deaths can be attributed to the same three error classifications—that is, prescribing, administering, and dispensing. Applying the same probabilities as above results in 0.39 deaths annually due to a prescribing error, 0.34 deaths due to a dispensing error, and 0.39 deaths due to an administering error. These values are the numerators for computing the sigma level.

Opportunities for Medication Errors Data

Calculating opportunities for medication errors within each of the three categories (prescribing, dispensing, administering) begins with determining the number of patients admitted

TABLE 2
Medication Error Opportunities

Error Classification	Opportunity for Error
Prescription errors	Drug-knowledge deficit
	Miscalculation of dosage
	Poor oral communication
	Poor written communication
Dispensing errors	Misinterpretation of order
	Name confusion
	Poor labeling
	Poor packaging and design
Administration errors	Wrong time
	Inappropriate dosage
	Incorrect drug
	Improper route of administration
	Wrong patient

annually. Florida hospitals' discharge data revealed that approximately 9,000 admissions occur annually with an average length of stay of 5.3 days (State of Florida 1997). Four potential prescribing errors exist, including drug-knowledge deficit, miscalculation of dosage, poor oral communication, and poor written communication, and the average patient receives five prescriptions during their hospital stay, resulting in 20 prescription error opportunities per inpatient stay. With 9,000 inpatients, there are 180,000 opportunities annually for an order to become a medication error (5 orders × 4 potential errors × 9,000 inpatients). This value—180,000—is the denominator for computing the Six Sigma level of prescribing errors.

Consider next dispensing errors, as each ordered medication is dispensed daily. Assuming an average length of stay of 5.3 days, 26.5 medications are dispensed per patient (5 orders × 5.3 days). Each time a medication is dispensed, up to four potential errors can occur, including misinterpretation of order, name confusion, poor labeling, and poor packaging and design. With 9,000 patients annually, there are 954,000 opportunities for dispensing errors per year (5 orders per day × 5.3 days × 4 potential errors × 9,000 patients). This value—954,000—is the denominator for computing the Six Sigma level of dispensing error.

With respect to administering medications, the average patient receives 12 medications per day, presenting up to five potential errors for each administration ranging from wrong time, to

inappropriate dosage (including omission), to incorrect drug, to improper route of administration, to wrong patient (Mullins 2002). Thus, each day a patient faces 60 opportunities for a medication administration error to occur. With a length of stay of 5.3 days and an average of 9,000 inpatients, there are 2,862,000 opportunities for administering errors (12 medications per day × 5 potential errors × 5.3 days × 9,000 patients). This value—2,862,000—is the Six Sigma level denominator for administration errors.

Results

For each type of error, the quotient of the numerator and denominator produces the Six Sigma ratio. Seventy-nine prescribing errors are determined to occur annually out of 180,000 potential opportunities for prescribing failures; thus, the Six Sigma ratio for prescribing errors is 0.000439 (79/180,000). Of the 954,000 dispensing failure opportunities, 67 errors that result in patient harm occur; this results in a Six Sigma ratio for dispensing errors of 0.000070 (67/954,000). The average hospital administers 2,862,000 medications annually, yielding 79 errors that result in patient harm; the Six Sigma level for administering errors is 0.000028 (79/2,862,000).

Each of the Six Sigma levels is easily converted to the number of medication errors per million opportunities, or "defects per million" as referred to in the Six Sigma conversion table (see Appendix 1). For prescribing, the example hospital has 439 medication errors per 1 million error opportunities, yielding a Six Sigma level of 4.7. The example hospital has 70 dispensing errors per 1 million error opportunities, yielding a Six Sigma level of 5.4. For administering, the example hospital has 28 errors per 1 million opportunities, yielding a Six Sigma level of 5.5. Analyzing the Six Sigma level for each area of medication errors shows that our example hospital is operating at a high (good) Six Sigma level (see Table 3).

Ideally, the hospital will seek to achieve a level of Six Sigma—that is, to have no more than 3.4 medication errors per 1 million opportunities. Comparing Six Sigma level for each area of medication errors shows that more errors occur per opportunity in prescribing. Improvements in the area of medication prescribing will reduce medication errors and improve the Six Sigma level for prescribing error. The Six Sigma ratio can also be computed for medication errors that result in patient death. Assuming 0.39 deaths occur annually as a result of a prescribing error and there are 180,000 failure opportunities, the Six Sigma level for prescribing errors that cause patient death is .0000022, or 2.2 deaths per million. The Six Sigma ratio for dispensing errors that cause patient death is .000000035, or .35 per million. This is based on 0.34 dispensing-error–related deaths per year and 954,000 annual dispensing-failure opportunities. For administering errors, 0.39 deaths are estimated to occur annually and 2,862,000 opportunities for failure exist (annually). Thus, the Six Sigma level of administering error deaths is .00000011, or .11 per million. All of these Six Sigma ratios represent a sigma

TABLE 3
Medication Errors Case Example

Error Classification	DPMO[*]: Patient Harm	Sigma Level: Patient Harm	DPMO: Patient Death	Sigma Level: Patient Death
Prescription errors	439	4.7	2.2	6.0+
Dispensing errors	70	5.4	0.35	6.0+
Administration errors	28	5.5	0.11	6.0+

[*]Defects per million opportunities

level that is greater than six. Thus, for medication errors contributing to patient deaths, the example hospital is operating at a Six Sigma level.

MANAGERIAL IMPLICATIONS

For decades, healthcare organizations have implemented TQM programs to increase quality, improve patient satisfaction, and enhance financial performance. Although these organizations realized notable successes initially with TQM, today's TQM programs are often compliance driven rather than quality improvement driven. Integrating Six Sigma with existing TQM programs returns the focus to process improvement through root-cause analysis. Healthcare management can attach Six Sigma onto current TQM efforts, causing minimal disruption and cost to the organization. The Six Sigma methodology reduces errors and thereby improves quality through its distinctive metric approach.

Six Sigma's data measurement methodology is the impetus for healthcare organizations to rethink their approach to problem analysis. Its focus on concurrent process analysis requires virtually every component of every service to be reported, measured, and recorded on a regular basis. Using the detailed data, healthcare organizations can better study their processes and implement a drill-down approach to improvement. Existing TQM tools, such as Pareto and control charts, may be the first step for such a drill-down approach. Without the detailed data required by Six Sigma, however, root-cause analysis is difficult. Thus, Six Sigma's metric approach refocuses the organization on the original objective of TQM—that is, process improvement.

Integrating the Six Sigma metrics with TQM also provides a measure of comparability that can be used to facilitate process improvement. Hospitals can use the Six Sigma metric to compare internal projects as well as develop external benchmarks. Internal project comparisons can be used for resource allocations by identifying high-need projects. The identification of benchmark performers and their processes will encourage shared knowledge and ultimately improved processes.

CONCLUSION

Six Sigma is a new management philosophy that extends TQM efforts by using

detailed metrics to identify and eliminate process variation. Manufacturing and engineering operations have shown Six Sigma to be a successful strategy for reducing errors and improving efficiencies. The question involving the use of Six Sigma in healthcare is whether or not healthcare managers can mimic its success and at what cost. This research demonstrates that integrating the metrics of Six Sigma with existing TQM programs can improve quality without significantly increasing costs.

This article presents a framework for including Six Sigma in an organization's TQM plan as well as provides a concrete example using medication errors. The Six Sigma approach fosters constancy of purpose by refocusing the organization on the ultimate TQM goal of high quality. Six Sigma's measurement scheme allows detailed root-cause analysis that uses a concurrent approach rather than the retrospective complaint approach typical with TQM. Furthermore, Six Sigma data can be used to identify improvement opportunities, benchmark with peer hospitals, and objectively monitor and assess hospital performance. In essence, Six Sigma can take TQM to the next level, a level focused on process improvement in quality and service.

References

Arndt, M. 2002. "Where Precision is Life or Death." *Business Week* 3792: 72–74.

Buck, Jr., C. R. 1998. "Health Care Through a Six Sigma Lens." *Milbank Quarterly* 76 (4): 749–54.

Clancy, C. M. 2003. "Supporting a Culture of Continuous Quality Improvement in Hospitals and Other Health Care Organizations," Testimony on Patient Safety Before the Senate Permanent Subcommittee on Investigations, Committee on Governmental Affairs, June 11. [Online information; retrieved 9/18/03.] http://www.ahrq.gov/news/tst61103.htm.

Department of Health and Human Services (HHS). 2002. "2001.10.11: HHS Announces $50 Million Investment to Improve Patient Safety" [Online information; retrieved 3/28/02.] http://www.hhs.gov/news/press/2001pres/20011011.html.

Ettinger, W. 2001. "Six Sigma Adapting GE's Lesson to Health Care." *Trustee* 54 (8): 10-16.

Grim, S. A. 2001. "Six Sigma Business Strategy Aims at Improving Quality of Care." *Journal of Health Care Compliance* 3 (3): 73-75.

Harry, M., and R. Schroeder. 2000. *Six Sigma*, 108-15. New York: Doubleday Publishers.

Institute of Medicine (IOM). 2002. "Guidance on the Collection of Patient Safety Data." Display/HCSX-H-01-05-A. [Online information; retrieved 3/28/02.] http://www4.nas.edu/webcr.nsf/Projectscope.

Institute on Safe Medication Practices (ISMP). 2002. "ISMP Survey Shows Weaknesses Persist in Hospital's Error Detection, Reporting and Analysis." [Online information; retrieved 9/05/02.] http://www.ismp.org/MSAarticles/Reporting Survey.html.

Joint Commission on Accreditation of Healthcare Organizations (JCAHO). 2002a. "Patient Safety." [Online information; retrieved 3/25/02.] http://www.jcaho.org.

———. 2002b. "Sentinel Events." [Online information; retrieved 3/18/02.] http://www.jcaho.org/sentinel/sestats.html.

Lazarus, I. R., and K. Butler. 2001. "The Promise of Six Sigma." *Managed Healthcare Executive* 11 (9) : 22–26.

Lazarus, I. R., and B. Stamps. 2002. "The Promise of Six Sigma." *Managed Healthcare Executive* 12 (1) : 27–30.

Longest, Jr., B., J. Rakich, and K. Darr. 2000. *Managing Health Services Organizations and Systems*, 4th edition, 407–12. Baltimore, MD: Health Professions Press.

Managed Care Outlook. 2002. "Six Sigma Techniques Help Improve Claims Processing." *Managed Care Outlook* 15 (14): 3.

Mullins, C. 2002. Personal Interview, August 14, 2002.

Pande, P. S., R. P. Newman, and R. R. Cavanagh. 2000. *The Six Sigma Way*, 3–18. New York: McGraw-Hill.

Pallarito, K. 2002. "US Hospitals Repeat Same Medication Errors: Report." [Online information on *Health News* web site; retrieved 9/05/02.] http://12.42.224.152/healthnews/reuters/NewsStory0521200210.html.

Phillips, J., S. Beam, A. Brinker, C. Holuist, P. Honig, L. Y. Lee, and C. Pamer. 2001. "Retrospective Analysis of Mortalities Associated with Medication Errors." *American Journal of Health-System Pharmacy* 58 (22): 2130.

Receivables Report for America's Health Care Financial Managers. 2000. "Management Strategy Proves Effective in Patient Financial Services." *Receivables Report for America's Health Care Financial Managers* 15 (12): 11–13.

Simmons, J. C. 2002. "Using Six Sigma to Make a Difference in Health Care Quality." *The Quality Letter* 14 (4): 2–11.

State of Florida. 1997. Discharge Database for State of Florida, retrieved from The University of South Florida, August 2002.

Thompson, P., and M. Lewis. 2002. "UVa Compliance Department Uses Six Sigma Model to Improve Performance." *Journal of Health Care Compliance* 4 (5): 19–24.

Appendix 1

Six Sigma Conversion Table

Yield (%)	Defects per Million Opportunities	Sigma
6.68	933200	0
8.455	915450	0.125
10.56	894400	0.25
13.03	869700	0.375
15.87	841300	0.5
19.08	809200	0.625
22.66	773400	0.75
26.595	734050	0.875
30.85	691500	1
35.435	645650	1.125
40.31	598700	1.25
45.025	549750	1.375
50	500000	1.5
54.975	450250	1.625
59.87	401300	1.75
64.565	354350	1.875
69.15	308500	2
73.405	265950	2.125
77.34	226600	2.25
80.92	190800	2.375
84.13	158700	2.5
86.97	130300	2.625
89.44	105600	2.75
91.545	84550	2.875

continued

Yield (%)	Defects per Million Opportunities	Sigma
93.32	66800	3
94.79	52100	3.125
95.99	40100	3.25
96.96	30400	3.375
97.73	22700	3.5
98.32	16800	3.625
98.78	12200	3.75
99.12	8800	3.875
99.38	6200	4
99.565	4350	4.125
99.7	3000	4.25
99.795	2050	4.375
99.87	1300	4.5
99.91	900	4.625
99.94	600	4.75
99.96	400	4.875
99.977	230	5
99.982	180	5.125
99.987	130	5.25
99.992	80	5.375
99.997	30	5.5
99.99767	23.35	5.625
99.99833	16.7	5.75
99.999	10.05	5.875
99.99966	3.4	6

Source: Pande, Newman, and Cavanagh 2000

PRACTITIONER APPLICATION

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For decades, healthcare organizations have relied on TQM techniques to provide process improvement. Although the results of many TQM efforts have been successful, large gaps remain between the current level of healthcare quality and the desired level of healthcare quality; this is particularly true for medication errors. This article demonstrates how Six Sigma, a new management tool that seeks a nonexistent error rate, can be used in reducing medication errors.

Six Sigma is new to the healthcare industry and its value and application are not fully understood. The authors present a concrete example of how a hospital can easily integrate Six Sigma into existing quality management efforts by using JCAHO's Failure Mode and Effects Analysis and previously collected data. Furthermore, the reader is shown the computational ease of determining sigma levels using data that can be easily collected by any hospital. JCAHO categorizes the medication processes into three areas: prescribe, dispense, and administer, and this article analyzes the sigma level for each of these processes independently. The authors suggest using existing multidisciplinary teams to identify opportunities for failure and previously developed data-collection tools for counting errors. The integration of Six Sigma is facilitated by the ability to use established (and existing) quality improvement techniques. Although each hospital has its own set of measures, the authors use an average hospital to demonstrate the continuum of a Six Sigma project. Not only does this allow the practitioner to view all of the needed steps, but it gives the practitioner ideas on how to begin to apply Six Sigma. The use of actual data also shows the steps necessary to compute the sigma levels.

How to use the sigma levels to identify opportunities for improvement, allocate resources, and track successes is also addressed. The authors thoroughly explain the administrative advantages of having one indicator, the sigma level. Not only is the sigma level advantageous when comparing intrahospital projects, it is also advantageous when comparing hospitals across a system or throughout the industry.

In summary, Six Sigma's measurement orientation and goal of a near-zero error rate adds tremendous value to an organization's existing quality improvement efforts. The quantitative measure of Six Sigma yields a relative comparison that healthcare practitioners can use for tracking both the progress and success of quality improvement projects. Overall, Six Sigma will assist management in resource allocation for TQM projects, facilitate the reporting process, and presumably contribute to more successful quality improvement endeavors.