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The art of performance improvement at Yale-New Haven

Six Sigma effort paying dividends for CT hospital

Fifteen new "Green Belts" walk around Yale-New Haven Hospital in New Haven, CT, using their skills to attack and subdue deviates. But these Green Belts are not the martial arts kind -- they are trained in the art of using data to identify problems and improve hospital performance.

Yale-New Haven Hospital is working with GE Medical Systems of Waukesha, WI, to apply the Six Sigma quality improvement process to health care. Six Sigma is a statistical methodology that has been used widely by General Electric to identify and remove deficiencies from its manufacturing and business processes. GE is now showing other companies how to achieve similar improvements in their own industries.

At GE, experts in the use of the Six Sigma process are known as Black Belts. They lead performance improvement projects and teach coworkers how to collect and analyze data. Once a beginner has been trained, he or she is known as a Green Belt.

Several Six Sigma quality improvement projects have been initiated as part of training the Green Belts at Yale-New Haven Hospital. Because of the improvements identified through Six Sigma, calls to schedule radiology procedures are being answered more quickly, there are fewer infections among ICU patients, and nurses working in the operating rooms scramble for equipment less frequently. The effort has worked so well that the hospital has signed a three-year contract to train another 35 staff members and expand the use of Six Sigma in the facility.

"We're trying to get this disseminated throughout the institution and make this the way we work," says **Richard Stahl**, MD, associate chief of staff at Yale-New Haven Hospital. "We're also going to train our executives in Six Sigma. The goal

Six Sigma helps to clarify issues and costs

Not only can the Six Sigma methodology be used to get to root problems in health care delivery, but it can help give administrators a better understanding of the opportunity costs associated with not making changes, says **Bradley Schultz**, a master black belt/consultant at GE Medical Systems.

For example, the turnaround time for a report in a radiology department may be 48 hours with a standard deviation of 48 hours, but the customer expectation is having a report within 24 hours. Using Six Sigma, it was determined that radiologist behavior contributed 50% to the overall process variability.

Health care organizations may be reluctant to take on aspects of physician behavior, but the Six Sigma analysis shows what the organization would be missing by not changing the way the doctors practice. "Unless we take on that dynamic, that means that 50% variability stays in the process, regardless of what else we do," says Schultz.

Managers can use the results of a Six Sigma analysis to weigh whether difficult changes must be undertaken, he continues. "For instance, a very common example is an academic institution that struggles with balancing its desire to educate and its medical mission," he says. Because of the dual role of academic medical centers, there might be a wide variation in how heart attack patients are treated.

"If we are able to standardize and decrease that variability we can get a more predictable process. But that kind of runs contrary to the educational mission. So in that case we at least have the ability to understand the opportunity costs associated with the degree of latitude that we take on in the educational mission, versus the degree of standardization that we're trying to achieve in a competitive market environment," says Schultz.

is to be self-sustaining and be able to do all of this on our own."

Practical application

At Yale-New Haven Hospital, the theory of Six Sigma has been put to practical use in both the administrative and clinical areas.

One of the places where the hospital applied Six Sigma was improving its ability to field calls for scheduling MRI and other radiological exams. The hospital's staff was having trouble answering all of the calls in a timely manner, says Stahl. Callers typically got a recording and had to wait a long time on hold to talk to a scheduler, he says, and often they hung up before a scheduler could come on the line.

"We've been concerned about the level of service in that regard and loss of business," says Stahl.

The Six Sigma project involved data collection and using fishbone diagrams to discover "some of the critical factors causing the deviation from our desired performance in this area," he says. The fishbone diagram also is known as a cause-and-effect diagram. It is used to explore all the potential or real causes that result in a single effect or output. This helps managers search for root causes of adverse events.

The quality improvement team determined that callers had to be able to speak to a live scheduler within 30 seconds, or else the interaction was considered a defect. Data gathered from the telephone company included call abandonment rates, call volumes, and the length of time callers spent on hold at various times of the day. Schedulers were also asked to complete logs on how they were spending their time during the day.

Problems and solutions

The various pieces of data were compared to identify mismatches between call volume and staffing levels. "A lot of it turned out to be some simple things that the folks responsible for making the decisions didn't even realize," says Stahl.

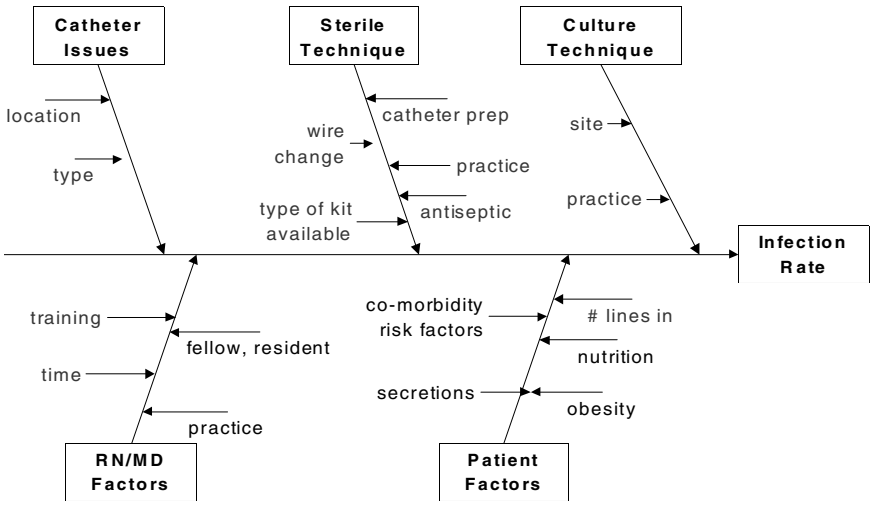
For example, the team determined that schedulers were spending a lot of time giving out directions to the radiology facilities and one of several different parking lots.

Schedulers "were spending as much as an hour and a half doing that out of an eight-hour shift. We certainly thought that wasn't a good use of time. We'd rather have them scheduling more exams," he says.

Once the problem was diagnosed, the team was able to devise several straightforward solutions. Schedulers now forward calls to an automated direction line that the hospital operates as soon as they are done booking the exam. "We're also working on narrowing down the selection of parking lots, ideally to one. We're not quite at that point, but we're pretty close to being able to eliminate that whole process step," says Stahl.

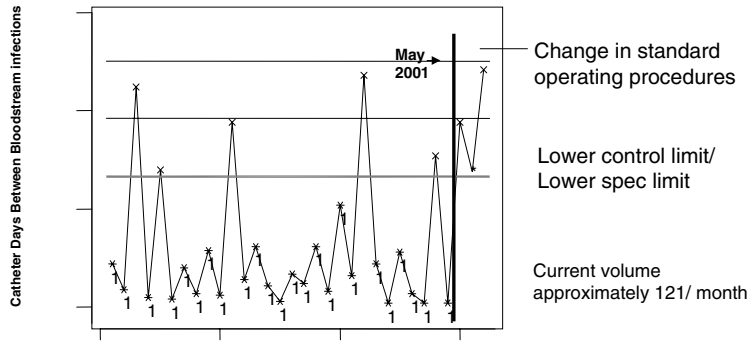
Another important improvement has been making data on telephone traffic available on a real-time basis, he adds. That allows a supervisor to determine when call volume is increasing and the call abandonment rate is going up. "So now from minute-to-minute or hour-to-hour our super-

Figure 1: What contributes to infections?



Source: Yale-New Haven Hospital, New Haven, CT.

Figure 2: Control Chart for Central Lines January '00 to October '01



3 data points in a row above the LCL/LSL are the first indications of sustain becoming visible

Source: Yale-New Haven Hospital, New Haven, CT.

visor can actually look at the call abandonment rate or the volume of calls coming in and know when to just immediately flex up and get someone else in there answering the calls."

Real-time data allow staffing to be planned better, he says, to handle calls during lunch and at peak times. "That eliminates a lot of the predictable variation," Stahl says.

As a result of the Six Sigma project, call abandonment rates that were running at between 60% and 80% have been lowered to 30% or less.

Clinical improvement

In the clinical area, the Yale-New Haven staff identified reducing the number of hospital-acquired

Six Sigma Explained

Six Sigma has its roots in the language of statistics. "Sigma" is the Greek letter that in statistics defines a standard deviation from the norm. In Six Sigma, higher sigma numbers correspond to fewer defects. At the Six Sigma level, there are only 3.4 errors per million opportunities, which is nearly error-free.

Striving toward the Six Sigma level involves five steps:

- defining a problem;
- measuring what is important;
- using statistical analysis to find the root causes of variation in performance;
- working together as a team to develop improvements and implement those changes;
- sustaining those improvements over time.

Using Six Sigma in a health care environment has at least two major benefits, says **Bradley Schultz**, a master black belt/consultant at GE Medical Systems. The first is that it more accurately than other QI strategies describes the performance of health care organizations.

"Think of almost any metric that a health care organization is driven by and you'll find that the metric is some type of average: cost per unit of service; worked hours per procedure. What health care has missed for a while is taking into consideration the impact of variability, especially when it comes to service-level metrics. Rarely do patients ever feel the average performance of an organization. They feel the variability."

For example, patient wait time is usually measured in the average number of minutes it takes to see a clinician. But there's a significant difference between an institution that has a 10-minute average wait with a 2-minute standard deviation, and an institution with a 10-minute average wait with a 30-minute standard deviation. In the first case, patients may only experience a wait of between 6 and 14 minutes, whereas in the second case, the longest wait may be an hour and a half.

The goal of Six Sigma is to reduce the range of that variation so the results are more uniform and there are fewer incidents of poor performance.

The second advantage of Six Sigma, Schultz says, is that most clinicians respond well to data. "By using a methodology like Six Sigma to gain an understanding of what drives variability in an organization, we have a much stronger platform when it comes to creating the need for change in an organization."

Six Sigma was born in a manufacturing environment, where it is used to ensure that production line processes meet specifications. But Schultz says it can be very useful in a human process like health care as well, where the causes of variability are more subtle.

"Really it becomes more of a matter of how you use the data and the analytics to drive behavior, as opposed to set feeds and speeds on a machine," he says.

To find variation in health care, Six Sigma looks at four different types of metrics: service level, service cost, customer satisfaction, and clinical excellence. The metrics are expressed in the following questions, he says:

- What are you doing?
- How well do you do it?
- Are your customers happy with it?
- Are you actually improving the quality of people's lives?

Six Sigma uses a capability analysis, similar to one used in manufacturing, to determine the probability that a process will produce results that are unacceptable to the customer, he says. The aim is to set specifications for service-level parameters, and to ensure that the organization is delivering results within those limits.

"In other words, if we set an upper specification limit of 15 minutes for patient wait time in a radiology department, we want to make sure that not only is the average below 15 minutes, but the tails of the curve that extend beyond the average are also inside of that specification limit," Schultz says.

Six Sigma can be viewed as a journey, he continues. At the end of the journey is the Six Sigma level of quality, where six standard deviations can fit between the mean and the specification limit (hence the name Six Sigma). If that could be achieved, the probability of failing to meet customer expectations is 3.4 in 1 million. But Schultz says for health care organizations reaching that destination is less important than taking the trip.

"I think what's more critical for health care institutions is to get an accurate baseline of where they are, and then gain an understanding of what drives that variability, then understand whether those factors are controllable or not controllable," he says. The objective should be to "leverage the controllable factors to pull the tail end of that curve in as far as we possibly can."

Service indicators

Because much of health care involves customer service, the Six Sigma methodology breaks service down into three main indicators:

- access to service;
- service cycle time;

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blood stream infections in an intensive care unit as an important quality improvement project.

"There had been different opinions among the medical staff as to how to do that, what the issues were. We began to collect data on our blood stream infections and got people to come together and discuss the issues and to agree that it was important to do this," says Stahl.

Using the Six Sigma methodology, team members mapped out all of the processes involved and developed fishbone diagrams to determine the various causes of infections. Each of the six oblique lines in **Figure 1** describes a potential source of infection that contributes to the measure of interest, the infection rate. Team members collected data on the incidents of infection, the types of intravenous catheters being used in the ICU, and how they were being inserted.

"We realized that there was some variation in terms of the way that some of these catheters were inserted or changed. There was also variation in terms of how they were cared for once they were in place," says Stahl.

Figure 3: Central Line-Associated BSI Rate

Type of ICU	No. of Units	Central Line-Days	Pooled Mean	Percentile				
				10%	25%	50% (median)	75%	90%
Coronary	105	199,108	4.9	0.0	1.7	4.7	6.7	10.0
Cardiothoracic	45	285,207	2.8	0.0	1.0	1.8	3.1	4.3
Medical	124	462,000	6.1	0.0	3.6	5.3	7.3	10.2
Medical/Surgical	220	828,642	4.5	1.0	2.4	4.6	6.3	7.9
Neurosurgical	41	91,985	5.4	1.5	2.7	4.4	7.8	9.3
Pediatric	63	216,095	8.0	1.8	4.6	7.1	10.1	13.6
Surgical	142	717,788	5.7	1.2	2.5	4.9	7.0	9.0
Burn	16	19,433	12.8	.	.	.	.	.
Respiratory	7	12,528	4.1	.	.	.	.	.
Trauma	19	83,951	7.0	.	.	.	.	.

Source: CDC, Atlanta.

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• cycle time associated with results reporting.

Indicators can be developed to show how well each department is providing service. For example, in the radiology department, one measure might be patient and referring physician dissatisfaction with access to service. Other indicators might be the number of reports backlogged or employee dissatisfaction with the workload.

The Six Sigma team completes a baseline assessment to determine how well the system is performing, Schultz explains. "In performing a baseline, we would go out and measure these things objectively, gain an understanding of our measurement system's capabilities, and then summarize the results."

Once the issues affecting service are understood, the data are used in what GE calls a "Work-Out" session between all the parties involved. The meetings are generally led by those closest to a process or issue. The goal is to find workable solutions and develop action plans for eliminating unnecessary steps or streamlining tasks.

"We use the baseline assessment and get that information in front of the key stakeholders associated with that process, and then facilitate a discussion on what areas of attack will lead to the greatest ROI for the institution," says Schultz.

Return on investment doesn't necessarily translate into hard dollars, he emphasizes, as some institutions would rather improve service levels than create financial gains.

Much of the data needed for Six Sigma analyses can be found in hospital information systems, he says. "There is actually a tremendous amount of data that is in the hospital's systems that really is just waiting to be liberated and utilized. One of the first things we would do for performing a baseline measurement is to understand what data is available systemically, and what data we may have to collect on our own."

But just because data are available in a hospital's system doesn't mean they are good, he says. To determine what can be used, the Six Sigma team measures how much statistical error is in the data. If there is a lot of error, it becomes hard to determine the source of variation, Schultz explains.

The Six Sigma analysis always draws from existing data first, he says, but if there is too much error present, then the team must collect its own data. Schultz estimates that 40% of the time existing data from hospital systems can be used, and the other 60% of the time the team has to perform its own measurements.

GE Medical Systems has developed a standardized set of data collection tools to minimize the amount of statistical error that is introduced into the process, he says. The company also has a large amount of benchmarking data to use in comparison, especially around cost and productivity issues, Schultz adds.

Once the data have been collected, the Six Sigma team uses various statistical tools such as analysis of variance (ANOVA) and regression to explore the underlying reasons for defects. "If you are able to quantify the drivers of variability, you put yourself in a position where you have a much better opportunity to drive behavior than if you hadn't performed that analysis first," he says.

For example, the analysis might find that 70% of variability is attributable to the management of contrast agents in a radiology department. "What this does is it gives us a very clear sense of what's going to get us the greatest leverage in improving the process, and also what's the opportunity cost of those things we consider uncontrollable," says Schultz.

Once it began discussing and dissecting the data, the team realized that it would make sense to establish standard operating procedures for inserting, changing, and maintaining a catheter. "The different leaders from the hospital, both in the ICU and infection control, got together and put together a formal standard procedure for changing these lines," he says.

The procedure was videotaped so that it could be used to orient resident physicians rotating through the ICU on what the best practice is. The team also developed a standard procedure for caring for the lines, including the method and timing for changing dressings.

Standardization was applied to the supplies and equipment used in the process, says Stahl. A kit was created that included in one plastic bag all the materials needed for wound care and changing a catheter. Included in the kit are a gown, gloves, mask, hat, the proper antiseptic, and the sterile instruments to be used. Having such a kit makes it easy for the nurses and physicians because they did not have to remember all the various components and search for them, he adds.

Taking a cue from construction sites and manufacturing plants that monitor the number of days since the last work-related injury, the Six Sigma team decided to track the number of catheter days since the last infection (see **Figure 2**).

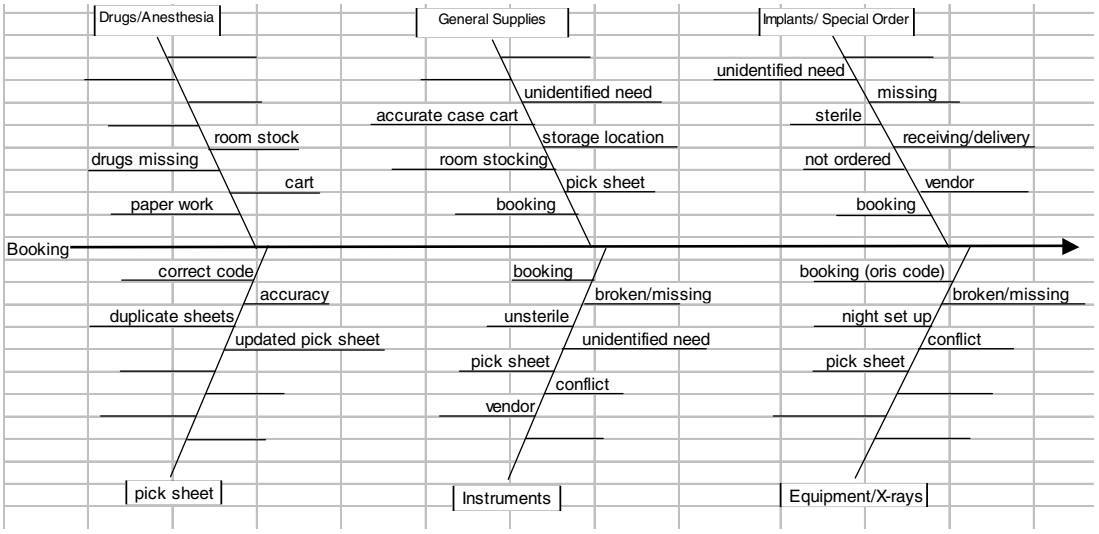
"Once these standard practices were implemented, we saw a very noticeable and statistically significant reduction in our hospital-acquired infections in the ICU," Stahl says. That improvement has been sustained, he adds. "We are now significantly better than the national benchmark, whereas before the performance wasn't as good as we wanted it to be." (See **Figure 3** for national rates of central line-associated bloodstream infections.)

Satisfaction in the OR

The use of Six Sigma at Yale-New Haven Hospital hasn't been limited to raising productivity and lowering infection rates. It has also been used to improve the quality of the work environment for both surgeons and nurses.

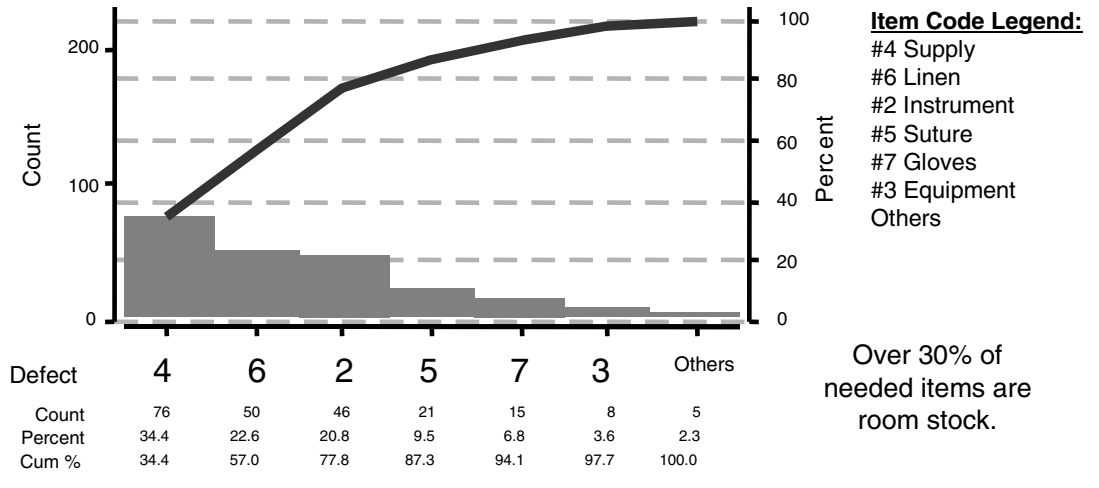
Surgeons are viewed as major hospital customers, Stahl says, so Yale-New Haven wants to make sure they remain loyal and continue to bring cases there. Likewise, it's important to keep nurses happy with the facility because they are critical to

Figure 4: OR Case Materials



Source: Yale-New Haven Hospital, New Haven, CT.

Figure 5: Analysis: Pareto Chart for Needed Items



Defect	4	6	2	5	7	3	Others
Count	76	50	46	21	15	8	5
Percent	34.4	22.6	20.8	9.5	6.8	3.6	2.3
Cum %	34.4	57.0	77.8	87.3	94.1	97.7	100.0

Source: Yale-New Haven Hospital, New Haven, CT.

the hospital.

The Six Sigma team decided that having all the materials and equipment in the operating room necessary to complete a surgery is an important factor for both surgeons and nurses. If a nurse has to leave the OR to locate a piece of equipment or fetch more supplies, not only is she unhappy, but the surgeon doesn't like having to wait for the nurse to return.

"We had to pick a metric that would reflect that, and the metric we chose was the number of times the nurse had to leave the room or call out of the room," says Stahl. The Six Sigma team decided that the maximum number of times a nurse should leave the OR or call on the phone for something is 1.5 times per 100 case minutes, which equals about once per hour.

"We documented our level of performance, we looked at the things the nurses were running for, the reasons they had to run for them or why they weren't there," he says. Staff from the operating rooms were gathered for brainstorming sessions, and the team developed process maps and fishbone diagrams (See **Figure 4**.)

Some of the factors involved were difficult to address, says Stahl, such as the design of forms used to pick equipment and supplies for OR case carts. But there were simple things also involved, he adds, such as making sure there was enough sterile linen in the OR. (See **Figure 5**.)

"We also found that there was a lot of variation in the things that they needed. For example, we were stocking six different types of sterile gowns. So we got a consensus that we really wouldn't lose anything by only stocking three [types of] sterile gowns. We tried to simplify things in that manner," he says.

The number of gowns and drapes stocked in the operating rooms was increased, Stahl says. For certain cases, additional drapes and gowns were placed on the supply carts.

Has this had an effect? Stahl did not have the final results of the project, but he says it should make a difference. "We proved in a statistically significant way that the number of trips out of the room did correlate very highly with nursing satisfaction."

Future projects

In the future, Yale-New Haven Hospital plans to apply Six Sigma to projects targeting clinical areas, such as cardiovascular services and stroke, and operational issues such as staff productivity and retention.

The three-year initiative with GE Medical Systems aims to make the Six Sigma methodology self-sustaining at the hospital, says Stahl. That will involve continuing to train hospital personnel until several reach Black Belt expertise, and adding dozens of Green Belts to the ranks of those already at the facility.

The first group of Six Sigma trainees included nurses, physicians, department heads, and members of the finance department. Those early converts to the art of Six Sigma have gotten their colleagues excited about the methodology, Stahl says, and now other staff members are requesting to be trained.

"Interest is starting to increase, and word is getting out," he says. "Also people can tell that management is very interested in this and wants to use it to tackle their challenges and improve our performance."

Editor's Note: For more information about Six Sigma, contact Carolyn Pexton at (925) 552-6975 or carolyn.pexton@med.ge.com. ◆