SIX SIGMA AND HEALTHCARE

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Abstract

Six Sigma is gaining momentum in the US hospitals. Many hospitals are joining the ranks of leading healthcare institutions such as Stanford in the West to Yale-New Haven in the East. Six Sigma is a process to improve the quality and customer satisfaction while reducing the cost of delivery and enhancing the revenue. The Healthcare industry embraced Six Sigma only after it was fully developed, tested, and tried by many in the manufacturing sector. Companies such as Motorola, Allied Signal, Xerox, and General Electric used it to generate significant bottom line results coupled with increased customer satisfaction, and reduced product development time to market with higher quality products.

The Six Sigma approach optimizes the average (represented by Greek letter Mu) and reduces the variance (process represented by Greek letter Sigma or standard deviation) of a desired process. The desired outcome can be a reduction of the patient registration time in Emergency Department, lost charges for billing in Patient Financial Services, delinquent medical records, diagnostic results turn around times, accounts receivables days, patients' length of stay, or medication errors. The outcome can also be increased physician satisfaction, market share, and patient flow. To put Six Sigma in perspective, for instance, 200,000 wrong prescriptions per year amounts to 3.8 Sigma and 68 per year amounts to 6 Sigma. The success of Six Sigma is due to its unique appeal to the medical and professional staff on one hand and the fiscal services staff on the other.

This paper covers the concepts, methodologies, tools, success sites, and benefits of Six Sigma for healthcare. The intended audience includes: hospital management/ industrial engineers, operational improvement staff, decision support staff, CFOs, CEOs, COOs, CNOs, CMOs, CIOs and department managers. The participants will take away simple do-it-yourself tools and other information to apply Six Sigma to their operations.

What is Six Sigma?

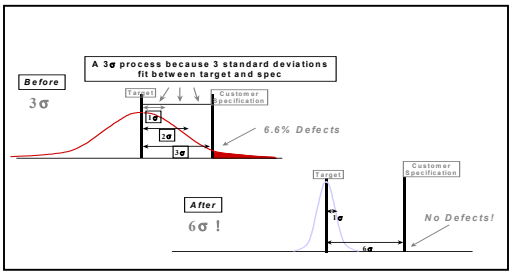
Sigma has several meanings depending on the context. It could be:

- Greek alphabet
- Mathematical Symbol for Summation
- Statistical term for standard deviation
- Quality Level Indicator
- Management Philosophy

Sigma in this context refers to Level of quality and a management philosophy. Six Sigma is six times sigma quality level as measured by defects or instances over the customer specified acceptable limit. This corresponds to only 3.4 defects per million opportunities (DPMO) or 99.9997% close to perfection. Most businesses are at three sigma quality level with 66,800 DPMO or 93.32 %. The DPMO for various sigma levels are: One Sigma 691,500, two Sigma 308,500, three Sigma 66,800, four Sigma 6,200, five Sigma 230, and six Sigma 3.4.

There are businesses that operate at levels equal to Six Sigma and above. For instance, the airline industry operates at

eight sigma. Higher sigma levels yield lower defects per customer specification limits which means customer satisfaction levels are high. This results in more business with greater revenues and larger contribution margins. Indeed both the customer and the business win with increased quality provided by the higher Sigma level.



There are examples both in manufacturing and the service industry that applied Six Sigma to their operations and benefited tremendously and include: General Electric, Motorola, Allied Signal, Honeywell, Ford, Star wood Hotels, Sears Roebuck, and Federated Logistics

How is Six Sigma different from previous TQM, CQI type of efforts?

Both TQM (Total Quality Management) and CQI (Continuous Quality Improvement) of the last two decades are also improvement programs. The key differences are:

1) Customer centricity is the main theme of Six Sigma. It starts with the customer needs as captured via Voice of the Customer (VOC)
2) Return on the Investment is a key component of Six Sigma. For instance, in 1996 GE spent $200M with a return of $150M; 1997 GE spent $400M with a return of $600M and 1998 GE spent $400M with a return of $1Billion
3) With Six Sigma, organization's management philosophy and culture are shaped to become the best in its class.

Who are the Key Players in Healthcare & Hospitals?

The Healthcare industry has many players:

a) Providers including Physicians, Hospitals, Free standing/Hospital Affiliated Outpatient Centers; Nursing Homes, Skilled Nursing Facilities, Long Term Care Facilities, and Home Care services
b) Contractors for construction/ renovation and suppliers for equipment and other Material
c) Management Services for managing hospitals or specific hospital departments
d) Outsourcing to include all the contract services from rehab and billing to bio-medical equipment maintenance.
e) Payers cover Federal (Medicare, Veterans Admin.), State (Medicaid), County, and City; Private payers, Third party payers i.e. Insurance Companies, and Health Maintenance Organizations (HMO)
f) Consumers.

Among the healthcare players, hospitals are a major player with which many of the other players interact routinely. Physicians bring the consumers (patients) of healthcare to hospitals where some players build facilities, equip them and supply medical and other materials, others manage the hospitals or some departments of the

hospitals while still others pay for the services.

Why is Six Sigma Important to Healthcare? Hospitals?

Six Sigma demonstrated value to many industries both in manufacturing and service sectors by improving the quality, reducing the cost, and increasing revenues. The multi-billion dollar healthcare industry can benefit from Six Sigma to achieve similar results.

Quality should not be compromised in the health care as the consequences can be very harmful resulting in the loss of human productivity or human life. There are many opportunities to make mistakes when rendering healthcare services. In the fall of 1999, the Institute of Medicine (IOM) released a report titled " To Err Is Human: Building a Safer Health System" by Linda T. Kohn, Janet M. Corrigan and Molla S. Donaldson. This report created an immediate sensation with its estimate of 44,000 to 98,000 deaths per year in hospitals due to medical errors. These errors are attributed more to system problems rather than healthcare worker mistakes. There are many other studies that suggest the need to improve the quality of care in hospitals.

Which Hospitals have used Six Sigma?

There are many hospital systems or hospitals that use Six Sigma. Some use it system or hospital wide, some in selected areas or departments whereas others use it to solve specific issues. To name a few of the hospitals that use Six Sigma:

- Long Island Jewish, NY;
- Stanford Medical Center, CA; Northwestern Memorial, IL
- M.D. Anderson, TX
- Virtua Health System, NJ
- Charleston Area Medical Center, WV
- Boston Medical Center, MA
- Yale New Haven Medical Center, CT
- Verdugo Hills Hospital, CA
- Johns Hopkins Hospital, MD
- Good Samaritan Hospital, OH.

What are the Underlying Principles of Six Sigma?

The data driven Six Sigma approach optimizes the average (represented by Greek letter Mu) and reduces the variance (process represented by Greek letter Sigma or standard deviation) of a desired process. Improvement in the average alone is not enough as the average is seen by the business and the variation is still felt by some customers. Unless the variation is reduced, the customer experience cannot be changed. The mean is optimized by improving the process and the variation is improved by delivering the results consistently. The desired outcome or effect is usually expressed as Y, the dependent variable and the causes are expressed as Xs the independent variables. Of the many Xs, only vital few Xs have major impact on the Y i.e. by moving these levers, the Y can be improved significantly. The improvement process is to identify those vital few Xs and their relationship to Y as a mathematical equation.

Examples of Y, the desired outcome include: reduction in the patient registration time in Emergency Department, lost charges for billing,

delinquent medical records, diagnostic results turn around times, accounts receivables days, patients' hospital length of stay or medication errors. Other outcomes are increase in the physician satisfaction, market share, or patient flow . As the Y improves, not only the quality improves but also the cost is reduced. The success of Six Sigma is due to its unique appeal to the medical and professional staff on one hand and the fiscal services staff on the other.

What are the Basic Methodologies of Six Sigma?

There are two basic Six Sigma methodologies:

- DMAIC for existing processes and
- DFSS for designing new products/processes.

DMAIC stands for the initials of a process improvement methodology covering **D**efine, **M**easure, **A**nalyze, **I**mprove and **C**ontrol. Each step has 3 sub-steps. The application of DMAIC methodology is discussed later.

DFSS stands for **D**esign **F**or **S**ix **S**igma meaning to build the Six Sigma quality into the product or process right at the design stage. DFSS follows a process called DMADV. Similar to DMAIC, the first letter of each of the six steps form the name covering **D**efine, **M**easure, **A**nalyze, **D**esign, and **V**erify.

The firsts three steps are common to both methodologies. In the Design phase, various alternatives are evaluated and the best features of various alternatives are incorporated into the final design while ensuring the design criteria are met. Verification phase involves prototyping and testing the design and then sharing it for full production.

Where Can a Hospital Obtain the Expertise to Implement Six Sigma?

There are many ways hospitals can bring Six Sigma talent to their institution. They can:

a) send staff to training centers to be trained in the Six Sigma methodologies, tools and techniques

b) Bring trainers to the institution

c) Hire experienced staff

d) Join network of organizations with similar goals

e) Engage consultants that are willing to teach hospital staff while they do the projects

Where Can a Hospital Place the Expertise to Implement Six Sigma?

Depending on the organizational structure, Six Sigma can be with one of the following functions either at the corporate or facility level:

1) Management Engineering or similar function otherwise known as Hospital Industrial Engineering, Operations/ Performance/ Organizational Improvement
2) TQM, CQI
3) Finance
4) Decision Support
5) Human Resources

Who are the Key Players in Implementing Six Sigma?

To clearly identify the roles and responsibilities, successful organizations used the following titles:

a) Champion/ Sponsor to lead the charge preferably at C level of

the organization and could be COO, CFO, CMO or CEO if it is a small to medium size hospital and a VP level person if it is a large hospital

b) MBB (Master Black Belt) can lead the Six Sigma effort for the hospital
c) BB (Black Belt) can lead several Six Sigma projects and also can mentor the Green Belts. Typically, this should be a dedicated full time position without other functional responsibilities to get the full impact of the position that can save $100k to $500k every year for the hospital
d) GB (Green Belts) are the project staff and can have other jobs besides working on the Six Sigma projects but should be allowed to give the time the project requires
e) YB (Yellow Belt) is relatively new to the Six Sigma terminology. YB has interest to become GB down the road and is willing to learn the tools now

How to Implement Six Sigma program in a Hospital?

Here are some steps the hospital can follow to implement Six Sigma.

1) Have a sponsor from the C-level i.e. executive management
2) Develop a project team consisting of people with content and statistics knowledge.
3) Have a Green Belt (GB), Black Belt (BB) or Master Black Belt (MBB) designated to mentor the project. If the hospital does not have trained/certified people in Six Sigma, consider sending their staff to be trained or engage organizations to do the training on location.
4) Start a project funnel i.e. a list of potential projects. Some sources for project ideas are: Reports from JCAHO (Joint Commission on Accreditation of Healthcare Organizations, governmental or regulatory agencies, Quality Assurance (QA) findings for improvements, opinion surveys for patients, physicians, and staff, balanced score cards or dashboards for the performance monitoring
5) Select a project that is a high priority for the hospital so that resources will be allocated and the recommendations are likely to be taken seriously for implementation.
6) Develop a realistic project plan and get the needed resources.
7) Recognize that the effectiveness of the implementation is due to both the quality of the solution and acceptance of the change with a structured change management process.
8) Establish a project review mechanism for the stakeholders to review the project status at designated milestones to ensure the project is on schedule.
9) Provide necessary support to make sure the people provide data and participate in brainstorming sessions
10) Confirm that the anticipated improvements are achieved both intangible and tangible in the form of Return On the Investment (ROI)
11) Make sure the plan to sustain the results from the pilot is defined

with adequate documentation to institutionalize the results

12) Recognize and reward the teams and publicize the success stories
13) Celebrate the success and officially close the project
14) Repeat the process for another high priority project for improvement with members from a different team if possible with access to the past team members as a resource
15) Stay focused on this as a corporate initiative rather than treating it is a local project.

How to Apply DMAIC Six Sigma Methodology & Tools?

As mentioned earlier, DMAIC stands for **D**efine, **M**easure, **A**nalyze, **I**mprove and **C**ontrol. Six Sigma tools are used here to reduce the backlog by increasing the patient throughput in the Cardiac Catheterization Lab (CCL) of a hospital. The key steps will be covered under each phase followed by its application to the CCL.

The Vice President for Ancillary Services heard of Six Sigma from her Imaging and Cath. Lab department managers who use GE equipment. As the hospital is new to the Six Sigma, they invited GE to help them with the program details.

Define phase: The project team identified referring MDs, cardiologists, and CCL patients as the external customers and CCL Management as internal customer.

In CCL, based on the opinion surveys and focus group discussions with referring physicians, cardiologists and patients expressed the need to reduce patient waiting time. This waiting time refers both scheduling for the procedure and waiting while the procedure is done in the lab when the patient arrives. Administration and Finance saw this as an opportunity not only to improve the satisfaction of various customers but also to increase the patient throughput and hence the revenue for the department. This project is selected under the sponsorship of the VP of Ancillary services. The CCL project team developed a Business case.

A high level process was defined as 3 key task groups.

- Pre-Room task group covering Patient Registration, Pre-Op Prep, and Pre-Op Holding;
- In-Room covering Intra-op Prep., Procedure, and Post-Procedure Management; and
- Post-Room covering Patient Recovery, and Discharge/ Transfer

The project scope excluded Post-Room tasks.

Measure phase: The project team selected CTQ characteristics using Quality Function Deployment (QFD) to translate VOC to characteristics. The principles behind QFD are: the CTQs are listed and prioritized and the high priority items are selected for improvement. For each What, a How is described to two or three levels; The final CTQs are: to reduce the cycle times for two sub-cycles. The project team then defined performance standards covering objective function, opportunity, and defect with specification limits. The team collected cycle time data from the electronic logs and verified that against observed data for a day. Verification of the measurement system is done to ensure it is reliable, repeatable, and reproducible and does not introduce measurement errors of its own. A Gage

R&R (Repeatability and Reproducibility) analysis was done using Minitab - a software used to do all the statistical analyses for the Six Sigma projects- to measure the gage contribution of 2% that was less than the 10% acceptable level.

Analyze phase: To establish process capability, the project team analyzed the data by first determining the process stability using the Run Chart. It showed no trends, mixtures, clusters or oscillations in the data indicating the process is stable.

The shape of the distribution was normal and the parameters are 30 min. mean and 5.7 min. standard deviation. The team then determined the baseline capability in terms of the Z value as 0.29 and 756,003 as corresponding Defects Per Million Opportunities (DPMO).

The performance objectives were defined using Benchmarking and then variation sources identified by the project team with the help of Cause & Effect (Fishbone or Ishikawa diagram). A Pareto chart was used to select the variables with high impact needing low effort. The team also used Box Plots & ANOVA and Multiple Regression to display and assess the key variables. Some of the Xs relate to: 1) Patients such as age, sex, procedure(s) done, InPatient/Outpatient/Emergency, etc.; 2) Care givers such as referring MD, cardiologist, tech etc.; 3) Time such as day of Week, Hour of Day etc.

Improve phase: As the basic tools described in the Analyze phase helped to identify the vital few variables (Xs), the team decided not to use Screening Design of Experiments (DOE) tool.

The team wanted to discover variable relationships between Y and Xs as Y= f (X1, X2, X3, etc). This transform equation is to help optimize process mean and minimize the variation by increasing or decreasing values for Xs. Full and fractional factorial analysis of DOE would have been helpful if the number of variables are many and the historical data is either not available or not reliable. The data is available and reliable, therefore the team did not consider a DOE.

As part of the improvement phase, the team considered the peer best practices from benchmarking, and brainstormed the solutions with the staff that are familiar with the processes. The workflows are rearranged especially as the impact of the Xs cannot be directly evaluated by varying them in a controlled experiment. Standard Operating Procedures (SOPs) are developed to reduce the process variation. The project team did not have to establish operating tolerances as the variables are not quantifiable. Otherwise, the team was prepared to use Simulation tools such as Crystal Ball to narrow down the range of values for Xs.

The changes made include:

a) Revised patient schedules and scheduling slots to match patient factors;
b) staff schedules to match the workload including the techs' break times by modifying the guidelines; c) Prepared a checklist to ensure proper supplies in the CL Rooms; d) Implemented a dual page reminder system to the cardiologists 60 min. prior and 20 min. before the patient is in the room waiting for MD The team piloted the solution before institutionalizing the implementation

Control phase: To ensure the Xs and Ys are measured properly with minimal measurement errors, if any , the team defined and validated the measurement

system. Then it determined the process capability using the pilot data and found the Z score to be Z st: 1.6 DPMO: 516,667 as compared to the baseline of Z = 0.29, DPMO=756,003 showing the process clearly improved.

Statistical Process Control charts i.e.Xbar-R charts were used to detect unfavorable trends by checking if the data falls outside the upper and lower control limits. Mistake proofing was done by building cross checks in the software program for scheduling. Risk management was done using Failure Modes and Effects Analysis (FMEA) to prevent, detect and correct defects.

The project team prepared

a) Audit guidelines too periodically audit the data and results and
b) Control plan documentation as to what, when, who and how of the follow-up for sustaining the gains.

Any Other Case Studies covering Implementation of Six Sigma?

Case Study #1: A non-profit teaching hospital with 944 beds and 6000 employees, 400,000 OP & ER visits, and 40,000 IP discharges
Challenge:

- Patient safety due to medical infections driving up risk and cost
- Declining staff, patient & physician satisfaction.

Wave 1 projects included:

- Patient safety
- MRI (Magnetic Resonance Imaging) Patient scheduling
- OR (Operating Room) Materials Management
- New Born unit staffing.

Results:

- Reduced infection rates by 75% with savings of $1.2M/Yr.
- Had their entire exec team, four physicians and 15 Green Belts trained;

Case Study #2: A non-profit four hospital system with 7000 employees, 1600 physicians; $475M annual revenue
Challenge:

- Patient safety due to medical infections driving up risk and cost
- Declining staff, patient & physician satisfaction.

Wave 1 projects included:

- ED Patient Satisfaction
- Recruiting Cycle time
- Key talent retention
- OR(Operating Room) throughput
- CHF (Congested Heart Failure) LOS (Length Of Stay)

Results:

- Six full time BBs including the first MD BB trained;
- Reduced CHF LOS from 6 to 4 days
- Patient education improved from 27% to 80%
- Chart consistency improved from 67% to 93%

Case Study #3: A non-profit religious hospital with 560 beds and 2100 employees, 37,000 ER visits
Challenge:
Peri-Operative process improvement
Wave 1 projects included:

- Room Turn Around Times (TAT) in OR and Endoscopy
- OR Schedule management
- Patient's Length Of Stay in Recovery Room

Results:

- Reduce Room TAT by 60% for complex and 52% for simple cases
- Reduced case delays and increased capacity by 6% resulting in $1.7 M/Yr

What are Some Critical Success Factors?

In addition to strong top management support, there are few factors that will ensure the success of Six Sigma implementation.

1) Senior management sponsor with willingness to support thru resources
2) Select team members that can devote the needed time
3) Provide adequate training to the team members
4) Select projects that are meaningful and manageable
5) Make the project team do the implementation

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Authors' Biographical Sketches:

Mr. Ganti is a Senior Internal Consultant and a Certified Black Belt with GE Medical Systems. He has an MSIE degree and is a senior member of IIE and a life member of HIMSS. He published/ presented over 35 papers in leading professional journals/ conferences and developed hospital staffing and quality control methodologies.

Dr. Anita G. Ganti is a physician and a Paul Harris Fellow Rotarian. During her externship, she developed clinical pathways and standard protocols using statistical tools while serving as a liaison with Center for Medicare and Medicaid. She believes in the Six Sigma tools and promotes them to her peers to enhance the quality of and access to medical care.