Sandra L. Furterer

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I dedicate this book to my loving family, my husband Dan, and my children Kelly, Erik, and Zachary who provide constant support and the true purpose in my life. My children provide the incentive for me to strive for excellence to be a guiding example for their lives.

I also dedicate this book to my parents, Joan, and the late Mel Brumback, who instilled in me the value of education and a lifelong love of books and learning, and also to my siblings, Dan, Neil, Tim, and Kathy, who encouraged the competitive spirit and being our best in all we do.

Preface

The purpose of this book is to provide an enterprise Lean Six Sigma methodology to enable alignment and optimization of processes across the entire organization. Healthcare has finally embraced Lean Six Sigma tools, even though it has been much later than many industries, there is great value and advantage for applying these tools and methods in healthcare. Healthcare is struggling with shrinking revenues and trying to control costs, what better environment could there be to apply Lean Six Sigma.

In Chap. 1, we provide a description of the author's Strategic Business Process Architecture methodology that can enable enterprise-wide improvement. In Chap. 2, we provide a description of the Lean Six Sigma methodology that can guide our process improvement projects. In Chap. 3, we provide an application of Lean Six Sigma that successfully reduced the patient Length of Stay and Door to Doctor time in a hospital's Emergency Department. In Chaps. 4 and 5, we provide an application of Lean Six Sigma and 5S in an operating room. In Chap. 6, we provide an application of Lean tools applied for preparing patients for surgery. In Chap. 7, we provide an application of how Lean Six Sigma was used to reduce the number of CT scans in an Emergency Department. In Chap. 8, we describe how we reduced the linen loss throughout the hospital by applying Lean Six Sigma. In Chap. 9, we used Lean Six Sigma to design and implement sepsis protocols to reduce the mortality related to sepsis infections. In Chap. 10, we design women's services in an outpatient women's center. In Chap. 11, we provide an innovative Patient Care Operating Model that can reduce delays in the inpatient value chain activities. In Chap. 12, we discuss labor management flaws and best practices in healthcare. In Chap. 13, we provide insights into several critical success factors that can enhance your organization's Lean Six Sigma program. In Chap. 14, we provide a brief view into the future of Lean Six Sigma in healthcare. These case studies are representative of healthcare case studies, but generalized to protect the confidentiality of specific healthcare organizations.

Acknowledgments

My thanks and appreciation goes to all of the Lean Six Sigma team members, project champions, and Lean Six Sigma mentors that worked so diligently and courageously on the Lean Six Sigma projects that enabled us to enhance and improve the patients' experience in the healthcare environments. As with any successful operational excellence program, there are so many wonderful participants that guide, mentor, champion, encourage, and make change happen, I thank you for your dedication to helping make the patients' experience in the hospitals one of healing, compassion, and care.

Special thanks goes to several people for their contributions to development and production of the book at Springer UK.

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Chapter 1
Enabling Enterprise Performance Excellence Through Strategic Business Process Architecture Modeling Techniques

Abstract We start this book with a description of an Enterprise Performance Excellence (EPE) methodology that links the Lean Six Sigma methodology discussed in Chap. 2 with other systems engineering methodologies that can help to optimize the entire enterprise's processes. EPE helps to understand the organization from a cross-functional enterprise view so that the Lean Six Sigma program can be aligned with the strategic and operational plans as well as focused on key bottleneck processes within the healthcare organization. This methodology starts with understanding the value chains of the organization and functionally decomposing the business functions that provide services to the customers or patients. Following is a description of the EPE methodology.

Introduction

Six Sigma is both a quality management philosophy and a methodology that focuses on reducing variation, measuring defects, and improving the quality of products, processes, and services.

There are several critical success factors to a successful Lean Six Sigma program, including:

- Basing the Lean Six Sigma project selection on key business priorities (Furterer 2008).
- Focusing on key business areas (Furterer 2008).
- Aligning the program with strategic initiatives and prioritize the projects based on business strategy (Furterer 2008).
- Defining a vision of what the organization will look like after implementing Lean Six Sigma and embracing the change (Sureshchandar et al. 2001).
- Top management support through leadership. This factor includes management's setting of goals and providing leadership and direction (Hoffman and Mehra 1999).
- Strategy that is complementary and integrated with existing policies and strategies (Dale 1994).
- Clear links between strategic goals and the change strategies (Newman 1994).

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These critical success factors point to the need to align an organization's Lean Six Sigma program with the organization's strategic plan, and to the key business processes that enable the enterprise to meet the customers' needs and expectations. It also includes the need to understand the Lean Six Sigma program's vision. Many times an organization's Lean Six Sigma projects are identified from a bottom-up approach, not one that is top-down and aligned with the enterprise goals and strategic plans. In some organizations people who want to get certified as a Green or Black Belt will often choose a project themselves based on a perceived need for improving a process. Although these projects often achieve improvement and financial savings, there is no direct visibility or traceability to the organization's strategic goals.

Business Architecture is a relatively recent body of knowledge that comes out of the information systems realm (Bieberstein et al. 2008). Business Architecture can provide an enterprise-wide understanding of the business. It attempts to connect the business strategies to planned change initiatives focusing on Information Technology (IT) projects that can provide tactics to meet the business strategies. In many organizations, the Business Architecture is documented and developed by the IT organization as a way to understand the business processes. The business processes enable the extraction of key business elements that support required capabilities of the business to meet customers' needs. This provides traceability from the businesses' strategies, to the business requirements through to the implemented IT. Demonstrating the alignment between IT initiatives and the business strategies helps to ensure that resources of people, time, and money are applied appropriately.

Business Architecture modeling techniques and methods can be used to also provide prioritized alignment with the Lean Six Sigma program goals and the enterprise's Six Sigma projects and improvement initiatives. This can provide alignment between the business strategies and goals and the organization's improvement plans.

We will first describe the concepts that helped to evolve the Business Architecture methods and tools. We will then discuss the activities that can be used to integrate Business Architecture methods and models to gain alignment between an enterprise's Six Sigma improvement efforts, key processes, and the business' strategic goals.

Underlying Concepts Evolving to Business Architecture

Business Architecture modeling techniques incorporate the concepts of quality management, business process management, and information systems analysis.

Quality Management encompasses the evolution from Statistical Process Control, Total Quality Management, Business process reengineering (BPR), and Six Sigma bodies of knowledge. Business process management (BPM) encompasses documenting, understanding, managing, and controlling key processes in the business enterprise. The goal of BPM is to improve products and services through a structured approach to performance improvement that centers on

systematic design and management of a company's business processes. (Chang 2006) Business processes and workflow are more easily automated through off-the-shelf Business Process Management Systems (BPMS). Business Architecture has components of many of these concepts, providing for the synthesis of business processes and information systems methodologies.

BPM and BPMS both support Lean Six Sigma process improvement through documentation of processes, and automated collection of process metrics. An enterprise can use Business Architecture principles and methods as the foundation for identifying the processes that need to be improved to enable the business strategies. It provides the documentation of the business processes and the identification of the optimized business processes and components that can be used across multiple business units, markets, and processes. It enables standardization of processes and alignment of process improvement initiatives with the key processes that enable the business' strategic plan.

Business Architecture is helping to provide a context and prioritization of business strategies that can help to focus Lean Six Sigma improvement efforts.

Business Architecture

Business Architecture helps us to understand the business processes, and the three to five year strategies of the business. It helps us to understand the business processes that enable meeting the needs of our customers, and to understand the business capabilities that provide business functionality to meet these needs. Business Architecture helps us to define the optimized business components that support the business functionality and the factors that contribute to variability in the business processes (Rosen 2008).

Business Architecture provides models that describe the business entities (business processes and relevant business information), their relationships, dynamics, and rules that govern their interaction to achieve enterprise-wide objectives.

Business Architecture Elements

The elements of the Business Architecture describe the business enterprise, shown in Fig. 1.1.

The business architecture first includes understanding the customer's needs and expectations. Next, we capture and document the business strategies and goals, as well as the external and internal influencers on the business. The relationship between the business goals and the capabilities that support the goals should be understood. We use the value chain showing a chain of activities that provide value to the customer (Porter 1985) to understand and decompose our processes. The functional decomposition provides a hierarchical organization of functions and the processes that they include. Each value chain and the subsequent business

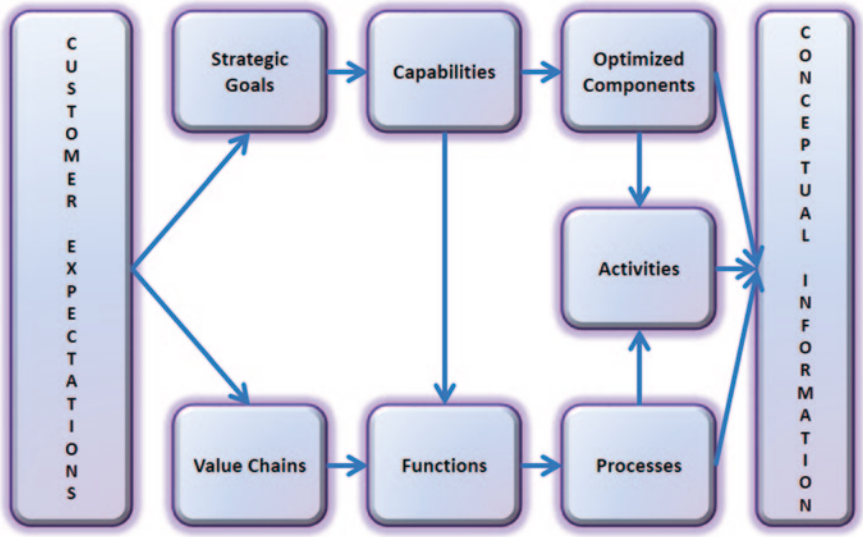

Fig. 1.1 Conceptual business architecture elements

functions will be used to further decompose the processes. This ensures traceability from the value chains to business processes that provide customer value and provides an organizational inventory of the high level activities that they perform to meet the customer's needs.

The business capabilities enable the business functions. How the business implements its processes is likely to change frequently, the basic capabilities of a business tend to remain constant. The business processes and their activities describe the sequence of activities that enable the business to meet the customer's expectations and provide value through the value chains.

The business components are identified to optimize the activities that support the business. These components consist of the activities that require similar people, process, and technology. They allow the standardization of the business processes by componentizing the activities that can be used in multiple areas of the business, across many business units and markets (IBM Corporation 2005). The conceptual information describes the information and roles that exist in the business, which are part of the business processes.

Strategic Business Process Architecture Methodology

The following Strategic business process architecture (SBPA) Methodology provides a "how to" description for developing and leveraging business architecture that helps to ensure alignment with your Lean Six Sigma initiatives in an organization (Furterer 2009a, b). The SBPA models can be used as the basis for identifying

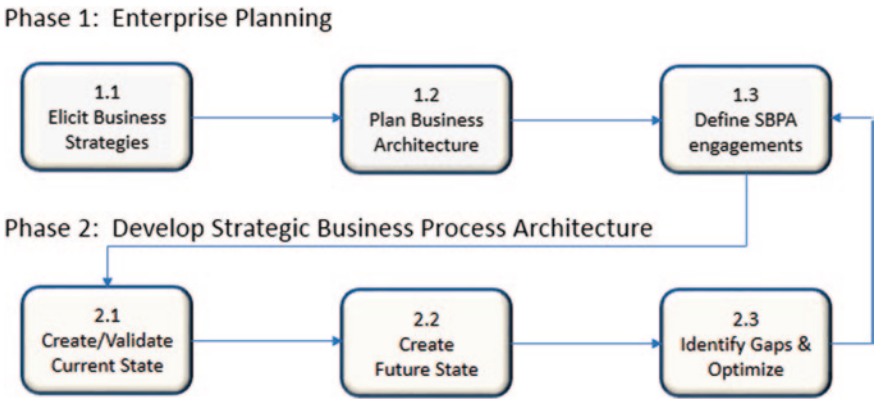

Fig. 1.2 Business architecture development methodology

and prioritizing the key processes and extracting improvement projects in an organization's Lean Six Sigma program.

The business architecture methodology, Fig. 1.2, is composed of two main phases:

Phase I Enterprise Planning.

Phase II Strategic Business Process Architecture Modeling.

The SBPA helps to integrate and provide a synthesis across the enterprise and align to customer's needs; to identify the business capabilities that are required to support the entire enterprise and to optimize the business processes. The SBPA provides the inputs to the information system architecture (information, application, and technology) to create the IT roadmaps that support the business strategies. The methodology also provides a roadmap for process optimization and improvement.

Phase I: Enterprise Planning

Phase I, Enterprise Planning, is used to elicit, harvest, understand and document the business strategies, and plan the related business architecture engagements that will enable these strategies.

The objectives, steps, and deliverables of each activity in Phase I, Enterprise Planning are shown in Fig. 1.3 and described following.

Elicit Business Strategies

Purpose The purpose of this step is to elicit, validate, and understand the future strategies of the business. This will help to align the business strategies and the future IT and process improvement initiatives.

There are several steps for eliciting the business strategies from the enterprise. First the Business Architect harvests the business strategic plans, and Strengths,

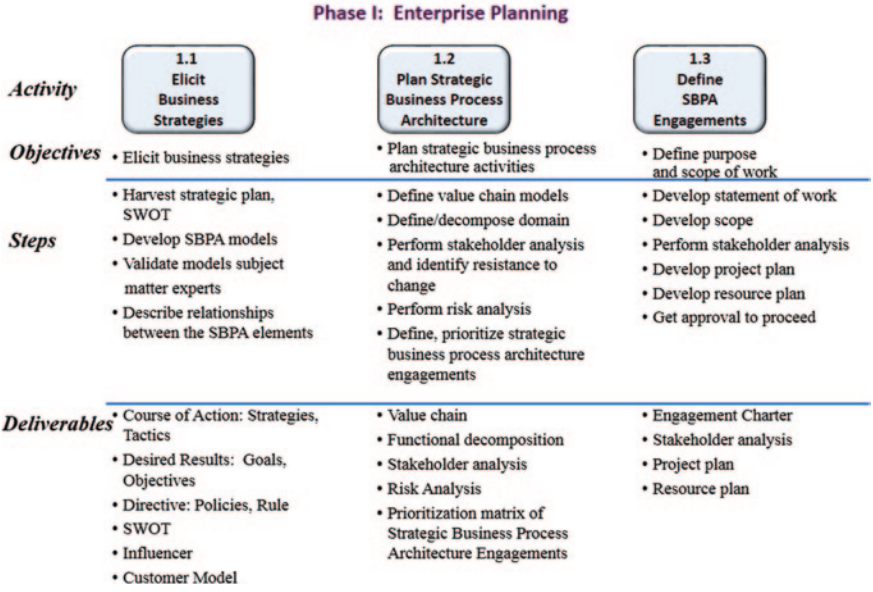

Fig. 1.3 *Phase I*. Enterprise planning

Weaknesses, Opportunities, and Threats (SWOT) for each business unit. Next, we develop the SBPA models. Since the models are our translation from the business planning documents to our strategic business models, we must validate them with the business leaders. We then develop the relationships between the elements of the strategic business models. Our last step in eliciting the business strategies is to identify any gaps in the alignment as we developed the traceability between the relationships of the strategic elements of the models.

Plan Strategic Business Process Architecture

Purpose The purpose of this step is to plan the SBPA engagements based on the business strategies, and critical business processes. It is important to understand the critical stakeholders in the enterprise. Since resources are always limited, this step helps us to focus our resources, time, and talents on the most critical business processes and strategies while building the SBPA models.

In the Plan SBPA activities, we first develop the value chains for the enterprise, so that these can be used to prioritize the business processes to model, based on the business strategies. We decompose the value chains into the business functions so that we can create the business process models from the prioritized value chains and subsequent business functions. We define the SBPA engagements that will derive the SBPA models aligned to the prioritized business strategies. We perform

a stakeholder analysis to identify the stakeholders and team members that should be involved in the SBPA engagements.

Define Purpose/Scope of Strategic Business Process Architecture Engagements

Purpose The purpose of this step is to define the scope, purpose, and objectives of the SBPA engagements, as well as to develop the project, risk, and communication plans of the engagements. There are usually not enough resources to create the entire business process architecture at once. So these activities are designed to break the work into manageable business process architecture engagements, based on the priorities identified in the prior phase.

In these activities the purpose and scope of the SBPA engagements should be defined. A statement of work or engagement charter can be developed that describes the scope of the engagements. A SIPOC can be used to scope the engagements. A detailed stakeholder analysis for the planned engagements will then be developed.

Phase II: Strategic Business Process Architecture Modeling

Phase II, SBPA Modeling, starts the business architecture modeling that is used to document the existing and proposed SBPA for the enterprise. In this phase we build the existing business architecture models to create a repository that can be used to understand the existing enterprise and drawn upon for process improvement. It is used to help us understand the gaps between the current state and what we desire in the future state. To improve the business processes and related technologies that support them, it is critical to understand the current processes, the existing inefficiencies, waste, and failure points, so that they can be eliminated in the future state processes.

The future state analysis provides the business architecture modeling for the future state within the planning horizon. This provides an understanding of the value chains, business processes, and the people's roles that perform the processes. It provides a view of the hand-offs and integration between departments and business units. This business architecture modeling provides the rationalized and optimized business components. The business components are the activities or sets of activities that provide the identified business capabilities that help to realize the business strategies and associated initiatives. These business components represent streamlined elements of the process that we want to incorporate in an optimized process in the future state.

The objectives, steps, and deliverables of each activity in Phase II, Develop SBPA are shown in Fig. 1.4 and described following.

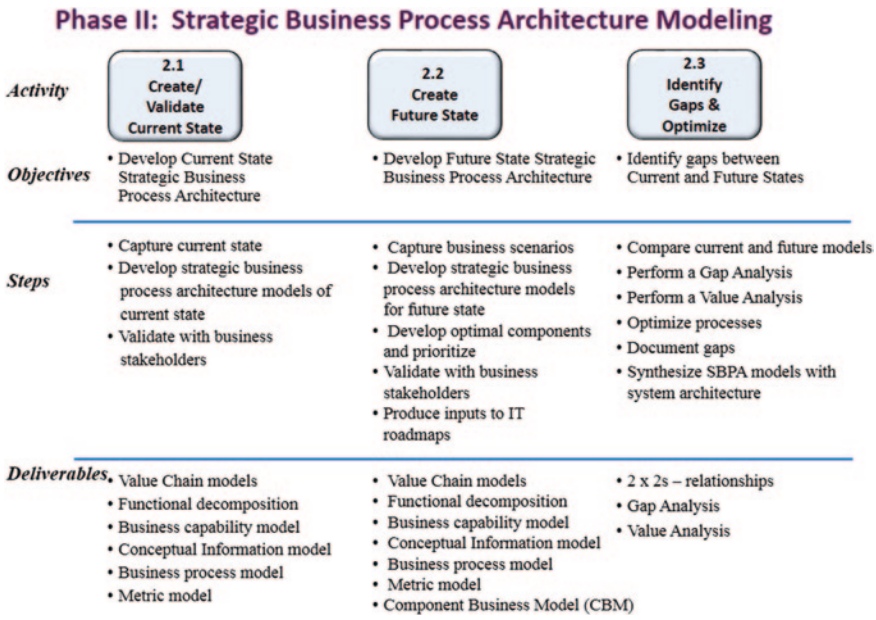

Fig. 1.4 *Phase II*. Strategic business process architecture modeling

The purpose of the Develop SBPA phase is to build the existing or "current state" SBPA models, to create a repository that can be used to understand the enterprise as it exists today. Additionally the future state SBPA is developed that aligns to the business strategies elicited from the business.

The current state analysis phase can be used to build the existing SBPA repository for purposes of business planning or to build a view related to an IT or process improvement change initiative (program or major project). This phase would be performed on an as-needed basis for each function where the current state SBPA models do not currently exist for those functions identified to be part of the scope of the engagement. This phase could also be performed when a view of the current state is needed for business planning activities.

The purpose of the future state analysis is to build the SBPA models based on the defined future state, or where we want to go based on business strategic planning or definition of the change initiative. The Future State SBPA models would be an input to the Information and Application Architectures and the initiative roadmaps for the enterprise. This phase could be performed when a view of the future state is needed for Enterprise planning activities or related to an initiative.

Create/Validate Current State

This step is to create the current state SBPA models if they do not exist, or to validate the models if they do exist.

Purpose The purpose of the Current State Analysis phase is to build the existing or "current state" SBPA models, to create a repository that can be used to understand the enterprise as it exists today. If the SBPA models do not yet exist for the functions defined as part of the scope of the change initiative, then the information should be elicited from the business and the business architect should develop the SBPA models. If the business process architecture models exist in the current state repository, then the business architect should validate these with the business to ensure the information still represents the current state of the business.

Frequency The current state analysis phase can be used to build the existing SBPA repository for purposes of business planning or to build a view related to a change initiative (program or major project). This phase would be performed on an as-needed basis for each program where the current state SBPA models do not currently exist for those functions identified to be part of the scope of the program initiative. This phase could also be performed when a view of the current state is needed for business planning activities.

Create Future State

Purpose The purpose of the Create Future State is to build the SBPA models based on the defined future state, or where we want to go based on business strategic planning or definition of the change initiative. The Future State SBPA models would be an input to the Information and Application Architectures and the IT or process improvement roadmaps for the enterprise.

Frequency The future state analysis would be used during Enterprise planning as part of the What-If planning and also during the IT initiatives. This phase would be performed on an as-needed basis for each program where the current state SBPA models do not currently exist for those functions identified to be part of the scope of the program initiative. This phase could also be performed when a view of the future state is needed for Enterprise planning activities.

Identify Gaps and Optimize

Purpose The purpose of this step is to identify gaps between the current state and the future state, as well as optimize the processes that are part of the scope of the engagement. The goal is to rationalize the processes and identify optimized components that will optimize the processes in each instance that the components exist.

Lean Six Sigma

Once the business architecture models are derived the next step is to optimize the processes. This is where Lean Six Sigma enters the picture. The Lean Six Sigma projects can be identified and scoped that align to the key business processes, and the business

strategies. Resources can be applied to these projects, from a central governing steering committee, to ensure alignment between the business strategic initiatives and the Six Sigma projects, and to assess the improvement projects' success and financial savings.

Conclusions

Through the derivation and development of the SBPA, we can optimize the enterprise and enhance operational excellence. SBPA applies the underlying principles of business process management through documenting, controlling, and improving processes that align with the business strategies.

We can leverage the improvement methodologies through the Lean Six Sigma program to improve the processes. The SBPA modeling and data collection helps to provide a prioritization of the key processes that need improvement, which align with the business strategies and goals of the enterprise. The business architecture helps the organization focus on the important Lean Six Sigma improvement projects and the processes that truly matter to the business, and enable us to better meet our customer's expectations through streamlined and optimized processes.

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Chapter 2
Lean Six Sigma Roadmap

Abstract The purpose of this chapter is to provide a roadmap to applying the Lean Six Sigma (LSS) methodology and the key tools that can be applied when implementing LSS in healthcare processes. This chapter was originally published in Furterer (2009), and adapted for the healthcare enterprise. A little over twenty-one percent (21.3 %) of the industrial workforce is engaged in educational services and healthcare, and social assistance occupations (US Census Bureau). Service industries are the fastest growing segment of our economy and now account for almost 70 % of economic activity, and over 85 million employees (US Census Bureau North American Product Classification). Healthcare processes include both clinical and nonclinical processes, and both types can be improved using LSS methodologies and tools.

Lean Six Sigma Overview

Lean Six Sigma (LSS) is an approach focused on improving quality, reducing variation, and eliminating waste in an organization. It is the combining of two improvement programs, Six Sigma and Lean Enterprise. Six Sigma is a quality management philosophy and methodology that focuses on reducing variation, measuring defects (per million output/opportunities), and improving the quality of products, processes, and services. The concept of Six Sigma was developed in the early 1980s at Motorola Corporation. Six Sigma became popularized in the late 1990s by General Electric Corporation and their former CEO Jack Welch. Lean Enterprise is a methodology that focuses on reducing cycle time and waste in processes. Lean Enterprise originated from the Toyota Motor Corporation as the Toyota Production System (TPS) and increased in popularity after the 1973 energy crisis. The term "Lean Thinking" was coined by James P. Womack and Daniel T. Jones in their book, Lean Thinking (Womack and Jones 1996). The term "Lean Enterprise" is used to broaden the scope of a Lean program from manufacturing to embrace the enterprise or entire organization (Alukal 2003).

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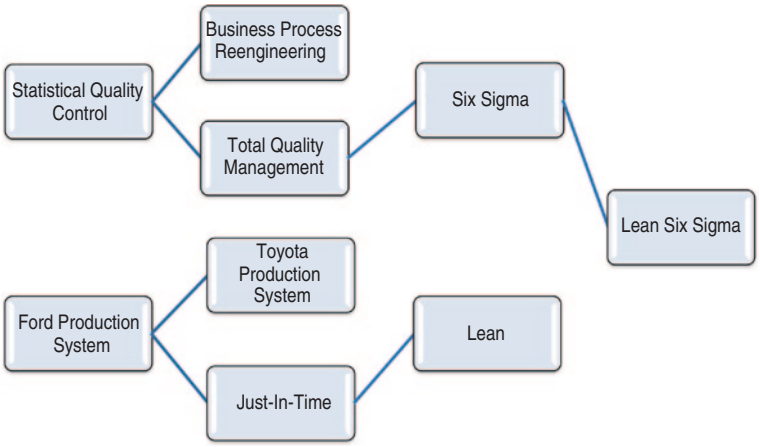

Fig. 2.1 Evolution of quality and productivity to Lean Six Sigma

Figure 2.1 shows the evolution to the combined methods of Lean and Six Sigma.

In the 1920s, at Western Electric, the concepts of control charts and statistical process control (SPC) were developed by Walter Shewhart. Dr. Edward Deming installed SPC in Japanese manufacturing as he assisted Japan in their rebuilding efforts after World War II. Japan's successes in the 1970s have repopularized SPC in United States businesses. Total Quality Management (TQM) was a natural outgrowth of SPC adding process improvement methodology. In the 1980s Business Process Reengineering (BPR), and TQM became popular. BPR encouraged completely throwing out the old process and starting over, many times within the context of implementing major information systems changes. TQM focused on a less structured approach with the principles of Quality and process improvement. These methodologies evolved to Six Sigma.

On the Productivity side, the Ford Production System was used to assemble cars, which was the basis for the TPS. Just-in-time production philosophies joined with TPS which evolved into Lean. Now Lean and Six Sigma are merging to capitalize on the best of both improvement philosophies and methodologies.

Six Sigma uses the DMAIC (Define, Measure, Analyze, Improve, and Control) problem solving approach, and a wide array of quality problem solving tools. Use of these tools varies based on the type of process studied and the problems that are encountered. There are many powerful tools in the Lean tool set that help to eliminate waste, organize, and simplify the work processes.

Lean Six Sigma Applications in Private Industry

The concept of combining Lean Manufacturing and Six Sigma principles began in the middle to late 1990s, and has quickly taken hold as companies recognized the synergies. There are many examples of manufacturing companies implementing

a combined effort of Lean and Six Sigma. An early example, starting in 1997, was by an aircraft-engine-controls firm, BAE Systems Controls, in Fort Wayne, Indiana. They blended Lean-manufacturing principles with Six Sigma Quality tools. Their "Lean Sigma" strategy was "designed to increase velocity, eliminate waste, minimize process variation, and secure its future in the evolving aerospace market" (Sheridan 2000). They started with implementing Lean initiatives and then identified a synergy between Lean and the Six Sigma quality program that had been launched while the company was a part of General Electric. BAE Systems Controls implemented the following lean initiatives: (1) kaizen events, (2) takt-time-driven one-piece-flow product cells, (3) kanban pull system and point-of-use storage bins on the plant floor, (4) lean production cells, (5) mistake proofing, and (6) use of a multi-skilled workforce. As part of the Six Sigma program, they implemented statistical methods and team leadership with the use of Black Belts. In BAE Systems Control's implementation of LSS, they improved productivity by 97 % and customer lead time by 90 %. Their value added productivity increased 112 % in 5 years, work in process was reduced by 70 %, product reliability improved by 300 %, and there were zero lost workdays in 1999 (Sheridan 2000).

Another early innovator combining Lean and Six Sigma was Maytag Corporation. Maytag implemented Lean Sigma in 1999. They designed a new production line using the concepts of Lean and Six Sigma. Maytag reduced utilized floor space to one-third of that used by Maytag's other product lines. Maytag also cut production costs by 55 %. Their Lean Sigma effort helped Maytag to achieve savings worth millions of dollars (Dubai Quality Group 2003).

Lean Six Sigma has been implemented at Northrop–Grumman, an Aerospace Company. They had already begun to implement Lean Thinking when they embarked upon their Six Sigma program. Northrop integrated the Workout™ events (a problem solving process developed at GE) with the Lean Thinking methods and Kaizen events. They used Six Sigma's strategy and methods within their Product Teams, not as a stand-alone program. Their formal process integrated WorkOut™, Kaizen, and DMAIC into the Six Sigma Breakthrough WorkOut™. Subject matter experts and a Black Belt were used on their project team. They performed a 4 to 5 day Define/Measure phase. They then performed the Measure, Analyze, and Improve phases for roughly 30 days each. The final activities included a post-WorkOut phase as the Control, Integrate, and Realize phase (McIlroy and Silverstein 2002).

Lockheed Martin Aeronautical Systems reduced costs, improved competitiveness, customer satisfaction, and the first-time quality of all its manufactured goods. They had separate Lean and Six Sigma projects, depending on the objective of the project and the problem that needed to be solved (Kandebo 1999).

The Six Sigma DMAIC problem solving methodology is used to improve processes. The phases of the DMAIC are well-defined and standardized, but the steps performed in each phase can vary based on the reference used. The Define phase is where the scope of the project charter is developed. The goal of the Measure phase is to understand and baseline the current process. In the Analyze phase, we analyze the data collected in the Measure phase to identify the root

DEFINE	MEASURE	ANALYZE	IMPROVE	CONTROL
1. Develop project charter 2. Perform stakeholder analysis 3. Perform initial VOC and identify CTS 4. Select team and launch the project 5. Create project plan	6. Define the current process 7. Define detailed VOC 8. Define the VOP and current performance 9. Validate Measurement System 10. Define COPQ and Cost/Benefit	11. Develop cause and effect relationships 12. Determine and validate root causes 13. Develop process capability	14. Identify breakthrough & select solutions 15. Perform cost/benefit analysis 16. Design future state 17. Establish performance targets, project scorecard 18. Gain approval to implement and implement 19. Train and execute	20. Measure results & manage change 21. Report scorecard data & create process control plan. 22. Apply P-D-C-A process. 23. Identify replication opportunities 24. Develop future plans

Fig. 2.2 DMAIC activities

causes of the problems identified. In the Improve phase, the improvement recommendations are developed and implemented. The goal of the Control phase is to ensure that the improvements had a positive impact and that they will be sustained and controlled. In Fig. 2.2, is a description of the activities that can be performed within each phase of the DMAIC problem solving methodology (Brassard and Ritter 2001).

Define Phase

The purpose of the Define phase is to delineate the business problem and scope the project and process to be improved. The following steps can be applied to meet the objectives of the Define phase:

1. Develop project charter
2. Perform stakeholders analysis
3. Perform initial Voice of Customer (VOC) and identify Critical to Satisfaction criteria (CTS)
4. Select the team and launch the project
5. Create project plan.

Figure 2.3 shows the main activities mapped to the tools or deliverables most typically used during each step of the Define phase.

Develop Project Charter

The first step in the Define phase is to identify and delineate the problem. The project charter can help to identify the elements that help to scope the project, and identify the project goals.

	Define Activities	Tools / Deliverables
1	Develop project charter	▪ Project charter ▪ SIPOC (Supplier – Inputs – Process – Output – Customer) ▪ High Level Process Map
2	Perform stakeholder analysis	▪ Stakeholder analysis definition ▪ Stakeholder commitment scale ▪ Communication planning worksheet
3	Perform initial Voice of the Customer (VOC) and identify Critical to Satisfaction (CTS)	▪ Critical to Satisfaction (CTS) summary
4	Select team and launch the project	▪ Responsibilities matrix ▪ Ground rules ▪ IFR (Items for Resolution
5	Create project plan	▪ Work plan

Fig. 2.3 Define activities and tools/deliverables

Project Name: Name of the Lean Six Sigma Project

Project Overview: Background of the project.

Problem Statement: Business problem, describe what, when, impact, consequences.

Customer/Stakeholders: (Internal / External) Key groups impacted by the project.

What is important to these customers – CTS: Critical to Satisfaction, the key business drivers.

Goal of the Project: Describe the improvement goal of the project.

Scope Statement: The scope of the project, what is in the scope and what is out of scope.

Financial and Other Benefit (s): Estimated benefits to the business, tangible and intangible.

Potential Risks: Risks that could impact the success of the project. Can assess risk by probability of occurrence and potential impact to the project.

Milestones: DMAIC Phase and Estimated Completion Dates

Project Resources: Champion, Black Belt Mentor, Process Owner, Team Members.

Fig. 2.4 Project charter template

A project charter template is provided in Fig. 2.4.

Following is a description of the elements of the project charter that helps to scope and define the business problem.

Project name. The name of the project. Describe the process to be improved along with the project goal.

Project overview. Provides a project background and describes basic assumptions related to your project.

Problem statement. A clear description of the business problem. What is the challenge or the problem that the business is facing? The problem statement should consider the process that is impacted. Define the measurable impact of the problem. The team should be specific as to what is happening, when it is occurring, and what the impact or consequences are to the business of the existing problem.

Customers/Stakeholders. Define the customers, both internal and external, and the stakeholders that are being impacted by the problem or process to be improved.

Critical to satisfaction. Identify what is important to each customer/stakeholder group. They can be identified by what is critical to quality (CTQ) (defects), delivery (time), and cost.

Goal of the project. What is the quantifiable goal of the project? It may be too early in the problem solving method to identify a clear target, but at least a placeholder should be identified relating to what should be measured and improved.

Scope statement. The scope should clearly identify the process to be improved, and what is included or excluded from the scope for the LSS project. The scope can also address the organizational boundaries to be included and possibly, more importantly, which should be excluded. It can also include a temporal scope of the timing of the process and data collection activities. The deliverable scope includes what specifics should be delivered from the project, such as improvement recommendations, and implementation plan and so forth.

Projected financial and other benefits. Describes potential savings, revenue growth, cost avoidance, cost reduction, Cost of Poor Quality (COPQ), as well as less tangible benefits such as impact to morale, elimination of waste and inefficiencies.

Potential risks. Brainstorm the potential risks that could impact the success of the project. Identify the probability that the risk could occur, on a high, medium, or low scale. Identify the potential impact to the project if the risk does occur, on a high, medium, or low scale. The risk mitigation strategy identifies how you would potentially mitigate the impact of the potential risk if it does occur.

Project resources. Identify the project leader who is in charge of the overall project. Identify the division and department of the project leader or project team. Identify the process owner, the person who is ultimately responsible for implementing the improvement recommendations. The project champion is the director (or above) level who can remove the barriers to successful project implementation. Project sponsor is the executive level person who sponsors the project initiative and is the visible representative of the project and the improvements. Continuous Improvement Mentor or the Master Black Belt is the team's coach who helps to mentor the team members in application of the tools and the DMAIC methodology. Finance is the financial representative who approves the financial benefits or savings established during the project. Team members or support resources are those people who are part of the project team, or who provide support, information, or data to the project team.

Suppliers	Inputs	Process	Outputs	Customers
Merchandising	Strategies, market information	Identify items to advertise	Items to advertise	Marketing
Marketing	Items to advertise	Identify price and discounts	Prices, discounts	Ad firm
Ad firm	Prices, discounts, items	Design circular	Circular design	Ad firm
Ad firm	Circular design	Develop circular	Draft Circular	Marketing
Marketing	Draft Circular	Approve circular	Approval	Ad firm
Ad firm	Approval	Finalize circular	Final Circular	Marketing
Marketing	Final Circular	Distribute circular	Circular	Customers

Fig. 2.5 SIPOC example

Milestones. The milestones are the estimated key dates when each phase will be completed, and when the project improvements will be approved.

SIPOC (Suppliers-Input-Process-Output-Customer)

The SIPOC is a useful tool in the Define phase to help scope the project and understand the process. SIPOC shows the interrelationships between the customers, and suppliers and how they interact with the process. It also identifies the inputs used in the process steps and the outputs of the process. The process steps transform the inputs into the outputs. The best way to construct the SIPOC is to identify the five to seven high-level process steps that bound the process. For each process step identify the inputs to the process and who supplies the inputs. Next identify the outputs of each process step and the customer of the output. Figure 2.5 is an example of a SIPOC for creating a circular advertisement.

High-Level Process Map

A process is a description of activities that transforms inputs to outputs. A process map is a graphical representation of the process, interrelationships and sequence of steps. The high level or level 1 process map utilized in the Define phase can be derived from the process steps identified in the SIPOC. The process steps can be simply turned 90° and be displayed horizontally instead of vertically. Process maps are a valuable tool in helping to understand the current process, identify the inefficiencies and non-value added activities, and then create the future state process during the improve phase. If there is sufficient knowledge of the process, a more detailed, level 2 process can be created in the Define phase, but typically, additional interviews must be held to collect the information, so a level 1

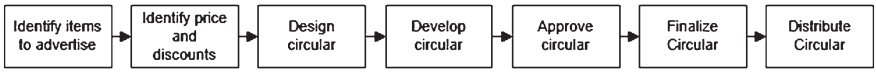

Fig. 2.6 Level 1 process map

process map is usually sufficient, as shown in Fig. 2.6 which is a process map for a company's advertising circular process.

Perform Stakeholder Analysis

It is critical to clearly identify the customers and stakeholders that are impacted by the process because the quality of the process is defined by the customers. Quality is measured by first understanding then exceeding the customers' requirements and expectations. There is a high cost of an unhappy customer: Ninety-six percent (96 %) of unhappy customers never complain; 90 % of those who are dissatisfied will not buy again; and each unhappy customer will tell his or her story to as many as 14 other people (Pyzdek 2003).

Customers and stakeholders can be: my peers, people who report to me, my boss, other groups within the organization, suppliers, and external customers. The customers can include both internal and external customers of the process. Each process does not always interface directly with an external customer of the company, but will have internal customers. The internal customers are people who receive some output from the process, such as information, materials, product, or a service step. It is ultimately the boundary of the process that is being improved that determines who the customer is.

The stakeholder analysis definition identifies the stakeholder groups, their role and how they are impacted, as well as their concerns related to the process. There is an additional column which provides a quick view of whether the impact is positive (+), such as reducing variation, or negative (−), such as resistant to change. This is a high-level view that will be further detailed in the Measure phase. Figure 2.7 is an example of a stakeholder definition.

The next step in the stakeholder analysis is to understand the stakeholders' attitudes toward change, as well as potential reasons for resistance. Additionally, the team should understand the barriers to change as a result of the resistance. Next, activities, plans, and actions should be developed that can help the team to overcome the resistance and barriers to change. A definition of how and when each stakeholder group should participate in the change effort should be developed in the Define phase, and then updated throughout the DMAIC project. Figure 2.8 shows a stakeholder commitment.

The stakeholder commitment scale can be used to summarize where the stakeholders are regarding their acceptance or resistance to change. The team should determine, based on initial interviews and prior knowledge of the stakeholder groups, the current level of support or resistance to the project. Strongly supportive indicates that these stakeholders are supportive of advocating for and making change to happen. Moderately supportive indicates that the stakeholders will help, but not strongly. The neutral stakeholders will allow the change and not stand

Stakeholder Analysis Definition			
Stakeholders	**Role Description**	**Impact / Concern**	**+ / -**
External customer	Customers who receive our marketing efforts related to marketing programs, including advertising circulars, and commercials.	• Timely information • Accurate information • Coupons	+ + +
Marketing	Internal marketing department who plan, develop and deploy marketing programs.	• Timely deployment • Ability to reach and impact customers	+ +
Information Technology	Information technology department that provides technology	• Clear requirements • Accurate Data	+ +

Fig. 2.7 Stakeholder analysis definition

Stakeholder Commitment Scale							
Stakeholders	**Strongly Against**	**Moderate Against**	**Neutral**	**Moderate Support**	**Strongly Support**	**Communication Plan**	**Action Plan**
External Customer		X			O	• Surveys • Market Research	Test pilot
Marketing			X		O	• Email • Meetings	Engage on project
Information Technology	X			O		• Intranet • Email • Meeting	Engage on project Communicate process and requirements
X = At Beginning of Project					O = At End of Project		

Fig. 2.8 Stakeholder commitment scale

in the way, but not go out of their way to advocate for the change. Moderately against, stakeholders do not comply with the change, and have some resistance to the project. Strongly against, stakeholders will not comply with the change and will actively and vocally lobby against the change. A strategy to move the stakeholders from their current state to where the team needs them to be by the end of the project should be developed. This change strategy should include how the team will communicate with the stakeholders and any activities in their action plan to gain support and implement change.

Perform Initial Voice of Customer (VOC) and Identify Critical to Satisfaction (CTS)

In the Define phase, the team can perform an initial VOC data collection to understand the CTS criteria. CTS' are the elements of a process that significantly

affect the output of the process. It is critical to focus throughout the phases of the DMAIC problem solving process and the Six Sigma project on the CTS.

In the Define and Measure phases, the focus is on collecting information from the customer to understand what is important to them regarding the process, product, or service. Identify the Measure phase in the measure of your process directly related to the CTS criteria. Identify the root causes in the Analyze phase related to the CTS. The improvement recommendations implemented are aligned by eliminating the root causes related to the CTS. The variability to be controlled by implementing control mechanisms in the Control Phase should reduce the variability related to the CTS.

Some references refer to identifying the CTQ, but the CTS broadens the elements of the CTS by including CTQ,, Critical to Delivery (CTD), and Critical to Cost (CTC). There may also be critical elements in the process to measure related not only to quality, delivery, and cost, but to time, as well. For a Six Sigma project, not everything should be a CTS. The CTS should be specific to the scope of the project and the process to be improved. If there are more than a few CTS identified for the project, the scope is probably too large for a reasonable Six Sigma project to be completed in 3 to 6 months. The CTS should describe the customer need or requirement, not how to solve the problem.

The steps to identify the CTS are (George et al. 2005):

1. Gather appropriate VOC data from market research, surveys, focus groups, interviews, etc.
2. Extract key verbatims from the VOC data collections, identifying why a customer would do business with your organization.
3. Sort ideas and find themes, develop an Affinity or Tree Diagram.
4. Be specific and follow-up with customers where needed.
5. Extract CTS' and specifications from customer information.
6. Identify where you are missing data and fill in the gaps.

The VOC is a term used to "talk to the customer" to hear their needs and requirements or their "voice." Many different mechanisms can be used to collect VOC, including interviews, focus groups, surveys, customer complaint and warranty data, market research, competitive information, and customer buying patterns. We will further discuss VOC during the Measure phase, where more detailed and extensive VOC can best be performed. The initial VOC is used to identify the CTS'. In the Define phase, the CTS Summary is a listing of the CTS' based on knowledge of the process and the customer to this point.

Select Team and Launch the Project

The Six Sigma project team should be selected based on those team members who have the knowledge of the process, and have the commitment to work on the project. The roles and responsibilities of the project team members should be clearly defined.

Role / Responsibility	Team Leader	Black Belt	Champion	Process Owner	Team members
Facilitate meetings	X				
Manage project	X				
Mentor team members	X	X			
Transfer knowledge of Six Sigma tools		X			
Remove roadblocks			X		
Monitor project progress			X		
Approve project			X		
Implement improvements				X	
Subject matter expertise				X	
Apply Six Sigma tools					X
Statistical Analysis					X
Data collection					X

Fig. 2.9 Responsibility matrix

A team is a group of people working together to achieve a common purpose. Teams need a clearly defined purpose and goals which are provided through the Six Sigma project charter. They also need well-defined roles and responsibilities, which can be provided through developing a responsibilities matrix. The responsibilities matrix, in Fig. 2.9, identifies the team members, their roles, and high-level responsibilities on the Six Sigma project. Another important component of forming the team, is to brainstorm and identify ground rules. The ground rules identify how the team will interact with each other and ensure that the behavioral expectations are clearly defined at the start of the project. The team's common set of values and ethics can be established during the development of the team ground rules.

Sample team Ground Rules:

- Treat everyone with respect
- Listen to everyone's ideas
- When brainstorming, do not evaluate ideas
- Contribute fully and actively participate
- Come to team meetings prepared
- Make decisions by consensus
- Identify a back-up resource to complete tasks when not available.

Create Project Plan

The LSS project plan is developed in this last step of the Define phase. The resources, time, and effort for the project are planned. A project plan template is provided in Fig. 2.10. Additional tasks can be identified within each phase and major activity.

Excel or a project planning software such as Microsoft Project can be used to track tasks completed against the project plan. An important part of the project planning is to perform a risk analysis to identify potential risks that could impact the successful completion of the project.

The team can brainstorm potential risks to the project. They can also assess the probability that each risk would occur on a scale of High, Medium, or Low occurrence. The impact of the risk should also be assessed, that is, if the risk were to occur, what level of impact would it have on the successful completion of the project (High, Medium, or Low). It is also important to develop a risk mitigation strategy that identifies if the risk occurs, how will the team mitigate the impact of the risk to reduce or eliminate the impact of the risk. Figure 2.11 shows a simple risk matrix.

Another tool that is useful while planning and managing the project is an Item for Resolution (IFR) form. This helps the team to document and track items that need to be resolved. It enables the team to complete the planned agendas in meetings, by allowing a place to "park" items that arise that cannot be resolved in the meeting, due to either time constraints or lack of data or access to appropriate decision makers. Figure 2.12 shows an IFR form. It includes a description of the item to be resolved. A priority (High, Medium, Low) should be assigned to each item. The status of the item, open (newly opened), closed (resolved), hold (on hold-not being actively worked) should be identified. The owner who is responsible for resolving the issue, as well as the dates that the item were opened and resolved, should be completed on the IFR form. A description of the resolution should also be included. This helps the team to keep track of key decisions and ensures that the items are resolved to the satisfaction of all team members. The log of IFRs can also be used during the lessons learned activity after the project is complete to identify where the problems arose and how they were resolved, to incorporate these items into the risk mitigation strategies for follow-on projects.

Another helpful tool that should be developed in the Define phase, but be used throughout the LSS project is a communication plan. The communication plan can be used to identify strategies for how the team will communicate with all key stakeholders. It can be useful to help overcome resistance to change by planning how frequently and in the manner that the team will communicate with the stakeholders. Each key stakeholder or audience of a communicated message should be identified. The objectives or message that will be communicated is then developed. The media or mechanism of how to communicate with the audience is then identified. This can be face-to-face, email, web-sites, etc. The frequency of the communication is important, especially for those more resistant to change having more frequent communication. The last element of the communication plan is to clearly identify who is responsible for developing and delivering the communication to the audience. The communication plan is shown in Fig. 2.13.

Task Name	Duration	Start Date	End Date	Resources	Predecessor
Define					
1. Develop project charter					
2. Identify stakeholders					1
3. Perform initial VOC and identify CTS					2
4. Select team and launch the project					3
5. Create project plan					4
Measure					
6. Define the current process					5
7. Define the detailed VOC					6
8. Define the VOP and current performance					7
9. Validate Measurement System					8
10. Define COPQ and Cost/Benefit					9
Analyze					
11. Develop cause and effect relationships					10
12. Determine and validate root causes					11
13. Develop process capability					12
Improve					
14. Identify breakthrough & select practical approaches					13
15. Perform cost/benefit analysis					14
16. Design future state					15
17. Establish performance targets, project scorecard					16
18. Gain approval to implement, and implement					17
19. Train and execute					18
Control					
20. Measure results & manage change					19
21. Report scorecard data and create process control plan					20
22. Apply P-D-C-A process					21
23. Identify replication opportunities					22
24. Develop future plans					23

Fig. 2.10 DMAIC project plan

Potential Risks	Probability of Risk Occurring (High/Medium/Low)	Impact of Risk (High/Medium/Low	Risk Mitigation Strategy

Fig. 2.11 Risk matrix

ITEMS FOR RESOLUTION

#	Issue	Priority	Status	Owner	Open Date	Resolved Date	Resolution

Fig. 2.12 Item for Resolution (IFR) form

Audience	Objectives/Message	Media/Mechanism	Frequency	Responsible

Fig. 2.13 Communication plan

Team Meeting Management

Some best practices for team meeting management are:

- Respect people and their time
- Determine critical/required participants for emails, meetings, and decisions
- Cancel or schedule meetings ahead of time
- Always create a meeting agenda and send it out in advance of the meeting. The agenda should include required and optional participants
- Recap action items, meeting minutes
- Using voting in emails to make easy decisions, or agree upon a meeting time
- Track meeting attendance, and resolve habitual lack of attendance.

The planned meeting agenda should include the following:

1. Date, time, and proposed length of the meeting
2. Meeting facilitator's name
3. Meeting location
4. Required and optional attendees
5. Purpose of the meeting
6. Desired outcomes
7. Topic with time and proposed outcome for each topic.

Some tips that the meeting facilitator can use to keep the meeting productive are:

- Listen, restate what you think you heard
- Ask for clarification and examples
- Encourage equal participation, circle the group
- Summarize ideas, discussion
- Corral digressions, get back to the agenda
- Close the discussion.

Summary

The Define phase is a critical phase of the project. It is important to spend ample time in the Define phase developing the project charter and getting the buy-in of the project champion, the team members, and all stakeholders. The time spent clearly defining the scope of the project will reap dividends by reducing issues during the remaining phases of the project. A process or a problem poorly defined will require the team to revisit the DEFINE phase when improvement efforts bog down or lose focus in subsequent phases.

Measure Phase

The purpose of the Measure phase is to understand and document the current state of the processes to be improved, collect the detailed voice of the Customer information, baseline the current state, and validate the measurement system. The activities performed and tools applied during the Measure phase are discussed below.

1. Define the current process
2. Define the detailed VOC
3. Define the Voice of the Process (VOP) and current performance
4. Validate the measurement system
5. Define the COPQ.

Figure 2.14 shows the main activities mapped to the tools or deliverables most typically used during that step.

	Measure Activities	Tools/Deliverables
6	Define the current process	▪ Process Map ▪ Operational definitions ▪ Metrics ▪ Baseline ▪ Data collection plan
7	Define the detailed Voice of the Customer (VOC)	▪ Surveys, interviews, focus groups ▪ Affinity diagram ▪ Quality Function Deployment
8	Define the Voice of the Process (VOP) and current performance	▪ Pareto charts ▪ VOP matrix ▪ Benchmarking, check sheets, histograms ▪ Statistics
9	Validate the measurement system	▪ Measurement system validation ▪ Gage R&R (Repeatability & Reproducibility)
10	Define the Cost of Poor Quality (COPQ)	▪ Cost of Poor Quality

Fig. 2.14 Measure phase activities and tools/deliverables

Level	Type/Name	Purpose
Level 1	Macro or High Level	▪ **Scope the improvement project** ▪ **Provide project and process boundaries** ▪ **Provide a high-level view of the process**
Level 2	Process Map	▪ **Identify process improvement areas** ▪ **Identify process inefficiencies** ▪ **Identify waste**
Level 3	**Process Map or Process Flow Chart**	▪ **Identify improvement area** ▪ **Identify value vs. non-value added activities** ▪ **Provide detailed how-to (almost procedural level)**

Fig. 2.15 Process map level and purpose

Define the Current Process

The first step of the Measure phase is to profile the current state. SIPOC and process mapping are excellent tools to document the current process steps, the information that is used, the people who perform the work, and the internal and external customers of the services. In a process improvement effort there are typically three levels of process maps that are used to help by documenting the current or AS-IS process. Figure 2.15 shows the three levels and where they should be applied.

An example of a level 2 process map for making a Peanut Butter and Jelly Sandwich is shown in Fig. 2.16.

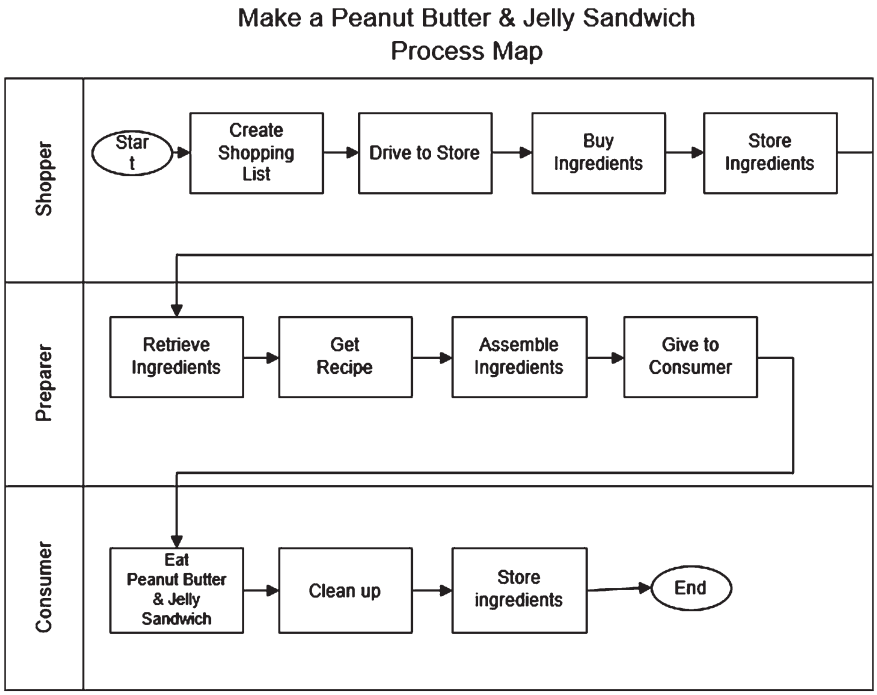

Fig. 2.16 Process map for making a Peanut Butter & Jelly Sandwich

It is also important to identify any process measures and related metrics that are used to measure quality and productivity of the processes. The current profile of the people and cultural state should be understood, including the level of skills and training of the employees, and their resistance or acceptance levels to change.

The steps to complete a process map are:

1. Identify level (one, two, or three) to map and document
2. Define the process boundaries
3. Identify the major activities within the process
4. Identify the process steps and uncover complexities using Brainstorming and Storyboarding techniques
5. Arrange the steps in time sequence and differentiate operations by symbol
6. Validate the Process Map by a "walk through" of the actual process and by having other process experts review it for consistency.

Define Detailed Voice of Customer (VOC)

In the Measure phase, the voice of the customer information should be collected to define the customers' expectations and requirements with respect to the service delivery process. VOC is an expression for listening to the external customer and

understanding their requirements for your product or service. Examples of requirements are their expectations for responsiveness, such as turnaround time on vendor (customer) invoices, or error-rates, such as employee (customer) expectations of no errors on their paycheck. The voice of the customer can be captured through interviewing, surveys, focus groups with the customers, complaint cards, warranty information, competitive shopping. Quality Function Deployment (QFD) can be used to organize the voice of the customer information.

Personal interviews are an effective way to gain the voice of the customer, however, it can be expensive and training of interviewers is important to avoid interviewer bias. However, additional questioning can occur to eliminate misunderstanding. The objectives of the interview should be clearly defined before the interviews are held.

Customer Surveys

Customer surveys are a typical way to collect VOC data. The response rate on surveys tends to be low, 20 % is a "good" response rate. It can also be extremely difficult to develop a survey that avoids and asks the questions that are desired. Customer survey collection can be quite expensive. The steps to create a customer survey are (Malone 2005):

1. *Conceptualization*. Identify the survey objective and develop the concept of the survey, and what questions you are trying to answer from the survey.
2. *Construction*. Develop the survey questions. A focus group can be used to develop and/or test the questions to see if they are easily understood.
3. *Pilot* (*try out*). Pilot the questions by having a focus group of representative people from your population. You would have them to review the questions, identify any unclear or confusing questions, and tell you what they think about the questions asked. You would not use the data collected during the pilot in the actual results of the surveys.
4. *Item analysis*. Item analysis provides a statistical analysis to determine which questions answer the same objectives, as a way to reduce the number of questions. It is important to minimize the number of questions and the total time required to take the survey. Typically, the survey time should be 10 minutes or less.
5. *Revision*. Revise the survey questions, and roll out the customer survey, or pilot again if necessary.

Focus Groups

Focus groups are an effective way to collect VOC data. A small representative group, typically 7 to 10 people are brought together and asked to respond to predetermined questions. The focus group objective should be developed and the questions should support the objective. The participants should be selected by a

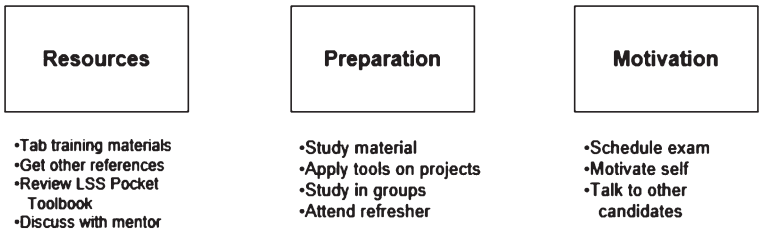

Fig. 2.17 Affinity diagram for Six Sigma Black Belt exam preparation

common set of characteristics. The goal of a focus group is to gather a common set of themes related to the focus group objective. There is no set sample size for focus groups. Multiple focus groups are typically run until no additional themes are derived. Advantages of focus groups are:

- They tend to have good face validity, meaning that the responses are in the words of the focus group participants;
- Typically, more comments are derived in an interview with one person at a time;
- The facilitator can probe for additional information and clarification;
- Information is obtained relatively, inexpensively.

Some of the disadvantages of focus groups are:

- The facilitator skills dictate the quality of the responses;
- They can be difficult to schedule;
- It can be difficult to analyze the dialog due to participant interactions.

Affinity diagrams organize interview, survey, and focus group data after collection. The affinity diagram organizes the data into themes or categories. The themes can first be generated, and then the data can be organized into the themes, or the detailed data can be grouped into the themes. An example of a simple affinity diagram for ways to study for a Six Sigma Black Belt exam is shown in Fig. 2.17.

Data Collection Plan

A data collection plan should be developed to identify the data to be collected that are related to the CTS criteria.

The data collection plan ensures:

- Measurement of CTS metrics.
- Identification of the right mechanisms to perform the data collection.
- Collection and analysis of data.
- Definition of how and who is responsible to collect the data.

Figure 2.18 shows a data collection plan.

Critical to Satisfaction (CTS)	Metric	Data collection mechanism (survey, interview, focus group, etc.)	Analysis mechanism (statistics, statistical tests, etc.)	Sampling plan (sample size, sample frequency)	Sampling instructions (who, where, when, how)
Speed to market	Cycle time	Project management tool	Statistics (mean, variance); t-test	One year of projects	Collect data from project management system for last year
	Functionality delivered	Requirements traceability tool	Count	50 projects (30 development, 20 support)	Extract data based on sampling plan

Fig. 2.18 Data collection plan for software application development Six Sigma project

The steps for creating a data collection plan in the Measure phase are:

1. Define the CTS
2. Develop Metrics
3. Identify data collection mechanism (s)
4. Identify analysis mechanism (s)
5. Develop sampling plans
6. Develop sampling instructions.

A description of each step in the data collection plan development follows:

1. Define the CTS criteria (George et al. 2005):

   CTS is a characteristic of a product or service which fulfills a critical customer requirement or a customer process requirement. CTS's are the basic elements to be used in driving process measurement, improvement, and control.
2. Develop metrics: In this step, metrics are identified that help to measure and assess improvement related to the identified CTS'. Some rules of thumb for selecting metrics are to (Evans and Lindsey 2002):

- Consider the vital few versus the trivial many.
- Metrics should focus on the past, the present, and the future.
- Metrics should be linked to meet the needs of shareholders, customers, and employees.

It is vital to develop an operational definition for each metric, so it is clearly understood how the data will be collected by anyone that collects it. The operational definition should include a clear description of a measurement, including the process of collection. Include the purpose and metric measurement. It should identify what to measure, how to measure it, and how the consistency of the measure will be ensured. A summary of an operational definition follows.

Operational Definition

Defining the Measure, Definition.

A clear, concise description of a measurement and the process by which it is to be collected.

Purpose. Provides the meaning of the operational definition, to provide a common understanding of how it will be measured.

Clear way to measure the process.

- Identifies what to measure
- Identifies how to measure
- Makes sure the measuring is consistent.

3. Identify data collection mechanism(s): Next you can identify how you will collect the data for the metrics. Some data collection mechanisms include: customer surveys, observation, work sampling, time studies, customer complaint data, emails, websites, and focus groups.
4. Identify analysis mechanism(s): Before collecting data, consider how you will analyze the data to ensure that you collect the data in a manner that enables the analysis. Analysis mechanisms can include the type of statistical tests or graphical analysis that will be performed. The analysis mechanisms can dictate the factors and levels for which you may collect the data.
5. Develop sampling plans: In this step you should determine how you will sample the data, and the sample size for your samples. Several types of sampling are:
    - Simple Random Sample: Each unit has an equal chance of being sampled.
    - Stratified sample: The *N* (population size) items are divided into subpopulations or strata, and then a simple random sample is taken from each strata. This is used to decrease the sample size and cost of sampling.
    - Systematic sample: *N* (population size) items are placed into k groups. The first item is chosen at random, the rest of the sample selecting every *k*th item.
    - Cluster Sample: *N* items are divided into clusters. This is used for wide geographic regions.
6. Develop sampling instructions: Clearly identify who will be sampled, where you will sample, and when and how you will take your sample data.

Quality Function Deployment

Quality Function Deployment and the House of Quality is an excellent tool to help to translate the customer requirements from the Voice of the Customer into the technical requirements of your product, process, or service. It can also be used to relate the customer requirements to potential improvement recommendations developed during the Improve phase. Figure 2.19 shows the format for the House of Quality.

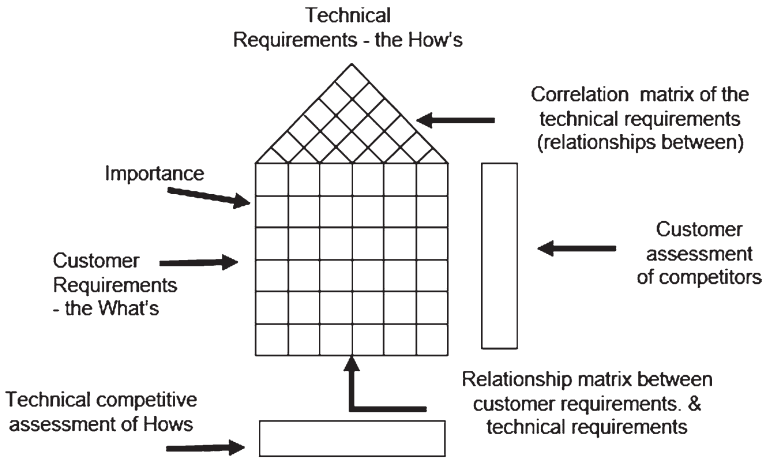

Fig. 2.19 Quality function deployment house of quality

The steps for creating a House of Quality are (Evans and Lindsey 2002):

1. Define the customer requirements or CTS' characteristics from the Voice of the Customer data. The customer can provide an importance rating for each CTS.
2. Develop the technical requirements with the organization's design team.
3. Perform a competitive analysis, having the customer's rank your product, process, or service against each CTS to each of your competitors.
4. Develop the relationship correlation matrix by identifying the strength of relationship between each CTS and each technical requirement. Typically a numerical scale of 9 (high strength of relationship), 3 (medium strength of relationship), 1 (low strength of relationship), and blank (no relationship).
5. Develop the tradeoffs or relationship between the technical requirements in the roof of the House of Quality. You can identify a positive (+) relationship between the technical requirements, as one requirement increases the other also increases; no relationship (blank) or a negative (−) relationship, there is an inverse relationship between the two technical requirements. An example of a positive relationship can be illustrated in the design of a fishing pole. The line gauge and tensile strength both increase as the other increases. A negative relationship can be illustrated by line buoyancy and tensile strength. As tensile strength of the line increases, the buoyancy will be less.
6. The priorities of the technical requirements can be summarized by multiplying the importance weightings of the customer requirements by the strength of the relationships in the correlation matrix. This helps to identify which of the technical requirements should be incorporated into the design of the product, process, or service first.

Define the Voice of the Process (VOP) and Current Performance

There are many tools that can be used to assess the VOP and current performance. We will discuss the VOP matrix, Pareto charts, benchmarking, check sheets, and histograms.

VOP Matrix

A VOP matrix, developed by the author, can be used to achieve integration and synergy between the DMAIC phases and the critical components of the process to enhance problem solving. The VOP matrix includes the CTS, the related process factors that impact the CTS, the operational definition that describes how the CTS will be measured, the metric, and the target for the metric. An example of a VOP matrix for the inventory asset management process for a college in a university is shown in Fig. 2.20.

Pareto Chart

A Pareto chart helps to identify critical areas causing the majority of the problems. It provides a summary of the vital few rather than the trivial many. It demonstrates the Pareto principle that 80 % of the problems are created by 20 % of the causes,

CTS	Process Factors	Operational Definition	Metric	Target
Faculty/Staff Awareness of Process	Procedures exist	Procedures exist and are auditable	Number of departments with procedures	100% of departments have procedures by Jan. 1
	Training in procedures	All faculty will take 1 hour training session within 3 months of hire	Number of faculty trained	100% of faculty are trained within 3 months of hire or Jan. 1
Documented location of assets	Procedures exist	Procedures exist and are auditable	Number of departments with procedures	100% of departments have procedures by Jan. 1
	Training in procedures	All faculty will take 1 hour training session within 3 months of hire	Number of faculty trained	100% of faculty are trained within 3 months of hire or Jan. 1
Identify of Assets	Description on PO	All purchasers will input detailed description of asset on PO	Number of POs with detailed description	95% of POs sampled have detailed descriptions
	Description in system	PO description will transfer to asset management system	Number of asset descriptions in asset mgt.	95% of POs sampled have detailed descriptions
Efficiency of Yearly Scanning	Training	All property managers will be trained in process	Number property managers trained	100% of property managers trained within 3 months
	Process	Quality of process	Proportion of items found on first try	95% of items found on first scan

Fig. 2.20 VOP matrix for inventory asset management process

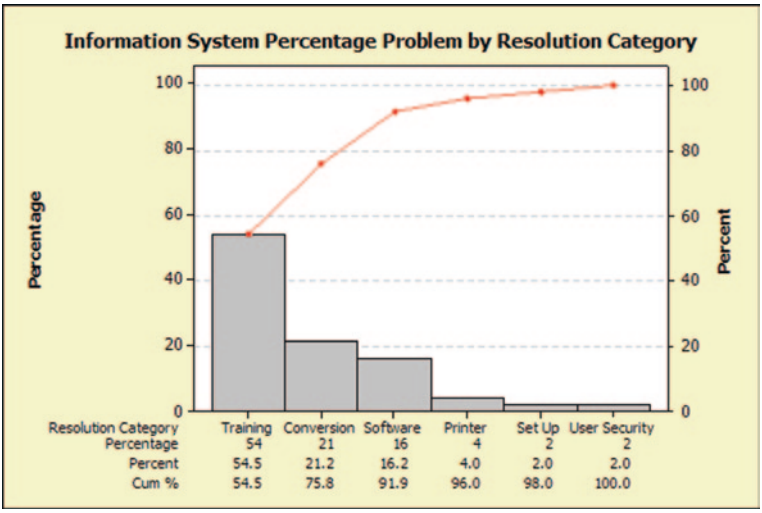

Fig. 2.21 Pareto chart of resolution categories to an information systems to help desk

so that these root causes can be investigated in the Analyze phase. It helps us to arrange the problems in order of importance and focus on eliminating the problems in the order of highest frequency of occurrence.

Following are the steps for creating a Pareto Chart.

Step 1 Define the data categories, defect, or problem types.
Step 2 Determine how the relative importance is defined (dollars, number of occurrences).
Step 3 Collect the data, compute the cumulative frequency of the data categories.
Step 4 Plot a bar graph, showing the relative importance of each problem area in descending order. Identify the vital few to focus on.

An example of a Pareto chart (Fig. 2.21) that identifies the resolution categories for problems reported to an Information Systems Help Desk for a financial application.

Benchmarking

Benchmarking is a tool that provides a review of best practices to be potentially applied to improve your processes. In a Six Sigma project, process benchmarking is typically performed. The organization should document the process that they will benchmark, then select who they will benchmark. It is not necessary to benchmark a company in the same industry, but to focus on the process to be benchmarked, and select an organization that is known for having world class or best practice

Defect Type	Tally	Total
Incorrect Case Name	𝍸	5
Incorrect Docket Number	||	2
Incorrect Court Name	𝍸 |	6
Incorrect Cite Segment	||	2
Incorrect Decided Date	𝍸 ||	7
Incorrect Segment Coding	||	2
Missing Text	𝍸 𝍸	10
Incorrect Primary Embedded Citations	||	2
Copyright Material Included	||	3

Fig. 2.22 Check sheet for errors loading data

processes. The next step is to work with the organization to collect the data and understand how the data can be used to identify ways to improve your processes and identify potential improvement opportunities to be implemented in the Improve phase. This is similar to Motorola's benchmarking process (Evans and Lindsey 2002). It is important to be careful when process benchmarking to ensure that you are comparing apples to apples, meaning that the organization's characteristics are similar to your own, so that the benchmarked process applies to your process.

Check Sheet

A check sheet is a graphical tool that can be used to collect data on the process and types of defects so that root causes can be analyzed in the Analyze phase. The steps to create a check sheet are:

Step 1 Choose a characteristic to track, i.e., defect types
Step 2 Set up the data collection check sheet
Step 3 Collect data using the check sheet.

An example of a check sheet for potential errors when loading data for an online research system is shown in Fig. 2.22.

A Pareto Chart can then be created from the data collected on a check sheet.

Histogram

A histogram is a graphical tool that provides a picture of the centering, shape, and variance of a data distribution. Minitab or Excel is commonly used to create a

histogram. It is always important to graph the data in a histogram as the first step to understanding the data.

Statistics

Statistics can also be used to assess the VOP related to the metrics that are measured. Once the data is collected, it can be tested to see if the data distribution follows a Normal Distribution, using a test for normality. The null hypothesis is that the data is Normal. If the null hypothesis is not rejected, then the statistics that would describe the Normal distribution are the mean and the standard deviation. The mean is the average of the sample data. The mean describes the central location of a Normal distribution. The sample standard deviation is the square root of the sum of the differences between each data value and the mean divided by the sample size less one. Standard deviation (Sigma) is a measure of variation of the data. 99.997 % of all data points within the normal distribution are within Six Sigma.

Validate the Measurement System

It is important to validate the measurement system to ensure that you are capturing the correct data and that the data reflects what is happening. It is also important to be able to assess a change in the process with our measuring system as well as the measurement system error. We must ensure that the measurement system is stable over time and collecting the data that allows us to make appropriate decisions.

Measurement Systems Analysis

A measurement systems analysis includes the following steps (Gitlow and Levine 2005):

1. Prepare a flow chart of the ideal measurement system
2. Prepare a flow chart of the current measurement system
3. Identify the gaps between the ideal and current measurement systems
4. Perform a Gage Repeatability & Reproducibility (R&R) study

The measurement process variation is due to two main types of variation:

- Repeatability related to the gage
- Reproducibility related to the operator.

The Gage R&R study assesses both the repeatability and the reproducibility. Minitab or other statistical software can be used to assess the measurement system error, and improve the measurement system if necessary.

Define the Cost of Poor Quality (COPQ)

Cost of Poor Quality (COPQ)

The last step in the Measure phase can be to assess the COPQ related to your Six Sigma project. The COPQ identifies the cost related to poor quality or not doing things right the first time. The COPQ translates defects, errors, and wastes into the language of management which is cost or dollars. There are four categories of COPQ: (1) prevention; (2) appraisal; (3) internal failures; and (4) external failures.

Prevention costs are all the costs expended to prevent errors from being made or, the costs involved in helping the employee do the job right every time. Appraisal costs are the results of evaluating already completed output and auditing the process to measure conformance to established criteria and procedures. Internal failure cost is defined as the cost incurred by the company as a result of errors detected before the output is accepted by the company's customer. External failure cost is incurred by the producer because the external customer is supplied with an unacceptable product or service.

Examples of prevention costs are:

- Methods improvements
- Training
- Planning for improvement
- Procedures
- Quality improvement projects
- Quality reporting
- Data gathering and analysis
- Preventive maintenance
- SPC training costs
- ISO 9000 training costs.

Examples of appraisal costs are:

- Inspections
- Process Audits (SPC, ISO)
- Testing activity and equipment depreciation allowances
- Product audits and reviews
- Receiving inspections and testing
- Reviews (meeting time)
- Data collection
- Outside endorsements and certifications.

Examples of internal failure costs are:

- Reaudit, Retest, and Rework
- Defects and their impacts
- Unscheduled lost time
- Unscheduled overtime

- Excess inventory
- Obsolescence
- Scrap
- White Collar mistakes.

Examples of external failures are:

- Warranty
- Technical support
- Customer complaints
- Customer bad will costs
- Customer appeasement costs
- Lost business (margin only) due to poor quality
- Product liability
- Return/Refunds
- White Collar mistakes.

The COPQ can help to identify potential categories of waste embedded in the process.

Analyze Phase

The purpose of the Analyze phase is to analyze the data collected related to the Voice of the Customer and the VOP to identify the root causes of the process problems, and to develop the capability of the process. The activities performed and tools applied during the Analyze phase are discussed below.

1. Develop cause and effect relationships
2. Determine and validate root causes
3. Develop process capability.

Figure 2.23 shows the main activities mapped to the tools or deliverables most typically used during that step.

Develop Cause and Effect Relationships

There are several tools that can be used to generate the root causes of the problems identified in the Measure phase.

Cause and Effect Diagram

The Cause and Effect diagram can be used to brainstorm and document root causes of an effect or problem. It is helpful to group the causes into categories, or use categories to brainstorm the causes. Typical categories are people, machine,

	Analyze Activities	Deliverables
11	Develop cause and effect relationships	Cause and Effect Diagrams Cause and Effect Matrix Why-Why Diagram
12	Determine and validate root causes	Process Analysis, Histograms and Graphical analysis, waste elimination and summary of wastes, 5S, Kaizen, FMEA, correlation analysis, regression analysis, basic statistics, confidence intervals, hypothesis testing, ANOVA, survey analysis.
13	Develop process capability	DPPM / DPMO, Process Capability

Fig. 2.23 Analyze phase activities and tools/deliverables

materials, methods, measurements, and environments. Transactional categories are places, procedures, policies, people, and information systems. The steps for creating a cause and effect diagram are:

1. Define problem
2. Brainstorm all possible types of causes
3. Brainstorm and organize causes by groups: people, machines, materials, methods, measurement, and environment. Can also add information systems
4. Brainstorm/identify subcauses for each main cause.

An example Cause and Effect Diagram is shown in Fig. 2.24.

Cause and Effect Matrix

The Cause and Effect Matrix can be used to understand if the same root causes contribute to multiple effects. It is helpful to use the Cause and Effect Matrix if you have multiple CTS characteristics or effects. The matrix establishes the relationship $Y = F(X)$, where Y equals the output variables, and X represents the input/process variables or root causes. To create the Cause and Effect Matrix, brainstorm the potential causes for the multiple CTS' or problems. The Cause and Effect Matrix helps to relate the CTS' or output variables (Y's) to the process or input (X's) variables. The team can rate the strength of relationship between the CTS (Effects) and the causes. A scale of 9 can be used for a high relationship, 3 a medium relationship, 1 a low relationship, and blank as no relationship. The customer should rate the importance of each CTS on a scale of 1–10, with 10 being the highest importance. This importance can be then multiplied by the relationship number to gain a total priority of the effects to understand where process

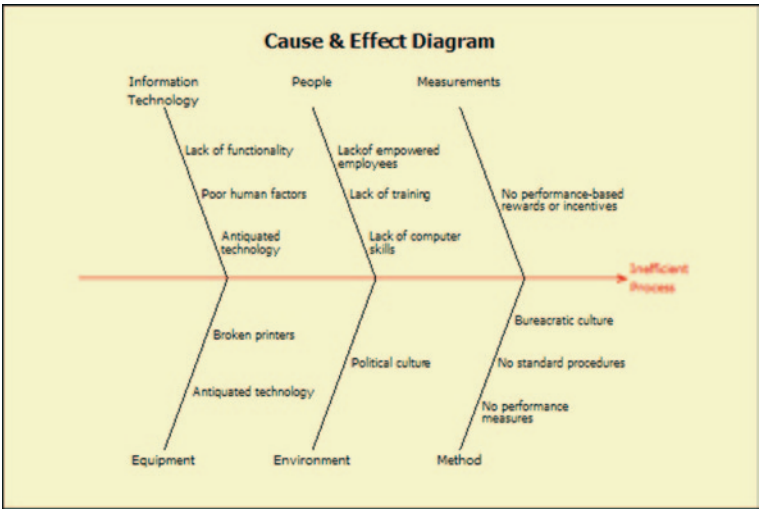

Fig. 2.24 Cause and effect diagram

	Effects					
	Y1	Y2	Y3	Y4	Total	**Relative Weighting**
Causes/Importance:						
X1						
X2						
X3						
X4						
X5						

Fig. 2.25 Cause and effect matrix template

improvement recommendations should be focused in the Improve phase. The relative weightings provides the order of importance, with 1 being the first effect to focus on related to the highest total score. A template for a Cause and Effect Matrix is shown in Fig. 2.25.

Why–Why Diagram

The Why–Why diagram is also a powerful tool to generate root causes. It uses the concept of the five Why's, where you ask the question why several times until the root cause is revealed. Following are the steps to create a Why–Why diagram

1. Start on left with problem statement
2. State causes for the problem
3. State causes of each cause
4. Keep asking why five times

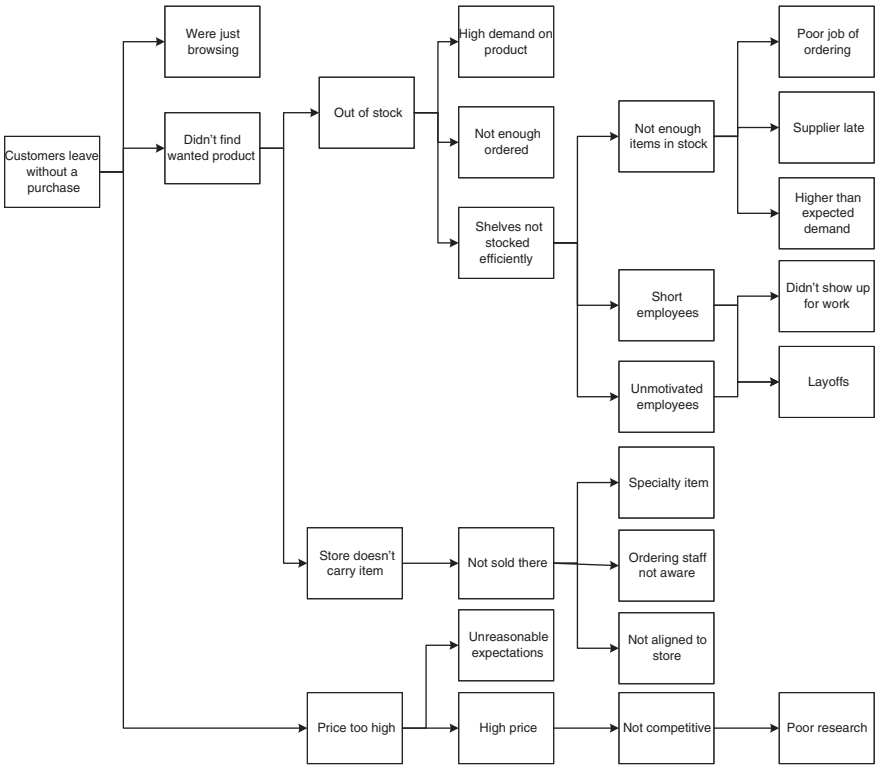

Fig. 2.26 Why–Why diagram

5. Try to substantiate the causes with data
6. Draw the diagram.

Figure 2.26 shows a sample Why–Why diagram for why potential customers leave a store without making a purchase.

It is critical that once you brainstorm the potential root causes of the problems, that you collect additional data to substantiate the causes.

Determine and Validate Root Causes

Process Analysis

To determine and validate root causes, the Six Sigma team can perform a process analysis coupled with waste elimination. A process analysis consists of the following steps:

1. Document the process (using process maps from the Measure phase).
2. Identify nonvalue added activities and waste.
3. Consider eliminating nonvalue added activities and waste.

4. Identify and validate (collect more data if necessary) root causes of nonvalue added activities and waste.
5. Begin generating improvement opportunities.

Value added activities are those activities that the customer would pay-for, that add value for the customer. Nonvalue added activities are those that the customer would not want to pay-for, or don't add value for the customer. Some are necessary, such as for legal, financial reporting, documentation reasons, others are unnecessary, and should be reduced or eliminated. You can assess the percent of value added activities as:

$$100 \times \left(\text{Number of value added activities} \middle/ \text{Number of total activities}\right) \%$$

where value added activities include operations that add value for the customer, and nonvalue added activities include delays, storage of materials, movement of materials, and inspections. The number of total activities include the value added activities and the nonvalue added activities.

You can also calculate the percent of value added time as:

$$100 \times \left(\text{Total time spent in value added activities} \middle/ \text{Total time for process}\right) \%$$

Typically, the percent of value added time is about 1 to 5 %, with total nonvalue added time equal to 95 to 99 %.

During the process analysis, the team can focus on areas to identify inefficiencies in the following areas (Process Flow Analysis Training Manual 1982):

- Can labor intensive process be reduced, eliminated, or combined?
- Can delays be eliminated?
- Are all reviews and approvals necessary and value added?
- Are decisions necessary?
- Why is rework required?
- Is all of the documentation, tracking, and reporting necessary?
- Duplicated process across the organization?
- What is slipping through the cracks causing customer dissatisfaction?
- Activities that require accessing multiple information systems.
- Travel—look at the layout requiring the travel.
- Is it necessary to store and retrieve all the information, do we need many copies?
- Are the inspections necessary?
- Is the sequence of activities or flow logical?
- Are standardization, training, and documentation needed?
- Are all of the inputs and outputs of a process necessary?
- How is the data and information stored and used?
- Are systems slow?
- Are systems usable?
- Are systems user friendly?
- Can you combine tasks?
- Is the responsible person are too high or low of a level?

Waste Analysis

Waste Analysis is a Lean tool that identifies waste into 8 different categories to help brainstorm and eliminate different types of wastes. The 8 wastes are all considered nonvalue added activities and should be reduced or eliminated when possible. Waste is defined as anything that adds cost to the product without adding value. The eight wastes are:

- Transportation: Moving people, equipment, materials, and tools.
- Overproduction: Producing more product or material than is necessary to satisfy the customers' orders, or faster than is needed.
- Motion: Unnecessary motion, usually at a micro or workplace level.
- Defects: Any errors in not making the product or delivering the service correctly the first time.
- Delay: Wait or delay for equipment or people.
- Inventory: Storing product or materials.
- Processing: Effort which adds no value to a product or service. Incorporating requirements not requested by the customer.
- People: Not using people's skills, mental, creative, and physical abilities.

5S Analysis

5S is a Lean tool that helps to organize a work place. The 5S's are:

- *Simplify*. Clearly distinguish between what is necessary and what is unnecessary, disposing of the unnecessary. A red tag is used to identify items that should be reviewed for disposal.
- *Straighten*. Organize the necessary items so they can be used and returned easily
- *Scrub*. Fix the root cause of the dirt or disorganization
- *Stabilize*. Maintain and improve the standards of the first three S's.
- *Sustain*. Achieving the discipline or habit of properly maintaining the correct 5S procedures.

Kaizen

Kaizen is a Lean tool that stands for kai equals change and zen equals for the good. It represents continuous incremental improvement of an activity to constantly create more value for the customer by eliminating waste. A Kaizen consists of short-term activities that focus on redesigning a particular process. A Kaizen event can be incorporated into the Analyze or Improve phase of the Six Sigma project to help to design and/or implement a focused improvement recommendation.

The Kaizen event follows the Plan-Do-Check-Act (PDCA) cycle, including the following steps:

PLAN:

1. *Identify need*. Determine the purpose of the Kaizen.
2. *Form Kaizen team*. Typically six to eight team members.
3. *Develop Kaizen objectives*. To document the scope of the project. The objectives should be SMART (Specific, Measurable, Attainable, Realistic, and Time-based).
4. *Collect current state baseline data*. From Measure phase or additional data as needed.
5. *Develop schedule and Kaizen event agenda*. Typically one week or less.

DO:

6. Hold Kaizen event using DMAIC

Sample Kaizen Event Agenda:

- Review Kaizen Event Agenda
- Review Kaizen Objectives and Approach
- Develop Kaizen Event ground rules with team
- Present baseline measure and background info
- Hold Event:
  - *Define*. Problem (derived from objectives), agree on scope for the event
  - *Measure*. Review measure baseline collected
  - *Analyze*. Identify root causes, wastes, and inefficiencies
  - *Improve*. Create action item list and improvement recommendations
  - *Control*. Create standard operating procedures to document and sustain improvements. Prepare summary report and present to sponsor.
- Identify and assign action items
- Document findings and results
- Discuss next steps and close meeting.

7. Implement: Implement recommendations, fine tune, and train.

CHECK/ACT:

8. *Summarize*. Summarize results

Kaizen Summary Report Items:

- Team Members
- Project Scope
- Project Goals
- Before Kaizen Description
- Pictures (with captions)
- Key Kaizen Breakthroughs
- After Kaizen Description
- Results
- Summary

Process Step	Potential Failure Mode	Potential Effects of Failure	SEVERITY	Potential Causes of Failure	OCCURRENCE	Current Process Controls	DETECTION	RPN	Recommended Action

Fig. 2.27 Failure mode and effect analysis form

- Lessons Learned
- Kaizen Report Card with Follow-Up Date.

9. Control: If targets are met, standardize the process. If targets are not met, or the process is not stabilized, restart Kaizen event PDCA cycle.

Failure Mode and Effect Analysis (FMEA)

A Failure Mode and Effect Analysis (FMEA) is a systemized group of activities intended to recognize and evaluate the potential failure of a product or process, identify actions that could eliminate or reduce the likelihood of the potential failure occurring and document the entire process.

The FMEA process includes the following steps:

1. Document process, define functions
2. Identify potential failure modes
3. List effects of each failure mode and causes
4. Quantify effects: severity, occurrence, detection
5. Define controls
6. Calculate risk and loss
7. Prioritize failure modes
8. Take action
9. Assess results.

A simple FMEA form is shown in Fig. 2.27.

The Risk Priority Number (RPN) is calculated by multiplying the Severity times, the Occurence times the Detection ratings. The Severity is estimated for the failure, and given a numerical rating on a scale of 1 (low severity) to 10 (high severity). The Occurrence is given a numerical rating on a scale of 1 (low probability of occurrence) to 10 (high probability of occurrence). The detection scale is reversed, where a numerical rating is given on a scale of 1 (failure is easily detected) to 10 (failure is difficult to detect).

A Pareto diagram can be created based on the RPN values to identify the potential failures with the highest RPN values. Recommendations should be developed

for the highest value RPN failures to ensure that they are incorporated into the improvement recommendations in the Improve phase.

Correlation Analysis

Correlation analysis measures the linear relationship between two quantitative variables which provides the relationship $Y = F(X)$ or the dependent variable (CTS) is a function of the independent variable(s). A correlation analysis can be run between any two variables, regardless of whether they both are independent or one is dependent and the other is independent. The correlation coefficient (r) is a measure that measures the strength of the relationship between the two variables. The r value falls between $+1.0$ and -1.0. The $+1.0$ signifies a positive strong correlation or positive linear relationship between the two variables. As one variable increases, so does the other variable. For example, as the number of customers increase, the sales increase. The -1.0 signifies a negative strong correlation or negative linear relationship between two variables. As one variable increases, the other variable decreases. A general rule of thumb is that an r value of $+.80$ or greater, or $-.80$ or less signifies a significant correlation between the two variables.

If we establish correlation between x and y, that does NOT necessarily mean variation in x caused variation in y. There may be a third variable that is actually causing the variation that we have not accounted for. To conclude that there is a relationship between two variables does NOT mean that there is a cause and effect relationship.

Linear Regression Analysis

Linear Regression Analysis is a statistical tool that generates a prediction equation that allows us to relate independent factors to our response variable or dependent variable. We use the coefficient of determination, R^2, that allows us to identify the fit of the prediction equation. A simple linear regression relates a single x variable to a single y variable. A simple linear regression equation attempts to fit a line in with an equation of $Y = a + b\,x$. Where Y is the dependent or response variable; a is the Y-intercept value; and b is the slope of the line. A multiple linear regression relates multiple x's to a single y. The linear regression requires at least one independent variable and at least one dependent variable. The R-squared value will be between 0 and 1.0. Ideally, the R^2 value should be greater than 0.64 to represent a significant model. This means that our model accounts for 64 % of the variation in the output.

Confidence Intervals

Confidence interval estimation or confidence intervals provide a range where there is some desired level of probability that the true parameter value is contained within it. It helps us to determine how well the subgroup average approximates the population mean. Confidence intervals help us understand the parameters between

		Conclusion Drawn	
		Do not reject Ho	**Reject Ho**
Actual or True State	Ho True	Correct conclusion	Type I error
	Ho False	Type II error	Correct conclusion

Fig. 2.28 Type I and Type II errors

which the true population parameter, the mean, or standard deviation lies. As the sample size increases, the confidence interval width decreases. As the confidence level increases, say from 95 to 99 %, the confidence interval will increase in width.

Hypothesis Testing

The purpose of hypothesis testing is to:

- Determine whether claims on process parameters are valid
- To understand the variables of interest, the CTS'.

The hypothesis test begins with some theory, claim, or assertion about a particular characteristic (CTS) of one or more populations or levels of the *X* (independent variable).

The null hypothesis is designated as Ho (pronounced "H-O"), and defined as there is no difference between a parameter and a specific value. The alternative hypothesis is designated as, there is a difference between a parameter and a specific value. The null hypothesis is assumed to be true, unless proven otherwise. If you fail to reject the null hypothesis, it is not proof that the null is true.

In hypothesis testing there are two types of error. Type I error, or Alpha Risk is the risk of rejecting the null hypothesis when you should not. The probability of a Type I error is referred to as alpha. Type II error or Beta Risk is the risk of NOT rejecting the Null Hypothesis when you should. The probability of a Type II error is referred to as Beta.

When performing an hypothesis test, you select a level of significance. The level of significance is the probability of committing a type I error, or alpha and is typically a value of .05 or .01. Figure 2.28 shows the Type I and Type II errors.

The steps for performing an hypothesis test are:

1. Formulate the null and alternative hypotheses
2. Choose the level of significance, alpha, and the sample size, *n*
3. Determine the test statistic
4. Collect the data and compute the sample value of the test statistic
5. Run the hypothesis test in Minitab or a statistical package
6. Make the decision. If the *p*-value is less than our significance level, alpha, reject the null hypothesis, if not, then there is no data to support rejecting the null hypothesis. Remember, if *p* is low, Ho must go!

Test Statistics	Number of variables	Test	Parameters
Mean	1	1 sample Z	Variance
Mean	1	1 sample t	Variance unknown
Mean	2	2 sample t	Variance unknown, assume equal variances
Mean	2	2 sample t	Variance unknown, do not assume equal variances
Mean	2	Paired t-test	Paired by subject (before and after)
Proportion	1	1 Proportion	
Proportion	2	2 Proportion	
Variance	1	1 Variance (Chi-Square	
Variance	2	Variance (F-test)	

Fig. 2.29 Summary of hypothesis tests

Some of the most common hypothesis tests are summarized in Fig. 2.29.

ANOVA (Analysis of Variance)

Analysis of Variance is another hypothesis test, when you are testing more than two variables of populations. Following are the steps for running ANOVA.

1. Formulate the null and alternative hypotheses
2. Choose the level of significance, alpha, and the sample size, *n*
3. Collect data
4. Check for normality of data, using a test for normality
5. Check for equal variances, using an F-test
6. Run the ANOVA in Minitab or another statistical package
7. Make the decision.

Common Types of ANOVA:

- One-way ANOVA: testing one variable at different levels, such as testing average grade point average for high school students for different ethnicities.
- Two-way ANOVA: testing two variables at different levels, such as testing the average grade point average for high school students for different ethnicities and by grade-level.

Customer Survey Analysis

Most surveys are attribute or qualitative data, where you are asking the respondent to answer questions using some type of Likert scale, asking importance, the level of agreement or perhaps, level of excellence.

Ways to Analyze Survey Data:

1. Summarize percent or frequency of responses in each rating category using tables, histograms, or Pareto charts
2. Perform attribute hypothesis testing use Chi square analysis

Unlike hypothesis testing with variable data, statistically with attribute data we are testing for dependence, not a difference, but you can think "makes a difference."

We formulate our hypotheses as:

- Ho: "{factor A} is independent of {factor B}"
- Ha: "{factor A} is dependent on {factor B}"

In addition to the p value, we use contingency tables to help understand where the dependencies (differences) exist.

The customer survey analysis steps include:

1. State the Practical Problem
2. Formulate the hypotheses
3. Enter your data in MINITAB or other statistical package
4. Run the Chi Square
5. Translate the statistical conclusion into practical terms.

If *p*, the significance level is low, then reject Ho (if *p* is low, Ho must go). If you fail to reject the null hypothesis, Ho, that means that you fail to reject the hypothesis that the values are independent. If you reject Ho that means that they are dependent, or dependencies or differences exist.

Develop Process Capability

To develop the process capability, you can calculate the DPMO (Defects Per Million Opportunities) and related sigma level, or you can calculate the capability indices. We'll first discuss DPMO.

DPMO

Six Sigma represents a stretch goal of six standard deviations from the process mean to the specification limits when the process is centered, but also allowing for a 1.5 sigma shift toward either specification limit. This represents a quality level of 3.4 defects per million. This is represented in Fig. 2.30.

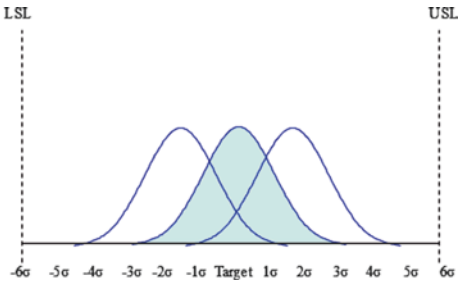

Fig. 2.30 3.4 DPMO representing a 6 Sigma quality level, allowing for a 1.5 sigma shift in the average

Sigma Level	DPMO
6 σ	3.4 DPMO
5 σ	233 DPMO
4 σ	6,210 DPMO
3 σ	66,810 DPMO
2 σ	308,770 DPMO
1 σ	691,462 DPMO

Fig. 2.31 Sigma to DPMO conversion (assuming 1.5 sigma shift)

The greater the number of sigmas, the smaller the variation (the tighter the distribution) around the average. DPMO provides a single measure to compare performance of very different operations, giving an apples to apples, comparison, not apples to oranges. Figure 2.31 shows a Sigma to DPMO conversion.

DPMO is calculated as:

$$\text{DPMO} = (\text{Defects} \times 1,000,000) / (\text{Units} \times \text{Opportunities})$$

where, defects is the number of defects in the sample; units is the number of units in the sample, and opportunities is the number of opportunities for error. For example, for a purchase order, for taking a sample of 100 purchase orders, finding five defects, with 30 fields on the purchase order (opportunities for errors), we calculate a DPMO of 1,667 or about 4.4 sigma.

Process Capability Study

Process Capability is the ability of a process to produce products or provide services capable of meeting the specifications set by the customer or designer. You should only conduct a process capability study when the process is in a state of statistical control. Process capability is based on the performance of individual products or services against specifications. According to the Central Limit

theorem, the spread or variation of the individual values will be greater than the spread of the averages of the values. Average values smooth out the highs and lows associated with individuals.

Following are the steps for performing a process capability study:

1. Define the metric or quality characteristic. Perform your process capability study for the metrics that measure your CTS characteristics defined in the Define and Measure phases
2. Collect data on the process for the metric, take 25 to 50 samples
3. Perform graphical analysis (histogram)
4. Perform a test for normality
5. Determine if the process is in control and stable, using control charts. When the process is stable, continue to step 6
6. Estimate the process mean and standard deviation
7. Calculate the capability indices, usually: Cp, Cpk.

A process can be in control, but does NOT necessarily meet the specifications

$$\text{Cp} = (\text{Upper Specification Limit} - \text{Lower Specification Limit})/\,6\sigma$$

$$\text{Cpk} = \text{Minimum of } \{\text{CPU}, \text{CPL}\} \text{ where:}$$

$$\text{CPU} = (\text{Upper Specification Limit} - \text{Process Mean})/\,3\sigma$$

$$\text{CPL} = (\text{Process Mean} - \text{Lower Specification Limit})/\,3\sigma$$

established by the customer or engineering. You can be in control and not capable. You can be out of control or unstable, but still meet specifications. There is no relationship between control limits and specification limits. However, you must be in control before you use the estimates of standard deviation from your process to calculate process capability and your capability indices.

There are typically three scenarios regarding process capability:

1. Process spread is less than the specification spread. The process is quite capable. Figure 2.32 shows this scenario. Cp and Cpk are greater than 1.33.

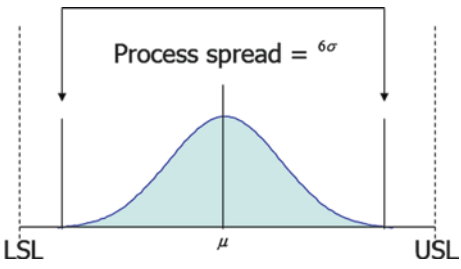

Fig. 2.32 Process is quite capable

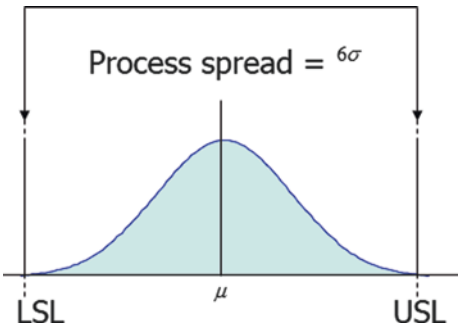

Fig. 2.33 Process is just capable

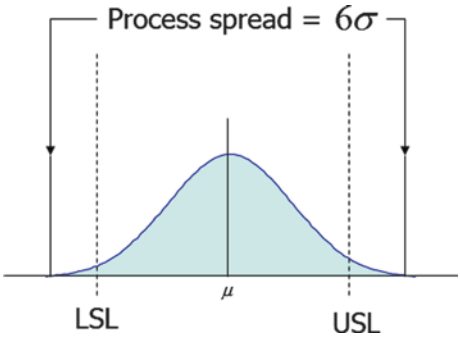

Fig. 2.34 Process is NOT capable

2. Process spread is equal to specification spread, an acceptable situation, but there is no room for error. If the mean shifts, or variation increases, there will be nonconforming product. Figure 2.33 shows this scenario

$$\text{Cp} = \text{Cpk} = 1.$$

3. Process spread is greater than the specification spread. The process is NOT capable. Figure 2.34 shows this scenario. Cp and Cpk are less than 1.

Improve Phase

The purpose of the Improve phase is to identify improvement recommendations, design the future state, implement pilot projects, train, and document the new processes. The activities performed and tools applied during the Improve phase are discussed below.

1. Identify improvement recommendations
2. Perform cost/benefit analysis
3. Design future state
4. Establish performance targets and project scorecard
5. Gain approval to implement, then implement
6. Train and execute.

	Improve Activities	Deliverables
14	Identify improvement recommendations	▪ Revised QFD ▪ Recommendations for improvement ▪ Action Plan
15	Perform cost/benefit analysis	▪ Cost/Benefit Analysis ▪ Cost of Poor Quality
16	Design future state	▪ Future state process map ▪ Future state Value Stream Map ▪ Design of Experiments
17	Establish performance targets and project scorecard	▪ Dashboards/scorecards ▪ Revised VOP Matrix
18	Gain approval to implement, and implement	▪ Project presentations
19	Train and execute	▪ Training plans, procedures

Fig. 2.35 Improve phase activities and tools/deliverables

Figure 2.35 shows the main Improve activities mapped to the tools or deliverables most typically used during that step.

Identify Improvement Recommendations

The Six Sigma team should use the data collected in the first three phases of the DMAIC to identify improvement recommendations. The recommendations should be designed to eliminate the root causes. The team should anticipate things that can go wrong or the type of resistance that you may have, and design plans to work around these barriers

Quality Function Deployment (Revised)

The QFD House of Quality can be used to map the CTS to the Improvement recommendations, to ensure that the recommendations help to satisfy the CTS characteristics. The Customer Requirements on the left of the QFD matrix become the CTS', and the technical requirements become the improvements.

The House of Quality can also be used to prioritize the recommendations, by weighting the CTS' and multiplying the weighting by the strength of the relationship in the relationship matrix of the QFD matrix.

Recommendations for Improvement

The recommendations for improvement can be a listing, with a description of the recommendation ideas. During the design of the recommendations, input should be obtained from the process owners to assess the reasonableness of the solutions.

Information from the following previously used tools can be used to develop the improvement recommendations:

- QFD
- Waste Analysis
- Process Analysis
- Cause and Effect Analysis (Diagram and Matrix)
- Why–Why Diagram
- 5S
- Kaizen
- Process Map or Value Stream Map.

Action Plan

The action plan for the improvement recommendations can be divided into short-term and long-term recommendations. Short term is 3 months or less, and long-term recommendations are those that can be implemented in greater than 3 months.

The action planning should include project plans, with resources, timelines, and risk analysis.

Change management is important when planning the improvement recommendations pilot projects. The following steps can be used to enhance the probability of success for the pilot projects.

1. Create a vision of the future state and communicate with the stakeholders.
2. Understand what is in it for each stakeholder, include them in the solution.
3. Identify who will be resistant to change, and who will be receptive. Gain some early adopters, and engage them in the change process.
4. Implement the change, incorporating training and appropriate resources.
5. Monitor improvement, measure, and assess results.
6. Implement new processes, systems, and organizational structures if needed.

Perform Cost/Benefit Analysis

Cost/Benefit Analysis

You can perform a cost/benefit analysis or a COPQ assessment, to determine the return on investment or savings that are estimated by implementing the improvement recommendations.

In a cost/benefit analysis, we need to decide whether the benefits of the project outweigh the costs. We can use the Benefit/Cost Ratio:

$$\text{B}/\text{C Ratio} = \frac{\text{Present value of benefits}}{\text{Present value of costs}}$$

If the B/C Ratio is greater than 1, than you can accept the project, the benefits outweigh the costs.

Cost of Poor Quality

The COPQ categories can be used to assess the costs that can be eliminated by implementing the improvement recommendations. The team can either use this or the Cost/Benefit Analysis, or compare the improvement in the COPQ before and after the recommendations are implemented.

Design Future State

It is important to design the new future state by developing a future state process map. The team should challenge the boundaries and incorporate quality and Lean principles.

Future State Process Map

The future state process map is simply a process map of the new process incorporating the improvement recommendations.

Design of Experiments (DOE)

Design of Experiments can be used to identify key variables and levels that optimize process performance and improvement quality. It helps to design a robust process that is insensitive to uncontrollable factors. It allows you to look at many factors simultaneously and to assess the interaction of variables. It enables the identification of the critical factors and the associated levels for the process design.

The steps for performing a Design of Experiment are:

1. Set experimental objectives
2. Select process variables
3. Select an experimental design, identify hypotheses
4. Execute the design
5. Check that the data are consistent with the experimental assumptions
6. Analyze and interpret the results
7. Use/present the results, incorporate them into your future state design.

There are many types of experimental designs, the most common are:

- One factor experiments: allows for the manipulation of one factor.
- Two factor experiments: allows for the manipulation of two factors.

- Full factorial experiments: Consists of all possible combinations of all selected levels of the factors to be investigated.
- Fractional factorial experiments: Studies only a fraction or subset of all the possible combinations of factors.

Establish Performance Targets and Project Scorecard

In this step the team should identify the performance targets for the metrics identified in the Measure phase. They also should track pilot project status using project scorecards.

Dashboards/Scorecards

You should also create dashboards or scorecards to assess the performance of your process after trying out the improvement recommendations in the pilot projects.

The project scorecards or dashboards can be used to identify improvements in your process against your metrics that you have identified. The metrics should relate to your CTS' characteristics.

Scorecards should include the following ways to present your metrics (Pyzdek 2003):

- Assessment of improvement of central tendency and variation overtime. SPC Average and Range charts can be used to meet this objective.
- Graphical distribution using a histogram for the most recent time period.
- Assessment of quality or number of defects, using SPC percent defective chart.
- Outliers showing a distribution of individual defectives using a dot plot.

Revised VOP Matrix

You can revise your VOP Matrix from the measure phase to relate your CTS', process factors, operational definition, metric, and more realistic targets for your metrics.

Gain Approval to Implement, Then Implement

The Six Sigma project team should create a presentation and deliver it to the project sponsor, champion, and other management that must approve the improvement recommendations. The champion presentation should be a high-level executive summary.

The team can use the PDCA cycle to implement the pilot recommendation projects. Plan: You can Plan your improvements; Do: Implement your improvements, usually on a pilot scale; Check: Verify that the improvement improved the process based on your metrics; and Act: If the improvements made a positive difference, implement them on a broader scale, if not, refine the improvements and try again. You may go through the PDCA cycle several times.

Train and Execute

The team should develop detailed procedures, as necessary to ensure consistency of the new process. They should develop and rollout training. The train the trainer concept is sometimes used to reduce the resources needed to train. A core group of people are trained on the new process and then they train others in the organization, and become subject matter experts. The process owners should be included in the change process, and changes should be communicated to appropriate stakeholders. The team can use the future state process map as a training guide. They should assess the effectiveness of the training as part of the control plan in the next phase.

Control Phase

The purpose of the Control phase is to measure the results of the pilot projects, and manage the change on a broader scale; report scorecard data and the control plan, identify replication opportunities and develop future plans for improvement. The activities performed and tools applied during the Control phase are discussed below.

1. Measure results and manage change
2. Report scorecard data and create process control plan
3. Apply P-D-C-A process
4. Identify replication opportunities
5. Develop future plans.

Figure 2.36 shows the main Control activities mapped to the tools or deliverables most typically used during that step.

Measure Results and Manage Change

In the Control phase, the team should verify that the training and implementation was carried out correctly. They need to collect and analyze data to ensure process performance and improvements were made. The team needs to further manage the

	Control Activities	Deliverables
20	Measure results and manage change	▪ Hypothesis tests, Design of Experiments
21	Report scorecard data and create process control plan.	▪ Basic statistics, graphical analysis, sampling, mistake proofing, FMEA, control plan, process capability, DPMO; Control charts
22	Apply P-D-C-A process.	▪ Replication opportunities
23	Identify replication opportunities	▪ Standard Work, Kaizen
24	Develop future plans	▪ Dashboards/Scorecards, action plans

Fig. 2.36 Control phase activities and tools/deliverables

change for rollout of the pilot recommendations on a broader scale. The team needs to keep all of the stakeholders in the loop by developing and implementing a communication plan. We will collect data after we improve the process, for the same CTS' and metrics identified in the Measure Phase. We will then assess whether the changes implemented made a "statistically" significant difference, using:

- Hypothesis testing

  OR

- Design of Experiments

Report Scorecard Data and Create Process Control Plan

In this step, the team should demonstrate the impact of the project's metrics, and create or revise the Process Control Plan. The Plan helps to deploy the Six Sigma approach across large areas and to coach groups through the major quality processes.

The purpose of the Control Plan is to maintain the gains. If a conscious plan and effort is not made to ensure that people continue to use the new process, the gains can slip, and when push comes to shove, and people get pressured and busy, they can very easily slip back to their old ways and old processes. The control plan can include:

- Deploying new policies, and removing out-dated policies
- Implement new standards
- Modify procedures
- Modify quality appraisal and audit criteria
- Update prices and contract bid models
- Change information systems
- Revise budgets
- Revise forecasts
- Modify training.

Useful tools that can be used to derive the information to create a control plan include:

- Project planning for creating the control plan
- Brainstorming
- Failure Mode and Effects Analysis
- SPC
- Process Map
- Training
- Procedures
- Mistake Proofing
- Statistics, graphical tools, sampling, FMEA, process capability, DPPM/DPMO.

A control plan format is provided in Fig. 2.37.

For each major process step on the future process map, the control plan should identify how you will control the process step (control mechanism); how you will measure the process step; how critical it is to ensure control for that step; actions to be taken if problems occur; and who is responsible for monitoring control for each process step.

Mistake Proofing

Mistake proofing is a tool that helps to prevent errors in your process. Errors are inadvertent, unintentional, accidental mistakes made by people because of the human sensitivity designed into our products and processes.

Mistake proofing, also called Poka Yoke, is the activity of awareness, detection, and prevention of errors which adversely affect our customers, our people and result in Waste.

Some of the underlying mistake proofing concepts are:

- You should have to think to do it wrong, instead of right.
- Easy to perform inspection at the source.
- Reduces the need for rework and prevents further work (and cost) on a process step that is already defective.
- Simplifies prevention and repair of defects by placing responsibility on the responsible worker.

Process Step	Control Mechanism	Measure/ Metric	Criticality (High, Medium, Low)	Action to be taken if problems occur	Responsibility

Fig. 2.37 Control plan

Statistical Process Control (SPC) Charts

Statistical Process Control Charts are an effective tool to monitor and control the process, and ensure that the process is not out of control. SPC control charts are a graphical tool for monitoring the activity of an ongoing process. The most commonly used control charts are also referred to as Shewhart control charts, because Walter A. Shewhart first proposed the general theory in the 1920s at AT&T Western Electric. Figure 2.38 identifies the most commonly used control charts.

The following steps can be used to implement control charts:

1. Determine the type of chart, quality characteristic, sample size and frequency, data collection mechanism
2. Select the rules for out of control conditions
3. Collect the data (10 to 25 subgroups)
4. Order data based on time order
5. Calculate the trial control limits, create charts (Minitab)
6. Identify out of control conditions
7. Remove points where you can assign causes
8. Recompute the control limits.

Apply P-D-C-A Process

Applying the PDCA to help people continually improve the process. There is the need to focus on:

- What are we trying to accomplish?
- How will we know that change is an improvement?
- What change can we make that will result in improvement?
- If the process is performing to plan, then standardize the activities, if not, then study why not and develop a new plan for improvement.
- Focus on the next most important root cause and implement additional improvements.

Most Common Variables Charts	Most Common Attributes Charts
▪ X-bar and R-charts (average and range) ▪ X-bar and s-charts (average and standard deviation) ▪ X (individual) and moving range	▪ P-charts (proportion non-conforming) ▪ NP-charts (number non-conforming items) ▪ C-charts (number non-conformities) ▪ U-charts (number non-conforming per unit)

Fig. 2.38 Commonly used control charts

Identify Replication Opportunities

In this step, it is important to identify opportunities where you can replicate the same process in the organization. This will leverage the improvement effort across the organization, and potentially save additional money for the company. Identifying replication opportunities can help to support organizational learning.

Develop Future Plans

The purpose of developing future plans is to recognize the time and effort that went into the LSS project by reflecting on the lessons learned and incorporating these into future projects. Some important questions are:

- Have you identified lessons learned?
- Have you identified the next opportunity for improvement?
- Have you shared the learnings with others?
- Have you documented the new procedures?
- Has everyone been trained that needs to be?
- Take time to celebrate.

Dashboards and scorecards can be used to assess where you need to focus improvement efforts in the future. Also, the cause and effect analysis can be used to identify the next root cause to focus improvements on.

Summary

This chapter provided a comprehensive overview of the LSS DMAIC problem solving approach along with key tools of each phase.

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Chapter 3
Hospital and Emergency Department Throughput Improvement

Abstract Visits to emergency departments (ED) are increasing and overcrowding has become a serious problem for hospitals, patients, physicians, and clinical staff. In this case study, a cross-functional team representing the ED, inpatient floors, and units including clinical, ancillary support staff, and non-clinical members applied Lean Six Sigma methodologies and tools to drastically reduce the patient length of stay (LOS) and the percent of patients Left Without Being Seen. There was a 31 % reduction in LOS which is closely tied to patient satisfaction. The percent of Left Without Being Seen was reduced from 6.5 to 0.3 %. The door to doctor time was reduced by 78 % to an average of 23 minutes. Patient Satisfaction scores increased by 24 to 89.9 % which placed this ED department in the top 1 % of EDs nationally.

Introduction

Emergency departments (ED) across the United States are experiencing increased volume and overcrowding. There are many reasons for this crowding in the ED including higher patient acuity, prolonged ED evaluations, inadequate bed capacity, a severe nursing shortage, problems with access to on-call specialists, and the use of the ED by those with no other alternative to medical care, such as the uninsured. Even those with health insurance need to access the ED as primary care networks have been unable to meet demands of unscheduled healthcare (American College of Emergency Physicians 2002).

The hospital is an approximately 500-bed acute care facility, accredited by the Joint Commission. It is affiliated with over 700 physicians representing 27 medical specialties. Its Centers of Excellence include: The Heart Center, The Cancer Center, Minimally Invasive Surgical Institute, and the Orthopedic Institute.

Our hospital-wide cross-functional team worked together to apply Lean Six Sigma tools and methods to significantly improve the patient throughput and time spent in the ED when they seek emergency medical care. To ensure a system and

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hospital-wide view of the processes, the team created the Emergency Services Value Chain. This Value Chain consisted of providing emergency services to patients that came to the ED and were either discharged after assessment, testing, and medical care and disposition, or were admitted to the hospital due to their critical condition. The Emergency Services Value Chain is shown in Fig. 3.1.

The Emergency Services Value Chain consists of the following activities:

- Triage: Assess patient condition and acuity.
- Register: Collect patient personal, demographic, and insurance information.
- Treat: Nurse and physician stabilize the patient, provide treatment, and order diagnostics tests.
- Test/Diagnose: Perform lab and radiology diagnostic tests.
- Disposition: Determine patient disposition (discharge or admit to hospital).
- Transport: Move patient to room if admitted.
- Discharge or Admit: Discharge patient from ED, or admit patient to hospital.

We used the DMAIC (define, measure, analyze, improve, control) problem solving methodology to improve the throughput, measured by patient (LOS) and the percent of patients who leave without being seen (LWBS) treated. A truly cross-functional team was engaged on the project. The team represented clinical and nonclinical team members from the ED, administration, the hospital floors, Information Technology, Case Management, Environmental Services, Radiology, and Lab Services.

The average patient ED LOS was reduced by 86 minutes and 21 % within the first month of the piloted improvements, while the standard deviation was reduced by 43 minutes and 19 % in the same time period. This showed statistically significant improvement with a p value of zero.

Define Phase

The Hospital and ED Throughput Improvement Project was kicked off in May 2009. This project was identified as a strategic project for the hospital. The chief executive officer (CEO) and the chief operating officer (COO) identified the project team participants by selecting key Vice Presidents and Directors in the organization that represented the critical cross-functional areas in the Emergency Services Value Chain.

Fig. 3.1 Emergency services value chain

The author, a certified Six Sigma Master Black Belt was assigned as the Lean Six Sigma project leader and facilitator for the project. As the project lead, she worked with the CEO and COO to understand the desired scope of the project. The CEO and COO wanted a very quick turnaround time in reducing the LOS. The project time frame to piloting the improvements was reduced from a proposed five months to just three months.

The Lean Six Sigma DMAIC problem solving approach was combined with the concepts of Theory of Constraints and Systems Engineering to identify the critical constraints impeding ED patient flow. The goal was to implement improvements that could quickly improve patient flow, and then form additional Lean Six Sigma teams that targeted the critical constraints.

The following steps were executed in the Define Phase:

1. Develop project charter
2. Perform stakeholder analysis
3. Perform initial voice of customer (VOC) and identify critical to satisfaction (CTS)
4. Select team and launch the project
5. Create project plan.

Develop Project Charter

The team reviewed the initial draft of the project charter in the first team meeting. The project charter is shown in Fig. 3.2, Project Charter.

Project Charter

This project is focused on improving patient throughput in the ED. About 40 % of the patients seen through the ED are admitted to the hospital, versus 60 % that are seen are discharged.

The Emergency Department had been experiencing delays in moving the patients through the ED in a timely manner. They recently built a larger ED to be able to better handle anticipated patient volume, and better manage patient flow. However, the patient LOS was still not meeting expectations of ED physicians, nurses, staff, and administration. For January through April 2009 patients, it took an average of 5.8 hours for a patient to be seen, treated, tested, and discharged and an average of 8.7 hours for a patient to be seen, treated, tested, and admitted to the hospital. There were excessive delays and an average 6.5 % of the patients left without being treated or seen by an emergency department physician (EDP), due mainly to long delays in the ED.

The primary stakeholders are the ED Patients, Medical Associates (Doctors, Nurses, Technicians), and Ancillary Services (lab, radiology, pharmacy, transportation) that provide care to the patients. Secondary stakeholders are emergency

Project Overview: This project is focused on improving patient throughput in the ED.

Problem Statement: The Emergency Department is experiencing delays in moving the patient through the ED in a timely manner. There are excessive delays and a high percentage of patients left without being seen.

Customer/Stakeholders: ED Patients, Medical Associates (Doctors, Nurses, Technicians, Transportation), Administration, EMS, Inpatient areas, diagnostic departments.

What is important to these customers – CTS (Critical to Satisfaction): Patient Satisfaction, Quality of Care, Throughput Time, Waiting time.

Goal of the Project: Improve ED throughput time to 3 average hours for discharged patients and 5 average hours for admitted patients.

Scope Statement: The scope includes the ED processes starting from patient entrance, to triage, treat, transport, test/diagnose, disposition and discharge/admit.

Projected Financial Benefit (s): Improved revenue; increased volume (reduction of Left Without Being Seen (LWBS)), increased volume through increased performance; reduced costs through improved efficiency (time per patient).

Fig. 3.2 Project charter

medical services (EMS), Registration, Admitting Physicians and Consultants, Regulatory Agencies, and Hospital Administration.

The goals of the project were to improve ED throughput time to 3 average hours for discharged patients and 5 average hours for admitted patients. There could be an improvement in patient satisfaction and quality of care due to the synergistic relationship between throughput, quality, and satisfaction.

The scope includes the ED processes starting from patient arrival, triage, test and diagnosis, treatment, transporting the patient, to finally disposition and discharge or admit to the hospital. This project also included identifying the major constraints to throughput, the root causes, and improvement recommendations.

Projected Financial Benefits include improved revenue, increased volume (reduction of Left Without Being Seen (LWBS)), increased volume through increased performance, and reduced costs through improved efficiency (time per patient).

Perform Stakeholder Analysis

The primary stakeholders are the ED Patients, Medical Associates (Doctors, Nurses, Technicians), and Ancillary Services that provide care to the patients, Fig. 3.3. The primary stakeholders have a critical stake in the success of the project, and the processes to be improved. The ED patients are those that come to the ED either as walk-ins, or are brought in by ambulance. The Medical Associates include the ED clinical staff, including the physicians, physician assistants,

Stakeholders	Who They Are?	Potential Impacts/Concerns
ED Patients	Patients that go through the Emergency Department. Includes patients who are seen and discharged, admitted, or who leave without being seen	▪ Quality of Care ▪ Low waiting time ▪ Patient Satisfactions
Medical Associates	Physicians and Physician Assistants, Nurses, and Medical Technicians who provide care for ED patients.	▪ Efficient processes ▪ Patient Satisfactions ▪ Patient Throughput ▪ Patient Capacity
Ancillary services	Support Staff, Environmental Services, Lab, Radiology, Pharmacy	▪ Efficient use of resources ▪ Patient Satisfaction ▪ Patient Throughput

Fig. 3.3 Stakeholder analysis—primary stakeholders

nurses, and medical technicians. The Ancillary Services staff includes Radiology, Transportation, Lab, and Pharmacy who provide services for the ED patients.

The secondary stakeholders are involved in the process, but at a less critical level than the primary stakeholders. The secondary stakeholders, shown in Fig. 3.4 are: EMS who bring the patients to the hospital via ambulance, Registration who registers the patients, Admitting Physicians and Consultants who admit patients to the hospital from the ED, Regulatory Agencies who provide standards for compliance, and the hospital's Administration who administer the hospital.

Suppliers-Inputs-Processes-Outputs-Customers

The suppliers-inputs-processes-outputs-customers (SIPOC) is used to ensure the scope of the project is well understood, and is shown in Fig. 3.5. It is also a check and balance for the customer and stakeholder analysis. Any customer and supplier should also be identified as a project stakeholder.

The high-level process steps are the triage, patient registration, treat, diagnose/test, disposition, transport, and discharge or admit. The patients come into the ED either by EMS or by private vehicle. The patients request ED care, and some are referred by their primary care physicians to go to the ED. In triage, the initial acuity of the patient is assessed. The patients are also registered in the medical information system by registration personnel. The nurse will see the patient and ensure that they are stabilized. The physician or physician assistant will also see the patient, and determine the disposition. Lab and imaging diagnostic tests are ordered and performed on the patients. The patient may be further treated based on the results of the tests. The physician determines whether the patient will be discharged from the ED, or admitted to the hospital. The patient is then either discharged or admitted.

Stakeholders	Who They Are?	Potential Impacts/Concerns
EMS	Emergency Medical Services who transport patients to the ED from outside the hospital	▪ Quality of Care ▪ Low waiting time ▪ Patient Satisfaction
Registration	Register the patient	▪ Correct registration ▪ Accurate billing
Regulatory Agencies	Regulatory Agencies who define regulatory criteria.	▪ Quality of Care ▪ Revenue Integrity
Administration	Administration of the Hospital	▪ Efficient processes ▪ Patient Satisfaction ▪ Patient throughput

Fig. 3.4 Stakeholder analysis—secondary stakeholders

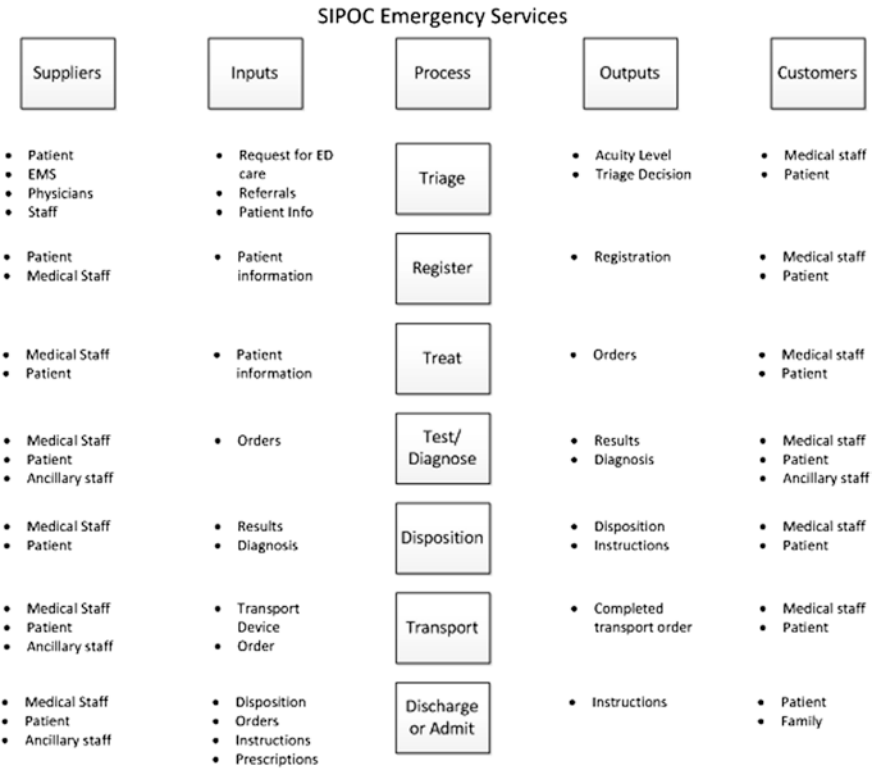


Fig. 3.5 Suppliers-Inputs-Processes-Outputs-Customers (SIPOC)

Perform Initial Voice of Customer and Identify Critical to Satisfaction

The Critical to Satisfaction Criteria for this project are:

- Patient throughput time measured by LOS;
- Patient Satisfaction assessed by the percent of patients leaving without treatment;
- Quality of Care measured by quality of care measures;
- Patient waiting times, such as waiting to be seen by the EDP, waiting to be triaged, waiting for tests or test results, waiting for transportation, and waiting to be admitted or discharged.

Select Team and Launch the Project

The cross-functional team was identified and formed. The following areas were included as team members:

- ER nurses and physicians
- Admitting and registration
- Compliance
- Imaging, Lab Diagnostics
- Floor, unit nursing
- Chief Nursing Officer
- Information Technology
- Decision Support/Finance
- Pharmacy
- Environmental Services
- Administration.

Rules of Engagement:
The following rules of engagement were embraced by the project team:

- Be present and be committed at the meetings.
- Look at issues, not people; not to be defensive.
- Be open to new ideas.
- Think outside of the box.
- Help each other work together as a team.
- Be respectful for people to finish their thoughts.
- Focused structure: agendas, outcomes, and parking lot issues.
- Limit our time; keep our meetings to the time; and finish meetings.
- Fix the process, do not fix blame.

The rules of engagement are critical to ensure the smooth running of the team meetings, so that the team can stay on topic, and change management can begin.

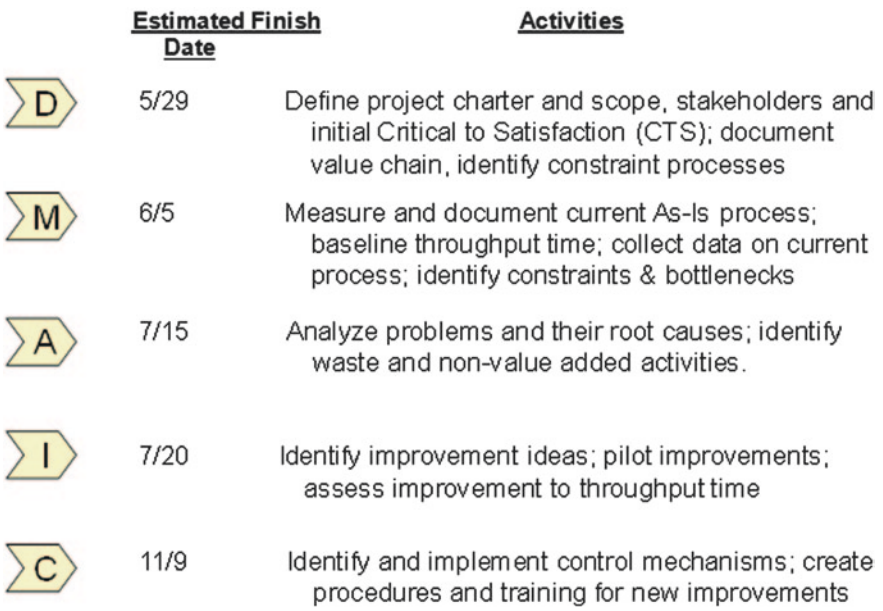


Fig. 3.6 Initial project milestones

Create Project Plan

The aggressive project milestones are shown in Fig. 3.6. The project was started at the end of May, and the initial pilot improvement ideas were designed by mid July. The pilot period started on July 22nd. The pilot activities continued for several months, and the control plan was implemented in November. The project scope was much broader than was feasible to fully implement in only two months as initially proposed.

Measure Phase

The Measure Phase included the following activities:

1. Define the current process
2. Define detailed Voice of Customer (VOC)
3. Define the voice of process (VOP) and current performance
4. Validate measurement system.

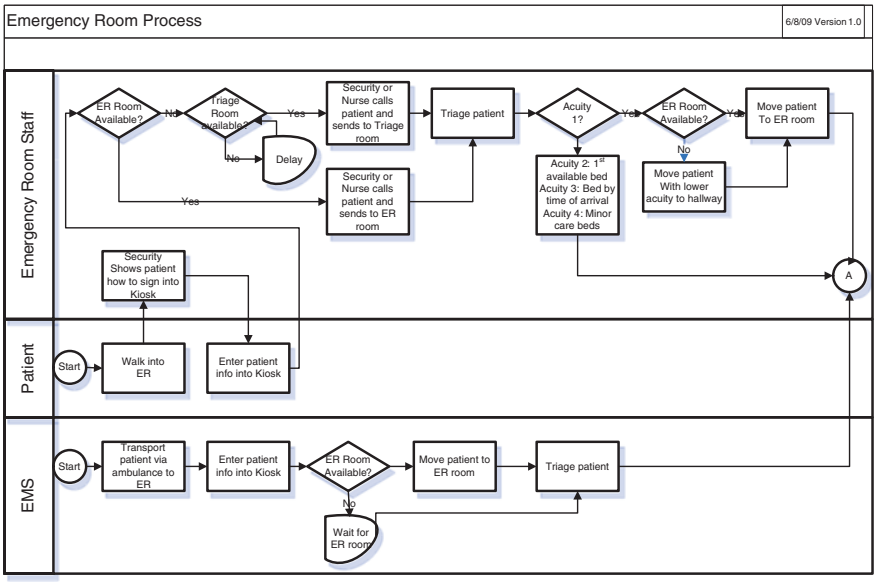


Fig. 3.7 Current state process map

Define the Current Process

The first step in the Measure phase was to map the current process by creating detailed process maps of the current processes in the Emergency Services Value Chain. The patient arrival, triage assessment, and assigning an ED bed is shown in Fig. 3.7. There were several additional process maps that were also generated, including, lab test processing, radiology diagnostic testing, registration and admitting, patient transportation, and hospital bed assignment for patients admitted to the hospital from the ED.

Define Detailed Voice of Customer

The internal VOC was gathered during the weekly team meetings as the team developed the current state process maps and later identified the performance targets and goals. There was no direct collection of ED patient voice of customer beyond the existing patient survey process, and collection of patient complaints on as needed basis.

Critical to Satisfaction (CTS)	Metric	Data collection mechanism (survey, interview, focus group, etc.)	Analysis mechanism (statistics, statistical tests, etc.)	Sampling plan (sample size, sample frequency)	Sampling instructions (who, where, when, how)
ED Patient Throughput Time: Admitted from ED; Discharged; LWBS	Time from when patient arrives at ED to when they leave: Total LOS; Triage time: EDP time	ED Bed Board System	Minitab: Basic statistics; confidence intervals; throughput time calculations	January through April 2009 data	Verify and validate data with team and subject matter experts.
Patient Wait Time at visit	Wait time for ED; Disposition to Leave ED	ED Bed Board System	Minitab: Basic statistics; confidence intervals; throughput time calculations	January through April 2009 data	Verify and validate data with team and subject matter experts
Left without being seen	Percent of LWBS	ED Bed Board System	# patients LWBS / Total # Patients	January through April 2009 data	Verify and validate data
Lab time; Diagnostic time; Admit time; Register time	Lab time; Diagnostic time; register time; admit time	Within departments (system and manual)	To Be Determined	Jan through Apr 09	Verify and validate data

Fig. 3.8 Data collection plan

Define the Voice of Process and Current Performance

The VOP and current performance was an extensive data collection experience. The data collection plan was developed by the team, and shown in Fig. 3.8. The goal is to measure the Critical to Satisfaction criteria identified in the Define phase, including patient throughput time, patient wait time, and patient satisfaction.

The operational definitions were developed for each metric.

The purpose of the first set of metrics was to measure the overall ED patient throughput time, and then the detailed process times.

Process Throughput and Time Metrics

The Patient LOS is the time from when the patient arrives at the ED (signs in at the Kiosk) to when they leave the ED, either being discharged and leaving in a private vehicle or being moved by patient transport to the hospital to be admitted. The

time when the patient arrives is captured in the ED Bed Board when the patient signs in at the Kiosk in the ED waiting room. The nurse selects a field on the ED Bed Board when the patient physically leaves the ED, which is logged in the electronic ED Bed Board system. This ED Bed Board system tracks the major process steps and records the time of each step. It also provides alerts if the patients are waiting in any one step beyond identified target times. The following times are measured:

ED Patient Throughput Time (Length of Stay) Time from arrival to leaving the ED.

Wait for ED Physician The time from patient arrival to when the physician first sees the patient.

Triage Time The time from patient arrival to when the nurse completes the triage assessment and defines the patient acuity level.

Time to ED Bed The time from when the patient arrives to when they are placed in an ED Bed.

Time from Bed to Physician The time from when the patient is placed in the ED Bed to when the physician first sees them.

EDP Visit Time The time from when the EDP initially sees the patient to when they determine the disposition (whether to discharge or admit the patient). The EDP visit time includes the time to receive the diagnostic (typically lab and radiology) tests and results.

Lab Turnaround Time Time from when the lab order is placed to when the results are available to the EDP.

Radiology Turnaround Time Time from when the radiology tests are ordered to when the results are available to the EDP.

Disposition to Leave ED The time from when the EDP provides the patient disposition (discharge or admit) to when they leave the ED.

Disposition to Receive Admitting Orders The time from when the physician provides the disposition to admit to the time when the nurse receives the admitting orders from the admitting physician.

Admit Orders to Assign Bed The time from when the nurse receives the admit orders to when they assign the hospital bed.

Assign Bed to Leave ED The time from when the hospital bed is assigned to when the patient leaves the ED.

Disposition to Discharge The time from when the patient receives the admitting orders to when they leave the ED.

Figure 3.9 shows a Gantt chart of the process steps and relative times of each step in the current baseline performance.

To assess the baseline process performance, we collected data from the ED Bed Board electronic system for data from January through April. We validated the data and removed any data inconsistencies, such as process times that were not selected at the appropriate process step that would cause negative time values.

The second set of metrics collected was the patient volume metrics and the percent of patients leaving the ED without being treated.

We tracked the number of ED visits on a daily basis, as well as the percent of patients that were admitted to the Hospital from the ED. The other statistic that we

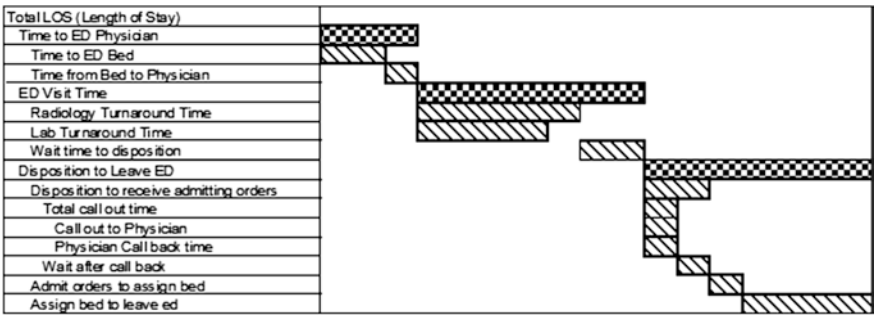


Fig. 3.9 Baseline ED process time line

tracked was the Percent of Patients leaving the ED without being seen or treated by an EDP. The patient volume metrics are discussed in the next section.

Patient Volume Metrics

ED Visits The number of patients that came to the ED on a daily basis

ED Admissions The number of patients that were admitted to the hospital from the ED

LWBS The Percent LWBS patients is the number of patients LWBS divided by the Total ED visits for that time period.

The baseline metrics are shown in Fig. 3.10. The baseline metrics showed that the team had a tough road in front of them to get to the desired metrics of 3 and 5 hours for discharged and admitted patients, respectively. The current baseline was 5.8 hours for discharged patients and 8.7 hours for admitted patients. For all patients combined, the baseline LOS was 6.9 hours.

We created histograms of the LOS for all patients using Minitab®. The histogram is shown in Fig. 3.11. The histogram for LOS for admitted patients is shown in Fig. 3.12, and the histogram for LOS for discharged patients is shown in Fig. 3.13.

The histograms illustrate non-normal distributions with fairly long tails indicating a few patients with quite long length of stays. These are typically patients that are held in the ED when critical care beds are not available in the hospital due to increased volumes. The standard deviation for the admitted patients was 3.1 hours and for discharged patients was 3.0 hours. The standard deviation across all patients was 3.1 hours.

Validate Measurement System

We reviewed the electronic data in the ED Bed Board to validate the data collected electronically in the ED. We observed the processes to understand how the data are collected, and whether they are consistent and represent the process times.

	Baseline	
	ED Admitted	ED Discharged
Total LOS:	8.7 hours	5.8 hours
% LWBS:	6.50%	
Total Time to EDP:	93	109
- Triage Time:	34	34
- Wait time triage to EDP:	65	79
- Time to ED Bed:	61	81
- Bed to Physician	34	55
Treat/Diagnose to Disposition Time:	192	175
- Radiology Diagnostic Time:	138	270
- Lab Time:	119	
- EDP Time to Visit	192	175
Disposition to Leave ED	223	64
- Disposition to get admit orders	103	
- Total Call out Time	41	
- Call out to Physician	13	
- Physician Call Back	29	
- Wait after call back	37	
- Admit Orders to Assign Bed	42	
- Assign Bed to Leave ED	112	

Fig. 3.10 Baseline process time and LWBS metrics

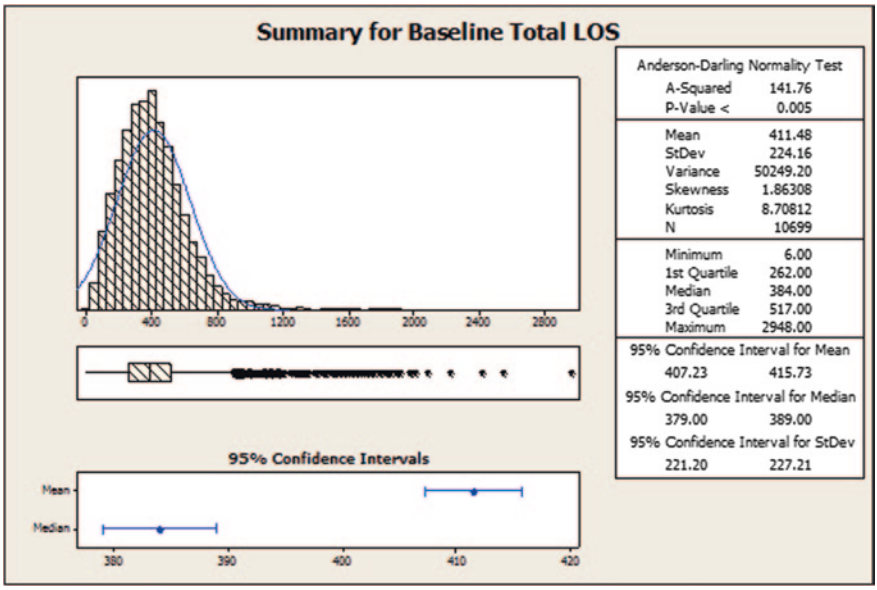


Fig. 3.11 Histogram of baseline length of stay—all patients

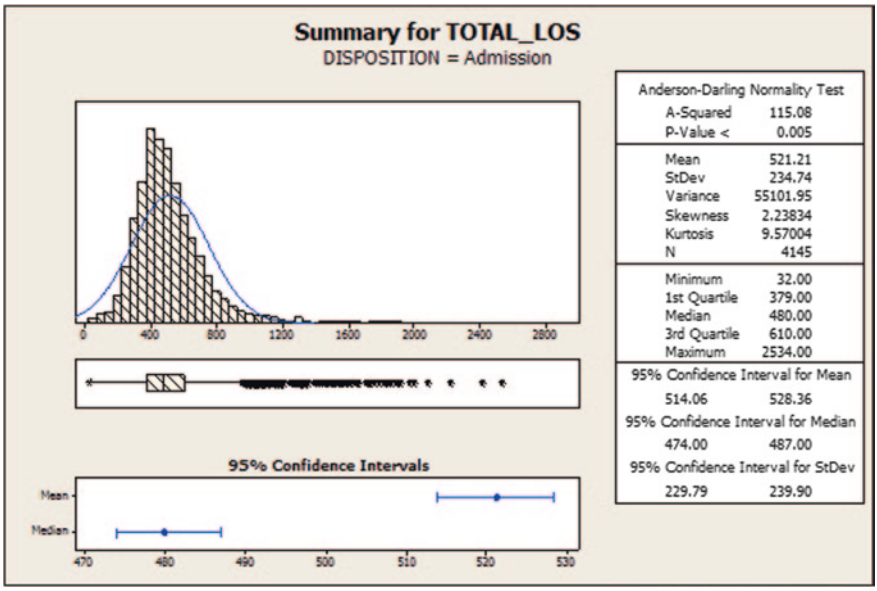


Fig. 3.12 Histogram of total LOS (minutes) for admitted patients

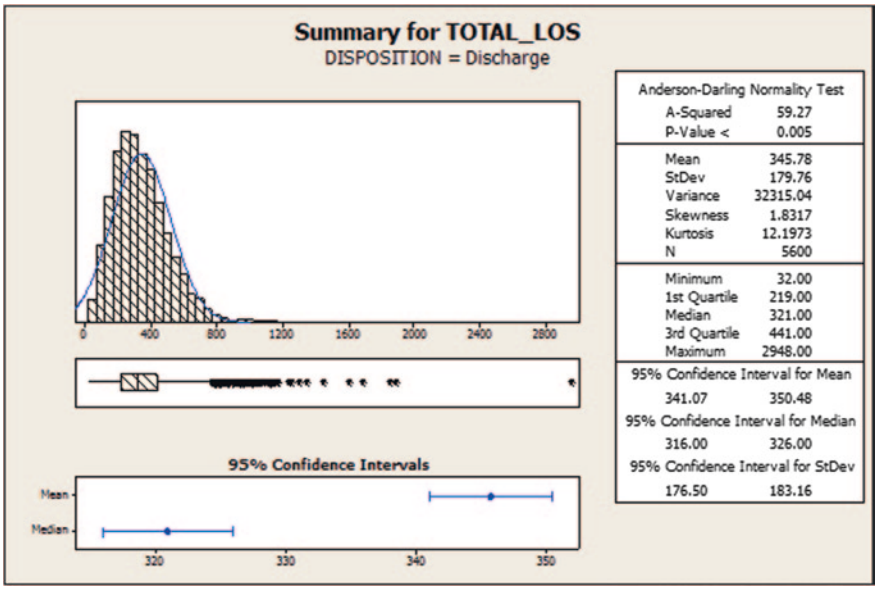


Fig. 3.13 Histogram of total LOS (minutes) for discharged patients

Analyze Phase

The following activities were performed for the Analyze Phase to identify and validate the root causes and to assess whether the process is currently capable of meeting the desired specifications for the LOS:

1. Develop cause and effect relationships.
2. Determine and validate root causes.
3. Develop process capability.

Develop Cause and Effect Relationships and to Determine and Validate Root Causes

We collected and analyzed data from the electronic ED Bed Board system regarding the metrics identified in the measure phase. We stratified the data in many ways to determine the relationships between different process factors.

Patient Demographics

We first provide some patient demographics:

The average patient age is 55 years of age. There are 56 % females and 44 % males.

For the patients that were admitted to the hospital 54 % of the patients are females, and 46 % are males. Of the discharged patients, 58 % of the patients are female and 42 % are males. Therefore, the sicker patients tend to be males. Males are also more likely to leave against medical advice (AMA), with 56 % of the AMA patients being males, and 44 % are females. Of the expired patients, 55 % were males and 45 % were females. Of the patients who leave without being seen by an EDP, 58 % are female and 42 % are male. Therefore, the women who tend to be less sick, also will leave quicker if there is a longer wait to be seen by the EDP. Twenty-two percent of the patients are self-pay (do not have insurance) that come through the ED. The demographics statistics are summarized in Fig. 3.14.

Statistical Analysis

We then performed our statistical analysis:

The first analysis was a correlation analysis to determine if there were any significant correlations between the following variables, with the R (correlation coefficient), shown in Fig. 3.15. Generally, to show a strong linear relationship between two variables, the R value should be close to $+0.80$ or above, or -0.80 or below. The R value can range from 1 to -1. An R of 1 shows a positive linear

Demographic Characteristic	Percent Males	Percent Females
Percentage of Patients	44%	56%
Admitted Patients	46%	54%
Discharged Patients	42%	58%
Against Medical Advice (AMA)	56%	44%
Left Without Being Seen (LWBS)	42%	58%
Expired Patients	55%	45%
Average Age: 55	Self-Pay: 22%	

Fig. 3.14 Patient demographics

Variable 1	Variable 2	Correlation Coefficient (R)
Relatively Strong Positive Correlations		
Time to ED Physician and	Time to ED Bed	.931
Time to Assign Hospital Room	Time from ED Disposition to Admit Orders Received	.722
Length of Stay	Time from ED Disposition to Admit Orders Received	.614
ED Census	Hour of Day	.596
ED Census	Clinical Staffing	.594
Time from ED Disposition to Admit Orders	Time Disposition to Call	.564
Length of Stay	Time to Assign Hospital Room	.523
Imaging tests	Lab tests	.501
Relatively Low Positive Correlations		
Length of Stay	ED Physician Visit Time	.450
Length of Stay	Time from Hospital Room Assigned to Leave ED	.449
Length of Stay	Imaging Tests	.407
Length of Stay	Lab tests	.407
Length of Stay	Total Time to EDP	.41
Staffing	patient arrival patterns	.33
Length of Stay	Time to ED Bed	.264
Length of Stay	Arrival Time of Day	.05
Low Negative Correlations		
Length of Stay	ED Physician	-.024
Length of Stay	Day of Week	-.094
Length of Stay	ED Nurse	-.074
Length of Stay	Acuity Level	-.212
Acuity Level	Number of Imaging Tests	-.287

Fig. 3.15 Correlation analysis with R (correlation coefficient)

relationship, as the one variable increases, the other variable also increases. An R of -1 shows a negative linear relationship, as the one variable increases, the other variable decreases.

The variables that had a very high positive correlation were:

(1) Time to EDP and time to ED Bed. This demonstrates that the longer it takes to get a patient placed in an ED Bed, the longer the time is until the patient first sees an EDP.
(2) Time to Assign Hospital Room and Time from ED Disposition to Admit Orders Received. The time after the EDP provides the disposition to admit the patient, and the time that it takes to receive the admitting physician's admitting orders is correlated to the time it takes to assign the hospital room. These times are both in the back end of the process in the steps to get the patient admitted to the hospital.
(3) LOS and Time from ED Disposition to Admit Orders Received. The time it takes to call the admitting physician and get the admitting orders back from them is highly correlated to the LOS, meaning that this time tends to be fairly lengthy and extends the entire patient's LOS.
(4) ED Patient Census and Hour of Day. The ED Patient Census is fairly well correlated to the time of day.
(5) Time from ED Disposition to Admit Orders to Time Disposition to Call. It makes sense that the time to call out for admitting physician orders to when the orders are received is correlated.
(6) LOS and Time to Assign Hospital Room. The total LOS is somewhat correlated to the time to assign the hospital room.
(7) Imaging tests and lab tests. The number of imaging tests and lab tests are correlated. Many imaging tests also require lab tests, such as a pregnancy test being required for women of child bearing age prior to performing a CT Scan of the abdomen. Additionally, 72 % of the patients get at least one lab test, while there is a median of 1 radiology test per patient.
(8) Clinical Staffing in the ED (Nurses and Medical Technicians) and ED Census by hour of the day were fairly well correlated.

The remaining variables that we tested did not have a very high positive or negative correlation.

Graphical Analysis

We graphed the patients' census and arrival patterns by hour of the day, shown in Figs. 3.16 and 3.17. The patient arrival patterns are fairly predictable, and peak at around 10 am. The patient census is also fairly predictable, and mimics the arrival patterns phased approximately by the average LOS of 6 hours. The ED patient census tends to peak about 5 pm. The patient's get "clogged" in the system due to the peak arrivals in the middle of the day, and it takes 6 to 7 hours to finally move them through the system.

The departures per hour are roughly an inverse of the patient arrival patterns by hour. The patients' departures peak about 10 pm, shown in Fig. 3.17. So the arrival peak is 10 am and the patients don't clear out until roughly 12 hours later.

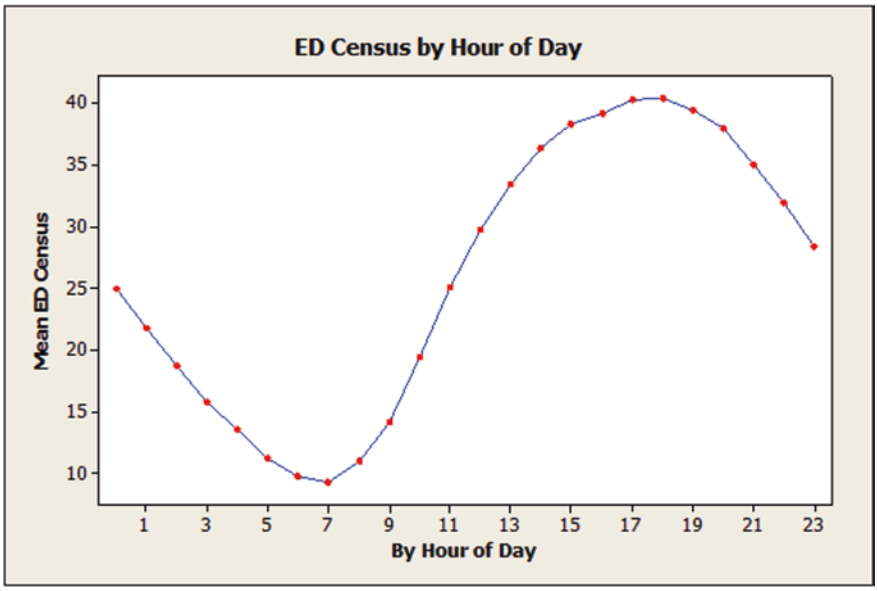


Fig. 3.16 ED patient census by hour of day

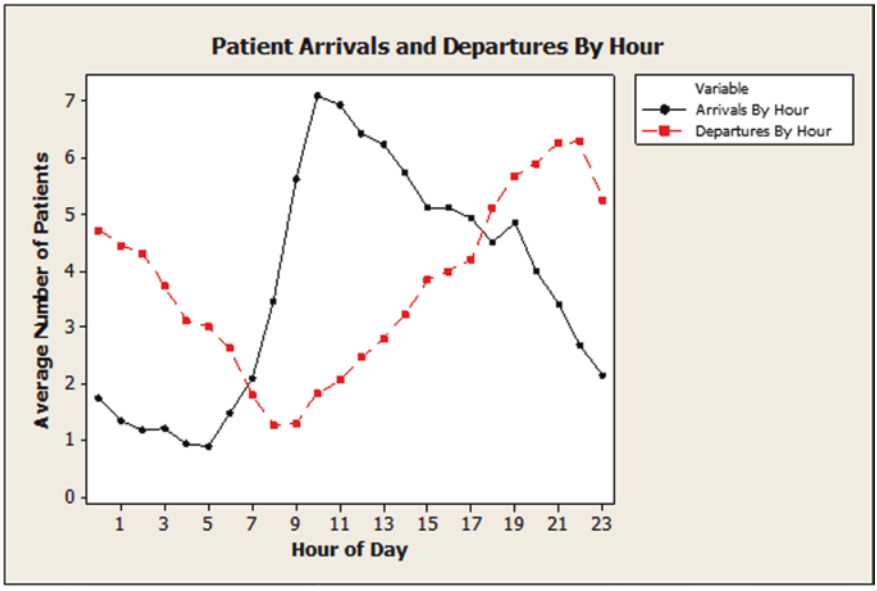


Fig. 3.17 Patient average arrivals and departures by hour of day

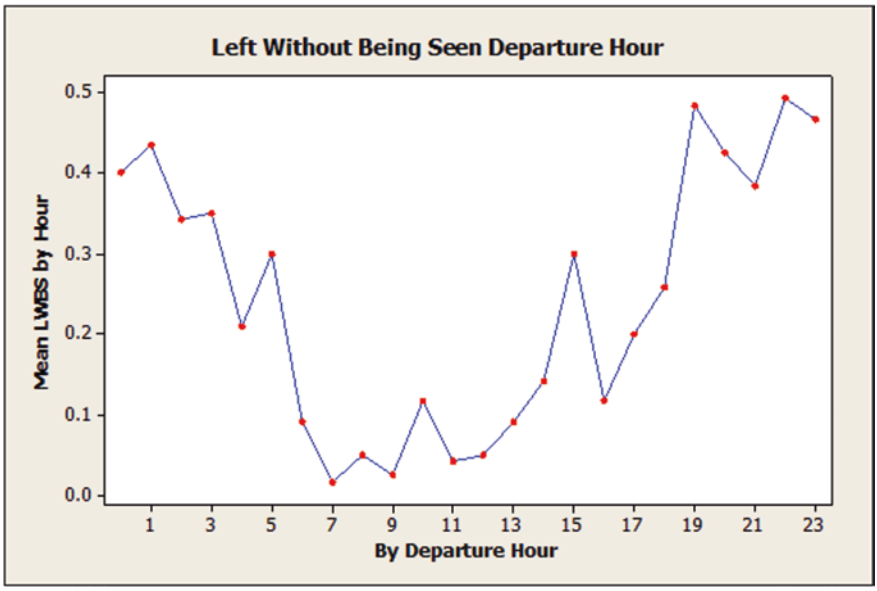


Fig. 3.18 Mean patients left without being seen by departure hour

The mean patient LWBS pattern is similar to overall patient departure patterns, shown in Fig. 3.18. The patient LWBS pattern also appears to peak with the patient departure rates. However, this is somewhat misleading, because the ED staff only records the patient as an LWBS when they are called from the waiting room when they would have been triaged, but the patient could have left hours earlier, and just did not notify anyone of their departure.

Another interesting finding is that the average triage time for the patients that were LWBS is twice the average of the admitted and discharged patients (53 min compared to 34 minutes), as shown in Fig. 3.19. So it appears that the patients that wait almost an hour for triage get tired of waiting early in the process, and if we can improve the patients' experience right at the beginning and get them triaged faster, we may be able to drastically reduce the LWBS percentage.

The average LOS differs slightly by day of the week, as does the average ED Census, so the more patients in the system, the longer the LOS. The Average LOS by day and the average ED Census by day are shown in Fig. 3.20.

Takt Time, Identifying Constraints/Bottlenecks and System Capacity

We calculated the takt time for the ED Value Chain to assess the required LOS based on the current volumes. With the complexity of the value chain that we are trying to improve, it is important to identify the key bottlenecks so that it focuses our improvement efforts. The takt time describes the time that is required to complete each unit to be able to meet the customer demand.

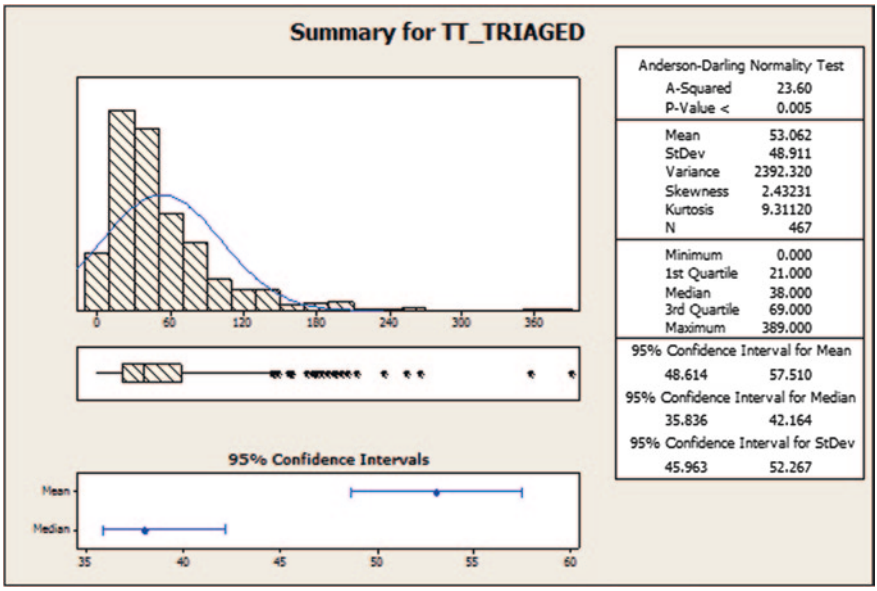


Fig. 3.19 Average triage time for left without being seen patients

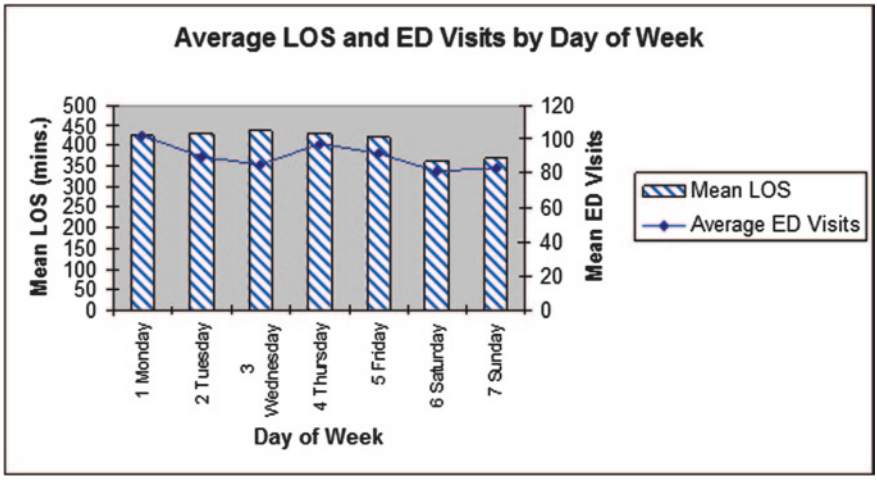


Fig. 3.20 Average length of stay by day of week

Takt Time = Total Available Time/Number of ED Visits
Total Available Time = 32 hospital rooms * 1,440 min per day = 46,080
Number of ED visits per day = 90
Takt time = 46,080/90 = 512 min per day = 8.5 h per day
We then calculated the patient volume capacity.

Process	Staff	Available Time	Demand	Takt Time
Triage	1	1440	91	15.8
Register	1	1440	91	15.8
Enter orders into system	1	1440	74	19.5
Perform Labs	1	1440	66	22.3
Perform Xray	2	2880	53	55.5
Perform CT	1	1440	36	40.6
Perform Ultrasound	1	1440	12	121.7
Perform Disposition	2	2880	91	31.6
Call for admit orders	1	1440	34	42.8
Take report	8	11520	34	342.1
Move patient	1	1440	34	42.8
Discharge	8	11520	57	200.9

Fig. 3.21 Takt time for major processes

Patient volume capacity = Total Time Available/System cycle time

Patient volume capacity = 46,080/409 = 113 patients

Since the average number of patients per day is 90, the ED is working at only 80 % of capacity (90/113). Once the census gets above about 85 per day, the LWBS rate sky rockets.

The process with the lowest needed takt time will constrain the process the most. The takt time for each major process is shown in Fig. 3.21. The triage and registration processes are the most constraining bottlenecks in the ED process. Entering orders and then performing the labs are the next most constraining bottlenecks.

Develop Process Capability

The process is not stable, as shown in the X-bar and S control charts in Fig. 3.22. Therefore, a long-term process capability should not be assessed until control and stability is attained. A process capability analysis was performed, in Fig. 3.23, showing that the short-term process capability index Cp is 0.09, with a Cpk of −0.18. The existing process, as designed, is not capable of meeting the target LOS of 3 to 5 hours.

Cause and Effect Analysis

The team performed a cause and effect analysis using the five Whys and Why–Why Diagrams. The team started with asking the following questions, and asked Why at least five times until they believed they reached the root causes of each question.

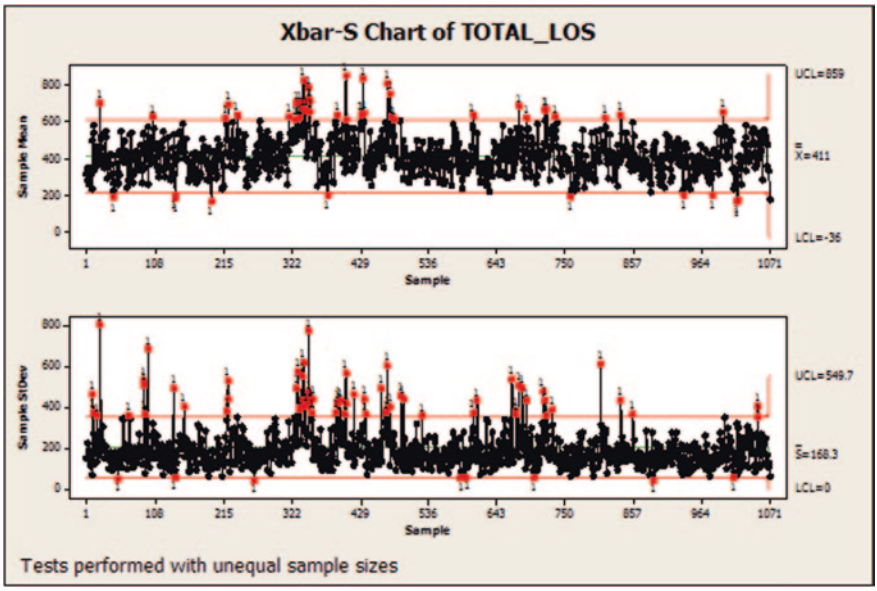


Fig. 3.22 Length of Stay X-bar and S control charts

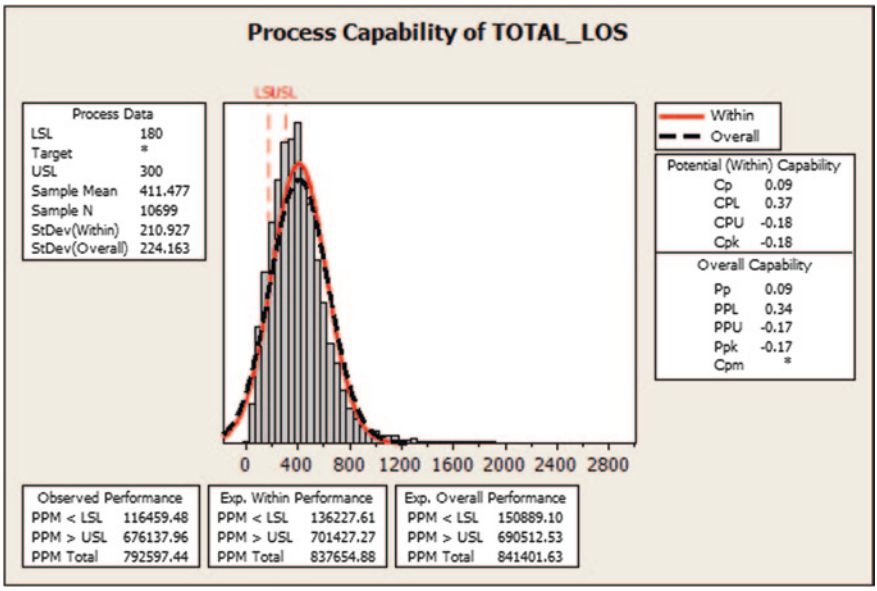


Fig. 3.23 Process capability analysis

- Why is the patient flow not continuous?
- Why are admitting physician call backs taking on average 43 minutes?
- Why are patients waiting in minor care?
- Why is triage time an average of 34 minutes for admitted and discharged patients, but an average of 53 minutes for patients that are LWBS (treated)?
- Why are there delays in registering patients?
- Why are there delays in the nurse seeing patients?
- Why are there delays in expediting time to physicians?
- Why are there delays in radiology diagnostic testing?
- Why are there delays in lab tests?
- Why are there delays in discharging patients?
- Why are there delays in assigning beds for admitted patients?
- Why are there delays in moving patients to rooms?

The following root causes were identified for the key questions asked.

Why is the patient flow not continuous?

- More discharges occur in the PM, causing batches of patients to be discharged.
- Unit clerks on the floors batch discharges and schedule discharge order entry around lunch and end of shifts, which clogs the hospital rooms and prevents patients from being able to be admitted from the ED.
- Not prioritizing ED admissions or separating them from other admissions.
- Charts are not organized in one place.
- Staff is not always available.
- No training available to enter rooms as clean by cleaning staff.
- No expectations for cleaning personnel to enter rooms as cleaned directly into system.
- Order entry is not user friendly.
- No consequences for hiding beds, not turning them over quickly.

Why are admitting physician call backs taking on average 43 minutes?

- Not calling out fast enough to physicians, or not calling back frequently enough.
- No dedicated call person to call to request admitting orders from admitting physicians.
- Not calling on-call physicians using agreed to protocols.
- Medical staff by-laws for call backs may be too liberal (three call backs 15 min apart before calling on-call physician).

Why are patients waiting in minor care?

- Minor care patients are not the focus of ED physicians, due to lower acuity, they are seen first by physician assistants.
- Physicians batching several minor care patients to see them all at once after the physician assistants have seen the patients.
- Lack of flow and staffing.

Why is triage time an average of 34 minutes for admitted and discharged patients, but an average of 53 minutes for patients that are LWBS (treated)?

- Only one triage nurse, even when volume increases.
- No surge policies or procedures to address intense volume increases into the ED.
- Too busy and forget to triage.
- Triaging is not a priority.
- No one "owns" patients in waiting room.
- No clinical visibility of patients in waiting room.
- Staffing not based on potential ED admits from actual ED volume and admission trends.

Why are there delays in registering patients?

- Registrations screens are not organized efficiently.
- Quick registration requires screens several layers deep.
- The way registration staffing is scheduled and registration is done.
- Wrist bands print only in one place.

Why are there delays in the nurse seeing patients?

- Nurses must do what the techs would do, because the techs are transporting patients.
- No script for communicating expectations to patients.
- No one in charge or focused on patient flow.
- Nursing coverage is down due to call outs and staffing.
- Nurses call in sick, can't schedule on short notice, and not enough ED nurses as backup.
- Staffing not based on actual ED volume.
- Transport not trained to transport telemetry patients, so nurse must transport them.
- Transportation prioritization not always aligned to ED needs.
- If patient is already moved when transport arrives, they won't take the next patient.
- No paging or easy way to contact the nurse.
- Admitting several patients in a batch at the same time, due to no floor nurse available to take report.

Why are there delays in expediting time to physicians?

- Staffing not based on actual ED volume and patient arrival patterns.
- No process to deal with ED surge in volume.
- Number of tests ordered by physicians varies.
- Some ED physicians do not see patients near the end of the shift.
- Not having prompt discharge instructions.
- Physicians are batching to see several minor care patients at the same time.
- Twelve-hour shifts create fatigue and slowness toward end of shift.
- Staff works multiple shifts during week.
- Radiologists go to lunch together.
- Delays at the end of shift in reading radiology results.

Why are there delays in radiology diagnostic testing?

- Shorter contrast is not used, takes 1½ hours to prep patient with contrast.
- Not always prioritizing, planning, or sequencing tests.
- Competing modalities for tests.
- After hours tests may not be prioritized.
- After hours radiology services don't read directly on PACS (in-house radiology system).
- Sometimes radiologists leave early.
- Radiologists go to lunch together.

Why are there delays in lab tests?

- Pregnancy tests are not always ordered right away.
- Not always planning, prioritizing, or sequencing tests.
- Label printers go down.
- Specificity of some tests.
- High volume of diagnostic tests.

Why are there delays in discharging patients?

- Wait on physician to do discharge instructions and prescriptions.
- Wait on nurse to discharge patient physically and from the system.
- Private physicians want to see their patients before they are discharged.
- Physician Assistants batch to physicians from minor care.
- Homeless patients need shelter and medications.
- Patient may not have a ride.
- Patients eat before they leave.

Why are there delays in assigning beds for admitted patients?

- Inefficient admit and discharge processes.
- Unit/floor staffing is not integrated with ED staffing.
- Late physician rounding.
- Too many steps and ways to communicate.
- Admitting must have order to enter bed.
- Not updating the system with potential and actual discharges.
- No way to identify pending discharges in the bed board system.
- When Bed Board System person is not there, no one assigned to cover.

Why are there delays in moving patients to rooms?

- Cleaning personnel are not trained to enter cleaned rooms directly into the system.
- No status in system for pending versus actual discharges.
- No clear definition for pending versus potential discharges.
- No pending information from Assistant Nurse Manager who knows pending discharge information.
- ED not calling physicians promptly.
- Liberal call back policies.

- Practices of not giving the physician the messages.
- Not leveraging the Bed Board System.
- No easy communication method to give report to floor/unit.
- More discharges in PM versus AM, but staffing assigned to AM.
- Transports not prioritized based on flow between the ED and floors/units.

Figure 3.24 shows one example of a Why–Why Diagram for asking the question, "Why is the patient flow not continuous?"

The next step in the cause and effect analysis was to align the causes by the process steps and then prioritize them based on the CTS Criteria of LOS, wait times and patients LWBS.

An example of one of the Cause and Effect Matrices is shown in Fig. 3.25.

To derive the high priority root causes, we first prioritized the critical to satisfaction (CTS) criteria, with the LOS being given the highest priority of a nine, the wait times being given a five, and LWBS as a three. It is important

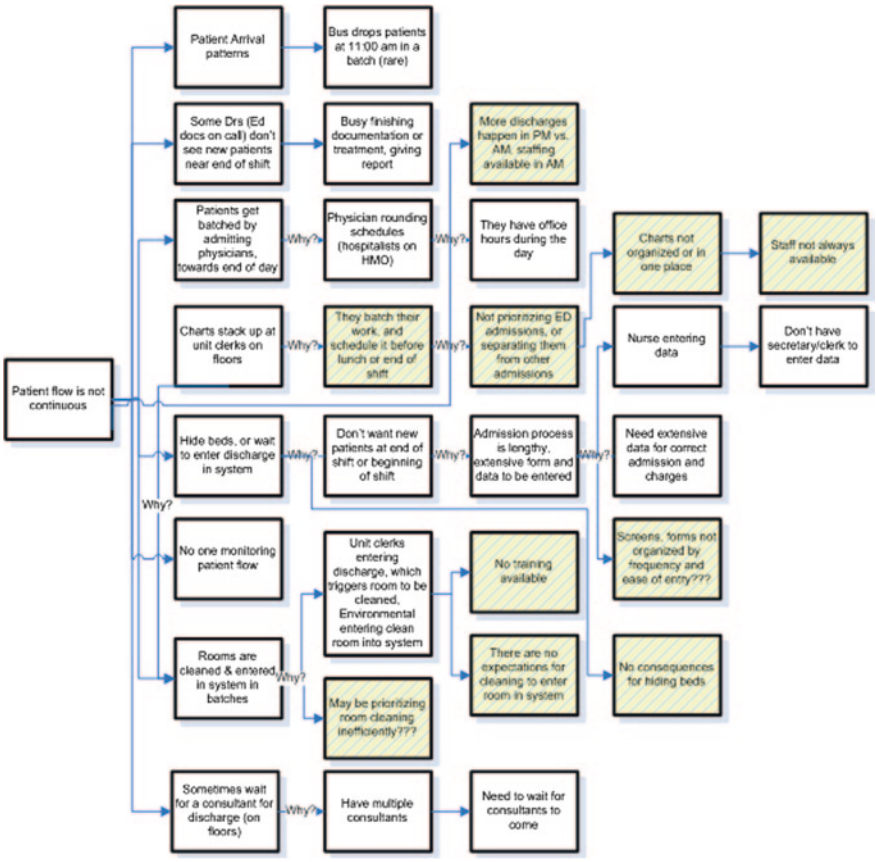


Fig. 3.24 Why–Why diagram for "Why is the patient flow not continuous?"

Cause & Effect Matrix			Critical to Satisfaction Criteria			
		Importance:	Total LOS	Wait Times	% LWBS	TOTAL IMPACT SCORE
			9	5	3	
Process Steps	Root Causes					
Treat Patient	Admitting several patients in a batch at the same time		9	9		126
	No paging or easy way to contact nurse for report		5	5		70
	Transporter does not transport next person unless on list, if patient already transported		9	9		126
	Transporter prioritization is not always aligned with ED needs		9	9		126
	Transporters not trained for telemetry transport		3	3		42
	Techs are transporting patients		9	9	9	153
	Staffing not based on potential ER admits from actual ED patient volume trends		9	9	9	153
	Nurses call in sick, can't schedule at short notice		9	9	9	153
	No one in charge of patient flow (to get patient to next step)		9	9	9	153
	No surge process to re-align staff for high patient volumes		9	9	9	153
	12 hour shifts create fatigue and slowness at end of shift; nurses work multiple shifts		9	9	9	153
	Patients don't understand flow (perception)				9	27
	Some Drs don't see new patients near end of shift		5	5	3	79
	Physicians batching (waiting) to see several minor care patients		9	9	3	135
	Minor care patients are not the focus of the ED physicians		9	9	3	135
	8 beds for minor care, but not always staffed		9	9	9	153
	Lack of flow, staffing		9	9	9	153

Fig. 3.25 Cause and effect matrix

to not have the patients leave, but the team believed that if the LOS and wait times were decreased that the patients would not leave as frequently. Each cause was assigned a strength of relationship to each CTS, with a nine being a very strong relationship, a five being a medium strength, three being a low strength, and blank being no relationship. An example of the strength of relationship is that one root cause for the Triage process step is that only one triage nurse is assigned even with patient surges in volume. This has a very high

impact, and therefore a very high strength of relationship (9 rating) with all three CTS'. This results in an overall weighting of 153, derived by multiplying each CTS importance rating by the strength of relationship weighting: $((9 * 9) + (9 * 5) + (9 * 3)) = (81 + 45 + 27) = 153$. Assigning the root cause weighting gives us a focus of the high priority improvement areas as we move into the Improve phase of the project. The highest priority root causes are shown in Fig. 3.26.

Cause & Effect Matrix			Critical to Satisfaction Criteria			
		Importance:	Total LOS	Wait Times	% LWBS	TOTAL IMPACT SCORE
			9	5	3	
Process Steps	Root Causes					
Triage	Only 1 triage nurse even when have patient volume surges		9	9	9	153
	No surge policies/procedures		9	9	9	153
	Staffing based on potential ER admits from actual ED patient volume trends		9	9	9	153
	No clinical visibility to waiting room		9	9	9	153
	No one "owns" patients in waiting room		9	9	9	153
Treat Patient	Techs are transporting patients		9	9	9	153
	Staffing not based on potential ER admits from actual ED patient volume trends		9	9	9	153
	Nurses call in sick, can't schedule at short notice		9	9	9	153
	No one in charge of patient flow (to get patient to next step)		9	9	9	153
	No surge process to re-align staff for high patient volumes		9	9	9	153
	12 hour shifts create fatigue and slowness at end of shift; nurses work multiple shifts		9	9	9	153
	8 beds for minor care, but not always staffed		9	9	9	153
	Lack of flow, staffing		9	9	9	153
	Not always planning, prioritizing or sequencing tests, and adjust for competing		9	9	9	153
	High volume of diagnostic tests		9	9	9	153
Assign bed	Unit (floor) staffing is not integrated with ED, surgery (hospital-wide) needs/staffing		9	9	9	153
	Late physician rounding		9	9	9	153
	Need a way to define and identify pending discharges in the bed board system		9	9	9	153
Admit patient	No training to have cleaning update clean room in system when done cleaning each room		9	9	9	153
	Not getting info from Assistant Nurse Managers who know pending discharges		9	9	9	153
	No real time updates in bed board		9	9	9	153
	ED not calling physicians promptly		9	9	9	153

Fig. 3.26 Cause and effect matrix of high priority causes

Improve Phase

The following steps were executed in the Improve Phase:

1. Identify improvement opportunities and plans
2. Perform cost/benefit analysis
3. Design future state
4. Establish performance targets and project scorecard
5. Pilot improvements
6. Train and execute.

Identify Improvement Opportunities and Plans

The team developed an improvement plan based on eliminating the identified root causes. Improvements were categorized into the following themes:

- Hospital Bed Assignment
- Triage and Waiting Room
- Admitting Physician Call Out and Call Back
- Patient Transport
- Patient Flow
- Minor Care Staffing
- Diagnostic Tests
- ED and Floor Reporting Process
- Discharge Process
- Dashboards, Metrics, and Performance Monitoring.

Hospital Bed Assignment

The first improvement category was focused on the bed board process and system. The electronic bed board was not being utilized to its full capacity. They needed to better utilize the bed board system to provide hospital-wide bed availability and visibility of beds. This would improve the time to assign beds for admitted ED patients. The Assistant Nurse Managers would need to provide the information of the bed availability on a real-time basis. Prior to the pilot, the Admitting Department assigned beds. The team proposed that the Nurse Supervisors should assign the hospital beds, to reduce the amount of time and non-value added activities involved in the Admitting Clerk calling to the floors to request open beds.

They also proposed implementing pre-emptive bed assignment for those patients most likely to be admitted. This would enable the earlier assignment of the beds by requesting beds when the admitting orders were initially received by the nurses.

Triage and Waiting Room

When a surge in patient volume occurs, they propose to add a triage nurse to more quickly triage the patients. When there are ED beds available, they will place the incoming patients into an ED bed immediately, and triage the patient in the ED bed, instead of triaging them in the triage room and then sending them back to wait in the waiting room. They also will do the medication reconciliation in the ED room, not in the triage room.

Admitting Physician Call Out and Call Back

The team proposed to add a dedicated communication secretary during the peak ED census times of 2 to 10 pm. This dedicated person would focus on calling the admitting physicians for admitting orders. The medical policy requires the admitting physician to be called every 15 minutes for three times, and then the on-call physician can be called. Previously, the admitting physicians were not called consistently, or quickly. The average time to call out to the admitting physicians was 13 minutes with a standard deviation of 20 minutes. The average time for the physician to call back was 29 minutes with a standard deviation of 34 minutes. There was also an average of 1.8 call attempts before the admitting physicians called back.

Patient Transport

The team added an ED dedicated patient escort during the peak admitting times of 3 to 11 pm. We prepared a cost/benefit analysis estimating a rate of return based on proposed increased ED volumes from gaining additional patients and reducing the number of patients leaving the ED without treatment. The benefit to cost ratio was 13.4 to 1 (benefits to cost). The desired benefit to cost ratio is greater than 1. We showed that there was a positive return on investment when adding additional staff for the dedicated communication secretary, the patient escort, and the Nurse Supervisors for assigning beds.

Patient Flow

The team proposed to add additional electronic alerts on the ED Bed Board to improve visibility of the status of each patient and which step in the process they are at in the Emergency Services Value Chain. The team also developed an ED surge plan with volume and ED room availability triggers.

Minor Care Staffing

The team realigned minor care staffing to add a physician for minor care when ED volume increases.

Diagnostic Tests

The team implemented both lab and imaging diagnostic testing improvements. Since many of the imaging exams that expose a patient to radiation (X-rays, CT scans) require a pregnancy test for women of child bearing age, we decided to fast track pregnancy and other tests required for radiology exams. The team also created another Lean Six Sigma team to investigate and reduce the number of imaging exams and to provide appropriate CT scans. The amount of radiation exposure that CT exams give can be equivalent to 1,000 X-rays, so it is critical to ensure that all tests are medically appropriate.

To decrease the time to draw the specimens for tests, we added an alert to the electronic ED Bed Board to track the time it takes for the phlebotomist to draw the specimens.

ED and Floor Reporting Process

We redesigned the reporting process to streamline the communication and hand off for admitted patients from the ED to the floors or units. We also automated the transfer form to reduce the time it took for the ED nurses to re-write information that was already electronically captured in the ED Electronic Medical Record.

Discharge Process

We formed another Lean Six Sigma team to investigate and improve the discharge process for the floors, so that more beds are available when they are needed to admit patients from the ED.

Dashboards, Metrics and Performance Monitoring

We developed a dashboard, metrics, and performance monitoring processes to measure performance aligned to flow and throughput. We incorporated necessary performance measures to ensure metrics and performance is met. A sample dashboard is provided in Fig. 3.27. We also developed a Flow Dash Board that identified where each patient is in the ED Value Chain, and which process is holding the patient from moving through the value chain and being released. An example of the Flow Dash Board is shown in Fig. 3.28.

	Baseline		Target		Improved		% Improvement	
	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged
Total LOS:	8.7hrs	5.8 hours	5 (43%)	3 (48%)	5.6	3.9	36%	33%
% LWBS:	6.50%		3.50%		0.51%		92%	
Total Time to EDP:	93	109	35	35	26		75%	
Triage Time:	34	34	15	15	11		68%	
Wait time triage to EDP:	65	79	20	20	20		73%	
Time to ED Bed:	61	81	35	42	13		82%	
Bed to Physician	34	55	20	20	13		72%	
Treat/Diagnose to Disposition Time:	192	175	109	91	161		11%	
Radiology Diagnostic Time:	138	270	154	154	N/A			
Lab Time:	119				N/A			
EDP Time Visit	192	175	109	91	160		13%	
Disposition to Leave ED	223	64	127	33	155	47	30%	27%
Disposition to get admit orders	103		59		77		25%	
Total Call out Time	41		23		N/A			
Call out to Physician	13		7		N/A			
Physician Call Back	29		17		N/A			
Wait after call back	37		21		N/A			
Admit Orders to Assign Bed	42		24		25		40%	
Assign Bed to Leave ED	112		64		64		43%	

Fig. 3.27 Emergency services value chain metrics dashboard example

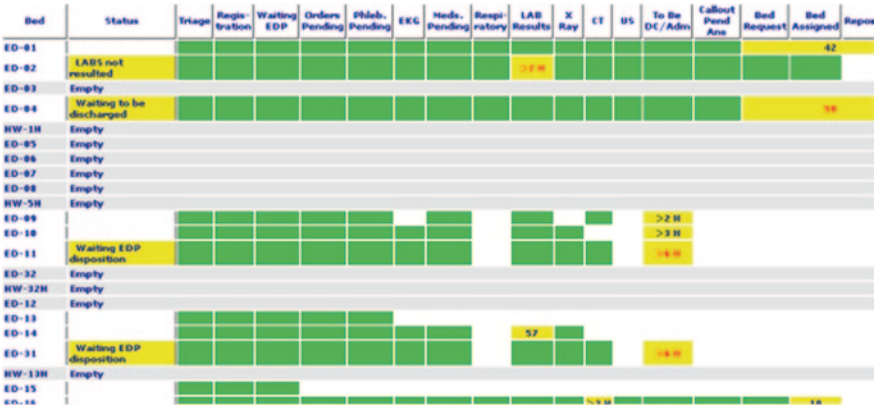


Fig. 3.28 Flow status board

Perform Cost/Benefit Analysis

We performed a cost/benefit analysis to determine if it was cost beneficial to add three needed people, a communication secretary, an ED-dedicated patient escort, and an additional ED nurse. We justified the additional resources based on the additional revenue that would be realized by reducing the patients leaving without treatment.

Design Future State

We designed the new process and updated the original process maps.

Establish Performance Targets and Project Scorecard

The metrics dashboard with the targets are shown in Fig. 3.29.

Pilot Improvements

The team began the pilot on July 20th. We tracked improvement on a weekly basis, and further tweaked the improvement ideas, and continued to generate additional ideas. We also started a detailed ED process Lean Six Sigma improvement project to continue additional process improvements. We created revised process maps based on implementing the improvement ideas.

In the first week of the pilot, the percentage of patients that LWBS was reduced from 6.5 to 3.5 %, meeting our initial target. We also met our targets for the time to get the patient to the ED bed, reducing the time for admitted patients by

	Baseline		Target		Improved		% Improvement	
	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged
Total LOS:	8.7hrs	5.8 hours	5 (43%)	3 (48%)	6.1	4.1	30%	29%
% LWBS:	6.50%		3.50%		0.60%		91%	
Total Time to EDP:	93	109	35	35	32		66%	
Triage Time:	34	34	15	15	13		62%	
Wait time triage to EDP:	65	79	20	20	25		62%	
Time to ED Bed:	61	81	35	42	16		74%	
Bed to Physician	34	55	20	20	16		53%	
Treat/Diagnose to Disposition Time:	192	175	109	91	166		14%	
Radiology Diagnostic Time:	138	270	154	154	170		-23%	
Lab Time:	119				57		109%	
EDP Time Visit	192	175	109	91	175		9%	
Disposition to Leave ED	223	64	127	33	171	47	23%	27%
Disposition to get admit orders	103		59		70		32%	
Total Call out Time	41		23		24			
Call out to Physician	13		7		5			
Physician Call Back	29		17		19			
Wait after call back	37		21		46			
Admit Orders to Assign Bed	42		24		44		-5%	
Assign Bed to Leave ED	112		64		67		40%	

Fig. 3.29 Metrics dashboard three month improvement

30 minutes (50 %) and reducing the time for discharged patients by 42 minutes (51 %).

This was a great way to start the pilot activities.

Within the first month of the pilot, we met the following targets:

- Percent LWBS: 7 to 0.64 % (91 % improvement!)
- Time to ED Bed: (78 % improvement!)
  - Admitted: 61 to 13 minutes (target 35)
  - Discharge: 81 to 18 minutes (target 42)
- Triage time: (~56 % improvement)
  - Admitted: 14 minutes (target 15)
  - Discharge: 15 minutes (target 15)

Other improvements in the first month were:

- Total LOS—Improved by 24 to 28 %
  - Admitted: improved by 2.4 hours (8.7 to 6.3 hours)
  - Discharged: improved by 1.4 hours (5.8 to 4.4 hours)
- Cut Triage Time by more than Half: 34 to 15 minutes
- Improved Time from Bed Assigned to Leaving ED by 40 % (112 to 67 minutes)
- Total Time to EDP improved by 35 %
  - Admitted: 93 to 60 minutes
  - Discharged: 109 to 68 minutes
- Improved Admit Orders to Assign Bed Time by 24 % (42 to 32 minutes)

Culture change was also quite significant. We had an intense focus on wanting to reduce and prevent patients from leaving without treatment. One of the physician assistants even called a patient on their cell phone when they found out that they had just left the ED because they could not wait any longer. The patient was still in the parking lot, returned to the ED, and was treated. One of the ED physicians that had drastically reduced their schedule due to the chaos in the ED returned to the ED full time after seeing the drastic improvements, and reduction in the LOS, and reduction in the chaos in the ED.

The improvements continued to be quite significant 3 months after the pilot improvements began. A histogram of the improvements in LOS is shown in Fig. 3.30.

The following key improvements were observed:

- Total LOS—Improved ~30 %
  - Admitted: improved by 2.6 hours (8.7 to 6.1 hours)
  - Discharged: improved by 1.7 hours (5.8 to 4.1 hours)

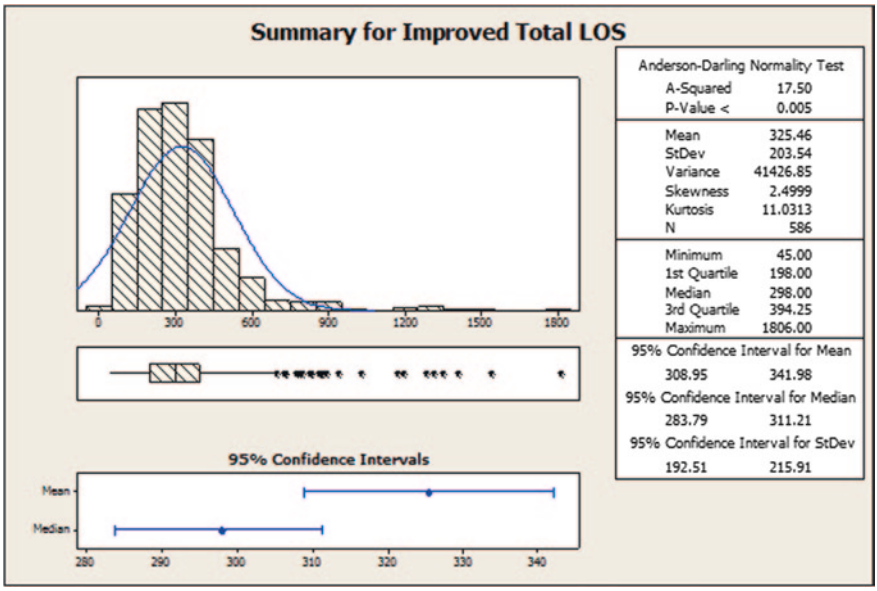


Fig. 3.30 Histogram of improved length of stay (minutes)

- Percent LWBS: 7−0.6 % (91 % improvement!)
- Front end time:
  - Triage Time = 13 minutes (from 34)
  - Time to EDP = 32 minutes (from 93)
- Diagnostic time: 166 minutes (from 184)
- Back end time:
  - Disposition to Leave ED 171, 47 (from 223 to 64)
  - Disposition to get admit orders 70 (from 103)
  - Time to assign bed 44 (from 42)
  - Assign bed to leave ED 67 (from 112)

The improved ED time line is shown in Fig. 3.31. The improved census pattern by hour of the day also improved by getting patients through the ED more quickly, as shown in Fig. 3.32. The revised metrics after 3 months is shown in Fig. 3.33.

Train and Execute

The team trained based on the needs of the improvement effort. To train the nurses in how to update the Hospital Bed Board, formal training sessions were held with the nurses and unit clerks. The Nurse Supervisors were formally trained in how

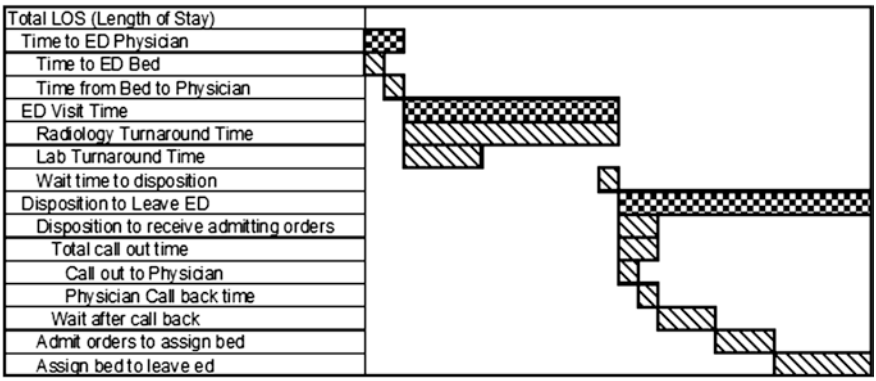


Fig. 3.31 Improved ED process time line

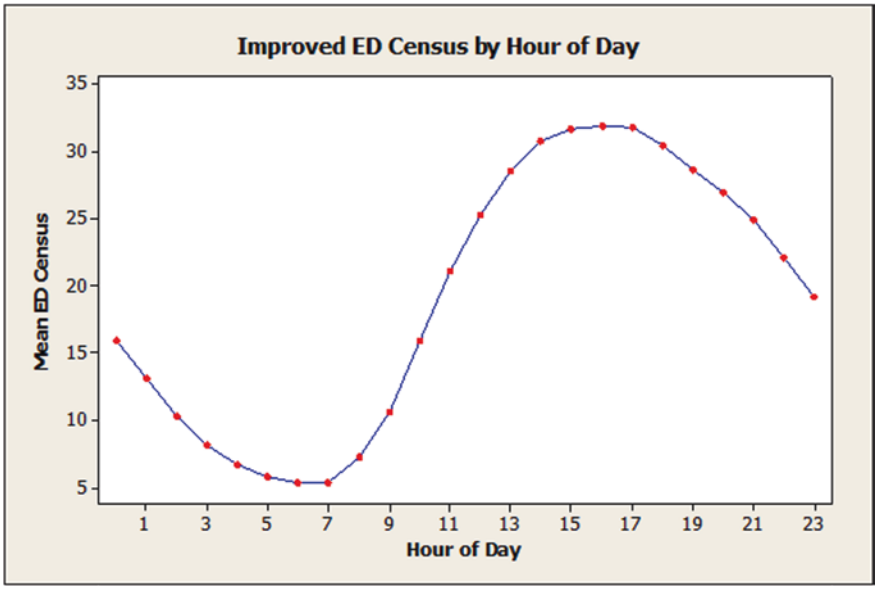


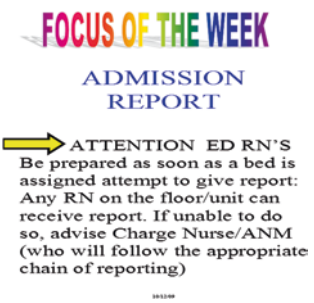
Fig. 3.32 Improved ED census by hour of day

to assign hospital beds, and how to monitor the ED Bed Board to know when a bed was requested. They also received on-the-job training for their new positions. A 'focus of the day' was used to train ED clinical and nonclinical staff in the new process changes. This was a tool that was used on a weekly basis to highlight the mostly small process changes to be implemented throughout the pilot and beyond on a continuous improvement basis. An example of a 'clinical focus of the week' is given in Fig. 3.34.

	Baseline		Target		Improved		% Improvement	
	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged	Admitted	Discharged
Total LOS:	8.7hrs	5.8 hours	5 (43%)	3 (48%)	6.1	4.1	30%	29%
% LWBS:	6.50%		3.50%		0.60%		91%	
Total Time to EDP:	93	109	35	35	32		66%	
Triage Time:	34	34	15	15	13		62%	
Wait time triage to EDP:	65	79	20	20	25		62%	
Time to ED Bed:	61	81	35	42	16		74%	
Bed to Physician	34	55	20	20	16		53%	
Treat/Diagnose to Disposition Time:	192	175	109	91	166		14%	
Radiology Diagnostic Time:	138	270	154	154	170		-23%	
Lab Time:	119				57		109%	
EDP Time Visit	192	175	109	91	175		9%	
Disposition to Leave ED	223	64	127	33	171	47	23%	27%
Disposition to get admit orders	103		59		70		32%	
Total Call out Time	41		23		24			
Call out to Physician	13		7		5			
Physician Call Back	29		17		19			
Wait after call back	37		21		46			
Admit Orders to Assign Bed	42		24		44		-5%	
Assign Bed to Leave ED	112		64		67		40%	

Fig. 3.33 Metrics dashboard three month improvement

Fig. 3.34 RN focus of the week example



Hypothesis Test

We performed a *t* test to assess whether the improvement in LOS was statistically significant. We first performed a test to assess whether the variances were equal before and after improvements. The standard deviation for the LOS for each patient during the baseline period of January through April was 224.2, and 191.0 after implementing the improvements. The variance was significantly different (reduced) after the improvements, with a *p* value of 0.000.

We then performed the two-sample T test to assess whether the LOS had shown a statistically significant improvement. The LOS before improvements

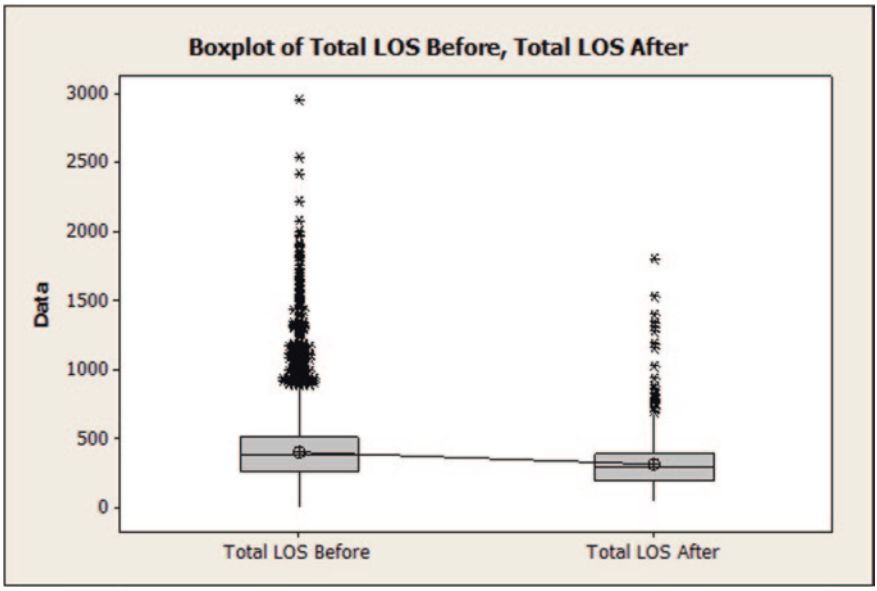


Fig. 3.35 Boxplots of average Length of Stay before and after

was 411 minutes and after improvement was 325 minutes, showing a statistically significant improvement with a *p* value of 0.000.

The box plots of the average LOS before and after improvement are shown in Fig. 3.35.

Patient Satisfaction

We also assessed whether the ED patient satisfaction increased. The patient satisfaction survey that is normally used to assess patient satisfaction was compared between the last two quarters. The patient satisfaction from April to June was 65.9 %. The patient satisfaction for the third quarter, July through September, coinciding to the ED pilot, was 73.5 %. This was a 12 % improvement in patient satisfaction, which was statistically significant at the 95 % confidence level. This patient satisfaction put the ED into the 90th percentile and second place compared to the other Regional Healthcare Centers in the system. For the previous year, October through September, the patient satisfaction was 68.9 %. So patient satisfaction had dipped prior to the pilot, and increased significantly during the pilot. By the end of the project, the patient satisfaction had increased by 24 to 89.9 %, putting the ED into the top 1 % of hospitals nationally.

Control Phase

The purpose of the Control Phase is to implement control mechanisms and procedures to ensure that the process maintains the levels of improvements attained during the pilot activities.

The following activities were executed in the Control Phase:

1. Measure results and manage change
2. Report scorecard data and create process control plan
3. Identify replication opportunities
4. Develop future plans.

Measure Results and Manage Change

The pilot activities started at the end of July. By the end of November, the LOS for all patients was 4.7 hours, down from 6.9 hours, having a 31 % improvement of over 2 hours for the LOS. The LWBS percentage was reduced by 6.2 % from 6.5 to 0.34 %, a 95 % improvement.

The admitted patients' LOS was reduced from 8.7 to 6.0 hours, a 2.7 hours reduction and a 31 % improvement. The discharged patients' LOS was reduced from 5.8 to 3.9 hours, a 1.9 hours reduction and a 33 % improvement. The up front times showed the greatest improvements, as follows:

– Triage time improved from 34 to 12 minutes, a 65 % improvement
– Time from Door to Doctor from 100 to 27 minutes, a 72 % improvement
– Time to ED Bed from 74 to 13 minutes, an 82 % improvement

The back end times are not as dramatically improved, as follows:

– Treat/Diagnose to EDP Disposition time from 184 to 165 minutes, a 10 % improvement
– Disposition to get admit orders from 103 to 77 minutes, a 25 % improvement
– Admit orders to assign bed from 42 to 34 minutes, a 19 % improvement
– Assign bed to leave ED from 112 to 70 minutes, a 38 % improvement.

Change Management

To manage the change throughout the project, we used many change management techniques. The Define phase performing the project chartering and customer/stakeholder analysis helped with getting the team members and subject matter experts bought into the project. The CEO was at the initial project team kick-off

Audience	Objectives/Message	Media/Mechanism	Frequency	Responsible
Project Team	Weekly 2 hour working meetings	Working meetings; email	Weekly	**Team leader**
Executive team	Weekly status; performance metrics update	Mission critical meetings; email	Weekly or as needed	**Team leader**
CEO	**Project status**	**Meetings as needed; email**	**As needed**	**Team leader**

Fig. 3.36 Communication plan

meeting to speak with the team to describe the importance of the project and his expectations. A communication plan was developed as shown in Fig. 3.36.

To continue to manage the change after the initial improvement ideas were piloted, we kept the improvement team together, meeting weekly until the LOS targets were met, then we met every other week for just 1 hour each week to discuss continuous improvement ideas and to ensure the gains were maintained. We continued to send out the Emergency Service Value Chain status and performance against the metric dashboard on a weekly basis to the executive team.

Report Scorecard Data and Create Process Control Plan

The control plan is a detailed guide for maintaining all of the positive changes that you have implemented. We developed the control plan defining the metric and control mechanisms for each step in the value chain. The extensive Emergency Department Bed Board information system and the ED Dashboard will be used to provide data and metrics to control the process. The control plan is shown in Fig. 3.37.

From a management perspective, the ED Director will monitor control on a weekly basis to ensure that the process is in control and stable and determine when additional improvements are needed. A monthly ED process improvement meeting is held on an on-going basis to generate and implement continuous improvement.

Identify Replication Opportunities

The Lean Six Sigma problem solving approach can and has been replicated in other areas in the hospital. Many of the improvements can be replicated in other Emergency Departments.

Process Step	Control Mechanism	Measure / Metric	Criticality (High/ Medium / Low	Who	When
Triage	Dashboard: ED Bed Board	Triage Time	Low	ED Director	Weekly
Place in ED Bed	Dashboard: ED Bed Board	Time to ED Bed	Medium	ED Director	Weekly
Nurse assesses patient	Dashboard: ED Bed Board	None	Low	ED Director	Weekly
Registration	Dashboard: ED Bed Board	Registration time	Medium	ED Director	Weekly
Enter orders	Dashboard: ED Bed Board	Time to enter orders	High	ED Director	Weekly
Draw Specimens	Dashboard: ED Bed Board	Time to draw specimens	High	Lab Director	Weekly
Perform lab results	Dashboard: ED Bed Board	Time to perform lab results	Medium	Lab Director	Weekly
Perform Radiology Tests	Dashboard: ED Bed Board	Time to perform radiology tests	High	Radiology Director	Weekly
EDP Visit	Dashboard: ED Bed Board	EDP Visit time	High	ED Physician	Weekly
Call and obtain admit orders	Dashboard: ED Bed Board	Time to get admit orders	Medium	ED Director	Weekly
Request and assign bed	Dashboard: ED Bed Board	Time to assign bed	Medium	Nurse Manager	Weekly
Report, move and admit to hospital	Dashboard: ED Bed Board	Time from assign bed to leave ED	High	ED Director	Weekly
Discharge patient	Dashboard: ED Bed Board	Time from disposition to leave ED	Medium	ED Director	Weekly

Fig. 3.37 Control plan summary

Develop Future Plans

The ED process improvement team will continue to meet to identify and implement additional improvements.

Conclusions

This project has been extremely challenging, due mainly to the large scope and the complexity of the processes. However, we achieved great success in improving the ED Value Chain, in all of the metrics that we measured, especially in overall LOS, the percent of patients leaving without being seen, the door to doctor time, and with patient satisfaction.

Project Critical Success Factors

The following key factors contributed to the success of this project:

- CEO's visible commitment; engagement; and gentle encouragement toward goals
- Key team members selected to participate
- Experienced facilitator with technical and change management skills

- Information Technology involvement as key participant
- ED Bed Board providing data, process metrics, and discipline
- Admin team monitoring performance on a weekly basis
- ED Director and Nurse Manager engaged and willing to change
- ED Staff willing to pilot improvements
- ED Physicians as key process innovators.

Even though the process changes will not be directly replicated on another project for the same hospital, many of the best practices can be shared with sister hospitals in the hospital system as well as other hospitals through this book and journal articles.

Reference

Crowding Resources Taskforce of the American College of Emergency Physicians. (2002). *Responding to emergency department crowding: A guidebook for chapters*. Dallas: American College of Emergency Physicians.

Chapter 4
Operating Room Turnaround and On Time Starts Improvement

Abstract The next two chapters describe the improvements made to a community-based acute care hospital's Operating Room environment with respect to the following areas: (1) Chapter 4. Performing turn around time between surgical cases, and improve on-time start of operating room cases. (2) Chapter 5. Improve OR location and organization of equipment, instruments and supplies.

Lean, Six Sigma, Theory of Constraints, and Supply Chain Management tools and methods were applied to improve the OR processes.

The Value Chain for providing surgical services is one of the most complex for the hospital because it touches almost every function in the hospital. It starts with identifying the supplies, equipment and instruments needed for the surgeries, customized for each procedure and surgeon. The supplies, equipment and instruments are sourced, purchased, received, and managed. The supplies and instruments are prepared and picked for the surgeries. The operating rooms are prepared, including moving and setting the equipment, furniture, supplies, and instruments. The patient flow includes registration, testing and diagnosis, surgery scheduling, and preparation for surgery in Pre-op. The surgery is performed; the patient is recovered in Post-op, and is either discharged or admitted/transferred to the hospital as appropriate. The OR is then turned around for the next surgical case. The Provide Surgical Services Value Chain is shown in Fig. 4.1.

Two projects were performed that focused on key elements of the surgical services value chain. One project focused on improving the turnaround of the OR, and the preparation of the OR for the first cases of the day. The second project focused on the locations, and organization of the equipment, furniture, supplies, and instruments in the OR area.

The remainder of this chapter will focus on the first project improving turnaround of the OR and the preparation of the OR for the first cases of the day.

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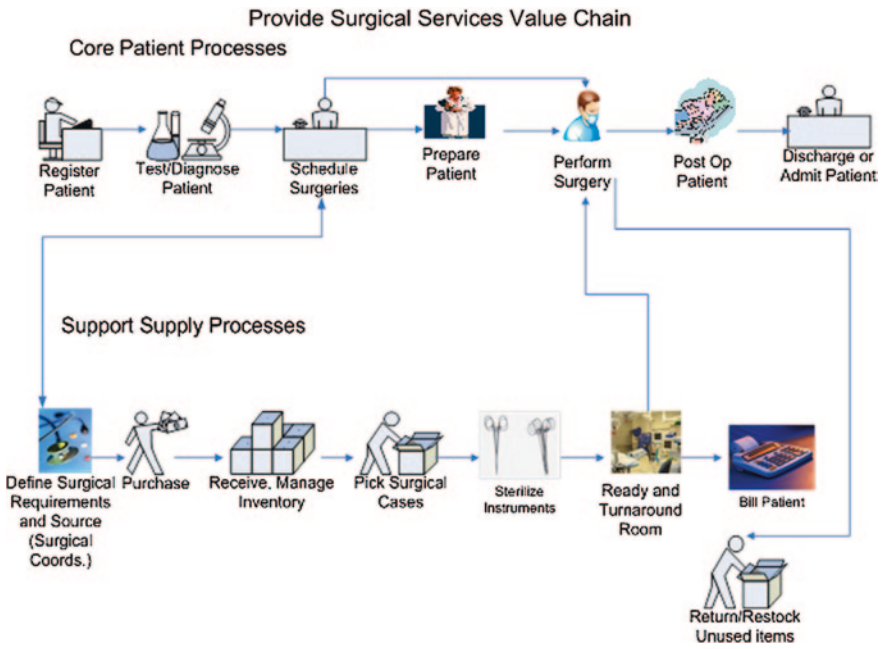

Fig. 4.1 Provide surgical services value chain

Lean Six Sigma Project for OR Turnaround and On Time Starts of Cases

The DMAIC (Define, Measure, Analyze, Improve, Control) problem solving methodology was used to improve the OR turnaround and start the OR cases on time.

Define Phase

The following steps were performed in the Define Phase:

1. Develop project charter
2. Perform stakeholder analysis
3. Identify critical to satisfaction (CTS)
4. Select team and launch the project
5. Create project plan.

Develop Project Charter

The executive team has identified an opportunity to improve the time it takes to clean and set up the OR between cases, as well as start the first cases in each room

on time in the morning. The corporate goal for turning the room around is 30 minutes or less, however the average turnaround time in the OR is 40 minutes. The average time for starting cases on time is 23 minutes late.

Project Overview The OR turn around time is not meeting the deployed corporate targets of an average 30 minutes turnaround time. Turnaround time is defined as time from wheels out of the patient from the prior surgery to wheels in of the patient for the next surgery. Our current average turn around time is 40 minutes.

Customer/Stakeholders The stakeholders for the project include the OR surgeons, nurses, anaesthesiologists, anaesthesiologist technicians, sterilizer processing, OR liaisons, OR case scheduling, OR director, charge nurse, inventory control, patients (in and out patients), and families.

The CTS criteria of the stakeholders includes quick turnaround time of the OR, starting the OR cases on time, patient care and safety, patient satisfaction, physician and staff satisfaction, and staff productivity.

The goals of the project are to reduce the OR turnaround time between cases while providing continued patient care and safety, to meet the average 30 minutes turnaround time.

The project includes the processes involved in cleaning the room after a case and preparing the room for the next case, and communication for making the turnaround happen. This time is the time from wheels out of the patient to wheels in of the following patient. The project also includes the activities related to starting cases on time in the morning for each OR.

We anticipate a reduction of time between cases, and a decrease in overtime due to cases not starting on time.

The project charter is shown in Fig. 4.2, Project Charter.

Project Name: Operating Room (OR) Turnaround and On-Time Starts Project

Project Overview: The operating room turn around time is not meeting the deployed targets of an average 30 minute turnaround time. Turnaround time is defined as time from wheel out to wheel in of patient. Our current average turn around time is 40 minutes.

Customer/Stakeholders: Surgeons, Nurses, Anaesthesiologists, Anaesthesiologist techs, Sterilizer Processing, SPD/OR Liaisons, Case Scheduling, Administration, patients (in and out patients) and families, Materials Control.

What is important to these customers – Quick turnaround time of Operating Rooms; patient care and safety, patient satisfaction, associate/employee satisfaction, productivity.

Goal of the Project: To reduce the Operating Room turnaround time between cases while providing continued patient care and safety, to meet the desired targets. The targeted goals are: Average turn around time of all cases = 30 minutes; General surgery & small cases = 15 minutes; Ortho & large cases = 20 Minutes; Open heart and major spines = 30 minutes. We will define specific project and Holy Cross goals after the Measure phase.

Scope Statement: The project includes the processes involved in cleaning the room after a case and preparing the room for the next case, communication for making the turnaround happen. This time is the time from wheel out of the patient to wheel in of the following patient.

Projected Financial Benefit (s): Reduction of time between cases; enhanced OR utilization, Revenue, Efficiency, Productivity, Decrease in overtime.

Fig. 4.2 OR turnaround and on time case starts project charter

Stakeholders	Who They Are?	Potential Impacts/Concerns
Surgeons and Physician Assistants	Surgeons who perform surgery, and physician assistants who assist in surgery	▪ Patient care and safety ▪ On time surgery schedules ▪ OR Turnaround times
Nurses and Nurse Managers (Circulator, Pre-op holding, ANM/Charge nurses, clinical coordinators)	OR nurses and managers who care for patients in the OR.	▪ Patient care and safety ▪ On time surgery schedules ▪ Efficiency ▪ OR Turnaround times
Anaesthesiologists, Anaesthesiologist techs	Anesthesiologists and anesthesiologist techs who provide anaesthesiology care	▪ Patient care and safety ▪ On time surgery schedules ▪ OR Turnaround times
SPD/OR Liaisons; Sterilize processors	Associates who provide communication between Sterile Processing and the OR; Sterilize Processors	▪ Patient care and safety ▪ On time surgery schedules ▪ Efficiency ▪ Turnaround times ▪ Patient Satisfaction ▪ Staff Satisfaction
Patients and Families	Patients and their families who receive OR care.	▪ On time surgery schedules ▪ Patient care and safety

Fig. 4.3 Primary stakeholders

Perform Stakeholder Analysis

The primary stakeholders are the OR surgeons, and staff. The OR staff includes the nurses [including nurses, nurse managers (Circulator, Pre-op holding, Charge nurses, clinical coordinators)]. Other stakeholders are anaesthesiologists and anaesthesiologist techs who provide anaesthesiology care; sterile processing OR liaisons and sterilizer processors who are associates who provide communication between Sterile Processing and the OR and Sterilize Processors who sterilize OR instruments. Patients and their families who have surgery in the OR are also primary stakeholders of the project. The primary stakeholder analysis is shown in Fig. 4.3.

There are several secondary stakeholders of the project. Inventory control manages OR materials and supplies. Ancillary services include the lab and radiology that provide diagnostics for surgery patients. Case scheduling schedules OR cases. Physician offices schedule surgeries for their patients. Vendors provide medical devices, and perform diagnostic testing for OR patients. The last secondary stakeholder group is recovery who cares for the patients when they complete the surgical case. The secondary stakeholders are shown in Fig. 4.4.

Suppliers-Inputs-Processes-Outputs-Customers

The Suppliers-Inputs-Processes-Outputs-Customers (SIPOC) for the case turnaround is shown in Fig. 4.5. There are five high-level process steps in the OR

Stakeholders	Who They Are?	Potential Impacts/Concerns
Materials control	Provide sterile and non-sterile materials for surgery	▪ OR Turnaround times ▪ Scheduling
Ancillary Services	Ancillary services such as lab, radiology who provide diagnostics for surgery patients	▪ Patient care and safety ▪ Case scheduling ▪ Providing timely and accurate results
Case Scheduling	Schedule OR cases	▪ Case Scheduling ▪ On-time cases ▪ Accurate case schedule (procedure, physician, side)
Physician offices	Physician offices who schedule patients for surgery	▪ Patient care and safety ▪ On time surgery schedules ▪ Getting patient scheduled ▪ Vendor notification; availability of devices
Vendors	Vendors who provide medical devices, and perform diagnostic testing.	▪ Patient care and safety ▪ On time cases ▪ Use and availability of product
Recovery	Staff who provide recovery services for surgery patients	▪ OR Turnaround time ▪ On time surgery schedules ▪ Patient care and safety

Fig. 4.4 Secondary stakeholders

turnaround process. When the case is about 10 minutes from being complete, the OR nurse calls to the front desk to notify them that the technicians should be available to start cleaning the room. When the case is complete and the bandages are on, the OR team moves the patient from the OR table to a bed. The patient is moved to recovery. The team cleans the room, removing trash, used instruments, and equipment after it is wiped down. The materials for the next case have already been staged outside the room, and were prepared the day before the case. Once the room is cleaned from the prior case, the scrub nurse and circulating nurse set up the room for the next case.

The SIPOC for the processes for starting the OR cases on time in the morning is shown in Fig. 4.6. There are four high-level processes for starting a case on time in the morning. The focus for starting the cases on time in the morning for the first cases in each OR is important. If the first cases do not start on time in the morning, then the timeliness of the entire schedule is jeopardized for the entire day. The materials, equipment, and instruments are planned the prior day through the night shift based on the schedule for the surgical cases for the next day. The materials, equipment, and instruments are picked from the Core inventory room, that is stored within the center of the OR area. The OR team readies the room in the morning, ensuring that all of the supplies, equipment and instruments are available and set up in the room. If the patient and OR team are ready, the case starts on time.

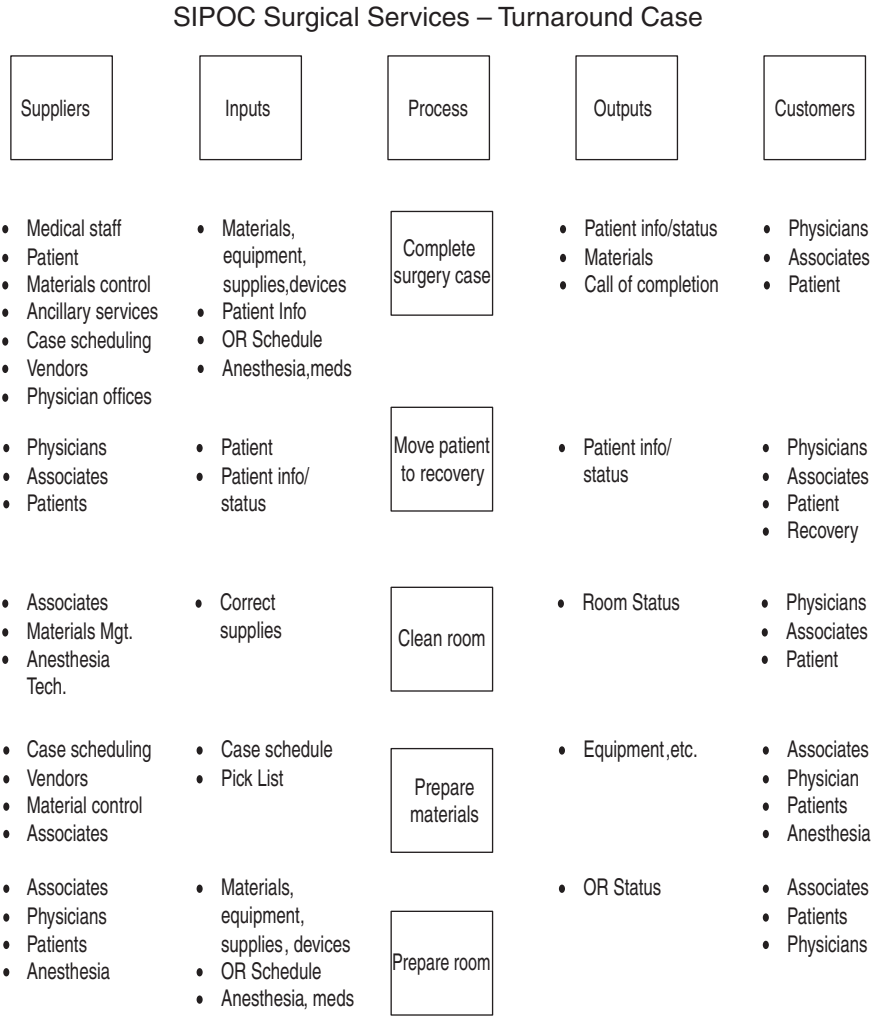

Fig. 4.5 Case turnaround SIPOC

Identify Critical to Satisfaction

The CTS criteria for this project are:

- Quick turnaround time of OR: This includes cleaning the room from the prior case to readying the room for the new case.
- On time case starts: This includes picking materials, equipment and instruments the day before for the case, and readying the room in the morning to start the first cases in each room on time.

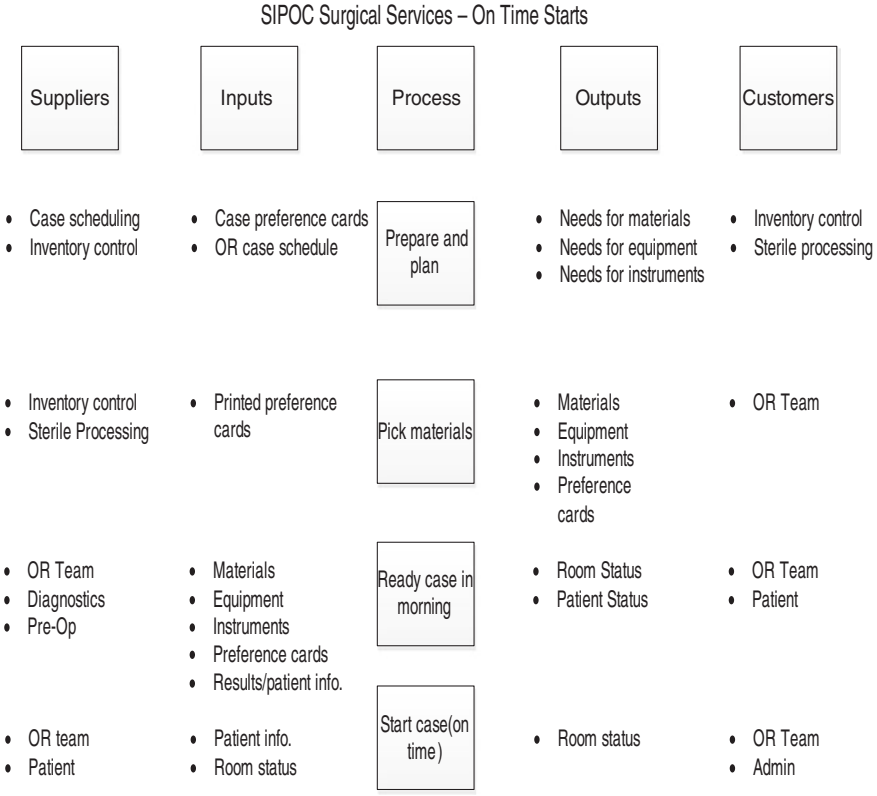

Fig. 4.6 On time start SIPOC

- Patient care and safety: Ensuring and providing patient care and safety.
- Patient satisfaction: Ensuring the satisfaction of the patients.
- Associate satisfaction: Ensuring the satisfaction of the OR staff, balancing patient care, safety, and timeliness.
- Physician satisfaction: Ensuring the OR physicians' satisfaction.
- Productivity: Ensuring appropriate use of personnel resources in the OR to manage operating costs.

Select Team and Launch the Project

The team was formed, consisting of the OR Executive Director, the OR surgical coordinators, inventory control, instrument sterile processing, Pre-op, Post-op, Chief of Anesthesia, Operational Excellence Master Black Belt, and Black Belts.

Create Project Plan

The project was started in October. The Define phase was completed by October 31. The Measure phase started in November and was completed on January 8 of the next year. The Analyze phase ended January 22nd. The Improve phase finished December 31st. The Control Phase was completed in April of year 3. The project milestones are shown in Fig. 4.7.

Rules of Engagement:

The following rules of engagement were embraced by the project team:

- Be present and be committed at the meetings
- Look at issues, not people; not to be defensive
- Be open to new ideas
- Think outside the box
- Help each other work together as a team
- Be respectful for people to finish their thoughts
- Focused structure: agendas, outcomes, parking lot issues
- Limit our time; keep our meetings to the time; finish meetings
- Fix the process, do not fix blame
- Everyone's point of view is appreciated and important
- It's your meeting and project, feel comfortable to contribute.

The rules of engagement are critical to ensure the smooth running of the team meetings, so that the team can stay on topic, and change management can begin.

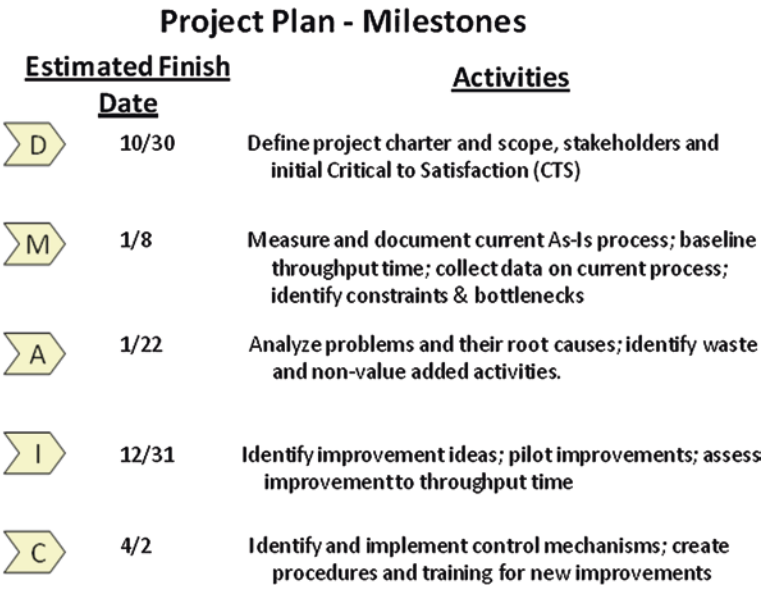

Fig. 4.7 Project milestones

The Define phase is important in defining a clear project scope, identifying the project stakeholders, and planning for the rest of the project. The team moved next into the Measure phase.

Measure Phase

The Measure Phase included the following activities:

1. Define the current process
2. Define detailed voice of customer (VOC)
3. Define the voice of process (VOP) and current performance
4. Validate measurement system.

Define the Current Process

The first step was to map the current process by creating detailed process maps of the processes to turnaround the OR between surgical cases, shown in Fig. 4.8, and the processes for readying the rooms for on-time starts of cases in the morning, shown in Fig. 4.9.

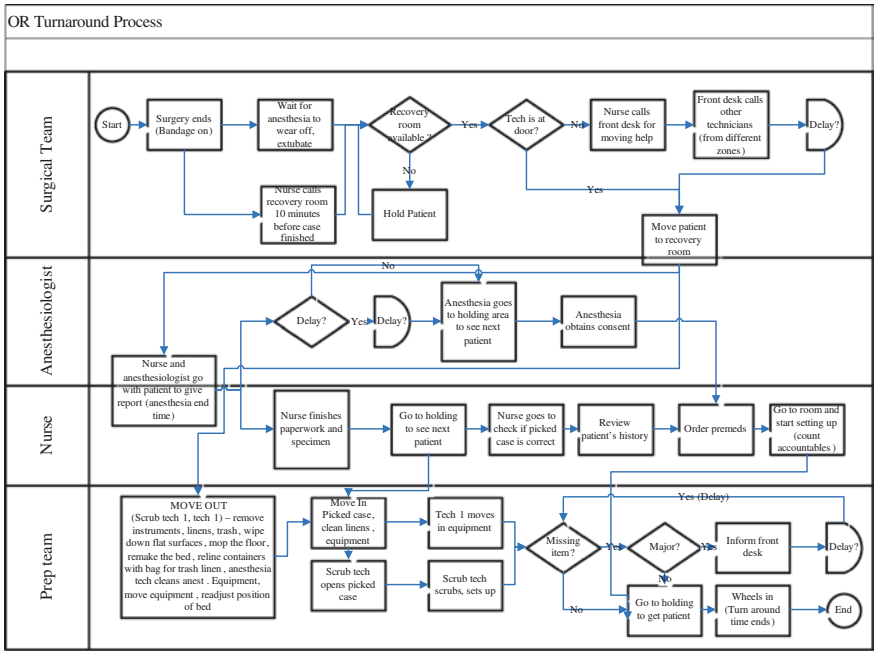

Fig. 4.8 Process map of OR turnaround

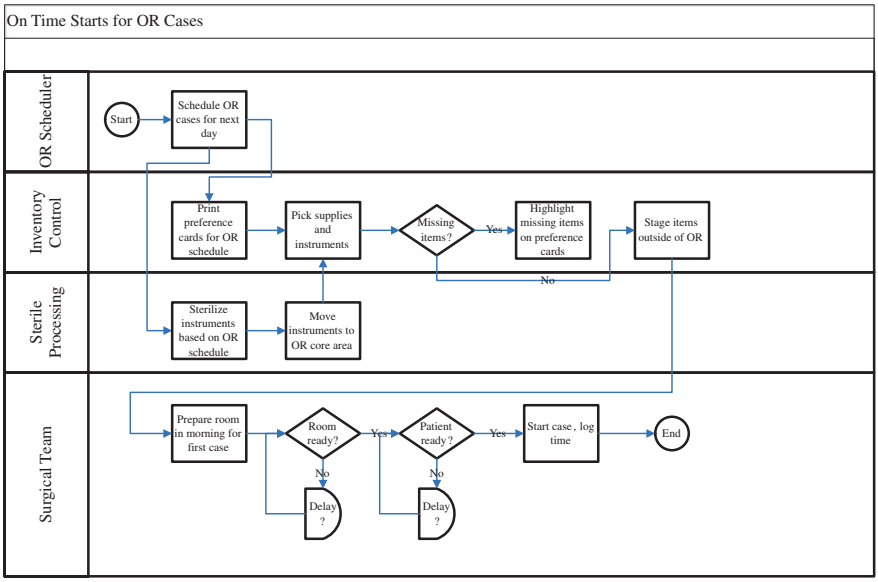

Fig. 4.9 Process map of on time starts of OR cases

We also filmed the turnarounds of the rooms, including the cleaning of the room, and the set up of the supplies and instruments by the OR team.

Data Collection Plan

To measure the CTS' we developed the data collection plan shown in Figs. 4.10 and 4.11. We measured and baselined the time to turnaround the OR, as well as the time to start the first cases in each room for the day. We measured the delays to starting the cases on time for the first cases and turning the cases during the day. We assessed staff and physician satisfaction using surveys developed for this project. We used the existing productivity measures that assess the productive staff hours compared to the number of procedures performed.

We operationally defined each measure to ensure a consistent measurement system.

OR Turnaround Time

OR turnaround time is the time from when the patient is wheeled out after surgery is complete to when the next patient is wheeled into the OR. The purpose is to understand the time it takes to turnaround the OR from one case to the following case within the same room, excluding surgeons who have two rooms. We extracted the data from the Operating Room Management system and calculated

Critical to Satisfaction (CTS)	Metric	Data collection mechanism (survey, interview, focus group, etc.)	Sampling plan (sample size, sample frequency)	Baseline
Quick turnaround time of Operating Rooms (same surgeon and room); don't include when have 2 rooms	OR turnaround Time: Time from wheels out to wheels in; by surgeons, and by room	ORM (OR management module), recorded in system. Have raw data. Can retrieve circulator and scrub tech staff. Excel spreadsheet	January through September 2009	Mean = 40 mins Stdev = 21 N= 1179
Starting cases on time	On time starts: 1st cases for a surgeon (1st 2 cases in 1st 2 rooms of day (7:30 and 8:00 am start times))		Jan through Sep 09 data	Mean = -22.90 minutes Standard Deviation = 40.10 Median = -13
Starting on time cases (by time buckets)		Time Buckets: Early or on time: 11% (201/1824) Late 10 mins or less: 36% Late 11 mins <= 20 mins: 26% Late 21 mins <= 30 mins; 12% Late > 30 mins: 14%		

Fig. 4.10 Data collection plan, page 1

Critical to Satisfaction (CTS)	Metric	Data Collection Mechanism (survey, interview, focus group, etc.)	Analysis mechanism (statistics, statistical tests, etc.)	Sampling plan (sample size, sample frequency)	Sampling instructions (who, where, when, how)
Patient care and safety delays	Delays impacting turnaround time, patient care and safety	Purple sheet, and put into Excel spreadsheet			See Pareto chart: Largest delay is MD Late
Associate satisfaction		Survey		All staff for 2 weeks	See results
Productivity	Total productive minutes	Current standard 7.85 hours of staffing for 1 hour of surgery			YTD (1/22/10): 99.4%

Fig. 4.11 Data collection plan, page 2

the moving range of the difference between the actual start time of the next case minus the actual end time of the prior case, for the same room and same surgeon. We removed values greater than 90 minutes as cases not intended or scheduled to follow directly after the prior case in the same room. We also removed cases with the same surgeon at the same time in different rooms since one of the rooms is purposely held for the specific surgeon to reduce surgeon downtime.

On Time Starts (of Cases)

The On Time Start measures the timeliness of the OR cases starting when scheduled. The purpose is to assess the timeliness of the start of the OR cases based on their scheduled start times. For the first case for a surgeon, we measured the first case of a surgeon that started by either 7:30 or 8:00 a.m. start times. For surgeons with two rooms used sequentially, we removed those times since the range of time would appear as negative across the surgeon. We also measured the on time starts of all cases.

Delays Impacting Turnaround Time and On Time Starts of Cases

This measure assesses delays that impact starting cases on time, and turning around the room in a timely manner. The purpose is to understand the root causes of delays that impact turnaround time. The delays are currently recorded in the OR and entered into an Excel spreadsheet for tracking. We created a bar chart of the frequency by delay reason.

Associate Satisfaction

The associate satisfaction survey assesses the job satisfaction of the staff that works in the OR. The purpose is to understand the perception of staff satisfaction with their jobs.

This assesses whether the staff believes that they have the tools to do their jobs, whether management supports them and enables them and removes barriers to provide great patient care. We created a staff satisfaction survey that was distributed to all OR staff, to measure a baseline. We analyzed the data through statistical Chi Square analysis by question, to determine whether the associates are satisfied with their jobs in the OR.

Productivity

The productivity metric measures total productive time of the staff in the OR. The purpose is to assess the efficiency of the staff that provides services in the OR. We used the existing productivity measures as a baseline for the fourth quarter of year one.

Define Detailed Voice of Customer

The voice of the customer surveys were used to assess patient, staff, and physician's satisfaction with the OR processes.

Question	% Rating Strongly Disagree	% Rating Somewhat Disagree	% Rating Neutral	% Rating Somewhat Agree	% Rating Strongly Agree	Chi-Square p-value / Significant (Yes/No)
1. The front desk/management team communicated effectively with me today regarding my cases/cases.	0	2	4	3	12	0.008 (Yes)
2. The turnaround time was appropriate for this procedure	2	1	2	3	12	0.000 (Yes)
3. Patient safety took precedence over starting on time today.	0	0	1	3	17	0.000 (Yes)
4. I had the equipment and supplies I needed to do my cases.	0	2	1	5	14	0.000 (Yes)
5. My case started on time today	7	0	1	7	5	.187 (Yes)
6. People worked together in the department today to get the job done.	1	1	0	5	16	0.000 (Yes)
7. It bothers me when cases do not get started on time.	0	0	2	4	14	0.002 (Yes)
8. My patients were ready in holding today leaving me time to attend to room preparation	2	2	4	3	11	0.011 (Yes)

Fig. 4.12 Staff satisfaction survey

All but one of the questions' ratings was statistically significant. All but one of the questions were rated the highest percent of ratings in the 5-Strongly Agree category. The question, "5. My case started on time today." Had 7 ratings of strongly disagree and agree, and five rated as strongly agree, with no ratings of disagree, and only one rating of neither agree nor disagree. This indicates that some of the cases start on time, while others do not.

The following questions all received a high percentage of strongly agree ratings: front desk communication; the turnaround time; patient safety; equipment and supplies available; people worked together; it bothers staff when cases do not start on time; patients were ready in holding. The ratings are shown in Fig. 4.12.

The results show overall fairly high satisfaction with the processes around OR case readiness and turnaround of rooms, as well as communication and management. The only area where there was a mix of responses was in "My case started on time today." This supports the need for this project.

Define the Voice of Process and Current Performance

The Pareto Chart in Fig. 4.13 shows the percentage of cases by surgery procedure category. Orthopedic cases consist of 31 % of the cases in the OR, followed by general surgery cases consisting of 25 % of the cases.

The graphic in Fig. 4.14 illustrates the major activities and average timeline for the cardiac cases. There is an average of 21 minutes to clean and setup the room, and then another 23 minutes to set up anesthesia equipment for the surgery, before wheels in. There is an average 34 minutes of patient prep and anesthesia patient time before incision. The surgeries averaged 84 minutes, with a 10-minutes patient wake up after the close.

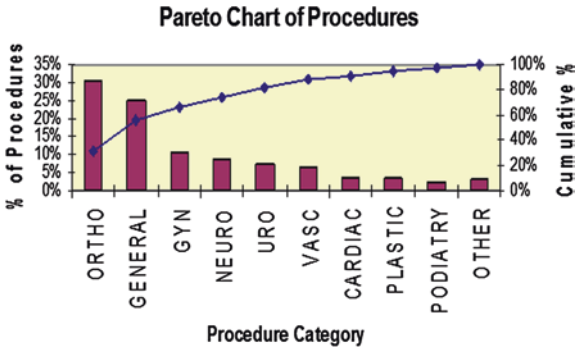

Fig. 4.13 Pareto chart of surgical cases by procedure category

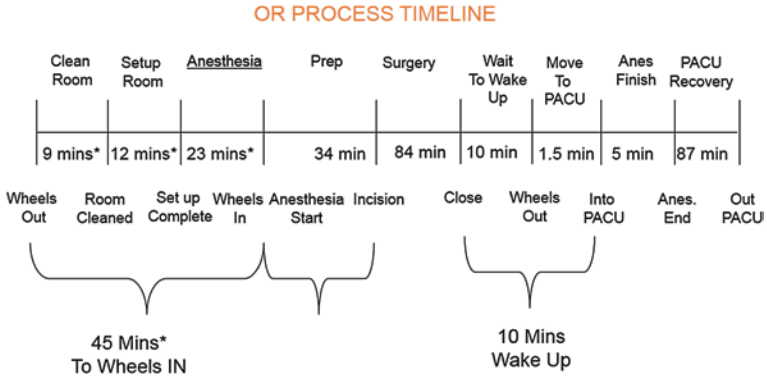

Fig. 4.14 OR cardiac process timeline

Turnaround Times

The baseline for the turnaround time is an average of 40 minutes with a standard deviation of 21 minutes. The histogram is shown in Fig. 4.15.

The average turnaround time by surgical procedure category is shown in Fig. 4.16. Neurology cases have the longest average turnaround time of 50 minutes, followed by vascular cases with an average of 47 minutes. The lowest average turnaround case types are ICD with 24 minutes, Ear nose throat (ENT) with 25 minutes, and Cardiac cases average 31 minutes.

The average case turnaround times also differed by surgeon. We stratified the average turnaround time for each surgeon.

On Time Starts

The on time start average time is minus 19 minutes, representing start times that are 19 minutes late, with a standard deviation of 22 minutes. The average on time start for those cases that start on time or early, averages 10 minutes, with a

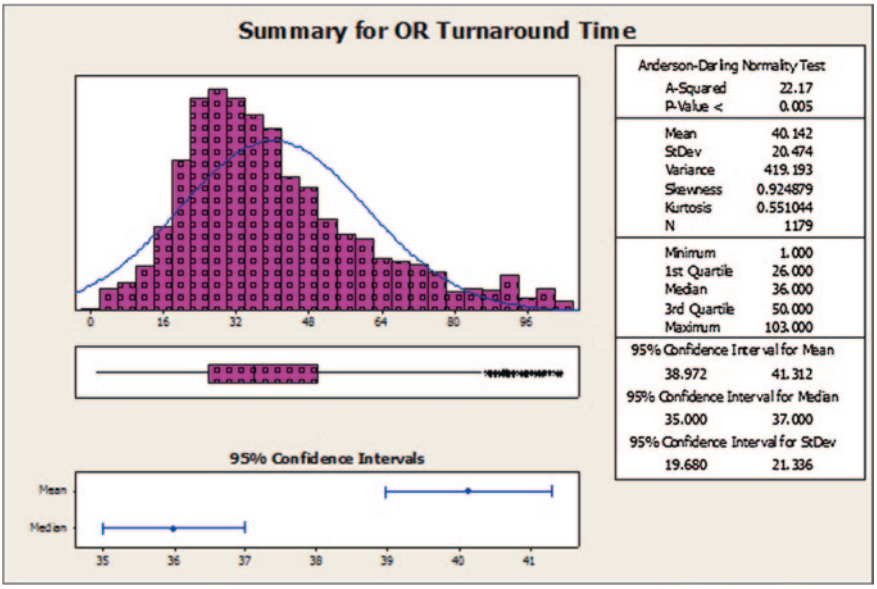

Fig. 4.15 Baseline of turnaround time

Procedure Type	Mean Turnaround Time (minutes)	Standard Deviation	Median Turnaround Time (minutes)
Bariatric	36	19	34
Cardiac & Pacer	34	20	30
ENT	25	6	27
General	40	20	36
ICD	24	28	24.5
OBGYN	42	21	37
Neuro	50	17	47
Oral	35	14	33
Ortho	35	19	31
Plastic	35	18	31
Podiatry	40	24	33
Urology	32	19	27
Vascular	47	25	44.5
Average Turnaround Time	40		

Fig. 4.16 Average turnaround time by procedure category

standard deviation of 31 minutes. The average on time start for those cases that start late is −23 minutes, with a standard deviation of 19 minutes.

Eleven percent (11 %) of the cases start early or on time. Thirty-six percent (36 %) of the cases start 10 minutes late or less. Twenty-six percent (36 %) of the cases start between 11 and 20 minutes late. Twelve percent (12 %) of the cases start between 21 and 30 minutes late. Fourteen percent (14 %) of the cases start more than 30 minutes late. The on time start histograms are shown in Figs. 4.17, 4.18, and 4.19. The percentage of on-time starts for the first case of the day and for all cases by percent in the early/on-time and late categories are shown in Fig. 4.20. We also

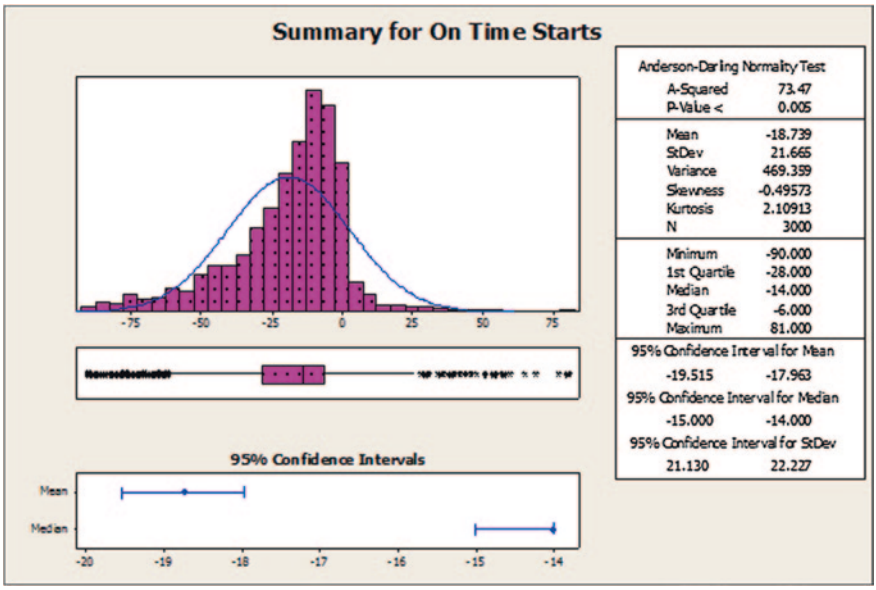

Fig. 4.17 On time starts (late, on time, early)

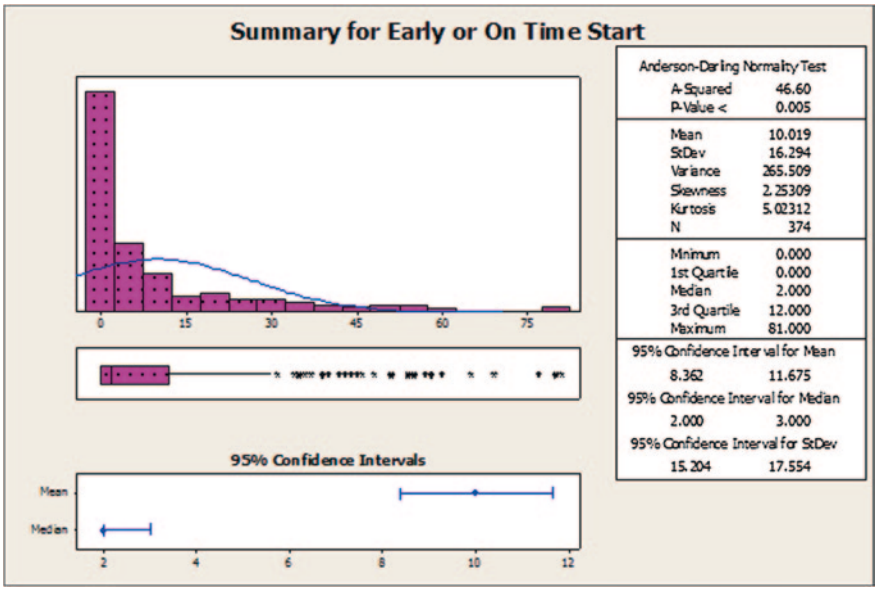

Fig. 4.18 On time starts (early, on time starts)

stratified the on time start data by surgeon and procedure category to determine if there were particular surgeons or procedure types that had longer on time start times. The on-time start times by procedure category are displayed in Fig. 4.21.

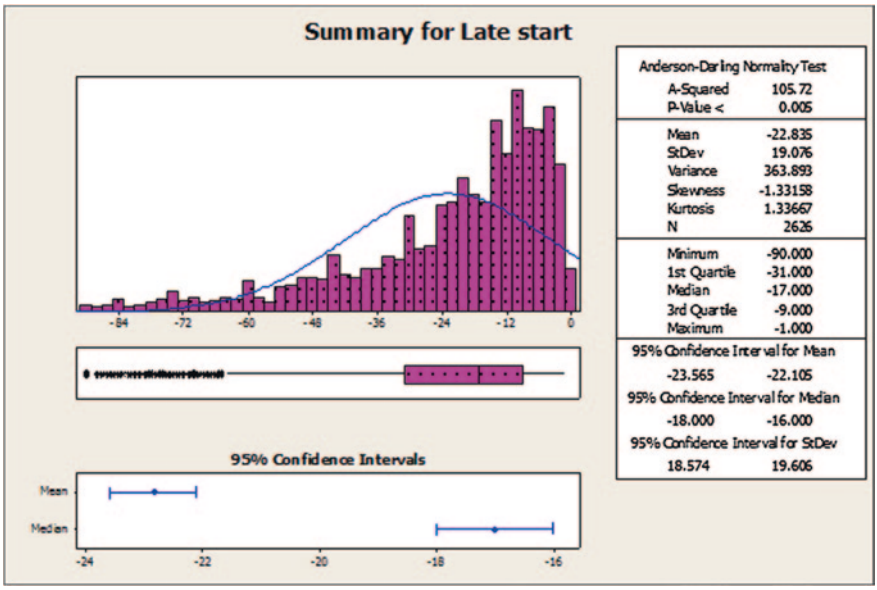

Fig. 4.19 On time starts (late starts)

Category	Percent First Case of Day	All Cases
Early or on time	11%	11%
Late 5 minutes or less	16%	10%
Late 6 to 10 minutes	20%	14%
Late 11 minutes <= 20 minutes	26%	22%
Late 21 minutes <= 30 minutes	12%	15%
Late > 30 minutes	14%	28%

Fig. 4.20 Percent cases on time baseline: first cases of the day

Delay Reasons

The most frequently occurring delay reason for starting cases on time or turning them around in a timely manner is the MD (surgeon) being late. The Pareto chart is shown in Fig. 4.22.

By Procedure Category	Mean On Time Starts	Standard Deviation	Median
ANESTHESIA	-9	9	-13
BARIATRIC	-9	9	-7
CARDIAC	-26	42	-17
ENT	-11	10	-9
GENERAL	-15	34	-9
GYN	-20	40	-12
ICD	-13	3	-14
NEUROS	-31	42	-21
ORAL	-11	1	-10.5
ORTHO	-17	42	-8
PACER	-42	57	-19
PLASTIC	-14	15	-9.5
PODIATRY	-10	9	-9.5
RADIATION	-7	6	-6
UROLOGY	-12	25	-9
VASC	-34	46	-22

Fig. 4.21 On time starts by procedure category

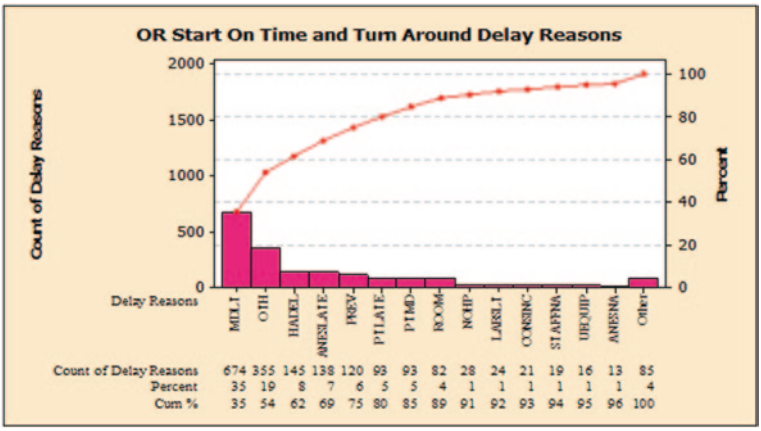

Fig. 4.22 Delay reasons

Validate Measurement System

The operational performance analyst validated the metrics for the turnaround times and on-time starts by developing the baseline measurements and comparing them to the existing OR metrics. The baselines were consistent with the established metrics.

Analyze Phase

The following activities were performed for the Analyze Phase to identify and validate the root causes and to assess whether the process is currently capable of meeting the desired specifications.

1. Develop cause and effect relationships
2. Determine and validate root causes
3. Develop process capability.

Develop Cause and Effect Relationships

We filmed the OR turnarounds, both the cleaning activities as well as the set up of the next surgical case. Filming the activities was incredibly helpful in having the team understand the activities, and the barriers that caused inefficiencies in the process. Many of the people would never have believed the variability in the process unless they actually saw the recorded turnaround processes. The team viewed several turnarounds in both general surgery and orthopedic rooms. They made observations regarding what was done well and what was not consistent. The team also brainstormed potential causes of inefficiencies regarding starting OR cases on time. We then created a cause and effect matrix to understand the root causes for both the timely turnaround of the OR cases and the on-time starts of the first cases of the day in each room. We rated the importance of the effects of the OR turnaround as high (10) and the on-time starts as medium (5). We then rated the level of each cause related to each effect on a scale of 9-high, 3-medium, 1-low, and blank as no relationship. We categorized the causes into methods, people, furniture/equipment/rooms, communication, supplies, and instruments. We multiplied the importance by the rating for each cause to get a relative weighting of where to focus first on improvements. We grouped them into High (A), Medium (B), and Low (C) relative weightings. The cause and effect matrices are shown in Figs. 4.23 and 4.24.

The highest rated methods causes are:

- No standard process and order of activities
- Schedule changing as physicians see fit
- Labs not ready.

Cause & Effect Matrix	Effects			
	Turnaround Barriers	Delays in on time starts	Total	Relative Weighting
Importance	**10**	**5**		
Causes				
Methods:				
No responsibility for organizing sub-sterile rooms	**3**	**3**	45	**C**
Cases finishing at same time, people not available to clean at same time	**9**		90	**B**
Assumption that you need more than 1 tech per room	**1**		10	**C**
Circulating nurse leaves and doesn't come back	**1**		10	**C**
No standard process and order of activities	**9**	**9**	135	**A**
Schedule changing as physicians see fit	**9**	**9**	135	**A**
Anesthesia clinician not coming promptly to room	**3**	**3**	45	**C**
Bed not available when patient needs to come out	**9**		90	**B**
No hospital room available to assign to patient - no physical bed to move the patient on (take out on stretcher)	**1**		10	**C**
Holding area nurses have too many patients		**9**	45	**C**
All cases start at same time		**9**	45	**C**
Patient still being processed in admitting	**9**	**9**	135	**A**
Admitting batching and not available		**3**	15	**C**
Cases run late at night, instruments go down late, low staffing at night in Sterile Processing	**3**	**3**	45	**C**
Patient not ready in holding	**3**	**9**	75	**B**
Physician offices not consistently getting paperwork that is needed	**9**	**9**	135	**A**
Tech not available to clean room, busy, break	**9**		90	**B**
Anesthesia not seeing patient, in holding area, or night before (pre-screening)	**9**	**9**	135	**A**
Patient not told correct time to be here		**9**	45	**C**
Labs not ready	**9**	**9**	135	**A**
Changing priorities when in middle of cleaning room; no set priorities	**9**	**3**	105	**B**
Need to be able to communicate what is done in a room.	**9**		90	**B**

Fig. 4.23 Cause and effect matrix: methods

Cause & Effect Matrix	Effects: Turnaround Barriers	Effects: Delays in on time starts	Total	Relative Weighting
Importance	10	5		
Causes				
People:				
Have perception that they don't have time to do their job	1		10	C
Lack of accountability	9	9	135	A
Lack of commitment	9	9	135	A
People say that's not my job	9	9	135	A
Physician perception on turnaround time	3		30	C
Surgeon not here on time	9	9	135	A
People are coming in late to morning report and don't hear all they need to	1	1	15	C
OR team not being trained on the new process	9	9	135	A
Furniture/Equipment/Rooms:				
Having nothing to transport trash on (heavy bags)	1		10	C
Not able to find furniture	3	3	45	C
Reps have stuff laid out on every surface	1		10	C
Equipment not ready in room (depends on night before)	9	9	135	A
Communication:				
Lack of communication	3	3	45	C
Don't get communication from front desk	3		30	C
Morning report runs late because it's filled with fluff-not pertinent info		3	15	C
Miscommunication with vendors, not being notified for devices	9	9	135	A
Supplies and Instruments:				
No sterile batteries available	1	1	15	C
Case cart lost	9	9	135	A
Missing items for case	9	9	135	A
Need to take back unused items back to Core	1		10	C
Wrong rep there for surgery	9	9	135	A
Instruments not ready	9	9	135	A
Cleaning supplies not available	1		10	C
Case not picked correctly	9	9	135	A
Too much checking of supplies & instruments	3	3	45	C
Accuracy of preference cards	9	9	135	A
No room for extra supplies not used in surgery	3		30	C
Rep trays not here.	9	9	135	A

Fig. 4.24 Cause and effect matrix: other causes

The highest rated people causes are:

- Lack of accountability
- Lack of commitment
- People say that's not my job
- Surgeon not here on time.

The highest rated Furniture/Equipment/Rooms cause is:

- Equipment not ready in room.

The highest rated Communication cause is:

- Miscommunication with vendors, not being notified of devices.

The highest rated Supplies and Instruments causes are:

- Case cart lost
- Wrong rep for their surgery
- Instruments not ready
- Case not picked correctly
- Accuracy of preference cards
- Rep trays not here.

Determine and Validate Root Causes

To ensure that we are getting to the root causes, we performed a Why-Why analysis and created a Why-Why diagram.

Develop Process Capability

The goal of the turnaround time is 30 minutes or less. We set the upper specification to 30 minutes, and the lower specification to 15 minutes. The goal of the on time start times is to be between 30 minutes late and 30 minutes early.

The goal of the on-time starts are as follows:

1. Average of all cases: $\leq$30 minutes
2. General and small cases: 15 minutes
3. Orthopedic and large cases: 20 minutes
4. Heart and neuro (major spine) cases: 35 minutes

To develop the process capability, we first had to determine if the distributions for the metrics were Normal distributions. The null hypothesis is that the data distributions are Normal, and if we fail to reject the null hypothesis then we can conclude that the data follows a Normal Distribution. However, the OR turnaround time and the On-time Start times are not Normal Distributions (p-values less than 0.005). We fit non-normal statistical distributions for the OR turnaround times, and found the

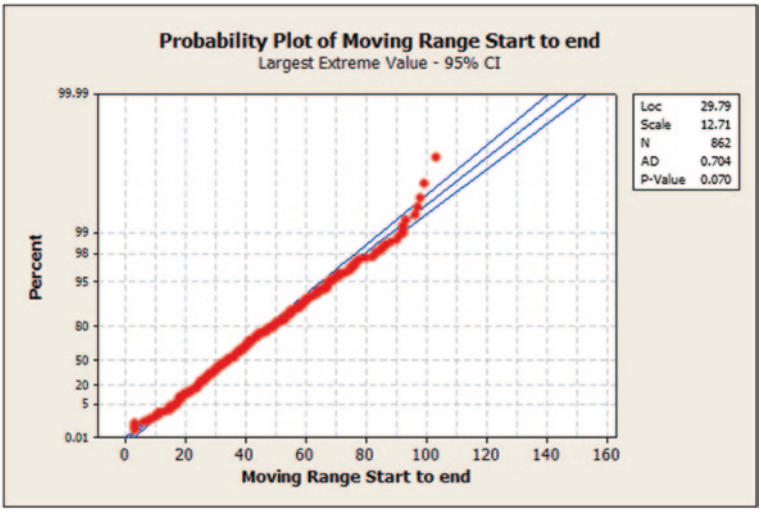

Fig. 4.25 Distribution fit for process capability: OR turnaround

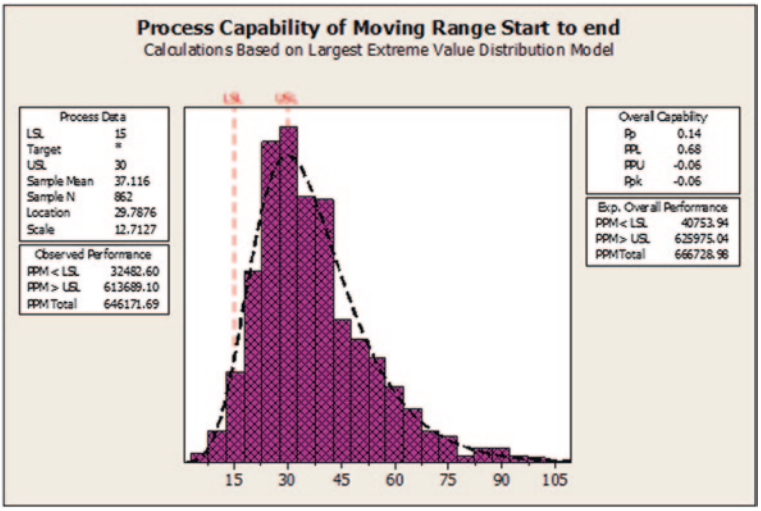

Fig. 4.26 Process capability: OR turnaround

Largest Extreme Value distribution to fit the best, shown in Fig. 4.25. For the On-time start times, since there were negative values, and most of the distributions (Weibull, Exponential) required positive values only, we used the Normal distribution assumption. We developed the process capability for the turnaround time, and found that currently the process is not capable of meeting the specification of 15 to 30 minutes, shown in Fig. 4.26. The Pp = 0.14 and the Ppk = −0.06. The process is not capable

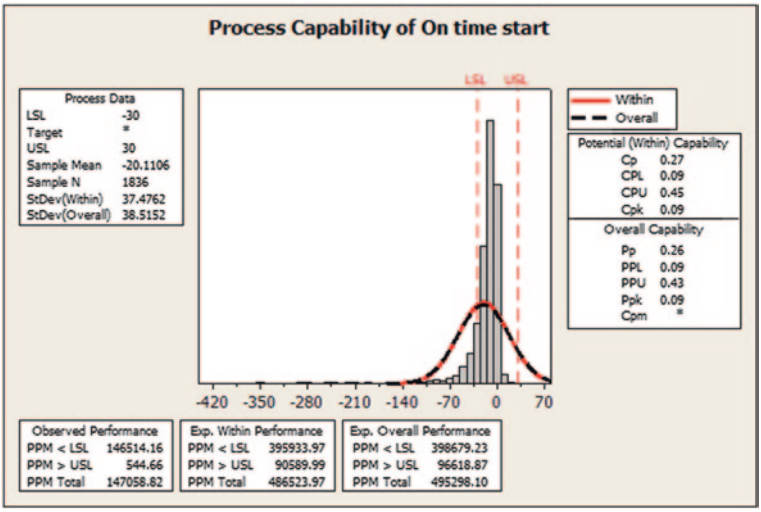

Fig. 4.27 Process capability: on-time case starts

of meeting our upper and lower specification for on-time starts of −30 minutes late to 30 minutes early. The Cp = 0.27 and the Cpk = 0.09, shown in Fig. 4.27. This is much lower than our goal of a Cp of 1.33 or greater. We then moved onto the improve phase, to identify improvements to the current process.

Improve Phase

The following steps were executed in the Improve Phase:

1. Identify improvement opportunities and plans
2. Perform cost/benefit analysis
3. Design future state
4. Establish performance targets and project scorecard
5. Pilot improvements
6. Train and execute.

Identify Improvement Opportunities and Plans

OR Turnaround

The team first focused on improving the OR turnaround process. Since one of the highest rated root causes was the lack of a standard process, the team developed a standard turnaround process, focusing on eliminating the inconsistencies and lack of

alignment with the AORN (American OR Nurses) requirements, and the policies and procedures. The team gathered some of the staff that perform the OR turnarounds to develop the new process. We clearly identified the order of the tasks, ensuring first that the trash is removed and that the dirty room is cleaned, communicate that the cleaning is complete, and then set up the room for the next case.

The team decided to practice the new process that was designed on paper to see if it worked well, and to determine if improvements could be made by aligning some of the activities to be performed by different people in parallel. We then revised and standardized the process. We then filmed the new process, and our media personnel put together a very professional training film of the new OR turnaround process. We introduced the new process at one of the OR staff meetings, with the CEO stressing the importance of improving the OR turnarounds to increase OR capacity, as well as patient, staff, and surgeon satisfaction.

Improvement Plan OR Turnaround and On Time Starts:

There were barriers that were identified that had to be removed before we could implement the new OR turnaround process and that would also help to improve on-time start of cases. We developed an improvement plan that addressed and removed these barriers and root causes.

Perform Cost/Benefit Analysis

For implementing the new OR turnaround process, and the 5S organization of the OR, there was very little cost, and none that was not covered by the existing OR budget.

Design Future State

We designed the future state by developing the OR turnaround film, and the implementation plans. The process maps did not change, since the OR process changes were at a more detailed work instruction level, rather than the higher process map level.

Establish Performance Targets and Project Scorecard

Our performance targets for turnaround time are as follows:

- Average of all Cases: $\leq$30 minutes
- General and small cases: 15 minutes
- Orthopedic and large cases: 20 minutes
- Heart and neuro (major spine) cases: 35 minutes

OR Turnaround Improvement Plan: High Priority Items

Improvement Idea	Causes	Owner	Implementation Date
- Develop and implement new process; - Assign techs with hall person with 2 rooms in a team and have each team huddle in the morning to discuss the day (cases, equipment, supplies, instruments needed, etc.) Debrief at end of day with a few of the teams.	No standard process or order of activities; assuming need more than 1 tech; circulating nurse leaving and not coming back; have perception don't have time; lack of organization; people coming in late for morning report	OR staff	4/3 for the huddle meetings
Look at scheduling process in more detailed, schedule and planned time for case, and average for cases	Schedule changes	Enterprise Performance Excellence	June
Talk with Admitting to quantify time to admit. Have dedicated admitting person for surgery from 7 am to 10 am	Patient still being processed in admitting; admitting batching	Patient Access	April
Physician's offices; stat labs; added labs, look at pre-screening prep patient. Six Sigma project.	Labs not ready; Miscommunication with vendor (Dr. Office);	Green Belt Lean Six Sigma Process	July

Fig. 4.28 OR turnaround improvement plan: high priority items

Pilot Improvements

Our formal piloting of the improvements began in June, when we kicked off the new OR turnaround process. The CEO and Chief Nursing Officer, as well as the OR management and the Master Black Belt spoke to the OR staff to describe the importance of standardizing the OR processes, and improving efficiency throughout the OR. The CEO said that this project had the complete backing of the administrative council, his direct reports, and was the number one priority in the organization.

There was quite a gap of time between when we completed the initial design of the new process and when we rolled it out. The OR staff and OR management was extremely comfortable in the current process, and was resistant to change. The CEO, CNO, VP of Human Resources, the OR Director, and the Master Black Belt met to map out an approach to implementing the change. We decided to bring in an outside consultant that would be able to focus on a daily basis implementing the detailed improvement plans, help to train the OR staff on the new process, implement accountability, process discipline, and incorporate the new daily OR turnaround and On-time start metrics.

The OR turnaround and on-time start improvements are shown in Figs. 4.28, 4.29, 4.30, 4.31, and 4.32. A summary of the improvements is as follows:

OR Turnaround Improvement Plan: High Priority Items

Improvement Idea	Causes	Owner	Implementation Date
Implement 5S organization and standardization; Pref-cards are being updated; -Board outside on door for required equipment for next case. Verify boards are on doors. Night people should write on board what is missing from the room, for each room for first case. (Checklist of night shift accountability)	Equipment not ready	Circulators to implement putting required equipment on board on door	4/2
Talk with Materials Management about getting appropriate linens – specific to what OR needs.	Linen not available	Enterprise Performance Excellence (EPE)	4/30
Implement dashboard (manual calculation – need to automate) and incorporate process into performance evaluation and skill competencies; getting in line with synergy model.	Lack of accountability and commitment.	OR Director (EPE look at automation of dashboard) OR synergy model for competencies and performance evaluation.	4/30

Fig. 4.29 OR turnaround improvement plan: high priority items (continued)

Process Standardization and Improvement

- Implement a standard turnaround process.
- Implement team huddles to plan and debrief at the end of the day.
- Bring patients from admitting to Pre-op earlier in the morning, and do not batch.

Organize the OR (5S)

- Implement shift hand-offs to verify equipment and cases are ready.
- Remove unneeded equipment, supplies, and beds.
- Develop check sheets to ensure substeriles, hallway supplies, OR cabinets are re-stocked.
- Organize and identify all equipment and bed locations, “a place for everything and everything in its place.”

People, Skills, Competencies, and Evaluation

- Implement turnaround and cleaning competencies, incorporate into performance evaluation.
- Ensure all appropriate staff are following the process.

Improvement Idea	Causes	Owner	Implementation Date
Implement surgeon dashboards; require surgeons be 10 minutes early and send letters to communicate how much it costs when late or how it reduces delays. Recognize on-time physician - post on-time and nominate for physician of the quarter.	Surgeon late, physician getting lost	OR staff	4/3 for the huddle meetings
List of vendors' trays required by procedure and surgeon.	Vendor trays	Materials Management	4/30
Implement 5S organization and standardization	Case cart lost; missing items for case	5S	5/15
Rationalize most used instruments, and 5S organization.	Instruments not ready; checking of instruments	5S: Six Sigma project	5/15
Updating preference cards to improve accuracy; Need a metric for accuracy of pref cards (review of pick lists) and perform audit of supplies (then later move to every 6 months or annual); Standardize preference cards across procedure categories	Case not picked correctly; Accuracy of preference cards; taking back items to Core	Coordinators; Sterile Processing	On-going
Standardize how we pick cases (tech 1s shouldn't have to check cases) and put on same place on cart. Track accuracy of picking cases	Checking of supplies for cases; no room for extra supplies used in surgery	OR scheduler and Materials Management	Put procedure / checklist and review next meeting (4/9)

Fig. 4.30 OR turnaround improvement plan: high priority items (continued)

OR Turnaround Improvement Plan: Medium Priority Items

Improvement Idea	Causes	Owner	Implementation Date
Implement dashboard measuring OR teams for cleanliness and organization; implement checklists; Nurse's job to keep it clean, monitor trash on floor – keep up with it during surgery. Put in an audit to measure cleanliness of room when techs start cleaning.	Lack of organization	Circulator; Scrub	4/30
How to coordinate and pull techs from entire OR? Know when surgeon is out of room, so front desk better coordinate and anticipate multiple rooms coming out at same time, pulling techs based on time out. Long term: electronic status board, with electronic charting.	Cases finishing at same time; tech is not available	Charge front desk coordinator	4/30
Stretcher should stay outside of room until bed is available (techs)	Bed not available when patient comes out		4/30
Six Sigma project;	Patient not ready in holding	Six Sigma project	7/8
Will assign techs on night shift- assign someone as a runner to floors, and others have assigned rooms	Changing priorities when in middle of cleaning room, no set priorities	Evening OR supervisor	4/12
Part of the OR turnaround process.	Need to be able to communicate what is done in a room.		4/30

Fig. 4.31 OR turnaround improvement plan: medium priority items

OR Turnaround Improvement Plan: Low Priority Items

Improvement Idea	Causes	Owner	Implementation Date
5S organization, assign responsibilities for sub-sterile room organization and stocking	No one responsible for Sub-sterile room	5S	5/15
Do a Six Sigma project; Anesthesiologist	Process	New Six Sigma project	7/8
Part of Six Sigma project.	Holding area nurses have too many patients	Green Belt Lean Six Sigma	7/8
Nursing doing a lessons learned from busy season	No hospital room available to assign	Nursing	5/30
Included in board on door improvement above.	All cases start at same time		
Additional Sterile Processing Staff later. Down several positions, they are posted. Six Sigma project should address.	Cases run late at night, instruments go late and not available	Green Belt Lean Six Sigma Process	7/8
Look on tracker and call admitting to process patient right away. Send letter to physician offices to have their patient's here 2 hours prior to surgery time.	Patient not told correct time; patient late other reasons.	Physician office; patient late	4/30
Dashboard showing turnaround times, weekly or monthly.	Physician perception of turnaround time		5/15
Post fluff notices on the board if staff will commit to read it. Remove those from the meeting and focus on getting ready for the day.	Morning meeting: people coming in late	OR front desk	3/29
Use back table and then clean	Nothing to transport trash on	OR staff	4/30
5S organization	Not being able to find furniture; cleaning supplies available	5S	5/15
Reps should be instructed to only bring in what they need to the work area, coordinators should monitor.	Reps have laid out stuff on all surfaces	Coordinators	4/30
Front desk more pro-actively pulling and coordinating staff.	Lack of communication; not communicating with front desk	OR Front desk	4/30

Fig. 4.32 OR turnaround improvement ideas: low priority items

Instruments

- Implement instrument tracking to reduce missing and incomplete trays.
- Replace missing instruments to complete trays.

Metrics and Flow Control

- Implement process metrics and dashboards that track improvement in on-time starts, turnaround, and manages flow.
- Implement a flow control sheet to manage flow and ensure on-time starts.
- Implement surgeon and anesthesia dashboards to assess and control physician lateness.

Flow Control Board: A Major Breakthrough

The OR pilot progressed at a snail's pace for the first six months. We saw some improvement, mostly in fits and starts. We really struggled with buy-in and engagement at all levels and with all functions throughout the OR, including the OR staff, the anesthesiologists, and the surgeons. The general consensus in the OR was that we were trying to get everyone to work harder at the potential risk of patient safety. Whether this was a very gross misunderstanding perpetuated out of poor communication, lack of understanding of how Lean Six Sigma can help simultaneously with quality and service delivery, or whether it was just a smoke screen to divert the focus away from change, we weren't sure. We constantly had to reinforce and explain the value of the approach and the importance of the improvements. What finally enabled us to turn the corner and gain buy-in from the OR staff, the anesthesiologists and the surgeons was implementing the Flow Control Board.

It became painfully obvious that functional silos were alive and thriving in the OR. Each function, scrub tech, surgical nurse, inventory control, sterile processing, anesthesia, and surgeon, would perform their 'job' but had no way to communicate the status of their outcome. For example, identifying when the room is ready, the patient is ready, anesthesia has seen the patient, the surgeon has seen the patient, and the patient is ready to be wheeled in. There was also incredible fear of being blamed for the case starting late, so very few problems were recorded or surfaced. More often than not, even if there were a series of issues that could cause the case to be delayed, only the last delay would be recorded. This last delay was typically 'MD late,' since all of the other issues had been resolved as they waited for the surgeon. Why was the surgeon late? Because there was no predictability or communication that the OR team was close to starting on time. It was an impossible situation that was almost impossible to fix.

The Master Black Belt and the Black Belts came up with a solution that was seeded by the CEO. He had made the comment that what the OR needs is a 'traffic

OR FLOW BOARD

OR Room	Scheduled Start Time	Procedure	Surgeon	Preop Room	Readiness: Patient	Preop	Room	Anesthesia	Surgeon	Wheels In	Close	Wheels Out	Room Clean
1	8:00	Total Knee	PC	4	Y	Y	Y	Y	Y	N	N	N	N
2	7:30	Total Knee	JT	3	Y	N	N	Y	Y	N	N	N	N
3	7:30	Prostate	KF	6	Y	I	N	Y	Y	N	N	N	N
4	7:30	Excision	DF	5	Y	Y	Y	Y	Y	Y	N	N	N
5	7:00	Endoscope sinus	CC	2	Y	Y	Y	N	N	N	N	N	N
6	8:00	Repair hernia	AE	1	Y	Y	Y	N	N	N	N	N	N
7	8:00	Hysterectomy	DC	11	Y	Y	Y	Y	Y	Y	N	N	N
8	8:00	Excision	DW	7	N	I	Y	Y	Y	N	N	N	N
9	7:30	Replace Aortic	DJ	9	N	Y	Y	I	Y	N	N	N	N
10	7:30	Total Knee	EB	10	I	Y	Y	Y	Y	N	N	N	N
11	8:00	Total Hip	EB	12	Y	Y	Y	Y	Y	N	N	N	N
12	8:30	Total Knee	RL	8	Y	Y	Y	Y	Y	N	N	N	N
14	8:00	Total Hip	KB	14	Y	Y	Y	Y	Y	N	N	N	N
15	7:00	Hysterectomy	KD	15	Y	Y	Y	Y	Y	N	N	N	N
16	7:30	Hernia	KP	16	Y	I	Y	Y	Y	Y	N	N	N
17	8:00	Cerv Lami	RK	17	Y	N	N	Y	Y	N	N	N	N

Fig. 4.33 Flow control board

cop' to direct traffic. When he had been in the OR trying to fix the problems, he could apply pressure and direct traffic, and even show improvement, but as soon as he left, it went back to the same chaos.

We had been waiting for a large Information Technology (IT) project to progress that would implement an OR tracking board that would enable the following process steps to be tracked:

- Room ready
- Patient ready
- Anesthesia arrived
- Surgeon arrived.

When it became obvious that the IT solution was going to be very laborious and not very user-friendly, we realized that all we really needed was to have a simple shared Excel spreadsheet that allowed different people in the OR to notify everyone else that their 'job' was complete. The Chief of Anesthesia saw the value and required the anesthesiologists to notify everyone that they had arrived and saw the patient via the Flow Control Board. Prior to this milestone, there was no way to easily know if anesthesia had arrived or had seen the patient in Pre-op. This was a huge success, since anesthesia had been a very huge bottleneck up to this point in moving the patient to the ready state. The Flow Control Board is shown in Fig. 4.33. From the beginning of the project to about 1 year later, we had improved the on time starts for first cases by 8 %, from 11 to 19 %. Within one week of implementing the Flow Control Board, we further improved the on time starts for first cases by another 16 to 35 %.

Train and Execute

When we kicked off the new OR turnaround process, we showed the new OR film and made process checklists and the film available to all of the OR staff. The OR Manager ensured that the surgical coordinators understood the new process, and assessed their ability to perform the new process by direct observation. The surgical coordinators, then assessed the OR staff. Each responsible person was assessed through direct observation of them performing the OR turnaround process, and the competency assessment was added to their performance evaluation. Disciplinary action was also implemented if the new process and the 5S organization was not adhered to by each OR staff associate.

Control Phase

The purpose of the Control Phase is to implement control mechanisms and procedures to ensure that the process maintains the levels of improvement attained during the pilot activities.

The following activities were executed in the Control Phase:

1. Measure results and manage change
2. Report scorecard data and create process control plan
3. Identify replication opportunities
4. Develop future plans.

Measure Results and Manage Change

On-Time Starts

By the beginning of January 21st in year 3, we achieved improved on time starts, as follows:

- First Cases of Day On time starts from 11 to 35 % (24 %)

The *p*-value for the two-proportion test is 0.000, showing a significant improvement of 24 % in the percent of on-time starts for the first case of the day. The Minitab output for the two-proportion test to assess whether there was a statistically significant improvement in the on-time starts from 11 to 35 % follows:

Test and CI for Two Proportions

Sample	X	N	Sample p
1	201	1,824	0.110197
2	19	54	0.351852

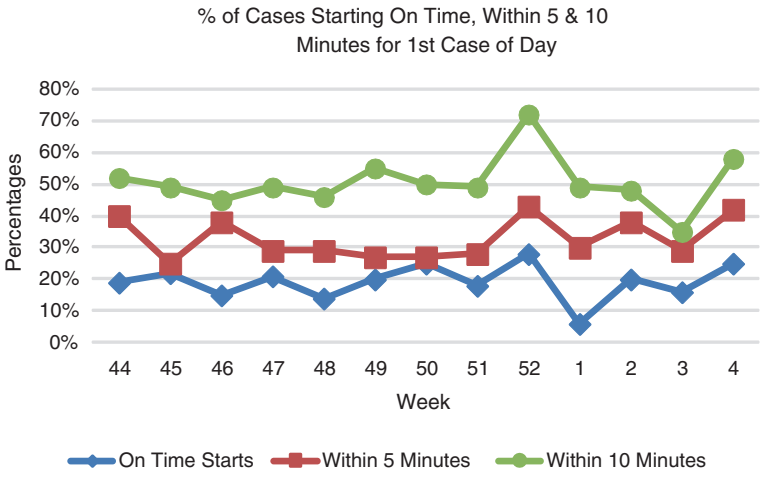

Fig. 4.34 Graph of on time starts, starts within 5 and 10 min

Difference = p (1) − p (2)
Estimate for difference: −0.241654
95 % CI for difference: (−0.369833, −0.113476)
Test for difference = 0 (vs. not = 0): Z = −3.70 p-value = 0.000
Fisher's exact test: p-value = 0.000

The percent of on time starts, starts within 5 and 10 minutes is shown for weeks 44 of year 2 through week 4 of year 3, in Fig. 4.34.

Turnaround Time

By the end of year 3, the Turnaround Time improved as follows:

- Mean: 40 to 34 minutes (15 % improvement)
- Standard Deviation: 20.4 to 14 minutes (34 % improvement)

Both the mean and variance showed a statistically significant improvement, with a *p*-value of 0.000 for the mean and a value of 0.001 for the variances. The Minitab output for the two sample *t*-test and the test of two variances follows:

Two-Sample T-Test and CI

Sample	N	Mean	St Dev	SE Mean
1	1,179	40.0	20.4	0.59
2	219	33.9	14.0	0.95

Difference = mu (1) − mu (2)
Estimate for difference: 6.10
95 % CI for difference: (3.90, 8.30)
T-Test of difference = 0 (vs. not =): T-value = 5.46 p-value = 0.000
DF = 412

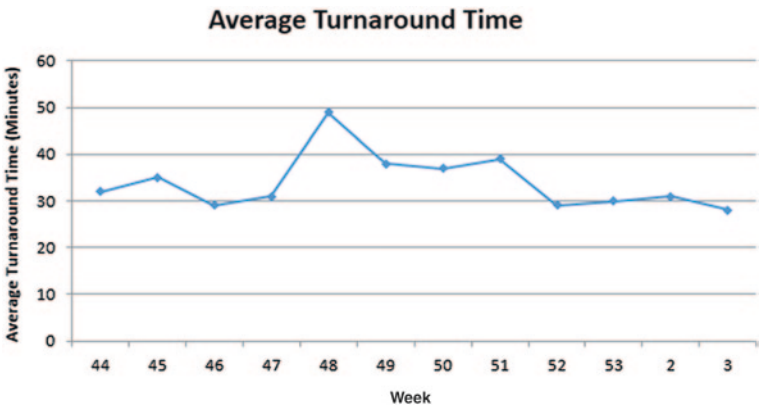

Fig. 4.35 Improvement of turnaround time

Procedure Type	Mean Turnaround Time	Standard Deviation		Improved Mean Turnaround Time	Improved Standard Deviation	% Improvement	Statistically Different? P-Value
Cardiac	34	20		35	6.5	-4%	No, .86
General	40	20		32	13.4	21%	Yes, 0.000
OBGYN	42	21		29	8.1	32%	Yes, 0.000
Neuro	50	17		45	14.4	9%	No, .294
Ortho	35	19		38	15.1	-8%	No, .132
Plastic	35	18		22	9.1	38%	Yes, .013
Urology	32	19		25	4.8	21%	Yes, .004
Vascular	47	25		34	15.6	28%	No, .304
Average Turnaround Time	40			34		16%	

Fig. 4.36 Improved turnaround time by procedure category

Test for Equal Variances

95 % Bonferroni confidence intervals for standard deviations

Sample	N	Lower	St Dev	Upper
1	1,179	4.31701	4.51664	4.73490
2	219	3.37803	3.74166	4.18929

F-Test (Normal Distribution)

Test statistic = 1.46, p-value = 0.001

The turnaround time from October 25th year 2 to January 11th year 3 is shown in Fig. 4.35.

The turnaround time for each procedure category before and after improvement is shown in Fig. 4.36. Plastic surgery had a 38 % improvement in Turnaround Time, OB/GYN had a 32 % improvement, General and Urology Surgery each had a 21 % improvement. The other specialty areas did not yet see a significant

improvement in the turnaround time. Although the difference in turnaround time for Vascular was 13 minutes with a 28 % difference, because of the small sample size and the large standard deviation, the difference was not statistically different. This demonstrates the importance of performing the hypothesis tests to assess whether the difference was statistically significant.

Change Management

The OR staff, surgeons, and anesthesiologists were at first extremely resistant to change, so we brought in an external consultant that was experienced in implementing process improvements and change. We also used the Dr. John Kotter change model (Kotter 2011) to implement the improvements.

(1) Acting with Urgency:
   a. We gained top management support and they visibly communicated this support for the project and emphasized the importance of the project to the organization.
(2) Develop the Guiding Coalition:
   a. We formed the project team and developed the scope of the project in the Define phase. Throughout the project we brought in subject matter experts who helped develop the new process and generate improvement ideas.
(3) Developing a Change Vision:
   a. We developed the new OR Turnaround process, creating a film, process work instructions and checklist.
   b. We developed the implementation plan and a detailed work plan to stage the improvements
(4) Communicate the Vision Buy-in:
   a. We communicated the changes at the new process rollout meeting, attended by the CEO, CNO, Master Black Belt and OR management. We communicate the changes and status of the improvement at the OR staff morning meetings and huddles.
   b. The OR surgical coordinators model the behavior of the new process, being assessed on the new process, and assessing the OR staff on the new process. The circulating nurses on each team ensure that the new process is followed.
(5) Empowering Broad-Based Action:
   a. We identified and removed obstacles to change. We implemented a suggestion system to get ideas from any and all of the OR staff. The project team evaluated these ideas and incorporated many of the ideas into the new process.
   b. We incorporated accountability to adhere to the new process.
(6) Generating Short Term Wins:

a. We implemented a reward system to provide rewards (meal tickets, cakes, etc.).
b. We communicated the wins and significant improvement to the OR staff and hospital administration.

(7) Do not Let Up:
a. We incorporated the new metrics dashboard into the daily huddles and morning meetings.
b. We incorporated the process competencies into the performance evaluation system.

(8) Make Change Stick:

a. We provided change management and Lean Six Sigma training to OR staff and management to ensure the succession of the change in thinking to a fact-based decision process and one of continuous improvement.

Report Scorecard Data and Create Process Control Plan

The control plan is a detailed guide for maintaining all of the positive changes that you have implemented, shown in Fig. 4.37. We developed a dashboard that will help us to ensure control. Additionally, the 5S sustainability will be discussed in the next chapter, that will help to maintain the gains for the OR organization of equipment, furniture, supplies, and OR turnaround cleaning and setup. The dashboard that we implemented is shown in Fig. 4.38.

Identify Replication Opportunities

The concepts and ideas of the 5S organization could be implemented throughout the hospital, and we will use the 5S changes as a guide for other departments.

We can also use the learnings from our change management approach to better implement change in other Lean Six Sigma projects and change initiatives within the hospital and within the hospital system.

We can also implement the concepts of standardized and repeatable processes documented at a work instruction level in almost every hospital process. We will communicate the success of this process to share the value of Lean Six Sigma in healthcare.

Develop Future Plans

The future plans are to implement the more complex changes in the OR related to the following areas, which are shown in Fig. 4.39.

OR Control Plan

Control Plan Activities	Frequency	Responsible	Accountable	Signature	Informed		Checklist
5S: OR Organization							
1) Sub-sterlies stocking	Daily	Tech 1s	Surgical Coordinator	Tech 1's: completed restock; Service Surg. Coord: Verified	Exec. Director		1) Sub-sterile Checklist
2) Equipment Rooms	Weekly	Equipment Coordinator	Front Desk Coordinator	Equipment Coordinator	Exec. Director		2) Equipment room checklist
3) Verify hallways, furniture, equipment, OR Bed, sub-sterlies, cabinets, leftover supplies in OR rooms for surgery or returned.	Daily, between Shifts (at 2:30 pm; and 10:30 to 11:00 pm; 6:30 am.	Surgical Charge Nurses of each shift	Exec. Director	Surgical Charge Nurse of each shift	Exec. Director		3) Shift Handoff Setup Checklist
4) 5S audit	Monthly	Surgical Coordinators	Exec. Director	Surgical Coordinators	Exec. Director		4) 5S Audit Checklist
Surgery Execution							
1) Coordinate first case of day: room ready, patient ready, Anesthesia here, Surgeon here; time wheeled in.	Daily for first case of day	Front Desk Coordinator	Nurse Manager	Front Desk Coordinator	Exec. Director		5) Flow Control Board
2) On Time Starts First case of Day	Daily for first case of day	Operational Performance Analyst (EPE Center)	Exec. Director	Exec. Director	CNO, CEO, Sr. VP HR, Chief OR Committeee, Chief Anesth.		6) OR Metrics
3) Turnaround Time	Monthly	Operational Performance Analyst (EPE Center)	Exec. Director	Exec. Director	CNO, CEO, Sr. VP HR, Chief OR Committeee, Chief Anesth.		6) OR Metrics
4) Number cases by service	Monthly	Exec. Director	Exec. Director	Exec. Director	CNO, CEO, Sr. VP HR, Chief OR Committeee, Chief Anesth.		7) Number Cases
5) Surgeon and Anesthesia Late Analysis	Monthly	Operational Performance Analyst (EPE Center)	Exec. Director	Exec. Director	CNO, CEO, Sr. VP HR, Chief OR Committeee, Chief Anesth.		8) Surgeon and Anesth. late analysis
Sterile Processing							
1) Tray Average Cycle Time	Weekly	SPD Manager	Exec. Director	SPD Manager	Exec. Director, CNO		IMPRESS Report
2) Number Wet Loads	Weekly	SPD Manager	Exec. Director	SPD Manager	Exec. Director, CNO		IMPRESS Report
3) Percent of missing trays	Weekly	SPD Manager	Exec. Director	SPD Manager	Exec. Director, CNO		IMPRESS Report
4) Percent of incomplete trays	Monthly	SPD Manager	Exec. Director	SPD Manager	Exec. Director, CNO		IMPRESS Report
5) Tray errors	Weekly	SPD Manager	Exec. Director	SPD Manager	Exec. Director, CNO		IMPRESS Report

R Responsible for performing the activity
A Accountable to whom "R" is accountable to; this person would own and approve the work activity
S Signature
I Informed, must be notified of results of the activity when completed but need not be consulted

Fig. 4.37 OR control plan

- *Outpatient Patient Readiness Six Sigma Project* Improve the patient pre-admission process to ensure charts are ready the day before.
- *OR Tracker* Implement an OR tracker, big board, to identify where the patient is in each step of the surgical process (Pre-op, surgery, recovery).
- *Supplies Inventory Control System* Implement inventory control, and supply process improvements.
- *Instrument Tracking Six Sigma Project* Implement instrument tray tracking.
- *Pre-op Inpatient Readiness* Improve inpatient readiness and hand-off to surgery.
- *Flow Control*—Implement a tool to ensure on-time starts to assess the following:
  - Patient Ready
  - Room Ready
  - Anesthesia Ready

Metric	Baseline	Improvement	% Improvement
% of On Time Starts	11%	35%	24%
% Starts within 10 minutes	47%	51%	4%
Average Turnaround Time	Mean = 40 SD = 20.4	Mean = 34 SD = 14	Mean: 15% SD: 34%

Fig. 4.38 OR turnaround and on time start scorecard

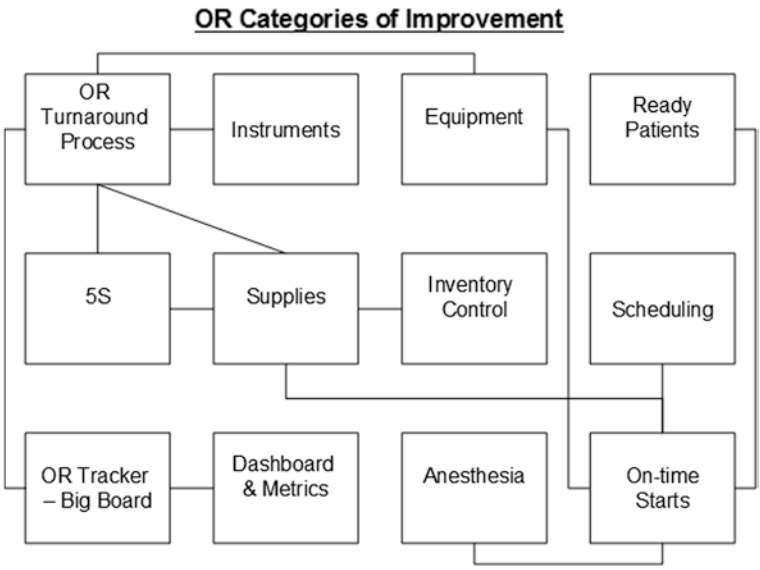

Fig. 4.39 Future OR plan categories

  - Surgeon Ready

- *Pre-op Readiness*
  - Analyzing coordinating who does what, in what order (Pre-op nurse, circulating nurse, surgeon, and anesthesia)
  - Visual control to assess status of each patient
  - Reducing labs, and tests to be done day of surgery
- *Same Day Case and Resource Planning* Reduce case time and room changes, and improve resource planning.
- *Preference Cards* Improving the accuracy and efficiency of the preference cards.

Summary and Project Critical Success Factors

This project was extremely successful, yet very difficult from a change management perspective. The OR staff was somewhat addicted to the natural chaos of their jobs, and believed that constant schedule changes, searching for instruments, equipment and supplies, putting out constant "fires," or issues with room turnarounds was just part of the job. It wasn't until we standardized the processes, put metrics in place, held people accountable to the metrics and change, and demonstrated the value of the new process and improvements that we achieved improvement.

The following key factors contributed to the success of this project:

- CEO commitment and support, visible communication of the organization-wide priority of this project.
- Following the Lean Six Sigma methodology to identify root causes, and identify improvements that engaged the OR staff to make suggestions and provide their input and feedback on the piloted improvements.
- Operationally defining the metrics, validating the measurement system and electronic data, and implementing the metrics dashboard that holds people accountable to these metrics.
- Using a formal change process, partially imbedded in the Lean Six Sigma methodology to make change happen.

Reference

Kotter J. P. (2011). *8 steps for leading change*. Kotter International. Retrieved from January 09, 2011 from http://www.kotterinternational.com/KotterPrinciples/ChangeSteps.aspx

Chapter 5
Applying 5S to Improve OR Organization

Abstract This chapter describes the project that was initiated with the OR Turnaround and On-time Case Starts project from Chap. 4. The need for this project became painfully obvious early in the OR turnaround project. When we first toured the OR to better understand the layout and processes, we saw the challenges the OR was facing with storage and management of the OR supplies, instruments, and equipment. The hallways were cluttered with supplies, both in storage from the vendor (vendor owned and managed), as well as storage that did not fit into the Core inventory storage area, and cases that are staged for the cases for the same day. There were also beds waiting for patients to come out of surgeries, and trash bags being staged while rooms are cleaned. These challenges resulted in the need for improving the OR location and organization of equipment, furniture, instruments, and supplies. Before pictures of the OR, prior to the start of the project are shown in Figs. 5.1 and 5.2. In Fig. 5.1, the OR case cart staging area is shown. One of the OR hallways is shown in Fig. 5.2. As is evident from the pictures, the areas lack organization, labeling, and visual control, so it is difficult to find desired supplies and equipment quickly.

The main Lean tool that was used in this project was 5S, which is a tool that helps to organize a work place. The 5S' are (Anything Lean 2013):

- *Sort* Clearly distinguishes between what is necessary and what is unnecessary, disposing of the unnecessary. A red tag is used to identify items that should be reviewed for disposal.
- *Straighten*(*Set in Order*) Organizes the necessary items so they can be used and returned easily.
- *Shine* Fixes the root cause of the dirt or disorganization.
- *Standardize* Maintains and improves the standards of the first three S'.
- *Sustain* Achieving the discipline or habit of properly maintaining the organization.

The Lean Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) problem solving methodology was used to guide the 5S activities.

S. L. Furterer, *Lean Six Sigma Case Studies in the Healthcare Enterprise*,
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Fig. 5.1 Before picture of OR case staging area

Fig. 5.2 Before picture of OR hallway

Define Phase

This project was initiated based on the need to organize the Operating Room (OR) to enable the OR staff to locate, store, and manage equipment, furniture, supplies, and instruments that are used on a daily basis for surgical cases.

Project Charter

Problem Statement There is no current standard organization being used in the OR areas to store equipment, furniture, supplies, and instruments. The current state of the OR areas lack of organization is causing inefficiencies within the OR processes.

Customer/Stakeholders The stakeholders of this project are the OR staff including nurses and technicians who provide OR patient care; OR physicians including surgeons, anaesthesiologists, and physician assistants who provide surgical care; Sterile Processing who clean, sterilize, sort, and store surgical instruments; Inventory and Materials Control personnel who store, pick, and manage supplies and instruments; Biomedical Engineering who maintains clinical equipment; Pre-op staff who care for patients prior to surgery; and Recovery room staff who care for patients after their surgery.

Goal of the Project Improved visibility of problem conditions, improved safety, reduced waste, improved morale, an increased sense of ownership of the workspace, improved productivity, improved quality, improve maintenance and shorter OR turnaround times. A new sense of discipline and order that carries over into all activities is a goal of the project.

Scope Statement The scope of the project includes implementing 5S in the OR Central Core, Operating Rooms, OR storage areas, Pre-op areas and Recovery Room, Sterile Processing area and remote storage areas on the second floor.

Critical to Satisfaction Available space; Time to find equipment, supplies, etc.; OR turnaround time; Reduce Preventive Maintenance (PM) time for OR Bio-med equipment.

The project champions are the Chief Executive Officer (CEO) and the Chief Nursing Officer (CNO).

The project charter is shown Fig. 5.3, Project Charter.

Stakeholder Analysis

The stakeholders of this project are the OR staff including nurses and technicians who provide OR patient care. They clean and setup the OR for surgical procedures. This stakeholder group also includes the Pre-operative and Recovery Room staff. The better organized the Pre-op, Recovery and OR areas are, the more efficient the processes can be to provide care to the OR patients. The OR physicians include surgeons, anaesthesiologists, and physician assistants who provide surgical care. They

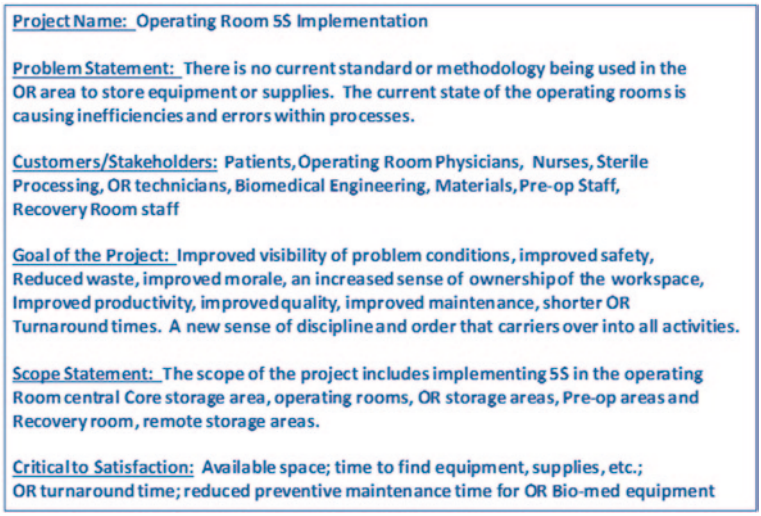

Fig. 5.3 5S project charter

have requirements for having all supplies, instruments, equipment, and furniture available when needed. Sterile Processing clean, sterilize, sort, and store surgical instruments. The Inventory and Materials Control personnel store, pick, replenish, and manage supplies. Biomedical Engineering maintains clinical equipment.

The stakeholder analysis is shown in Fig. 5.4.

Suppliers-Inputs-Processes-Outputs-Customers

The Suppliers-Inputs-Processes-Outputs-Customers (SIPOC) for the 5S is shown in Fig. 5.5. The five high level processes for the 5S activity are Sort, Straighten, Shine, Standardize, and Sustain. The sort activity includes sorting the various areas in the OR to remove unneeded furniture, equipment, instruments, and supplies. The Straighten activity encompasses defining standard setups for the OR, Core, and storage areas, so that each item has a home. Shine is the activity of cleaning the equipment and areas for storing the item while not being used. Standardize is the labeling and color coding of all items, so that it is visually easy to control and find items. Sustain is the activity that helps to maintain the organization and implement the discipline of organization. It includes identifying roles and responsibilities and auditing the level of cleanliness and organization in the OR.

The Critical to Satisfaction criteria for this project are:

- Available space- the space that is available and freed up due to better organization, and reduction of unneeded items.
- Time to find equipment, supplies, instruments, furniture.

Stakeholders	Who are they?	Potential Impact/Concerns	Responsibilities
OR Staff	▪ Nurses, techs that work in the Pre-op, OR and Recovery areas	▪ Readily available instruments, supplies and equipment ▪ Adequate workspace	▪ Classify equipment, furniture, instruments, supplies frequency of use ▪ Help to identify appropriate locations for instruments, supplies and equipment
OR Physicians	▪ OR physicians, anesthesiologist, physician assistants, who provide care to the patients in the OR	▪ On time starts ▪ Fast turnarounds	▪ Provide information to OR staff
Inventory and Material Control	▪ Associates who are in charge of the central core, OR supply inventory	▪ Adequate workspace ▪ Visibility of materials and inventory levels ▪ Standard location for materials	▪ Help to identify appropriate locations for supplies ▪ Continuously audit an sustain 5S in central core
Sterile Processing	▪ Associates that are in charge of OR instruments than need sterilizing	▪ Receive instruments in a timely manner ▪ Standard location for instruments ▪ Sterilization turnaround time	▪ Help to identify appropriate locations for instruments ▪ Continuously audit and sustain 5S
Biomedical Engineering	▪ Associates that are in charge of preventive and corrective maintenance of biomedical equipment	▪ Ease of finding equipment to perform preventive and corrective maintenance	▪ Deactivate assets found in sort phase ▪ Help to identify locations for equipment ▪ Continuously audit and sustain 5S

Fig. 5.4 Stakeholder analysis

- OR turnaround time- time to clean and setup the operating room for the next case.
- Reduced Preventive Maintenance time for OR Bio-med equipment, due to reducing the quantity of equipment, by eliminating unneeded equipment.

Project Kick off

The project was started in November 2009. We held a team kick off meeting to explain the project and identify the initial sorting activities as follows.

We mapped the DMAIC phases to the following 5S activities, as shown in Fig. 5.6.

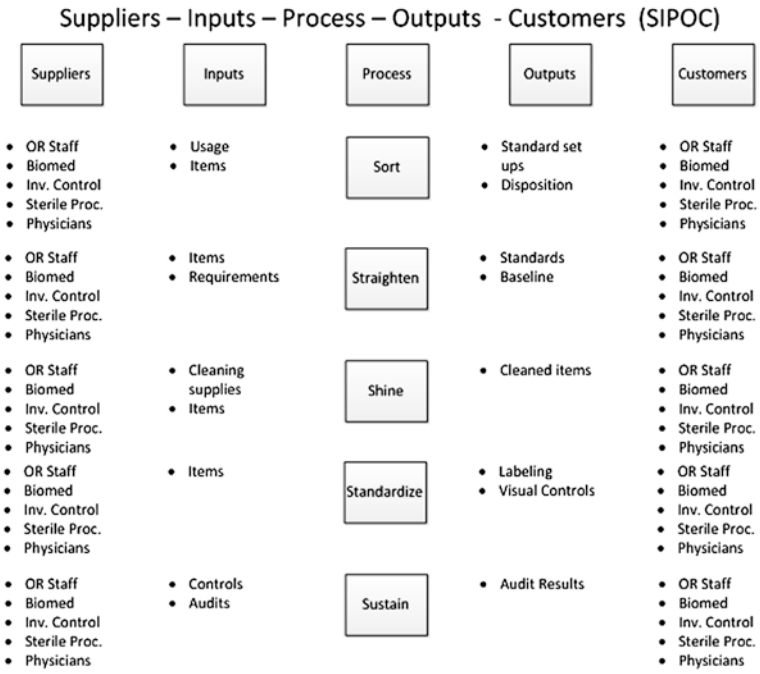

Fig. 5.5 SIPOC (suppliers-inputs-process-outputs-customers)

The define phase is important in defining a clear project scope, identifying the project stakeholders, and planning for the rest of the project. The Measure phase will be discussed in Measure Phase.

Measure Phase

The Measure Phase included the following Sort activities:

(1) Identify rooms and areas to be sorted.
(2) Identify roles and responsibilities of team members.
(3) Define time frames of sorting activities.
(4) Set up sorting area.
(5) Create OR room standard furniture and equipment set ups.
(6) Establish criteria for separating needed and unneeded items.
(7) Separate needed from unneeded items.
(8) Red tag unneeded hold items.
(9) Remove excess items from working areas.

We held a two-day sorting event of furniture and equipment. The team members used one of the OR rooms that was not in use for the two-day sorting event. They removed any furniture or equipment that was not a part of the standard OR

DMAIC Phase	5S Phase	5S Activities
Define		
Measure	Sort	1) Identify rooms and areas to be sorted. 2) Identify roles and responsibilities of team members 3) Define time frames of sorting activities 4) Set up sorting area. 5) Create OR room standard furniture and equipment set ups 6) Establish criteria for separating needed and unneeded items 7) Separate needed from unneeded items 8) Red tag unneeded hold items 9) Remove excess items from working areas
Analyze	Straighten	1) Decide where things belong 2) Decide how they will be put away 3) Make it as easy as possible to obey the put away rules 4) Color coding areas for supplies, type of equipment 5) Same category of equipment/supplies in close areas (unless posed safety issue) 6) All items that are used in conjunction placed close together 7) Outline aisles, places where items are kept 8) Standardize height, size of shelves if necessary
Analyze	Shine	1) Find root causes for things get disorganized 2) Find abnormalities 3) Engage Environmental Services and Engineering to repair root causes
Improve	Standardize	1) Create visual management so that abnormal state can be easily identified 2) Color coding and labeling, shadow boards, indicators of where things should be put
Control	Sustain	1) Create 5S committee 2) Create audit plan and schedule 3) Periodic spring cleaning schedule 4) Assess improvement

Fig. 5.6 DMAIC and 5S activities mapping

set up from each OR room. They also moved the equipment out of the equipment room and staged it in the sorting area. The surgical coordinators who are responsible for equipment and furniture went through the furniture and equipment in the staging area to identify the frequency of usage (daily, weekly, monthly, annually, or less than annually) and disposition of the furniture and equipment. If the usage was daily or weekly, the equipment or furniture was stored in the immediate OR area either in an OR as the standard set up, in the equipment room, or in another designated storage area. If the usage was monthly a storage area away from the OR was used. If the usage was annually or rarely, but the item was to be kept, it was stored in another area outside of the immediate OR area. The rest of the equipment and furniture was removed to a secondary staging area in the basement, so that all appropriate people could review whether they needed any of the items. Some of the outdated, unnecessary, broken, and not reparable equipment and furniture were discarded. The discarded equipment was removed from the equipment tracking system by Biomedical Engineering.

	Sort	Straighten	Shine	Standardize	Sustain
Level 5 **Focused on Prevention Measures**	Employees are continually seeking improvement opportunities.	A dependable, documented method has been developed to provide continual evaluation and a process is in place to implement improvements.	Area employees have devised a dependable, documented method of preventive cleaning and maintenance.	Every team member is continually seeking the elimination of waste with changes being documented and information being shared.	A general appearance of a confident understanding and adherence to the 5S principles is maintained. A culture of cleanliness and orderliness is expected of all.
Level 4 **Focused on Consistency**	A dependable, documented method has been established to keep the work area free of unnecessary items. "Red tag" area is being utilized.	A dependable, documented method has been established to recognize in a visual sweep if items are out of place or exceed quantity limits.	5S individual assignments are agreed upon or 5S is practiced by all consistently.	Standard Work is consistently followed by all team members. Areas consistently follow 5S standards.	All team members are actively engaged in driving continuous improvement in 5S scores. Scorecards are posted.
Level 3 **Making it Visual**	Unnecessary items have been removed from the workplace. "Red tag" area is well identified.	Designated locations are marked to make organization visible. Visuals (tape, paint) are in good shape.	Work and break areas have been cleaned on a daily basis and visual controls have been established for key items. Floors are clean.	Visual controls and Standard Work is in place and proven out.	Weekly 5S reviews are being conducted by the Manager and or others. Feedback is being acted upon.
Level 2 **Focus on the Basics**	Yes Necessary and unnecessary items have been separated.	Designated locations have been established for items.	Yes Work and break areas are clean and key items to check have been identified.	Yes Methods are being improved and practiced continually, but haven't been documented.	A recognizable effort has been made to improve the condition of the workplace.
Level 1 **Just Beginning**	Necessary and unnecessary items are mixed throughout the workplace.	Yes Items are randomly located throughout the workplace.	The work place is dirty, disorganized, and key items are not marked or are not identified.	Work place improvement methods are not consistently followed and/or are undocumented.	Yes Work place checks are randomly performed and or there is no visual measurement of 5S performance.
Score	2 Partially Complete	1 Incomplete	2 Partially Complete	2 Partially Complete	1 Incomplete

Fig. 5.7 Baseline 5S audit

A similar sorting activity was performed in the Pre-Op and Post-Op areas, as well as the Sterile Processing areas.

The team assessed the baseline 5S audit. The audit criteria are shown in Fig. 5.7. The baseline audit was 1.6. From a Sort perspective, the team has sorted necessary and unnecessary items. From a Straighten perspective, items are still randomly located throughout the workplace. From a Shine perspective, the work and break areas are clean and key items to check have been identified. From a Standardize perspective, methods are being improved and practiced continually, but have not been documented. From a Sustain perspective, work place checks are randomly performed and/or there is no visual measurement of 5S performance.

Analyze Phase

In the Analyze phase, we performed the following Straighten and Shine activities:

Straighten:

(1) Decide where things belong.
(2) Decide how they will be put away.
(3) Make it as easy as possible to obey the put away rules.
(4) Color coding areas for supplies, type of equipment.
(5) Same category of equipment/supplies in close areas (unless poses safety issue).
(6) All items that are used in conjunction placed close together.

(7) Outline aisles, places where items are kept.
(8) Standardize height, size of shelves, if necessary.

Shine:

(1) Find root causes for things to get disorganized.
(2) Find abnormalities.
(3) Engage Environmental Services and Engineering to repair root causes.

Straighten:

We identified locations for patient transport beds, case carts, equipment, furniture, supplies, and instrument trays in the OR space. We worked with the vendors to remove unneeded items from the OR space. We painted the equipment and furniture to be color coded for each OR room, and put a color-coded label on each OR door, so it is obvious if the wrong furniture and equipment are in a room. We worked to remove all unnecessary equipment, supplies, furniture, and instrument trays from the OR space, and only store what is used on a daily or weekly basis in the OR Core and surrounding areas. We standardized the OR case cart as much as possible, identifying what types of items are placed in which location on the cart, as well as where the cart will be stored. We also better labeled the OR case carts, so they could be more easily found when needed.

Shine:

We identified root causes of disorganization in the OR space, as shown in Fig. 5.8.

(1) No standard process for identifying frequency of use of equipment, supplies, instruments, and furniture.
(2) No methodology for storing items, identifying where they belong, or assigning responsibility for ownership and organization.
(3) No process for identifying what is needed in the OR space, and what is not needed.
(4) Lack of buy-in and commitment from the OR staff and management for implementing the 5S.
(5) No defined locations for the patient transport beds outside of the OR.
(6) No process for vendors to only bring what they need for a case each day, allowing vendors to store several days (weeks) worth of supplies in the OR space.
(7) Some consignment implants were recently purchased by the hospital, but no usage and frequency analysis of the supplies was performed.
(8) No standardized terminal cleaning schedule.
(9) Not placing trash in receptacles during surgical cases.
(10) Equipment and furniture not returned to rooms where they belong and are used.
(11) No process for returning unused supplies to the Core, and restocking them.
(12) Cleaning supplies not available.
(13) No set case cart organization.
(14) No standard set up for OR back tables.

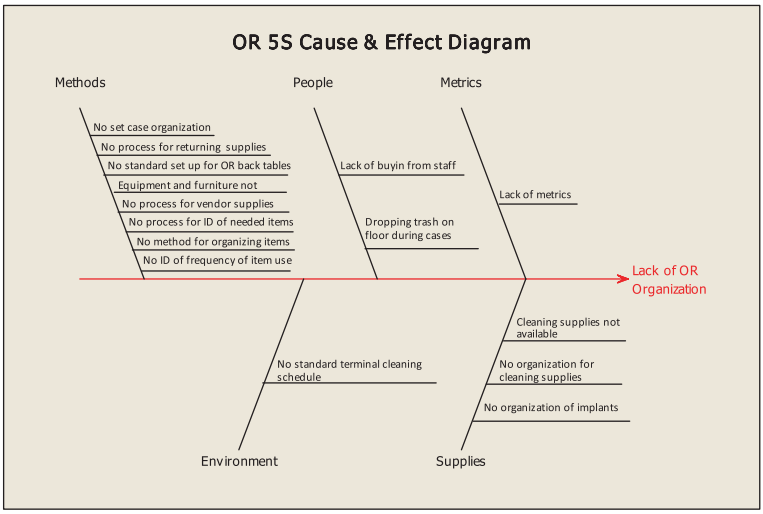

Fig. 5.8 Cause and effect diagram

(15) Cleaning supplies are not available because no set place is identified, and not enough cleaning supplies are available for each room.
(16) No 5S metrics have been implemented.

We identified any areas that needed to be repaired or cleaned.
We then moved into the Improve Phase.

Improve Phase

We performed the following Standardize 5S activities during the Improve phase:

(1) Create visual management so that the abnormal state can be easily identified.
(2) Color coding and labeling, shadow boards, indicators of where things should be put.

We created ideas for improving the organization of equipment, instrument trays, supplies, and furniture as follows:

5S Ideas for Improvement:

- Create schedule for cleaning patient bathrooms during busy times. (10 to 11 am)—Holding area.
- Have Environmental Services garbage and linen bins in PACU, during the day. (3 pm).
- Keep same bear warmer blanket used in Pre-Op (not soiled).
- Get rid of blanket warmer (Pre-Op), move linen cart so it does not block hallway
- Get folders for staff—get rid of big cabinet (PACU).

- Find a home for the X-ray machine.
- Get rid of the forms cabinet in Pre-op area, put up on wall.
- Get IVs in a dispensing unit.
- Fix isolation room.
- Get rid of cabinets, sink in clean utility room.
- Get pedestal sink in Pre-op holding, get rid of cabinets.
- Get new, standardized, rolling chairs for PACU and holding, need to be able to be moved higher or lower. (like golden ones in Phase 2).
- Visitor chairs that do not get stained, no wheels, not arm chairs.
- Skinny garbage cans at Pre-op at bedside.
- IV Poles too tall, need to be mobile.
- Pre-op needs IVs for all rooms.
- Holding area has no med room.
- Go through the soiled utility closet, get rid of things that are not needed. (split up the room)—only need sink and hopper. (make med room for Pre-op).
- Ask to have an environmental person dedicated.
- Do we need the suction machine?—Can respiratory maintain them?
- Breathing bags identification.
- Pre-op to have wipes to wipe off at the end of the day. In the basket, wipe down cables.
- Standardize tables, with wheels that roll, uniform Pre-op to Post-op.
- Clean out PED room area in Post-op.
- Put pull out tables on the walls in Pre-op, get rid of rolling tables.
- Convert storage area in Pre-op to nurses station and nurses station into med room—put blankets inside.
- Create cubbies/get shelving for SCD machines.
- Get rid of sink in isolation room.
- Need a patient going home chair.
- Reduce number of soiled linen and garbage cans.
- Identify standardized patient transport beds; bring beds closer to when the case is complete.

Another organization activity was done in the Substerile storage rooms. These are very small rooms right between two OR suites, where substerile items are stored. These are the rooms where people enter after they are scrubbed to go into the OR. Since they are very small spaces, and must be kept clear for the surgical teams to constantly walk through, these areas are important to organize. Before we organized these rooms, no one was responsible for restocking the rooms. The analyst created checklists for each substerile room, with par levels for restocking. He then redesigned the rooms with consistent bins and created markings for par levels.

Another activity was to organize the cabinets in the OR. The team plans to organize and assign ownership for restocking the OR cabinets on a daily basis.

Control Phase

We performed the following Sustain 5S activities in the Control phase:

(1) Create 5S committee.
(2) Create Audit Control Plan and Schedule.
(3) Periodic spring cleaning schedule.
(4) Assess improvement.

Create 5S Committee

We used the same OR Turnaround Process Improvement team as the 5S committee. This included team members from the OR, Sterile Processing, Pre-op, PACU, Anesthesia, and Enterprise Performance Excellence.

Create Audit Control Plan and Schedule

We developed the audit control plan, shown in Fig. 5.9. The 5S control plan includes a substerile checklist. The substerile instructions and checklist are shown in Figs. 5.10 and 5.11, respectively. The substerile checklist is to be completed by the Tech 1s on a daily basis after they have restocked their assigned substerile rooms. The equipment room checklist is shown in Fig. 5.12. The equipment room should be reviewed and the checklist should be completed by the equipment tech on a weekly basis. The shift handoff setup checklist is shown in Fig. 5.13. It is reviewed and completed at shift handoff by both surgical coordinators between each of the shifts.

5S Audit Control Plan

Control Plan Activities	Frequency	Responsible	Accountable	Signature	Informed		Checklist
5S: OR Organization							
1) Sub-steriles stocking	Daily	Tech 1s	Surgical Coordinator	Tech 1's: completed restock; Service Surg. Coord: Verified	Exec. Director		1) Sub-sterile Checklist
2) Equipment Rooms	Weekly	Equipment Coordinator	Front Desk Coordinator	Equipment Coordinator	Exec. Director		2) Equipment room checklist
3) Verify hallways, furniture, equipment, OR Bed, sub-steriles, cabinets, leftover supplies in OR rooms for surgery or returned.	Daily, between Shifts (at 2:30 pm; and 10:30 to 11:00 pm; 6:30 am.	Surgical Charge Nurses of each shift	Exec. Director	Surgical Charge Nurse of each shift	Exec. Director		3) Shift Handoff Setup Checklist
4) 5S audit	Monthly	Surgical Coordinators	Exec. Director	Surgical Coordinators	Exec. Director		4) 5S Audit Checklist

R Responsible for performing the activity
A Accountable to whom "R" is accountable to; this person would own and approve the work activity
S Signature
I Informed, must be notified of results of the activity when completed but need not be consulted

Fig. 5.9 Audit control plan

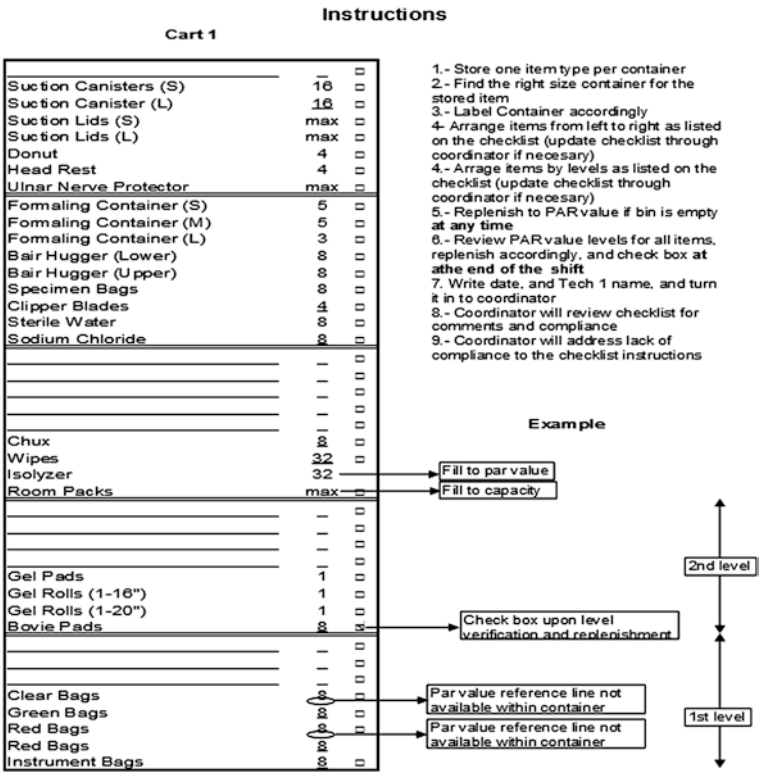

Fig. 5.10 Substerile checklist instructions

It is used to verify the organization of the hallways, furniture, equipment, beds, substeriles, and the leftover supplies are restocked. The 5S audit checklist is shown in Fig. 5.14. It is used to assess the overall progress of the 5S program.

Periodic Spring Cleaning Schedule

The next step in the Sustain phase is to set up a periodic spring cleaning schedule, to continue the removal of unneeded equipment, and furniture.

Assess Improvement

We used the 5S audit checklist to assess improvement of the 5S program. The original 5S Audit checklist is shown in Fig. 5.7. There were three 2s and two 1s. For the improved checklist, shown in Fig. 5.15, there are now three 3s and two

OR 17 (Substerile 1)

Cart 1			Cart 2		
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
Sterile Water	8	☐		_	☐
Sodium Chloride	8	☐	Pillows	2	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
Wipes	32	☐		_	☐
Bair Hugger (Upper)	4	☐		_	☐
Bair Hugger (Lower)	4	☐	Suction Lids (S)	max	☐
Chux	8	☐	Suction Lids (L)	max	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
Bovie Pads	8	☐		_	☐
Specimen Bags	8	☐		_	☐
Cliper Blades	4	☐		_	☐
Formalin Container (S)	5	☐		_	☐
Formalin Container (M)	5	☐	Donuts	2	☐
Formalin Container (L)	3	☐	Head Rest	2	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
Instrument Bags	8	☐	Repair Tags	8	☐
Isolyzer	32	☐	Bed Straps	_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
	_	☐		_	☐
Blue Bags	8	☐		_	☐
Red Bags	8	☐		_	☐
Clear Bags	8	☐	Suction Canister (S)	16	☐
Green Bags	8	☐	Suction Canister (L)	16	☐

Fig. 5.11 Substerile checklist

2s. Even though this showed improvement, there is still additional discipline and control that needs to be enhanced.

We eliminated nearly 400 square feet of outdated and unneeded equipment. We organized the OR hallways, so it looks better, and is easier to navigate the patients on beds to the OR. Figure 5.15 shows one of the OR hallways after improvement. Figure 5.16 shows the OR color schemes for each room. We painted the equipment and furniture, so that it is easy to return back to the correct OR when it is moved. Figure 5.17 shows the equipment room before the 5S, where it was nearly impossible to maneuver, and equipment had to be removed to get to other equipment. Figure 5.18 shows the equipment room after removing the unneeded equipment and defining a place for each piece of equipment. There is now space to walk between equipment and retrieve the needed equipment. The OR case cart storage area, before and after is shown in Figs. 5.19 and 5.20. There is also another equipment storage room further from the OR that stores equipment that is used less

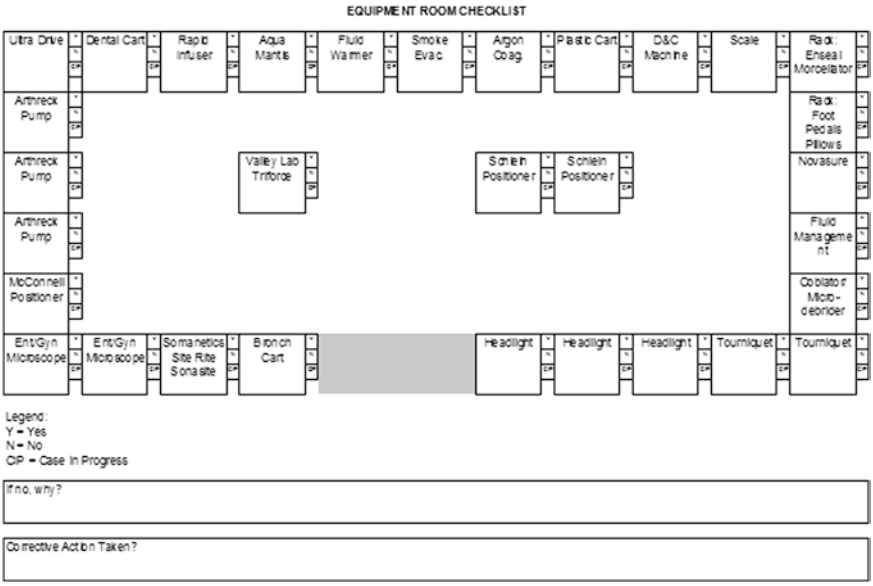

Fig. 5.12 Equipment room checklist

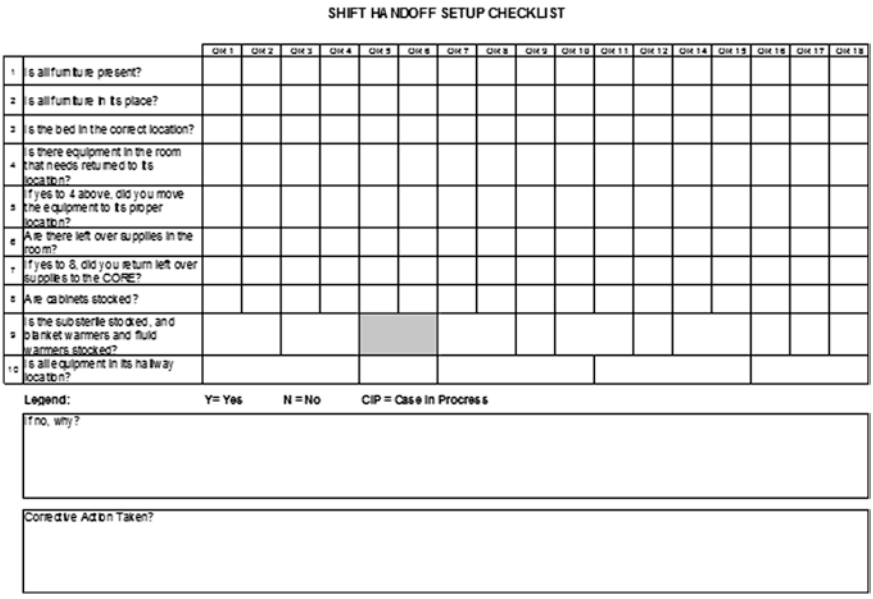

Fig. 5.13 Shift handoff setup checklist

	Sort	Straighten	Shine	Standardize	Sustain
Level 5 **Focused on Prevention Measures**	Employees are continually seeking improvement opportunities.	A dependable, documented method has been developed to provide continual evaluation and a process is in place to implement improvements.	Area employees have devised a dependable, documented method of preventive cleaning and maintenance.	Every team member is continually seeking the elimination of waste with changes being documented and information being shared.	A general appearance of a confident understanding and adherence to the 5S principles is maintained. A culture of cleanliness and orderliness is expected of all.
Level 4 **Focused on Consistency**	A dependable, documented method has been established to keep the work area free of unnecessary items. "Red tag" area is being utilized.	A dependable, documented method has been established to recognize in a visual sweep if items are out of place or exceed quantity limits.	5S individual assignments are agreed upon or 5S is practiced by all consistently.	Standard Work is consistently followed by all team members. Areas consistently follow 5S standards.	All team members are actively engaged in driving continuous improvement in 5S scores. Scorecards are posted.
Level 3 **Making it Visual**	Yes Unnecessary items have been removed from the workplace. "Red tag" area is well identified.	Yes Designated locations are marked to make organization visible. Visuals (tape, paint) are in good shape.	Work and break areas have been cleaned on a daily basis and visual controls have been established for key items. Floors are clean.	Yes Visual controls and Standard Work is in place and proven out.	Weekly 5S reviews are being conducted by the Manager and or others. Feedback is being acted upon.
Level 2 **Focus on the Basics**	Necessary and unnecessary items have been separated.	Designated locations have been established for items.	Yes Work and break areas are clean and key items to check have been identified.	Methods are being improved and practiced continually, but haven't been documented.	Yes A recognizable effort has been made to improve the condition of the workplace.
Level 1 **Just Beginning**	Necessary and unnecessary items are mixed throughout the workplace.	Items are randomly located throughout the workplace.	The work place is dirty, disorganized, and key items are not marked or are not identified.	Work place improvement methods are not consistently followed and/or are undocumented.	Work place checks are randomly performed and or there is no visual measurement of 5S performance.
Score	3 Partially Complete	3 Partially Complete	2 Partially Complete	3 Partially Complete	2 Partially Complete

Fig. 5.14 Audit checklist improved

Fig. 5.15 After pictures—OR hallway

Operating Room	Color Scheme
1	Green and Orange
2	Orange
3	Orange & Blue
4	Green
5	Yellow
6	Green & Blue
7	Blue
8	Blue & Pink
9	Blue & White
10	Pink
11	Purple & White
12	Red
14	Red & White
15	White
16	Purple & Orange
17	Purple & Green
18	Purple

Fig. 5.16 Operating rooms color schemes

Fig. 5.17 Equipment room before

frequently. This room was packed wall to wall, as shown in Fig. 5.21 before, but improved immensely as shown in Fig. 5.22. Figures 5.23 and 5.24 show the sub-sterile room before and after it was reorganized. The 5S Audit ratings before and after the 5S is shown in Fig. 5.25.

Fig. 5.18 Equipment room after

Fig. 5.19 Case cart store before

Fig. 5.20 Additional storage after

Fig. 5.21 Additional storage before

Fig. 5.22 Additional storage after

Fig. 5.23 Substerile before

Fig. 5.24 Substerile after

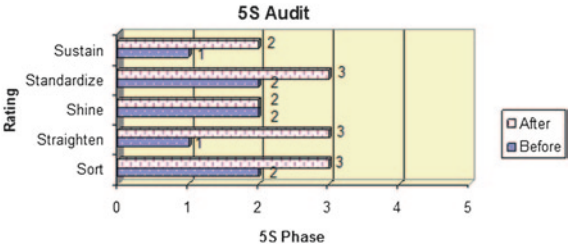

Fig. 5.25 5S audit rating before and after

Conclusions

The 5S project was very successful in organizing the OR. It was critical to remove equipment and furniture that was not used from the OR hallways and storage rooms. This enables the OR to be able to function at a higher level of efficiency and orderliness that is expected in an OR environment. It is now easier to clean and keep the OR clean, which is vital in the OR.

Reference

Anything Lean, (2013). 5S housekeeping. http://www.5sleanmanufacturing.com/5s_Housekeeping_s/232.htm

Chapter 6
Leaning the Surgical Outpatient Screening Process in an Acute Care Hospital

Abstract Elective surgery is a surgery that is a planned, nonemergency surgery, that can be scheduled at the convenience of the patient or the physician. The surgical procedure may extend life or improve the quality of life. In the year 2000, there were over 40 million inpatient surgical procedures performed in the United States, and 31.5 ambulatory or outpatient surgeries in 1996, based on the National Center for Health Statistics of the U.S Centers for Disease Control CDC (www.healthtools.com 2012). Typically a complete health history, physical examination, lab and diagnostic tests may be part of the preparation of the surgical patient prior to the elective surgery. Additionally, typing and screening of the patient's blood is also performed prior to surgery (www.healthtools.com 2012). A percentage of the patients who receive the elective surgery, may already be a patient in the hospital, and this preparation for surgery is performed under the guidance of the inpatient nurse. A patient that is not already in the hospital, but has scheduled their elective surgery is considered an outpatient from the perspective of the surgical preparation, even though the patient may be admitted after the surgery. This case will describe how the Lean Six Sigma team at an acute care hospital improved the pre-screening process for surgical outpatients applying Lean tools, with the Six Sigma DMAIC problem solving approach.

Define Phase

The project was initiated as part of the operating room project to improve the efficiency while ensuring patient care and safety of the operating room processes. The focus of this project was on streamlining the surgical outpatient preparation activities prior to their scheduled elective surgery. It is actually a consolidation of several similar case studies across several hospitals.

The surgical patient prescreening process was not providing the charts to the Operating Room in a timely, or high quality manner. The complete patient Prescreening information is often not available when the charts are sent to the Operating Room by 5 pm the day before the scheduled case. The staff is often working on the charts the same day that they are due

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to the OR, but are not able to complete all of them prior to the deadline. The patient presurgical documentation is usually faxed to the prescreening department, and comes in as separate documents, sometimes without the patient's name and date of birth on each page of the document, as required. The prescreening process requires extensive rework, including calling the surgeons' offices multiple times to get the required information. Since the primary care physicians provide the medical clearance and the history and physical, the surgeon's office must make multiple phone calls to the primary care physicians' offices. The prescreening department makes appointments with the patients for them to be interviewed to collect Prescreening information, such as lists of medications that the patient is taking, health and physical information, etc. The patients sometimes come to the hospital on average three times to complete all appropriate diagnostic tests, prescreening interviews and educational seminars to prepare for surgery. The percent of charts that are complete by 5 pm for the first cases of the day is 23 %. The percent of charts that are complete by 5 pm for all cases that are scheduled for the next day is not currently measured.

The following steps were executed in the Define Phase:

1. Develop project charter
2. Perform stakeholder analysis
3. Perform initial Voice of Customer (VOC) and Identify Critical to Satisfaction (CTS)
4. Select team and launch the project
5. Create project plan.

Develop Project Charter

The team generated the initial draft of the project charter in the first team meeting. The project charter is shown in Fig. 6.1, Project Charter.

Project Charter

This project is focused on streamlining the outpatient surgery pre-screening processes prior to the day of surgery. This includes gathering all of the appropriate documentation, interviewing the patient to collect additional information by a prescreening nurse, entering the data in an electronic medical record, and organizing the documentation into a chart.

The goal of the project is to assess the current outpatient prescreening area processes to identify inefficiencies and improvement recommendations to lead to throughput improvement from the Prescreening area to the surgical suite for the day of surgery.

The scope of the project includes an assessment of the Outpatient Prescreening area, and a process design with improvement recommendations. The project benefits of this project are to identify process inefficiencies and improvement recommendations that can reduce the delays in the Prescreening area on the day of surgery, enhance the throughput of the Operating Room Prescreening area, and

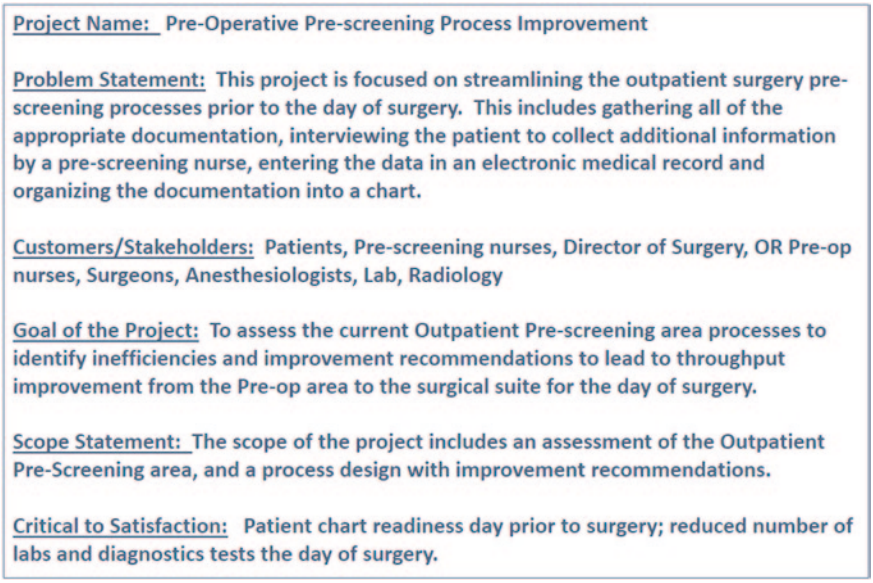

Fig. 6.1 Project charter

reduce unplanned cancellations of surgeries, due to the patient's prescreening not being ready. The CTS criteria are: patient chart readiness the day prior to surgery, reduced number of labs and diagnostic tests on the day of surgery, and reduced number of surgery cancellations due to the patient's chart not being complete.

Perform Stakeholder Analysis

The stakeholders are the Patients, Prescreening nurses, Director of Surgery, OR Prescreening nurses, surgeons, anaesthesiologists, lab, and radiology. The patients who have surgery are concerned that they are prepared for surgery, and do not have to come to the hospital several times to perform assessments and tests. The prescreening nurses review the patients' charts, physician orders, perform assessments and document information in the patient charts and the medical information system. They are concerned with not receiving the physician orders and information from the physicians' offices timely to ensure the prescreening of the chart and patient is complete. They are also concerned about having to work overtime to complete the charts and negatively impacting their productivity metrics. The Director of Surgery who manages the surgical department is concerned that the patients are ready for surgery, that the department meets their productivity goals, that there are reduced labs and diagnostic tests that need to be performed the day of surgery, and that the number of cancellations are reduced due to the patient not being properly prepared and screened for their surgery. The OR Prescreening nurses prepare the patients for surgery the day of surgery. They are concerned with having the patient charts ready when the patients arrive in Prescreening

Stakeholders	Who They Are?	Potential Impacts/ Concerns
Patients	Patients who have surgery	Prepared for surgery. Reducing number of times called and having to come to hospital for pre-screening activities.
Pre-screening nurses	Nurses who pre-screen the patients prior to surgery	Not receiving orders and information from surgeons' office timely. Needing to work overtime to complete charts that negatively impacts productivity
Director of surgery	Manage the surgical department	Patients ready for surgery. Meeting productivity goals. Reduced labs and diagnostics day of surgery. Reduced surgery cancellations due to pre-screening not complete.
OR Pre-op nurses	Prepare patients for surgery day of surgery	Having charts ready when the patients arrive in pre-op the day of surgery. Knowing what tests and assessments still needs to be performed the day of surgery.
Surgeons	Perform surgery	On time starts, no delays.
Anesthesiologists	Assess the patient pre-surgery	Ensuring the patient and/or chart has been screened by anesthesia prior to surgery.
Lab	Provide lab specimens and tests for pre-surgery readiness	Needing to provide staff to collect and perform labs day of surgery, instead of ensuring labs are complete.
Radiology	Provide radiology diagnostics tests for pre-surgery readiness	Needing to provide staff to perform radiology tests on the day of surgery, instead of ensuring tests are complete.

Fig. 6.2 Stakeholder analysis

the day of surgery. They also want to readily know what tests and assessment still need to be performed the day of surgery. The surgeons who perform the surgeries want to ensure that the scheduled surgery starts on time with no delays. The anaesthesiologists assess the patients presurgery, and are concerned about ensuring that the patient and the chart has been screened by anaesthesia prior to surgery. The Lab provides lab specimens and tests for presurgery readiness. They are concerned about needing to provide staff to collect and perform labs the day of surgery, instead of ensuring that the labs are complete. The Radiology department provides radiology diagnostic tests readiness and is concerned about needing to provide staff to perform tests on the day of surgery. The stakeholder analysis is shown in Fig. 6.2.

SIPOC (Suppliers-Inputs-Processes-Outputs-Customers)

The SIPOC is used to ensure the scope of the project is well understood, shown in Fig. 6.3. It is also a check and balance for the customer and stakeholder analysis. Any customers and suppliers should also be identified as a project stakeholder. The prescreening secretary reviews the surgery schedule in the OR information system and provides it to the prescreening department. The prescreening secretary puts the standard blank forms into patient charts for the patients scheduled for surgery and provides them to the prescreening nurses. The prescreening nurses assign the charts to prescreening nurses. The prescreening nurses match the required documents

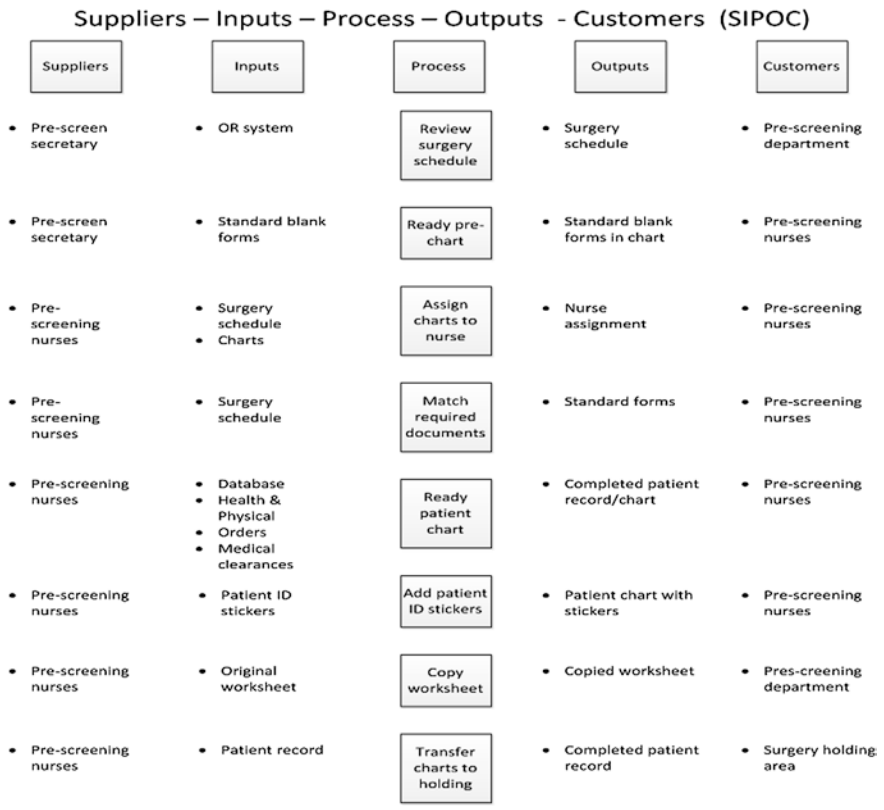

Fig. 6.3 SIPOC

according to the surgery type. The prescreening nurses perform the prescreening activities with the patient, documenting the health and physical, reviewing lab and test results, and ready the patient chart. The prescreening nurses place the patient ID stickers on each page of the patient's chart. The prescreening nurse copies the worksheet with the key patient information, and provides the charts to the OR surgical holding area by 5 pm the day prior to the scheduled surgeries.

Perform Initial Voice of Customer and Identify Critical to Satisfaction

The CTS Criteria for this project are:

1. Patient chart readiness the day prior to surgery.
2. Reduced number of labs and diagnostics tests on the day of surgery.
3. Reduction in number of cancellations due to the patient's prescreening not being complete.

Select Team and Launch the Project

The cross-functional team was identified and formed. The following areas were included as team members:

- Director of Surgery
- Director of Anesthesia
- Manager of Prescreening department
- Prescreening nurses
- Holding area nurses
- Lab
- Radiology.

Create Project Plan

The project was started April 14 and the Define phase was completed by May 15. The Measure phase was completed June 16. The Analyze phase was completed July 30. The Improve phase was completed in October and the Control phase was completed on July 17.

Measure Phase

The Measure Phase included the following activities:

1. Define the current process
2. Define detailed Voice of Customer (VOC)
3. Define the Voice of Process (VOP) and current performance
4. Validate measurement system

Define the Current Process

Value Stream Map

The value stream map provides a systems view of the departments and functions involved in preparing the patient for surgery. It shows the requirements for each function, the delays, wastes and opportunities for improvement in the value stream. It helps us to understand where the departmental silos exist and where we optimize processes in some departments at the price of suboptimizing the flow of the entire value stream. Admitting/registration recently made some process changes that optimized the use of the admissions staff, but negatively impacted the processes in the preadmitting area. By understanding the process from the start

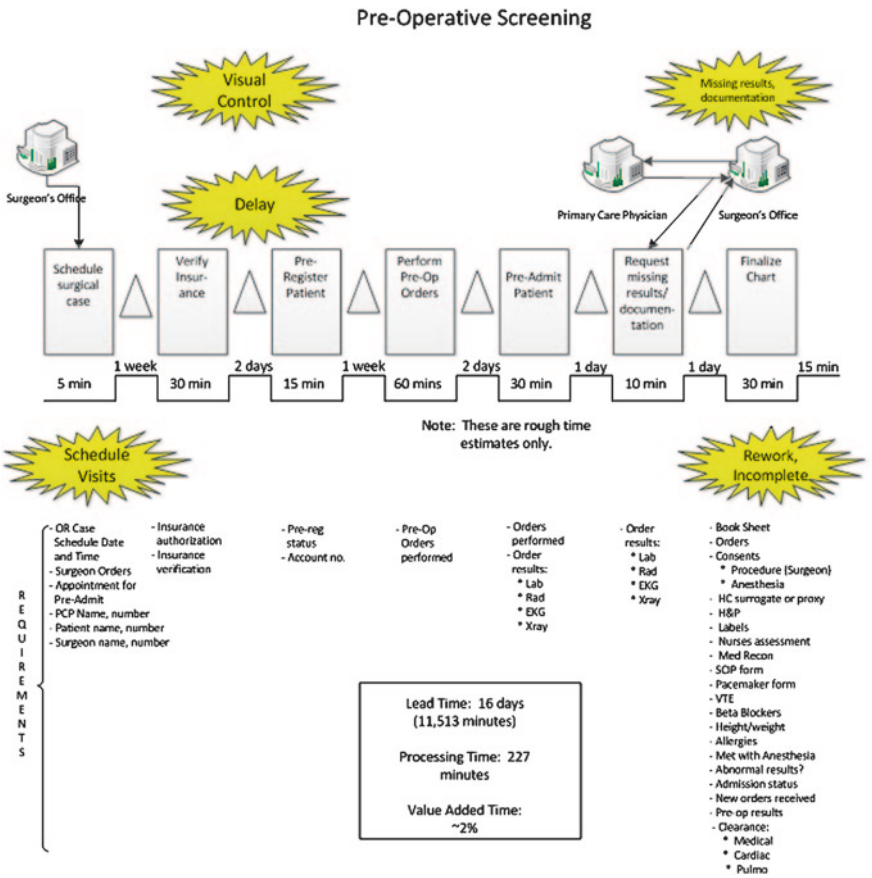

Fig. 6.4 Value stream: preoperative screening

to the end and the hand-offs between each function, we can better streamline the entire process that the patient is experiencing.

We have also provided a rough estimate of the lead time in the process compared to the value added processing time. The lead time includes the wait time and delays between the functions. The processing time is the value added time that is achieving the goals of the value stream, to ready the patient for surgery. In most value streams, there is typically only 2–5 % of the time spent in value added processing time, versus 95–98 % of the time spent in delays, wasteful, non-value added activities. In our estimated value stream lead time compared to process time, we found a 2 % value added time. For planned outpatient elective surgical cases, the lead time is roughly 16 days (11,513 min) from when the case is scheduled to when the surgery is performed. The value-added processing time is approximately 227 min, which is *2* % of the total lead time. Therefore, we have great opportunity to reduce the time to prepare the patient's chart.

The value stream is shown in Fig. 6.4.

The yellow kaizen blitz symbols identify opportunities for improvement in the value stream as follows:

- Scheduling Prescreening visits, instead of trying to catch the patient on the phone.
- Verifying insurance and preregistering the patients that are not currently meeting the needs of timely data entry of the nursing assessments.
- The charts are touched, worked on, and reviewed multiple times throughout the process. The goal should be to touch the chart once, or as few times as possible.
- The charts move to Prescreening holding without being completed consistently, and therefore require stat orders and additional review and completion of the charts.
- There are no visual controls that provide the status of the charts moving through the process.

Process Maps

The current state process maps show the more detailed activities that are performed in the Prescreening area. The process maps illustrate that the process is lengthy, with much redundancy and "touching" the chart by many people multiple times throughout the process. The surgical stakeholders are concerned that many activities are done on the day of surgery in the Prescreening holding area that could be done prior to the day of surgery.

Additionally, there is lack of consistency in how the presurgical assessments are performed and how the documentation is gathered and reviewed prior to surgery.

Define Detailed Voice of Customer (VOC)

The internal Voice of the Customer (VOC) was gathered in interviews with the Director of Surgery, Manager of the Prescreening department, and the Chief of Anesthesia. They identified their concerns and pain points with the current prescreening process. The Director of Surgery was sensitive to balancing the completeness of the charts with meeting the department's productivity goals. If the productivity goals were not met, the Director of Surgery would need to explain the reasons at the Productivity council weekly, until they met the targets. There was great motivation to streamline the processes, so that more work could be done with the same number of people. The Manager of the Prescreening department voiced frustration with not obtaining the physician's orders, medical clearances, and other patient information in a timely manner without having to call and 'harass' the offices. The Chief of Anesthesia wanted a more streamlined way to know which patients needed to be seen in person by an anesthesiologist and which charts needed to be reviewed and when.

Critical to Satisfaction (CTS)	Metric	Data Collection Mechanism	Analysis Mechanism	Sampling Plan
Patient chart readiness the day prior to surgery	all metrics	Patient readiness check sheet	Statistics	2 months
Reduced number of labs and diagnostics tests on the day of surgery.	Missing patient data	Patient readiness check sheet	Statistics	13 months
Reduction in number of cancellations due to the patient's pre-screening not being complete.	Number of cancellations day of surgery due to pre-screening not complete	OR Scheduler	Statistics	2 week manual study (4/12-4/27)

Fig. 6.5 Data collection plan

Define the Voice of Process (VOP) and Current Performance

The Voice of the Process (VOP) and current performance was an extensive data collection experience. The data collection plan was developed by the team, and shown in Fig. 6.5. The goal is to measure the CTS criteria identified in the Define phase, including patient chart readiness the day prior to surgery, reduced number of labs and diagnostics tests on the day of surgery, and reduction in number of cancellations due to the patients' prescreening not being complete.

The operational definitions were developed for each metric.

Patient chart readiness the day of surgery:

The Prescreening Manager began collecting the number of scheduled first surgical case charts daily that are ready by 5 pm the day prior to surgery. The data for January to April are shown in Fig. 6.6. The overall average is 35 % charts complete for the first cases of the day. This shows a large opportunity for improvement. The target is 100 % of the first case charts should be ready by 5 pm the prior day.

Reduced number of labs and diagnostic tests on the day of surgery:

The Prescreening area collected data on missing patient data in the charts over a period of time. The different data types include: Health and Physical assessment, orders, new orders, tests, database, surgical content, chart label, and labs. The missing patient data is shown in Fig. 6.7.

Reduction in number of cancellations due to the patient's prescreening not being complete:

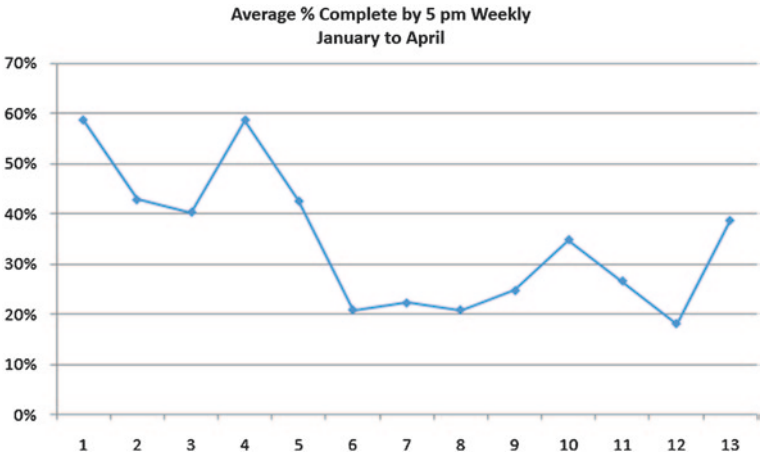

Fig. 6.6 Average percent of first case charts completed by 5 pm

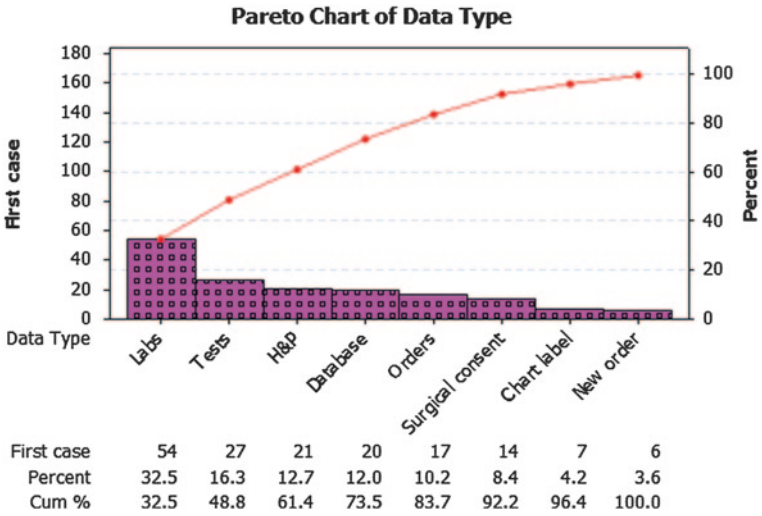

Fig. 6.7 Pareto chart of missing data

This would be a collection of the number of cancellations the day of surgery due to prescreening not complete. However, this was not collected, due to it being difficult to track and determine the reason for the cancellation. Additionally, the Director of Surgery anecdotally believed that cancellations were not a significant problem, so we decided not to track this metric.

Validate Measurement System

The Prescreening Manager validated the data collection process for assessing whether the cases were complete and the types of data missing, and found the data collection to be appropriate.

Analyze Phase

The following activities were performed for the Analyze Phase to identify and validate the root causes and to assess whether the process is currently capable of meeting the desired specifications for the Length of Stay:

1. Develop cause and effect relationships
2. Determine and validate root causes
3. Develop process capability.

Develop Cause and Effect Relationships and Determine and Validate Root Causes

A Cause and Effect analysis was performed to identify the root causes of the delays and inefficiencies in the process. The wait time between steps is quite significant, as can be seen in the Value Stream Map shown earlier in Fig. 6.4. The cause and effect diagram is shown in Fig. 6.8. Some of the root causes included the following:

Materials

- Missing Health and Physical
- Missing labs
- Missing database
- Missing tests
- Missing orders
- Missing surgical consents.

Personnel

- Dr. did not dictate the results
- Physician or medical office delays
- Patient did not come in for the prescreening assessment
- Patient did not get labs run
- Surgery was not booked.

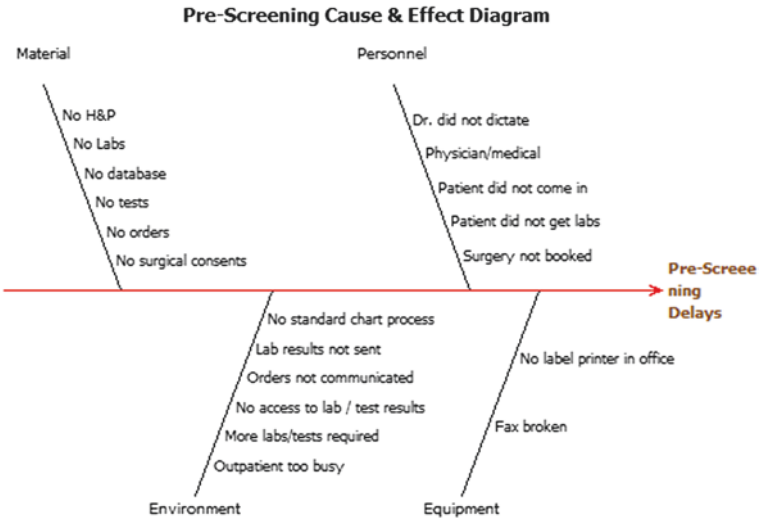

Fig. 6.8 Cause and effect diagram

Environment

- No standard chart process
- Lab results not sent from provider
- Orders not communicated to patient
- No access to lab or test results
- More lab or tests required
- Outpatient is too busy to print labels.

Equipment

- No label printer in prescreening office
- Fax broken, can't receive orders/results.

Takt Time, Identifying Constraints/Bottlenecks and System Capacity

We calculated the takt time for the Prescreening process to assess whether we have the prescreening nurse capacity to complete the required demand (patient charts). With the complexity of the process that we are trying to improve, it is important to identify the key bottlenecks so that it focuses our improvement efforts. The takt time describes the time that is required to complete each unit to be able to meet the customer's demand. Note that these are hypothetical numbers, not actual case numbers to protect the confidentiality of the healthcare provider.

Takt Time = Total Available Time/Number of required charts

Total Available Time = 5 prescreening nurses * 435 min per day = 2,175

Number of charts per day = 52
Takt time = 2,715/52 = 41.8 min per day = 0.7 h per day
We then calculated the patient chart volume capacity.
Patient chart volume capacity = Total Time Available/System cycle time
Patient chart volume capacity = 2,175/48 = 45 patient charts per day

Since the average number of patient charts per day is 52, and the department can only complete 45, the department is required to work at 115 % of capacity (52/45). This supports the finding that the charts are not complete by 5 pm, with only 33 % of the charts complete by 5 pm. This is due mainly to the nonvalue added delays in the process of waiting for orders, waiting for the patient to come into the hospital for their interviews and tests, waiting on results, etc.

Why-Why Analysis

We performed a why-why analysis to better understand the root causes. Sometimes asking why five times can better identify the root causes.

The why-why diagrams are shown in Figs. 6.9 and 6.10.

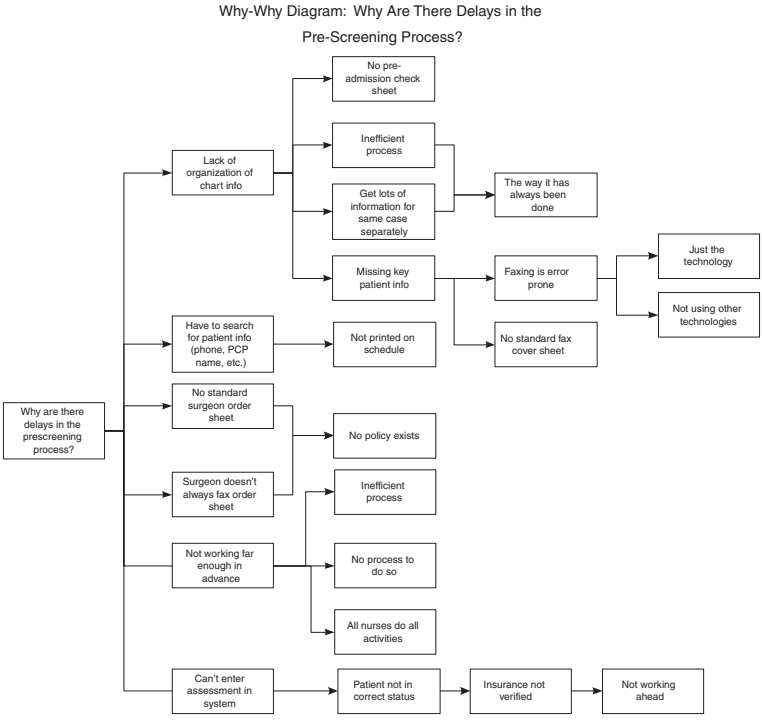

Fig. 6.9 Why-Why diagram one

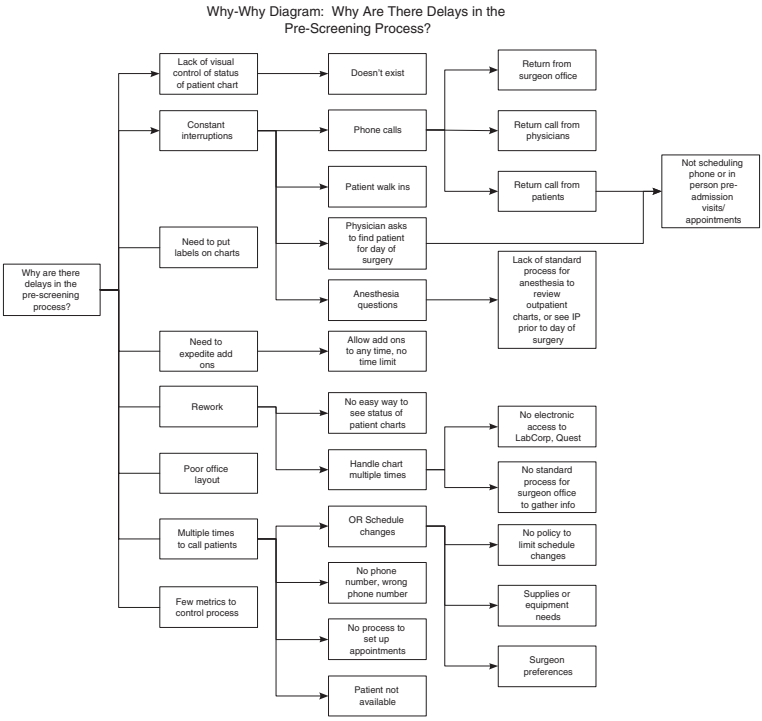

Fig. 6.10 Why-Why diagram two

Eight Wastes Analysis

The Eight Waste Analysis is used to identify process inefficiencies and redundancies. The wastes are shown in Fig. 6.11.

Issues and Root Cause Analysis

Figure 6.12 is a summary of the issues and root causes for delays in the surgical Prescreening process.

Develop Process Capability

We performed a process capability analysis for the percent of charts complete for first cases for January to April. The process is not stable, as is shown in Fig. 6.13. However, since the points that are initially out of control represent a higher percent of charts complete, we will calculate the process capability with those data points

Waste Type	Wastes in Pre-screening Process
Transportation: Any material movement that is unnecessary	. Inefficient work layout causing additional walking. . Searching for and moving charts.
Over Production: Producing more than needed, or faster than needed.	. Touching the charts multiple times to verify information. . Having to investigate the status of charts due to lack of visual control and chart tracking to easily know the status of each chart. . No standard surgeon order set.
Motion: Any movement of people that does not add value.	. Reaching for forms. . Reaching for documents from the fax machines that are placed too high. . Walking across the office for forms. . Walking around old, extra equipment (fax machines/printers).
Defects: Not meeting customer requirements; repairing mistakes in the process.	. Surgeons' not sending orders; missing information; results not accessible.
Delays: People waiting in the process. Information not available when needed.	. Lack of synchronization of resources; No patient appointments for Pre-screening and assessment. Documentation not provided by surgeons. Orders not provided by surgeons causing delays in accessing information. . Insurance verification group not performing their work early enough to have the appropriate registration status and electronic assessment available when needed by the Pre-screening nurses, causing the nurses to wait until the registration status is changed.
Inventory: Any excess materials or information; disorganized information or materials.	. Storing of chart information is not segregated by patient, but grouped by surgery date. . Storing excessive forms in the immediate work area (more than is needed for a week's worth of work). . Excessive clutter due to poor layout, and extra equipment, and materials in the work area that are not used frequently.
Processing: Effort which adds no value in the process leading to inefficiencies.	. No segregation of duties by pre-screening nurses causing multiple resources reviewing the same charts. . No visual control and check sheets to reduce having to re-review the chart to identify missing information.
People Skills: Waste of not using people's mental, creative and physical abilities.	. People performing activities at inappropriate skills levels; i.e. physicians and nurses applying chart/form labels.

Fig. 6.11 Eight waste analysis

left in the study. since a higher percentage complete charts is desirable. The process capability becomes the center line of the chart, which is 33 %.

The process is not capable of achieving our target of having 100 % of the charts complete for first cases by 5 pm the day prior to the scheduled surgery. The binomial process capability analysis is shown in Fig. 6.14. The Process *Z* value is 0.45, which shows that there is a great deal of room for improvement, which also is shown by the center line of 33 % of the charts being complete, compared to our target of 100 %.

Improve Phase

The following steps were executed in the Improve Phase:

1. Identify improvement opportunities and plans
2. Design future state
3. Establish performance targets and project scorecard
4. Pilot improvements
5. Train and execute.

Issues	Root Causes
Lack of organization of chart information	. No pre-screening check list
Getting information for same case separately across time and from surgeon and physicians.	. No efficient process for gathering documentation from surgeon and primary care physician (PCP).
Missing key patient information	. Faxing technology; no standard cover sheet
Having to search for PCP name, phone numbers, etc.	. No set process for gathering and consolidating information.
No standard surgeon order sheet; surgeon doesn't always provide orders timely, and without requesting them.	. No policy for a standard order sheet
Lack of visual control of status of charts in Pre-screening area	. No mechanism for visual control or tracking chart status
Constant interruptions during processing of Pre-screening data by phone calls (surgeons' offices, PCPs, patients), patient walk-ins, and request for status on charts, anesthesia questions	. No policy for scheduling patients for pre-screening visits or phone calls. . No standardization or measurement for anesthesia seeing outpatients or reviewing charts, or seeing inpatients prior to surgery.
Not working far enough in advance on charts, and preparing them prior to day before surgery.	. No standard process to ensure orders are performed far enough in advance, that documentation is received at least 3 days prior to surgery.
Can't enter assessments in system because insurance certification department hasn't entered the patient in the system or completed the insurance verification.	. Insurance certification department not working far enough in advance.
Rework, and handling patient charts multiple times.	. No electronic access to lab results . No standard process for the surgeons' office and PCPs to provide documentation timely, and at least 3 days prior to surgery.
Need to put labels on chart day of surgery; don't have medication orders scanned to pharmacy prior to day of surgery	. No process for who should print and apply labels prior to day of surgery to enable chart to be complete prior to day of surgery and to scan medication orders to pharmacy prior to day of surgery.
Multiple phone calls to reach patient for Pre-screening; wrong phone numbers or no phone numbers.	. No policy for scheduling patients for Pre-screening visits or phone calls; . Patient demographics not consistently provided or updated from surgeons' offices.
Frequent OR schedule changes for time of cases causes patient confusion, need to re-call the patient to provide the surgery time, convenience of surgeons.	. Need to align OR staff, equipment and supplies. . No policy to limit schedule changes.
Lack of privacy; noise in office; need to travel to retrieve forms and obtain patient chart status.	. Poor office layout.
Need to expedite add-ons late in the day prior to surgery.	. No policy to limit add-ons after a set time the day prior to surgery.
Lack of process control.	. Few control mechanisms or metrics to control the process.

Fig. 6.12 Issues and root causes

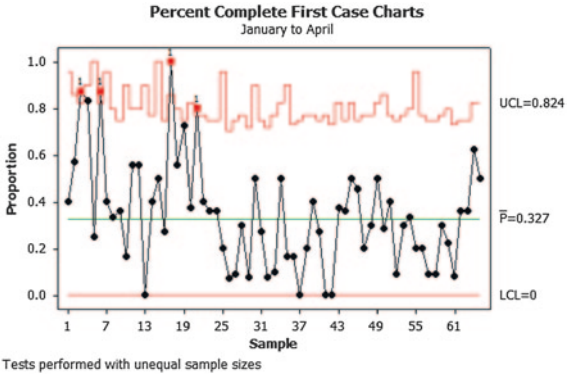

Fig. 6.13 Percent charts complete control chart

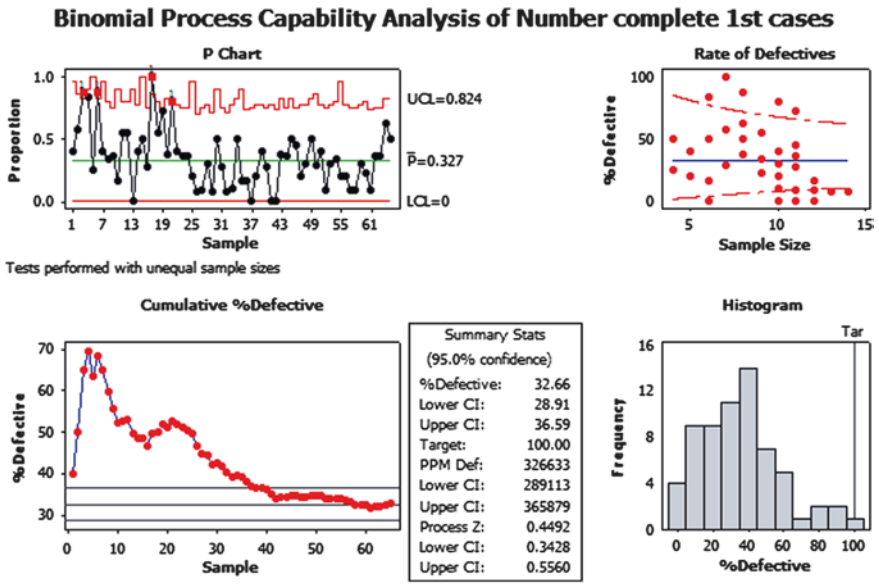

Fig. 6.14 Process capability

Identify Improvement Opportunities and Plans and Design Future State

Gaps From Best Practice

Best practice principles are not being applied consistently in the Prescreening outpatient surgical process. The following best practice principles based on systems and management engineering and Lean concepts are:

- *Reduce waste and rework* to touch the charts as few times as possible.
- *Optimize the entire value stream* from start to end, do not suboptimize functions within the value stream.
- Implement *visual controls* to be able to easily assess process status.
- Implement *mistake proofing*, such as check sheets to assess chart readiness, and reduce errors.
- Implement *metrics* to assess process control.
- *Standardize* and *document* the process to ensure process consistency and reduce process variability.
- *Pull work* based on *patient demand*, implementing *signals* for work.
- Organize *the work layout* to reduce unnecessary motion and travel, and eliminate unnecessary documents, equipment, and materials in the work area.
- Understand the patients' *requirements* and build your processes to meet their *needs*.

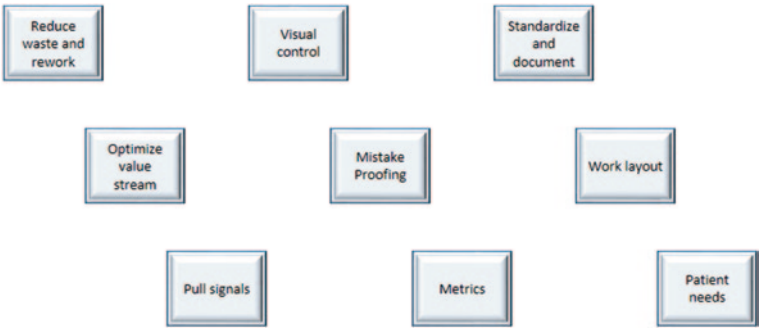

Fig. 6.15 Affinity diagram of best practice process improvements

The team developed improvement recommendations based on eliminating the identified root causes and incorporating best practices. The best practice categories are shown in the affinity diagram in Fig. 6.15.

Improvement Recommendations

The improvement recommendations are categorized by the best practice areas and shown in Figs. 6.16, 6.17 and 6.18.

Best Practice Improvement Recommendations

Following is a detailed description of the recommendations from Figs. 6.16, 6.17, and 6.18.

Reduce waste and rework to touch the charts as few times as possible.

- Re-align the Prescreening staff work activities to the highest priority patients, and have the prescreening nurses track the same patients from 1 week until the day before surgery. This helps the prescreening nurse get to know the patient and not keep handing the patients off between all of the prescreening nurses. The activities, owners, and priorities are shown in Fig. 6.19.
- Do consents, healthcare surrogate, and/or proxy in Prescreening materials.
- Align the staffing to the Prescreening visits from 7 am to 5 pm, based upon the average number of outpatient surgical cases, and the standard deviation.
- Print and put the labels on charts prior to the day of surgery. Outpatient registration can print the labels when the patient is registered during the Prescreening visit. For the patients who do not come in for a Prescreening visit, the Prescreening secretary can print the labels prior to the prescreening telephone appointment. Ensure there is a convenient printer in the Prescreening office to print labels.
- Purchase an automatic hole punch for the charts.
- Reduce OR schedule changes. This would require a process improvement project to identify the reasons for the schedule changes.

Best Practice Area	Improvement Recommendation
Reduce waste and rework	• Re-align the Pre-screening staff work activities to the highest priority patients, and have the pre-op nurses track the same patients from 1 week until the day before surgery. • Do consents, healthcare surrogate and/or proxy in prescreening materials. • Align the staffing to the pre-screening visits from 7 am to 5pm • Print and put the labels on charts prior to the day of surgery. Ensure there is a convenient printer in the prescreening office to print labels. • Purchase an automatic hole punch for the charts. • Reduce OR schedule changes. • Create a customized OR schedule for the pre-screening area to include the following fields: patient name and phone number, surgeon name and phone number, Primary Care Physician (PCP) name and phone number, whether the patient has a pacemaker, whether the patient is on beta blockers, reference lab where patients are getting pre-surgical labs performed. • Implement electronic access to Quest and LabCorp lab results.
Optimize the value stream	• Synchronize admitting, insurance verification and Pre-screenings processes. • Have an outpatient registrar register surgical patients for their pre-screening visit, and day of surgery (only those that did not visit). • Provide a list of surgical patients when they are scheduled by the OR Scheduler to insurance verification so that they process insurance timely. • Require pre-admitting patient visits. If the patient cannot come into the hospital for the Pre-screening visit, then schedule a telephone interview with the Pre-screening nurse for the nursing assessment and medication reconciliation. The pre-op visit will include a nursing Pre-screening assessment, anesthesia evaluation, social worker assessment for those patients that will need home health and/or rehabilitation services, nursing will provide education and documentation on the discharge instructions and information on the surgery, and completion of needed orders. • Anesthesia should see all inpatients the day before surgery and perform an anesthesia evaluation. • Anesthesia should review outpatient charts to evaluate high risk patients (4 days out from surgery date). • The OR scheduler should schedule the pre-screening surgical visits and the telephone nursing assessments when they schedule the surgical case with the surgeon's office. The OR scheduler should enter the reference lab where the patient is getting their pre-op labs performed in the medical information system to print on the OR schedule. The patients should be scheduled to come in 1 week from their scheduled surgery date (no more than 3 patients per hour). In the future, the hospital can investigate whether the Pre-screening surgical visit prior to 4 to 7 days before surgery will be billed separately and not bundled with the surgical visit. However, admitting would need to determine how the registration would be done and how many account numbers are needed. • The Pre-screening secretary should handle the patient telephone reminders of the pre-op visits and the telephone nursing assessments, and any necessary re-scheduling.

Fig. 6.16 Best practice improvement recommendations

- Create a customized OR schedule for the Prescreening area to include the following fields: patient name and phone number, surgeon name and phone number, PCP name and phone number, whether the patient has a pacemaker, whether the patient is on beta blockers, reference lab where patients are getting presurgical labs performed. This would need to be an IT project.
- Implement electronic access to Quest and LabCorp lab results. This would need to be an IT project.

Optimize the entire value stream from start to end, do not sub-optimize functions within the value stream.

Best Practice Area	Improvement Recommendation
Visual controls	• All documentation that comes in should be paper clipped with the pre-screening readiness check sheet. • Implement a simple Pre-screening Patient Tracker visual control to easily see what is missing from the patients' charts. Investigate downloading the OR schedule from the medical information system into a spreadsheet to track the status of the patients' charts, and share with all appropriate staff: Pre-screening, pre-op holding, anesthesia. • Implement a simple surgical inpatient tracking mechanism to ensure that the inpatients are ready for surgery.
Mistake proofing	• Implement a pre-screening readiness check sheet of all chart requirements, created when the patient case is scheduled.
Metrics	• Implement metrics to control the pre-screening process.
Standardize and document	• Implement desktop work instructions. • Require the surgeons to provide their orders on the standard order set. Track surgeon office compliance to this requirement (see Pre-Screening Patient Tracker). Send letter to surgeon's and PCPs with pre-screening requirements. • Require the surgeon's office to provide the pre-op documentation: orders, results, medical clearance, etc. no less than 3 days prior to surgery. Track surgeon office compliance to this requirement (see Pre-screening Patient Tracker). • Implement a standard fax cover sheet to provide necessary case information (see appendix). Include data fields: patient name; patient phone number; date of surgery; procedure; patient, surgeon phone number, Primary Care Physician (PCP), PCP phone number. • Implement a time limit for add-ons the day before surgery (4 pm). If add-ons are necessary after 4 pm, then schedule the surgeries for late the next day. • Register the patients for surgery during the Pre-screening visit so that they do not have to register the day of surgery. • Ensure charts are complete the day prior to surgery. • Hire a process engineer to continue the process improvements, and track process metrics across the hospital • For the pre-op holding area, put labels on inpatient forms in the afternoon prior to the day of surgery.

Fig. 6.17 Best practice improvement recommendations

Best Practice Area	Improvement Recommendation
• Pull work based on patient demand, implementing signals for work	• Apply the Pre-screening Patient Tracker and the Pre-screening Chart Readiness Checklist as tools to identify the patients who still have outstanding items for their charts. Use this list to determine the work priorities for the Pre-screening staff.
• Organize work layout	• 5S the office to remove equipment and supplies not needed, • Re-design the Pre-screening area for privacy, flow and quietness
• Build process to meet patients' needs	• Implement a surgical patient survey specific for the surgical experience, separate from the inpatient experience. • Implementing the above defined recommendations will better meet the patients' needs to help them to be better prepared for surgery. Based on the evidence in the literature this will help to reduce patients and their families' anxiety, and enhance patient satisfaction.

Fig. 6.18 Best practice improvement recommendations

Synchronize admitting, insurance verification, and Prescreenings processes.

- Have an admitting registrar register surgical patients for their Prescreening visit, and day of surgery (only those that did not visit). Labels should be printed by outpatient registration when the patient is registered for the Prescreening visit, or by the Prescreening department secretary at least one day prior to the Prescreening appointment for the Prescreening telephone call.

Priority	Pre-screening Nurse 1	Pre-screening Nurse 2	Pre-screening Nurse 3	Pre-screening Nurse 4	Secretary	Nurse Manager	Outpatient Registration
First	Pre-screening assessment appoint-ments.	Pre-screening assessment appointments.	Day of surgery patient chart preparation.	Patient chart review for patients 1 day from surgery; process add-ons.	Manage Pre-screening visit calendar and call patients for appointm ent reminder	Coordinat e day of surgery readiness; Coordinat e pre - screening visit , nursing assessments.	Register patients for pre-screening visits and day of surgery.
Second	Patient chart review for patients, keeping the same patients from 1 week out until the day before surgery, alternating weeks with the Pre-screening nurse 2.	Patient chart reviews for patients, keeping the same patients from 1 week out until the day before surgery, alternating weeks with the Pre-screening nurse 1.	Ensure H&Ps have been completed; Review charts with anesthesia.	Call patients with surgical case time.	Complete Pre-screening Patient Tracker. Follow-up with surgeons and PCPs for late documen tation (3 days out)	Coordinat e Pre-screening nursing activities.	Print and apply chart labels, prior to day of surgery, and for inpatients.

Fig. 6.19 Prescreening activities, owners and priority

- Have the insurance verification department pull the OR schedule daily, and ensure that the insurance verifications are performed no less than 10 days from surgery and within 1 day from being added if added less than 10 days from surgery.
- Require preadmitting patient visits if possible for all cases. If the patient cannot come in prior to surgery, then schedule a telephone interview with the Prescreening nurse for a nursing assessment and medication reconciliation. The Prescreening in person surgical visit will include a nursing Prescreening assessment, anesthesia evaluation, social worker assessment for those patients that will need home health and/or rehabilitation services, nursing to provide education and documentation on the discharge instructions and information on the surgery, and completion of needed orders. A study by Pearson et al. (2004) reviewed the evidence of best practice in preparing the patient for day surgery. The study found that both preoperative telephone screening or questionnaires, or a Prescreening clinic a few days prior to surgery were both effective in enhancing patient satisfaction, reducing cancellations, and reducing anxiety for patients and their families. The following suggestions are recommended.
  - Appointments should be set up with the OR Scheduler. Either a shared Outlook calendar can be used or the medical information system scheduling function to schedule the patients' Prescreening visit appointments. IT can set this up.
  - All patients should be encouraged to come into the hospital one week prior to their surgical date for a Prescreening surgical visit.

The Prescreening surgical visit will include the following activities:
Admitting:

- Admitting registration for the Prescreening visit and surgery.

Prescreening Nursing:

- Nursing Prescreening assessment
- Any labs or outstanding orders would be completed
- Missing items would be identified on the Prescreening check sheet and the readiness summary sheet.
- Provide education and documentation on the discharge instructions and information on the surgery, and completion of needed orders.

Anesthesia

- Anesthesia evaluation would be performed.

Social Worker

- Social worker assessment for those patients that will need home health and/or rehabilitation services.

If a patient cannot come in for a visit, the Prescreening telephone nursing assessment interview will include the nursing assessment and medication reconciliation. It is important that the Prescreening visit includes an anesthesia evaluation. Evidence has shown that the presurgical anesthesia evaluation significantly reduced surgical cancellation rates (Lew et al. 2004). The preanesthesia clinic also reduces the length of the hospital stay by performing discharge planning during the clinic, and by providing appropriate patient information regarding the surgery.

- Anesthesia should see all inpatients the day before surgery and perform an anesthesia evaluation.
- Anesthesia should review outpatient charts to evaluate high risk patients (4 days out from the surgery date).
- The OR scheduler should use either the medical information system scheduler or a shared Outlook calendar to schedule the Prescreening visits and the telephone nursing assessments when they schedule the surgical case with the surgeon's office. The OR scheduler should enter the reference lab where the patient is getting their Prescreening labs performed in the medical information system to print on the OR schedule. The patients should be scheduled to come in 1 week prior to their scheduled surgery date. In the future, the hospital can investigate whether they will bill separately for the Prescreening surgical visit. However, admitting would need to determine how the registration would be done and how many account numbers are needed.
- The Prescreening secretary should handle the patient telephone reminders of the Prescreening visits and the telephone nursing assessments, and any necessary re-scheduling.

Implement visual controls to be able to easily assess process status.

- All documentation that comes in should be paper clipped with the prescreening readiness check sheet that is created when the first piece of documentation comes into the prescreening office.
- Implement a simple prescreening Patient Tracker visual control to track whether the surgeons, anesthesia, and the Primary Care Physicians are adhering to our prescreening requirements. Investigate downloading the OR schedule from the medical information system into a spreadsheet to track the status of the patients' charts, and share with all appropriate staff: Prescreening, pre-op holding, anesthesia. Track the percentage of charts ready by 5 pm prior to the day of surgery. The chart readiness tracking metrics and graph are shown in Figs. 6.20 and 6.21. The Outpatient Prescreening Patient Tracker is shown in Fig. 6.22.
- Implement a simple surgical inpatient tracking mechanism to ensure that the inpatients are ready for surgery. The Surgical Inpatient Tracker is shown in Fig. 6.23.
- Implement a tracker to assess the compliance of Anesthesia in evaluating the outpatients and/or reviewing the charts, shown in Figs. 6.24 and 6.25.

% Charts Complete Day Prior to Surgery

NOTE: Enter data in yellow cells only
NOTE: Do not include add ons

Date	Day	# of Cases	# of Complete Case Charts	% Complete	Week	Month
3/5/2012	2	11	10	91%	10	3
3/6/2012	3	12	9	75%	10	3
3/7/2012	4	16	15	94%	10	3
3/8/2012	5	12	8	67%	10	3
3/9/2012	6	9	6	67%	10	3
3/12/2012	2	12	11	92%	11	3
3/13/2012	3	14	13	93%	11	3
3/14/2012	4	16	15	94%	11	3
3/15/2012	5	18	17	94%	11	3
3/16/2012	6	19	16	84%	11	3
3/19/2012	2	20	18	90%	12	3
3/20/2012	3	22	22	100%	12	3
3/21/2012	4	22	21	95%	12	3
3/22/2012	5	18	17	94%	12	3
3/23/2012	6	19	18	95%	12	3
3/26/2012	2	21	19	90%	13	3
3/27/2012	3	25	20	80%	13	3
3/28/2012	4	24	23	96%	13	3
3/29/2012	5	22	21	95%	13	3
3/30/2012	6	24	23	96%	13	3
4/2/2012	2	25	25	100%	14	4
4/3/2012	3	25	24	96%	14	4
4/4/2012	4	23	21	91%	14	4
4/5/2012	5	21	19	90%	14	4
4/6/2012	6	20	18	90%	14	4
4/9/2012	2	21	12	57%	15	4
4/10/2012	3	24	18	75%	15	4
4/11/2012	4	19	17	89%	15	4
4/12/2012	5	25	21	84%	15	4
4/13/2012	6	26	20	77%	15	4
4/16/2012	2	20	19	95%	16	4
4/17/2012	3	18	16	89%	16	4
4/18/2012	4	15	13	87%	16	4
4/19/2012	5	20	15	75%	16	4
4/20/2012	6	18	15	83%	16	4
4/23/2012	2	17	14	82%	17	4
4/24/2012	3	24	20	83%	17	4
4/25/2012	4	25	20	80%	17	4
4/26/2012	5	22	18	82%	17	4
4/27/2012	6	23	17	74%	17	4
4/30/2012	2	22	18	82%	18	4
5/1/2012	3	19	17	89%	18	5
5/2/2012	4	20	18	90%	18	5
5/3/2012	5	22	18	82%	18	5
5/4/2012	6	22	17	77%	18	5
5/7/2012	2	19	16	84%	19	5
5/8/2012	3	20	18	90%	19	5
5/9/2012	4	24	19	79%	19	5
5/10/2012	5	25	20	80%	19	5
5/11/2012	6	19	16	84%	19	5
5/14/2012	2	18	16	89%	20	5
5/15/2012	3	16	14	88%	20	5

Average of % Complete	
Week	Total
10	79%
11	91%
12	95%
13	92%
14	94%
15	77%
16	#DIV/0!
17	#DIV/0!
18	#DIV/0!
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49	#DIV/0!
50	#DIV/0!
51	#DIV/0!
52	#DIV/0!
53	#DIV/0!
Grand Total	#DIV/0!

Fig. 6.20 Percent charts complete by 5 pm prior to day of surgery data input form

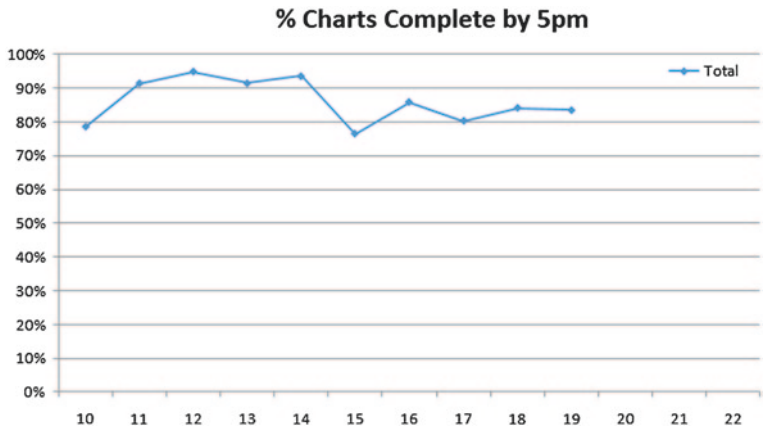

Fig. 6.21 Percent charts complete by 5 pm prior to day of surgery graph

Outpatient Pre-Screening Tracker

Patient Name	Date of Birth	Date of Surgery	Pre-Visit Appointment	Surgeon Name	Primary Care Physician	Date Receive Surgeon Preop Orders	Date Receive Surgeon Preop Docs	Date Receive Medical Clearance	Seen by Anesthesia/ Chart Reviewed (1 = Y, 0 = N)	Add on? (1 = Y, 0 = N)	Chart Ready 5 PM (1 = Y, 0 = No)	Pre-Visit Complete (1 = Y, 0 = N)	Date Pre-Visit Complete	Week
Surgical, Patient	9/6/1954	3/9/2012	3/6/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1		1	1	3/6/2012	10
Surgical, Patient	9/6/1954	3/9/2012	3/7/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	0		0	0	3/6/2012	10
Surgical, Patient	9/6/1954	3/9/2012	3/6/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1		1	1	3/6/2012	10
Surgical, Patient	9/6/1954	3/9/2012	3/17/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1		1	0	3/6/2012	10
Surgical, Patient	9/6/1954	3/9/2012	3/10/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	0		0	0	3/6/2012	10
Surgical, Patient	9/6/1954	3/9/2012	3/6/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1		1	1	3/6/2012	10
Surgical, Patient	9/6/1954	3/9/2012	3/9/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1		1	1	3/6/2012	10
Surgical, Patient	9/6/1954	3/9/2012	3/6/2012	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1		1	1	3/6/2012	10

Fig. 6.22 Outpatient prescreening tracker

Surgical Inpatient Tracker

Patient Name	Date of Birth	Date of Surgery	Inpatient Floor/Unit	Inpatient Nurse	Surgeon Name	Primary Care Physician	Date Receive Surgeon Preop Orders	Date Receive Surgeon Preop Docs	Date Receive Medical Clearance	Seen by Anesthesia/Chart Reviewed (1 = Y, 0 = N)	Chart Ready 5 PM (1 = Y, 0 = No)	Inpatient Report Complete Prior to Report Out (1 = Y, 0 = N)	Week
Surgical, InPatient	9/6/1954	3/9/2012	2S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1	1	1	10
Surgical, InPatient	9/6/1954	3/9/2012	3S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	0	0	1	10
Surgical, InPatient	9/6/1954	3/9/2012	3S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1	1	0	10
Surgical, InPatient	9/6/1954	3/9/2012	2S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1	1	0	10
Surgical, InPatient	9/6/1954	3/9/2012	2S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	0	0	1	10
Surgical, InPatient	9/6/1954	3/9/2012	3S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1	1	0	10
Surgical, InPatient	9/6/1954	3/9/2012	3S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1	1	1	10
Surgical, InPatient	9/6/1954	3/9/2012	3S	Imma Nurse	Dr. Surgeon	Dr. Primary	3/1/2012	3/6/2012	3/6/2012	1	1	1	10

Fig. 6.23 Inpatient prescreening tracker

% Anesthesia Seeing Inpatients & Reviewing Outpatient Charts

NOTE: Enter data in yellow cells only; Do not include add ons

Date	Day	# of Cases	# Seen by or Reviewed by Anesthesia	% Compliant	Week	Month
3/5/2012	2	11	11	100%	10	3
3/6/2012	3	12	10	83%	10	3
3/7/2012	4	16	12	75%	10	3
3/8/2012	5	12	8	67%	10	3
3/9/2012	6	9	8	89%	10	3
3/12/2012	2	12	11	92%	11	3
3/13/2012	3	14	13	93%	11	3
3/14/2012	4	16	14	88%	11	3
3/15/2012	5	18	17	94%	11	3
3/16/2012	6	19	17	89%	11	3
3/19/2012	2	20	16	80%	12	3
3/20/2012	3	22	22	100%	12	3
3/21/2012	4	22	22	100%	12	3
3/22/2012	5	18	17	94%	12	3
3/23/2012	6	19	17	89%	12	3
3/26/2012	2	21	19	90%	13	3
3/27/2012	3	25	20	80%	13	3
3/28/2012	4	24	23	96%	13	3
3/29/2012	5	22	21	95%	13	3
3/30/2012	6	24	23	96%	13	3
4/2/2012	2	24	18	75%	14	4
4/3/2012	3	23	21	91%	14	4
4/4/2012	4	21	20	95%	14	4
4/5/2012	5	19	18	95%	14	4
4/6/2012	6	20	20	100%	14	4

Average of % Compliant	
Week	Total
10	83%
11	91%
12	96%
13	92%
14	91%
15	#DIV/0!
16	#DIV/0!
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28	#DIV/0!
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33	#DIV/0!

Fig. 6.24 Percent anesthesia seeing inpatient and reviewing outpatient charts data input form

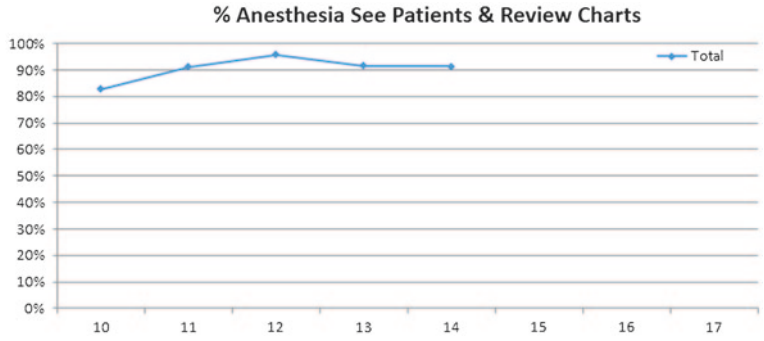


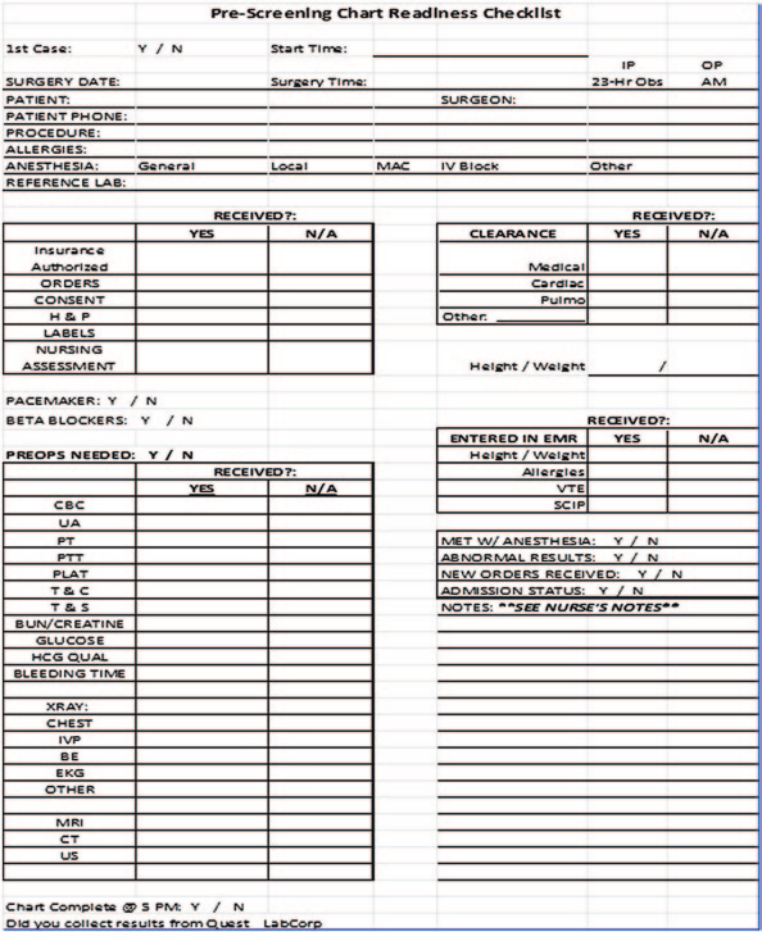
Fig. 6.25 Percent anesthesia seeing inpatient and reviewing outpatient charts graph

Implement mistake proofing, such as check sheets to assess chart readiness, and reduce errors.

Implement a *Prescreening Chart Readiness Checklist* of all chart requirements, created when the patient case is scheduled. This is shown in Fig. 6.26.

Implement metrics to assess process control.

- Implement metrics to control the prescreening process. The metrics are included in the Prescreening Patient Tracker (Fig. 6.18).
- Implement a daily huddle with key OR staff to identify and resolve issues with on-time starts (Fig. 6.27). Where there are identified issues with prescreening, these issues can be provided to the prescreening department.



Pre-Screening Chart Readiness Checklist

1st Case:	Y / N	Start Time:				
					IP	OP
SURGERY DATE:		Surgery Time:			23-Hr Obs	AM
PATIENT:				SURGEON:		
PATIENT PHONE:						
PROCEDURE:						
ALLERGIES:						
ANESTHESIA:	General	Local	MAC	IV Block	Other	
REFERENCE LAB:						

	RECEIVED?:	
	YES	N/A
Insurance Authorized		
ORDERS		
CONSENT		
H & P		
LABELS		
NURSING ASSESSMENT		

CLEARANCE	RECEIVED?: YES	N/A
Medical		
Cardiac		
Pulmo		
Other:		

Height / Weight /

PACEMAKER: Y / N

BETA BLOCKERS: Y / N

PREOPS NEEDED: Y / N

	RECEIVED?:	
	YES	N/A
CBC		
UA		
PT		
PTT		
PLAT		
T & C		
T & S		
BUN/CREATINE		
GLUCOSE		
HCG QUAL		
BLEEDING TIME		
XRAY:		
CHEST		
IVP		
BE		
EKG		
OTHER		
MRI		
CT		
US		

ENTERED IN EMR	RECEIVED?: YES	N/A
Height / Weight		
Allergies		
VTE		
SCIP		

MET W/ ANESTHESIA: Y / N

ABNORMAL RESULTS: Y / N

NEW ORDERS RECEIVED: Y / N

ADMISSION STATUS: Y / N

NOTES: ***SEE NURSE'S NOTES***

Chart Complete @ 5 PM: Y / N

Did you collect results from Quest LabCorp

Fig. 6.26 Prescreening chart readiness checklist

Daily OR Improvement Huddle

Date	Delay Reasons	Immediate Action	Root Cause Category	Systemic Improvement	Comments
3/6/2012	MD Late	Address with Surgeon	People	Track Surgeon On Time	
3/6/2012	Anesthesia Late	Address with Anesthesia	People	Track Anesthesia On Time	
3/6/2012	Type & Screen	Perform T&S	Method	Improve T&S process	
3/7/2012	Patient Late	Discuss with patient	People	Preadmission procedure	
3/7/2012	Patient Late	Discuss with patient	People	Preadmission procedure	
3/7/2012	Equipment	Find equipment	Equipment	Kaizen	
3/8/2012	Room not ready	Discuss with OR Staff	Method	Kaizen	
3/8/2012	Patient Late	Discuss with patient	People	Preamission procedure	
3/8/2012	MD Late	Address with Surgeon	People	Track Surgeon On Time	

Fig. 6.27 OR daily huddle issues tracking

Standardize and document the process to ensure process consistency and reduce process variability.

- Implement desktop work instructions that can be used to ensure that the procedures are followed.
- Require that the surgeons provide their orders on the standard order set. Track the surgeon office compliance to this requirement (see the Prescreening Patient Tracker). Send a letter to the surgeon's and PCPs with the prescreening requirements.
- Require the surgeon's office to provide the pre-op documentation: orders, results, medical clearance, etc. no less than 3 days prior to surgery. Track the surgeon office compliance to this requirement (see Prescreening Patient Tracker).
- Implement a standard fax cover sheet to provide necessary case information.
- Implement a time limit for add-ons the day before surgery (4 pm). If an add-on is necessary after 4 pm, then schedule the surgery at the end of the next day.
- Register the patients for surgery during the prescreening visit so that they do not have to register the day of surgery.
- Ensure charts are complete the day prior to surgery.
- Hire a process engineer to continue the process improvements, and track process metrics across the hospital.
- For the pre-op holding area, put labels on the inpatient charts in the afternoon prior to the day of surgery.

Pull work based on patient demand, implementing signals for work.

Apply the Prescreening Patient Tracker as a tool to identify the patients who still have outstanding items for their charts. Use this list to determine the work priorities for the prescreening staff.

Organize the work layout to reduce unnecessary motion and travel, and eliminate unnecessary documents, equipment, and materials in the work area.

5S is a Lean technique that helps to organize the work area. This recommendation includes implementing a 5S improvement project in the prescreening office to remove equipment and supplies that are not needed. If possible, re-design the prescreening area for privacy, flow and quietness.

The 5S steps would include:

- *Sort*. Sort out the unnecessary equipment, forms and supplies that are not used every day from the immediate area. There are broken or old fax machines that can be removed. There are a large number of forms in the office area. Only keep the forms that are used on a weekly basis within the office area. Store the other forms in a cabinet that can easily replenish the working area on a weekly basis.
- *Straighten*. Organize and straighten the prescreening area after removing the unneeded items from the sort activity. Identify storage areas for the items that aren't used daily. Keep only a week's worth of forms and supplies, and replenish the forms from the storage areas on a weekly basis. Identify a place for all of the equipment, supplies and forms. Have a place for everything and ensure that everything is in its place. Label and mark the equipment, forms and supplies clearly. Determine the following for each item (equipment, forms, and supplies):

  - Where it will be used
  - Where it will be placed
  - How much of each item will be placed
  - How it will be placed.

- *Shine*. Identify how often the area will be cleaned and organized, as follows:
  - Create an organizing schedule
  - Have a person responsible for each area
  - Remove root causes for disorganization
  - See the workplace through the patients' eyes!!

- *Standardize*. Standardize the organization.
  - Color code areas according to categories
  - Create "shadowboards"; Outline areas where things should be
  - Visual Management: Do you know what's going on in your area in 30 seconds or less?

- *Sustain*. DISCIPLINE. The following ideas will help sustain the organization of the prescreening area.
  - Keep the processes going through training, communication, and organization structures
  - Allocate time for maintaining the organization
  - Create awareness of improvements
  - Management support for maintaining
  - Training, rewards
  - Daily check sheets and a monthly 5S Scorecard can be used to assess the organization (see chapter on 5S case study)
  - Make a person responsible for each area.

Another project could be performed to re-design the Prescreening area for privacy, flow and quietness.

Understand the patients' requirements and build your processes to meet their needs.

- Implement a surgical patient survey specific for the surgical experience, separate from the inpatient experience.
- Implementing the recommendations in this report will better meet the patients' needs to help them to be better prepared for surgery. Based on the evidence in the literature this will help to reduce patients and their families anxiety, and enhance patient satisfaction.

Design Future State

The future state process maps were developed, and vetted with the process owners, the Director of Surgery and the Chief Nursing Officer.

Establish Performance Targets and Project Scorecard

The team established perform targets for the key metrics, which are shown in the Scorecard Fig. 6.28. This data are collected on the Prescreening Patient Tracker and the Prescreening Chart Readiness Checklist. Administration can easily see whether the areas are meeting their performance targets.

Pilot Improvements and Train and Execute

We began piloting the activities as soon as the Chief Nursing Officer and The Director of Surgery approved the recommendations. We began the implementation with the execution of the 5S project. This enabled the prescreening area to clean up, get rid of unnecessary equipment, supplies, and forms, and put their area in order. This was extremely successful, as the Black Belt worked daily with the prescreening area staff for 2 weeks to clean up the area. She ensured that owners were assigned to re-stock forms and incorporate the "shine" discipline so that daily the prescreening staff ensured that everything was back in its place. This enhanced the patient's experience when they came to the office for their prescreening appointments. Longer term, there will be a re-design of the office space to enhance patient comfort and privacy.

The Black Belt then worked with the prescreening staff to implement the Prescreening Chart Readiness Checklist and the Prescreening Patient Tracker. The prescreening manager was trained on the checklist and the prescreening patient tracker, and began immediately tracking the desired metrics. The Black Belt trained the prescreening nurses on how to use the Chart Readiness Checklist. She helped

Performance Scorecard		
Metric	Target	Weekly Value
% Charts Ready by 5pm	100%	95% (Amber)
% Pre-Visits Complete	90%	90% (Green)
% Anesthesia Seen/Reviewed	95%	99% (Green)
% Surgeon's Orders Received On Time	95%	80% (Red)
% Surgeon's Docs Received On Time	95%	75% (Red)
% Medical Clearance Received On Time	95%	80% (Red)

Fig. 6.28 Performance targets and scorecard

them to re-arrange the work aligning with the priorities identified in the improvement recommendations. She helped them to re-organize the patient assignments to the nurses, so that the nurses could follow the patient throughout their prescreening process. This ensured better consistency, and a better patient experience.

The Lean Six Sigma Master Black Belt developed a desktop instruction manual that enabled the processes to be standardized, and become repeatable, ensuring that everyone performed the work activities in a standard way. The Chart Readiness Checklist was an immense time saver, by enabling anyone to pick up the chart to readily see what prescreening activities remained for the patient to be ready for surgery, and what orders, results and documents were needed to complete the chart. This helped in the hand-offs between departments, especially to the holding area on the day of surgery.

IT helped the prescreening area get on-line access to patients' lab results.

Requiring almost all of the patients to come to the hospital for their prescreening visit reduced the number of missing orders, results, and documentation. Anesthesia more consistently saw the inpatients the day prior to surgery, and reviewed high-risk charts and saw those patients as necessary. Tracking these critical metrics helped to change the behaviors and enhance the patient experience.

Control Phase

The purpose of the Control Phase is to implement control mechanisms and procedures to ensure that the process maintains the levels of improvements attained during the pilot activities.

The following activities were executed in the Control Phase:

1. Measure results and manage change
2. Report scorecard data and create process control plan
3. Identify replication opportunities
4. Develop future plans.

Measure Results and Manage Change

The results of this project were highly successful and had great value to the patient experience and to the organization. The graphs for the percentage of patient charts ready by 5 pm and the percent of patients seen and/or charts reviewed by anesthesia are shown in Figs. 6.29 and 6.30. The percent of patient charts complete the day before for the first cases was hovering around 95 %, which is an excellent result. The anesthesia percentage was hovering around 92 % by the end of the project. Another excellent result, and validation that Lean Six Sigma works!

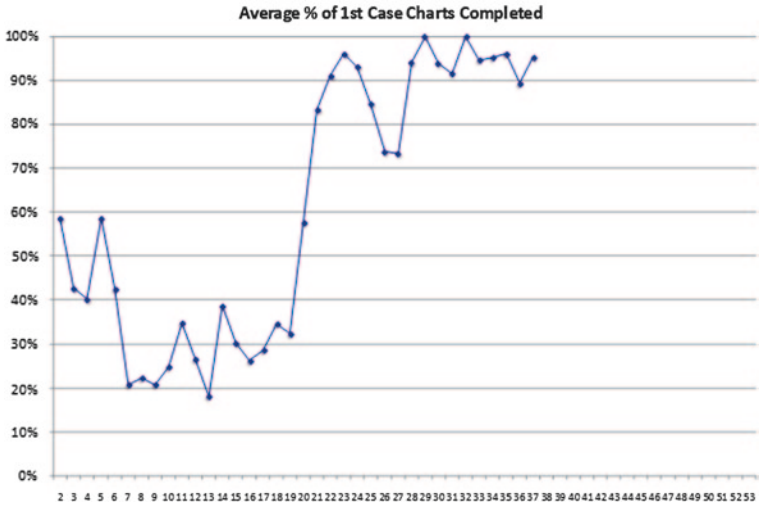


Fig. 6.29 Results of the percent patient charts ready by 5 pm

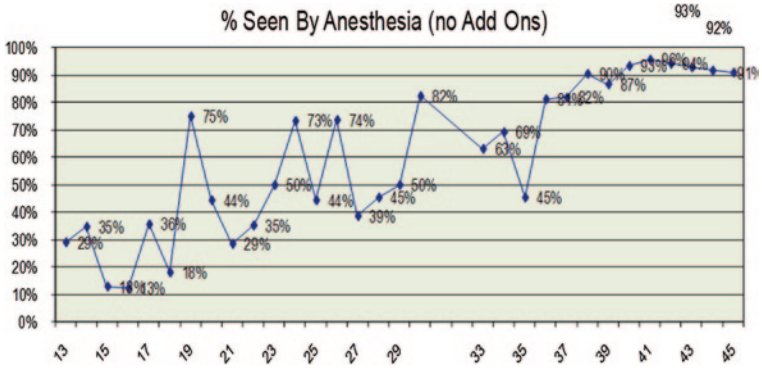


Fig. 6.30 Results of the percent of patients/charts seen or reviewed by anesthesia

Report Scorecard Data and Create Process Control Plan

A control plan provides methods to control the process and ensure that the standard process is adhered to, and incorporates metrics to track improvement. The following items are part of the control plan that have been discussed throughout the report.

- Outpatient Preadmission Tracker:

This spreadsheet can be used to 9*track compliance by the surgeons, the primary care physicians and anesthesia to the preadmission requirements.

- Surgical Inpatient Tracker:

The Surgical Inpatient Tracker can be used to ensure that the inpatient nurses are providing the appropriate surgical readiness information during their reports, and that they are available for the report and transfer of the patient to surgery. It also can be used to track Anesthesia compliance in evaluating the inpatients prior to the day of surgery.

- Preadmission Readiness Checklist:

The Preadmission Readiness Checklist is used to track the patient readiness requirements and any outstanding items prior to the day of surgery.

- Metrics:
  - The Percent of Charts Complete Prior to the day of surgery spreadsheet and chart can be used to track the improvement in readying charts for surgery.
  - The Percent of Cases that Anesthesia Evaluates and Reviews can be tracked on the "% Anesthesia Seeing Inpatients and Reviewing Outpatient Charts" spreadsheet and chart.
- Daily OR Improvement Huddle

The Daily OR Improvement Huddle spreadsheet can be used to identify issues, identify root causes and systemic improvements that can be implemented to improve the on time starts and turnarounds in the OR.

- Standard surgeon order set:

A standard surgeon order set form can be used to ensure that the surgeon's orders are received timely.

- Standard fax cover sheet:

The standard fax cover sheet can be used by the surgeon's and the Primary Care Physician offices to provide consistent information with the patient's chart documentation.

- Desktop work instructions with future state process maps:

The desktop work instructions manual with the future state process maps can be used to train the preadmission, and admitting staff on the new processes.

Identify Replication Opportunities

The Lean Six Sigma problem solving approach can and has been replicated in other areas in the hospital. Many of the improvements can be replicated in other hospitals.

Develop Future Plans

The prescreening department will continually improve their prescreening processes.

Project Critical Success Factors

The following key factors contributed to the success of this project:

- Chief Nursing Officer's and Director of Surgery's visible commitment; engagement; and *gentle encouragement* towards goals
- Key team members selected to participate
- Experienced facilitator with technical and change management skills
- Ability to implement new data collection and measurement techniques
- Team monitoring performance on a weekly basis
- Staff willing to pilot improvements
- Surgeons and Anesthesia as key process innovators.

Even though the process changes will not be directly replicated on another project for the same hospital, many of the best practices can be shared with other hospitals in the hospital system as well as other hospitals through this book and journal articles.

Summary

This case study provides a thorough analysis of the Preoperative Screening processes and identifies best practice recommendations to streamline the processes for a more satisfactory patient experience. Approximately 80 % of the recommendations were implemented during this project, which is an extremely effective project implementation. The results were stellar, and consistently maintained after the project.

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Chapter 7
Appropriate Use of CT Scan in the Emergency Department

Abstract This chapter describes a case study in a community-based acute care hospital that was able to successfully reduce the Computed Tomography (CT) utilization in their Emergency Department by 8.7 % for 1 year, and 13.8 % since the prior 2-year period. The reduction was especially important because 10 % of the U.S. population gets a CT scan each year, and use of CT imaging is growing more than 10 % per year, and with it, increased long-term exposure can increase potential cancer risks. The cross-functional team applied the Six Sigma methodology and tools to define the problem, measure the current state, identify root causes, and develop medical research-based and evidence-based CT guidelines to reduce CT utilization. The information presented in this case study is not designed or intended to provide medical advice or recommendations.

Introduction

"Computed Tomography" (CT) scanning, also called computerized axial tomography (CAT) scanning, is a medical imaging procedure that uses X-rays to show cross-sectional images of the body. A CT imaging system produces cross-sectional images or "slices" of areas of the body, like the slices in a loaf of bread. These cross-sectional images are used for a variety of "diagnostic and therapeutic purposes" (www.fda.gov).

"With the exception of patients who were allergic to dye or had renal insufficiency, CT was considered completely safe" (www.archinternmed.com). It is estimated that more than 62 million CT scans per year are currently obtained in the United States, including at least 4 million for children (www.archinternmed.com). Another study estimates the use of CT scans in the United States has increased more than threefold since 1993 to approximately 72 million scans annually (www.crcpd.org). "Each year, 10 % of the U.S. population gets a CT scan, and use of this imaging is growing more than 10 % per year" (Mettler et al. 2008).

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There are many diagnostic benefits to CT scan, however there are risks as well, mainly due to the radiation exposure from the CT scans. The risk to individuals is likely to be small, but because of the larger number of CT scans and number of people exposed, even small risks could translate into a considerable number of future cancers. (Mettler 2008). CT delivers much higher radiation doses than do conventional diagnostic X-rays. For example, a chest CT scan typically delivers more than 100 times the radiation dose of a routine frontal and lateral chest radiograph (de Gonza' lez et al 2009; Smith-Bindman 2009).

"Radiation doses from commonly performed diagnostic CT examinations are higher and more variable than generally quoted, highlighting the need for greater standardization across institutions." (Mettler 2008). The effective radiation dose varied significantly within and across institutions, with "… a mean 13-fold variation between the highest and lowest dose for each study type" (Mettler 2008).

One article estimated approximately 29,000 future cancers could be related to the number of CT scans performed in the US in 2007. The risks were higher as the CT scans performed increased with age at exposure up to the age of 45 years, and nearly one-third of the scans (30 %) were estimated to be performed in adults aged 35 to 54 years, 13 % in those aged 18 to 34 years, and 7 % in persons younger than 18 years. About 60 % of the scans were estimated to be performed in females. The risk per 10,000 scans varied with scan type, with higher risks for chest or abdomen CT angiography and whole-body CT. The risks were higher in females because of additional risk of breast and lung cancer. The scan types of highest risks were the ones also used most frequently, those of the abdomen and pelvis, head and chest angiography. The highest cancer types were lung, colon, then leukemia (Mettler 2008). Another study found the increased cancer risk in younger females. The authors also found the cancer risks declined with age and for males (Mettler, Thomadsen, 2008). They estimated one in every 270 40-year-old women undergoing a CT coronary angiogram will develop cancer from the procedure.

In a study by Kirsch et al. the 2006 Emergency Department CT utilization rate was 16.7 % for adults. The CT utilization rate ranged from 11.3 % for adults age 20 to 29 years of age to 24.6 % for adults over 65 years of age. The CT utilization rate varied by patient age, ED volume, training background of the provider, and disposition status of the patient. The number of CT scans ordered or performed in the ED has grown by 200 to 400 % over a 5-year period (Kirsch 2010). As the number of CT scans increase the cancer risks are also increasing. There is growing consensus and concern about the risk of CTs and overexposure of radiation due to this growing use of CT scans.

The growing concern related to patients' long-term radiation exposure due to the increased number of CT scans was the impetus for the formation of a Six Sigma project to reduce the number of CT scans ordered and performed in the Emergency Department (ED) at the hospital. The hospital is a community-based hospital serving a diverse demographic of patients. Six Sigma was used to develop guidelines and recommendations to reduce the number of CT scans, and to more appropriately use CT scans for diagnostic testing. There was a statistically

significant reduction (8.7 %) in the number of CT scans from the baseline time period of 2009 compared to 2010 after improvements were implemented. There was a 13.8 % reduction in CT scans from 2008 to 2010. This chapter will describe this very successful project.

Define Phase

In the Define phase the team was formed, and appropriate stakeholders were identified. The following steps were executed in the Define Phase:

1. Develop project charter.
2. Perform stakeholder analysis.
3. Identify Critical to Satisfaction (CTS).
4. Select team and launch the project.
5. Create project plan.

The project charter is shown in Fig. 7.1, and the project resources are shown in Fig. 7.2.

Project Name: Appropriate Use of CT Scan in the Emergency Department

Problem Statement: The problem involves the appropriate use of CT for diagnostic purposes in the ED: spine, abdomen/pelvis, chest, renal and facial/orbits. This can be a safety issue involving over exposure or repeated exposure to radiation. The problem also involves the use of non-contrast CT vs contrast CT. Using non-contrast might result in the need for another CT with contrast. Patients are not screened for histories of previous CT.

Customer/Stakeholders: ED physicians; Radiologists, Radiology technicians, ED Nurses (include triage nurses), Nurse educator, administration (lab and radiology), patients.

What is important to these customers – CTS (Critical to Satisfaction):
Number of CT tests; frequency of CT tests; appropriate use of CT; Decrease over-utilization of tests; appropriate diagnosis.

Goal of the Project: To reduce radiation exposure, to reduce overall number of tests, to utilize the tests appropriately; decrease in the radiation that patients receive from CT scans.

Scope Statement: To focus on the ED patients who receive CT scans of the spine, abdomen/pelvis, chest, facial/orbits. We are assuming a correlation between the CT scans and level of radiation (CT scans give highest level of radiation of scans give in ED). Not focusing during this project on long term radiation exposure, other than that the number and frequency of tests contributes to long term exposure.

Fig. 7.1 Project charter

Fig. 7.2 Project resources

Project Resources:

Project Leaders: Radiologist, ED Co-Director
Process Owners: ED Physicians, ED Co-Director, Radiologist, Nurse Trainer
Project Champion: Radiologist
Mentors/ Master Black Belt: Master Black Belt
Training Coordinators: Training Coordinators
Finance: Financial Analyst
Support Resources: Radiologists, ED Physicians, Nurse trainer,
As needed: Director Radiology, Lab Director

Develop Project Charter

Problem Statement

The radiologists, ED physicians and the radiology department, following the current literature that identified the increasing number of CT scans in the patient population, especially impacted by visits to the Emergency Department, decided to focus on an effort to reduce the use of CT scans in the Emergency Department at the hospital. About 60 % of the admissions to the hospital come through the ED. About 31 % of the patients received a CT scan during their visit during the time period of January through December 2009. The highest frequency of CT scans for diagnostic purposes in the ED are (1) spine; (2) abdomen/pelvis; (3) chest; (4) renal; (5) orbital/facial. There could also be a problem with ordering first CTs without contrast and then having to order another CT with contrast. Additionally, patients are not currently consistently screened for their histories of prior CT scans.

Customer/Stakeholders. The customer is the ultimate ED patient. The other project stakeholders are ED physicians, Radiologists, Radiology technicians, ED Nurses (including the triage nurses), the Nurse Educator, Lab, and radiology department.

What is Important to These Customers–Critical to Satisfaction (CTS).

Number of CT tests; frequency of CT tests; appropriate use of CT; Decrease over-utilization of tests; appropriate diagnosis, decrease in the radiation that patients receive from CT scans.

Goals of the Project. The goal of the project is to reduce the radiation exposure from CT scans, to reduce the overall number of CT scans, and to utilize the CT scans appropriately based on the symptoms presented.

Scope Statement. To focus on the ED patients who receive CT scans of the spine, abdomen/pelvis, chest, renal and facial/orbits. We are assuming a correlation between the CT scans and level of radiation (CT scans give the highest level of radiation of scans given in the ED). We are not focusing during this project on long-term radiation exposure, other than that the number and frequency of tests contributes to long-term exposure.

Project Milestones. The project started in September 2009, and was completed in December 2010.

Perform Stakeholder Analysis

The team performed the stakeholder analysis by defining the stakeholders impacted by the project, and what their concerns are, and how they are impacted by the project. The ED physicians assess the patient and order labs and diagnostic exams. They are concerned about the timely turnaround on diagnostic tests; the number of tests ordered for a patient, especially those exposing the patient to radiation; the frequency of the CT tests that a patient has encountered, increasing the cumulative radiation effects; that the CT exams are ordered appropriately for their symptoms; and that the patient is provided the appropriate diagnosis based on the results of the tests.

The radiologists read the radiology exams, including the CT scans, and provide the results of the exams. They are concerned about timely turnaround on the diagnostic tests; appropriate use of CT scans; appropriate diagnosis; radiation safety of patients; and number of CT scans ordered and performed on patients.

The next stakeholder group consists of the radiology technicians who perform the exams and the lab and radiology department staff who provide lab and radiology exams. They are concerned with timely turnaround on diagnostic tests; appropriate diagnosis and appropriate test delivery providing the appropriate level of radiation to the patient.

The patients are the critical customer stakeholders who receive diagnostic tests, results and ED physician diagnosis and disposition. They are concerned with radiation exposure and appropriate diagnosis, as well as timely turnaround.

The stakeholders are shown in Fig. 7.3.

Stakeholders	Who They Are?	Potential Impacts/Concerns
ED physicians	Physicians who order tests and provide diagnoses in the ED	▪ Timely turnaround on diagnostic tests ▪ Number of tests ▪ Frequency of tests ▪ Appropriate use of CT ▪ Appropriate diagnosis
Radiologist	Radiologists who provide radiology services/diagnosis	▪ Timely turnaround on diagnostic tests ▪ Appropriate use of CT ▪ Appropriate diagnosis ▪ Radiation safety ▪ Number of CT scans
Radiology technicians; Lab and Radiology staff	Staff who provide radiology and lab testing services	▪ Timely turnaround on diagnostic tests ▪ Appropriate diagnosis ▪ Appropriate test delivery
Patients	Patients who receive diagnostic tests	▪ Radiation exposure ▪ Appropriate diagnosis ▪ Timely turnaround

Fig. 7.3 Stakeholder analysis

Suppliers–Inputs–Processes–Outputs–Customers

The SIPOC is used to ensure the scope of the project is well understood. The SIPOC is shown in Fig. 7.4. The processes in the scope of this project are the ED physicians ordering the diagnostic tests, including CT scans, performing the diagnostic tests, and the radiologists' providing the test results to the ED physicians. The patients present themselves to the Emergency Department and describe their symptoms. The ED physician assesses the patient, and orders lab and diagnostic exams. The orders are entered into the ED Bed board system and into the medical record, and are then performed. Some lab test results are required before being able to perform certain radiology exams, including the CTs, for example pregnancy tests in women of child bearing age. The radiologists will read the exams and provide the results via the PACS radiology system, which the ED physicians then review to determine the patient disposition, to discharge or admit the patient to the hospital.

Identify Critical to Satisfaction

There are several characteristics that are Critical to the Satisfaction of the patients and the project stakeholders, as follows;

- Number of CT tests.
- Frequency of CT tests.
- Appropriate use of CT.

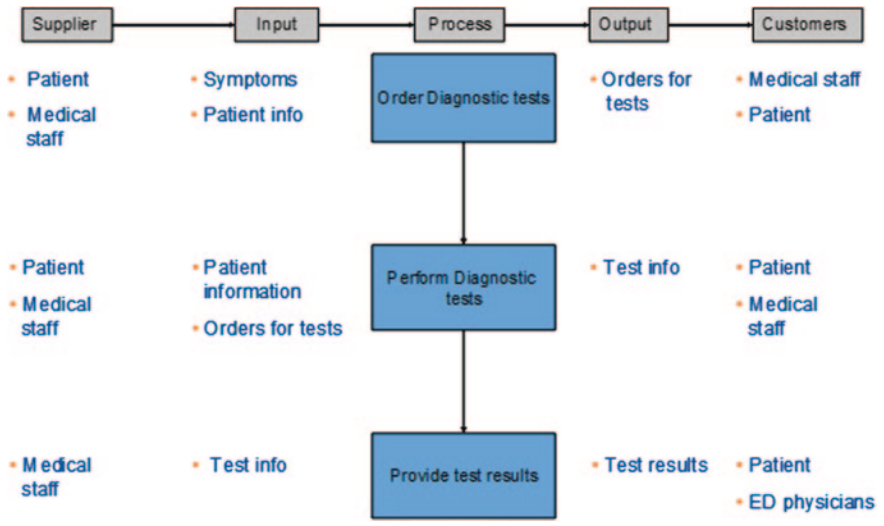

Fig. 7.4 Suppliers-Inputs-Process-Outputs-Customers (SIPOC)

- Decrease over-utilization of tests.
- Appropriate diagnosis.
- Decrease the radiation to patients.

The goal of the project is to reduce the number of CT tests and how frequently the patients have CT tests over time. It is important that the physicians order the tests appropriate to what is supported in the medical research literature and is evidence-based. There is also a focus to decrease over-utilization of tests, and providing the appropriate diagnosis, even as the CT tests are reduced. By reducing the number and frequency of the CT tests, this should also decrease the amount of radiation that the patients are exposed to.

Select Team and Launch the Project

The team members consisted of the internal stakeholders, including ED physicians, a radiologist, the radiology department director, the ED nurse educator, the Continuing Medical Education (CME) coordinators, and a Six Sigma Master Black Belt (the case's author). We launched the project October 1, 2009.

Create Project Plan

We developed the project milestones for each phase of the DMAIC problem solving methodology, shown in Fig. 7.5.

Once the project charter was complete, and the stakeholders were defined the team moved into the Measure Phase.

Measure Phase

The Measure Phase included the following activities

1. Define the current process.
2. Define detailed Voice of Customer (VOC).
3. Define the Voice of Process (VOP) and current performance.

Define the Current Process

The first step was to map the current process by creating detailed process maps of the current diagnostic processes in the Emergency Department. The process

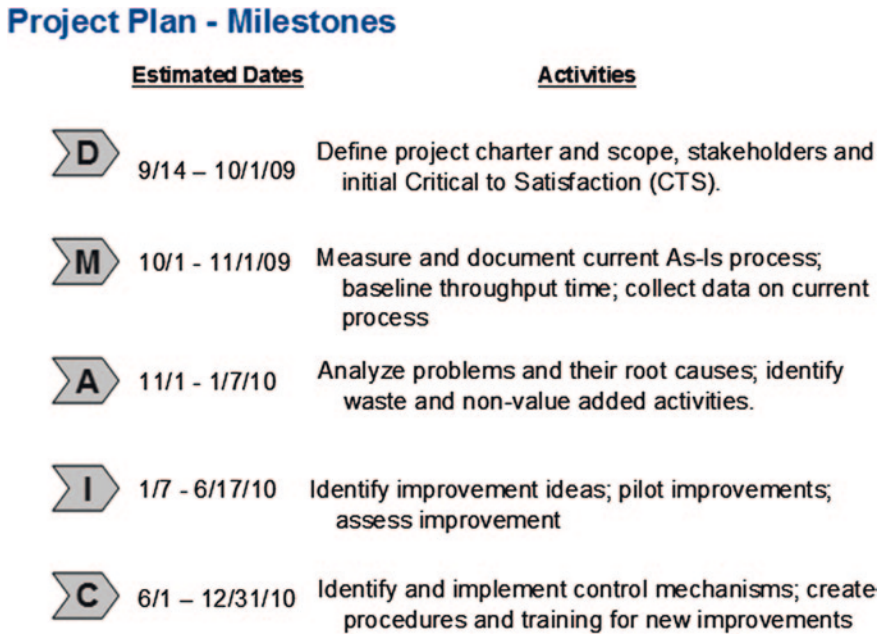

Fig. 7.5 Project milestones

maps are shown in Figs. 7.6 and 7.7. The patient arrives to the Emergency Department and signs in at the kiosk. If an ED room is available, the patient is placed in the ED room and is triaged by the nurse. Prior to improving the ED throughput, since the time to see a doctor was quite lengthy, averaging 93 minutes, the triage nurse assessed and triaged the patient. The ED physician will see and assess the patient, and then order diagnostic tests, including labs and radiology exams. The orders are requested by the ED physician by entering them into the ED Bed Board system. The unit associate then enters the orders into the medical information system. If labs are needed, the lab specimens are drawn by the nurse and/or phlebotomist. The lab tests are run and resulted. If oral contrast is needed for the CT scan, the nurse or radiology technician gives the oral contrast to the patient. If oral contrast was given to the patient, the patient must wait 60 minutes prior to the CT exam. The radiology technician retrieves the patient and moves them to the CT scan, and performs the exam. The radiologist reads the exam and provides the results to the ED physician. The ED physician then diagnoses the patient and provides the disposition to either discharge or admit the patient to the hospital.

The team developed the data collection plan to determine the voice of the process and the current baseline. The data collection plan is shown in Fig. 7.8.

Operational Definitions of the Metrics:

The operational definitions were developed for each metric.

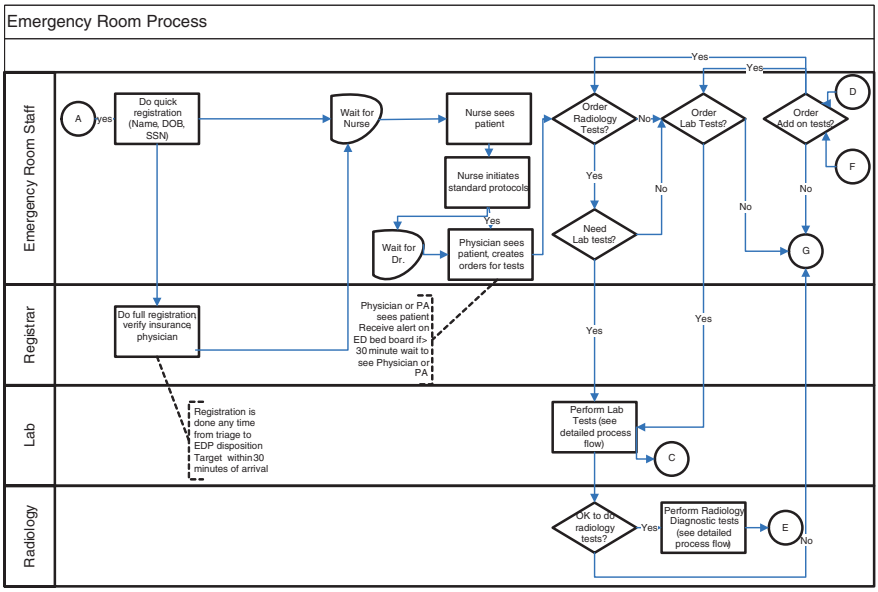

Fig. 7.6 Process map, page 1

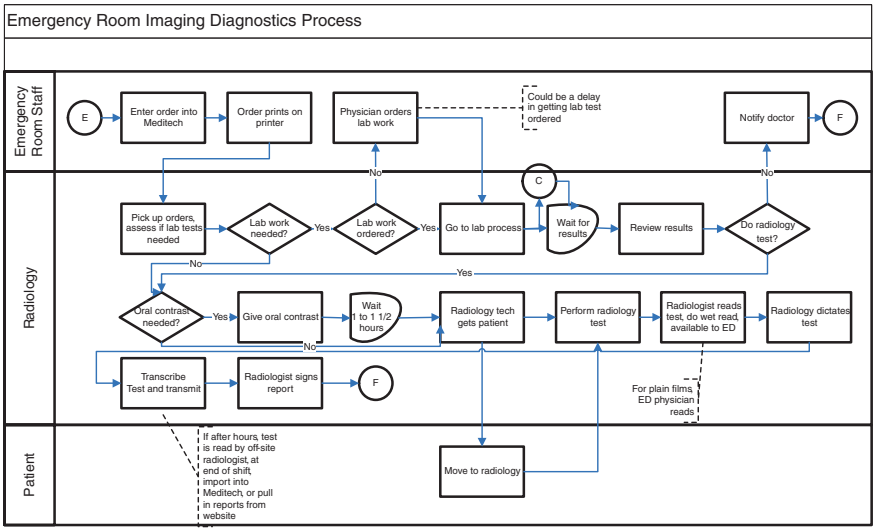

Fig. 7.7 Process map, page 2

Critical to Satisfaction (CTS)	Metric	Data collection mechanism	Sampling plan (sample size, sample frequency)
Number of CT scans by type: spine, abdomen/pelvis, chest, renal and facial/orbits	▪Percent of CT scans = Number of CT Scans / Number of ED Patients ▪ Percent of CT scans by type = Number of CT Scans by type/ Number of CT Scans	ED bed board; Radiology orders database	Initial baseline January through April 2009; revised baseline January to December 2009
Frequency of tests	Percent of CT scans per patient = Count of Patients with CT scans / Number of ED Patients	ED bed board; Radiology dept. database (Rad stats) from PACS data	Initial baseline January to April 2009; revised baseline January to December 2009
Appropriate use of CT (over-utilizations)	Appropriate use per medical research.	Medical research literature	
Appropriate Diagnosis	Number of positive tests for pulmonary embolism per patients across time frame	ED bed board or PACS	Number negative d-dimers Number positive d-dimers

Fig. 7.8 Data collection plan

Metric 1: Percent of CT Scans.

The purpose of the first metric was to measure the number of CT scans.

The percent of CT scans was calculated as the number of CT scans divided by the number of ED patients, during the defined time period.

Metric 2: Percent of CT scans by Modality.

The purpose of the second metric was to understand the highest frequency CT modality. The percent by modality was calculated as the number of CT scans for the modality divided by the total number of CT scans. The highest frequency CT exams included those of the spine, abdomen and pelvis, chest, renal and facial/orbits.

Metric 3: Appropriate use of CT scans.

The third metric was to assess the appropriate use of CT scans for the types that we were assessing. This was assessed through a review of the medical research.

Metric 4: Appropriate Diagnosis.

The last metric was to determine if the appropriate diagnosis was attained for those patients who used the CT scan, and were at risk of having a pulmonary embolism. This metric was defined as the number of positive tests per patient diagnosed with pulmonary embolism.

We used a baseline period of January through December 2009, and also January through April 2009 for the analyses, per the data available.

Define Detailed Voice of Customer

For the voice of the customer, we reviewed the ED Bed Board data that identified the number and types of CT scans across the patient population for the January through December 2009 time frame. The Pareto Chart by Modality is shown in Fig. 7.9.

The highest CT modality is CT of the brain without contrast, consisting of 32 % of the CTs performed. CT of the abdomen and CT pelvis without contrast were each 16 % of the CT exams. CT pelvis and abdomen with contrast consisted of 7.1 % each of the exams. The CT Spine without contrast was 5.9 %.

Thirty-one percent (31 %) of the patients visiting the ED during 2009 had at least one CT exam, shown in the histogram in Fig. 7.10. For the patients who were admitted to the hospital after visiting the ED, 47 % of the admitted patients had at least one CT exam.

Define the Voice of Process and Current Performance

The physicians searched the literature for each CT scan type (spine, abdomen/pelvis, chest, face/orbits) for guidelines for appropriate use of CT scans.

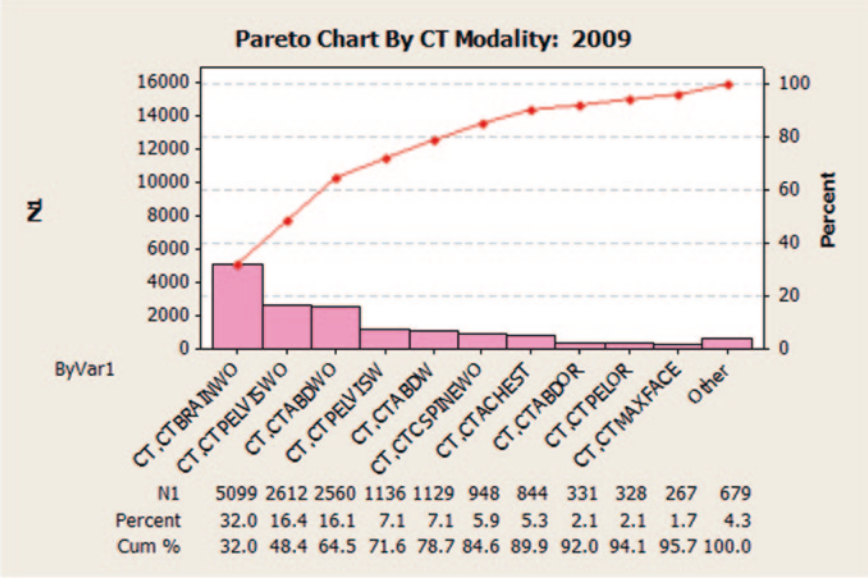

Fig. 7.9 Frequency of CT scans by modality

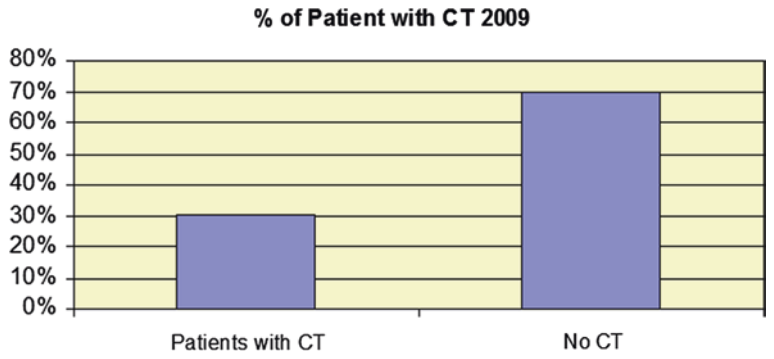

Fig. 7.10 Histogram of CT scans

The average number of CT scans ordered by the ED physicians varied from 10 to 92 % across the ED physician group, showing quite a bit of variability in how the ED physicians order CT scans, as shown in Fig. 7.11.

We also assessed whether the CT utilization was different by age, and found that CT scans were a higher percentage compared to the overall population for the older patients in age ranges 50 to 65 and over 65. The percentages of CT scans, and percentages of the ED population by age range is shown in Fig. 7.12. We performed a Chi square analysis to determine if the percentage of CT Scans by age range differed from the ED population percentage by age range. We found that the percentages of CT Scans by the age ranges for <18, 18–29, 30–39, and 40–49 were lower than the ED population percentages by age range. We also found that the percentages of CT Scans for the 50 to 65 and over 65 were higher than the ED population percentages by age range. The *p* value was 0.000. The observed versus expected values are shown in Fig. 7.13.

The Chi square output follows:

Chi Square Goodness-of-Fit Test for Observed Counts in Variable: CT Scans

Using category names in Age Range_1

Category	Observed	Test Proportion	Expected	Contribution To Chi-Sq
1	131	0.0379	381.92	164.852
2	856	0.1411	1421.86	225.199
3	912	0.1263	1272.73	102.239
4	1,225	0.1268	1277.76	2.179
5	1,751	0.1624	1636.50	8.010
6	5,202	0.4055	4086.22	304.672

N	DF	Chi-Sq	P-Value
10077	5	807.152	0.000

ED Physician	2009 % of Patients with CTs
EDP A	54%
EDP B	58%
EDP C	54%
EDP D	63%
EDP E	81%
EDP F	34%
EDP G	52%
EDP H	58%
EDP I	46%
EDP J	50%
EDP K	30%
EDP L	19%
EDP M	50%
EDP N	21%
EDP O	22%
EDP Q	72%
EDP R	55%
EDP S	10%
EDP T	48%
EDP U	21%
EDP V	56%
EDP W	31%
EDP X	18%
EDP Y	92%

Fig. 7.11 CT ordering patterns across physicians

Age Range	Count of Patients with At Least 1 CT Scan	% Patients with CT Scans by Age Range	Percentage in Age Range of ED Population
<18	131	1%	4%
19 to 29	856	8%	14%
30 to 39	912	9%	13%
40 to 49	1225	12%	13%
50 to 65	1751	17%	16%
> 65	5202	52%	41%
Grand Total	10077		

Fig. 7.12 % CT scans by age range compared to ED population

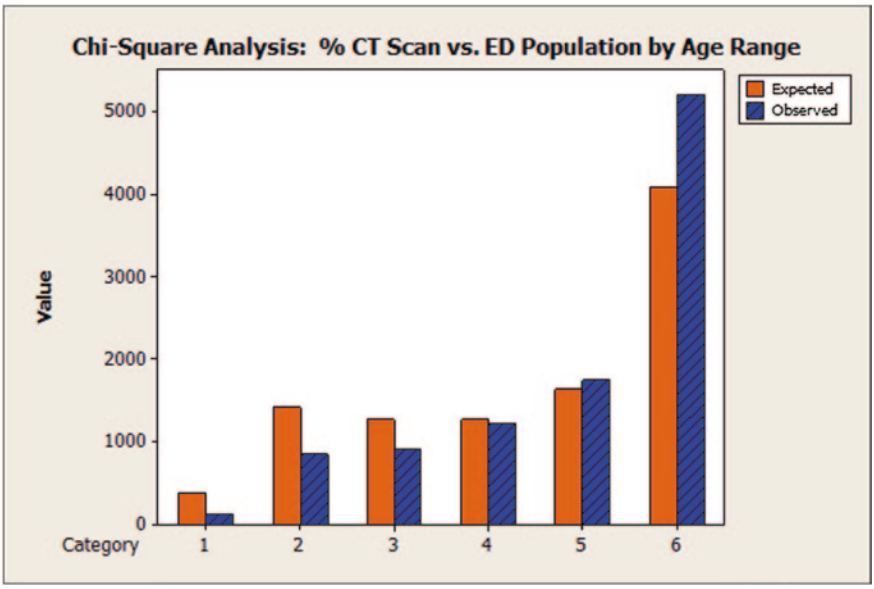

Fig. 7.13 Chi square analysis for % CT scans and ED population by age range

A D-Dimer lab test screens for a potential pulmonary embolism. If a positive result for a possible pulmonary embolism is received, the ED physician assesses whether a CT scan should be performed. For those patients where a D-Dimer test was given, along with a CT scan, 27 % of the diagnoses were a Pulmonary Embolism.

We then moved into the Analyze Phase.

Analyze Phase

The following activities were performed for the Analyze Phase to identify and validate the root causes of appropriate use of CT scan.

1. Develop cause and effect relationships.
2. Determine and validate root causes.

Develop Cause and Effect Relationships and Determine and Validate Root Causes

The root causes were quite straightforward for the potential overuse of CT scans and several were supported in the literature as well. The following root causes

were identified as contributing to the increasing and sometimes high usage of CT scans by particular ED physicians, as follows:

- There were no standard guidelines for when to Order CT scans across the ED physicians. The ED physicians used their experience, knowledge and judgment to determine when to order CT scans. All three of these elements could widely vary. Figure 7.11 shows the wide variability in the ordering patterns across the ED Physicians. The chart shows the percent of patients who had CT scans for each ED Physician. This ranged from 10 to 92 % across the ED Physicians.
- There was no measurement of amount of radiation exposure due to CT scans. Prior to this project, the radiology department did not measure the amount of radiation exposure to the patient from the CT scans.
- There was little focus on the appropriate use of CT scans in the Emergency Department either with the nurses, or the ED physicians.
- Patients may complain if there is no diagnostic test. "A popular current paradigm for health care presumes that more information, more testing, and more technology inevitably leads to better care" (www.archinternmed.com). "Patients who pressure doctors for tests they may not need are part of the problem, writes Dr. Bruce J. Hillman of the University of Virginia, and Jeff Goldsmith, president of Health Futures Inc., a Charlottesville, Va.-based health information policy and analysis company" (www.archinternmed.com).
- The type of patient insurance could have an impact on prescribing CT scans. We looked at the type of insurance that the patients had, or if they were a self-pay. For the most frequent insurance types, within the ED population, we analyzed the percent of patients compared to the percent of patients with at least one CT scan performed. For the Medicare patients, they made up 37 % of the patients, yet they had a higher percent (43 %) of patients with at least one CT scan. This was also true of patients with private insurance. They made up 28 % of the patients, yet they had 31 % of the patients with CT scans. The self-pay patients had a lower percent of patients with CT scans (17 %) compared to them

Insurance Type	Percent of Patients	Percent Patients with CTs	Statistically Significant Difference?
HMO	11%	9%	Yes (p-value = .001)
Medicare	37%	43%	Yes (p-value = .000)
Private	28%	31%	Yes (p-value = .001)
Self Pay	24%	17%	Yes (p-value = .000)

Fig. 7.14 Insurance breakdown by patients and number of CT scans

making up 24 % of the patient population. The HMO patients also had a lower frequency of CT scans (9 %) compared to the percent of patients with HMO insurance (11 %). The table summarizing this data is shown in Fig. 7.14.

- ED Physicians have a high potential for getting sued for malpractice. Miami-Dade County in south Florida has one of the highest malpractice rates in the country. The latest available data from the Medical Liability Monitor (2008 survey of malpractice rates), reports Dade County, Fla., as having the highest rates in the country with OB/Gyns and general surgeons paying as much as $238,728 for $1–$3 million coverage. Internists in Dade County also pay the most, as much as $54,710 (www.amednews.com, 2009).

We then moved into the Improve phase to develop the guidelines, based upon the current medical literature.

Improve Phase

The following steps were executed in the Improve Phase:

1. Identify improvement opportunities and plans.
2. Design future state.
3. Pilot improvements.
4. Train and execute.

Identify Improvement Opportunities and Plans and Design Future State

The medical literature suggested three ways to reduce the overall radiation dose from CT (Marchione 2010).

(1) Reduce the CT-related dose in individual patients. Using automatic exposure-control options on the latest generation of scanners can help.
(2) Replace CT use with other types of technology, such as ultrasound (US) and magnetic resonance imaging (MRI), which do not expose the patient to radiation. Depending upon the patient's symptoms, US and MRI can replace some of the CT scans, but not necessarily all of them. Additionally, depending upon the patient's Body Mass Index (BMI) and percent of body fat, CT can be a better diagnostic choice.
(3) Decrease the number of CT exams ordered.

CT scanning has become an integral diagnostic modality in the management of ED patients.

Figure 7.15 shows the radiation dose for different CT procedures, along with the equivalent number of X-rays for the equivalent effective dose, and the time period for the equivalent effective dose from natural background radiation. A CT examination with an effective dose of 10 millisieverts (abbreviated mSv;

Diagnostic Procedure	Typical Effective Dose (mSv)1	Number of Chest X rays (PA film) for Equivalent Effective Dose2	Time Period for Equivalent Effective Dose from Natural Background Radiation3
Chest x ray (PA film)	0.02	1	2.4 days
Skull x ray	0.1	5	12 days
Lumbar spine	1.5	75	182 days
I.V. urogram	3	150	1.0 year
Upper G.I. exam	6	300	2.0 years
Barium enema	8	400	2.7 years
CT head	2	100	243 days
CT abdomen	8	400	2.7 years

Fig. 7.15 Radiation dose by CT modality

1 mSv = 1 mGy in the case of X-rays) may be associated with an increase in the possibility of fatal cancer of approximately one chance in 2000. This increase in the possibility of a fatal cancer from radiation can be compared to the natural incidence of fatal cancer in the U.S. population, about one chance in five. Cancer risks and radiation exposure from computed tomographic scans (2009).

The team developed guidelines for prescribing diagnostic tests for the highest frequency types of CT scans ordered for the patient symptoms presented.

Guidelines to Order a CHEST CT Angiogram (Institute for Clinical Systems Improvement)

The Chest CT Angiograms are in the majority of cases ordered when a D Dimer is elevated, and there is a potential pulmonary embolism. Therefore, it seems reasonable to follow Well's Criteria to order a D Dimer when Predicting a Pulmonary Embolism (PE).

The team suggested that the following guidelines be observed when considering ordering a D-Dimer for Suspected PE. Figure 7.16 shows the Wells Clinical Model for Predicting the Pretest Probability of Pulmonary Embolism.

Keeping in mind that a VQ scan delivers 10 times less radiation than a CT scan of the Chest, consider obtaining VQ Scans on the patients with a low pretest probability, a negative Chest X-ray and a positive D Dimer (i.e., A typical Chest pain in a young female with SOB).

Guidelines for Abdominal CT Scans and Abdominal Imaging (BMJ 2009; Stoker 2009)

The literature supports plain CT scans of the Abdomen for patients presenting to the ED with abdominal pain. However, in the following situations when contrast will help the diagnostic process and yield better information to the radiologist and treating physician.

Variable	Points Assigned
Clinical signs and symptoms of deep venous thrombosis	3.0
An alternative diagnosis is less likely than pulmonary embolism	3.0
Heart rate >100 beats/min	1.5
Immobilization or surgery in the previous 4 weeks	1.5
Previous deep venous thrombosis or pulmonary embolism	1.5
Hemoptysis	1.0
Malignancy (on treatment, treated in the last 6 months, or palliative)	1.0
Score	**Clinical Assessment Probability**
<2 points	Low probability
2–6 points	Intermediate probability
>6 points	High probability

Fig. 7.16 Wells clinical model for predicting the pretest probability of pulmonary embolism

1. BMI less than 25 (low fat patients) use PO contrast.
2. Suspected Pancreatitis: If doing CT, do it with IV contrast to help stage.
3. For All PO contrast, wait 60 minutes. For distal Colon 90 minutes may be better.
4. Aortic dissection, need IV contrast.
5. Consideration of Diverticulitis: PO contrast will yield more diagnostic information and potentially help in long term management (abscesses, perforation, etc.).
6. Abdominal Trauma—give IV contrast.
7. Known malignancies: PO and IV contrast.
8. Pelvic US is useful in young females with lower abdominal pain as first line study.
9. Pregnant Patients with suspected Appendicitis: Consider MRI.

Guidelines for Cervical Spine Imaging

NEXUS low-risk Criteria

- No tenderness at the posterior midline of the cervical spine
- No focal neurologic deficit
- Normal level of alertness
- No evidence of intoxication
- No distracting injury

Canadian C-spine Rules

- Is there any high-risk factor that mandates radiography (age > 65, dangerous mechanism, paresthesias in extremities)?
- Is there any low-risk factor present that allows safe assessment of range of motion (simple rear-end MVC, delayed onset of pain, absence of midline tenderness)?
- Is the patient able to actively rotate neck 45° to the left and right?

When Should we CT the c-spine Instead of use Plain Radiograph?

High energy mechanism

- Hi-speed MVC.

- MVC with death on scene.
- Fall from height > 10 feet.

High Risk Clinical Parameter

- Neurologic signs suggestive of c-spine injury.
- Significant head injury.
- Age > 50 with moderate-energy mechanism.

Guidelines for Imaging Patients Presenting to the ED with Suspected Renal Colic (Baumgarten, 2007; Katz, 2006)

Purpose: to limit the amount of radiation the patient is receiving

Consider US and KUB as first line of testing

- Patients with a history of uncomplicated kidney stones, less than 50 years of age.

CT scan

- First time presentation with suspected Renal Colic.
- History of renal stone presenting with suspected Renal Colic over 50 years of age (concern is AAA).
- Patients with a history of complicated kidney stones (lithotripsy, stents, Large Stones).
- If an Operative procedure is contemplated.
- For pregnant patients start with renal and bladder US.

An important part of this equation is patient education concerning potential cumulative effects of radiation long term.

In the younger population check PACS for old prior studies.

Orbital CT / Facial Bones Sinus Imaging Recommendations

CT should be performed for a patient with orbital trauma with any of the following findings:

- Evidence of a fracture on physical examination.
- Limitation of extra ocular motility.
- Decreased visual acuity.
- Severe pain.
- Inadequate examination (usually because of soft tissue swelling), particularly in patients with altered mental status.
- Sinusitis: *Always* do plain sinus films first.
  - Clouding of the maxillary sinus indicates the possibility of blood or orbital fat in the sinus as the result of an orbital floor fracture.
  - Plain sinus films and a Waters view constitute a good screening tool with a minor injury.

The sensitivity of plain radiographs for detecting orbital fractures is poor (about 50 percent). In addition, plain radiographs are often difficult to interpret and are inadequate to determine whether or not a patient requires operative intervention.

They may be useful as a screening tool when CT is unavailable or for children with a minor mechanism of injury who would require sedation for CT.

Guidelines LS Spine Imaging

The initial Study for Low back pain and Trauma should be Plain Films.

LS Spine CT should be limited to fractures. Any Other Imaging of the LS spine (Pain Tumors Discs) should be done via MRI.

The guidelines were reviewed with other physicians in the hospital to gain their buy-in and input.

Pilot Improvements

The ED physicians began piloting the new guidelines in January 2010. They held a Grand Rounds for the hospital in March 2010 to share the guidelines. There was some reduction in the percent of CT scans in April 2010 to 41 % from the average percent of CT scan in 2009 of 48.3 %, shown in Fig. 7.17. The percentage of CT scans went up through September 2010. The team held a more extensive review of the CT Scan guidelines in another Grand Rounds session in mid October 2010. The Director and Co-Directors again worked with the ED Physicians to encourage the use of the CT Scan Guidelines. The percentage of CT scans was again reduced to an average of 39.6 % for October through December 2010, shown in Fig. 7.18. This was an 8.7 % reduction in the percentage of CT-scans ordered in the ED. We performed a two-proportion test, which was statistically significant with a p-value of 0.000.

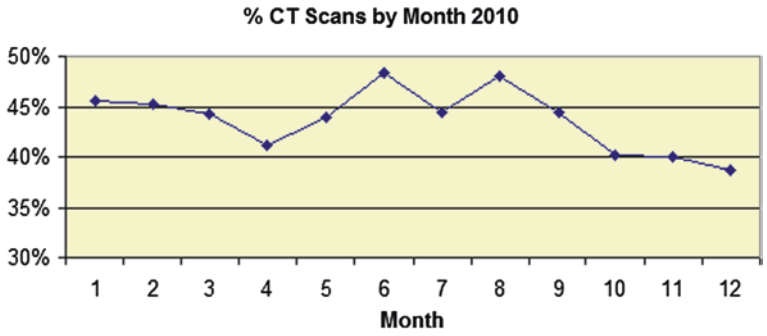

Fig. 7.17 Percent of CT Scans in 2010 by month

	2008	2009	2010 (Jan thru Sept)	2010 (Oct thru Dec)
Number of CT scans	17427	15933	12085	3701
Total Number Patients	32637	32963	26817	9346
% CT Scans	53.4%	48.3%	45.1%	39.6%
Count of Patients with CT Scans	10794	10079	7674	2352
% Patients with CT scans	33%	31%	29%	25%
	2008 to 2009	2009 to 2010 (Jan through Sept)	2009 to 2010 (Oct through Dec)	2008 to 2010 (Oct through Dec)
Reduction in %CT scans:	5.1%	3.3%	8.7%	13.8%

Fig. 7.18 Percent of CT scans in ED patient population, for January through June 2009, compared to January through June 2010

Modality	Count 2009	% 2009 by Modality	Count 2010	% 2010 by Modality	P-value
CT.CTBRAINWO	5099	32.0%	4792	30.4%	Reduced, 0.002
CT.CTPELVISWO	2612	16.4%	2558	16.2%	Same, 0.68
CT.CTABDWO	2560	16.1%	2508	15.9%	Same, 0.694
CT.CTABDW	1129	7.1%	1325	8.4%	Increased, 0.000
CT.CTPELVISW	1136	7.1%	1318	8.3%	Increased, 0.000
CT.CTCSPINEWO	948	5.9%	821	5.2%	Decrease, 0.004
CT.CTACHEST	844	5.3%	815	5.2%	Same, 0.607
CT.CTABDOR	331	2.1%	392	2.5%	Increased, 0.015
CT.CTPELOR	328	2.1%	389	2.5%	Increased, 0.015
CT.CTMAXFACE	267	1.7%	260	1.6%	Same, 0.494
CT.CTCHESTWO	158	1.0%	179	1.1%	Same, 0.228
OTHER:	540	3.4%	429	3%	Reduced, 0.001
Total	15951		15786		

Fig. 7.19 CT percentage by CT modality, before and after improvements (highest frequency CTs)

There was a 13.8 % reduction in the percent of CT scans since 2008 to October through December of 2010, with a statistical significance and a p-value of 0.000.

The percentages by patient for number of CT scans also was reduced from the baseline, as shown in Fig. 7.18. Six percent (6 %) of patients had three to a maximum of seven different CT modalities in the time period of 2009. For 2010, only 5 % of patients had 3 to 7 different CT modalities in this time period.

For the highest frequency of CT modalities, all percentages of CT exams per count of patients decreased or remained the same, except for the CT Abdomen with contrast and CT pelvis with contrast increased from 7 to 8 %; and the CT abdomen and pelvis with and without contrast increased as well. This data is shown in Fig. 7.19.

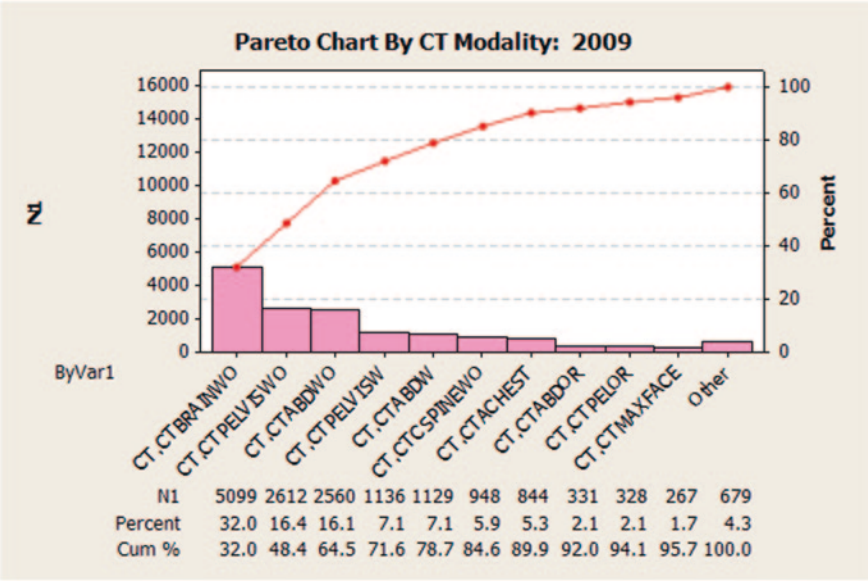

Fig. 7.20 Pareto chart by modality before improvements 2009

The Pareto charts before and after improvements by CT modality type are shown in Figs. 7.20 and 7.21. The highest modality by occurrence before and after improvements is the CT Brain without contrast, followed by the CT Abdomen without contrast.

The percentages of CT scans was either reduced or stayed the same for each physician, based on the statistical significance using a 2-proportion test, after implementing the CT guidelines.

The CT guidelines have been very effective in:

- Reducing the number of CT scans for the Emergency Department patients;
- Reducing their radiation exposure due to the CT scans;
- Using CT scans more appropriately.

Train and Execute

The Nurse Educator developed training to share the CT guidelines with the ED nurses. The Radiologist created a memo to ensure that the radiology technologists view the patient history prior to performing the ordered CT scan to assess whether the patient has had recent CT scans in the hospital. They would then notify the ED physician if there is history of prior CT scans in the hospital, to determine if the CT should still be performed.

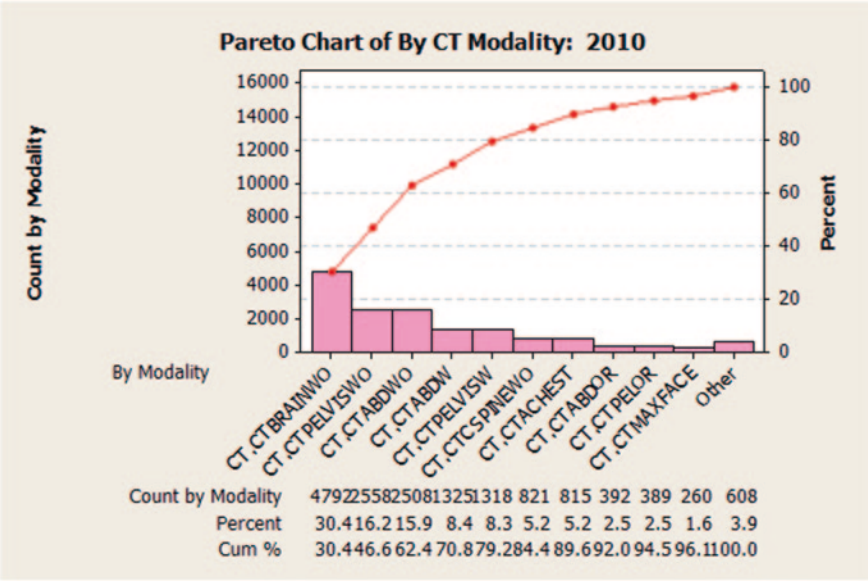

Fig. 7.21 Pareto chart by modality after improvements 2010

Control Phase

The purpose of the Control Phase is to implement control mechanisms and procedures to ensure that the process maintains the levels of improvements attained during the pilot activities.

The following activities were executed in the Control Phase:

1. Measure results and manage change
2. Report scorecard data and create process control plan
3. Identify replication opportunities
4. Develop future plans

Measure Results and Manage Change

We measured the results and continue to manage the implementation of the CT guidelines.

Report Scorecard Data and Create Process Control Plan

The control plan is to continue to monitor the following metrics:

(1) Percent of CTs across the Emergency Department patients

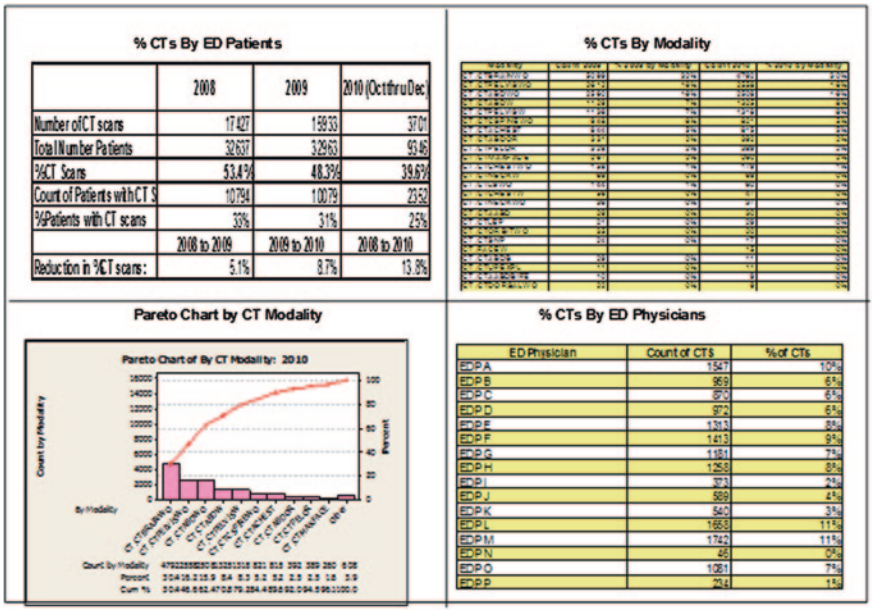

Fig. 7.22 Dashboard

(2) Frequency of CTs by modality.
(3) Average CTs per patient.
(4) Percent of CTs by Physician.
(5) Radiation exposure to patients. This metric had not yet been collected, but there are plans to capture the radiation received during the CT exams.

An example dashboard is shown in Fig. 7.22.

Identify Replication Opportunities

There are potentially other opportunities to implement the CT guidelines for the inpatients, as well as in other hospitals.

Develop Future Plans

Physicians can now receive up to 20 Continuing Medical Education requirements for performance improvement education and projects, as the physicians did for this project. They plan to continue other efforts to enhance practice performance using the Lean Six Sigma methodology.

Conclusions and Critical Success Factors

This project was very successful in applying the Six Sigma methodology to reduce the number of CT scans ordered and performed for the Emergency Services patients at the hospital. While nationally, Emergency Departments are increasing the usage of CT scans by about 10 % per year, this project demonstrates that applying CT technology appropriately provides satisfactory medical diagnoses, without jeopardizing patient safety. We successfully reduced the percent of CT scans by **8.7%** from 2009 to 2010 in the October through December timeframe, and **13.8%** since 2008. While many departments are increasing the number of CT scans, we have successfully reduced the utilization of CT scans to better align physician CT orders to medical guidelines.

The critical success factors of this project were:

- Physician specialists including ED physicians and radiologists working together to develop appropriate CT guidelines.
- Physicians and librarians working together to research appropriate medical guidelines for CT utilization.
- Application of the Six Sigma methodology in understanding the current state, the root causes, analysis of data to show and maintain improvement and change management to encourage buy-into the improvement ideas.

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Chapter 8
Linen Loss Reduction in an Acute Care Hospital

Abstract This chapter describes a case study in an acute care hospital that formed a cross-functional team to apply the Lean Six Sigma problem solving methodology and tools to improve the linen processes. The goal of the project was to identify and implement process improvements that would reduce linen loss. We applied the (Define-Measure-Analyze-Improve-Control)(DMAIC) problem solving approach and within the first 6 months of implementation we improved the soil to clean linen ratio by 1.1 % and saved over $75,000 for the first year.

Introduction

This case study provides an application of a Lean Six Sigma improvement project in the support services area of an acute care hospital. The goal of the project was to reduce linen loss across the hospital. Although at first glance, this problem seems like it would not have a great impact on hospital services, linen is used by almost every department in the hospital that touches patients of the hospital. The linen loss can be quite high. When we started the project, we did not have an understanding of which departments use or lose the most linen or the root causes of the linen loss. We didn't know if the highest amount of linen was leaving with patients when they are discharged, or when they get transferred to a Skilled Nursing Facility (SNF); if ambulances are taking the linen when they leave the Emergency Department (ED); if scrubs are "walking" out of the hospital; or if there is a problem with employee theft. This project applied Lean Six Sigma because it was (1) an important problem to the hospital, and (2) it is an unstructured problem, that could leverage the data analytical tools of Six Sigma.

This chapter will be organized into the phases of the Define-Measure-Analyze-Improve-Control(DMAIC) problem solving methodology. The purpose of each phase is described here:

(1) Define: The purpose of the Define phase is to delineate the business problem and scope the project and process to be improved.

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(2) Measure: The purpose of the Measure phase is to understand and document the current state of the processes to be improved, collect the detailed Voice of the Customer information, baseline the current state, and validate the measurement system.
(3) Analyze: The purpose of the Analyze phase is to analyze the data collected related to the Voice of the Customer and the Voice of the Process to identify the root causes of the process problems, and to develop the capability of the process.
(4) Improve: The purpose of the Improve phase is to identify improvement recommendations, design the future state, implement pilot projects, train, and document the new processes.
(5) Control: The purpose of the Control phase is to measure the results of the pilot projects, and manage the change on a broader scale; report scorecard data and the control plan, identify replication opportunities, and develop future plans for improvement.

Define Phase

The Supply Chain committee identified the problem of linen loss. This committee reviews supplies expense and identifies where there is potential opportunity for reducing these expenses. They identified opportunity in reducing loss of linen in the hospital. The hospital is part of a consortium of hospitals in the area who jointly own a linen processing facility. The clean linen in the hospital is received at the receiving dock on a daily basis from what is ordered the day before. The linen is distributed by hospital stores/materials management on a scheduled basis. The soiled linen is gathered by Environmental Services and shipped each morning after the clean linen is delivered. The soiled linen is taken to the linen facility and cleaned.

The following steps were executed in the Define Phase:

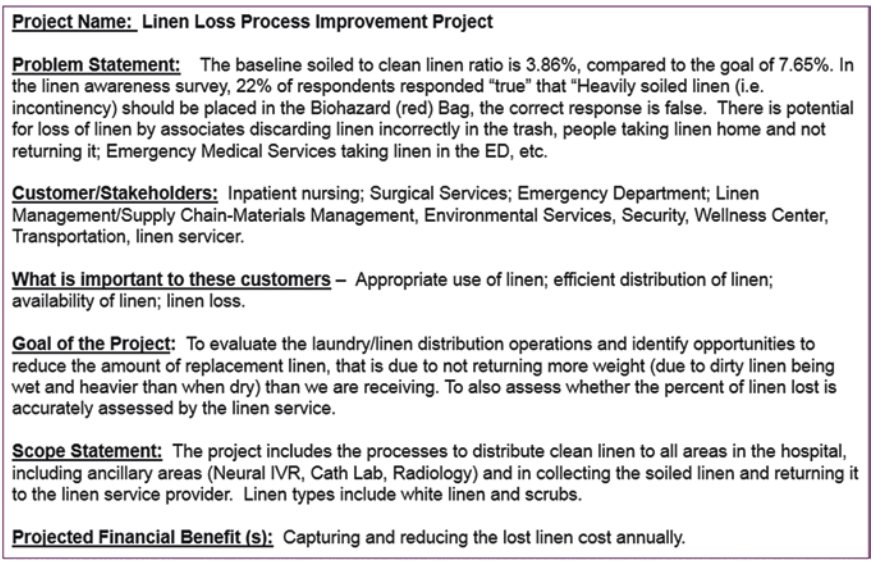
1. Develop project charter
2. Perform stakeholder analysis
3. Perform initial Voice of Customer (VOC) and Identify Critical to Satisfaction (CTS)
4. Select team and launch the project
5. Create project plan

Develop Project Charter

The project charter is shown in Fig. 8.1, Project Charter.

Perform Stakeholder Analysis

The primary stakeholders are the inpatient nursing units whose patients use linen during their hospital stay. They are concerned with having enough linen at any given time, and having presentable linen. The Materials Management or Hospital Stores



Project Name: Linen Loss Process Improvement Project

Problem Statement: The baseline soiled to clean linen ratio is 3.86%, compared to the goal of 7.65%. In the linen awareness survey, 22% of respondents responded "true" that "Heavily soiled linen (i.e. incontinency) should be placed in the Biohazard (red) Bag, the correct response is false. There is potential for loss of linen by associates discarding linen incorrectly in the trash, people taking linen home and not returning it; Emergency Medical Services taking linen in the ED, etc.

Customer/Stakeholders: Inpatient nursing; Surgical Services; Emergency Department; Linen Management/Supply Chain-Materials Management, Environmental Services, Security, Wellness Center, Transportation, linen servicer.

What is important to these customers – Appropriate use of linen; efficient distribution of linen; availability of linen; linen loss.

Goal of the Project: To evaluate the laundry/linen distribution operations and identify opportunities to reduce the amount of replacement linen, that is due to not returning more weight (due to dirty linen being wet and heavier than when dry) than we are receiving. To also assess whether the percent of linen lost is accurately assessed by the linen service.

Scope Statement: The project includes the processes to distribute clean linen to all areas in the hospital, including ancillary areas (Neural IVR, Cath Lab, Radiology) and in collecting the soiled linen and returning it to the linen service provider. Linen types include white linen and scrubs.

Projected Financial Benefit (s): Capturing and reducing the lost linen cost annually.

Fig. 8.1 Project charter

staff distributes the clean linen, and counts the returned unused linen. They are concerned with having streamlined ownership of the linen, instead of co-ownership with Environmental Services. They are also concerned with having control of the linen and the scrubs, and appropriate use of the linen, mostly by the Emergency Medical Services (EMS) that bring patients to the ED. They are concerned with having adequate linen in the facility, and having appropriate resources to manage the linen. The next stakeholder group is Surgical Services, including the Operating Room (OR) staff, Endoscopy, Sterile Processing, Outpatient (pre-op, holding, OR and recovery room) staff who provide linen for patients; and who use green scrubs. This group also includes labor and delivery that use scrubs. They are concerned with having enough linen and green scrubs when needed, and having the scrubs being secure. The ED uses linen, as well as provides some linen to EMS and ambulances, as is the protocol in the community. They are concerned about the EMS taking too much linen, linen being available when needed, and the linen being presentable. Environmental Services picks up soiled linen and strips the bed and pulls clean linens to make beds. They are concerned with the ease of collecting soiled linen in patient areas; having the space to store soiled linen; having to maneuver the linen carts through tight hallways with overhead pipes and low ceilings, and having to load and reload the linen to maximize the weight being sent out. They are also concerned with patient satisfaction related to not changing the beds daily when they are not soiled. Security provides hospital security, which could impact theft and access to linen. They are concerned with balancing linen availability while having it secure. The Wellness Center members use linen (towels) when they work out. They are concerned with towels walking out with members, the staff using linen to clean up spills, and balancing delivery and volume. They also said

Stakeholders	Who They Are?	Potential Impacts/Concerns
Inpatient nursing	Nurses who care for patients and provide linen to patients	▪ Having enough linen at any given time ▪ Having linen be presentable
Supply Chain / Materials Management	Distribute clean linen	▪ Streamlined ownership of linen (not co-ownership) ▪ Control of linen (not wide open) ▪ Appropriate use (ED- EMS) ▪ Control of scrubs ▪ Adequate linen in the facility ▪ Resource availability to manage linen (productivity standard)
Surgical Services	Operating room, Endoscopy, Sterile Processing, Outpatient (pre-op, holding, OR and recovery room) staff who provide linen for patients; and who use green scrubs; labor and delivery	▪ Have enough linen and scrubs when we need it ▪ Auto valet for the scrubs (vending machine) or a person
Emergency Department	Emergency Department staff who provide linen for patients in the ED.	▪ EMS services taking linen ▪ Linen available when needed ▪ Having linen be presentable

Fig. 8.2 Stakeholder analysis, page 1

Stakeholders	Who They Are?	Potential Impacts/Concerns
Environmental Services	Environmental services pick up soiled linen; strip the bed and pull clean linens to make beds.	▪ Ease of collecting soiled linen (have to go into patient rooms-hampers in patient rooms) ▪ Space to store soiled linen ▪ Difficulty loading and storing soiled linen. ▪ Ramp and pipes, safety and ergonomic issue.
Security	Provides hospital security, which could impact theft and access to linen.	▪ Linen availability ▪ Improved security
Wellness Center	Wellness Center members that use linen (towels) when they work out.	▪ Towels walking out ▪ Staff using linen to clean ▪ Members like towels ▪ Balance of delivery and volume
IVR, Cath Lab, Radiology	Ancillary departments that use linen	▪ Delays in linen delivery (delay 1st procedures) ▪ Insufficient supply of correct sizes (gowns)

Fig. 8.3 Stakeholder analysis, page 2

that the members do like having access to and being able to use the towels. The stakeholder analysis is shown in Figs. 8.2 and 8.3.

Suppliers-Inputs-Processes-Outputs-Customers

The Suppliers-Inputs-Processes-Outputs-Customers (SIPOC) for the linen loss reduction project is shown in Fig. 8.4. The first high-level process is ordering linen. Most linen is ordered on a daily basis by the departments. Hospital Stores

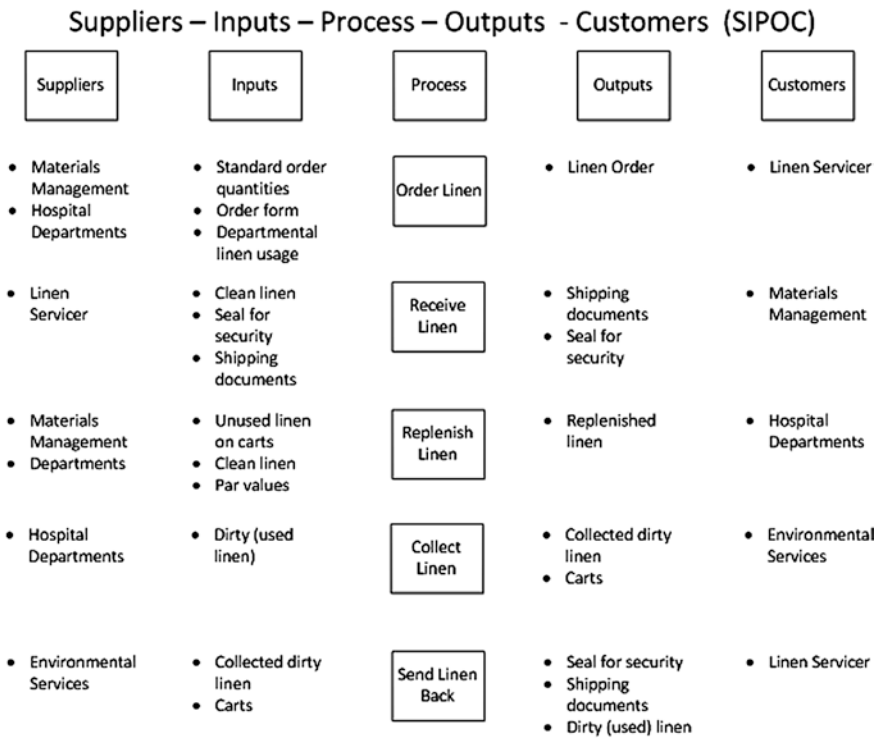


Fig. 8.4 SIPOC

consolidates the orders and faxes them daily to the linen service provider. The next process is to receive the linen on the receiving dock in the morning. Hospital Stores receives the linen and places the carts in the linen room. The Linen staff replenishes the linen to the floors either by a cart exchange or par level refills. Environmental Services collects the soiled linen from the patient hampers and locations in the ancillary departments, and then stores them in the basement until they are sent to the linen service provider in the morning.

Perform Initial Voice of Customer and Identify Critical to Satisfaction

The CTS criteria for this project are:

- **Appropriate use of linen:** That linen is used appropriately and is not lost or stolen.
- **Efficient distribution of linen:** That linen is distributed in an efficient and timely manner. We will not measure this CTS since it is out of scope of the project.

- **Availability of linen:** That linen is available when needed and in the appropriate quantities for use.
- **Security of linen:** That linen is secure and is not lost or stolen.
- **Loss of linen:** The amount of linen that is lost, not used and not returned to the linen processor.

Select Team and Launch the Project

The team consisting of the cross-functional stakeholder group was formed and the project was launched by reviewing the project charter that was developed by the Lean Six Sigma Master Black Belt mentor. The team members included: Materials Management/Linen, Nursing, Environmental Services, Wellness Center, Security, Surgical Services, ED, Imaging, and the Enterprise Performance Excellence Center.

Create Project Plan

Project Milestones

The project was started in May. The Define phase was completed by May 3rd. The Measure phase was completed on May 31st. The Analyze phase ended June 14th. The Improve phase ended January 31st. The Control Phase will continue until the improvements are complete and improvement is shown, which is estimated to be complete in June. The milestones are shown in Fig. 8.5.

After the team completed the Define phase, we moved into the Measure Phase.

Measure Phase

The Measure Phase included the following activities:

1. Define the current process
2. Define detailed VOC
3. Define the Voice of Process (VOP) and current performance
4. Validate measurement system

Define the Current Process

The first step was to map the current process by creating detailed process maps of the linen distribution, replenishment, and soiled linen collection. A description of each process follows.

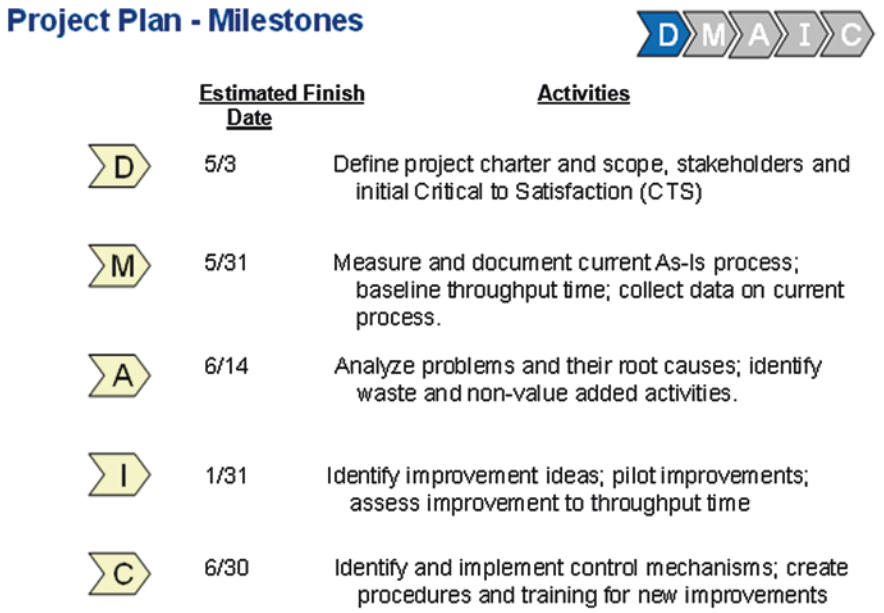


Fig. 8.5 Project milestones

Order Linen:

Materials Management will compare the usage to the demand for linen to determine the linen to order on a daily basis. They use a standard order form with standard quantities. If the quantities to order are more than 20 % over the standard order quantity, the Materials Manager must approve the order. Once the orders are complete, they are faxed to the linen service provider.

Replenish Linen:

For the departments with higher usage, they replenish linen on an exchange cart system. In the morning, the Linen Department takes a refilled cart to the department and exchanges it with the cart that was on the floor. It will have some linen on it that was not yet used. The Linen Department takes the cart to the basement, counts the returned items, and records the quantities in the Linen database. For the departments with lower linen usage, a par replenishment system is used to replenish linen. On Mondays, Wednesdays, and Fridays, the Linen Department takes a cart to these departments and replenishes the linen that is needed on the departmental cart. They scan the items and count the items replaced, then download them to the Linen database. A few departments will replenish the linen on an as-needed basis by calling or coming to the Linen Department and picking up the Linen. If no one is in the Linen department when the person arrives, they may or may not leave a note to notify the Linen department that they retrieved linen. Therefore, sometimes the linen is removed, but not recorded.

Receive Linen and Return Soiled Linen:

The clean linen is delivered each morning by the linen processor on the loading dock. Receiving verifies the seal number that is put on at the linen processor to ensure that no linen is removed from the truck in transit. They break the seal, unload the linen, and sign for receipt of the linen. The soiled linen that was collected from the prior day is moved to the basement and staged there until the morning. It is then moved to the shipping dock in the morning and moved onto the truck. A new shipping seal is created, the number is logged, and it is put on the truck with the dirty linen. The seal number is checked when it is received at the linen processor. The linen is not currently weighed at the hospital either when it is received or when it is being shipped to the linen processor.

Use Linen and Collect Soiled Linen:

In the Wellness Center, the linen cart is delivered in the morning by the Linen Department. It is left in the hallway outside the Wellness Center, and then is stored in the clean utility room by the Wellness Center staff. The Wellness Center uses mostly towels, and some flat sheets for massage tables. The Wellness Center stores some of the towels at the front desk. The members must ask for towels at the front desk. There is currently no limit to the number of towels that the members can use. After use, the towels are dropped in the linen hampers which are in the locker rooms, and in other locations throughout the Wellness Center. The Wellness Center staff collects the used towels several times a day and moves them to the soiled linen room. Sometimes the soiled linen room door is propped open for convenience, and is not secure. The soiled linen is collected daily from the soiled linen room.

In the ED, they receive the linen cart in the morning and in the evening. The cart is stored in the hallway, unsecured. The ED staff stocks each room with the linen that they think they will need for the day. However, during our walkthrough of the areas, the team noticed that there appeared to be excessive linen in the cabinets (more than one day's usage of linen). The ED staff collects the dirty linen after each patient is finished in the room, and places it in a linen hamper. Linen is stored in the EMS room in the open and is available for the EMS and ambulances to take as they desire. The soiled linen is collected daily from the hampers by Environmental Services staff.

Patient Floors:

On the patient floors, the linen is delivered daily in the morning to the clean utility room. The Patient Care Technicians (PCTs) or Licensed Practical Nurses (LPNs) take the linen that they need for their areas, place it on a rolling cart, and move it to their areas. The patients use the linen in the rooms when needed. The PCTs or LPNs remove the soiled linen and place it in linen hampers within each patient room. Environmental Services collects the dirty linen from the linen hampers and moves it to the linen shoots or to the basement. There is potential for loss due to the combination lock on the clean utility room not being changed, being an easily identified code, or the door not being secure. Additionally, linen is taken by the ambulance when a patient is transferred to a Skilled Nursing Facility (SNF).

The OR receives the linen daily in the morning. They store the carts in the hallway. The OR techs load up a cart and distribute the linen to the operating rooms, the Preoperative area, and the Post-Anesthesia Care Unit (PACU). The patients use the linen, and then it is placed in blue linen bags. The techs take the soiled linen bags to the soiled linen room after each surgical procedure. The scrubs are delivered to each locker room. The soiled scrubs are placed in linen bins, and picked up by Environmental Services several times a day. There is a large problem of OR staff leaving the hospital with the OR scrubs, which should not be done. The hospital is losing an average of about 10 pairs of scrubs a day or 3,650 scrubs a year.

Process Dirty Linen at Linen Service Provider:

After the soiled linen is placed on the truck each morning, the truck driver takes the linen to the Linen Service Provider (the plant). The truck driver unloads the carts, and places them on the ramps in the front of the plant. They verify the seal number that was placed on the truck before leaving the hospital. They scan the bar code on the cart, which registers the cart weight, and then places the cart on the scale. The weight of the cart is subtracted from the total weight with the cart and the dirty linen, to get the weight of the soiled linen. Each cart is weighed and the weight is recorded in the Linen System.

Each bag is opened and taken to a conveyor belt, where the linen is sorted into bins by type. Any trash that is mixed with the linen is removed, as well as any patient items that may have also got mixed with the linen. The linen drops into bags below the bins, and then the bags are moved to the washers. The carts are moved to the disinfector station and are disinfected. The linen is washed by linen type and then moved to the dryers, where they are dried and then moved to the presses, if necessary. The linens are pressed and then moved to the folding areas. As the linen is folded it is checked for stains. The stained linen is moved to the stained linen room. The stained linen is reviewed to see if it can be cleaned or discarded. The orders are built from the order forms, and moved to the weighing area. The linen is weighed. If there are more than 50 pieces, by linen type, over the number of pieces ordered, the pieces are counted and removed. If the order is underweight and therefore missing linen, the supervisor is notified, and he or she retrieves the missing linen and places it with the order. When the order is the correct weight, the plastic bag is heat sealed and moved to the loading dock. The truck is loaded for the specific hospital, sealed, and sent to the hospital.

The process maps for the linen distribution, replenishment, and soiled linen collection are shown in Figs. 8.6, 8.7, 8.8, 8.9, 8.10, and 8.11.

Data Collection Plan

To measure the CTS' we developed the data collection plan shown in Fig. 8.12.

Soil to Clean Ratio:

The soil to clean ratio is used to assess the linen loss in the hospital. Since soiled linen is potentially wet, it will be heavier than clean linen. The linen is expected to weigh 10 % more wet than dry. For example, if 1,000 pounds of dry

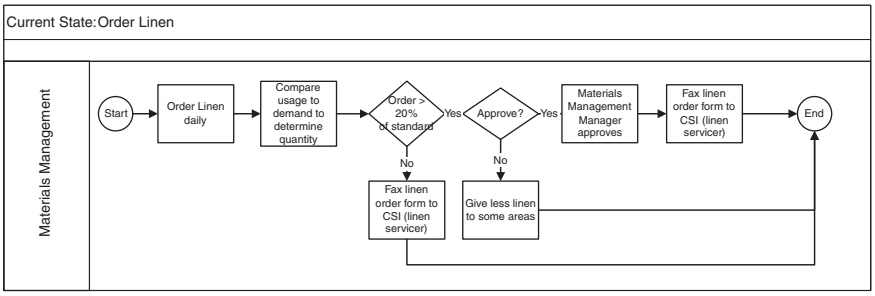


Fig. 8.6 Process map: order linen

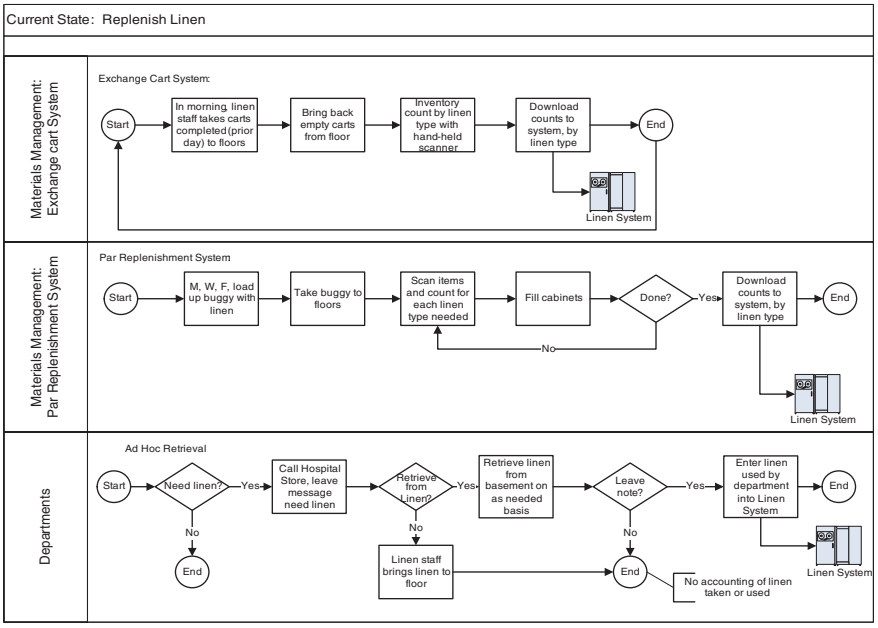


Fig. 8.7 Process maps: replenish linen

linen is delivered to the hospital, the expected soiled linen weight is 1,100 points [1,000 times 1.10 (or 110 %)]. So the soiled linen ratio is

$$\left[1 - \left(\frac{\text{Clean Weight}}{\text{Soiled Weight}}\right)\right] * 100\ \%$$

For example:

$$\left[1 - \left(\frac{1,000}{1,100}\right)\right] * 100\ \% = 9.1\ \%$$

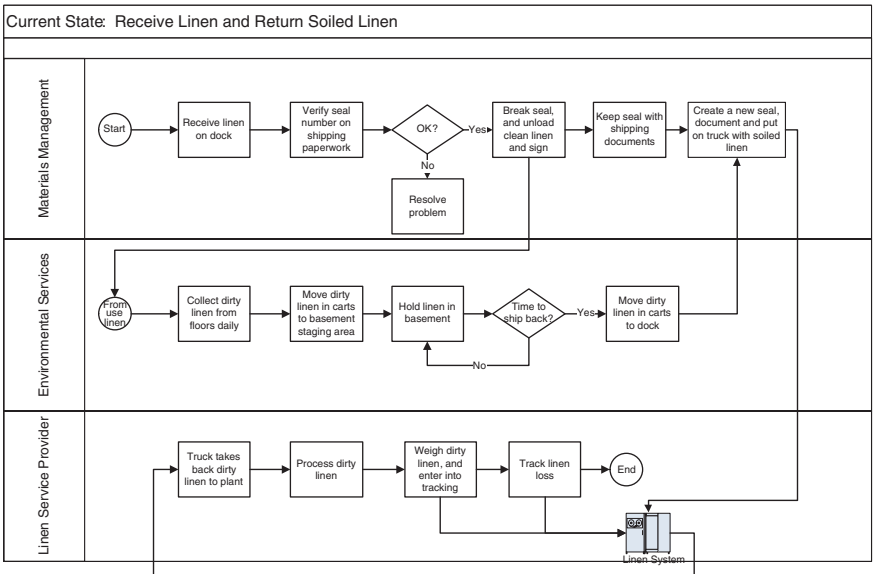


Fig. 8.8 Process map: receive linen and return soiled linen

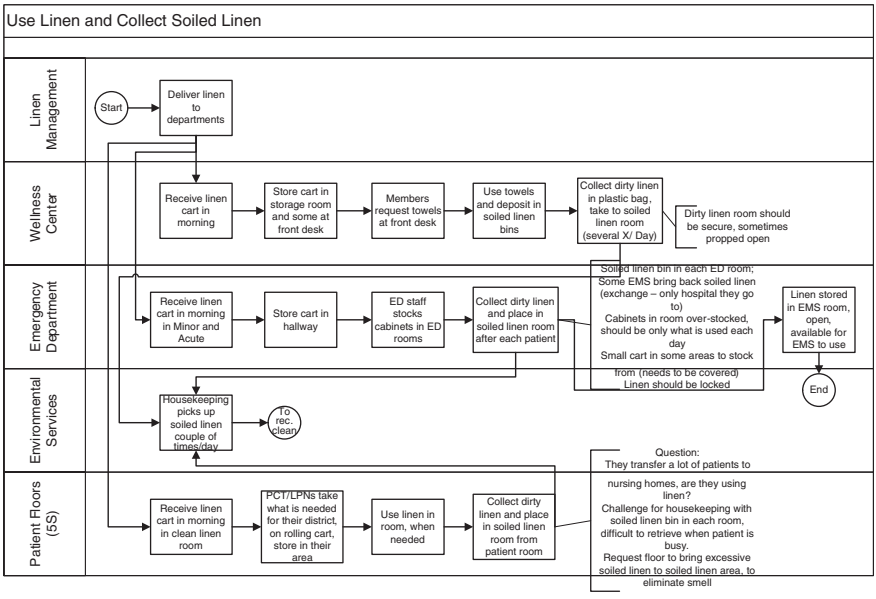


Fig. 8.9 Process map: use linen and collect soiled linen

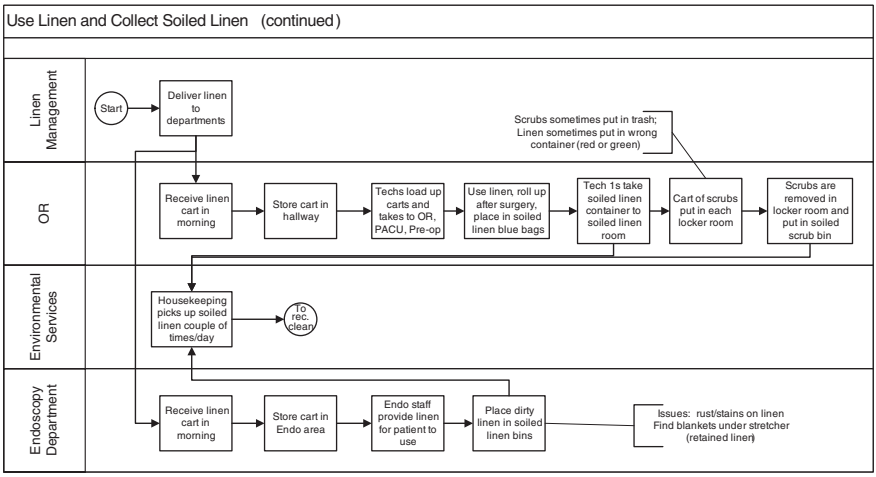


Fig. 8.10 Process map: use linen and collect soiled linen (continued)

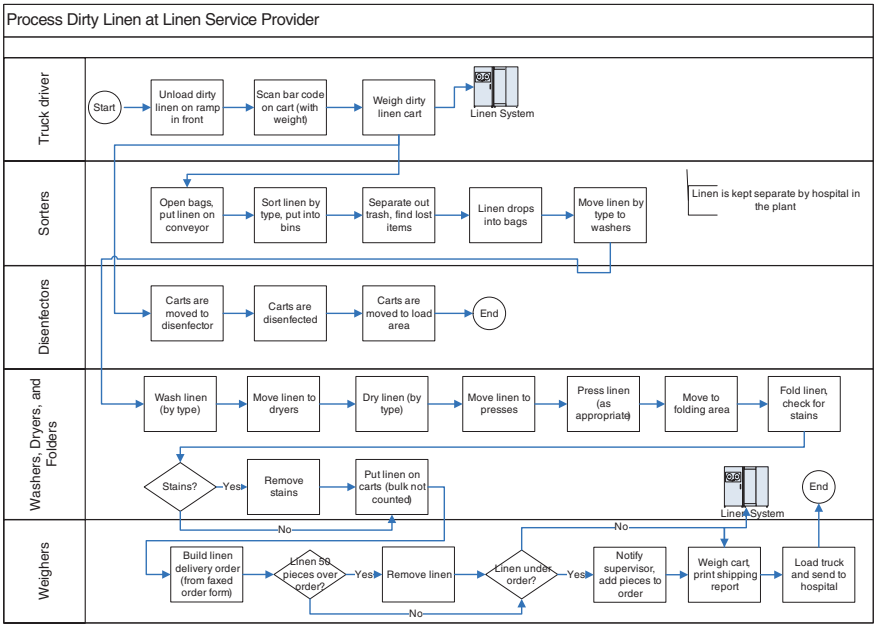


Fig. 8.11 Process maps: process dirty linen at linen service provider

Any soiled linen ratio less than 10 % shows a loss of linen, indicating that the hospital is returning less than what was delivered to them.

Critical to Satisfaction (CTS)	Metric	Data collection mechanism (survey, interview, focus group, etc.	Analysis mechanism (statistics, statistical tests, etc.)	Sampling plan (sample size, sample frequency)	Baseline
Linen usage Linen loss	Soil to Clean Ratio: 1 – (Clean/soiled)	Linen Servicer provides these numbers	Basic statistics	1st quarter	1 – (434,737/452,183 = 3.86%
Linen usage; appropriate use of linen	Pounds per adjusted patient days: (Pounds linen delivered/adjusted patient days)* 100%	Linen Servicer provides these numbers	Basic statistics	April	10.46%
Linen usage	Usage by department and type	Linen Database	Basic statistics	1/2 to 5/23	Average pieces linen used per day per department ~27
Annual linen replacement cost	Annual cost of replacing linen	Linen servicer provides these numbers	Basic statistics	Q1 and Q2	Scrubs, Linen and Total
Annual Linen Processing Cost	Cost of processing linen	Linen servicer provides these numbers	Basic statistics	Q1 and Q2	Scrubs, Linen, and Total

Fig. 8.12 Data collection plan

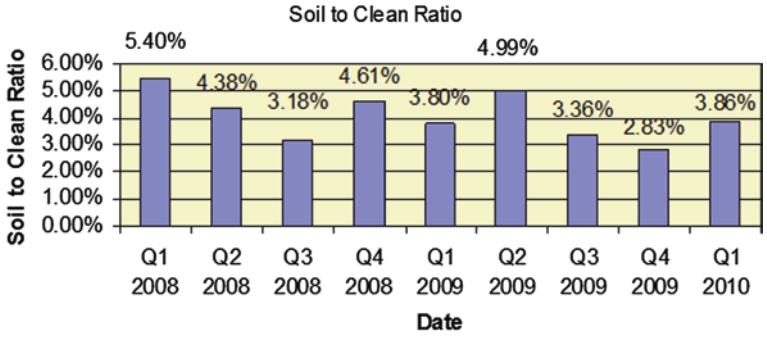


Fig. 8.13 Soil to clean ratio

The soil to clean ratio on a quarterly basis is shown in Fig. 8.13.

Pounds per Adjusted Patient Days:

The appropriate linen usage is measured by the pounds per adjusted patient days. This assesses the amount of linen used per patient. The national average is 14.89 pounds per adjusted patient day. (Encompass Textiles and Interiors 2004). The March value is 10.46 pounds per adjusted patient days, which is lower than the national average. Therefore, less linen is used for each patient than the national average. The monthly values are shown in Fig. 8.14.

Usage by Department:

The usage by department for the January through May 23 time period averages about 27 linen pieces per day per department.

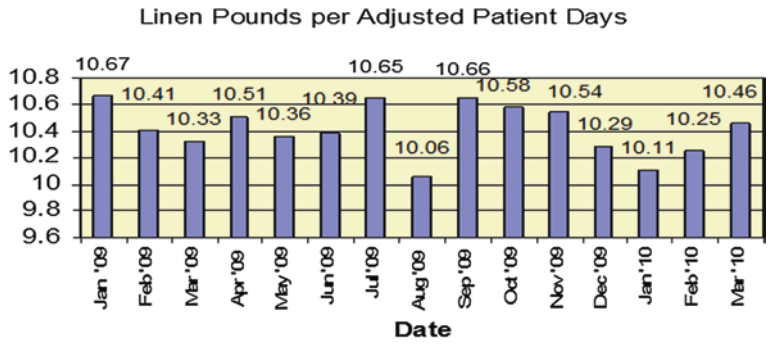


Fig. 8.14 Pounds per adjusted patient days

Define Detailed Voice of Customer

We walked through the linen processes to better understand the needs of the stakeholders and gained insight from the team members that represented the stakeholders. We derived the following CTS criteria.

- **Appropriate use of linen:** That linen is used appropriately and is not lost or stolen. This was measured by the linen loss variance, the soiled to clean ratio, and the linen pounds per adjusted patient days.
- **Efficient distribution of linen:** That linen is distributed in an efficient and timely manner. We will not measure this CTS since it is out of scope of the project. It is important that the departments have the linen in a timely manner, but since we're focused on linen loss, this is not part of the scope of the project.
- **Availability of linen:** That linen is available when needed and in the appropriate quantities for use. This is measured by understanding the linen usage in each department.
- **Security of linen:** That linen is secure and is not lost or stolen. This is measured by soiled to clean ratio, and linen loss variance.
- **Loss of Linen:** The amount of linen that is lost, not used, and not returned to the linen processor. This is measured by soiled to clean ratio and linen loss variance.

Define the Voice of Process and Current Performance

The current baseline performance for each metric is shown in Fig. 8.15.

The pounds per adjusted patient day and the average pieces used per day per department are both already meeting their targets. The hospital has a very good linen use per patient. However, the loss is still very high, causing costly linen replacement per year. The soil to clean ratio is currently at 3.86 % and the target is currently 7.86 %. We are estimating savings of 30 % reduction in replacement cost and an estimated savings of about 21 % in linen processing cost.

Metric	Current Baseline	Target for Improvement
Soil to Clean Ratio	3.86%	7.86% (higher is better)
Pounds per adjusted patient day	10.46%	14.89% (lower is better)
Linen usage: Average pieces used per day per department	27	38 (lower is better)
Annual Linen Replacement Cost	Confidential	Target to be determined
Annual Linen Processing Cost	Confidential	Target to be determined

Fig. 8.15 Current baseline and targets

Validate Measurement System

The linen service provider validated the soil to clean ratio by taking a sample of wet linen when it came to the plant, weighed it when it arrived, cleaned it, and then reweighed the same sample of linen when it was dry. The soil to clean ratio in this sample was about 11 %. Although they are expecting soiled linen weighing only 10 % more than the dry linen previously delivered, they are allowing a 1 % loss.

At the start of the project, the hospital did not currently weigh the clean linen received or the soiled linen being moved to the plant to be cleaned. We implemented an attribute acceptance sampling plan to validate the accuracy of the soiled linen measurement system. There is a median of 15 carts of soiled linen returned to the linen processor each day during the week (Monday through Friday). A sample of 5 soiled linen carts per day are taken and weighed before they leave the facility. The linen processor data, when they weigh the soiled linen carts upon arrival to the linen facility was compared to the sampled soiled linen cart weights. In September, there was a 0.2 % average difference (1.3 pounds) in the linen cart weights. In October, there was a −0.1 % average difference (−0.3 pounds) in the linen cart weights. An average 5 % weight variance is deemed acceptable for each cart. The lot is accepted if the number of defects in 5 items (weight difference of cart is greater than 5 %) is less than or equal to 1 cart. Otherwise reject the lot, and conclude that there is a significant difference in soiled linen weight between the hospital and the linen processor. We conclude that the measurement system is adequate.

Analyze Phase

The following activities were performed for the Analyze Phase to identify and validate the root causes and to assess whether the process is currently capable of meeting the desired specifications.

1. Develop cause and effect relationships
2. Determine and validate root causes
3. Develop process capability

Develop Cause and Effect Relationships and Validate Causes

We brainstormed the potential root causes for linen loss, and created several Why-Why Diagrams, shown in Figs. 8.16, 8.17, and 8.18.

There are many root causes of losing linen. Linen is not secured in the basement linen room. There is a door that leads to the hospital storeroom that is left unlocked, mainly for the convenience of the linen and hospital storeroom staff. We don't weigh the linen coming into or going out of the hospital. Therefore, we have no way of validating that the linen is being recorded properly by the linen service provider. The scale is broken, and it has not been a priority to get it fixed, nor to weigh or validate the linen weight coming in or out of the hospital.

The clean utility rooms on the nursing floor and units are not always locked. When they are locked, the combination many times never changes, is a simple code that almost anyone can guess, or is posted on the door.

Approximately 10 hospital scrubs leave the hospital or are unaccounted for each day. There is no adherence to the policy that the green scrubs must remain in the hospital. No one should be leaving or coming into the hospital dressed in the green scrubs. However, no one is holding the staff accountable to the policy. There is also no process to monitor people leaving the hospital with the scrubs. Although there is one main employee entrance/exit, the staff uses many of the multiple doors to the hospital. The scrubs are also distributed on open shelves in the OR locker rooms, with no securing or dispensing to appropriate staff. The scrubs are supposed to be returned to linen bins in the locker rooms, but are found in the trash. The OR staff is either not trained, or does not adhere to the policy.

The EMS that bring patients to the Emergency Room have open access to linen in the EMS room, take what they desire, and do not always bring the linens back. Patient linen is also open and unlocked in the ED rooms. The linen is often overstocked for the convenience of the staff, leaving large amounts of linen unsecured in the ED rooms. Linen is also on unlocked carts in the ED hallways.

When patients are transferred to Skilled Nursing Facilities (SNFs), linen often is transferred with them. It has not been policy to ask the ambulance drivers to bring their own linen.

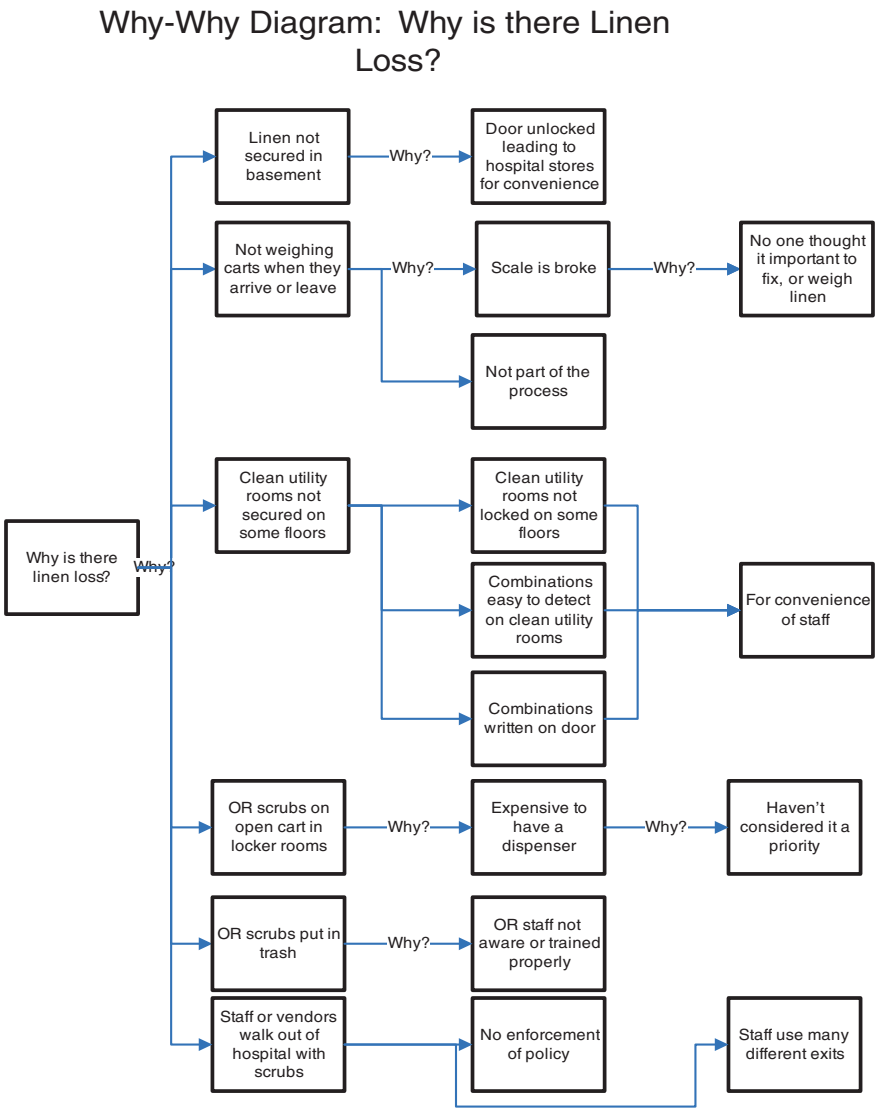


Fig. 8.16 Why-Why diagram page 1

Linen also is put in the wrong containers, sometimes in biohazard red bags, and also in the trash. The staff may believe that when linen is soiled with body fluids, it should be either discarded or put in the biohazard red bags. The linen in all cases should still be put in the blue linen bags, as it will be cleaned and disinfected appropriately by the linen service provider. The staff is either not well trained and/or are not being assessed against the appropriate linen competencies. Reject linen, linen that should be discarded due to being old, torn, or stained, also is found in the trash, as there is no process for how to handle rejected linen.

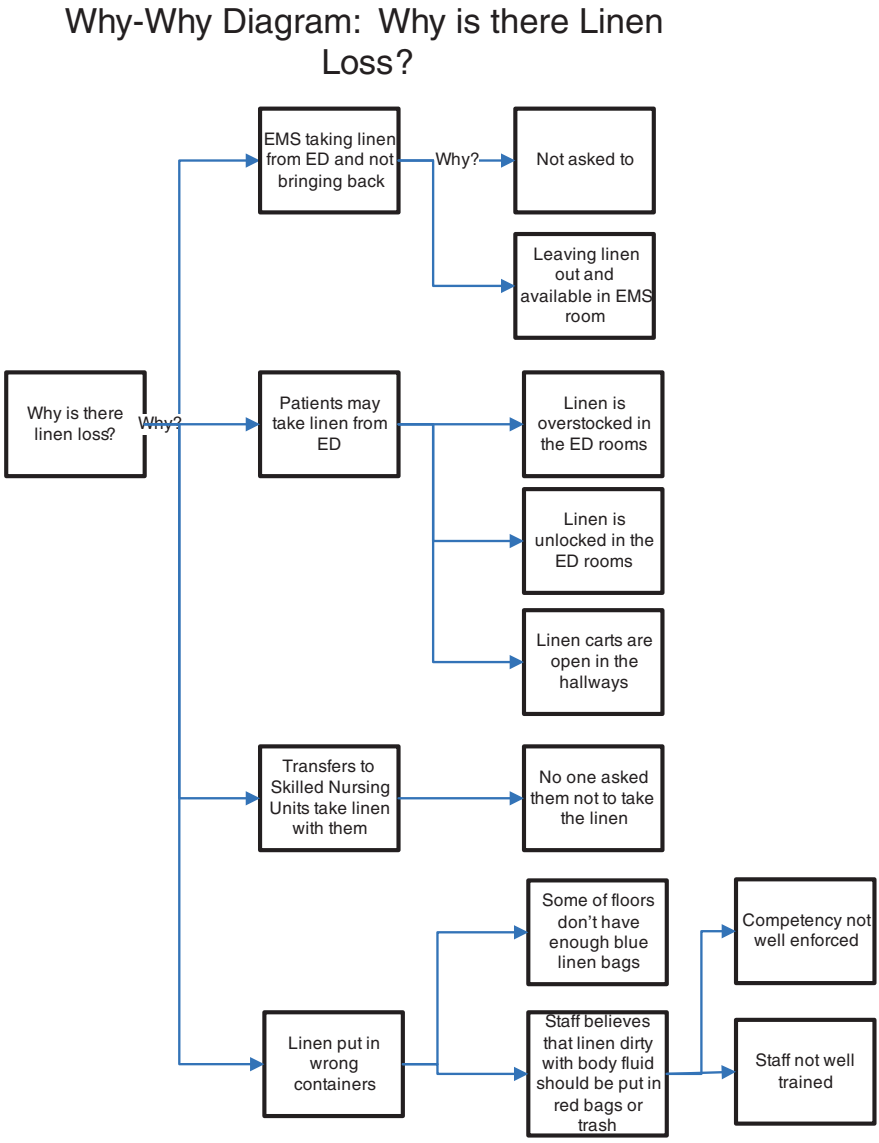


Fig. 8.17 Why-Why diagram page 2

Linen is also left open in patient rooms, and looks available to be taken home by the patients. The soiled linen hamper is in each patient room, and is not secured.

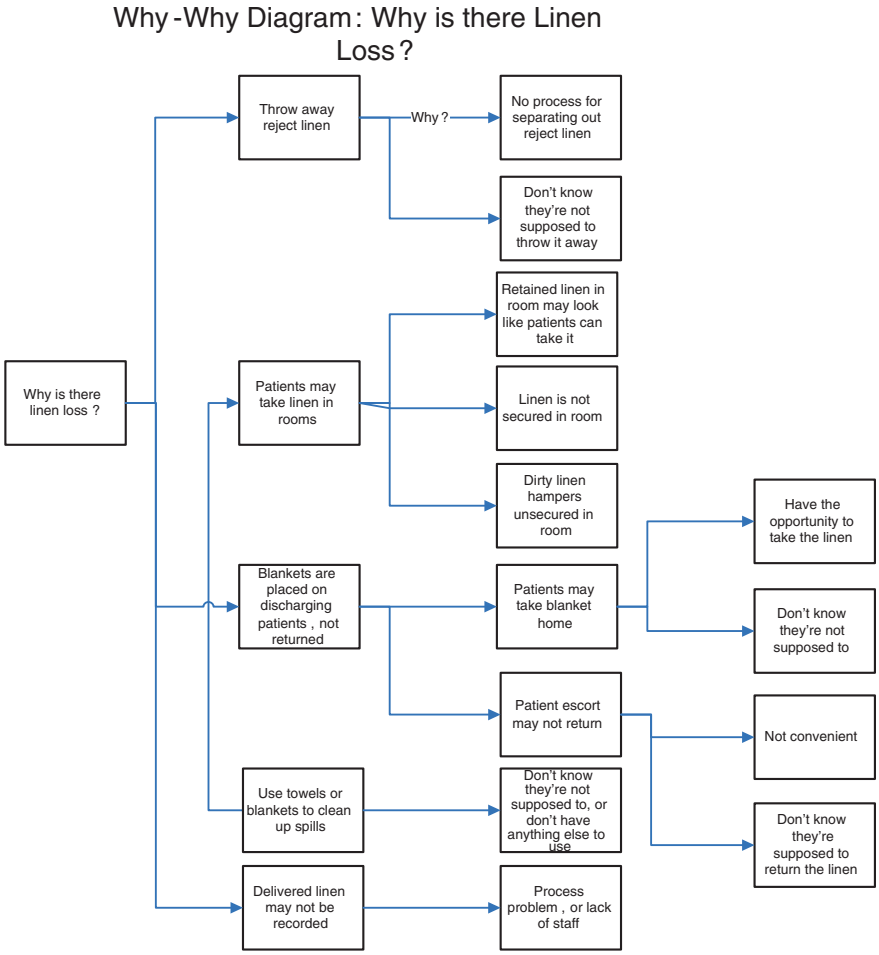


Fig. 8.18 Why-Why diagram page 3

Blankets are placed on patients when they are discharging, but there is no process to ensure that patient escorts return the linens. Sometimes towels and blankets are used to clean up spills, either because the appropriate cleaning items are not available, or the staff doesn't know that they shouldn't be using linen to clean up spills and leaks.

An additional root cause of linen loss may be either the lack of recording the taken or returned linen, or not accurately counting the returned or taken linen amounts.

Summary of Root Causes

Linen Not Secure:

- Clean Utility rooms not locked
- Clean Utility rooms' combinations rarely changed
- Clean Utility rooms combination easy to guess or written on door
- Linen carts in hallways unlocked
- Linen left in unlocked cabinets in rooms
- Linen left in hampers in rooms
- Scrubs on open carts, locker room accessible to all
- Linen room door unlocked

Measurement:

- Not consistently recording distributed linen
- Not accounting for where linen is used, stored, inventoried
- Not accounting for linen "removed" from the facility
- Not weighing or auditing clean linen received or dirty linen shipped to linen service provider

Linen/Scrubs "Walking Out" of the Hospital:

- People leaving with scrubs (not street clothes), no awareness or accountability to the policy
- Transport companies taking linen with transfers to SNFs (not following contracted policy)
- Patients taking linen (lack of awareness)
- EMS taking linens from hospital, not controlled

Linen Return:

- Linen placed in wrong containers (trash, or biohazard waste), due to lack of training, or no containers available
- No process for reject linen

Retained Linen:

- Linen retained in rooms, must be placed in soiled linen, considered dirty, won't weigh as much as soiled linen, may contribute to perceived linen loss
- Linen retained on gurney's by transportation
- Beds that are not occupied have linen on them.

Develop Process Capability

We developed the process capabilities for the three main metrics:

(1) Pounds per adjusted patient days
(2) Linen usage
(3) Soiled versus clean linen pounds

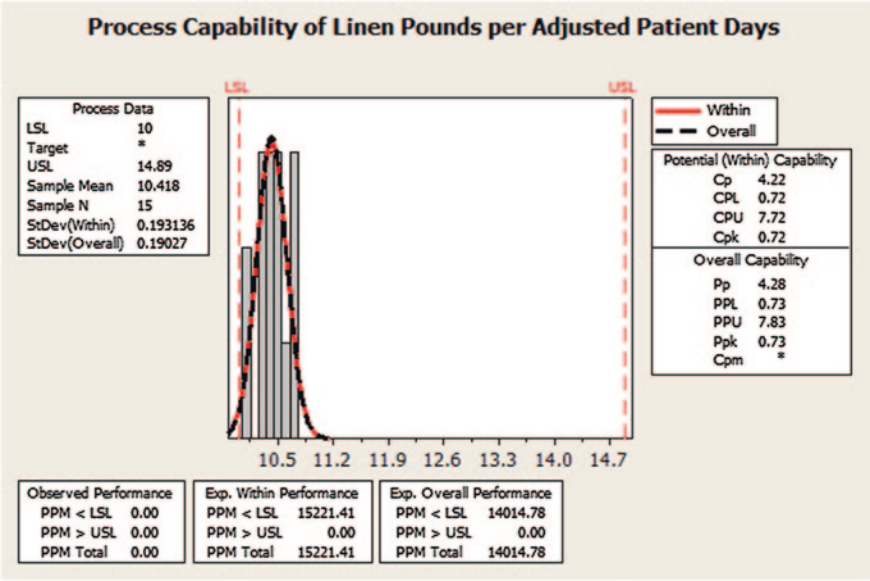


Fig. 8.19 Process capability for pounds linen versus adjusted patient days

Pounds per Adjusted Patient Days

We performed a process capability for the metric of pounds per adjusted patient days. We used a lower specification of 10, and an upper specification limit of 14.89. The Cp index was 4.22 and the Cpk index was 0.72. The process is capable of meeting the specifications, but is not centered. The lack of centering is actually a good indicator, as the lower the metric the more efficient the use of linen is per patient. The process capability is shown in Fig. 8.19.

Linen Usage

We then performed a process capability for the metric of linen usage. We looked at the linen usage data for January through May 23 for the high frequency usage item of flat sheets. We used an upper specification limit of 100 pieces and a lower specification of 0 pieces, for daily usage of flat sheets. The Cp index was 1.34 and the Cpk index was 1.32. The process is both capable and centered for the flat sheet daily usage. The process capability is shown in Fig. 8.20.

Soiled Versus Clean Linen Pounds

Finally, we performed a process capability for the soiled versus clean linen metric, using the difference between the soiled pounds minus the clean pounds

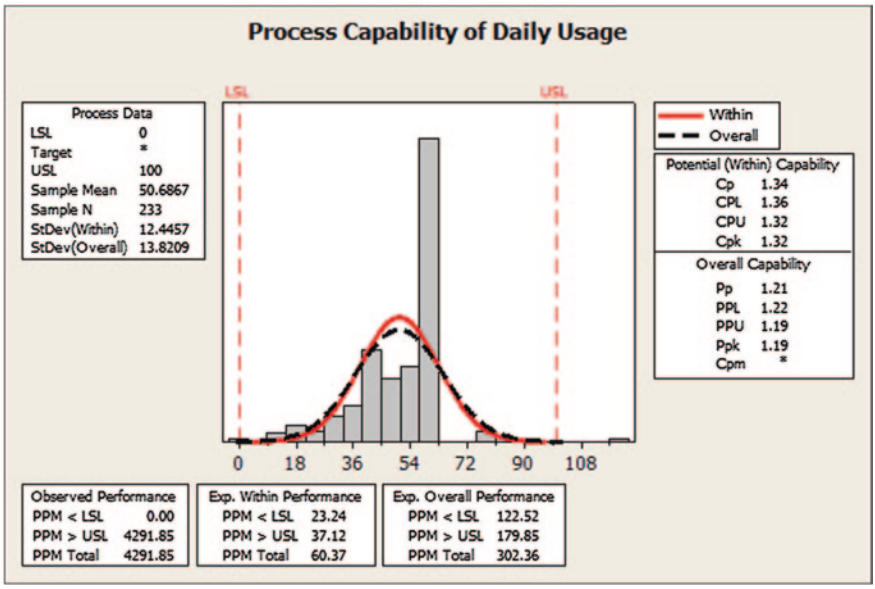


Fig. 8.20 Process capability of linen usage

on a daily basis from January 3rd to April 3rd. The upper specification was 750 pounds, and the lower specification was −750 pounds, since there are some days when the soiled pounds weigh less than the clean pounds. The Cp value is 0.19 and the Cpk value is 0.13. The process is neither capable nor centered, indicating once again that there is excessive linen loss. The process capability is shown in Fig. 8.21.

Summary

We have established that there is a significant loss of linen and the processes are not capable of securing the linen. We also identified the main root causes for the linen loss. We moved into the Improve phase, where we identified and implemented improvements to reduce the linen loss.

Improve Phase

The following steps were executed in the Improve Phase:

1. Identify improvement opportunities and plans
2. Perform cost/benefit analysis

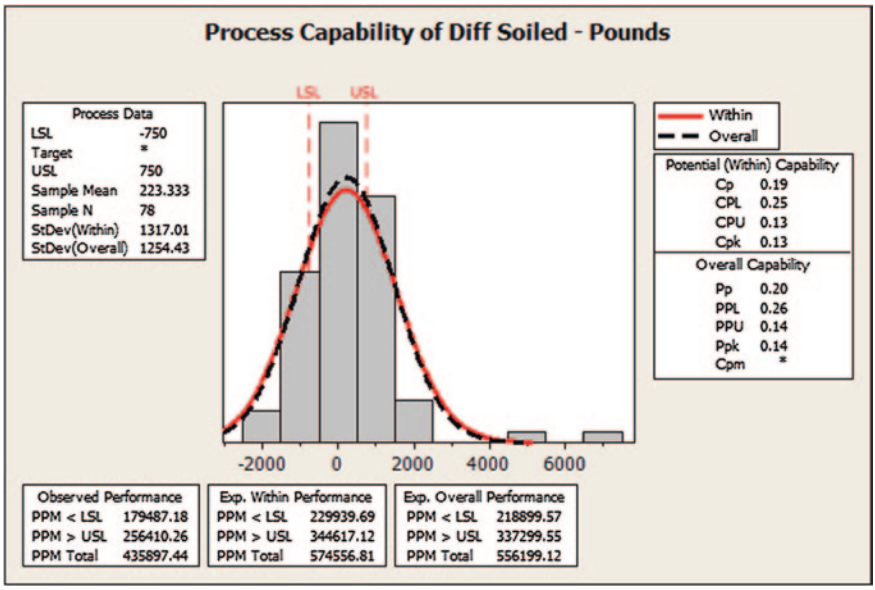


Fig. 8.21 Process capability: soiled versus clean linen

3. Design future state
4. Establish performance targets and project scorecard
5. Pilot improvements
6. Train and execute

Identify Improvement Opportunities and Plans

Once the team identified the root causes of potential linen loss, we implemented several improvement ideas, aligned to the root causes, as follows:

Linen Not Secure (Fig. 8.22)

To enhance the security of linen throughout the hospital, we need to better secure the linen. The linen carts need to be locked or stored in locked rooms. A longer term goal is to implement access card control for rooms with badge access for all clean utility rooms. A process was implemented for when Transportation moves patients and takes linen from the rooms. The linen was collected daily from patient transport devices so it is not left throughout the hospital.

Area for Linen Loss	Improvement Idea	Responsible	Planned implemen-tation date
Linen not Secure			
Linen not secured in basement	Enhance security of linen: Lock door to linen room. Put keycard entry to utility rooms and linen rooms (future)	Security	7/30
Loss from dock to linen room in basement	Monitor carts, don't leave linen in hallways unsecured	Environmental Services	8/5
Loss from linen carts to basement	Monitor carts, don't leave linen in hallways unsecured	Environmental Services	8/5
Linen utility rooms not locked on floors Combinations written on doors, or combination is easily known.	Change combinations every 90 days. Implement access card control for rooms – badge access for all clean utility rooms.	Engineering Security	Future
Transportation takes linen from floors.	Implement process to control	Transportation	8/15

Fig. 8.22 Improvement recommendations—linen not secure

Area for Linen Loss	Improvement Idea	Responsible	Planned implementation date
Measurement			
Not weighing carts when they arrive or leave	Weigh linen based on acceptance sampling plan. Replace scale on dock.	Master Black Belt; Director of Supply Chain, Facilities	8/5
Are we getting accurate usage? Counting of returned linen carts? Floors and departments take linen in basement and don't record	Implement better measurement, accountability and control of linen.	Supply Chain, Directors	8/15

Fig. 8.23 Improvement recommendations—measurement

Measurement (Fig. 8.23)

An acceptance sampling plan was implemented to select and weigh soiled linen carts prior to the soiled linen leaving to be cleaned by the linen service provider. We replaced the scale on the dock. We implemented a better measurement system to enhance the accountability and control of the linen. The returned linen was to be consistently counted when the linen carts are exchanged with the floors. We collected linen on the floors to determine how much linen is being retained on the floors, and how much is "walking" out of the hospital (being taken or stolen).

Area for Linen Loss	Improvement Idea	Responsible	Planned implementation date
Linen "walking" out of the hospital			
OR scrubs on open cart; put in wrong containers, vendors taking them; people walking out of the hospital with the green scrubs	Secure OR locker rooms. Implemented linen and scrub dispensers. Enforce policy on who can wear green scrubs. Put together a comprehensive list of the scrub uniform and color. Created a card to remind people not to leave with scrubs. Distributed fliers to remind people not to leave with scrubs, and reviewed it with the directors. Reviewed linen policies with directors and staff.	Directors Security Supply Chain Departments Nursing	8/15
Associates that spill something on their clothing, use OR scrubs, need to define a process for how to handle.	Implemented disposable scrubs.	Linen manager	7/30
Transfers to SNFs (skilled nursing facilities) taking linen	Adhere to policy that no linen will go with transport companies when transfer patients to Skilled Nursing Facilities (SNFs).	Nursing, Case Management	7/30

Fig. 8.24 Improvement recommendations—linen "walking" out of the hospital

Area for Linen Loss	Improvement Idea	Responsible	Planned implementation date
Linen "walking" out of the hospital			
ED: EMS taking linen and not bringing them back	Only have what will be used that day in cabinets, re-stock daily. Lock linen carts. Implement scrub and linen dispensers. Making up bundles so that EMS can't help themselves, charge person gives them a linen bundle on arrival. Implement a tally log to track linen taken by EMS. Restrict number of sheets available to EMS, set par level. Contact chiefs, send letters to anticipate the change, charge nurse can give them their linen packet when they register the patient. Get disposable sheets for EMS in ED.	Supply Chain, ED Director.	8/15
Employee entrance/exit not consistent, people enter at all/any entrances; no camera	Perform a door assessment process, as part of a lock down procedure.	Security	Future
Discharge, blankets thrown on patients and not returned.	Transport and volunteers need to know to return blankets used during discharge.	Transportation	8/15

Fig. 8.25 Improvement recommendations—linen "walking" out of the hospital (continued)

Linen/Scrubs "Walking Out" of the Hospital (Figs. 8.24 and 8.25)

To prevent scrubs from being taken out of the hospital and not returned, we secured the OR scrubs by implementing a scrubs dispensing machine. As an interim step, the OR Director secured the ORs locker rooms to only OR staff. We also enforced the existing policy on who can wear green scrubs. We generated a comprehensive list of scrub uniform colors for each department. We developed

a card to handout to people who are coming into or out of the hospital in green scrubs, to remind them in a courteous manner not to leave the facility with the green scrubs. We also posted and distributed handouts to remind staff not to leave the hospital with scrubs. We reviewed the linen policies with directors and staff to gain their support of the policies. We implemented disposable scrubs so that when staff has to change their clothes, they can use the disposable scrubs. The Director of Case Management also contacted the transport companies that transfer patients to SNFs to ensure that they do not take our linen when transferring the patients. The linen committee also met with the main ambulance companies to stress that the EMS truck drivers should not be removing linen from the hospital.

In the Emergency Room, we changed the procedure to only have what will be used that day in cabinets, and to restock the cabinets daily. They began securing the linen carts. The ED also began making up linen bundles that the charge person gives to them, so that the EMS can't help themselves to linen. The ED contacted the chiefs to notify them of the change.

Security performed a door assessment process, as part of a lockdown procedure to ensure that access is not available to people who do not need to be in certain areas, including having access to linen. We also trained patient transporters and volunteers to know to return blankets used during discharge. We then also implemented linen dispensers in the ED since about 25 % of linen loss occurs through the ED, mostly by EMS trucks taking and not returning linen. We implemented a single use dispenser for the EMS trucks. We also implemented secure bulk dispensers to load the linen delivered daily into the secure dispensers. The ED staff loads the ED rooms from the secure bulk linen dispensers.

Linen Return (Fig. 8.26)

We again reinforced linen awareness and training of appropriate used linen placement in the correct containers. Linen should not be placed in trash or hazardous waste containers. We incorporated a consistent reject linen procedure, by notifying staff of the reject linen bag that is placed on each linen cart. We reminded the staff that they need to ensure that the soiled linen is placed in the linen shoots between 7 and 11 p.m. We also trained the staff not to use linen for cleaning up leaks and spills, and ensured that they had appropriate cleaning towels to clean up spills.

Retained Linen (Fig. 8.27)

We improved the awareness of the linen policies and procedures, including having staff only put linen in rooms for what they are using for that day to avoid having to clean linen that was left in a patient's room, but not actually used. We also reinforced at staff meetings to clean out cabinets once a month and return unused linen. We worked with Transportation to ensure that they removed unused linen

Area for Linen Loss	Improvement Idea	Responsible	Planned implemen-tation date
Linen Return			
Placing linen in wrong containers	Linen training awareness; Linen awareness weeks.	Linen Manager	8/15
Linen put in wrong containers (trash, red bag, etc.); trash put in linen containers	Train staff. Implement process to have Environmental Services order, stock and distribute blue linen bags for linen return. Change lock on linen room and secure door.	Nursing Security	8/30
No process for separating out reject linen	Every cart has a discard bag on the linen exchange cart; Need to educate the floors on the linen exchange cart discard bag.	Linen Manager	8/15
Timing of linen being moved to soiled areas on floors, soil pick up schedule	Nursing needs to throw the linen to the linen shoot, at 7PM TO 11 PM.	Nursing	8/30
When have floods or spills, using towels and blankets to clean up	Awareness to staff.	Directors	8/30

Fig. 8.26 Improvement recommendations—linen return

Area for Linen Loss	Improvement Idea	Responsible	Planned implemen-tation date
Retained Linen			
Retained linen in rooms; looks like available for patients to take	Awareness, only put linen in rooms for what they are using for that day. Reinforce at staff meetings, clean out cabinets once a month. Send notice to volunteer services, to make it part of orientation duties on floors.	Nursing	8/30
Linen retained on gurney's of patient escorts.	Need to remove retained linen on gurney's.	Transportation	8/30
Beds that are not occupied, with linen on it.	Incorporate a process to pick up linen.	Linen Manager	8/30

Fig. 8.27 Improvement recommendations—retained linen

from the stretchers used for patient transport on a daily basis. We also incorporated a process for picking up unused linen on closed floors.

Perform Cost/Benefit Analysis

We performed a cost and benefit analysis to cost justify the linen and scrub dispensers. We calculated the Net Present Value as $625,539 for a

Metric	Baseline	Targeted Goal	Status
Soil to Clean Ratio	3.86%	7.86% (higher is better)	
Pounds per Adjusted Patient Day	10.46	14.89 (lower is better)	Met Goal prior to Project
Linen Usage: Average pieces used per day per department	27	38 (lower is better)	Met Goal prior to Project
Annual Linen Replacement Cost	Confidential	To Be Determined	
Annual Linen Processing Cost	Confidential	To Be Determined	

Fig. 8.28 Project scorecard and performance targets

5-year-project life. The estimated internal rate of return is 148 %. The estimated annual savings includes a 25 % reduction of linen replacement cost, and a 20 % reduction in linen processing cost. The annual cost of the linen dispensers includes a monthly lease cost to lease the dispensers. There is an initial cost of installing data and electrical drops for almost $10,000. The positive net present value and the very high internal rate of return provided the cost justification that was needed to convince the leadership team that this is a very strong investment. The linen and scrub dispensers were implemented in the first quarter of 2011.

Design Future State

Most of the changes either enforced existing policies or changed procedures and the changes were made as appropriate. We revised the process maps to represent the new processes.

Establish Performance Targets and Project Scorecard

We established performance targets and designed a project scorecard, as shown in Fig. 8.28.

Pilot Improvements

We piloted the improvement ideas identified and captured what worked and what needed to be further revised. The improvement ideas discussed above included the ideas that were actually implemented, or still planned to be implemented in the future.

Train and Execute

After the pilot phase was complete, we trained the personnel in the revised procedures and executed them throughout the hospital. We then moved into the Control Phase.

Control Phase

The purpose of the Control Phase is to implement control mechanisms and procedures to ensure that the process maintains the levels of improvements attained during the pilot activities.

The following activities were executed in the Control Phase:

1. Measure results and manage change
2. Report scorecard data and create process control plan
3. Identify replication opportunities
4. Develop future plans

Measure Results and Manage Change

We implemented many of the improvements identified starting in June. We performed a two proportion test comparing the baseline to the first 9 weeks of quarter four.

Test and CI for Two Proportions

Sample	*X*	*N*	Sample *p*
1	434,737	452,183	0.961418
2	268,735	282,611	0.950901

Difference = *p* (1) – *p* (2)
Estimate for difference: 0.0105176
95 % CI for difference: (0.00954302, 0.0114921)
Test for difference = 0 (vs. not = 0): $Z = 21.15$ *p*-value = 0.000
Fisher's exact test: *p*-value = 0.000

We compared the sum of the clean pounds for the 13 week period to the sum of the soiled linen pounds. The 1.1 % improvement in the soiled to clean ratio was a statistically significant improvement with a *p*-value of 0.0. This savings resulted in a reduction in the linen replacement cost per week.

Metric	Control Mechanisms	Actions to be taken if problems occur	Responsibility
Soil to Clean Ratio	Measure soil to clean ratio quarterly	Linen Committee implements further improvements	Linen Committee
Pounds per Adjusted Patient Day	Measure pounds per adjusted patient day		
Linen Usage: Average pieces used per day per department	Measure linen usage by department on a quarterly basis		
Annual Linen Replacement Cost	Measure linen replacement cost quarterly		
Annual Linen Processing Cost	Measure linen processing cost quarterly		

Fig. 8.29 Control plan

Report Scorecard Data and Create Process Control Plan

The linen committee will continue meeting on a quarterly basis to monitor the metrics in the control plan. If the metrics get worse, the committee will address the issues and identify additional ideas for improvement. The dashboard will be used to track the quarterly metrics, as shown in Fig. 8.28. The control plan is shown in Fig. 8.29.

Identify Replication Opportunities

We could potentially implement scrub dispensers in the future in the other areas where scrubs are used, labor and delivery and interventional radiology. This would further control scrubs within the hospital.

Develop Future Plans

After we implement the scrub and linen dispensers we will assess the improvement to ensure that we attain the estimated improvements.

Summary and Project Critical Success Factors

This linen loss reduction project has been extremely successful in reducing the linen loss in the hospital and is already in line to reduce linen costs for the first year. This was a great application of the Lean Six Sigma problem solving methodology and tools. We first defined the project, measured, and assessed the current

state process, analyzed the root causes, implemented the improvements, and assessed statistically significant improvement and implemented a control plan to further improve the linen loss, and ensure that the improved processes maintain their gains.

The critical success factors of the project were:

- Having a dedicated cross-functional team that applied the Lean Six Sigma approach and tools to improve the linen processes.
- Having a knowledgeable Lean Six Sigma Master Black Belt that facilitated the DMAIC problem solving methodology performed the analytics and mentored the team members.
- Having the buy-in of the leadership team to implement the improvements and the scrub and linen dispensers.
- Using change management tools to ensure buy-in and support to change the linen processes.

Reference

Encompass Textiles and Interiors. (2004). *Smart solution for linen use, now you see it… Now you don't. A campaign to prevent linen loss*, www.encompassgroup.net, McDonough, GA.

Chapter 9
Sepsis Protocol Design Project

Abstract Sepsis is a systemic infection that is the 10th leading cause of death in the United States. The sooner that the antibiotic protocols are started, the better is the patient's outcome. This case study applied the Lean Six Sigma methodology and tools to develop and implement Sepsis protocols in the Emergency Department of a community-based hospital to improve patients' sepsis mortality by 9.6 %, while improving the time that the sepsis protocols were administered from the time that the patient arrived to the Emergency Department. There is still improvement to be made in the consistency of administering the sepsis protocols for suspected sepsis patients in the ED. This chapter is not intended to provide medical advice or recommendations.

Introduction

"Sepsis is defined by a systemic inflammatory response syndrome, such as fever, tachypnea, tachycardia, or leukocytosis in response to a culture-proven or clinically suspected infection" (Morrell et al. 2009). The grading of sepsis includes severe sepsis, septic shock and refractory septic shock (Annane 2003; Levy et al. 2003). Severe sepsis includes the previously mentioned clinical criteria for sepsis as well as at least one sign of organ hypoperfusion or dysfunction. Septic shock is defined by severe sepsis with a systemic mean blood pressure <60 mm Hg (or 80 mm Hg if previous hypertension) after an attempt at adequate fluid resuscitation or a need for vasopressors to maintain a systemic mean blood pressure >60 mm Hg (or >80 mm Hg if previous hypertension). Refractory septic shock exists if dopamine >15 μg/kg/min or norepinephrine or epinephrine >0.25 μg/kg/min is required to maintain a mean blood pressure >60 mm Hg (80 mm Hg if previous hypertension) (Morrey et al. 2009).

Severe sepsis and septic shock continue to be a major health care problem. Overall mortality from severe sepsis or septic shock ranges from 30 to 60 % and

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accounts for 9.3 % of all deaths in the United States (Annane 2003; Angus et al. 2001; Sasse et al. 1995). Severe sepsis and septic shock is the 10th leading cause of death in the United States (Kung and Hoyert 2008). More than 750,000 cases of sepsis occur each year in the United States. The average cost per case of sepsis or septic shock is $22,000. Annual total costs related to patients with sepsis are estimated to be near $17 billion (Angus et al. 2001).

Due to the continuing persistence of sepsis and septic shock as a healthcare problem, the hospital's Emergency Department decided to use the Six Sigma approach to implement standardized protocols with the goals to reduce mortality, identify septic patients promptly, and to initiate treatment immediately.

This chapter will describe the application of the Six Sigma problem solving methodology regarding the better management of severe sepsis and septic shock, when presented in the Emergency Department (ED).

Define Phase

The following steps were executed in the Define Phase:

1. Develop project charter
2. Perform stakeholder analysis
3. Perform initial Voice of Customer (VOC) and Identify Critical to Satisfaction (CTS)
4. Select team and launch the project
5. Create project plan.

Develop Project Charter

The team developed the project charter that consisted of defining the problem, identifying the stakeholders, what is critical to satisfaction, the project goals, and the potential benefits.

The project charter is shown in Fig. 9.1, Project Charter.

Project Name. Sepsis Protocol Design Project.

Problem Statement. There is a national initiative to improve sepsis mortality. Sepsis mortality is one of the CMS (Center for Medicare and Medicaid Services) core measures. We want to provide excellent care to our sepsis/septic patients.

Customer/Stakeholders. ED (Emergency Department) physicians, Intensivists, ED Nurses, Nurse Educator, Administration, patients.

What is important to these customers. Prompt Treatment of the infectious illness they present with in the Emergency Department.

Goal of the Project. To reduce mortality, identify patients promptly, initiate treatment immediately.

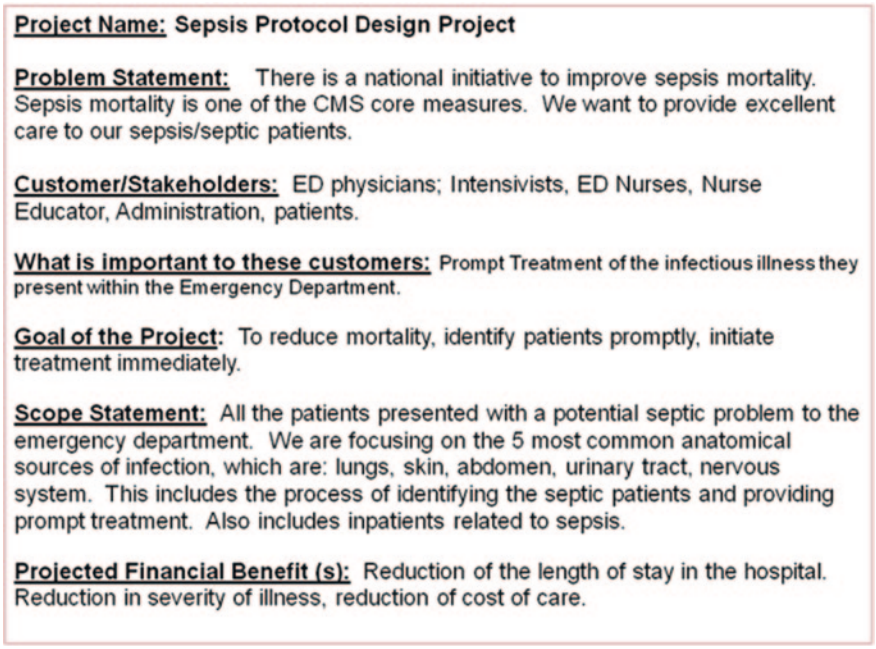

Fig. 9.1 Project charter

Scope Statement. All the patients presented with a potential septic problem to the emergency department. We are focusing on the five most common anatomical sources of infection, which are: lungs, skin, abdomen, urinary tract, nervous system. This includes the process of identifying the septic patients and providing prompt treatment. It also includes inpatients related to sepsis.

Projected Financial Benefit (s). Reduction of the length of stay in the hospital. Reduction in severity of illness, reduction of cost of care.

Perform Stakeholder Analysis

The Emergency Department Physicians are key stakeholders in identifying and treating septic patients in the ED. They are concerned with timely identification and treatment of septic patients, and reducing the sepsis mortality rate of these patients. Intensivists are physicians who care for patients in the Intensive Care Unit (ICU). They are concerned with the patients' sepsis mortality rate and with patient care. The ED nurses who provide patient care in the ED and the Nurse Educator who provides nurse education for ED nurses are concerned with patient care, patient mortality, and timely identification and treatment of sepsis/septic patients. The patients who come to the ED with sepsis are concerned with patient

Stakeholders	Who They Are?	Potential Impacts/Concerns
ED physicians	Physicians who treat ED patients for sepsis	▪ Timely identification and treatment ▪ Sepsis mortality rate
Intensivists	Intensive Care physicians who care for patients in ICU	▪ Sepsis mortality rate ▪ Patient care
ED nurses (includes triage nurses); nurse educator	ED nurses who provide ED patient care and who triage the patients; Nurse educator who provides nursing education	▪ Patient care ▪ Mortality ▪ Timely identification and treatment
Patients	Patients who have or may have sepsis	▪ Patient care ▪ Mortality ▪ Health
Administration	Hospital administration	▪ Sepsis mortality rate

Fig. 9.2 Stakeholder analysis

care, their mortality from sepsis and their health. Hospital administration is a project stakeholder, and is concerned with sepsis mortality rate across the hospital, not just in the ED, but when patients are admitted into the hospital's Intensive Care Unit. The stakeholder analysis is shown in Fig. 9.2

Suppliers-Inputs-Processes-Outputs-Customers

A description of the high-level process follows. The patient arrives to the Emergency Department with symptoms of sepsis or septic shock. The patient is registered, triaged, and assessed by the ED physician. The ED physician orders diagnostic tests which can include labs and imaging exams to assess the patient's condition. The diagnostic tests are performed. If sepsis is suspected or confirmed, the patient is admitted to the Intensive Care Unit. In the current state, there are no sepsis protocols that are initiated in the Emergency Department. The Suppliers-Inputs-Processes-Outputs-Customers (SIPOC) is shown in Fig. 9.3.

Perform Initial Voice of Customer and Identify Critical to Satisfaction

The Critical to Satisfaction criteria for this project are:

- Reduced mortality rate of sepsis patients
- Time to identify patients with sepsis
- Time to identify diagnostic results

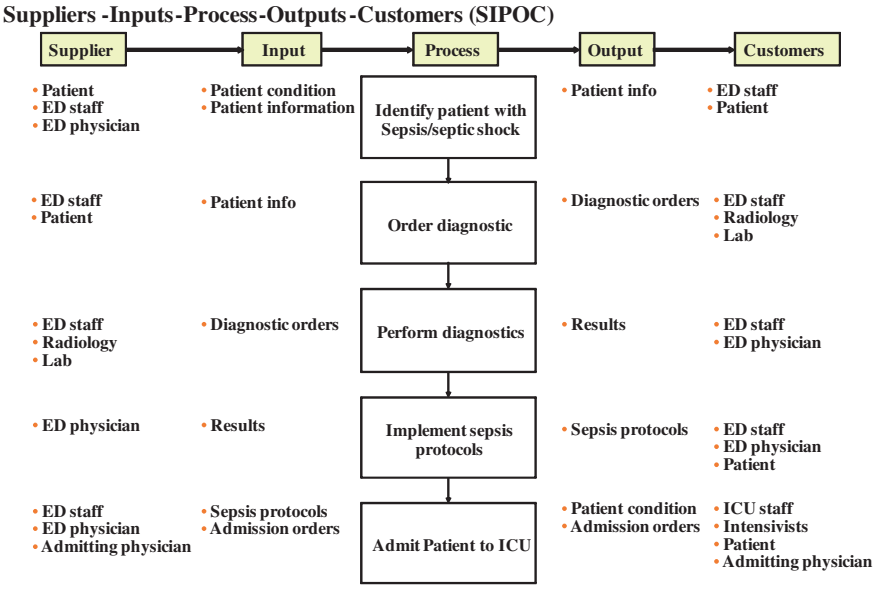

Fig. 9.3 SIPOC

- Time to administer treatment to identified patients with sepsis, within one hour of arrival (identification)
- Time to source control (identify source of the infection)
- Percent of patients receiving sepsis protocols.

These CTS' will be operationally defined in the Measure phase.

Select Team and Launch the Project

The team consisted of ED physicians and nurses, as well as the ED nurse educator, intensivists, Sepsis specialists, and a Lean Six Sigma Master Black Belt. It was important to have the extensive knowledge and buy-in of the intensivists and sepsis specialists involved on the project.

Create Project Plan

The project was started October 3, 2009. The Define phase was completed by October 22, 2009. The Measure phase was completed on November 7, 2009. The Analyze phase ended November 27, 2009. The Improve phase ended December 31, 2010. The Control Phase was completed with assessing improvement and implementing the control plan in January 2011. The project milestones are shown in Fig. 9.4.

After the team completed the Define phase, we moved into the Measure Phase.

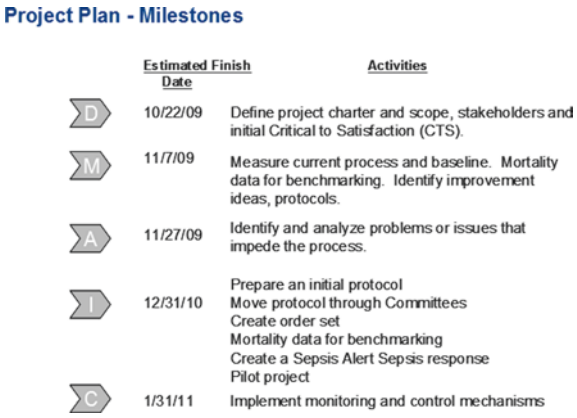

Fig. 9.4 Project milestones

Measure Phase

The Measure Phase included the following activities:

1. Define the current process
2. Define detailed Voice of Customer (VOC)
3. Define the Voice of Process (VOP) and current performance
4. Validate measurement system.

Define the Current Process

The first step was to understand the current process by creating detailed process maps shown in Fig. 9.5. A description of the process follows.

The patient arrives at the Emergency Department and signs into the kiosk in the lobby. If an ED bed is available, the patient will be moved immediately to an ED room. If an ED bed is not available, the patient will be triaged in the triage room. When the bed is available the patient will be moved to the ED room. The ED nurse will assess the patient and start any treatment, such as an IV as appropriate. The ED physician will assess the patient and order appropriate diagnostic tests, including imaging exams and lab tests. The imaging and lab departments will perform the exams, and provide the results. The ED physician will determine the patient's disposition. If sepsis or septic shock is diagnosed, the ED physician will contact the admitting physician for admission orders. The admitting physician will provide the admission orders to the Intensive Care Unit. The patient will be admitted to ICU and moved to the unit. If sepsis is not diagnosed, the patient will be admitted or discharged as appropriate per the ED physician's diagnosis and disposition. In

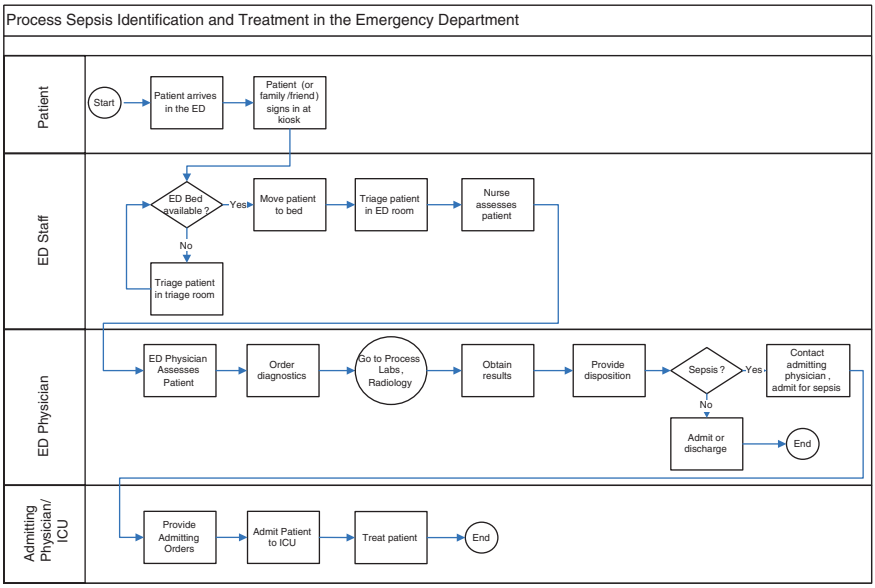

Fig. 9.5 Process map

the current state process, there was no application of sepsis protocols for sepsis or septic shock patients while they are in the Emergency Department.

Data Collection Plan

We developed the data collection plan to determine the metrics and operational definitions to measure the Critical to Satisfaction criteria. The data collection plan with the baseline metrics is shown in Fig. 9.6. The following metrics were defined.

Mortality Rate of Sepsis Patients

Defining the Measure. Mortality Rate of Hospital Sepsis Patients

The percent of patients that expire after being diagnosed with sepsis, across the entire hospital (not just the Emergency Department).

Purpose. To understand the sepsis patient mortality rate across the hospital.

Measure the Process. Quality Management has sepsis mortality rate information for the hospital, for Year-to-Date (YTD) from January 2009 through February 2010.

Time to Identify Patients with Sepsis

Defining the Measure. Time to identify patients with Sepsis

The time from when the patient arrives in the ED to when they are identified with Sepsis.

Purpose. To understand the time to identify that the patient has sepsis. This will be measured by calculating the time from arrival to EDP disposition.

Critical to Satisfaction (CTS)	Metric	Data collection mechanism	Baseline
Mortality Rate of Hospital Sepsis Patients	Mortality rate for septic patient	Director of Quality, Mortality rate: January 2009 through February 2010:	Mortality rate (Jan '09 to Feb '10): 21.8%
- Time to identify patients with sepsis - Time to source control	Time to identify patients with sepsis: Time from Arrival to EDP disposition	Collect from ED Bed Board for August 2009.	Average = 245 minutes Standard Deviation = 134 N = 111
Time to treatment	Time to begin treatment	Do not currently measure.	Do not currently measure.
Patients receive sepsis protocols.	Percent of patients receiving sepsis protocols.	Review of Electronic Medical Record and Patient Charts for patients' initial diagnosis of Sepsis for January 1 through June 2009.	Percent receiving sepsis protocol: 0%

Fig. 9.6 Data collection plan

Measure the Process. This is not currently measured in the current state, but will be measured in the future, as the time from when the patient arrives in the Emergency Department and signs into the kiosk to when the ED Physician provides the diagnosis or disposition.

Time to Treatment

Defining the Measure. Time to treatment

The time to begin sepsis treatment.

Purpose. To understand the time to start sepsis treatment.

Measure the Process. This is not currently measured in the current state, but will be measured in the future, as the time from when the patient arrives in the Emergency Department to when the sepsis protocol is started to be administered, but will be measured by the initial start time of the orders, making the assumption that the sepsis protocol is within the order set.

Percent of Patients Receiving Sepsis Protocols

Defining the Measure. Percent of patients receiving sepsis protocols

The percent of patients receiving sepsis protocols of those that are diagnosed with sepsis.

Purpose. To understand the percent of the patients that have obtained the sepsis protocols.

Measure the Process. The baseline time period is January 1 through June 30, 2009, for those patients diagnosed with sepsis. We calculate the percent of those patients that received sepsis protocols in the Emergency Department. There were 28 patients diagnosed with sepsis that came through the ED, and none of them received a sepsis protocol in the ED, since none had been implemented at this time.

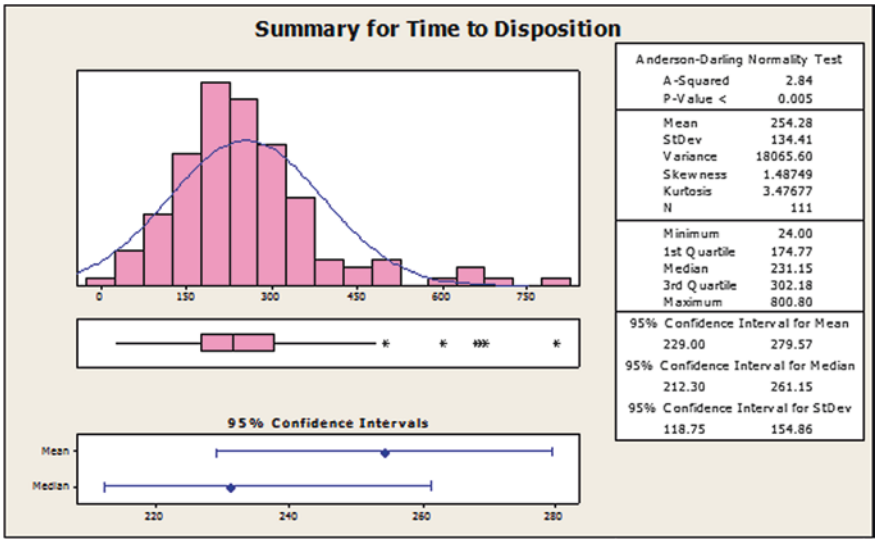

Fig. 9.7 Baseline—time to disposition (time to diagnose sepsis/time to identify source of infection) time from arrival to disposition

Define Detailed Voice of Customer

We met with the stakeholders to understand what is important to them regarding the patient care for septic patients. We derived the following Critical to Satisfaction criteria.

- Reduced mortality rate of sepsis patients
- Time to identify patients with sepsis
- Time to identify diagnostic results
- Time to administer treatment to identified patients with sepsis, within one hour of arrival (identification)
- Time to source control (identify source of the infection)
- Percent of patients receiving sepsis protocols.

Define the Voice of Process and Current Performance

The current baseline performance for each metric is shown in Fig. 9.6.

We currently only measure the following metrics:

- Sepsis mortality rate, which is 13.5 % for all patients that were diagnosed with sepsis in the hospital (not just the emergency department). This is for the time period of January 2009 through February 2010.
- The time to identify patients with sepsis is measured by the metric of time to ED physician disposition. The average time was 254 minutes, with a standard deviation of 134 minutes. The histogram of the distribution is shown in Fig. 9.7.

- The percent of patients that received sepsis protocols in the Emergency Department for the time period of January 1 through June 2009, which was 0 % of the 28 patients diagnosed with sepsis that presented in the Emergency Department. We did not currently have implemented sepsis protocols in the Emergency Department.

Validate Measurement System

We validated the ED Bed Board data for the sepsis patients by comparing the data to the patients' charts, or electronic medical records.

We then moved into the Analyze Phase of the project.

Analyze Phase

The following activities were performed for the Analyze Phase to identify and validate the root causes and to assess whether the process is currently capable of meeting the desired specifications for the Length of Stay:

1. Develop cause and effect relationships
2. Determine and validate root causes
3. Develop process capability.

Develop Cause and Effect Relationships and Validate Causes

The root causes were very obvious, and were the reason for the project to be initiated.

Summary of Root Causes

- **There were no standard protocols defined for sepsis in the Emergency Department.**
  - No standard protocols had been developed or implemented in the Emergency Department for treating sepsis. The patients would be admitted to the Intensive Care Unit (ICU), but no consistent, standard protocols were used across the Emergency Department to begin treatment prior to the patient being admitted to ICU. This would potentially lose precious treatment time for sepsis patients. The ED physicians used their experience and knowledge, but did not apply consistent, standard sepsis protocols.

- **There were no metrics to assess whether patients received antibiotics and other treatment for Sepsis.**
  - There were no standardized metrics or measures instituted in the Emergency Department to measure the time that it takes to assess, diagnose, and disposition a patient with sepsis, as well as begin treatment. The patients typically began treatment for sepsis once they were admitted to the ICU.
- **There was no use of a formal sepsis protocol database.**
  - There is a computer program that provides for an assessment of symptoms using the MUST (Multiple Urgent Sepsis Therapies) protocol (Howell and Shapiro 2004). Prior to this project, the Emergency Department did not use this program.

Develop Process Capability

We developed the process capabilities for 3 metrics:

1. Time to identify patient with sepsis
2. Percent of patient receiving sepsis protocols
3. Sepsis mortality rate.

Time to Identify Patient with Sepsis (Time to ED Disposition)

We performed a process capability for the metric of the time to identify the patients with Sepsis. The metric used was the time to ED Physician disposition. The lower specification is 0 minutes and the upper specification limit is 90 minutes. The process capability Cp index for the time to ED disposition was 0.37, which shows that the process is not capable. The Cpk index, which shows centering of the process between the upper and lower specification limits is −0.04, showing that the process is also not centered. The process capability for the time to disposition is shown in Fig. 9.8.

Percent of Patients Receiving Sepsis Protocols

We then performed a process capability for the metric of Percent of Patients Receiving Sepsis Protocols. For a proportion metric, the process capability is the percentage or proportion. The baseline percent of patient receiving sepsis protocols is 0 %. The desired capability is 100 %. The process is currently not capable of meeting this goal.

Sepsis Mortality Rate

The process capability of the sepsis mortality is 13.5 %. The desired capability is 10 %, with the lower the mortality the better. The process therefore is not currently capable of meeting the desired target.

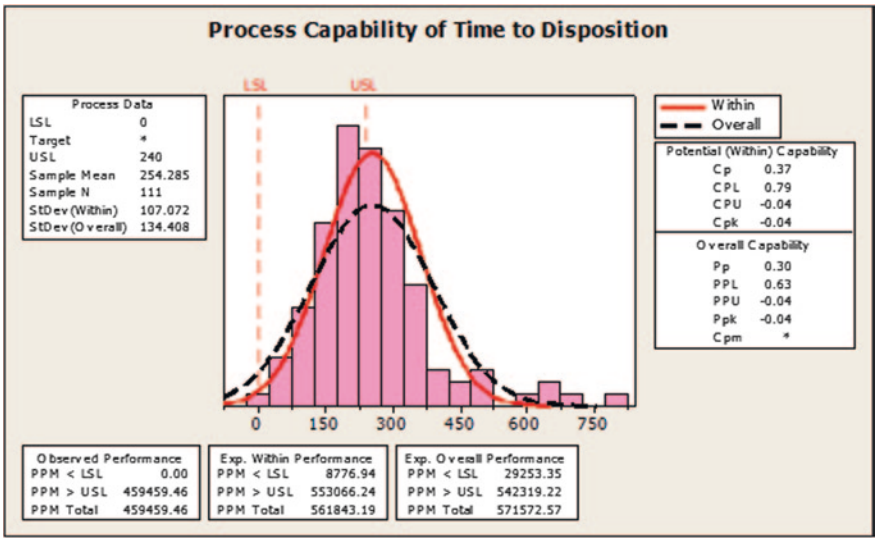

Fig. 9.8 Baseline process capability of time to disposition (time to diagnose sepsis/time to identify source of infection)

Summary

We have established that the current process is not capable of meeting our goals of providing a diagnosis of sepsis in a timely manner, nor performing and obtaining the diagnostic tests timely as well, or in achieving the desired sepsis mortality rates. We also do not have current sepsis protocols that are administered in the Emergency Department, and therefore will not be able to reduce sepsis mortality, or administer sepsis treatment in a more timely manner, while the patients are still in the Emergency Department. We have much opportunity for improvement.

Improve Phase

The following steps were executed in the Improve Phase:

1. Identify improvement opportunities and plans
2. Design future state
3. Establish performance targets and project scorecard
4. Pilot improvements
5. Train and execute.

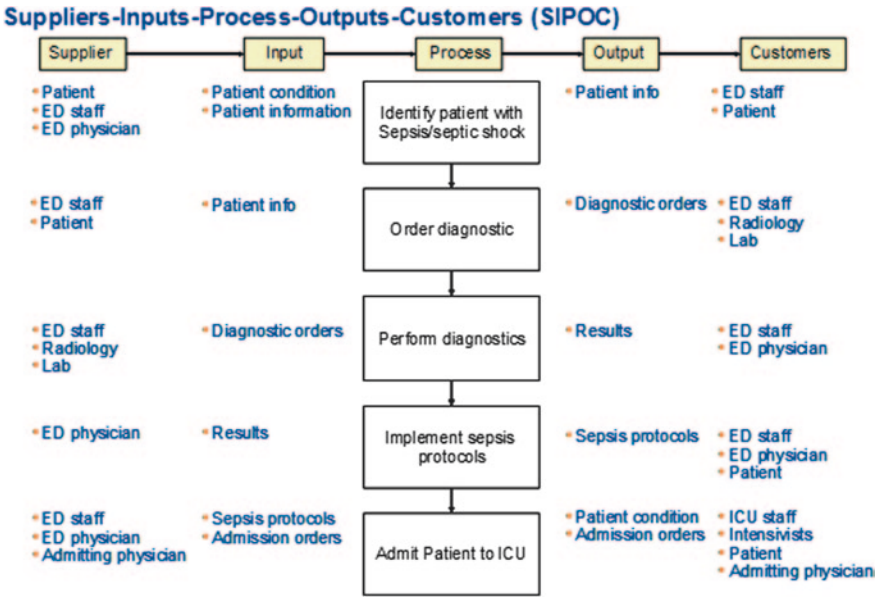

Fig. 9.9 Future state SIPOC

Identify Improvement Opportunities and Plans and Design Future State

The new high-level process steps for improving the process are shown in Fig. 9.9.

A new process step was incorporated after the sepsis diagnosis is identified by the ED Physician, "Implement Sepsis Protocol." In this step the newly generated sepsis protocols will be implemented when the patient's disposition is sepsis, urosepsis, septic shock, or other related sepsis diagnoses.

The team also implemented the Sepsis Survival alliance Sepsis Database that enables physicians for concurrent auditing and tracking of sepsis cases. It provides a decision tool to assess whether the appropriate Sepsis survival protocols were applied.

The team implemented a Sepsis Protocol based on the Multiple Urgent Sepsis Therapies (MUST) Protocol. They also implemented a standard order set aligned to the Sepsis Protocol. They implemented a Sepsis Alert to implement the Sepsis Protocol quickly.

The following sepsis protocols were piloted first in the Emergency Department.

The Emergency Department physician identifies sepsis as a primary diagnosis and enters this into their disposition in the Electronic Medical Record. They select the sepsis protocol orders which are then begun in the Emergency Department. Typically the sepsis patients will be admitted to the hospital, many of them to the critical care unit.

Following is a description of the sepsis protocol and order sets:

Patient Selection

1. SUSPECTED INFECTION AND
2. Patients with:

Systolic blood pressure <90 and/or lactate over 4 or MAP <65
AND
3. Patients with 2 out of 4 of the following:

- Fever (over 101) or temperature (under 96.8)
- Heart rate >90 bpm
- Respiratory rate >20 or $PaCO_2$ <32
- WBC >12 or <4 OR bands >10,000/mm^3.

STAT Laboratory Studies (Within 1 hour of identification)

- Serum Lactate
- CBC and BMP
- ABG
- Obtain cultures (blood, urine & UA, sputum, etc.)
- Type and Hold 2u PRBC
- PT, INR, PTT
- LFTs
- Pro-Calcitonin

Diagnostic Procedures:

- Chest x-ray

Interventions

- Fluid bolus 20 mL/kg
- First dose antibiotics within one hour (see below Empiric Antibiotic Choice per Source)
- Initiate ICU admission (*if no response after initial fluid bolus*)
- Airway and Respiratory assessment
- CVP placement, subclavian or intrajugular (*if no response after initial fluid bolus*)
- Foley catheter
- Arterial line, if on pressors

Consults:

- Intensivist
- Infectious Disease, Dr. _____

The following should be in a CRITICAL CARE setting
(no response to fluid bolus)
Dysfunction criteria for Severe Sepsis

- Hypotension
- Bilateral infiltrates and requires supplemental O_2 to maintain saturation above 90

- PaO_2/FiO_2 <300
- Creatinine >2; urine output <0.5 mL/kg after fluid
- Platelets <100,000
- INR >5
- PT >20
- Bilirubin >2
- Altered mental status
- Glucose >120 mg/dL with no history of diabetes

Early Goal Targets

- CVP 8–12 mm Hg
- Mean arterial pressure (MAP) 65 mm Hg
- Systolic blood pressure 90 mm Hg
- Central venous oxygenation ($ScvO_2$) over 70 % or mixed venous oxygen saturation (SvO_2) over 65 %
- Urine output >0.5 ml/kg/hr

Additional Orders

1. Insulin per protocol (Critical Care Hypoglycemia Protocol)
2. DVT Prophylaxis: Heparin 5,000 units SC every 8 hours

or _____

3. Stress Ulcer Prophylaxis: Famotidine 20 mg IV every 12 hours

or _____

Goal Directed Therapy (*antibiotics already given*)

Optimization of CVP—Step 1

- If CVP <8 mm Hg give sodium chloride 500 mL bolus over 15 min
- Recheck CVP every 15 min and repeat boluses as above until target goal CVP of 8–12 mm Hg is achieved; then continue to Step 2

Optimization of MAP—Step 2

- If MAP <65, start norepinephrine 2 mcg/min. May titrate by 2 mcg/min every 15 min to max 12 mcg/min to maintain MAP ≥65. Once MAP is achieved, continue to Step 3

Optimization of $ScvO_2$—Step 3

- If $ScvO_2$ under 70 % OR mixed $ScvO_2$ under 65 % AND Hgb under 10 then transfuse 1 unit PBRC or as needed)
- If $ScvO_2$ under 70 % OR mixed $ScvO_2$ under 65 % AND Hgb over 10 then start dobutamine 2.5 mcg/kg/min. May titrate by 2.5 mcg/kg/min every 15 min to max of 20 mcg/kg/min until $ScvO_2$ over 70 % or mixed $ScvO_2$ over 65 %. Once $ScvO_2$ is achieved, goal directed therapy complete.

Empiric Antibiotic Selection by Source
First dose given with one hour of admission

- *Suspected Community Acquired Pneumonia*
  - ceftriaxone 1 g IV every 24 hours, first dose stat
  - azithromycin 500 mg IV every 24 hours, first dose stat
    If allergic to penicillin or cephalosporins:

  levofloxacin 750 mg IV every 24 hours, first dose stat

- *Suspected Health Care Associated Pneumonia (HCAP) or Pseudomonas*
  - cefepime 2 g IV every 8 hours, first dose stat
  - levofloxacin 750 mg IV every 24 hours, first dose stat
  - vancomycin 1 gram IV every 12 hours × 2, first dose stat
    If allergic to penicillin or cephalosporins:

  levofloxacin 750 mg IV every 24 hours, first dose stat
  aztreonam 2 g IV every 8 hours, first dose stat
  vancomycin 1 g IV every 12 hours × 2, first dose stat

- *Suspected Urinary Tract Infection*
  - ceftriaxone 1 g IV every 24 hours, first dose stat
  - gentamicin 5 mg/kg IV stat
    If allergic to penicillin or cephalosporins:

  levofloxacin 750 mg IV every 24 hours, first dose stat
  gentamicin 5 mg/kg IV stat

- *Suspected Intra-Abdominal Infection*
  - levofloxacin 750 mg IV every 24 hours, first dose stat
  - metronidazole 500 mg IV every 8 hours, first dose stat
    If allergic to quinolones:

  ertapenem 1 g IV every 24 hours, first dose stat

- *Suspected Skin/Soft Tissue Infection*
  - piperacillin/tazobactam 4.5 g IV every 6 hours, first dose stat
  - vancomycin 1 g IV every 12 hours × 2, first dose stat
    If allergic to penicillin or cephalosporins:

  levofloxacin 750 mg IV every 24 hours, first dose stat
  vancomycin 1 g IV every 12 hours × 2, first dose stat
  clindamycin 600 mg IV every 8 hours, if diabetic foot ulcer or wound

- *Suspected Severe Sepsis with Unknown Source of Infection*

  - piperacillin/tazobactam 4.5 g IV every 6 hours, first dose stat
  - vancomycin 1 g IV every 12 hours × 2, first dose stat
    If allergic to penicillin or cephalosporins:

  levofloxacin 750 mg IV every 24 hours, first dose stat
  metronidazole 500 mg IV every 8 hours, first dose stat
  vancomycin 1 g IV every 12 hours × 2, first dose stat.

Note: *The above dosages are calculated based on normal creatinine clearance*

Metric	Baseline	Target
Mortality rate for septic patient	Mortality rate (Jan '09 to Feb '10): 21.8%	10%
Time to identify patients with sepsis: Time from Arrival to EDP disposition	Average = 254 minutes Standard Deviation = 136 N = 111	90 minutes
Time to begin treatment	Do not currently measure.	60 minutes
Percent of patients receiving sepsis protocols.	Percent receiving sepsis protocol: 0%	100%

Fig. 9.10 Performance metric targets

Establish Performance Targets and Project Scorecard

The team established the performance targets for each metric as shown in Fig. 9.10.

Pilot Improvements, and Train and Execute

The sepsis protocol pilot began in March 2010 in the Emergency Department after going through the appropriate approval committees to gain buy-into the protocols. A Grand Rounds information session was held with the physicians and other clinical staff to explain the sepsis protocols.

We initially assessed improvement of the pilots from March through May 2010, but did not have significant improvement in reducing the sepsis mortality rate, and realized that the sepsis protocol was not being used in the ED. We then restarted the pilot effort and then collected data to assess improvement for the May through September 2010 data.

We then moved into the control phase where we assessed whether there was improvement in the metrics related to implementing the piloted changes.

Control Phase

The purpose of the Control Phase is to implement control mechanisms and procedures to ensure that the process maintains the levels of improvements attained during the pilot activities.

The following activities were executed in the Control Phase:

1. Measure results and manage change
2. Report scorecard data and create process control plan
3. Identify replication opportunities
4. Develop future plans.

Measure Results and Manage Change

We collected the improved data for the metrics, and performed the appropriate hypothesis tests to assess improvement.

We first assessed the sepsis mortality improvement for the time period of June through September of 2010. We performed the two-proportion test in Minitab®.

Test and CI for Two Proportions: Mortality Rate

Sample	X	N	Sample p
1	66	303	0.217822
2	9	74	0.121622

Difference = p (1) − p (2)
Estimate for difference: 0.0962002
95 % CI for difference: (0.00841781, 0.183983)
Test for difference = 0 (vs. not = 0): Z = 2.15 p-value = 0.032
Fisher's exact test: p-value = 0.074

The before and after mortality is shown in Fig. 9.11. The mortality was reduced by 9.6 % from 21.8 to 12.2 %, a statistically significant improvement, with a p-value of 0.032.

We then assessed whether there was a significant improvement in the time from arrival to EDP disposition. We performed a 2-sample t-test as follows:

Two-Sample T-Test and CI: Time from Arrival to Disposition

Sample	N	Mean	St Dev	SE Mean
1	111	254	136	13
2	64	197.0	87.0	11

Difference = mu (1) − mu (2)
Estimate for difference: 57.0
95 % CI for difference: (23.7, 90.3)
T-Test of difference = 0 (vs. not =): T-Value = 3.38 p-value = 0.001 DF = 171

	Baseline: Jan 09 to Feb 10	June to September 2010
Sepsis Mortality	66	9
Total Cases	303	74
Percent Mortality	**21.8%**	**12.2%**

Fig. 9.11 Percent of patients receiving sepsis protocols—before and after

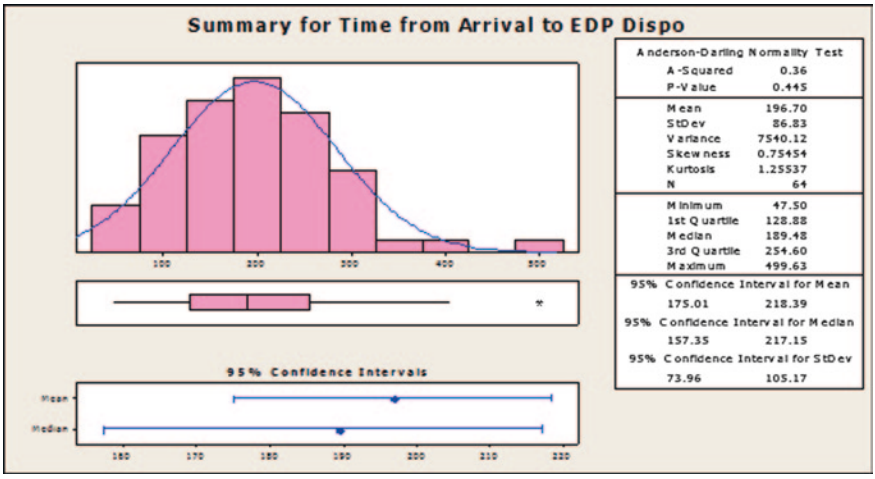

Fig. 9.12 Improvement—time to disposition

There was a significant improvement in the time from arrival to disposition, however it is not meeting the target of 90 min. The average time improved from 254 to 197, with a *p*-value of 0.001. The histogram is shown in Fig. 9.12 for the time to disposition.

Since the sepsis protocols had not been used in the past, we could not assess improvement, however, we did collect data on the time from arrival to when the orders were initially begun. The average was 33.6, with a standard deviation of 28.1. This is better than the target of 60 min. The histogram of the time to the orders is shown in Fig. 9.13.

We then assessed whether there was a significant improvement in the percent of patients diagnosed with sepsis that received the sepsis protocols in the Emergency Department. The baseline percentage was 0 %, and the improved percentage was 5.4 %, still far from meeting the target of 100 %. The percentages are shown in Fig. 9.14.

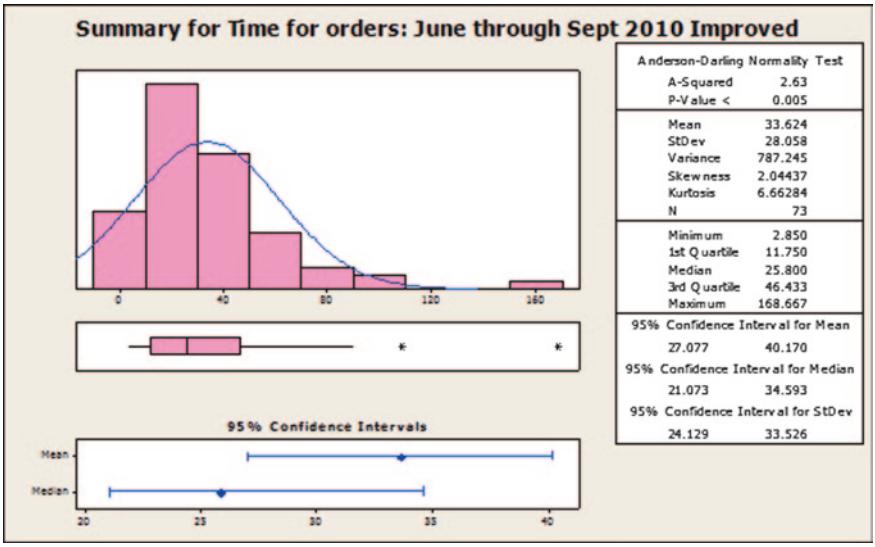

Fig. 9.13 Improvement—time to treatment

Fig. 9.14 Before and after percent of patients receiving sepsis protocol

Metric	Before (Baseline – Jan. 09 to Feb 10)	After Improvement (June 10 to Sept 10)
Number Receiving Sepsis Protocol	0	4
Number Sepsis Diagnosis	28	74
Percent Patients Receiving Sepsis Protocol	0%	5.4%
Statistically Significant Improvement?	Yes	P-value = .040

The metrics before and after improvement are shown in Fig. 9.15. We have shown improvement in all of the metrics, even though we still need to ensure that the protocols are delivered promptly to improve the percent of patients that receive the protocols and to further reduce the sepsis mortality.

We redid the process capability for the improved process for the time from arrival to disposition (Fig. 9.16) and the time to treatment (Fig. 9.17). The processes are still not capable of meeting the desired specifications. Further improvement and adherence to the protocols is needed.

Critical to Satisfaction (CTS)	Metric	Baseline	Improvement (June through September 2010)	Target	Significant Improvement / P-value
Mortality Rate of Hospital Sepsis Patients	Mortality rate for septic patient	Mortality rate (Jan '09 to Feb '10): 21.8%	Mortality rate: 12.2%	10%	Yes P-value = .032
- Time to identify patients with sepsis - Time to source control	Time to identify patients with sepsis: Time from Arrival to EDP disposition	Average = 254 minutes Standard Deviation = 136 N = 111	Average = 197 Standard Deviation = 86.8 N = 64	90 minutes	Yes P-value = .001
Time to treatment	Time to initial orders	Do not currently measure.	Average = 33.6 minutes Standard Deviation = 28.1 N = 73	60 minutes	Met Target
Patients receive sepsis protocols.	Percent of patients receiving sepsis protocols.	Percent receiving sepsis protocol: 0%	Percent receiving sepsis protocol: 5.4%	100%	Yes P-value = 0.040

Fig. 9.15 Before and after metric improvement

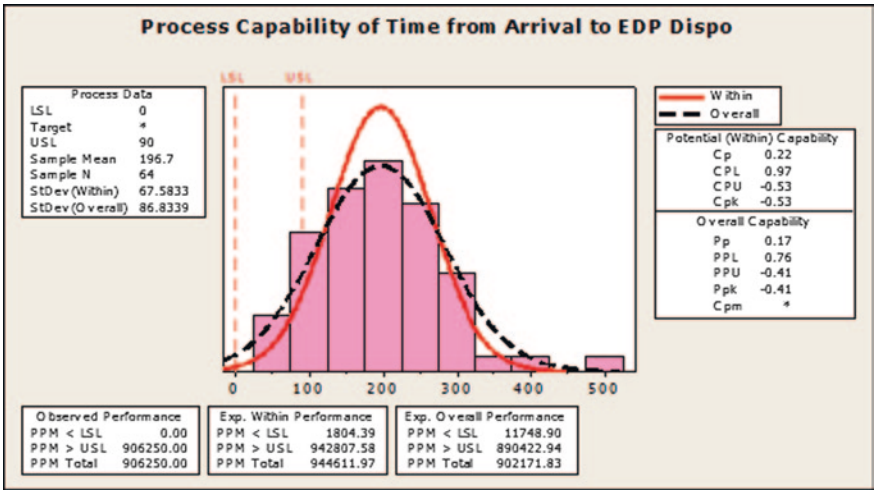

Fig. 9.16 Improved process capability of time to disposition

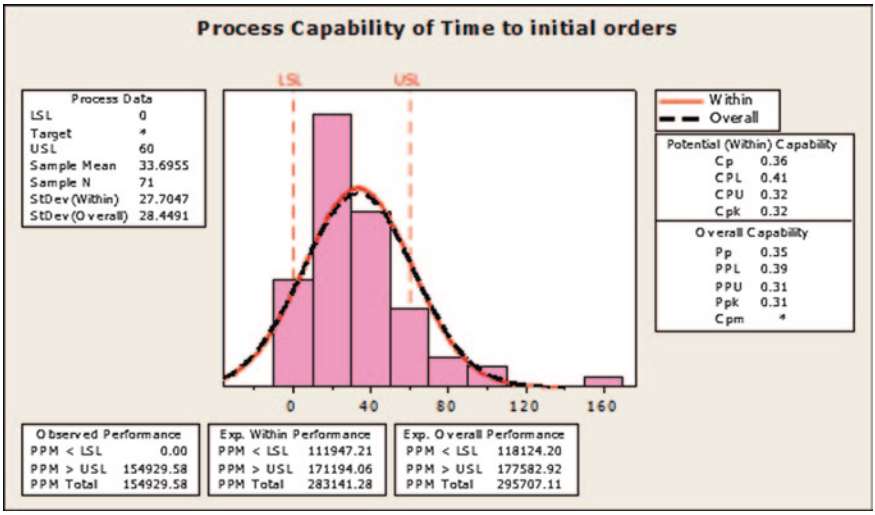

Fig. 9.17 Improved process capability of time to treatment

Metric	Baseline	Target	June through September 2010	Statistically Significant Improvement?
Sepsis Mortality Rate	21.7%	10%	12.2%	Yes, Statistically significant improvement (p-value = .032)
Time to identify patients with sepsis; time to source control (Time from Arrival to EDP Disposition Time)	Average = 254 minutes Standard Deviation = 136 N = 111	90 minutes	Average = 197 Standard Deviation = 86.8 N = 64	Yes P-value = .001
Time to treatment **(time to initial orders)**	**Did not measure**	**60 minutes**	**Average = 33.6 minutes** **Standard Deviation = 28.1** **N = 73**	**Met Target of 60 minutes**
% Patients receiving Sepsis Protocol	0%	100%	5.4%	Yes, Statistically significant Improvement

Fig. 9.18 Scorecard

Report Scorecard Data and Create Process Control Plan

The control plan for the sepsis project will be to monitor the metrics on a monthly basis. The metrics dashboard is shown in Fig. 9.18.

Identify Replication Opportunities

The sepsis protocols can be implemented throughout the hospital. Most patients with sepsis are admitted through the Emergency Department, but these same protocols can be used and continued in the critical care units and other hospital departments as appropriate.

Develop Future Plans

We need to identify additional improvements so that the performance targets can be met and further statistical improvements can be attained for the remaining metrics.

Summary and Project Critical Success Factors

- Engagement of the Emergency Department physicians, the intensivists, and sepsis specialists was critical to the success of the project.
- Applying the Six Sigma methodology to assess the baseline and improved metrics, and to apply the Six Sigma tools was also critical.
- Facilitation and analysis by the Six Sigma Master Black Belt was critical to ensure that the value of Six Sigma was attained.

Engagement of ED staff, including the nurse manager, the charge nurses, and the ED nurses is critical to ensure that the protocols are implemented in a timely manner.

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Chapter 10
Design of Women's Center Service Processes

Abstract A community hospital's Women's Center recently moved into a new facility to respond to the exponential growth of women's health care needs in their market area by redefining, refocusing, reconfiguring, and expanding its women's health services line. They had an existing smaller center, with fewer services that was part of their outpatient facility. The goal of the new facility is to create a "*one stop shopping*" model where women can receive a comprehensive range of services conveniently, comfortably, efficiently, and with speed and ease. A similar case was originally published in Cudney and Furterer (2012) and Cudney et al. (2013).

Project Goals

The intent of the Women's Center (WC) is to offer a diverse array of women's outpatient services in one location that provides convenient and easy access to multiple services including physician, diagnostic, ancillary, education, and outreach services. The vision of the WC is to build patient loyalty among women in the community and become the provider of choice for all their healthcare needs. It is expected that the WC will not only increase market share for outpatient services, but will also increase inpatient volume and referrals back to the hospital.

The new Women's Center plan assumes potential process and staffing changes, such as:

- Having radiology results available while the patient is in the center.
- Providing the ability to assess authorization of additional diagnostics.
- Being able to meet with a physician if the patient requests.

These process requirements need to be clearly defined before the new process and staffing is defined. The requirements significantly impact the processes. This project focuses on designing efficient processes that meet the needs of the customers (women) who will receive services at the Women's Center. The processes should have work flows that optimize throughput, reduce wait times, and provide next business day results to the patients that receive women's services. This project will use elements

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of the tools and methods of Six Sigma, Lean, and Design for Six Sigma. The project method applied was Define, Measure and Design, Analyze, Improve, Control.

Define Phase

The define phase activities included the following

(1) Create project charter
(2) Perform stakeholder analysis
(3) Create the team's project plan.

Create Project Charter

The first step was to develop a project charter, shown in Fig. 10.1.

Project Name Design of Women's Center Service Processes

Project Overview Many outpatient facilities are focusing on providing comprehensive services to women in a comfortable setting. In a qualitative study of women who had received a mammogram in the prior 3 years, without a history of cancer, satisfaction was related to the entire experience, not just the actual mammogram procedure. The authors of the described study found seven satisfaction themes from the focus groups: (1) appointment scheduling, (2) facility, (3) general exam,

Project Name: Design of Women's Center Service Processes

Problem Statement: A new Women's Center facility was being designed with the goal of incorporating streamlined processes that align with the patients' expectations and Voice of the Customer.

Customers/Stakeholders: Patients, Referring Physicians, Payers, Donors, Imaging technologists, Radiologists, Administration, Registration, Centralized Scheduling, Information Technology, Physicians, Marketing and Development.

Goal of the Project: To design the processes and metrics which result in optimal flow for the new Women's Center and align to the Voice of the Customer.

Scope Statement: The scope includes the new Women's Center diagnostic services (Mammography, Ultrasound, Stereotactic Biopsy, and Bone Densitometry), registration, and appointment scheduling.

Potential Benefits: Patient satisfaction, increased capacity due to efficient workflow, and resultant revenue are potential financial benefits of this project.

Fig. 10.1 Project charter

(4) embarrassment, (5) exam discomfort/pain, (6) treatment by the technologist, and (7) reporting results (Kimberly et al. 2005). This supports the focus of designing a seamless experience for women in the Women's Center through applying Six Sigma, Lean, and Design for Six Sigma methodology and tools.

Problem Statement

The results for patients who visited the former Women's Center were transmitted to the primary care provider (PCP) within an average 57 hours. There was large variability in how and when the test results were communicated to the patients. The desire is to open the new facility with streamlined processes that align to the patients' needs as defined and collected through the Voice of the Customer.

Some of the questions that the team had to answer before the new center opened were:

- How do we measure the success of the new women's center?
- What processes will stay the same for the new center?
- What processes will be different in the new center?
- What is our current state and future state?
- Should we perform activities in parallel or series? Or both?
- What is our forecasted demand? Do we have different processes based on our volume?
- What is our goal for waiting time? Is it different for the different areas (i.e., registration, radiology reception, gowned waiting room)?
- What should we prioritize patients by (i.e., appointment time, arrival time, waiting time)?
- What is an acceptable wait time when having two tests done?
- Will patients have their results available after their tests? Will the results be available for all types of tests (diagnostic/screening)?
- Will patients have the ability to meet with a physician given the test result comes back requiring further testing?
- Will patients be able to get a diagnostic test?

Customers/Stakeholders

External Patients (Women that receive services in the center), Referring Physicians, Payers, Donors.

Internal Imaging Technologists, Radiologists, Administration, Registration, Centralized Scheduling, Information Technology, Physicians, and Marketing and Development.

Goal of the Project

To design the processes and metrics which result in optimal flow for the new Women's Center and align to the Voice of the Customer.

Scope Statement

The scope includes the new Women's Center diagnostic services (Mammography, Ultrasound, Stereotactic Biopsy, and Bone Densitometry), registration, and appointment scheduling.

Projected Benefit(s)

Stakeholders	Role	Potential Impacts / Concerns
Patient (women)	Receive services in the center	▪ Customer Service ▪ Quality ▪ Efficiency
Referring physicians	Refer patients to the center and communicate results to the patient	▪ Quality of care
Payers	Pay for services, such as managed care, Medicare employers, self pay	▪ Quality ▪ Cost effective care
Donors	People who donate money to the center	▪ Quality of care ▪ Meet patient requirements
Imaging Technologist	Work in the center and perform procedures	▪ Patient satisfactions ▪ Improve / well designed work environment ▪ Associate satisfaction
Radiologists	Read and provide results of imaging procedures	▪ Reduced volume and revenue ▪ Physician satisfaction
Administration	Manage the hospital and center	▪ Volume ▪ Revenue ▪ Patient satisfaction ▪ Physician satisfaction ▪ Productivity
Patient scheduling	Registration who registers patients and performs insurance authorization, centralized scheduling who make the patient appointments	▪ Volume ▪ Productivity ▪ Timeliness of processes
Information Technology	Provide phone and computer systems	▪ Meet requirements ▪ On time ▪ On budget

Fig. 10.2 Stakeholder analysis definition

Patient satisfaction, increased capacity due to efficient workflow, and resultant revenue are potential financial benefits of this project.

Perform Stakeholder Analysis

The stakeholder analysis was performed to identify the project stakeholders. The stakeholder analysis definition is shown in Fig. 10.2.

Create Project Plan

A Gantt chart was used to keep the project development cycle on track and ensure that all key steps in the process were accomplished. The project plan includes the tasks, task durations, start and end dates, predecessors of each task, and the resources to perform each task. The project started in March 2010 and finished in November 2010.

Measure and Design Phase

The Measure and Design phase of the project is designed to gain information on the voice of the customer (VOC) to understand the needs of the customers and begin translating those customer requirements into the processes' technical elements, and to baseline the existing process. The main activities of this phase are to:

(1) collect VOC;
(2) translate VOC into technical requirements;
(3) define the operational definitions for how you will measure the process.

Collect Voice of the Customer

We first defined the market opportunities through a literature search and identified the following findings that support the importance of a comprehensive women's center:

Market Opportunities

Specific areas in which women have high mortality and morbidity rates include:

- 60 % of hospital patients are women.
- 50 % of all women over age 50 will have osteoporosis.
- Hypertension is three times higher for women than men.
- Depression is more common in women than men, affecting over 7 million women in the U.S.
- 75 % of Alzheimer's patients are women.
- 90 % of Rheumatoid Arthritis cases are women.
- 90 % of Lupus patients are women.
- An estimated 10 million women in the U.S. suffer from Urinary Incontinence.
- Women have twice the incidence of Multiple Sclerosis than men.
- 1 in 7 women age 45 or older has cardiovascular disease and 45 % of all female deaths are cardiac related.
- Almost 80 % of Fibromyalgia cases are female.
- Over 80 % of Bariatric surgery patients are women.

The team performed a literature search to identify customer requirements that impact satisfaction in a women's center. Engelman et al. (2005) performed focus groups to identify the factors and dimensions related to a patient's experience with a mammography procedure. They identified the number of coded text lines from the focus group transcripts for the factors and dimensions related to the patient experience. We developed a Pareto chart identifying the most important factors and the most important dimensions for each factor. The Pareto chart for the factors is shown in Fig. 10.3. The percentage importance based on the number of coded text lines for the dimensions of each factor are shown in Figs. 10.4,10.5, 10.6, 10.7, 10.8, 10.9, and 10.10.

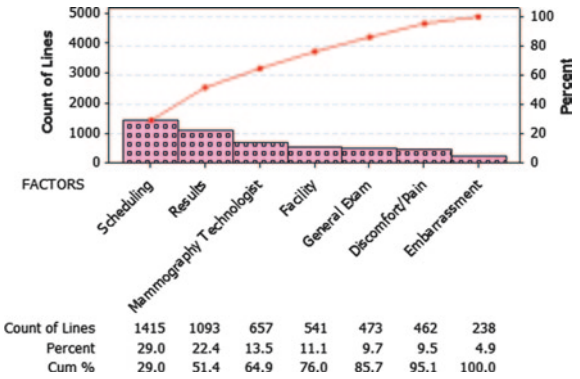

Fig. 10.3 Pareto chart of importance by factor

Factors	Dimensions	# of lines	Definition	Importance
Scheduling	Convenience	529	Convenience of scheduling an appointment	37%
Scheduling	Reasons	306	Reasons to schedule or not to schedule a mammogram	22%
Scheduling	Financial	213	Financial issues surrounding paying for the mammogram	15%
Scheduling	Scheduling Timing	187	Time between scheduling of appointment and actual appointment date	13%
Scheduling	Reminders	129	Reminders or other cues to schedule a mammogram	9%
Scheduling	Transportation	51	Transportation to/from the appointment	4%
		1415		

Fig. 10.4 Scheduling dimension

Scheduling was the highest importance factor, with the most important dimensions being scheduling convenience, reasons to schedule a mammogram, and financial issues around paying for a mammogram. Results was the next most important factor, with the important dimensions being the manner that the results are reported, the time it takes to receive the results, and the need to return for suspicious findings or additional procedures. The mammography technologist factor was the next most important element, with the important dimensions being the technologist's attitude toward the woman during the exam, the provision of the exam instruction, and the technologists' skill in performing the procedure. The facility was the next most important factor, with the most important dimension including the environment of the waiting room including cleanliness, having an

Factors	Dimensions	# of lines	Definition	Importance
Results	Notification	358	Method in which results are conveyed	33%
Results	Results timing	249	The time it takes to receive notification of results and anxiety while waiting for results	23%
Results	Return procedures	221	Suspicious findings resulting in repeat views or returning for other procedures	20%
Results	Questions	156	Provision of information or education to address abnormal results	14%
Results	Relief	55	Feeling of relief when test is normal	5%
Results	Misconception	54	Misconception that technologist reporting adequate film quality was providing results of the exam	5%
		1093		

Fig. 10.5 Results dimension

Factors	Dimensions	# of lines	Definition	Importance
Mammography Technologist	Attitude	215	Technologists attitude toward woman during procedure	33%
Mammography Technologist	Exam Instruction	183	Provision of exam instruction - necessary physical contact, breast placement	28%
Mammography Technologist	Skill/experience	149	Technologists skill and experience in performing mammograms (good/bad)	23%
Mammography Technologist	Breast positioning	110	Women's perception of technologists positioning of her breast (gentle/rough)	17%
		657		

Fig. 10.6 Mammography technologist dimension

educational video and magazines, noise level, décor, and beverage availability. The general exam was the next most important factor, with the issues surrounding the gown worn for the procedure being the most important, followed by instructions to prepare for the procedure, and the cold or warm machine plate. Discomfort and pain was the next most important factor, with the most important dimension including uncomfortable pressure due to the breast plate compression. The least most frequently discussed element of mammograms is the embarrassment factor, including the most important dimensions of the embarrassment from participating in an exam of a personal nature, embarrassment of discussing the mammogram with family, friends, or their health care provider, and self-consciousness due to being modest.

Factors	Dimensions	# of lines	Definition	Importance
Facility	Waiting Room	281	Environment of waiting room at facility (cleanliness, educational video, magazines, noise, décor, beverages)	52%
Facility	Distance traveled	77	Distance traveled by woman to reach the facility	14%
Facility	Changing area	73	Place where woman disrobes in preparation for procedure and where personal effects are stored	13%
Facility	Exam Room	68	Procedure/exam room environment	13%
Facility	Parking	42	Convenience of parking	8%
		541		

Fig. 10.7 Facility dimension

Factors	Dimensions	# of lines	Definition	Importance
General Exam	Gown	170	Issues surrounding the gown worn during exam	36%
General Exam	Preparation instructions	90	Instructions provided to prepare for mammogram (deodorant, jeweler, caffeine intake)	19%
General Exam	Plate temperature	89	Cold or warm machine plate	19%
General Exam	Safety/reliability	66	Questions about safety and reliability of procedure	14%
General Exam	Unfamiliarity/Apprehension	30	Unfamiliarity with mammogram procedure leads to feelings of apprehension, fear or being scared	6%
General Exam	Forget experience	28	Unpleasant exam causes woman to block it out or want to hurry through the exam	6%
		473		

Fig. 10.8 General exam dimension

Identify CTS Measures and Targets

The Women's Center is fortunate to have some very special donors and supporters. Marketing held several focus groups with these key donors to understand their critical requirements, so that we could extract the Critical to Satisfaction Criteria from the focus group qualitative data. The CTS' are shown in Fig. 10.11.

Develop Current State Value Stream Map

We developed a current state value stream map using the data in the information system that tracked process times. The value stream map is shown in Fig. 10.12. The main process steps are:

Factors	Dimensions	# of lines	Definition	Importance
Discomfort/Pain	Pressure	118	Uncomfortable pressure due to breast plate compression	26%
Discomfort/Pain	Skin Stretch	83	Breast placement and plate pressure causes breast and surrounding skin to pinch pull stretch or tug	18%
Discomfort/Pain	Horror stories	74	Stories about bad mammogram experiences from friends and/or family members	16%
Discomfort/Pain	Breast size	63	Size of breast determines level of pain experienced	14%
Discomfort/Pain	Height of machine	56	Short stature causes uncomfortable extension of breast up to machine	12%
Discomfort/Pain	Breast cysts	35	Fibrocystic disease leads to increased pain during mammogram	8%
Discomfort/Pain	Anticipation/fear	33	Anticipation of pain results in fear or anxiety for mammogram procedure	7%
		462		

Fig. 10.9 Discomfort/pain dimensions

Factors	Dimensions	# of lines	Definition	Importance
Embarrassment	Related to culture	89	Embarrassment of participating in exams of a personal nature due to cultural background	37%
Embarrassment	Mammogram discussion	62	Embarrassment surrounding discussing mammograms with family friends or health care providers (due to cultural background)	26%
Embarrassment	Modesty	54	Self conscious during appointment due to being modest	23%
Embarrassment	Privacy	27	Exam environment not conducive to privacy	11%
Embarrassment	About body or breast size	6	Self conscious about body image and/or large/small breast size	3%
		238		

Fig. 10.10 Embarrassment dimension

(1) Patient calls and schedules an appointment for a screening mammogram.
(2) The center verifies the insurance and authorizes the screening.
(3) The screening is performed at the Women's Center.
(4) The results are read by the Radiologist.
(5) The results are prepared in a letter and sent to the patient.
(6) Twenty eight and a half percent (28.5 %) of the patients require a diagnostic appointment for further scans and views. The diagnostic appointment is made.
(7) The center verifies the authorization for the diagnostic mammogram.
(8) The diagnostic procedure is performed.

Critical To Satisfaction
Environment
Comfortable
Ease of parking
Aesthetic rooms and geared psychologically to women
Creative access points to modern facilities
Guided through health issues in a nurturing, relaxing environment
Operational
Efficiently, with speed
Ease
Easy navigation throughout the system
Time-saving, convenience
Combined appointments
Same day results
Caring and competent professional staff
Customer focused amenities
Advanced technology as an enabler of superior care
One Visit, One Stop
Guided through health issues in a nurturing, relaxing environment
Service
Seamless integration of service components
All ages and life phases
Comprehensive range of services
One Visit, One Stop
Guided through health issues in a nurturing, relaxing environment
Coordination of medical and health concerns and treatments, multi-disciplinary team
Integrating between physicians, diagnostics, and ancillary
Functional medicine that combines traditional and integrative
Gender-specific medicine
Holistic care
Aligned with core values

Fig. 10.11 Critical to satisfaction (CTS) criteria

(9) The results are read by the radiologist and sent to the patient.
(10) About 3 % of the patients require a biopsy. The patient calls to schedule the biopsy appointment.
(11) The center verifies the authorization for the biopsy procedure.
(12) The biopsy procedure is performed.
(13) The results are provided to the patient.
(14) The patient receives the results. Further surgical procedures would be scheduled at a surgical center if necessary.

The lead time for the entire end to end process is 33.38 days [from screening to biopsy (if necessary)]. The value added cycle time is 185 minutes, or 12 days. There is clearly a great deal of wait time and delays in the current process.

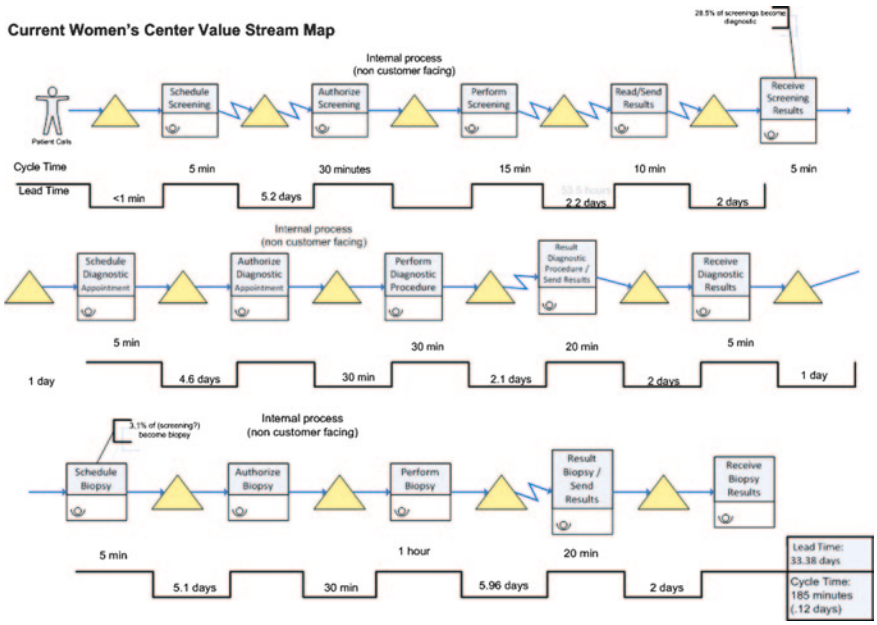

Fig. 10.12 Current state value stream map

Translate VOC into Technical Requirements

Quality Function Deployment

Using the voice of the customer we built three Houses of Quality. These are the steps we used to build it:

Step 1: List the customer requirements, with their importance rating on a scale of 1 (low) to 10 (high).

Step 2: List the technical process requirements that will affect more than one of the customer requirements, in the process.

Step 3: Compare the two (customer requirements to the technical process requirements) and determine the relationships, identifying a strong relationship (9), medium relationship (3), low relationship (1), or no relationship (blank).

Step 4: Obtain the weighting and ranking for the process requirements.

Step 5: Carry the weighting to the second House of Quality. Place the process requirements on the left vertically and identify the process components that will help to meet the process requirements.

Step 6: Determine the relationships between the process requirements and the process components.

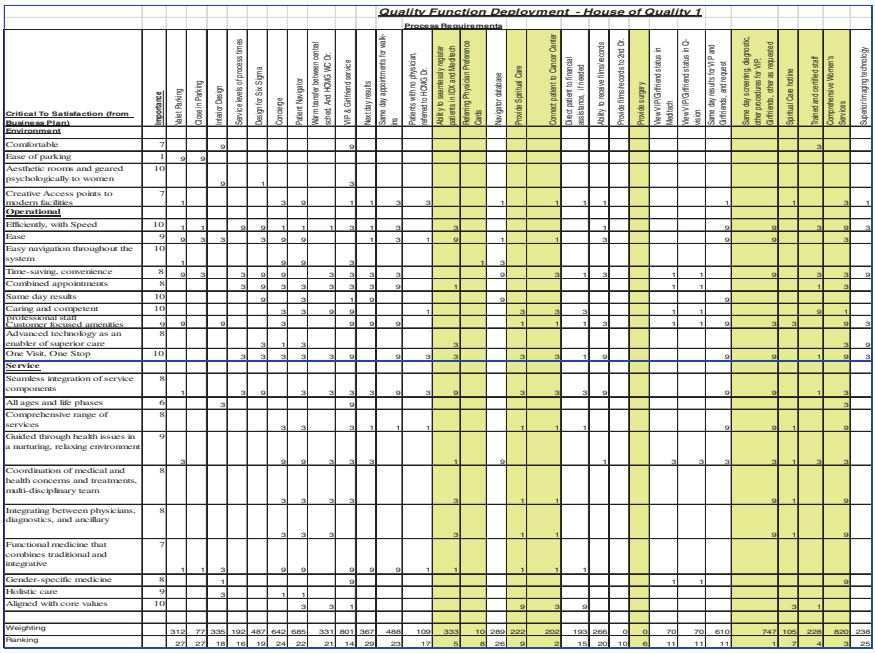

Fig. 10.13 House of Quality 1: customer and technical process requirements

Step 7: Carry the weighting to the third House of Quality. Place the process components on the left vertically and identify the process metrics that measure the process components.

Step 8: Determine the relationships between the process components and the process metrics.

The House of Quality 1 is shown in Fig. 10.13. The House of Quality 2 is shown in Fig. 10.14 and the House of Quality 3 is shown in Fig. 10.15.

Kano Analysis

The Kano analysis was used to identify the exciting performance related Critical to Satisfaction criteria that would provide excitement and be exciters to the Comprehensive Women's Centers patients, and the basic factors that if missing would be dissatisfiers. The Kano Analysis is shown in Fig. 10.16.

Create Operational Definitions and Conceptual Model

The following Operational Definitions were developed for the results times:

Operational definition Time from arrival in imaging reception to exam

Quality Function Deployment - House of Quality 2

Process Requirements	Importance	Schedule Service	Register Patient	Perform Service	Provide Imaging Results	Provide Spiritual Care	Connect to Cancer Center	Authorize Service	Process Self Referral	Request Records/ Films	Receive Referral	Perform Surgery	Process VIP Patient
		Process Components											
Valet Parking	312												
Close in Parking	77												
Interior Design	335			3									9
Service levels of process times	192	9	9	9	9			9		9		9	9
Design for Six Sigma	487	9	9	9	9			9		9		9	9
Concierge	642	3	3			1	1			1			9
Patient Navigator	685	9	2	3	9	1	9		3	3			9
Warm transfer between central sched. And HCMG WC Dr.	331	9											
VIP & Girlfriend service	801	9	9	9	9	9	9	9		3		3	9
Next day results	367				9	3	3						
Same day appointments for walk-ins	488	9	9	9									
Patients with no physician, referred to HCMG Dr.	109								9				
Ability to seamlessly register patients in IDX and Meditech	333		9										
Referring Physician Preference Cards	10				9								
Navigator database	289	9			9	3	9			1		3	9
Provide Spiritual Care	222					9	3						
Connect patient to Cancer Center	202					3	9						
Direct patient to financial assistance, if needed	193		9	9									
Ability to receive films/records	266									9			
Provide films/records to 2nd Dr.	0									9			
Provide surgery	0											9	
View VIP/Girlfriend status in Meditech	70												9
View VIP/Girlfriend status in Q vision	70												9
Same day results for VIP and Girlfriends, and request	610			3	9								9
Same day screening, diagnostic, other procedures for VIP, Girlfriends, other as requested	747	3	3	9	9	1	1	9					9
Spiritual Care hotline	105					9							
Trained and certified staff	228	9	9	9	9	3	9	9	1	3	1	9	9
Comprehensive Women's Services	820	9	9	9	9	9	9	9	3	9	3	9	9
Superior Imaging technology	238			9	9					9			9
Weighting		43,056	37,415	42,636	49,266	22,864	30,381	29,475	5,724	24,100	2,688	18,813	55,926
Ranking		7	5	3	2	8	6	4	11	10	12	9	1

Fig. 10.14 House of Quality 2: technical process requirements and process components

Quality Function Deployment - House of Quality 3

Process Components	Importance	Days to schedule service	Time to register	Time to Perform Service	Wait time for Register	Wait time for Service	Time to Provide Results (internal)	Time to Provide Results (external)	Time to connect to Spiritual Care	% patients receiving Spiritual Care	Time to connect to Cancer Center	% Patients Connect to Cancer Center	Time to authorize service	Time to provide records / films	Time to perform surgery	% of VIP patients processed
						Metrics										
Schedule Service	6	9														
Register Patient	8		9		9											
Perform Service	10			9		9										
Provide Imaging Results	11						9	9								
Provide Spiritual Care	5								9	9						
Connect to Cancer Center	7										9	9				
Authorize Service	9												9			
Process Self Referral	2															
Request Records/ Films	3													9		
Receive Referral	1															
Perform Surgery	4														9	
Process VIP Patient	12															9
Weighting		54	72	90	72	90	99	99	45	45	63	63	81	27	36	108
Ranking		11	7	4	7	4	2	2	12	12	9	9	6	14	15	1

Fig. 10.15 House of Quality 3: process components and process metrics

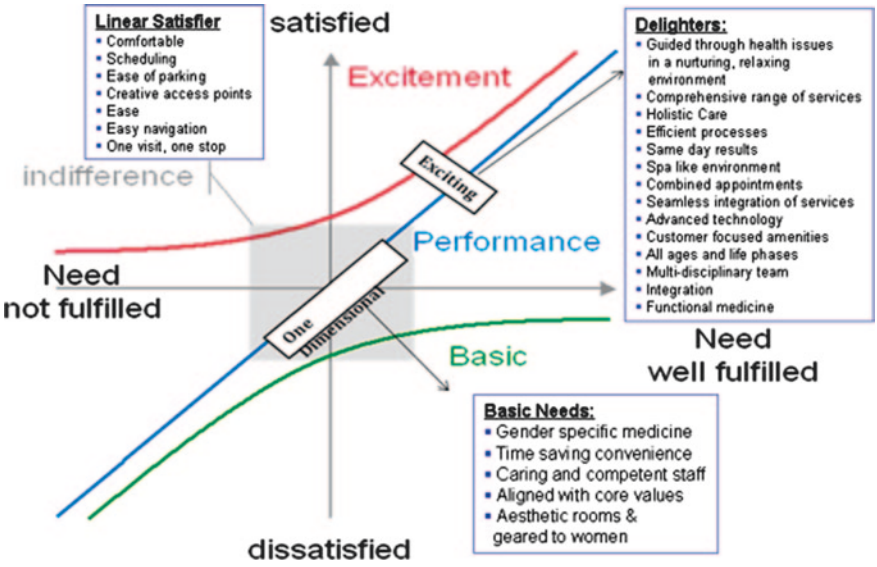

Fig. 10.16 Kano model for Women's Center

Defining the measure: The focus is on the time it takes to present at the Radiology reception desk until the procedure is initiated.

Purpose: We want to understand how long patients wait.

Clear way to measure the process:

We will measure the time that a patient waits in the waiting area of the Radiology department. This will be measured by calculating the elapsed time from when the patient presents at the Imaging reception desk until they enter the procedure room. To baseline we will use data from 4/1 to 6/24 and subtract CheckInTime from InProcessTime.

Operational definition: Time from procedure start to procedure completion.

Defining the measure The focus is on the time it takes to complete procedures.

Purpose: We want to understand how long the procedure takes.

Clear way to measure the process:

We will measure the time that a patient spends in a procedure room in the Radiology department. This will be measured by calculating the elapsed time from when the patient enters the procedure room until the procedure is complete. To baseline we will use data from 4/1 to 6/24 and subtract InProcessTime from CompletedTime:Mammo.

Operational definition: Time from procedure completion to results are available.

Defining the measure: The focus is on the time it takes to result and transmit procedure results.

Purpose We want to understand how long it takes for procedure results to be available.

Clear way to measure the process:

We will measure the time that a Radiologist takes to result procedures and for the techs to upload them into the medical information system for transmission. This will be measured by calculating the elapsed time from when the procedure is complete until it is available to the primary care physician (PCP).

Operational definition Time from exam completion to review with patient.

Defining the measure The focus is on the time it takes to communicate results to patients.

Based on the critical to satisfaction and the understanding of the current processes, the Master Black Belt developed a conceptual model of the Women's Center. The conceptual model helps to identify the key elements to incorporate into the design for the Women's Center, including the people, materials, and information used in the processes. The Women's Center Conceptual Model is shown in Fig. 10.17.

Analyze Phase

The following is the Analyze phase for the Women's Center project. The Analyze phase is focused on understanding the factors that contribute to an efficient process and the potential root causes of inefficiencies so they are reduced or eliminated with the potential to achieve a six sigma quality level. The main activities of this phase are as follows: (1) develop the new process, (2) perform process analysis, and (3) perform waste analysis and root cause analysis.

Develop New Processes

A business scenario method was used to develop the new processes. The following are the steps that we applied (TOGAF 2011).

(1) *Identify the business scenario objectives* Design the new processes to meet the customer requirements and Critical to Satisfaction characteristics identified in the voice of the customer analysis.
(2) *Identify the business scenarios to generate* The core processes were identified for the business scenarios.

- Schedule service
- Register patient
- Perform service

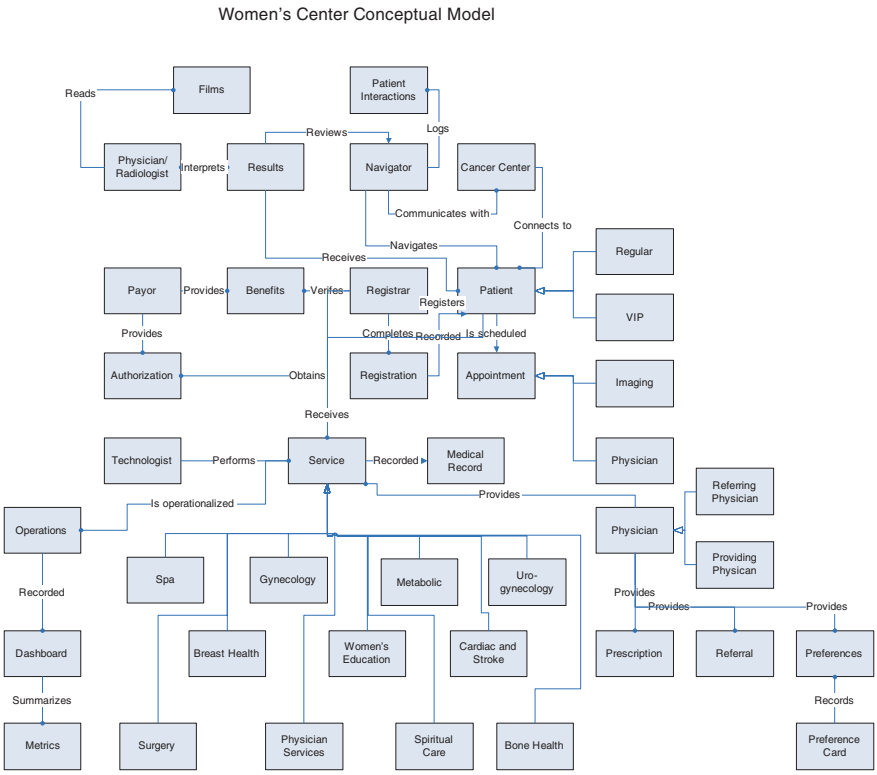

Fig. 10.17 Women's Center conceptual model

- Provide results
- Provide spiritual care
- Connect to cancer center
- Authorize service
- Self referral
- Request films
- Receive referral
- Perform surgery
- VIP (Very Important Person) processing
- Patient navigator processing

(3) Develop the business scenarios, asking the following questions for each scenario:

Business Scenario Checklist

- What is the overall objective of the scenario?
- What are any pre-conditions that must exist to start the scenario?
- What are the inputs (information, etc.) used to start the scenario?

Business Scenario Template

BUSINESS SCENARIO GENERAL INFORMATION
Use Case Name
Use Case ID
Intent
Start (Trigger) Stimulus

CUSTOMERS	
Primary Customers	
Secondary Customers	

PRE-CONDITIONS
1.
2.
3.
4.

ASSUMPTIONS			
#	Assumption	Date	Owner
1.			
2.			
3.			
4.			
5.			

Fig. 10.18 Business scenario template, page 1

- Walk through the "happy path" steps to get to the end result?
- Walk through alternate steps to get to the end result; and "not" to get to the end result (failure)?
- Think of who the person would interact with along the way?
- Think of what systems the person might interact with (generally)?
- Think of assumptions or needs the person might expect to require during the scenario?
- What is the final outcome, result, or output?
- What are the resources and people needed?

(4) Review the scenarios with the team and revise as necessary.
(5) Develop the process maps from the business scenarios.

The business scenario template is shown in Figs. 10.18 and 10.19.

A sample business scenario for Provide Imaging Results, is shown in Figs. 10.20, 10.21, 10.22, 10.23, 10.24, 10.25 and 10.26.

Perform Process Analysis

The process analysis defined the process inefficiencies for each proposed process, it is shown in Fig. 10.27.

	BASIC FLOW: Provide Imaging Results – Screening Mammography				
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.

POST-CONDITIONS			Service Level Goals
	Course	Description	
1.	Ideal		
2.	Alt-A		
3.	Alt-B		

	Alternate A:				
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.

REVISION HISTORY			
Date	Version	Description	Author

Fig. 10.19 Business scenario template, page 2

BUSINESS SCENARIO GENERAL INFORMATION	
Use Case Name	**Provide Imaging Results**
Use Case ID	004
Intent	Describes the process of providing imaging results
Start (Trigger) Stimulus	Patient receives imaging service

CUSTOMERS	
Primary Customers	Imaging Patient
Secondary Customers	Medical Group Patient

PRE-CONDITIONS	
1.	Patient has received an imaging service
2.	
3.	
4.	

ASSUMPTIONS	
1.	A preference card database exists with referring physician preferences of when Patient Navigator will provide which results to their patients.
2.	Patient Navigator will record discussions with patients, and call attempts when not successfully reaching the patient.
3.	Patient Navigator coordinates navigation of patient through Women's Center

Fig. 10.20 Business scenario provide results, page 1

BASIC FLOW: Provide Imaging Results – Screening Mammography					
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.
1.	Mammography technologist completes the study	Image from PACS	Radiology technologist		
2.	Radiologist reviews case	Image from PACS	Radiologist		PACS
3.	If need diagnostic screening, patient navigator notifies referring physician.		Patient Navigator		
4.	Radiologist may discuss case with referring physician.	Finding	Radiologist	Discussion information	
5.	Radiologist documents physician contact	Discussion information	Radiologist	Record of physician contact	
6.	Radiologist reports into Penrad		Radiologist	Radiologist report	Penrad
7.	Penrad sends data to Meditech	Result data After manual upload reference 8			Penrad
8.	Radiology staff uploads reports into Meditech 3 times a day	Results data	Radiology staff	Results data, letters reports faxed/mailed to ordering physician	Penrad/Meditech
9.	Penrad creates letter to patient	Result data		Patient letter	Penrad
10.	Review preference card for referring physician to identify whether can call patient with results	Preference card	Patient Navigator	Preferences	???
11.	Patient navigator calls patients to discuss results for those patients that they can call, for 1, 2, 3 results.	Results data, letters	Patient Navigator		
12.	If Patient Navigator cannot reach patient, tries several times, and records attempts.	Results data.	Patient Navigator	Record of calls	
13.	If patient needs additional procedure, Patient navigator or Dr. Office will facilitate appointment. Patient Navigator can call centralized scheduling with the verbal order, and do a warm transfer with the patient for demographics. Use Schedule Service Use Case	Patient info	Patient Navigator	Appointment request	
14.	Patient navigator ensures that certified mail is sent and retains records for follow up.	Patient	Patient Navigator	Record of certified mail	
15.	Create full report, when upload report into Penrad, generates final report that goes into Meditech	Results data	System	Full report	Meditech
16.	Patient receives results with letter, patient navigator, and referring physician.	Results		Results	
17.	- If patient requests, radiologist talks to patient	Patient request	Radiologist		

Fig. 10.21 Business scenario provide results, page 2

POST-CONDITIONS			Service Level Goals
	Course	Description	
1.	Ideal	Patient receives screening mammography results.	
2.	Alt-A	Provide Imaging Results – Diagnostic Mammography	
3.	Alt-B	Provide ultrasound results	
4.	Alt-C	Provide biopsy results	
5.	Alt-D	Provide bone density results	
6.	Alt-E	Provide results of other services	
7.	Alt-F	Patient calls Patient Navigator, Patient Navigator discusses results if permitted in referring physician preferences, or requests that patient calls referring physician.	

Fig. 10.22 Business scenario provide results, page 3

	Alternate A: Provide Imaging Results – Diagnostic Mammography				
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.
1.	Mammography technologist completes the study	Image from PACS	Radiology technologist		
2.	Radiologist reviews case	Image from PACS	Radiologist		PACS
3.	If positive finding, radiologist consults with physician for 4s and 5s (rare on a screening mammography).		Radiologist		
4.	Radiologist documents physician contact	Discussion information	Radiologist	Record of physician contact	
5.	Radiologist reports into Penrad		Radiologist	Radiologist report	Penrad
6.	Penrad sends data to Meditech	Result data After manual upload reference 8			Penrad
7.	Radiology staff uploads reports into Meditech 3 times a day	Results data	Radiology staff	Results data, letters reports faxed/mailed to ordering physician	Penrad/Meditech
8.	Penrad creates letter to patient	Result data		Patient letter	Penrad
9.	Patient Navigator divides results into BIRADS 0s, 4s and 5s and others	Results data, letters	Patient Navigator	Results data, letters	
10.	Patient Navigator checks preference cards for 4s, and 5s, to verify for the prescribing physician whether they can call the patient with the results.	Referring Physician Preference Card	Patient Navigator	Preferences	
11.	Patient Navigator checks preference cards for 1, 2, 3s, to determine whether they can call patient with results	Preference Card	Patient Navigator	Preferences	
12.	Patient Navigator calls patients to discuss results for those patients that they can call, for 1, 2, 3s.	Results data.	Patient Navigator		
13.	If Patient Navigator cannot reach patient, tries several times, and records attempts.	Results data.	Patient Navigator	Record of calls	
14.	For 4's and 5s, Patient Navigator will wait a few days, and ensure that the physician office and the patient received the results, and then call the patient.	Patient info	Patient Navigator	Patient results	
15.	If patient needs additional procedure, Patient navigator or Dr. Office will facilitate appointment. Patient Navigator can call centralized scheduling with the verbal order, and do a warm transfer with the patient for demographics. Use Schedule Service Use Case	Patient info	Patient Navigator	Appointment request	
16.	Patient navigator ensures that certified mail is sent and retains records for follow up.	Patient	Patient Navigator	Record of certified mail	

Fig. 10.23 Business scenario provide results, page 4

The following gaps were identified between the current and future state process maps:

Gaps between current state and future state vision

- Lack of seamless integration between the hospital medical information system and the medical group information system.
- Triage for spiritual care.
- Referral physician preference cards.
- Concierge process.
- Patient navigator and patient navigator process do not exist.

	Alternate B: Provide ultrasound results				
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.
1.	Same steps 1 to 2 as in Basic Flow				
3.	Radiologist dictates report into Powerscribe	Powerscribe	Radiologist	Final reports upload automatically into Meditech and it is faxed/mail to ordering Physician	Powerscribe /Meditech
4.	Radiologist discusses positive findings with physician as appropriate	Findings	Radiologist	Discussion	
5.	Patient Navigator reviews US results	Results	Patient Navigator	Results	
6.	Patient Navigator provides results to referring physician	Results	Patient Navigator	Results	
7.	Referring physician provides results to patient.	Result, Patient info	Referring Physician	Results	
8.	Patient Navigator reviews preference card. If referring physician preferences permits, Patient Navigator discusses results with patient.	Results	Patient Navigator	Discussion	

	Alternate C: Provide biopsy results				
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.
1.	Perform procedure biopsy-specimen sent to Pathology		Radiologist/Technologist		Stereotactic unit
.2.	Radiologist dictates procedure after pathology report becomes available.	Powerscribe	Radiologist/Patient Navigator	Final report to ordering physician	Powerscribe /PACS
3.	Patient Navigator discusses biopsy results with Referring Physician	Results	Patient Navigator	Results	
4.	Referring Physician provides biopsy results with patient	Results	Referring Physician	Results discussion	
5.	Report is sent to patient in certified mail	Results	Patient Navigator	Results	
6.	Patient Navigator verifies results are received in certified mail and documents receipt	Results	Patient Navigator	Record certified mail results	
7.	Patient Navigator reviews preference card. If referring physician preferences permits, Patient Navigator discusses results with patient	Results	Patient Navigator	Discussion	

Fig. 10.24 Business scenario provide results, page 5

- Patient navigator database and application to track patient interaction.
- Track utilization of spiritual care.
- Track connection to cancer center.
- Defined service levels for processes.
- Next day results not meeting marketed expectations of same day results.
- Seamless online appointment scheduling.
- Navigating through the Women's Center.
- Detailed future state process maps need to be completed.

	Alternate D: Provide bone density results				
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.
1.	Procedure is performed		Tech		Bone Density Unit
2..	Printed graphs sent to HCH Dr Kotler	Radiology staff	Radiology technologist/Radiology staff		
3.	Dr Kotler dictates final report into Powerscribe ADD Color graphs	Powerscribe	Dr Kotler	Final reports uploaded to Meditech automatically faxed/mailed to referring physicians	Meditech
4.	Returned to WC for mail distribution	Radiology staff	Radiology Staff	Reports mailed to referring physicians.	
5.	Final report mailed to Referring Physician	Report	Radiology Staff	Mailed report	
6.	Referring physician provides results to patient	Report	Referring Physician	Report	
7.	Patient Navigator reviews preference card. If referring physician preferences permits, Patient Navigator discusses results with patient	Report	Patient Navigator	Discussion	
	Alternate E: Provide results of other services				
#	Step Description	Inputs	People Responsible	Outputs	Equipment, IT, Etc.
1.	Complete other service				
2.	Provide report of results	Result	Radiologist or other provider	Results	
3..	Provide results to referring physician	Results	Patient Navigator	Results	
4.	Referring physician provides results to patient	Results	Referring physician	Results	
5.	Patient Navigator reviews preference card. If referring physician preferences permits, Patient Navigator discusses results with patient.	Results	Patient Navigator	Results	

Fig. 10.25 Business scenario provide results, page 6

Alternate F: Patient Navigator discusses results if permitted in referring physician preferences, or requests that patient calls referring physician.				
# Step Description	**Inputs**	**People Responsible**	**Outputs**	**Equipment, IT, Etc.**
1. Patient calls patient navigator for results	Patient info	Patient	Patient call	
2. Patient Navigator reviews patient chart and results	Results, Patient info	Patient Navigator	Results	
3. Patient Navigator review referring physician preference card	Preference card	Patient Navigator	Preferences	
4. If preferences permit, Patient Navigator reviews results with patient. If preferences do not permit review of results, requests for patient to call Referring Physician.	Preferences, Results	Patient Navigator	Discussion	

REVISION HISTORY			
Date	**Version**	**Description**	**Author**
6/10/10	1.0	Draft prior to scenario building	
8/14/10	1.1	Revised based on input and review from team	

Fig. 10.26 Business scenario provide results, page 7

Inefficiency
Process: Schedule Service
Having to do a warm transfer from Central Scheduling to Physician office
Process: Register Patient
If patient is not pre-registered, know late in the registration process that they are a VIP (not prior to arriving in WC)
Should ensure all patient items are available and accurate prior to registration in WC (labs, script, ID)
Ensure only needed patient information is provided from the patient when they register an existing patient (between imaging and Dr.)
Authorize Service:
Multiple rework loops if authorization is not OK or correct
Having to obtain a changed order for Medicare patient
Provide Spiritual Care:
Resourcing for WC needs to be identified
Connect to Cancer Center
Potential of not having preference card or not having it updated
Self Referral
Identify if accept self referrals
Perform Surgery
Rework getting labs, prep work, patient info, etc.
Multiple calls getting health history; informing of co-pay
Getting lab results timely
Having to bill from radiology to surgery and then have radiology reimbursed

Fig. 10.27 Potential process inefficiencies

The team developed and reviewed the process maps based on the business scenarios. A sample process map is shown in Fig. 10.28. The following process maps were developed:

- *Schedule*
  - Imaging service
  - Medical doctor
  - Cancel or re-schedule
- *Register patient*
  - Register imaging patient
  - Register imaging walk-in
  - Register physician patient
  - Register physician patient walk-in
- Authorize patient
- Provide spiritual care
- Connect to cancer center
- Process self referral
- Perform surgery
- Perform imaging service

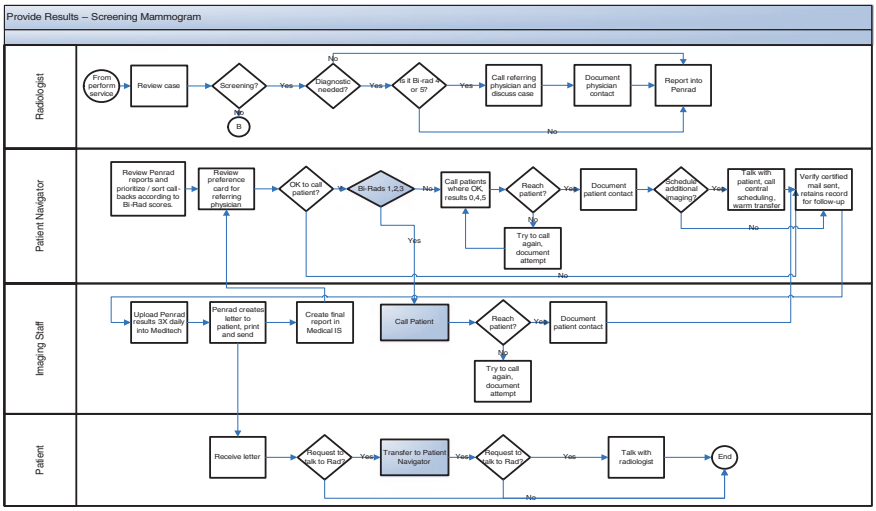

Fig. 10.28 Sample process map: provide results—screening mammogram

- Perform physician service
- *Provide results*
  - Screening mammogram
  - Diagnostic mammogram
  - Ultrasound results
  - Biopsy results
  - Bone density results
  - Other results
- Patient navigator
- Request records/films
- Process VIP patients

Perform Waste Analysis and Root Cause Analysis

The following wastes were identified for the future state processes, shown in Fig. 10.29.

We identified potential problems in the processes after they were piloted and created three Why–Why diagrams, shown in Figs. 10.30, 10.31 and 10.32.

- Why are there excessive wait times in the WC?
- Why do procedures take more than one business day to result?
- Why does it take a long time for the patients to receive the results?

Process	Types of Waste
Schedule	Over production: transfer between central scheduler and medical group Processing;: duplicate information in medical information and physician system
Register Patient	Defect: VIP patient not identified prior to visit or during visit Defect: Patient forgets prescription Processing and Delay: Need to call physician's office for prescription Delay: Register walk-ins
Authorize Patient	Defect: wrongnsurance Defect: wrong authorization Delay: verify medical necessity Processing: receive change order
Provide Spiritual Care	Delay: availability of resources
Connect to Cancer Center	Motion: patient going from WC to cancer center Delay: due to not having physician preferences to contact patient
Process Self Referral	Delay: referral to physician
Perform Surgery	Overproduction: scheduling and patient information in surgery system
Perform Imaging Service	Delay: wait times in lobby, procedure room
Perform Physician Service	Delay: wait times in lobby, room
Provide Results	Delay: providing results Delay: physician providing results Delay: not having physician preferences for patient contact Delay: radiologist reading Delay: not reaching patient
Patient Navigator	Inventory: patient navigator capacity
Request Records/Films	Delay: printing films
Process VIP Patients	Defect: VIP patient not identified as VIP Delay: difficulty fitting VP in schedule

Fig. 10.29 Waste analysis

Improve Phase

The purpose of the improve phase is to pilot the new processes and assess whether they are capable of meeting the desired targets. The following activities are performed:

(1) Implement pilot processes
(2) Assess process capabilities
(3) Optimize design

Implement Pilot Process

We implemented the processes when the Women's Center opened in September 2010, and compared the process times to the baseline in the previous imaging center. A detailed work plan was developed that included the activities required

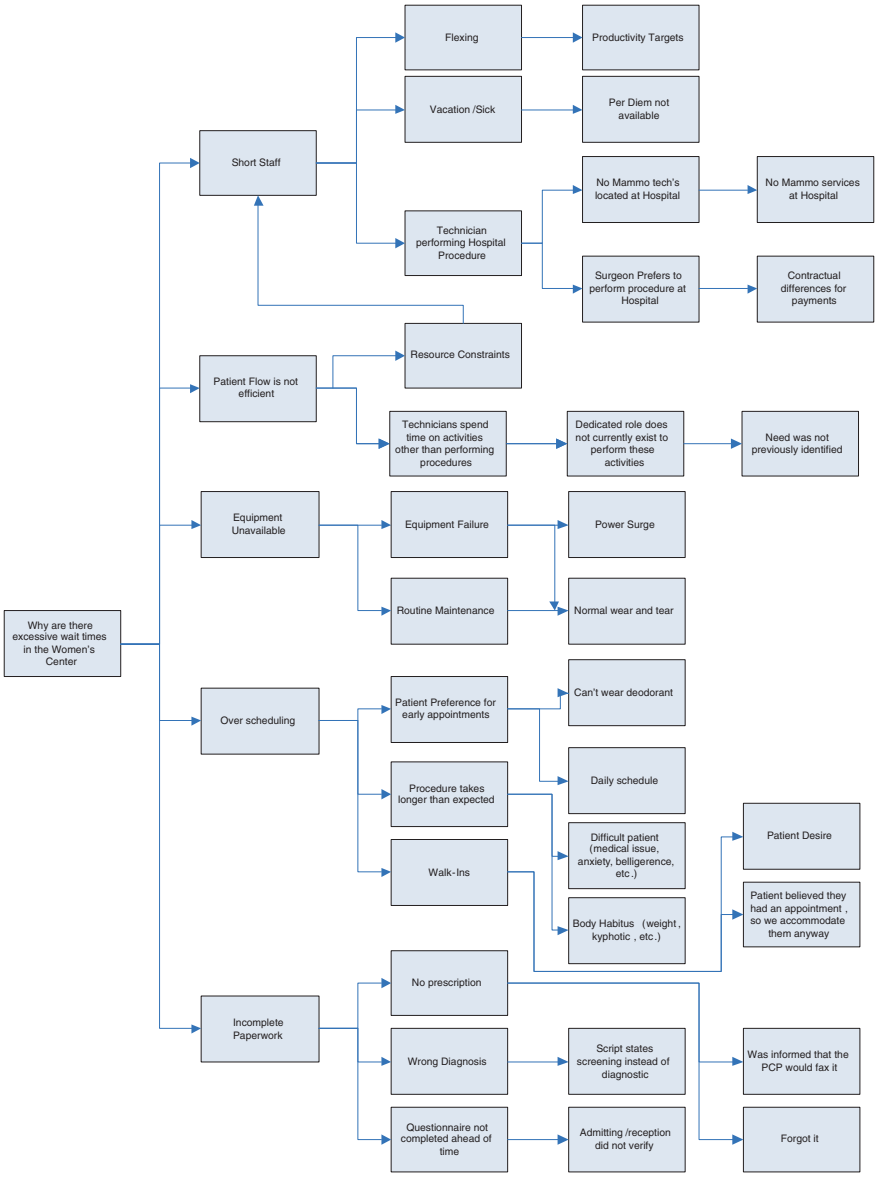

Fig. 10.30 Why–Why diagram: why are there excessive wait times?

to open the facility and implement the newly designed processes. The key process elements implemented were:

- Hire a patient navigator to navigate the patient through the system and communicate results of procedures.
- Hire an additional radiologist to provide results more quickly.

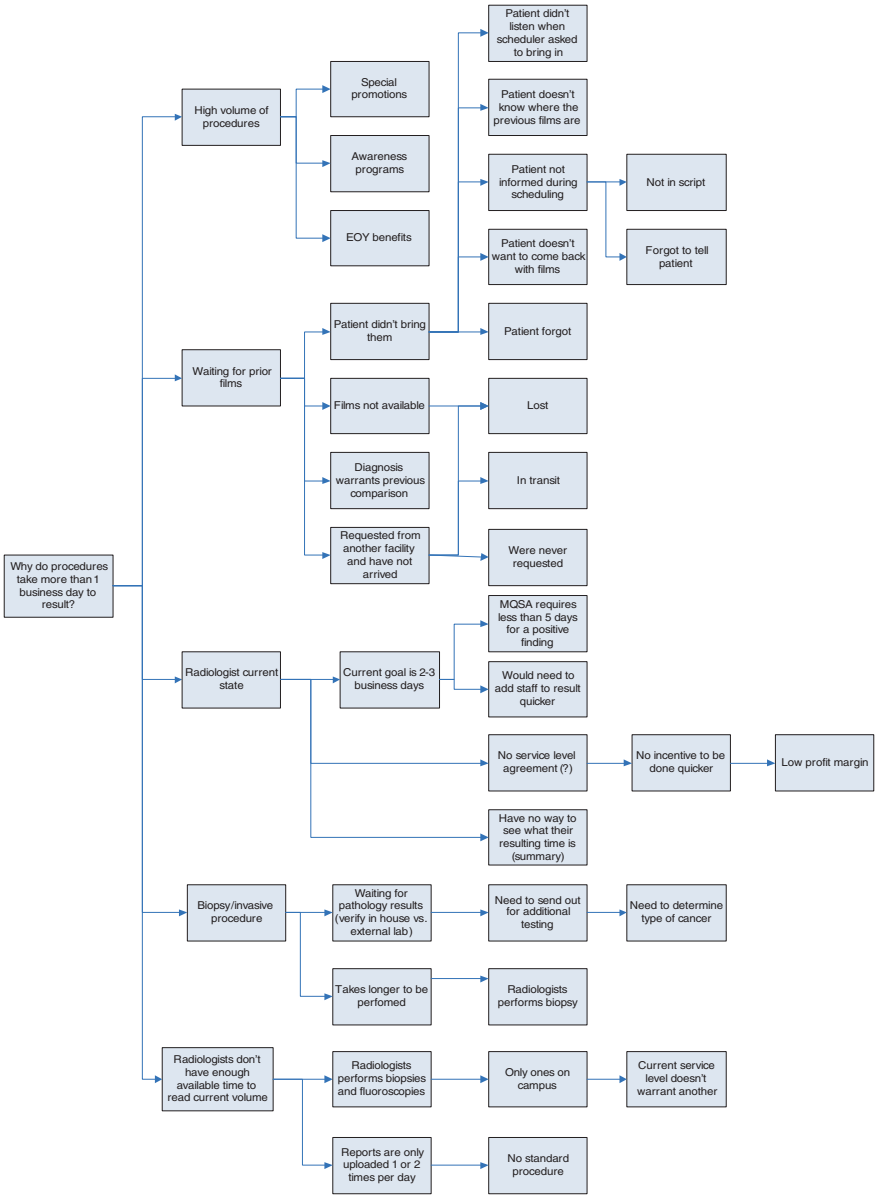

Fig. 10.31 Why–Why diagram: why do procedures take more than one business day to result?

- New spa-like facility.
- Incorporate additional services.
- Hire women's services focused physician.
- Train mammography technicians in customer service.
- Incorporate spiritual care resources into the center.

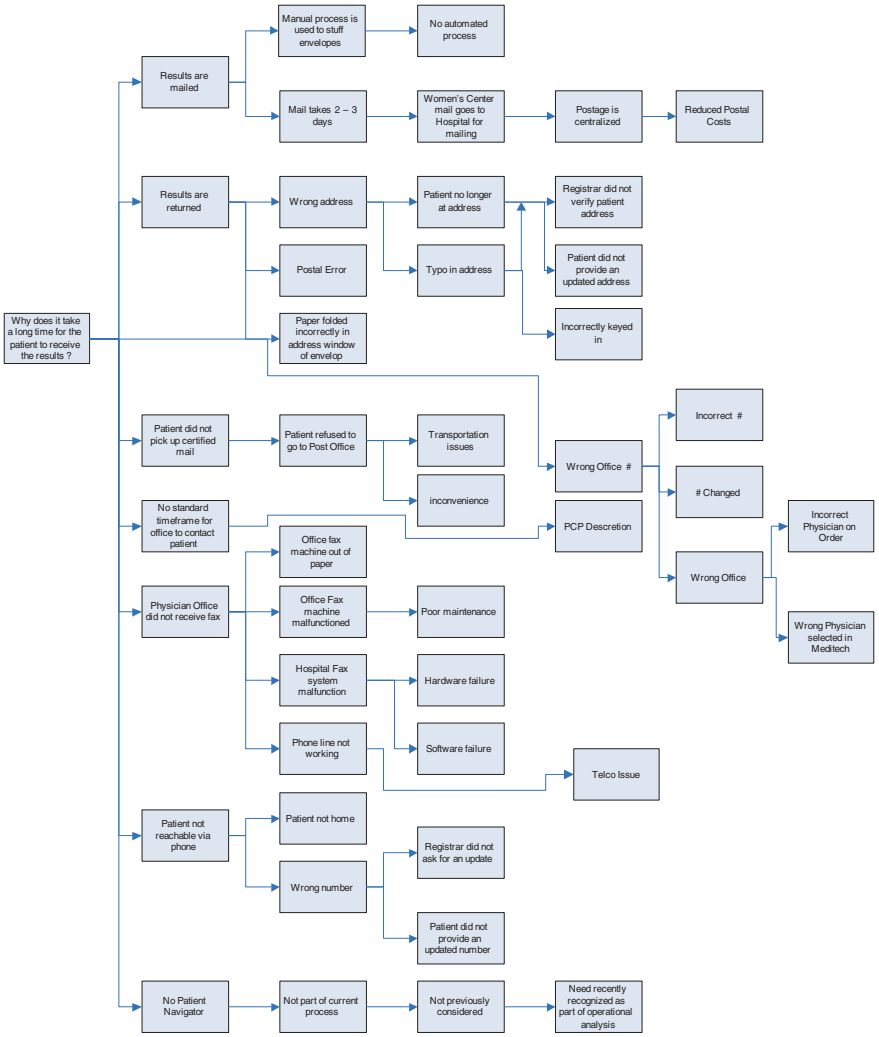

Fig. 10.32 Why–Why diagram: why does it take a long time for the patient to receive the results?

- Cross-train registration staff in imaging center and physician office scheduling systems.
- Hire a concierge to guide patients to their destinations.
- Have volunteers walk patients to their destinations.
- Incorporate a VIP service members (donors) and other important guests.
- Implement a process dashboard for metrics.
- Incorporate advanced imaging technology.

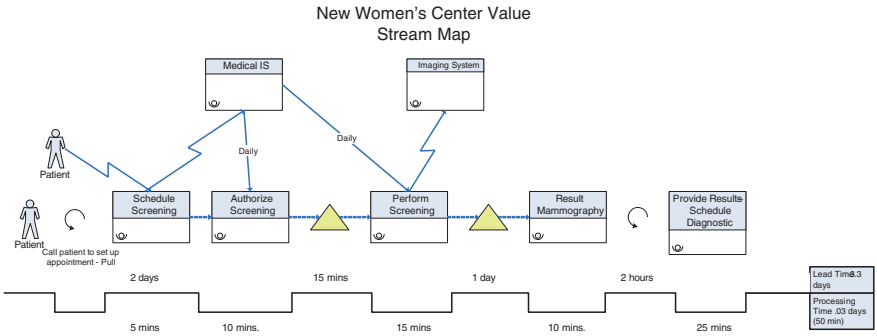

Fig. 10.33 Proposed value stream map

Assess Process Capabilities

The proposed value stream map for the initial mammogram screening was developed to assess process capability, shown in Fig. 10.33. The process as designed will be capable of meeting the proposed wait times, procedure times, throughput time, and results time.

Optimize Design

Further improvements were designed to streamline the processes, based on staffing, results turnaround, and throughput times. The patient navigator was hired in the first quarter of 2011. She has provided great value for our patients and referring physicians. She provides sociopsychological care to our patients by providing results more timely, guiding them through the system, and connecting them to spiritual care and to the cancer center when necessary. She has been a key differentiator in the process to provide the "delighters" of the patient being guided through the health system in a nurturing, relaxing environment; comprehensive care; holistic care; efficient processes; next day results; and seamless integration of services.

Takt Time Analysis

A takt time throughput analysis was performed to assess whether the cycle times could achieve the needed takt time. Takt time is calculated based on the available time of scheduled resources divided by the number of scheduled procedures. Figure 10.34 shows there are times of the day when the scheduled procedures exceed the staff capacity. This analysis helped to re-align the staffing to meet the patients' demand. The continuous line shows the desired takt time, and the box plots show when the average cycle time exceeds the desired takt time.

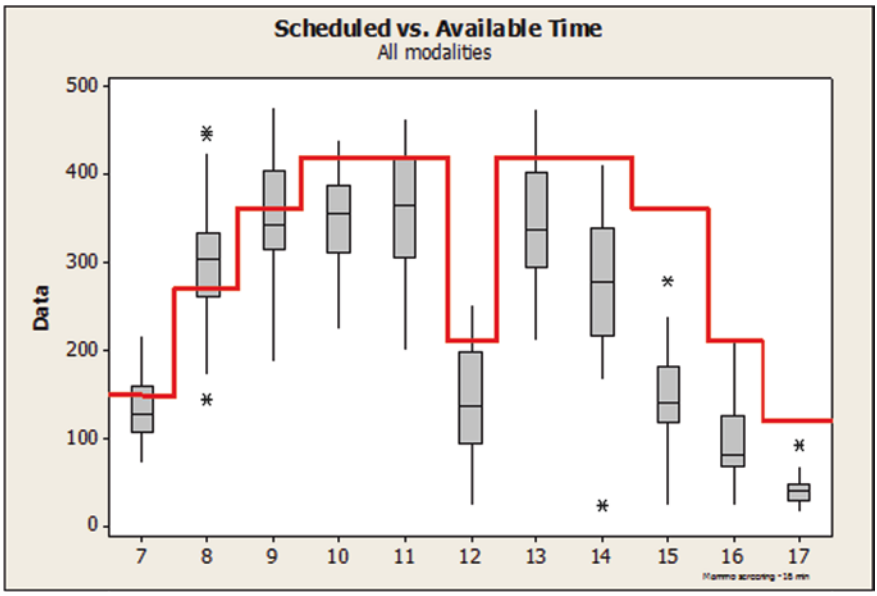

Fig. 10.34 Takt time analysis

Assess Performance, Failure Modes, and Risks

We assessed the potential failure modes in the processes and identified the potential risks:

(1) Focusing on productivity as the key metric impacts our ability to meet the quality indicators of patient wait and throughput times.
(2) The patient navigator continues to meet with referring physicians to describe the patient navigator services available, and complete physician preference cards that identify when it is appropriate for the patient navigator to share the patients' results directly with the patients and the timeframe to do so.
(3) Identifying the VIP members has been problematic with an information systems issue. This issue has been logged for the Information Technology Help Desk.
(4) There are several outstanding action items that have not yet been resolved and need the executive team to embrace and resolve the more political issues related to growth, volume, and physician relationships.

The results for the newly designed processes are shown in Fig. 10.35 and compared to the older imaging facility. The waiting time in the imaging area improved by 16 %, the procedure time increased 1 minutes, on average, by 7 %. The total throughput time decreased by 3 minutes or 8 %, compared to the process times in the older Imaging Center, prior to opening the new Comprehensive Women's Center facility. The time to result tests, which was a "delighter," improved by 58 % from 2.4 to 1 day.

Metric	Prior Imaging Center (Before)	Women's Center (After)	% Improvement
Imaging Waiting Area	Mean = 25 minutes Standard Deviation = 30.6; Count = 3219	21 minutes	16%
Procedure Time	Mean = 13 minutes; Standard Deviation = 23.1; Count = 3165	14 minutes	-7%
Total Throughput Time	Mean = 38 minutes; Standard Deviation = 36; Count = 3165	35 minutes	8%
Time to Result	Mean = 2.4 days (57.2 hours); Standard Deviation = 55.04 hours; count = 6693	1 day	58%

Fig. 10.35 Improved process times

Control Phase

The Control phase verifies that improvement was attained and ensures that control plans are implemented that will control the processes. The following activities were performed in the Control Phase: Develop dashboards and control plan.

Develop Dashboards and Control Plan

A dashboard was developed that would be used to control the process and could be reviewed continuously during the day, to assess the wait times, procedure times, throughput times, patients waiting for procedures, volume, and results times. A more static dashboard was created that would track performance on a monthly basis, shown in Fig. 10.36. The metrics were being met for average procedure time, average wait time, and average throughput time, but were not meeting targets for percent of patients waiting more than 45 min and percent of mammography patients being contacted by the navigator within 5 days of service. We continued to adjust staffing and improve the processes to better meet the targets.

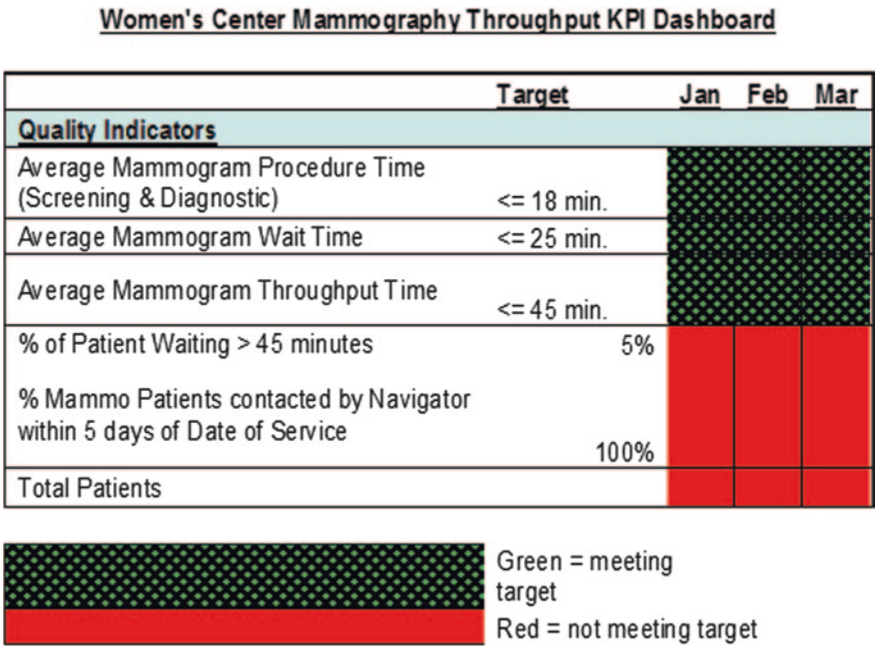

Fig. 10.36 Dashboard

The new design has been stabilized, but will be continually improved and monitored.

Conclusions

The Lean Six Sigma and Design for Six Sigma methodologies and tools were extremely successful in capturing the voice of the customer and translating the customer requirements into the process requirements and for improving a process that delights the customers of the Women's Center. The opening of the new Women's Center has surpassed the organization's and the customers' expectations. The facility provides comprehensive women's services in a nurturing a spa-like environment. The future looks bright for the next several phases of the center.

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Chapter 11
Innovating the Patient Care Operating Model: Integrated Value Care

Abstract The healthcare industry and hospitals in general have been providing care from an operating model perspective in much the same way since hospitals began. Yes, the medical technology has become much more advanced: imaging technology providing an ever-advancing and amazing view inside the body without a single incision; surgical techniques with cameras and robots enabling surgeons to perform surgeries with smaller incisions and quicker recoveries are just two examples. But the basic operating model has not changed. We are still managing the flow of patients through the healthcare system with a focus on the processes and care providers within a department providing care to each patient, but largely ignoring the flow and progression of a patient to the next step in their care. Patients sit in emergency rooms, with long delays, because the model doesn't incorporate pulling the patient through their emergency care by understanding where the patient needs to be in their next step of care in a proactive manner. The patient arrives in the emergency room, signs in, and sits down to wait. The triage nurse triages the patient and returns them to the lobby to wait with a vague priority rating of the rough order that they will be called to an emergency room. The patient is finally placed in a room, and waits for the next care provider to pick them out of a list of their other patients, in an unknown priority to assess their medical status, and push them to the next step of the process. Each care step is provided in a somewhat random order, not based on the series of activities that must be performed to make the patient well, but on them sitting in multiple queues for separate departments such as imaging, transportation, registration, scheduling, admitting, emergency physician, nurse, admitting physician, consulting physician, etc. Another example is in the inpatient operating model. The patient comes to the hospital in one of several input channels, being admitted through the emergency room, being a direct admit to registration based on a physician's orders, being admitted based on either a planned or emergency surgery. Once the patient is admitted to an inpatient floor, which could be after a long wait in one of the input channels, the patient sits and waits again for their initial assessment. "Normal" service level requirements, typically based upon a regulatory requirement from the government, require a patient's initial inpatient assessment to be performed within

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24 hours of admission. This seems like a long time to identify an initial diagnosis, let alone design a potential path of care for the patient. The patient then waits to be "roughly" scheduled for diagnostic tests that provide more insight into their maladies. The "roughly" term is used because a diagnostic test is ordered, but there is really no inpatient schedule. The patient is put on a list for the required department, but has little or no insight into when the test will be run, other than within a rough 24 hours period time-frame. Wouldn't it be patient-centered to provide the patient with a schedule each morning of the care, and tests that will be provided and performed for that day? In this way the family members can easily be a part of the patient's care, without waiting for days not knowing when the patient will get their tests. Wouldn't it also be novel to know when the patient is expected to be discharged based on standardized patient care protocols and inpatient schedules of patient care activities? The existing operating model in a hospital is inefficient and causes immense delays in patient care, when what could be minutes and hours of delays become days and weeks of delays. Is there a better way? The author believes there is a better way to manage the flow of care for a patient through the myriad activities, tests, transports, and hand-offs in a hospital, based on the principles of Lean, Six Sigma, Systems Engineering, and Business Architecture. This chapter will provide a proposal for a new and innovative value care operating model for providing patient care in a hospital setting. It is a proposal for future research and application for those brave care providers, in particular management engineering pioneers who seek to provide a better way.

Define Phase

In the Define Phase we will define the scope of the project, and the project goals. We will identify the key stakeholders for the project and identify their initial Voice of the Customer, their concerns and how the project impacts them.

The following steps were executed in the Define Phase:

1. Develop project charter
2. Perform stakeholder analysis
3. Perform initial Voice of Customer (VOC) and Identify Critical to Satisfaction (CTS)

Develop Project Charter

The project charter is shown in Fig. 11.1 and discussed next.

Project Charter

The existing operating model in a hospital is inefficient and causes immense delays in patient care, when what could be minutes and hours of delays become

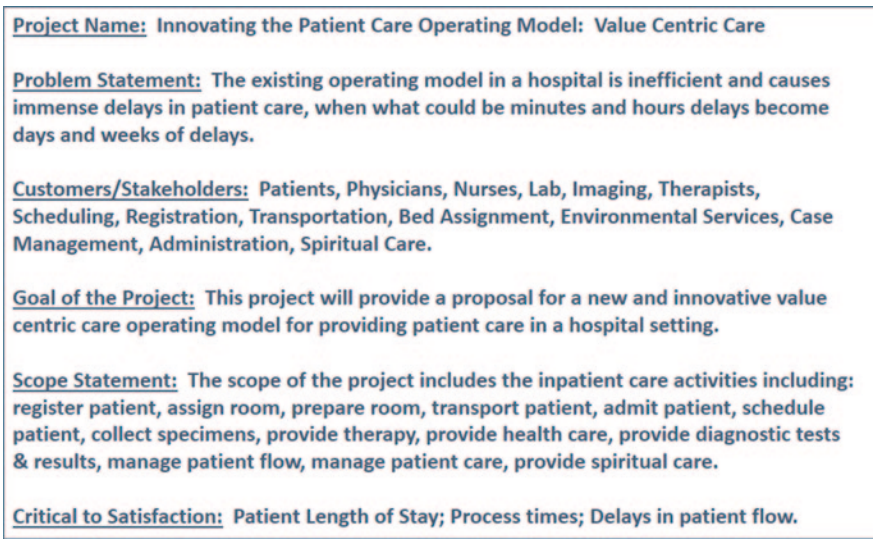

Fig. 11.1 Project charter

days and weeks of delays. The patient flow is managed within each siloed department, not across the continuum of care. The time that the patient spends in the hospital is impacted immensely by the delays in providing care, and moving the patient through each step in their care, and in the hand-offs between each department. If a patient stays over the weekend, their length of stay can be increased by almost 2 days, because physicians may not be easily available to write orders, perform consultations, and discharge the patient. Ancillary staff may not be available to perform diagnostic tests, and therapy, due to not scheduling staff on the weekend, due to higher pay differentials on the weekend. Patients are typically, in Lean terminology, "pushed" through the process based on physician orders, not "pulled" based on a plan of care, and an estimated and desired length of stay.

The primary stakeholders are the patients and their families, physicians, nurses, Lab, Imaging, therapists, Scheduling, Registration, Transportation, Bed Assignment, Environmental Services, Case Management, Administration, and Spiritual Care. The goal of the project is to provide a proposal for a new and innovative value centric care operating model for providing patient care in a hospital setting. The scope of the project includes the inpatient care activities including: register patient, assign room, prepare room, transport patient, admit patient, schedule patient, collect specimens, provide therapy, provide health care, provide diagnostic tests and results, manage patient flow, manage patient care, provide spiritual care. The CTS criteria are Patient Length of Stay; Process times; Delays in patient flow.

Perform Stakeholder Analysis

The stakeholders are patients who are admitted to the hospital as an inpatient. The Physicians provide care to the patients and are concerned with the quality of the patient's care; patient length of stay; appropriate diagnosis; access to tests and lab results; reduced patient delays in getting tests and results. The nurses provide care to the patient. They are concerned with the quality of their patient's care; patient length of stay; and nursing staffing levels being appropriate to provide quality of care. The Lab staff obtains lab specimens from the patient. They are concerned with the quality of care and lab staffing levels being appropriate to collect specimens in a timely and safe manner. The Imaging staff performs imaging tests for inpatients and is concerned with quality of the patient's care; imaging staffing levels; scheduling of tests; and number of reschedules of tests.

Therapists provide physician and occupational therapy care to the patients. They are concerned with quality of care; therapist staffing levels; and being incorporated into the patient care continuum. Scheduling schedules the patients for exams. They are concerned with the complexity of scheduling patients for tests; having appropriate clearances and insurance authorizations. The Registration department registers the patients as an inpatient. They are concerned with timely patient registration; reduced number of times the patient needs to provide the same information for multiple registrations. The Transportation department is concerned with patient transport turnaround time and transportation staffing levels. The Bed Assignment staff assigns inpatient beds to the patient. They are concerned with the patient being assigned to the right bed in a timely manner; and knowledge of clean, available beds. Environmental Services cleans the room and prepares them for the next patient. They are concerned with room cleaning turnaround time; and environmental services staffing levels. Case Management personnel manage the patients' cases, monitor their length of stay, and connect the patient to social services. They are concerned with sufficient staffing levels to provide case management services. Hospital Administration manages the business aspects of the hospital. They are concerned with productivity of personnel, the number of Full Time Equivalents (FTEs), the cost of providing services, patient experience, and the quality of the patient care. Spiritual Care staff provides spiritual and emotional support for patients and their families. They are concerned about being included in the patient care continuum.

The stakeholder analysis is shown in Fig. 11.2

SIPOC (Suppliers-Inputs-Processes-Outputs-Customers)

The SIPOC is used to ensure the scope of the project is well understood, and is shown in Fig. 11.3. It is also a check and balance for the customer and stakeholder analysis. Any customers and suppliers should also be identified as a project stakeholder.

Stakeholder	Role	Impact / Concern
Patients and their families	Patients who are admitted to the hospital and receive inpatient care, and their families.	Quality of care; reduced delays; knowledge of scheduled exams; knowledge of continuum of care;
Physicians	Physicians who provide patient care and diagnoses	Quality of care; patient length of stay; appropriate diagnosis; access to tests and lab results; reduced patient delays in getting tests and results
Nurse	Nurses who provide patient care	Quality of care; patient length of stay; nursing staffing levels
Lab staff	Lab staff, who enter orders, and collect lab specimens from patients	Quality of care; lab staffing levels
Imaging staff	Imaging staff who enter orders and perform diagnostic tests.	Quality of care; imaging staffing levels; scheduling of tests; number of re-schedules of tests
Therapists: Physical Therapists, Occupational Therapists	Physical Therapists, Occupational Therapists who provide patient therapy.	Quality of care; therapist staffing levels; incorporated into the patient care continuum
Scheduling	Schedulers who schedule tests.	Complexity of scheduling patients for tests; having appropriate clearances and insurance authorizations
Registration	Registrars who register the patient into the hospital	Timely patient registration; reduced number of times patient needs to provide same information for multiple registrations
Transportation	Transportation staff who transport the patients for admission, discharge, tests, and patient care	Patient transport turnaround time; transportation staffing levels
Bed Assignment	Nurses who assign inpatient hospital beds from direct admits, emergency room, and surgical patients admitted to the hospital.	Patient is assigned the right bed in a timely manner; knowledge of clean, available beds
Environmental Services	Environmental services who clean and prepare the patients' rooms	Room cleaning turnaround time; environmental services staffing levels
Case management	Case management personnel who manage the patients' cases, monitor their length of stay, and connect the patient to social services.	Sufficient staffing levels to provide case management services
Administration	Hospital administration who manage the business aspects of the hospital	Productivity; Number FTEs; Cost of providing services; patient experience; quality of care
Spiritual Care	Staff who provide spiritual and emotional support for patients and their families	That they are included in the patient care continuum.

Fig. 11.2 Stakeholder analysis

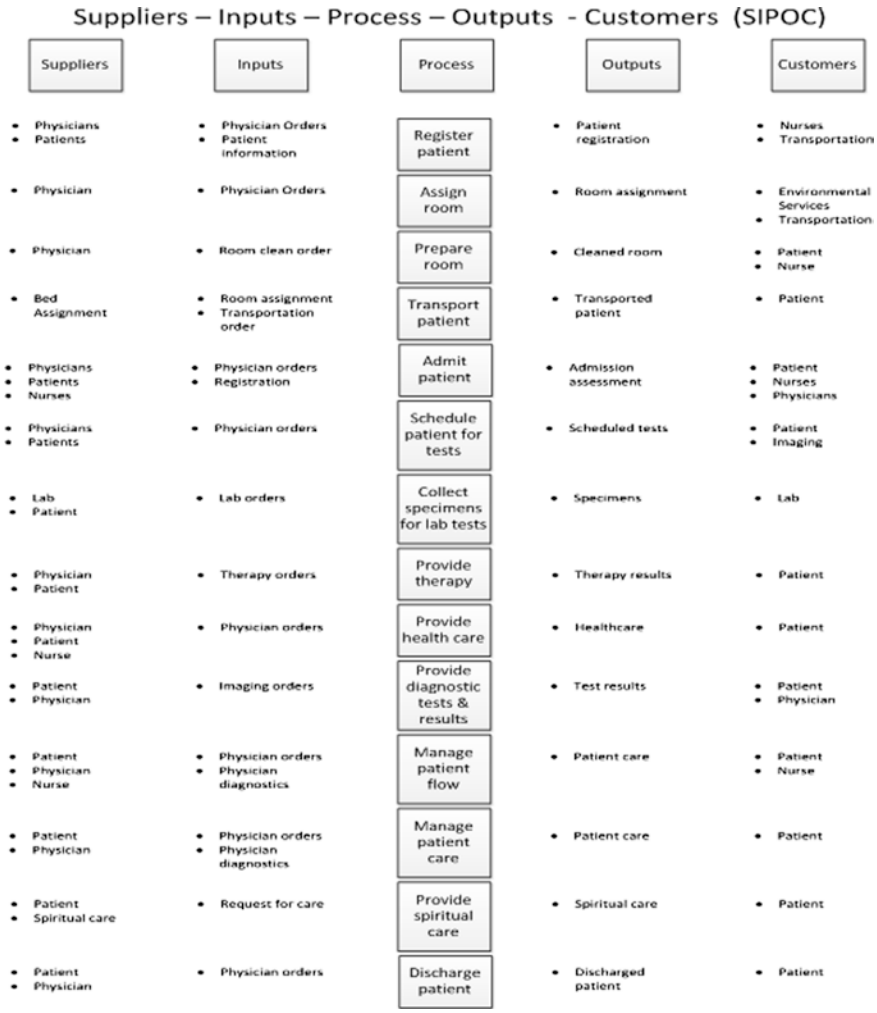

Fig. 11.3 SIPOC

The high-level process steps are the register patient, assign room, prepare room, transport patient, admit patient, schedule patient for tests, collect specimens for lab tests, provide therapy, provide health care, provide diagnostic tests and results, manage patient flow, manage patient care, provide spiritual care, discharge patient. The patients are admitted to the hospital in one of three ways: direct admit from physician's orders, from the emergency room, from the surgical suite. Admitting registers the patient. The Bed Assignment nurse assesses the type of bed and availability and assigns a bed once the desired bed type becomes available. Environmental Services receives an order to clean the room, and then cleans the room, after a potential delay because of other beds in the queue to be

cleaned. The patient is transported to their room by a transportation tech. Again there may be a delay waiting for a transport. The patient's initial admission assessment is performed by the nurse within 24 hours of arrival to the room. The physician sees the patient and provides orders for tests, therapy, and care. The tests are scheduled, performed, and the results are provided to the physician. The patient care is managed based on Case Management reviewing the patient's cases where there are excessively long lengths of stay compared to the average expected length of stay for a patient with the primary diagnosis. The patient is provided with therapy and health care based upon the physician's orders. Spiritual care is provided at the request of the patient. The patient flow is not proactively measured, other than Case Management reviewing their case if their length of stay exceeds the established averages. The patient is discharged and transported out of the hospital.

Perform Initial Voice of Customer and Identify Critical to Satisfaction

The Critical to Satisfaction Criteria for this project are:

- Patient length of stay as an inpatient. This is measured from the time that the patient is admitted to when they are discharged.
- Process Time is the time it takes to process different activities within the patient flow.
- Delay in patient flow: this is measured by tracking the time it takes to receive diagnostic tests, therapy, and care from when the physician order is requested until when the care is received.

Measure Phase

The Measure Phase included the following activities:

1. Define the current process
2. Define detailed Voice of Customer (VOC)
3. Define the Voice of Process (VOP) and current performance

Define the Current Process

The first step in the Measure phase was to understand the current processes. Several techniques were applied: value chain and functional decomposition; value stream mapping; and process mapping. Each technique will be discussed.

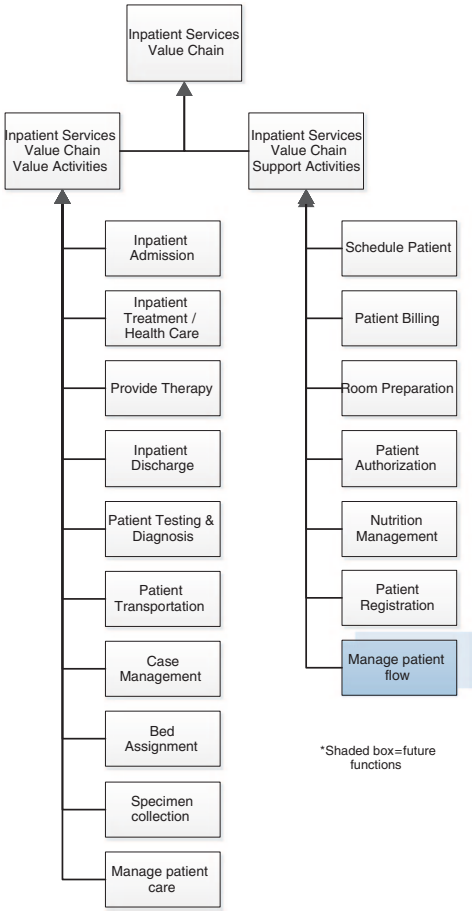

Fig. 11.4 Inpatient value chains and functional decomposition

A value chain consists of the high-level activities that provide value to the customer, or in this case, the inpatient. The value chain is made up of "value activities", those activities that are direct patient facing and bring value to the patient to help them receive care. The value chain is also made up of "supporting activities", those activities that are necessary to be performed, such as registration and billing, but doesn't "touch" the customer or directly provide care. The inpatient value chain is shown in Fig. 11.4. The functional decomposition provides an inventory of the activities performed in the value chain. It helps us to understand the activities performed to provide inpatient services. The functions can be decomposed, or broken into its next more detailed level of activities. This will typically continue for about three levels, or until a natural sequencing of the activities begins to form. At this point, it is time to create the process maps, which show the flow, or sequence of activities to be performed to achieve the process objective.

Value stream mapping can be used to understand the high level of activities and the time it takes to complete the activities. It is typically used to represent

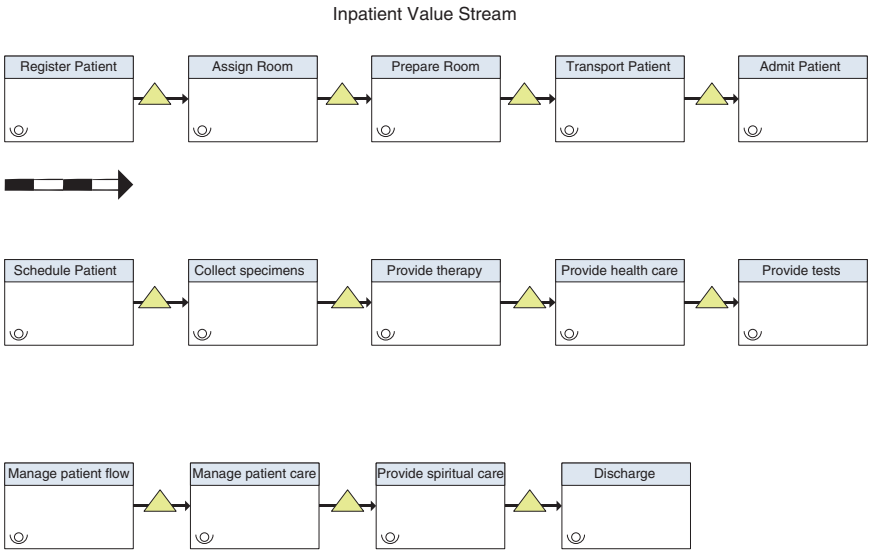

Fig. 11.5 Inpatient value stream map

information or material flow through the system. In our case, it will show how the patient moves through our inpatient system. A value stream map for the inpatient services is shown in Fig. 11.5. It incorporates the high-level activities, shows the inventory of patients waiting before each activity, and can show the processing times for standard diagnoses.

Define Detailed Voice of Customer

The Voice of Customer was defined through identifying inefficiencies and pain points in the existing processes. The following customer requirements were defined:

(1) Register once in the hospital, whether it is in the Emergency Room, Surgical Lobby, or Admitting Lobby.
(2) No or little wait for an inpatient room.
(3) Reduced time between steps in the process.
(4) Seamless hand-offs between steps in the process.
(5) Reduced time for admission assessment.
(6) Ability to have a planned schedule of inpatient tests and diagnostics.
(7) Plan of care, with estimated discharge dates.
(8) Reduced delays in getting tests and results.
(9) Reduced delays in physician consultant referrals.
(10) Someone to manage patient flow through the healthcare system.

(11) Reduced avoidable delays, which equals reduced length of stay.
(12) Standard treatment protocols.
(13) Someone to manage the plan of care.
(14) Updated, on-line, real-time bed board and room status.
(15) No holding beds when the patient is discharged, not updating the bed status immediately.
(16) Reduced delays in waiting for transport.
(17) Reduced delays in waiting for rooms to be cleaned.

We developed a Quality Function Deployment House of Quality, shown in Fig. 11.6. We developed technical requirements that would potentially fulfill the customer requirements. These requirements could be process and/or information technology requirements. We rated a strength of relationship between the customer and technical requirements, by assigning a 9 to a high strength of relationship, a 3 to a medium strength, a 1 to a low strength relationship, and a blank to no relationship. The strength of relationship identifies how much the technical requirement helps to meet the customer requirements. We ranked the importance of each customer requirement, based on our assessment of importance, with a 15 being the highest importance to a 1 being the lowest importance. We then multiplied the importance times each strength of relationship to derive a relative weighting across the technical requirements. The absolute weighting is the ranking across the technical requirements to determine the priority when implementing improvements to process and technology. The highest technical requirement in enhancing the inpatient customer experience is to incorporate service levels for process times. Many times we don't measure how long it takes the patient to receive services and move through the process, so it is extremely important to measure the processes so that we know if we improve. The next two most important technical requirements are to incorporate patient flow managers, and integrate the care providers across the value chain. These two requirements will ensure that personnel are engaged and focused on managing the flow, and pulling the patient through the care processes based on a care treatment plan, instead of pushing them through based mainly on physician orders. To help to reduce the delays in the process, and be able to estimate the length of stay, implementing standard care protocols is the next most important technical requirement. Incorporating Patient Care Managers who manage the care of the patients throughout their inpatient stay, and ensure that the patient is moving through their care plan is the next ranked technical requirement. The next technical requirement is to redesign the order entry processes to reduce the time to enter orders so that the patients will receive their diagnostic tests and results quicker. The next technical requirement is to design the integrated value centric care model, focusing on the value activities that provide value to the inpatient as they move through the process. This model will pull the patient through the steps of the processes, and reduce delays by providing better coordination between steps and hand-offs between care providers. Implementing inpatient scheduling, which would provide a daily schedule for the patient with a listing of their scheduled tests, therapy and care, would help to provide a better

Quality Function Deployment-House of Quality 1

		Technical Requirements											
Customer Requirements	**Importance (1 5 = high, 1 = low)**	Registration system and data integrated	Integrated Value Centric Care Model	Pull Patients	Service levels of process times	Patient Flow Managers	Inpatient Scheduling	Standard Treatment Protocols of Care	Patient Care Managers	Order Entry Process Improvement	Bed board status updates, real time	Integrated Care Providers Managing across value stream
1) Register once in the hospital, whether it is in the Emergency Room, Surgical Lobby or Admitting Lobby.	1	9										
2) No or little wait for an inpatient room.	6		9		9	9		1	1		3	9
3) Reduced time between steps in the process.	4		9		9	9	3	3	3	1		9
4) Seamless hand offs between steps in the process.	8		9			9	3	3	3	1		9
5) Reduced time for admission assessment.	10	3	3		9	9			3			3
6) Ability to have a planned schedule of inpatient tests and diagnostics.	14		3			3	9	3	3	9		3
7) Plan of care, with estimated discharge dates.	15		9		9	3	3	9	9	3		1
8) Reduced delays in getting tests and results.	7		9		9	9		9	9	9		9
9) Reduced delays in physician consultant referrals.	5		3		9	9		9	9	9		3
10) Someone to manage patient flow through the healthcare system	13			9	9	9	3	1		3		9
11) Reduced avoidable delays, which equals reduced length of stay	9			9	9	9	3	9		9		9
12) Standard treatment protocols	12				9	3	3	9	9	3		1
13) Someone to manage the plan of care.	11						3	9	9	3		9
14) Updated, on-line, real time bed board and room status	3									3	9	9
15) No holding beds when the patient is discharged, not updating the bed status immediately	2									9	9	9
Weighting		30	447	198	729	681	342	628	564	507	63	681
Ranking		11	7	9	1	2	8	4	5	6	10	2

Fig. 11.6 QFD house of quality

patient experience, as well as reducing delays to receive care. The requirement to pull the patient will help to focus the Patient Care Managers on pulling the patient through their standard care protocol. A requirement that is an enabler of getting patients admitted to beds quicker is to incorporate on-line, real-time updates, and status of the bed assignment system. This will ensure showing a bed as dirty, clean, available, or not available, which can help the bed assignments. The last requirement is to integrate the multiple registration systems to consolidate the data into the registrations that are required for billing purposes. The patient shouldn't need to provide the same information each time they move to a different service in the hospital, whether it is emergency services, inpatient services, surgical services or outpatient services. This information should automatically transfer to a single registration, and the billing system can pick up the appropriate information with the registration type related to the types of services being provided. Many medical information systems are designed first to handle patient billing, not with a focus on ease of use, and simplification of the patient flow. The House of Quality provides a great way to ensure that the Voice of the Customer is collected, and is aligned to the technical process and information system requirements.

Define the Voice of Process and Current Performance

The VOP and current performance includes mapping out the detailed processes related to providing inpatient care, as defined in the Value Chain and Functional Decomposition. Sample process maps are shown in Figs. 11.7, 11.8, and 11.9 for the inpatient admission process. It consists of a new patient notification and report, and patient arrival and admission assessment. Multiple process maps were developed for providing the inpatient care, including:

- Admission
- Doctor calls on the floor
- Doctor interaction
- Daily huddles
- Administering medication
- Transport
- Nursing morning activities
- On call consultations
- Order entry flow
- Recurring tasks
- Location supplies
- Taking and giving report
- Transferring the patient to another level of care

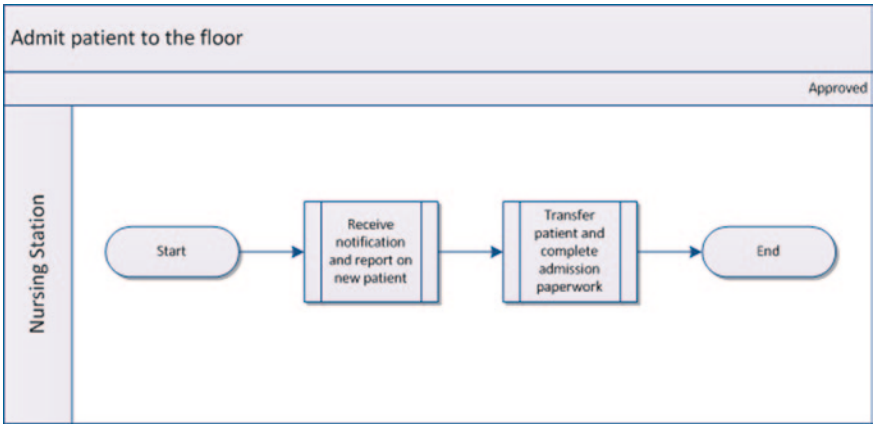

Fig. 11.7 Process map—admit patient to the floor

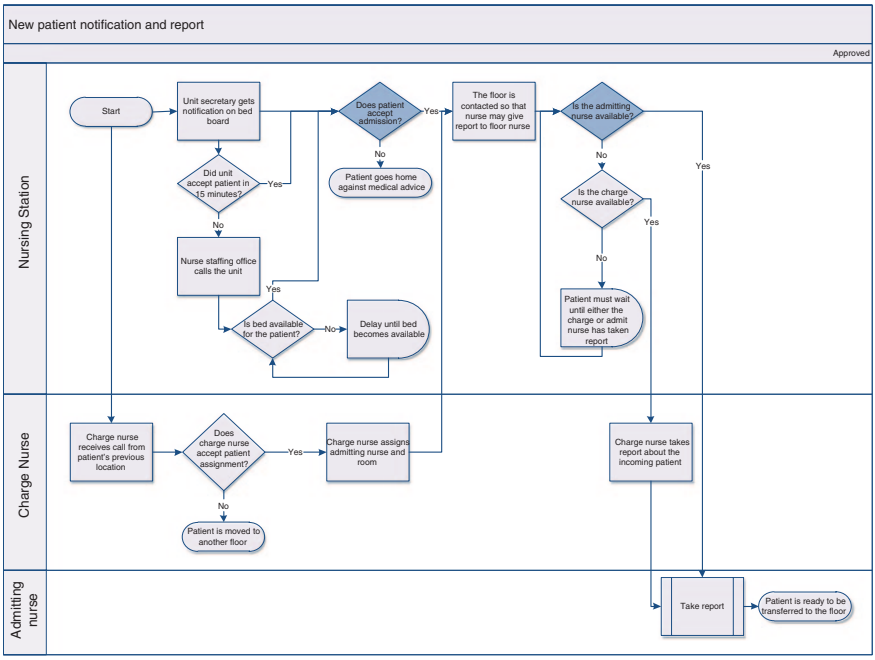

Fig. 11.8 Process map—new patient notification and report

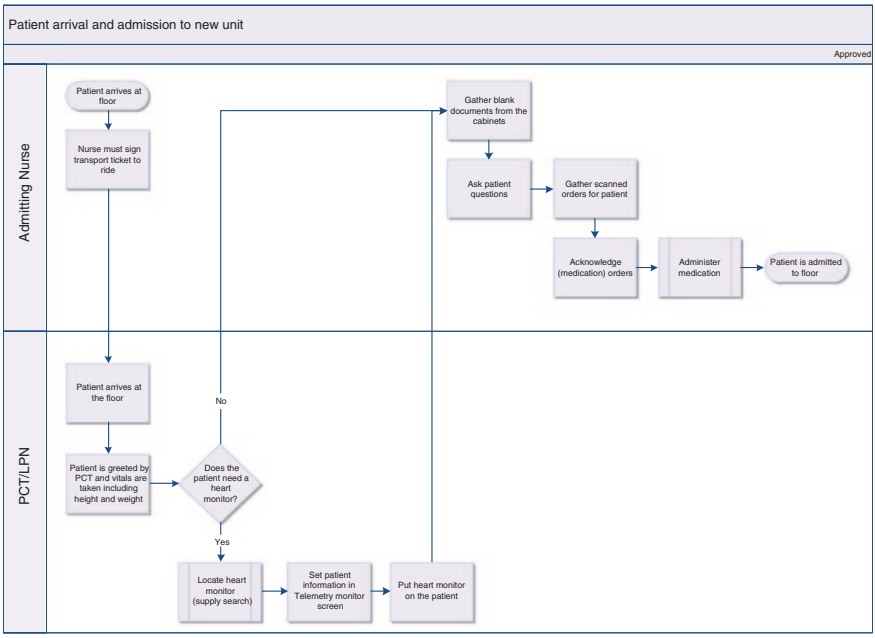

Fig. 11.9 Process map—patient arrival and admission to new unit

Analyze Phase

The following activities were performed for the Analyze Phase to identify and validate the root causes.

1. Develop cause and effect relationships
2. Determine and validate root causes

Develop Cause and Effect Relationships and Determine and Validate Root Causes

Cause and Effect Analysis

A cause and effect analysis using the 5 Whys and Why-Why Diagrams was generated, shown in Figs. 11.10, 11.11, 11.12, 11.13, 11.14, 11.15, 11.16, 11.17, and 11.18. The following question was the starting point for understanding the root causes, and then we asked Why at least 5 times until the root causes were understood. The following potential root causes were identified.

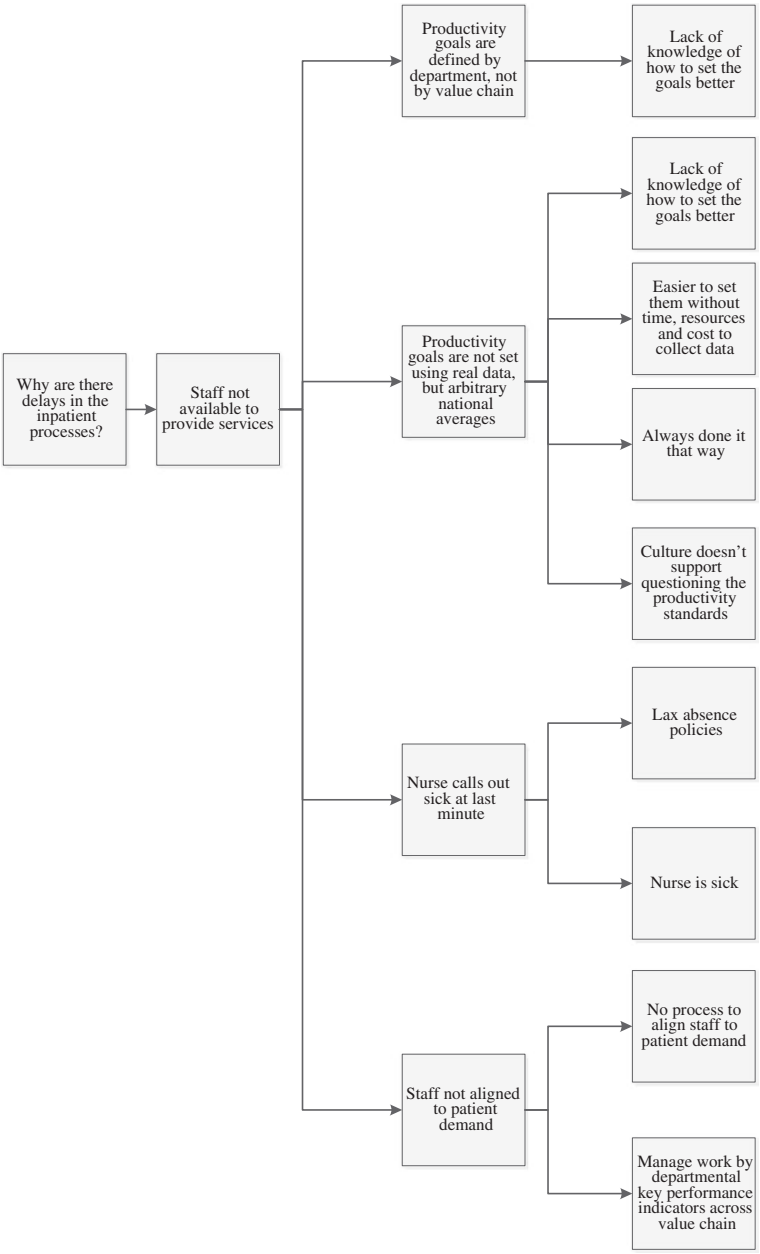

Fig. 11.10 Why why diagram 1

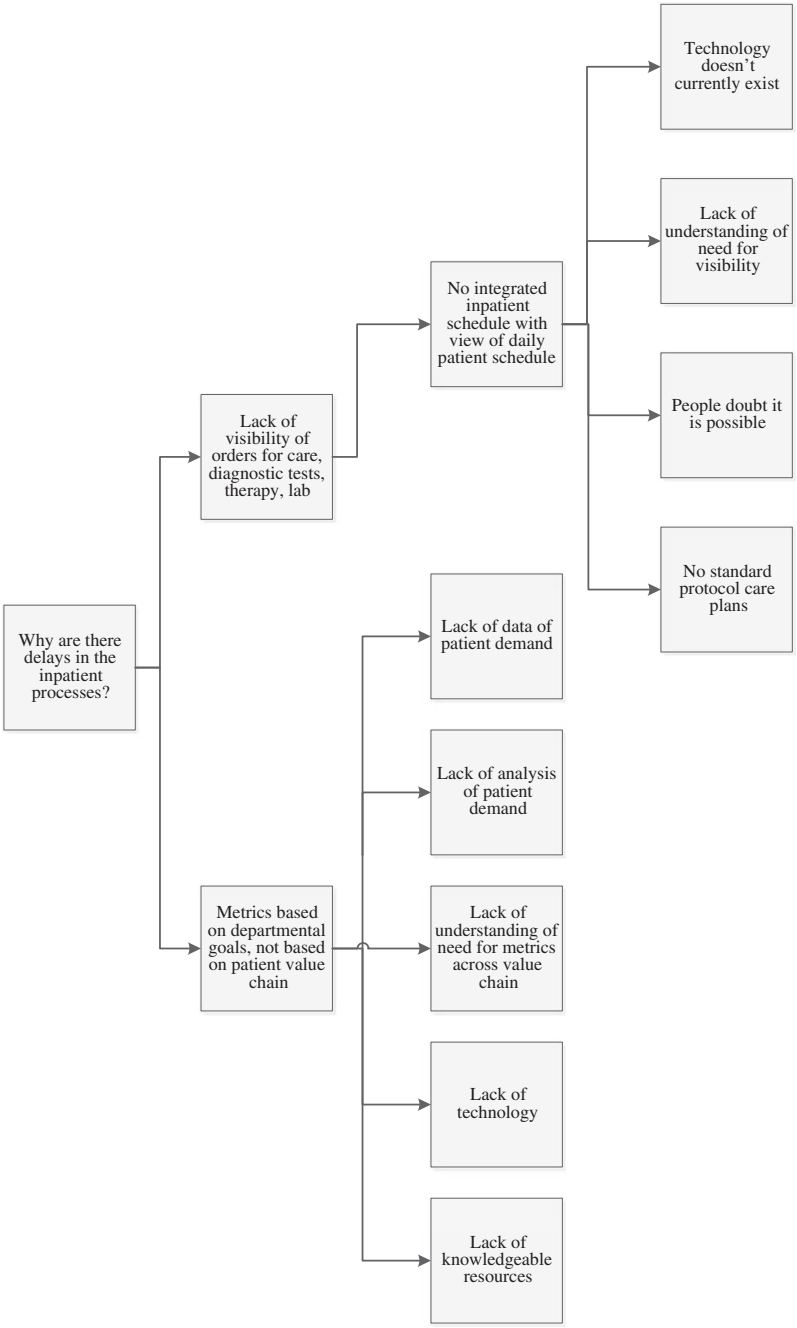

Fig. 11.11 Why why diagram 2

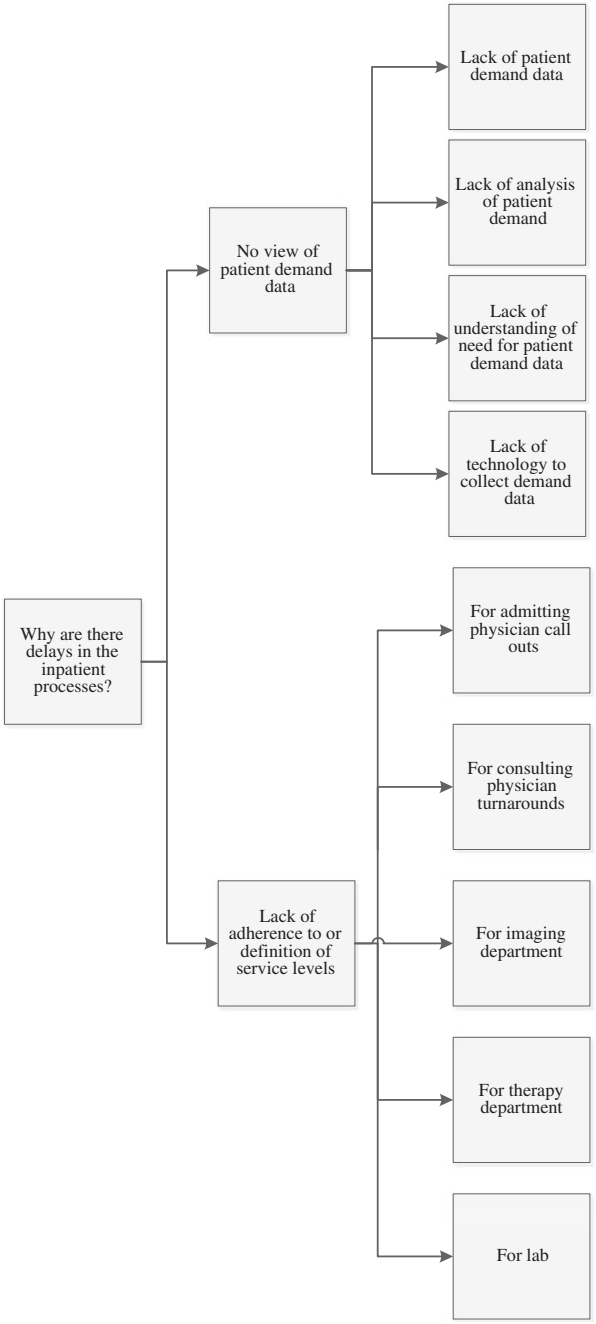

Fig. 11.12 Why why diagram 3

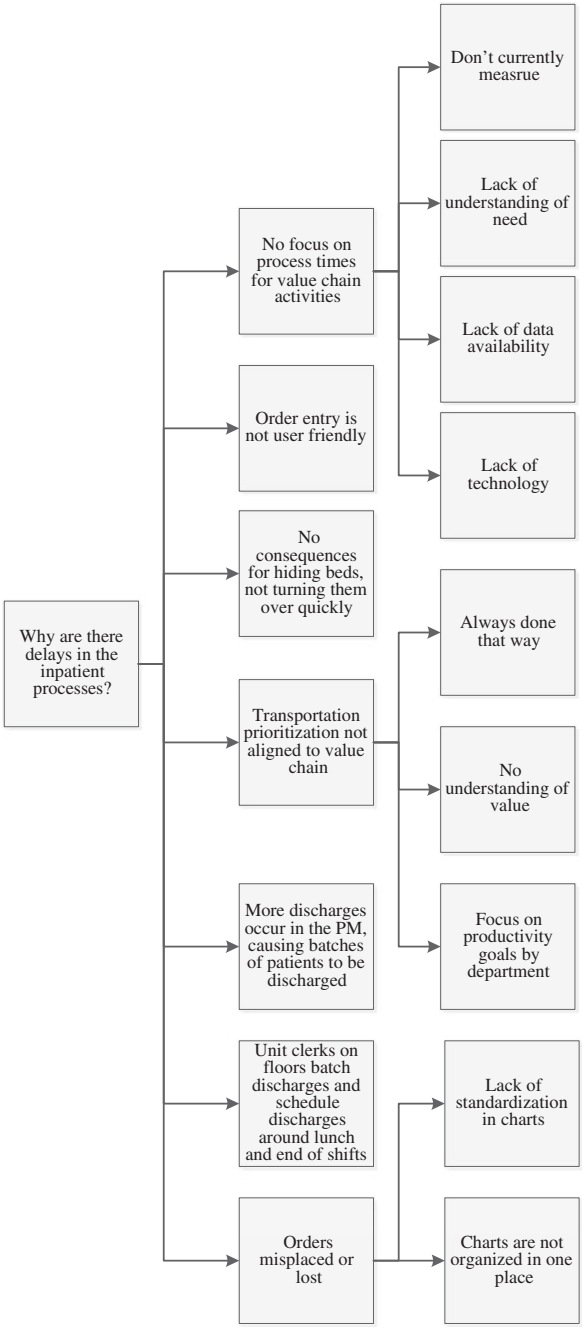

Fig. 11.13 Why why diagram 4

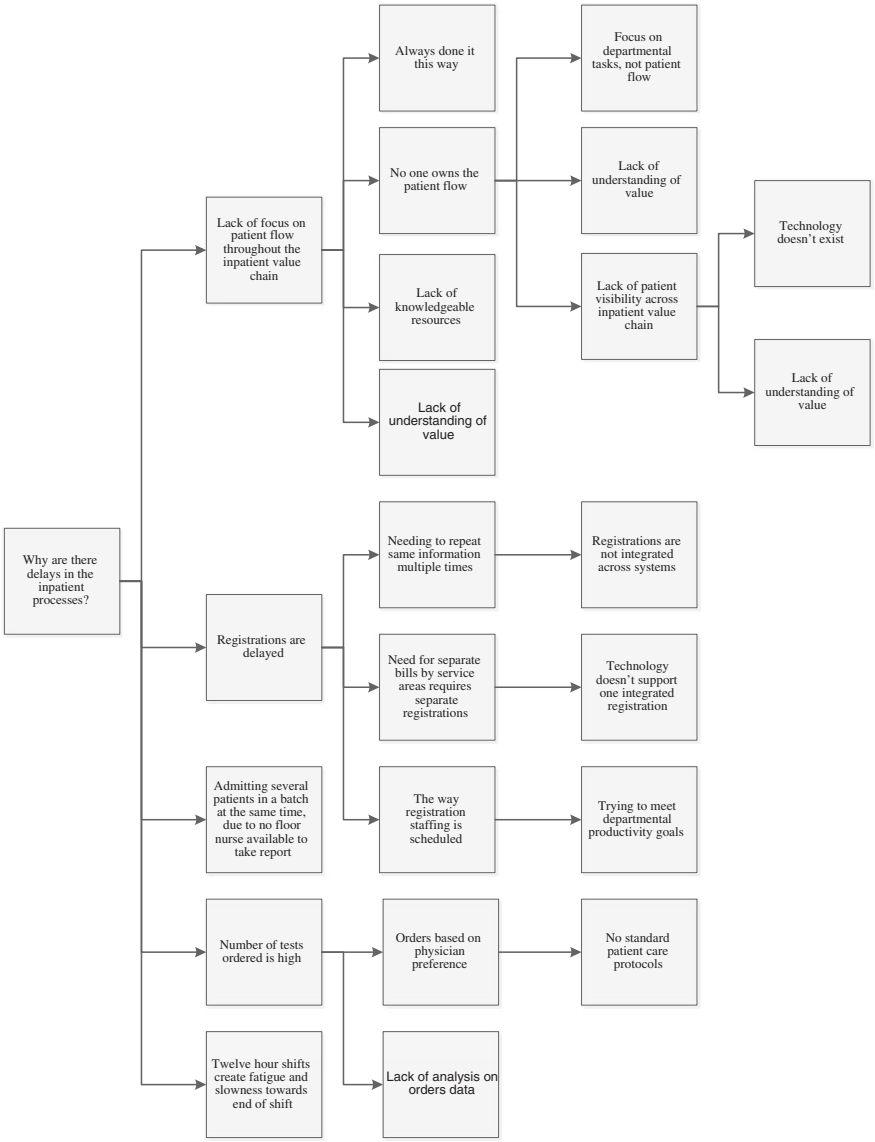

Fig. 11.14 Why why diagram 5

Why are There Delays in the Inpatient Processes?

- Staff not available to provide services
  - Productivity goals are defined by department, not by value chain

    Lack of knowledge of how to set the goals better

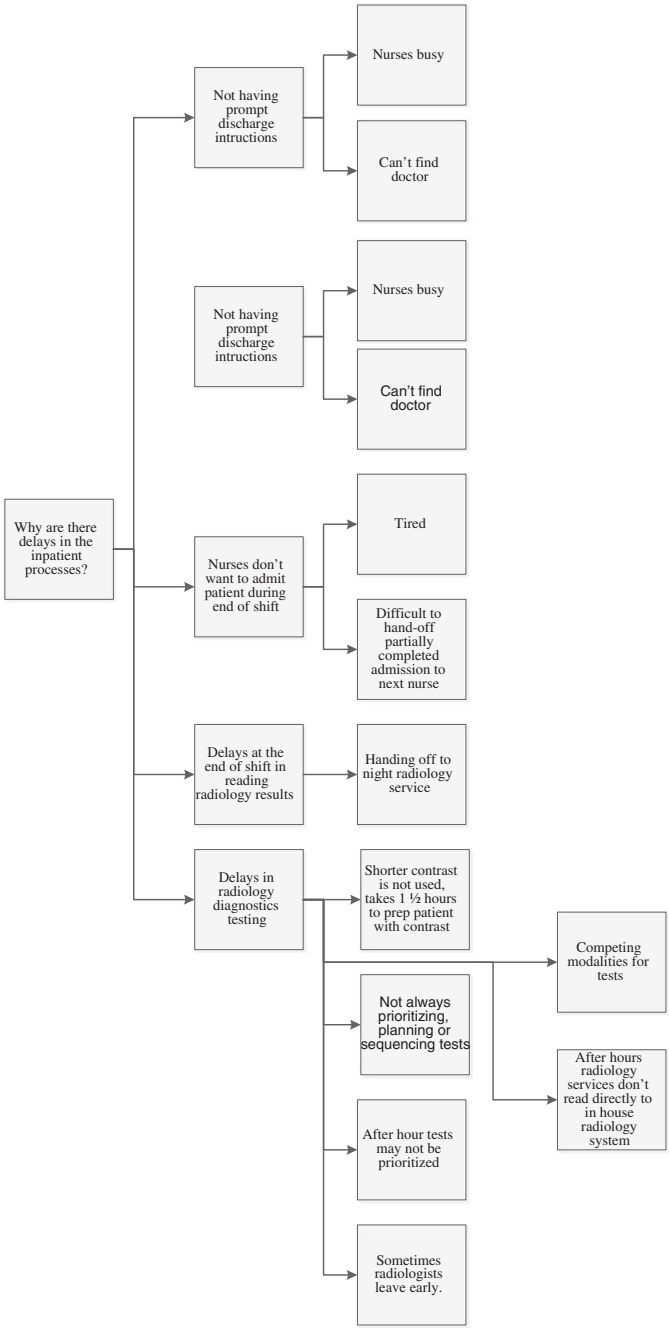

Fig. 11.15 Why why diagram 6

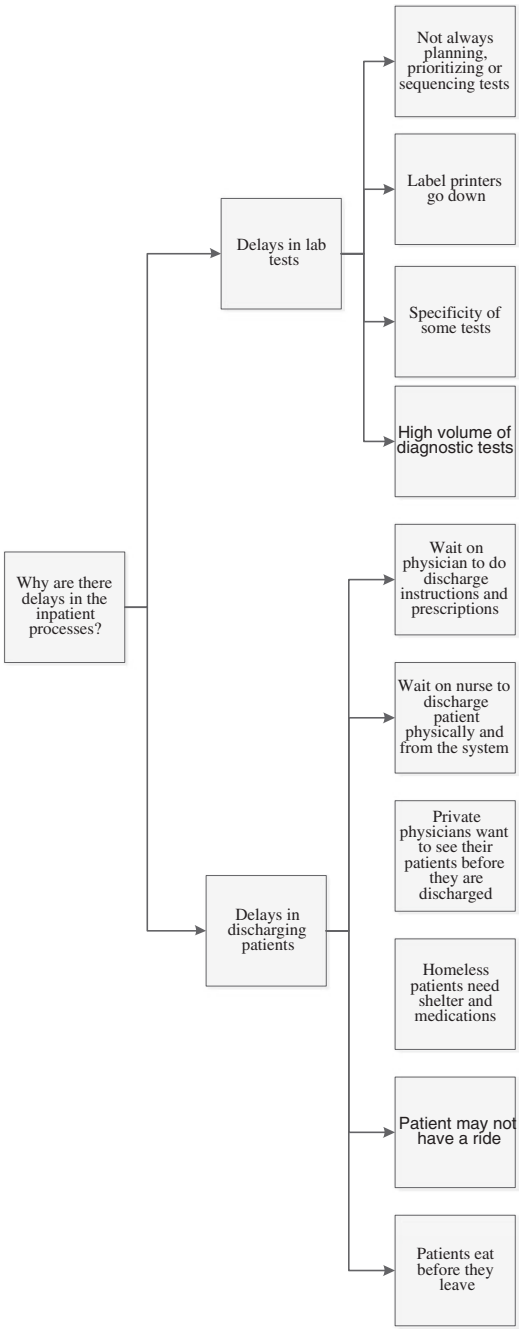

Fig. 11.16 Why why diagram 7

– Productivity goals are not set using real data, but arbitrary national averages

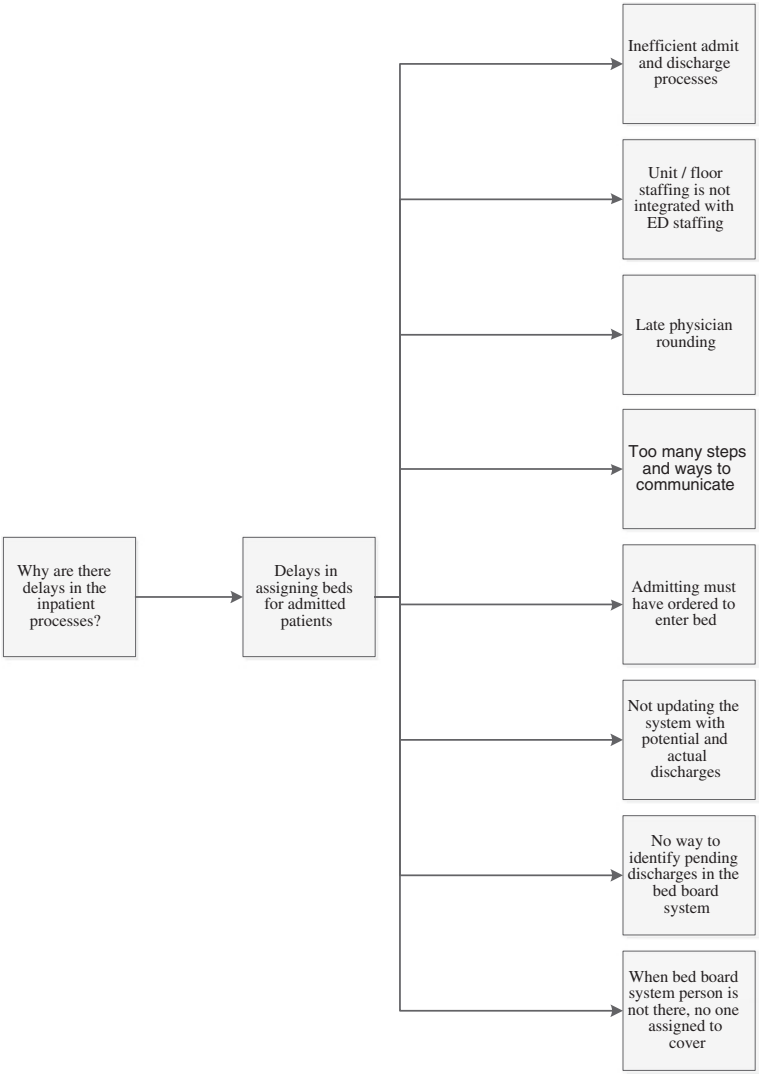

Fig. 11.17 Why why diagram 8

Lack of knowledge of how to set the goals better
Easier to set them without time, resources, and cost to collect real data
Always done it that way
Culture doesn't support questioning the productivity standards

– Nurses call out sick at last minute
Lax absence policies
Nurse is sick

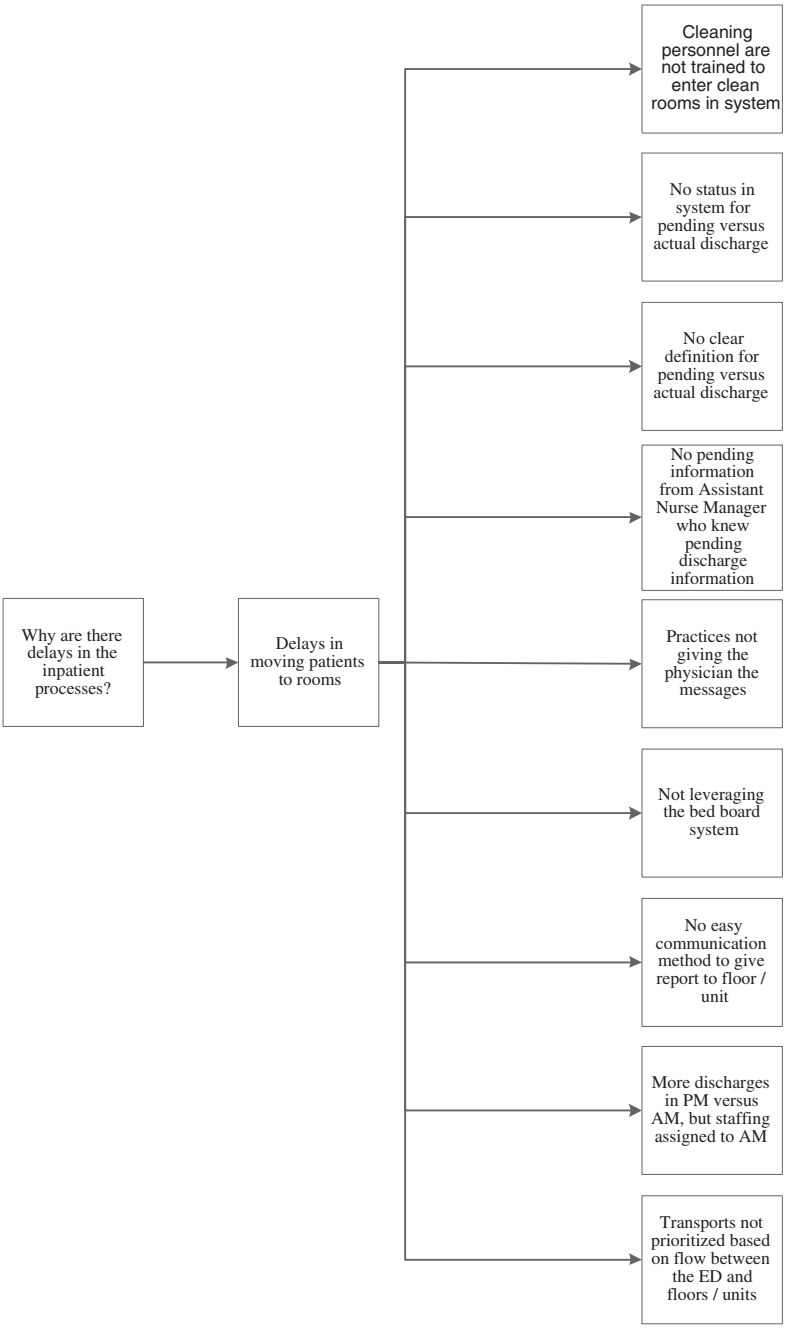

Fig. 11.18 Why why diagram 9

  - Staff not aligned to patient demand

    No process to align staff to patient demand
    Manage work by departmental key performance indicators, not across value chain

- Lack of visibility of orders for care, diagnostic tests, therapy
  - No integrated inpatient schedule with view of daily patient schedule

    Technology doesn't currently exist
    Lack of understanding of need for visibility
    People doubt it is possible
    Poor process

- No standard protocol care plans
- Metrics based on departmental goals, not based on patient value chain
  - Lack of data of patient demand
  - Lack of analysis of patient demand
  - Lack of understanding of need for metrics across value chain
  - Lack of technology
  - Lack of knowledgeable resources

- No view of patient demand data
  - Lack of patient demand data
  - Lack of analysis of patient demand
  - Lack of understanding of need for patient demand data
  - Lack of technology to collect demand data

- Lack of adherence to or definition of Service Levels
  - For admitting physician call outs
  - For consulting physician turnaround time
  - For imaging department
  - For therapy department
  - For lab

- No focus on process times for value chain activities
  - Don't currently measure
  - Lack of understanding of value
  - Lack of data availability
  - Lack of technology

- More discharges occur in the PM, causing batches of patients to be discharged.
- Unit clerks on the floors batch discharges and schedule discharge order entry around lunch and end of shifts, which clogs the hospital rooms
- Orders misplaced or lost
  - Lack of standardization in charts.
  - Charts are not organized in one place.

- Order entry is not user friendly
- No consequences for hiding beds, not turning them over quickly.

- Lack of focus on patient flow throughout the inpatient value chain
  - Always done it this way
  - Lack of understanding of value
  - Lack of knowledgeable resources
  - No one owns the patient flow

    Focus on departmental tasks, not patient flow
    Lack of understanding of value
    Lack of patient visibility across inpatient value chain

- Technology doesn't exist
- Lack of understanding of value
- Registrations are delayed
  - Needing to repeat same information multiple times
- Registrations are not integrated across systems
  - Need for separate bills by service area requires separate registrations
  - Technology doesn't support one integrated registration
  - The way registration staffing is scheduled
- Trying to meet departmental productivity goals
- Transportation prioritization not always aligned to value chain
  - Always done that way
  - No understanding of value
  - Focus on productivity goals by department
- Admitting several patients in a batch at the same time, due to no floor nurse available to take report.
- Number of tests ordered is high
  - Orders based on physician preferences

    No standard patient care protocols

  - Lack of analysis on orders data
- Not having prompt discharge instructions
  - Nurses busy
  - Can't find doctor
- Twelve hour shifts create fatigue and slowness toward end of shift.
- Nurses don't want to admit patient during end of shift
  - Tired
  - Difficult to hand-off partially completed admission to next nurse
- Delays at the end of shift in reading radiology results.
  - Handing off to night radiology service
- Delays in radiology diagnostic testing
  - Shorter contrast is not used, takes 1 ½ hours to prep patient with contrast.
  - Not always prioritizing, planning, or sequencing tests.
  - Competing modalities for tests.

  - After hours tests may not be prioritized.
  - After hours radiology services doesn't read directly on in house radiology system.
  - Sometimes radiologists leave early.

- Delays in lab tests
  - Not always planning, prioritizing, or sequencing tests.
  - Label printers go down.
  - Specificity of some tests.
  - High volume of diagnostic tests.

- Delays in discharging patients
  - Wait on physician to do discharge instructions and prescriptions.
  - Wait on nurse to discharge patient physically and from the system.
  - Private physicians want to see their patients before they are discharged.
  - Homeless patients need shelter and medications.
  - Patient may not have a ride.
  - Patients eat before they leave.

- Delays in assigning beds for admitted patients
  - Inefficient admit and discharge processes.
  - Unit/floor staffing is not integrated with ED staffing.
  - Late physician rounding.
  - Too many steps and ways to communicate.
  - Admitting must have order to enter bed.
  - Not updating the system with potential and actual discharges.
  - No way to identify pending discharges in the bed board system.
  - When bed board system person is not there, no one assigned to cover.

- Delays in moving patients to rooms
  - Cleaning personnel are not trained to enter cleaned rooms directly into the system.
  - No status in system for pending versus actual discharges.
  - No clear definition for pending versus potential discharges.
  - No pending information from Assistant Nurse Manager who know pending discharge information.
  - Practices not giving the physician the messages.
  - Not leveraging the bed board system.
  - No easy communication method to give report to floor/unit.
  - More discharges in PM versus AM, but staffing assigned to AM.
  - Transports not prioritized based on flow between the ED and floors/units.

The next step in the cause and effect analysis was to prioritize them based on the Critical to Satisfaction Criteria of Length of Stay, process times and reducing delays in the processes. We first ranked the importance of the CTS' on a scale

of 1 to 10, with 10 being high and 1 being low. We rated delays as the most important with a 10, reducing process times as a 5, and because if delays and process times are reduced, it will have a positive impact on delays, we ranked that the lowest, with a 1. There are also many other types of improvement projects that can also effectively impact length of stay related to clinical pathways and protocols.

We then applied an impact rating for each potential cause for how much the root cause impacted the CTS, using a scale of 9 as high, 3 as medium, 1 as low, and blank as none.

The Cause and Effect matrices are shown in Figs. 11.19, 11.20, 11.21, and 11.22, 11.23, 11.24, 11.25.

We achieved the overall weightings by multiplying each CTS importance rating by the strength of relationship weighting. Ranking the root cause weighting gives us a focus of the high priority improvement areas as we move into the Improve phase of the project.

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	CTS: Patient Length of Stay	CTS: Process Time	CTS: Reduce Delays	Priority	Ranking (Low = 0 to 50, Med = 51 to 100, High = Over 100)
	3	5	10		
Why are there delays in the inpatient processes?					
Staff not available to provide services	9	9	9	162	**High**
Productivity goals are defined by department, not by value chain	1	9	9	138	**High**
Lack of knowledge of how to set the goals better	1	3	3	48	Low
Productivity goals are not set using real data, but arbitrary national averages	1	3	9	108	**High**
Lack of knowledge of how to set the goals better	1	3	9	108	**High**
Easier to set them without time, resources and cost to collect real data		1	3	35	Low
Always done it that way		1	1	15	Low
Culture doesn't support questioning the productivity standards	1	3	9	108	**High**
Nurses call out sick at last minute	1	3	3	48	Low
Lax absence policies	1	3	3	48	Low
Nurse is sick	1	3	3	48	Low
Staff not aligned to patient demand	9	9	9	162	**High**
No process to align staff to patient demand	9	9	9	162	**High**
Manage work by departmental key performance indicators, not across value chain	3	9	9	144	**High**
Lack of visibility of orders for care, diagnostic tests, therapy	9	9	9	162	**High**
No integrated inpatient schedule with view of daily patient schedule	9	9	9	162	**High**
Technology doesn't currently exist	9	9	9	162	**High**
Lack of understanding of need for visibility	1	3	3	48	Low
People doubt it is possible	1	3	9	108	**High**
Poor process	1	3	3	48	Low

Fig. 11.19 Cause and effect analysis prioritization by CTS—page 1

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	CTS: Patient Length of Stay	CTS: Process Time	CTS: Reduce Delays		Low = 0 to 50 / Med = 51 to 100 / High = Over 100
No standard protocol care plans	9	3	3	72	Med
Metrics based on departmental goals, not based on patient value chain	9	9	9	162	**High**
Lack of data of patient demand	3	9	9	144	**High**
Lack of analysis of patient demand	1	3	3	48	Low
Lack of understanding of need for metrics across value chain	1	3	9	108	**High**
Lack of technology	1	9	9	138	**High**
Lack of knowledgeable resources	3	9	9	144	**High**
No view of patient demand data	1	3	9	108	**High**
Lack of patient demand data	1	3	9	108	**High**
Lack of analysis of patient demand		1	3	35	Low
Lack of understanding of need for patient demand data		1	3	35	Low
Lack of technology to collect demand data		3	9	105	**High**
Lack of adherence to or definition of Service Levels	1	3	3	48	Low
For admitting physician call outs		1	3	35	Low
For consulting physician turnaround time	3	3	9	114	**High**
For imaging department	1	3	9	108	**High**
For therapy department	1	1	1	18	Low
For lab	1	3	3	48	Low
No focus on process times for value chain activities	1	9	3	78	Med
Don't currently measure	3	9	9	144	**High**
Lack of understanding of value	1	3	3	48	Low
Lack of data availability	1	9	3	78	Med
Lack of technology	1	9	3	78	Med
More discharges occur in the PM, causing batches of patients to be discharged.	9	3	3	72	Med

Fig. 11.20 Cause and effect analysis prioritization by CTS—page 2

Improve Phase

The following steps were executed in the Improve Phase:

1. Identify improvement opportunities and plans
2. Design future state
3. Establish performance targets and project scorecard

Identify Improvement Opportunities and Plans, and Design Future State

Improvement plans were developed based on eliminating the identified root causes and improving flow across the inpatient value chain. Improvements were categorized into the following themes:

- Value Chain integration
- Enhance productivity measurement
- Inpatient scheduling
- Predictive bed demand
- Order entry and diagnostics
- Information Technology
- Patient Transport

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	CTS: Patient Length of Stay 3	CTS: Process Time 5	CTS: Reduce Delays 10	Priority	Ranking (Low = 0 to 50, Med = 51 to 100, High = Over 100)
Unit clerks on the floors batch discharges and schedule discharge order entry around lunch and end of shifts, which clogs the hospital rooms	9	3	3	72	Med
Orders misplaced or lost	9	3	3	72	Med
Lack of standardization in charts.	9	3	3	72	Med
Charts are not organized in one place.	1	1	1	18	Low
Order entry is not user friendly.	3	1	1	24	Low
No consequences for hiding beds, not turning them over quickly.	9	1	3	62	Med
Lack of focus on patient flow throughout the inpatient value chain	9	9	9	162	**High**
Always done it this way	1	1	1	18	Low
Lack of understanding of value	9	9	9	162	**High**
Lack of knowledgeable resources	1	1	1	18	Low
No one owns the patient flow	9	9	9	162	**High**
Focus on departmental tasks, not patient flow	9	9	9	162	**High**
Lack of understanding of value	1	1	1	18	Low
Lack of patient visibility across inpatient value chain	9	9	9	162	**High**
Technology doesn't exist	9	9	9	162	**High**
Lack of understanding of value	9	9	9	162	**High**
Registrations are delayed	1	1	1	18	Low
Needing to repeat same information multiple times		1	1	15	Low
Registrations are not integrated across systems		1	1	15	Low
Need for separate bills by service area requires separate registrations	1	1	1	18	Low
Technology doesn't support one integrated registration	1	9	9	138	**High**
The way registration staffing is scheduled	1	9	9	138	**High**
Trying to meet departmental productivity goals	1	9	9	138	**High**

Fig. 11.21 Cause and effect analysis prioritization by CTS—page 3

- Discharge planning
- Value Chain Process Metrics

Value Chain Integration

This improvement idea is to integrate the process activities and resources that perform these activities across the inpatient value chain. We suggest integrating the key resources that manage these activities including:

- Nurse patient care coordinators
- Case Management
- Transportation
- Bed Assignment
- Room Cleaning - Environmental Services
- Physicians
- Inpatient Scheduling
- Imaging Diagnostics
- Lab

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	CTS: Patient Length of Stay	CTS: Process Time	CTS: Reduce Delays		Low = 0 to 50 Med = 51 to 100 High = Over 100
	3	5	10	Priority	Ranking
Transportation prioritization not always aligned to value chain	1	9	9	138	**High**
Always done that way	1	3	3	48	Low
No understanding of value	1	3	3	48	Low
Focus on productivity goals by department	1	9	9	138	**High**
Admitting several patients in a batch at the same time, due to no floor nurse available to take report.		3	9	105	**High**
Number of tests ordered is high	9	9	9	162	**High**
Orders based on physician preferences	3	3	3	54	Med
No standard patient care protocols	9	3	9	132	**High**
Lack of analysis on orders data	1	1	1	18	Low
Not having prompt discharge instructions	3	3	3	54	Low
Nurses busy	1	3	9	108	**High**
Can't find doctor	1	3	9	108	**High**
Twelve hour shifts create fatigue and slowness towards end of shift.	3	1	1	24	Low
Nurses don't want to admit patient during end of shift	1	1	1	18	Low
Tired	1	1	1	18	Low
Difficult to hand-off partially completed admission to next nurse	3	1	1	24	Low
Delays at the end of shift in reading radiology results.	1	1	1	18	Low
Handing off to night radiology service	1	1	1	18	Low
Delays in radiology diagnostic testing	1	3	9	108	**High**
Shorter contrast is not used, takes 1 ½ hours to prep patient with contrast.	1	1	1	18	Low
Not always prioritizing, planning or sequencing tests.	3	1	3	44	Low
Competing modalities for tests.	1	1	3	38	Low

Fig. 11.22 Cause and effect analysis prioritization by CTS – page 4

Some best practices in the healthcare industry encourage this type of care coordination where nurse patient care coordinators in a physically centralized location, which we will call the Central Care Hub, work with nurse managers or patient care coordinators in the units and floors to coordinate patient care, using standard practice protocols based on the patient's primary diagnosis while in the hospital. One such example is CareLogistics®, (CareLogistics 2013). They have a patient care model augmented by their software that manages the patient flow through every step of the process, including scheduling of tests and diagnostics.

For our model, the central location is where the bed assignments are managed with the centralized nurse care coordinators. They coordinate with environmental services to ensure that the rooms are cleaned and that the most recent status of the beds (dirty or clean) are updated in the bed board system. An environmental services manager works out of the Central Care Hub to align with the needs of bed assignment. A Transportation manager works in the Central Care Hub to align with the needs of transporting patients to inpatient rooms from whatever location in the hospital they are admitted from. The Central Care Hub Patient Care Coordinator works with the floor and unit nurse managers, the Case managers, and the physicians to coordinate and execute the standard care protocol plans. Inpatient Scheduling schedules Imaging Diagnostics and the Lab orders within the Central Care Hub. The Central Care Hub acts as a command center where all patient flow activities are

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	CTS: Patient Length of Stay	CTS: Process Time	CTS: Reduce Delays		Low = 0 to 50, Med = 51 to 100, High = Over 100
	3	5	10	Priority	Ranking
After hours tests may not be prioritized.	1	1	1	18	Low
After hours radiology services doesn't read directly on in house radiology system	1	1	1	18	Low
Sometimes radiologists leave early.	1	1	1	18	Low
Delays in lab tests	1	3	9	108	**High**
Not always planning, prioritizing or sequencing tests.	1	1	9	98	Med
Label printers go down.	1	1	1	18	Low
Specificity of some tests.	1	1	1	18	Low
High volume of diagnostic tests.	9	3	9	132	**High**
Delays in discharging patients	9	3	3	72	Med
Wait on physician to do discharge instructions and prescriptions.	3	3	3	54	Med
Wait on nurse to discharge patient physically and from the system.	3	3	3	54	Med
Private physicians want to see their patients before they are discharged.	3	3	3	54	Med
Homeless patients need shelter and medications.	1	1	1	18	Low
Patient may not have a ride.	1	1	1	18	Low
Patients eat before they leave.	1	1	1	18	Low
Delays in assigning beds for admitted patients	3	3	9	114	**High**
Inefficient admit and discharge processes.	3	3	3	54	Med
Unit/floor staffing is not integrated with ED staffing.	1	3	3	48	Low
Late physician rounding.	9	3	9	132	**High**
Too many steps and ways to communicate.	1	3	3	48	Low
Admitting must have order to enter bed.	1	1	1	18	Low

Fig. 11.23 Cause and effect analysis prioritization by CTS—page 5

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	CTS: Patient Length of Stay	CTS: Process Time	CTS: Reduce Delays		Low = 0 to 50, Med = 51 to 100, High = Over 100
Not updating the system with potential and actual discharges.	3	3	3	54	Med
No way to identify pending discharges in the bed board system.	3	3	3	54	Med
When bed board system person is not there, no one assigned to cover.	1	1	1	18	Low
Delays in moving patients to rooms	9	3	9	132	**High**
Cleaning personnel are not trained to enter cleaned rooms directly into the system.	1	1	1	18	Low
No status in system for pending versus actual discharges.	3	3	3	54	Med
No clear definition for pending versus potential discharges.	1	1	1	18	Low
No pending information from Assistant Nurse Manager who know pending discharge information.	1	1	1	18	Low
Practices not giving the physician the messages.	1	1	1	18	Low
Not leveraging the bed board system.	9	9	9	162	**High**
No easy communication method to give report to floor/unit.	3	3	3	54	Med
More discharges in PM versus AM, but staffing assigned to AM.	9	3	9	132	**High**
Transports not prioritized based on flow between the ED and floors/units.	9	3	9	132	**High**

Fig. 11.24 Cause and effect analysis prioritization by CTS – page 6

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	CTS: Patient Length of Stay	CTS: Process Time	CTS: Reduce Delays	Priority	Ranking (Low = 0 to 50, Med = 51 to 100, High = Over 100)
	3	5	10		
Why are there delays in the inpatient processes?					
Staff not available to provide services	9	9	9	162	**High**
Productivity goals are defined by department, not by value chain	1	9	9	138	**High**
Productivity goals are not set using real data, but arbitrary national averages	1	3	9	108	**High**
Lack of knowledge of how to set the goals better	1	3	9	108	**High**
Culture doesn't support questioning the productivity standards	1	3	9	108	**High**
Staff not aligned to patient demand	9	9	9	162	**High**
No process to align staff to patient demand	9	9	9	162	**High**
Manage work by departmental key performance indicators, not across value chain	3	9	9	144	**High**
Lack of visibility of orders for care, diagnostic tests, therapy	9	9	9	162	**High**
No integrated inpatient schedule with view of daily patient schedule	9	9	9	162	**High**
Technology doesn't currently exist	9	9	9	162	**High**
People doubt it is possible	1	3	9	108	**High**
Metrics based on departmental goals, not based on patient value chain	9	9	9	162	**High**
Lack of data of patient demand	3	9	9	144	**High**
Lack of understanding of need for metrics across value chain	1	3	9	108	**High**
Lack of technology	1	9	9	138	**High**
Lack of knowledgeable resources	3	9	9	144	**High**

Fig. 11.25 Cause and effect analysis prioritization by CTS – page 7

managed to reduce delays in the flow of the patient through the inpatient value chain activities. The Central Care Hub is shown in Fig. 11.26.

Enhance Productivity Measurement

A huge drain on productivity and an inherent cause of delays in the inpatient flow is the way that many hospitals measure productivity of their personnel. Since the human resource is a large "controllable" cost of providing hospital services, most hospitals attempt to closely manage personnel, and align resources with patient demand. One inherent weakness is the lack of sound data on which to base the productivity standards, as well as attempting to manage too closely to a forecasted demand, that is always going to have error. Some days the hospital will over schedule and have too much staff, and end up sending staff home, or the inverse, under staff the units, floors, and departments and need to call in staff. This can cause morale challenges when staff are called in, and then sent home without working a full shift. Unrealistic productivity standards that are not based on the actual work performed and the variables of the particular hospital can result in staff being required to take vacation days when the hospital dictates, and end up with no or few vacation days for the staff to take at their own discretion. This can also lead to morale challenges and lack of employee engagement.

Cause and Effect Analysis Prioritization by CTS

Possible Root Causes	Patient Length of Stay	CTS Process Time	Reduce Delays		Low = 0 to 50 Med = 51 to 100 High = Over 100
No view of patient demand data	1	3	9	108	High
Lack of patient demand data	1	3	9	108	High
Lack of technology to collect demand data		3	9	105	High
For consulting physician turnaround time	3	3	9	114	High
For imaging department	1	3	9	108	High
Don't currently measure	3	9	9	144	High
Lack of focus on patient flow throughout the inpatient value chain	9	9	9	162	High
Lack of understanding of value	9	9	9	162	High
No one owns the patient flow	9	9	9	162	High
Focus on departmental tasks, not patient flow	9	9	9	162	High
Lack of patient visibility across inpatient value chain	9	9	9	162	High
Technology doesn't exist	9	9	9	162	High
Lack of understanding of value	9	9	9	162	High
Technology doesn't support one integrated registration	1	9	9	138	High
The way registration staffing is scheduled	1	9	9	138	High
Trying to meet departmental productivity goals	1	9	9	138	High
Transportation prioritization not always aligned to value chain	1	9	9	138	High
Focus on productivity goals by department	1	9	9	138	High
Admitting several patients in a batch at the same time, due to no floor nurse available to take report.		3	9	105	High
Number of tests ordered is high	9	9	9	162	High
No standard patient care protocols	9	3	9	132	High
Nurses busy	1	3	9	108	High
Can't find doctor	1	3	9	108	High
Delays in radiology diagnostic testing	1	3	9	108	High
Delays in lab tests	1	3	9	108	High
High volume of diagnostic tests.	9	3	9	132	High
Delays in assigning beds for admitted patients	3	3	9	114	High
Late physician rounding.	9	3	9	132	High
Delays in moving patients to rooms	9	3	9	132	High
Not leveraging the bed board system.	9	9	9	162	High
More discharges in PM versus AM, but staffing assigned to AM.	9	3	9	132	High
Transports not prioritized based on flow between the ED and floors/units.	9	3	9	132	High

Fig. 11.26 Highest priority root causes - page 1

A fuller description of the flaws and best practices of labor management in healthcare is provided in Chap. 12.

Inpatient Scheduling

Inpatient scheduling is an innovative concept that virtually no hospitals that we found were doing. The concept is to provide a daily schedule for inpatients of their diagnostic tests including the following modalities: radiology, ultrasound, CT scan, MRI, nuclear medicine, interventional radiology and dialysis. A second phase of inpatient scheduling could incorporate schedules for patients' physical and occupational therapy, but this endeavor is fraught with many challenges, due to the complex nature of scheduling appropriate therapy type and skill level of the therapists.

The current state of inpatient scheduling is extremely manual. There is not extensive technology for the healthcare industry to enable easy centralized inpatient scheduling. There are many nuances in the requirements for providing

an inpatient schedule that is different from outpatient scheduling. Key inpatient scheduling requirements are as follows:

(1) Provide a detailed inpatient schedule on a daily basis, available in the morning of the patient's daily appointments for diagnostic tests.
(2) Enable streamlined order entry from the floors and inputs.
(3) Incorporate resource availability of the delivering departments into the scheduling technology.
(4) Incorporate technician skill set of the delivering departments into the scheduling technology.
(5) Provide the ability to seamlessly order transportation for when the patient must travel to their appointment throughout the hospital.
(6) Provide the ability to change appointments and schedules when necessary based on patient or service delivering department, and notify the nurse and patient of the revised patient schedule.
(7) Provide automated reminders for patient preparation.
(8) Provide prioritization of appointments by priority, modality, preparation time, recovery time, etc.
(9) Provide the ability to schedule stat orders.
(10) Provide metrics for schedule adherence and timeliness of service delivery.
(11) Provide historical demand data.

A future state process map is provided in Fig. 11.27, proposing just one possible way to design an inpatient scheduling process.

Fig. 11.27 Central care hub

Predictive Bed Demand

It can be very valuable for the Central Care Hub to perform statistical analysis on the number of Adjusted Occupied Beds. The Adjusted Occupied Beds is a statistic that measures the number of patients in inpatient beds on a weekly basis. This number is used to staff and set productivity targets. An example analysis showing a time series chart in Fig. 11.28 and the related histogram is shown in Fig. 11.29. This statistical analysis can help us plan for staffing. This same analysis can be performed to understand trends on a daily, weekly, monthly, and seasonal basis. There are hospitals that are located in warm vacation climates that are heavily impacted by the tourist season, so this seasonality would want to be considered in the statistical analysis.

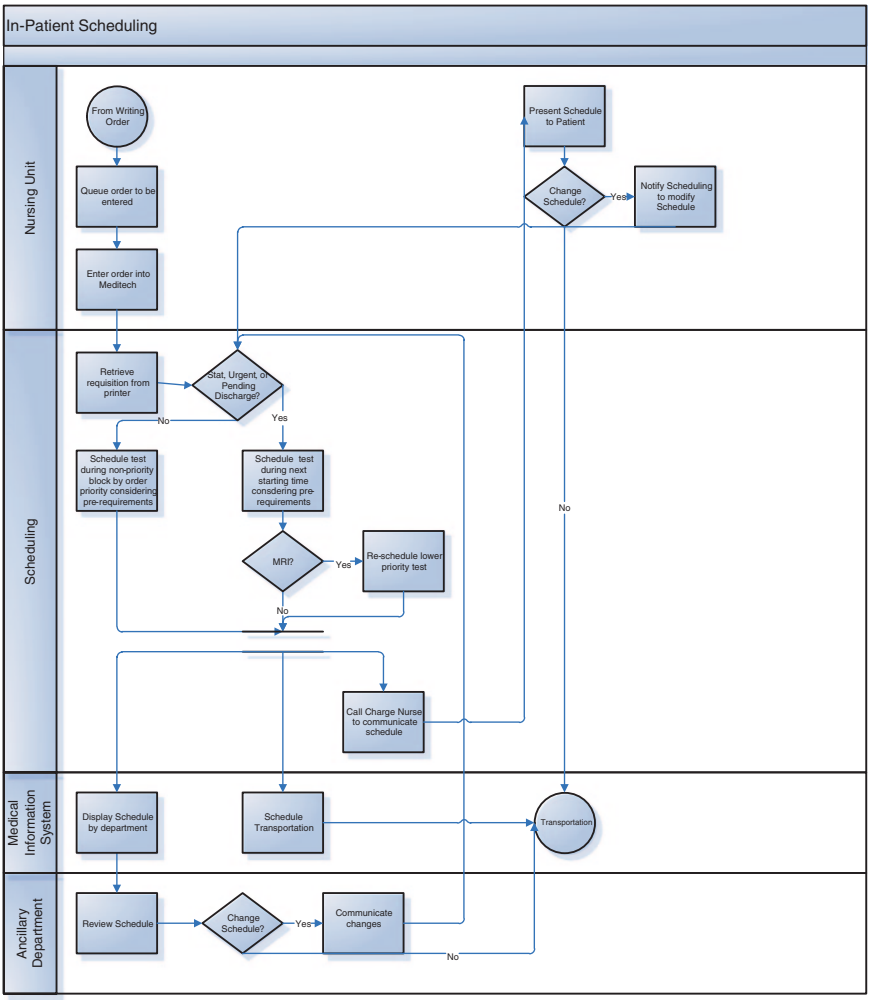

Fig. 11.28 Inpatient future state process map

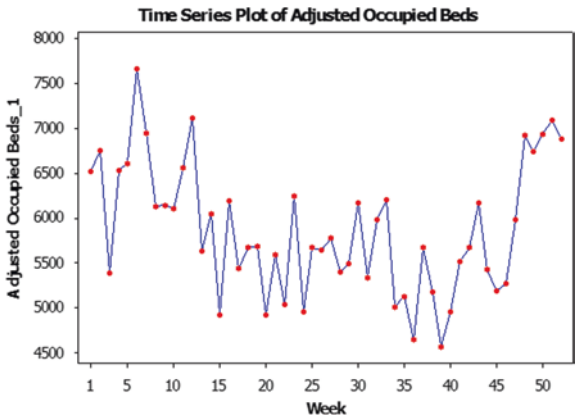

Fig. 11.29 Patient demand profile time series plot

Order Entry and Diagnostics

It is important to reduce the delays in entering orders into the medical information system for diagnostic tests. Some of the root causes of the delays around order entry include batching of orders around the lunch hour and change of shift; orders being misplaced or lost due to lack of standardization and organization in patient charts. Additionally, the number of tests ordered is high, due to lack of standard patient care protocols. The order entry system is also not user friendly and takes extra time to enter orders. A process improvement project should be initiated to reduce delays in getting orders in the system; sometimes this can cause an additional one-half to a day of delays in the patients receiving their diagnostic tests.

Information Technology

The information technology to support providing an inpatient schedule so that the patient and their family knows roughly when the patient will receive tests, care, and therapy, was not currently available. Some software organizations are now creating enterprise systems that can help to know where the patient is at any moment, and schedule tests, care and therapy. One particular healthcare organization was attempting to adapt the outpatient scheduling system to be used for inpatient scheduling. However, this was not going to be an easy task, nor did it currently have the ability to meet all of the defined requirements listed in the inpatient scheduling section of this chapter. As more healthcare organizations begin to think innovatively to be more patient-focused and responsive, they will begin asking for this type of technology that can schedule and track patients' movements throughout the hospital via radio frequency identification and similar technologies. Patient tracking technologies can help with patient transportation, entering orders for transport to and from tests.

Using simulation software applications can be very effective to simulate the end-to-end inpatient value chain activities. The trouble, or challenge, is to get the data that is required to identify appropriate statistical distributions and

assumptions to ensure simulation model validity. But just because it is challenging, does not mean that it's not valuable. Hiring an industrial or management engineer with this skill set would enhance the hospital's ability to be able to analyze process times, better predict patient demand, and perform staffing and resource capacity analysis.

Enhancing the bed assignment technology to be able to integrate the bed assignment and knowledge of open beds throughout the hospital, understanding where the demand for beds is coming from (emergency department, surgery, direct admit), integrating with order entry and scheduling, as well as transportation orders will enhance the ability to manage inpatient flow. Again, there are starting to be enterprise patient tracking, bed assignment, and transportation systems that enable managing the inpatient value chain. Some of these information systems are still in their infancy from a user friendliness to provide metrics that help to manage patient flow, but as hospitals demand this type of detailed process level data, the software vendors will most likely respond. Business Process Management Systems (BPMS) can also be extremely helpful to enhance managing the inpatient value chain and flow of the patient throughout the hospital. Many of the current information systems are built to satisfy billing requirements instead of patient flow and process improvement, but again as the healthcare industry demands innovation, these systems may become more popular as well.

There is a very real need for integrating registration information across the many places where patients are registered, including the emergency department, surgical services, outpatient services, and inpatient services. Gone should be the day where patients need to keep providing the same information every time they move to a new service provider in the healthcare system. The Ohio State University medical system does an excellent job at integrated electronic medical record. Once a patient provides their registration information, it is accessible to any OSU medical provider, whether it is within a hospital setting, a physician's office, an outpatient facility, etc.

Patient Transport

Transporting the patient to and from tests, care and therapy throughout the hospital needs to be more tightly integrated with the ordering and scheduling of these physician orders. We discussed the need for integrating the technology of order entry, scheduling and patient locating ability. The processes also need to be integrated within the Central Care Hub.

Discharge Planning

Another area that can help reduce delays in the inpatient activities is to improve the discharge planning. The idea for discharge planning is to understand discharge patterns throughout the day, and focus on understanding root causes of delays, so that patients can be discharged earlier in the day. Reducing discharge delays can

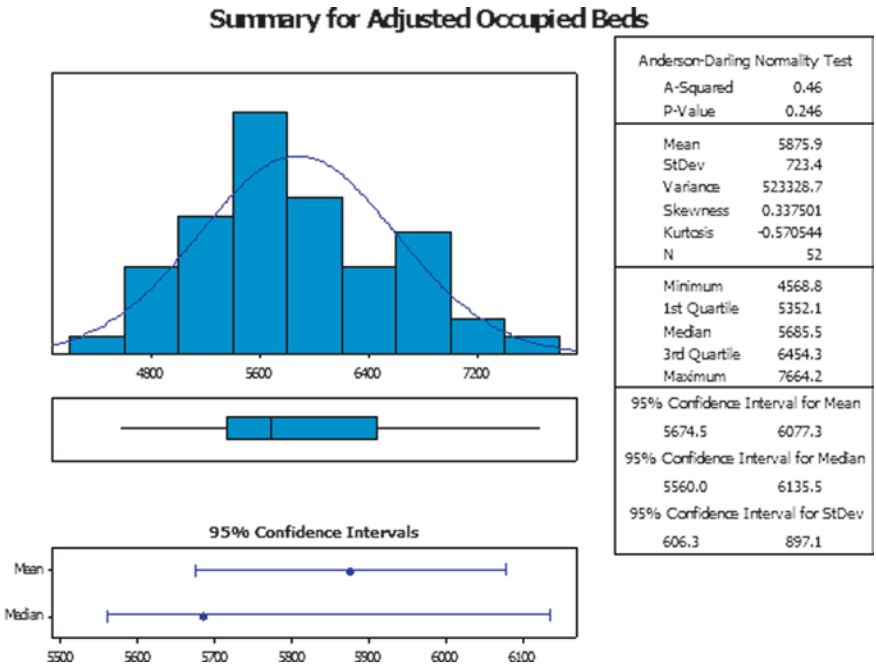

Fig. 11.30 Patient demand profile histogram

make room for the patients that need rooms as they come into the hospital through the emergency room, surgery, and direct admits. A sample discharge time in minutes by month is shown in Fig. 11.30.

Process improvement projects can be executed to reduce delays in the inpatient value chain activities, and provide a better patient experience.

Value Chain Process Metrics

When the goal is to improve processes, we must have process metrics that indicate that we have improved. Many organizations do not collect data at a process level that can provide insight into how our processes are performing. A BPMS which collects data on how long it takes to complete tasks within a workflow can be used to collect process times on the value chain activities. A process measurement system should be put in place that can measure key metrics including:

- Process times
- Process defects
- Cost of processes

Implementing a value chain process measurement system is a huge undertaking, but it can be prioritized and focused to collect key metrics in our existing information systems, and then migrate to a more robust BPMS. The potential inpatient

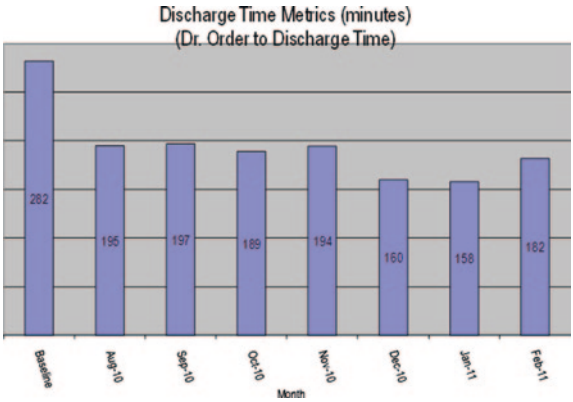

Fig. 11.31 Discharge statistics

value chain scorecard (Fig. 11.31) can be used as a guide for key metrics to collect in the inpatient value chain.

Control Phase

The purpose of the Control Phase is to implement control mechanisms and procedures to ensure that the process maintains the levels of improvements attained during the pilot activities.

The following activities were executed in the Control Phase:

1. Create scorecard data framework and create process control plan
2. Identify replication opportunities
3. Develop future plans

Measure Results and Manage Change

Since this chapter is a conceptual design of an innovative care model, we did not yet implement this model, and will develop how we might control the processes once they are implemented.

Create Scorecard Data Framework and Create Process Control Plan

The control plan is a detailed guide for maintaining all of the positive changes that you have implemented. We developed the control plan defining the metric and control mechanisms for each step in the value chain. The control plan scorecard is shown in Fig. 11.32.

Value Chain Activities:	Target Average Process Time (minutes)	Actual Average Process Time (minutes)	Variance %
Register Patient	30	60	-100%
Assign room	30	45	-50%
Prepare room	30	42	-40%
Transport patient	15	14	7%
Admit patient	60	188	-213%
Schedule patient for tests	30	175	-483%
Collect specimens for lab tests	60	52	13%
Provide therapy	60	110	-83%
Provide health care	60	130	-117%
Provide diagnostic tests and results	120	115	4%
Discharge patient	60	85	-42%
True Length of Stay (LOS) (time from admission to discharge)	4.8 days	5	-4.2%

Fig. 11.32 Potential inpatient value chain scorecard

We encourage the designation of a value chain owner that would be responsible for implementing the process improvements, the enhanced or new technology and monitoring the processes post implementation to ensure that improvement in the metrics are achieved.

Conclusions

We challenge the reader to embrace the principles of systems engineering and process improvement that are core elements of this case study, and attempt to design and implement the Patient Care Operating Model of Integrated Value Care.

Reference

Care Coordination Model (2013). Website: http://www.carelogistics.com/solution/care-coordination-model.aspx, CareLogistics®.

Chapter 12
Labor Management in Healthcare: Flaws and Best Practices

Abstract Labor Management is critical in healthcare and especially so in acute care hospitals, where 50 to 70 % of the costs are attributed to labor costs. According to the American Hospital Association labor represents more than half the cost of business in a healthcare facility (aha.org). The purpose of this article is to describe best practices of labor management, and how they can be applied to effectively manage an acute care hospital.

Introduction to Labor Standards

Labor management and labor standards were first widely developed and applied starting in the peak of the industrial revolution in the late 1800s. Frederick Taylor, commonly referred to as the father of Scientific Management, was an extremely successful Industrial Engineer. He furthered Adam Smith's division of labor principle (Smith 1776), where each person completes a specialized number of small tasks. Frederick Taylor incorporated work measurement including time studies to understand work elements and assess how long each element takes to perform. The methodology of developing labor standards, or how long it should take to perform work, and therefore how much work the operators are expected to complete in a certain time period, is developed by performing the following direct observation time study steps (Smith 1978):

(1) Step 1: State the objective
    a. For direct observation time study, the objective is usually "to determine the time which should be allowed to perform the observed tasks".
(2) Step 2: Notify the appropriate persons
    a. The department manager, and the operator who is performing the work being measured should be notified. This is to ensure that the process is stable, that the conditions are representative of the normal working environment, and that the operator has the reasonable skills to perform the work.

S. L. Furterer, *Lean Six Sigma Case Studies in the Healthcare Enterprise*,
DOI: 10.1007/978-1-4471-5583-6_12, © Springer-Verlag London 2014

(3) Step 3: Determine the scope
   a. The time frame to collect the data and ensuring the appropriate number of observations is developed in the scope.
(4) Step 4: Select the operator
   a. The operator should use the agreed upon and appropriate method to perform the work during the study.
(5) Step 5: Establish activity elements
   a. The elemental activities that make up the work should be identified, and then timed as activity elements. Those elements that are paced and/or performed by a machine should be separated from operator-based activities. The elements should make sense. They should be easily recognizable from a starting and end point perspective. They should be of a reasonable length to observe and capture the timing of them.
(6) Step 6: Conduct the study
   a. When conducting the study, the job condition should be recorded, and then the time to perform the tasks.
   b. The analyst should rate the operator's performance. Normal pace is assumed to be 100 %. A person working faster than normal receives a performance rating higher than 100 %, and one who is working at a slower pace than normal would receive a performance rating below 100 %. The performance factor will increase fast (shorter times), and reduce slow (longer) times to the normal time.
(7) Step 7: Specify the allowances
   a. Allowances are adjustments to the normal time to account for nonproductive portions of the workday.
   b. Personal time includes breaks and lunch.
   c. Loss of production due to fatigue.
   d. Delays, usually unavoidable that are not within the control of the operator.

The underlying philosophy of work measurement and setting a productivity standard through measuring the actual work performed should enable the operator to make a target volume of quantity by working at a normal pace. The magnitude of the allowance should be a matter of bilateral agreement between the operators and management. Negotiated allowances are used because only the unavoidable delays are considered to be measurable with standard technology. The unavoidable delays are commonly measured using work sampling techniques. Work sampling defines the activity elements that make up the work, has an analyst observe what tasks are being performed at set intervals, to determine the percent of the day that is spent on the different activities.

There are *critical elements* that must be applied to develop an appropriate labor standard:

(1) The actual work performed should be observed and measured to develop the work standard.
(2) The unavoidable delays should be identified through observation, and an allowance be applied to the performance factor, so as not to penalize the operator for delays beyond his or her control, that are systemic to the work design. Only

through application of process improvement efforts can these unavoidable delays be removed, and therefore enable a tighter standard.
(3) The work standard should be agreed to between management and the operator.

This practice of measuring work has over 130 years of application defining labor standards, and has been widely accepted as a sound methodology.

Healthcare Development of Labor Standards

Healthcare as an industry has adopted vastly different methods to develop labor standards, which will now be described.

Standards Based on Organization Structure, Not Work Performed

Healthcare develops standards typically based on organizational structure and management reporting departments, such as operating room, lab, rehab therapy, endoscopy, critical care floor, emergency department, and so on. While these organization reporting units can represent a group of similar work, the actual work activities can vary widely. For instance, the operating room can include several different work functions, such as:

(1) *Anesthesia activities*. Room prep, patient assessment, administer anesthesia, monitor patient
(2) *Orderly activities*. Retrieving and setting up or equipment; helping to position patients; ordering surgical supplies; stocking surgical supplies, cleaning, and turning over surgical suites after surgery.
(3) *Scrub tech activities*. Open and set up cases, including instruments and supplies; assist in surgery by providing needed supplies and instruments; helping remove used instruments, trays, and supplies
(4) *Circulator nurses*. Interview and assess patient' readiness for surgery; document patient care, treatment and status; transfer patient care to post anesthesia care, record specimens.
(5) *Department managers*. Manage staff; define staffing schedules; problem solve; manage crises; monitor time reporting; apply discipline; manage surgeon, anesthesia, and vendor relations; administer performance evaluations, rewards, and recognition.
(6) *Surgical coordinators*. Manage cases; update preference cards; interface with surgeons.

Similar vast differences exist in the lab related to just one of the departments, pathology:

(1) *Pathologist activities*. Perform gross cut of specimens; documentation; assess pathology of specimens; dictate results and reports.
(2) *Lab technicians*. Enter orders, process specimens, create specimen slides
(3) *Transcriptions*. Transcribe results; correct records; manage pathologists' schedules.

The type of specimens in number, type and how they are billed vary vastly, as do the number of slides that make up a billable order across cytology and histology, sub-specialties within the pathology lab.

One more example is in infusion therapy, a unit of work, giving a shot to a patient can equate to 1 minute of work, versus chemotherapy equating to one and a half hours of work. This is a huge disparity in the time to actually perform the work.

Standard Setting Based on Benchmark Databases Not Based on Actual Work Performed

A common approach in healthcare to developing departmental standards is to first collect actual volume and number of hours worked by pay period (typically 2 weeks), across a year time period. The labor standard is calculated as:

$$\text{Labor standard} = \text{Productive hours worked} \big/ \text{units produced}$$

Finance will review a national productivity benchmark standard database, such as Premier, and assess where this proposed standard fits against the average or best productive organizations. The standard is then moved based upon a targeted productive hours, based on the standard best or better practice range. For instance, if the proposed target based upon the historical worked hours and volume is at the 50th percentile, equating to the average hospital in the database, and the organization wants to set a standard at better practice of the 25th percentile, this equates to only 25 % of the organizations are more productive than this level. The standard is then moved to this more stringent level, without measuring or observing the actual work, or understanding the unavoidable delays that the workers cannot control. Only management can improve processes and reduce systemic unavoidable delays. The workers may assist in improving processes, but management must implement the process improvement program, approve projects and resources, and remove barriers and challenges to successful change. Another fundamental problem with an industry standard database is that many times the work activities and characteristics of the staff, such as skill levels, patient acuity, work design, and unavoidable delays is not an apples to apples comparison between the organization setting the standard and the organizations in the database. It is extremely difficult to assess the critical factors that contribute to worker's efficiency of the organization that are at the 25th best percentile.

An example of an apples to oranges comparison of the actual work from an organization in the database compared to one of the organization's setting a standard was in the transportation department. The Director was being compared to a productivity standard that allowed four full time equivalent (FTE) patient escorts for the entire hospital. When the director inquired to the 25th percentile organization he found that they had only four FTEs in a centralized patient transportation organization, but every department had patient escorts but this work was not included in the standard.

Fixed Departments Expected to Fluctuate with Patient Volume

The volume measure applied is selected based on whether the department's volume fluctuates based on the patient volume or is a fixed department whose work does not change based upon the patient's needs. The better practice organizations do not expect fixed departments to vary their work schedules or paid time off with patient volume when they are not a patient facing department. For example, the process improvement group in our hospital has three FTEs. If one of the Six Sigma analysts do not work, the department is "more" productive, yet we were not actively helping the organization reduce the inefficiencies that would actually make the organization more productive, because we were taking the required paid time off. Additionally, if a patient care department is not meeting their productivity standard, the fixed departments must cover for these departments, that they cannot control the work of, penalizing fixed departments for the nature of their job activities.

Standard is Developed Based on Aggregate Volume, but Work is Managed Daily

The standard is typically based on peak (best) volume across the pay periods for the year, yet the productive worked hours is expected to be managed and controlled on a daily basis. The volume fluctuates daily, and the work hours are expected to align to the fluctuating volume, yet the standard is based on either the average bi-weekly pay period average or a select peak volume activity based on three to four pay periods. Worse yet, there may be no correlation between the standard that was re-aligned to meet the benchmark database 25th percentile range and the daily worked hours and volume.

Summary of the Fatal Flaws of Healthcare Productivity Setting Practices

This section discusses the fatal flaws of healthcare productivity standard setting practices, shown in Fig. 12.1.

- Setting arbitrary standards that the processes are neither designed for or are capable of meeting
  - The industry-wide productivity standard database assumedly includes unavoidable nonproductive time. If an arbitrary "better" 25th percentile target standard is selected, this should include less unavoidable delays or nonproductive time than the standard at the 50th percentile. Arbitrarily moving the standard requires that some work is not performed. This work could be

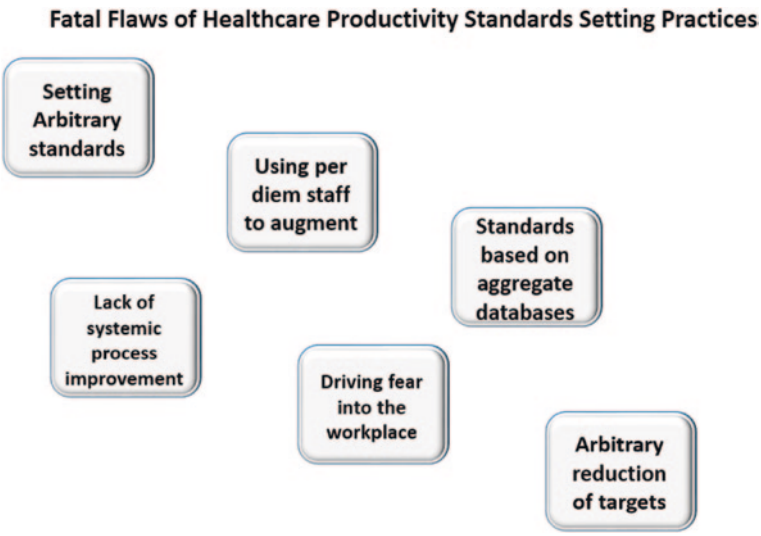

Fig. 12.1 Fatal flaws of healthcare productivity standards setting practices

value-added, such as bathing the patient prior to surgery, or nonvalued-added such as looking for a chart. Who decides what work is not performed? The nurse will probably spend the time to look for that chart because no orders can be entered without it, so does the value-added activity get missed? The root cause for a missing chart needs to be systematically investigated and removed, yet there won't be time for that with unrealistic productivity standards in place. Instead of using the time to improve processes when volume is low, like some world-class organizations do, staff is sent home and flexed off. We need to consciously either improve the work or decide what work is not done if we are going to set standards below what the process is capable of producing.

- Using per-diem staff to augment peak volumes when highly skilled staff is not available, which induces pay check variability for our core staff
  - The assumption of using per-diem or part time staff to augment peak volumes sounds reasonable in a low skill or resource plenty industry, but healthcare is far from this type of environment. Highly skilled clinical areas such as the surgery, emergency services, and critical care are examples of areas where skilled and available per-diem staff virtually do not exist. You are instead incorporating great variability in some of your most skilled and valued associates' pay checks week after week, season after season and year after year. Additionally, hiring per diem staff uses these resources for extended periods without give them needed benefits, and causes increased hiring costs, lack of retention, and the need to constantly recruit and re-hire per diems. This costly cycle will continue.

- Not basing standards on the actual work performed and the existing design and capability of the processes
  - The standards are based on aggregate benchmark databases that are not an apples to apples comparison of the work, and give little insight into the process factors that impact efficiency and productivity.
- Arbitrary reduction of productivity targets
  - Arbitrarily reducing productivity standards based on target benchmarked percentiles, not based on eliminating inefficiencies in the work can lead to inaccurate standards.
- Not incorporating systemic process improvement
  - Not incorporating systemic process improvement to eliminate process inefficiencies and make the work truly more efficient causes workers to select activities to be eliminated that may be necessary to the quality and safety of the patient. Process improvement is the only sustainable way to be more productive and efficient.
- Driving fear into the workplace
  - This type of labor management causes great fear, uncertainty, apathy, and disgruntled employees. Expecting associates to meet productivity standards that are unrealistic, not based upon the actual work and processes, and for unavoidable delays that they cannot control, creates fear, and poor morale.

Recommended Standard Development Methodology

Following is a recommended standard development methodology, shown in Fig. 12.2.

- Base the productivity standards on the actual work across service lines. This includes creating a cross-functional productivity standard based on the functions that do the work across a service line. This will help eliminate cross-purpose goals, such as transportation or housekeeping flexing off to meet productivity standards, when patients are being discharged.
- Create productivity standards based on daily work and patient volume patterns.
- Create standards based on day of week, time of day, seasonality, and other appropriate factors.
- Perform work sampling to identify unavoidable delays.
- Perform process improvement Kaizens to identify and eliminate root causes of unavoidable delays.
- Ensure that the standard includes a performance factor that accounts for unavoidable delays, personal and fatigue time.
- Gain consensus and buy-in to the standard from the workers performing the work.
- Revise productivity standards when the work changes or inefficiencies have been systematically reduced or eliminated.
- Have a standard try out period to pilot and assess the validity and appropriateness of the standard.

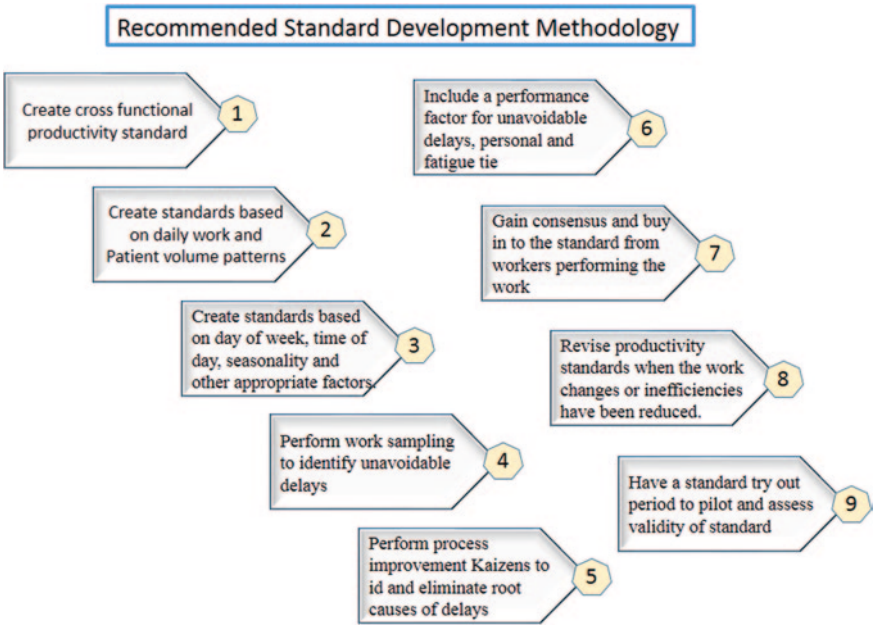

Fig. 12.2 Recommended standard development methodology

If the FTEs must be managed and reduced due to low volumes:

(1) Grow the volume. Hire business development associates to develop business with physicians and surgeons to build volume.
(2) Proactive reduction of services. When the volume is low, we need to proactively determine which services need to be reduced, to avoid burning out our associates and expecting them to meet unrealistic standards.

Conclusions

This chapter presents flaws in current labor standard setting in healthcare and proposes application of best practices for developing labor standards to meet the critical need of managing labor in healthcare where labor costs can exceed 50 % of the costs of doing business.

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Chapter 13
Critical Success Factors of Enterprise Performance Excellence

Abstract There are a wide variety of ways to structure an organization's Enterprise Performance Excellence program. This chapter describes practical guidance based on the literature and the author's experience for designing your Enterprise Performance Excellence program to help enhance the success of the program.

Introduction

A critical success factor with respect to a Six Sigma program or projects is defined as "… the essential ingredients without which a project stands little chance of success" (Coronado and Antony 2002). The author had developed framework components for successful implementation of Six Sigma in service-based organizations (Furterer 2004) including local government that she adapted to the components for a successful enterprise-wide Lean Six Sigma program in healthcare. The key components are shown in Fig. 13.1, and will be described in the next section. The author reviewed the literature for the critical success factors identified in quality management and process improvement programs. These success factors mapped to each key component are shown in Figs. 13.2, 13.3 and 13.4. These critical success factors provide support for the key components of the Enterprise Performance Excellence program.

Key Components

Value and Strategic Alignment

The value proposition is used to "sell" or convince management of the value of implementing a Lean Six Sigma program. There can be many facets related to the Lean Six Sigma value proposition, depending on who is defining the value. The value can be defined from a customer perspective first and foremost. We should

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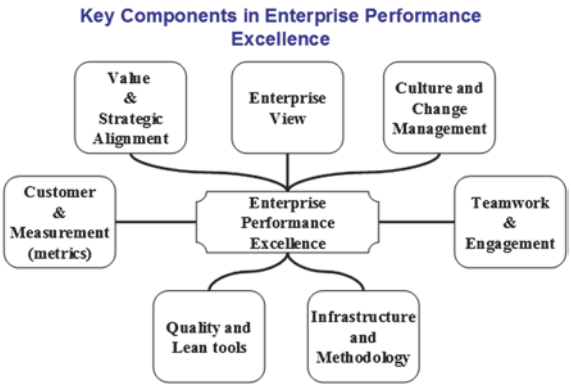

Fig. 13.1 Key components in enterprise performance excellence

Key Component	Critical Success Factor
Value and Strategic Alignment	▪ Basing the Lean Six Sigma project selection on key business priorities; (Furterer, 2008) ▪ Focusing on key business areas; (Furterer, 2008) ▪ Aligning the program with strategic initiatives and prioritize the projects based on business strategy; (Furterer, 2008) ▪ Top management support through leadership. This factor includes management's setting of goals and providing leadership and direction. (Hoffman and Mehra, 1999) ▪ Strategy that is complementary and integrated with existing policies and strategies. (Dale, 1994) ▪ Clear links between strategic goals and the change strategies. (Newman, 1994) ▪ Convince management of the value of Lean Six Sigma to the customer. (Dale, 1994)
Enterprise View	• Systems thinking (Deming, 2000) • Value chain (Porter, 1980)
Culture and Change Management	• Top management commitment. (Sureshchandar, Chandrasekharan, and Anantharaman, 2001) • Clear vision and mission. (Sureshchandar, Chandrasekharan, and Anantharaman, 2001) • Values that support the changing culture. (Newman, 1994) • Change strategy that builds flexibility to respond to customers, and focuses on the technical, political, individual and organizational elements of change. (Newman, 1994) • Social responsibility of the organization. (Sureshchandar, Chandrasekharan, and Anantharaman, 2001)

Fig. 13.2 Critical success factors

focus on understanding the value and requirements from a voice of customer perspective Another perspective can be from the perspective of reducing or avoiding costs as budgets are becoming increasingly stagnant or even decreasing. Yet another perspective could be to focus on the value of applying Design for Six Sigma to innovate the processes.

Lean Six Sigma can provide value by:

(1) Reducing or avoiding costs of providing healthcare services. One example of avoiding costs is the ability to not hire additional staff or resources due to streamlined processes and the release of additional staff capacity.
(2) Helping to better understand and satisfy customers' needs, including both internal and external customers, as well as partners, suppliers, and collaborators.

Key Component	Critical Success Factor
Teamwork and Engagement	• Training and education. (Sureshchandar, Chandrasekharan, and Anantharaman, 2001) • Employee empowerment. (Hoffman and Mehra, 1999) • Employee involvement and participation. (Hoffman and Mehra, 1999) • Recruitment and selection. (Sureshchandar, Chandrasekharan, and Anantharaman, 2001) • Drive fear from the organization and a safe environment without repercussions. (Robertson and Gill, 2000) • Reward and recognition systems that support the culture and program. (Robertson and Gill, 2000) • Encourage innovation. (Robertson and Gill, 2000) • Upward mobility and well-defined career path. (Poister and Harris, 2000) • Teamwork (Robertson and Gill, 2000)
Infrastructure and Methodology	• Visionary leadership. (Sureshchandar, Chandrasekharan, and Anantharaman, 2001) • Project management with projects focused on critical to quality characteristics and financial benefits. • Dedicated resources with Black belt structure. • Action plan and awareness. • Top management support through financials, personnel, greater organizational autonomy and effective oversight. (Poister and Harris (2000)) • Design of services. • Management of key business processes. • Highly disciplined problem-solving approach. • Program methodology. • Continuous process improvement • Communication throughout the program. • Benchmarking of processes, products, financials, customer satisfaction, and employee satisfaction. (Sureshchandar, Chandrasekharan, and Anantharaman, 2001) • Incorporate suppliers into the value chain.

Fig. 13.3 Critical success factors (continued)

Key Component	Critical Success Factor
Quality & Lean Tools	• Quality tools • Lean tools
Customer and Measurement	• Outcome-based, results oriented performance measurement system. (Hoffman and Mehra, 1999) • Measurement and feedback. (Dale, 1994) • Measure customer satisfaction. (Dale, 1994) • Link projects to financial benefits and business strategy. (Dale, 1994) • Customer focused on defining needs and requirements. (Poister and Harris, 2000) • Customer-satisfaction as the main goal. (Robertson and Gill, 2000)

Fig. 13.4 Critical success factors (continued)

(3) Improving processes to innovate processes, eliminate waste, improve quality and productivity, and reduce variation.

Symptoms of environments where extensive waste and nonvalue-added activities exist can be used to convince management that improvement is needed. Some of the symptoms that are common are:

- My employees complain that they need more staff or that morale is bad.
- Customers (internal and external) complain that communication is poor, there are many errors or rework, or there are long wait times.
- Expediting and fixing problems is rampant or the norm.

- You trust the system and processes, only if someone is there to guide the customer through the process (patient advocate).
- Audits (financial, etc.) show noncompliance.

The following function is a relational qualitative function, not a strict mathematical function, but can be used to represent the Lean Six Sigma overall value proposition:

Lean Six Sigma Value Proposition = Quality of Service Delivery × Trust × Financials

where:

- *Quality of Service Delivery* is measured by defects in the service delivery process; the ability to meet customers' expectations; the ability to be responsive to customer's service delivery needs, which incorporates process measures related to productivity and cycle time; and variability of processes which can lead to errors and responsiveness issues related to service delivery.
- *Trust* is measured by the relationships built between internal and external customers, suppliers, partners, and collaborators and can be evaluated through customer and stakeholder surveys.
- *Financials* includes the costs and revenues of providing services and can be measured by the reduction in costs related to the Lean Six Sigma program, and by the revenues that can be attained by providing excellent services.

A critical component of a Lean Six Sigma program and the DMAIC problem solving approach encourages defining performance measures that can be used to assess the Lean Six Sigma Value Proposition, which will be discussed in the measurement component.

The second element of this component is to provide value by aligning to the strategic objectives and goals of the organization. Use of the Balanced Scorecard (Norton and Kaplan 1996) can provide a balanced performance measurement system, by measuring not only the financials, but the internal processes, the workforce, and the customer and growth opportunities. The Malcolm Baldrige National Quality Award Healthcare Criteria encourage tracking results in the following categories: Healthcare and Process Outcomes; Customer-Focused Outcomes; Workforce-Focused Outcomes; Leadership and Governance Outcomes; and Financial and Market Outcomes. The Key Performance Indicators can be identified for each result area, which can then enable identifying the strategic Process Improvement (PI) projects and priorities. Another great way to develop your enterprise-wide PI projects and priorities is to extract the Critical to Satisfaction (CTS) criteria from the patient satisfaction survey data. Many hospitals use nationally compared patient satisfaction benchmark data to assess where their hospital stands with regard to patient satisfaction and can even use correlation analysis to identify the CTS'. The correlations are derived for the customer survey questions that most highly correlate to the "would recommend your hospital" question. If noise or nurse communication is highly correlated to the "would recommend your hospital" ratings, then this provides a key focus to the Critical to Satisfaction and the Voice of the Customer.

Customer Focus

Defining the customer of the processes and services in a healthcare organization can be quite complex. There are potentially many customers of a healthcare organization including: (1) the patient (2) internal employees or associates (3) physician partners (4) suppliers and vendors. Whether these people are defined as customers or stakeholders is dependent upon how the scope of the Lean Six Sigma project is defined and which processes are part of the improvement effort. It is important that the project team comes to agreement as to who the customer is, for the different projects and components of the processes. It is important to engage the different customer and stakeholder groups to understand their "voice" and their requirements with respect to the services that they receive that are provided by the processes that need to be improved. Again, the patient satisfaction, associate, and physician surveys can be valuable tools in capturing the voice of the customer. Some hospitals are creating patient advisory boards that are used as an on-going tool to derive the customers' requirements. Customer grievance and complaint data are also tools to capture what needs to be improved. It is important to collect the complaints in a way (database) that we can trend, identify improvement areas, and assess that improvement has taken place.

Culture and Change Management

This framework component incorporates the cultural and change management aspects of the organization related to the Enterprise Performance Excellence Program. It includes developing a change strategy that addresses how to change the culture to focus on continuous improvement and measurement, focusing on the customer, the technical, political individual, and organizational elements of change. Mapping the political terrain (Bolman and Deal 1997) can help to identify the stakeholders and their acceptance or resistance to change. A communication plan and strategy can be developed to address how to help the stakeholders become less resistant to change. The inherent structure of the DMAIC problem solving approach, and the focus on data and measurement, helps with the culture and change management component. The project management components of Lean Six Sigma and clearly defining the mission, vision, and goals of the Lean Six Sigma projects also helps with changing the culture to embrace quality, productivity, and continuous improvement.

Also important to help change the culture is to thoroughly and continuously communicate the status of the Lean Six Sigma effort and projects. This communication can include formal project kick-off meetings where the mission, vision, and goals of the Lean Six Sigma program and projects are discussed. At the beginning of the program and projects, it is critical to identify and communicate the mission, vision, values, goals, roles, and responsibilities of the projects and project teams. Throughout the projects, it is important to provide continuous status of the

projects through periodic status meetings and reports so that the organization is aware of the successes and learnings from the projects.

It is also important to show that the senior management team is committed to leading and owning the Lean Six Sigma effort. The CEO, senior management team, and the project champions should show their constant and continued commitment and support to the Lean Six Sigma effort. The project champions should be trained with an understanding of the Lean Six Sigma methodology and tools, and should spearhead the project effort and remove obstacles and barriers to successful implementation. Project champions should be at a Director level or above, be well respected in the organization, and be willing to advocate for change.

We used the Dr. John Kotter change model (Kotter 2011) to implement improvements and manage change within our Enterprise Performance Excellence program.

(1) Acting with Urgency:
   a. Gaining top management support and visibly communicating this support for the projects, emphasizing the importance of the project to the organization.
(2) Develop the Guiding Coalition:
   a. Form the project team and properly scope the projects. Throughout the project we engage appropriate subject matter experts who help to develop the new process and generate improvement ideas.
(3) Developing a Change Vision:
   a. Develop the new processes, creating innovative ways to transfer this knowledge (social media, intranet, videos, on-line training, etc.).
   b. Develop the implementation plan including a detailed work plan to stage the improvements.

(4) Communicate the Vision Buy-in
   a. Develop and deploy a communication plan to communicate the changes and status of the improvement efforts.
   b. Management must model the behavior of the new process, assess understanding and compliance to the new process.

(5) Empowering Broad-Based Action:
   a. Identify and remove obstacles to change. Implement suggestion systems to get ideas from any and all of the staff.
   b. Incorporate accountability to adhere to the new processes.

(6) Generating Short-Term Wins:
   a. Implement a reward system to encourage change and improvement.
   b. Communicate the wins and significant improvement to all staff and hospital administration.
   c. Celebrate success and share best practices and lessons learned.

(7) Do not Let Up:
   a. Incorporate the new metrics dashboards into the daily metrics monitoring and control.
   b. Incorporate the process competencies into the performance evaluation system

(8) Make Change Stick:

a. Provide change management and Lean Six Sigma training to staff and management to ensure the succession of the change in thinking to a fact-based decision process and one of continuous improvement.

Teamwork and Engagement

Most of the quality and process improvement programs, such as Total Quality Management (TQM), Business Process Reengineering (BPR), Six Sigma, Lean, and Lean Six Sigma incorporate elements to address managing the people in the organization. They advocate empowering employees to make and be accountable for decisions about their processes. They include training, education, and providing the right skills for people to do their jobs. The Lean Six Sigma program is based upon a team structure where team members solve problems together. This component also includes rewarding and recognizing employees for their involvement on project teams, their teamwork and efforts, and their successful implementation of process and financial improvements, and meeting the goals and objectives of the project. In a healthcare organization, it is important to engage the physicians to be advocates for change and improvement. Many physicians are partners, but not employees of the hospital, so clearly defining how they are to be engaged in the improvement program and projects is important. Since their involvement is vital to the organization's ability to implement process change and innovate new processes, this should be well planned and well managed. Appropriate resources should be engaged and committed to the problem solving teams, where it is part of their regular duties and activities to improve the processes, not based on a voluntary after thought, or "if they get the time" to improve processes. Successful organizations do not send their clinical or nonclinical staff home when the patient census is low, they engage them in problem solving teams, projects, and activities.

Infrastructure and Methodology

The infrastructure and methodology component provides the structure to support the Lean Six Sigma effort. It includes defining a methodology of how to perform the problem solving and improvement effort (DMAIC). It includes having visionary and committed leadership as a critical element of success. It includes incorporating a project management structure to ensure that the projects are successful and continually move toward a successful implementation. This component also includes developing a communication plan to communicate the mission, goals, objectives, and progress of the Lean Six Sigma program and projects. A common complaint of organizations new to Six Sigma is that it takes too long. This can be true when the following mistakes are made:

- Lean Six Sigma team members are not properly trained to understand when to stop collecting and analyzing data. They must define and understand the Critical to Satisfaction Criteria, measure the CTS, identify the root causes, and implement improvements to improve the CTS. The CTS are the common thread that help you to understand when to stop, when you have collected enough data, and when you have improved.
- Defining targets for your metrics is important so that you know if you have improved enough, and to assess when you can turn your efforts to other projects.
- When resources are not committed to work on the projects.
- When project champions are not assigned who remove barriers, encourage the teams, and hold the teams accountable to complete their projects within the planned milestones.
- When teams do not create project plans, estimate phase milestones, and are not held accountable to complete their projects.

Selecting the appropriate problem solving methodology is also important. Not every project needs extensive statistical analysis. We can apply four different problem solving approaches:

(1) The typical DMAIC Six Sigma problem solving methodology, for strategically important, unstructured, complex, and cross-functional problems, that should take from 4 to 6 months to complete.
(2) Rapid Process Improvement projects that are shorter in duration, usually within one department, are not as complex, and can be completed in 2 to 3 months.
(3) Kaizen Events is another approach that are small focused improvement efforts, where little data collection is needed, or it has already been done within a larger Six Sigma project, where 2 to 4 weeks can be spent designing and piloting a new or improved process.
(4) Design for Six Sigma which can be used to design and innovate new processes for new services.

The infrastructure component also includes how to organize the Enterprise Performance Excellence program, and define the reporting structure. We will describe the infrastructure that is used at an acute care hospital for their Enterprise Performance Excellence program.

EPE Mission:

To provide guidance, direction, mentoring, training, and improvement services to the hospital, to enable Enterprise Performance Excellence in all operations and processes.

The EPE Center provides the following services.

EPE Center Services:

- Enterprise Performance Excellence program *methodology* and *structure* to enable performance improvement.
- *Guidance* and *mentoring* to EPE teams, Black Belts, Green Belts, White Belts, Champions, and Executive Steering Committee.

- *Training* and *Education* as appropriate to further the EPE program methodologies and tools.
- Performance improvement *consulting* expertise and *services.*

The Enterprise Performance Excellence Center Director reports directly to the CEO. The Executive Team prioritizes projects, and provides guidance for the EPE projects, who should be trained, and are trained as, and act as project champions. They provide the typical Executive Steering Committee function of an enterprise-wide process improvement program. The EPE Center's Director is a Master Black Belt and Industrial Engineer, develops and deploys the governance infrastructure, facilitates complex, enterprise-wide improvement and innovation projects, and mentors and trains Green and Black Belts. Two Black Belts that are also Industrial Engineers are part of the EPE Center. They facilitate projects, engage in internal consulting activities on EPE projects, mentor Green Belt and Black Belt candidates, and train Green and Black Belts.

There are currently 20 Lean Six Sigma certified associates (1 Master Black Belt, 3 Black Belts, and 16 Green Belts). We have trained 43 Green Belt candidates, where some of the projects are still in progress. We plan to train another 30 Green Belt candidates and 15 Black Belt candidates in 2011. Our goal is to train all of the Directors by 2012. We will have the majority (over 90 %) of the Directors trained at the Lean Six Sigma Green Belt level by the end of 2011. Most of the Green Belts and Black Belts are full time associates that work on improvement projects in addition to their full time duties. The Enterprise Performance Excellence Governance Structure is shown in Fig. 13.5. The EPE Center reports

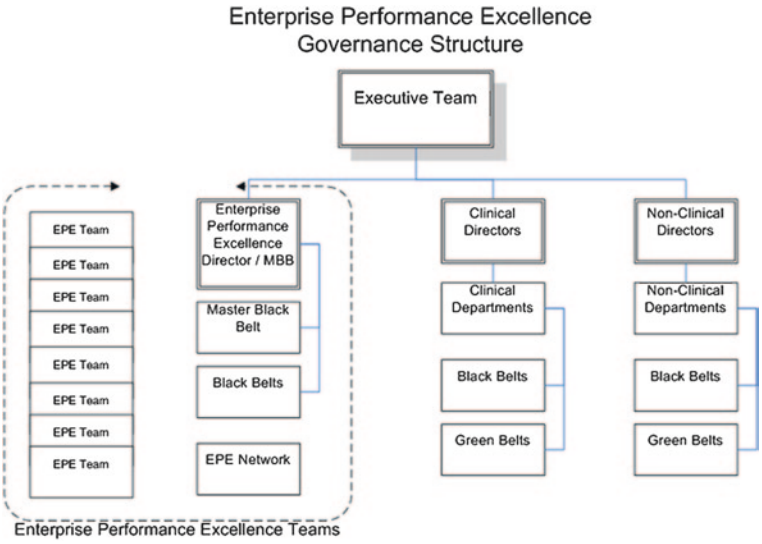

Fig. 13.5 Enterprise performance excellence governance structure

directly to the CEO. The EPE teams are formed and worked on projects based on the strategic goals and objectives of the organization. The EPE Center Master Black Belt and Black Belts mentor the Green Belt and Black Belt candidates. The Green Belt and Black Belts who have gone through the training work on additional improvement projects within their departments and some work on the enterprise-wide improvement efforts. We also have an EPE Network that consists of anyone who is trained in Lean Six Sigma.

The Lean Six Sigma Network Mission is to:

- Provide and share best practice processes.
- Provide and share Lean Six Sigma best practices, projects, etc.
- Mentor Green and Black Belts through their projects.
- Help on projects, data analysis, tools training, etc.
- Supports teams and the program.
- Advocates for Enterprise Lean Six Sigma.
- Meets with teams to remove roadblocks.

Quality and Lean Tools

Quality and Lean Tools are valuable techniques to solve problems and improve the quality and productivity of the processes. Figure 13.6 shows a mapping of the DMAIC phases to the most common tools that can be applied in a healthcare

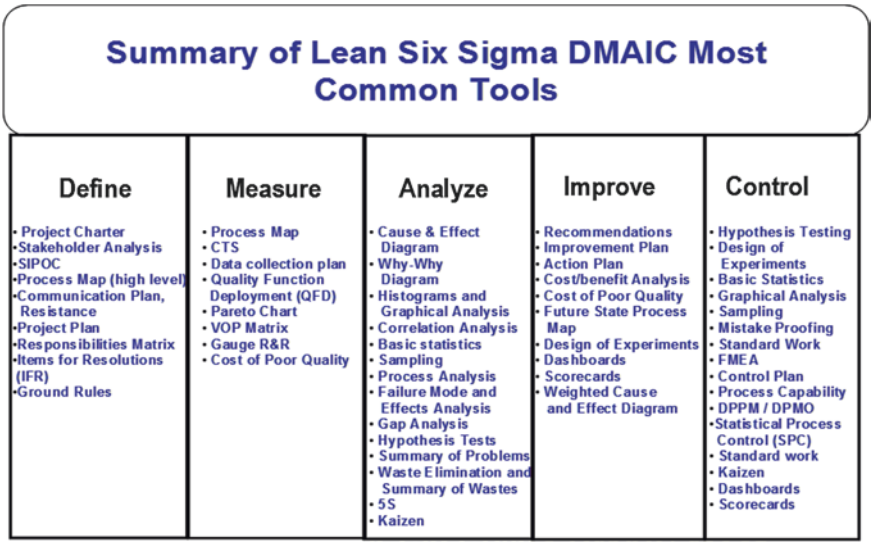

Fig. 13.6 Summary of Lean Six Sigma DMAIC most common tools

setting. Many of the tools are similar to other service environments, but somewhat different from a manufacturing setting, especially in the Lean area. The major Lean tools applicable in a healthcare setting are the Lean Wastes, the 5S, Why–Why Diagrams, standard work, Kaizen, and visual control. Many of the commonly used Six Sigma tools in a healthcare setting are: process mapping, cause and effect analysis, stakeholder analysis, project charters/project management, SIPOC, statistical analysis, Quality Function Deployment, dashboards and scorecards, mistake proofing, Failure Mode and Effects Analysis, improvement plans, and control plans.

Measurement (Metrics)

The measurement component includes defining and applying performance measurements and metrics that can be used to measure improvements in quality, productivity, variability, service delivery, and financials. The performance measurements should be defined within the problem solving methodology at a process level. The metrics measure the Critical to Satisfaction characteristics to show improvement and ensure that we are meeting the customers' requirements.

The Executive Steering Committee should review the status of the projects and meet with the project leaders on a monthly or bi-weekly basis, using a dashboard that assesses the following status levels:

Green. The project is progressing well, and meeting the estimated DMAIC phase milestones.
Yellow. The project is in jeopardy of missing an estimated DMAIC phase milestone, or there are significant barriers that are impeding progress
Red. The project has missed a DMAIC phase milestone.

Last, but of course not least, the teams and the organization should take the time to celebrate their success in improving processes and making change happen. Change is not easy, so we should also pause, be thankful, and celebrate with our team members. It is important to also track, measure, and monitor the status of the Six Sigma projects to ensure that they are completed.

Conclusions

We started this chapter with the caveat that there are many ways to set up an Enterprise Performance Excellence program with the goal of this chapter to provide some sound ideas for either setting up or enhancing your program.

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Chapter 14
The Future and Challenge of Lean Six Sigma in Healthcare

Abstract This book provides an overview of Lean Six Sigma and the Define-Measure-Analyze-Improve-Control (DMAIC) methodology, and real-world healthcare case studies applying these methods and tools. This chapter describes a view into the future with the attempt at projecting where Lean Six Sigma for healthcare will evolve over the next decade.

The Future and Challenge of Lean Six Sigma in Healthcare

One of the exciting elements of the Lean Six Sigma evolution, has been how many somewhat diverse and at first glance, disparate methods and tools have come together to provide a more holistic and integrated toolkit for solving extremely complex problems.

The world is getting more complex each day. The problems are getting bigger and more complex, so the tools to solve these problems need to evolve as well.

We can go back to the Evolution of Quality graphic, in Fig. 2.1 of Chap. 2, adding the information stream and the business process management elements to set the stage for our discussion on the future evolution of Lean Six Sigma, shown in Fig. 14.1. The economy in the United States of America and in many other countries in the world is becoming an information, service, and knowledge age. Our economy has evolved from tangible, craft, agricultural, manufacturing economies, to an intangible information, service, and knowledge-based one. We discussed the progression from Statistical Process Control, which provided control of discrete manufacturing processes, broadening to Business Process Reengineering (BPR), and Total Quality Management (TQM). BPR and TQM incorporated a broader view of the quality management principles and philosophies that needed to be in place to effect change within the cultures that were applying these methods. Six Sigma brought a more structured problem solving approach, the mentoring and training focus of the belt structure, and a broader toolkit of tools. The Lean side

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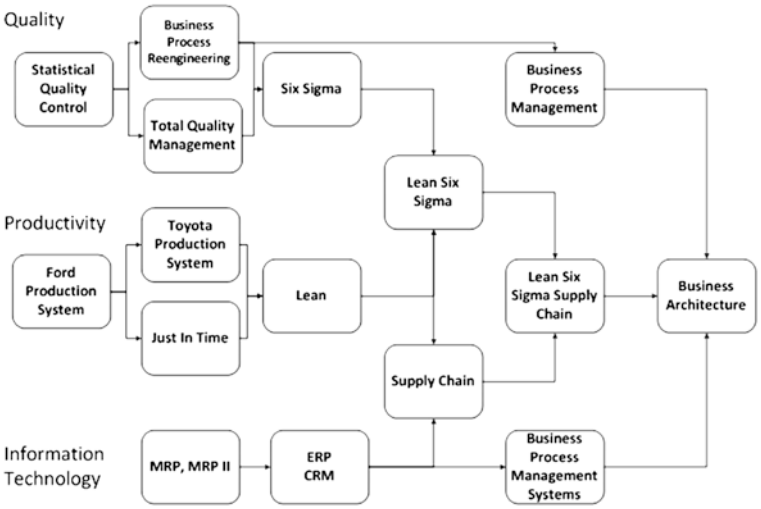

Fig. 14.1 Evolution of quality

evolved from the Ford Production System hat provided an assembly process to manufacture and assemble discrete products. Lean and Just-in-Time broadened the spectrum to include more of the supply chain elements. At this same time, information technology was advancing from non-integrated Material Requirements Planning (MRP) and Material Resource Planning (MRP) II applications focusing on managing the shop floor and purchasing processes to integrated Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) information systems that evolved into managing the entire supply chain. The supply chain focus provides an end-to-end view from sourcing of suppliers through the logistics and distribution networks, to the enterprise and back to the distribution channels to get products to the market. The three streams of quality, productivity, and information technology have integrated over the last few years into Lean Six Sigma Supply Chain, with many variations on the combinations of the names. The other elements that are evolving to enhance quality in organizations is Business Process Management and Business Process Management Systems which provide an holistic approach to managing, documenting, improving, and controlling our processes to enhance operational excellence. Business Architecture, as discussed in Chap. 1 can help us to solidify and organize business process management.

For the future, the author sees this integration evolution approach continuing to more tightly couple and integrate the entire enterprise and supply chain, and the philosophies and tools within Lean, Six Sigma, Business Process Management, and the Supply Chain areas. As we look at the underlying elements of the three major methodologies, there are many challenges in healthcare that can be addressed by integrating Lean, Six Sigma, Business Process Management, and Supply Chain. We will address the following challenges and how Lean Six

Sigma and an Enterprise Performance Excellence view can help address these challenges:

- Information Technology that Enables Processes, Services, and Measurement
- New and Varied Problem Solving Approaches
- Process Innovation With Design for Six Sigma and TRIZ http://www.triz-journal.com/archives/what_is_triz/, 2013.
- Customer-focus and engagement–Voice of the Customer and Quality Function Deployment
- Teamwork and Engagement
- Quality Management System, incorporating Business Process Management

Information Technology that Enables Processes, Services, and Measurement

Enterprise Resource Planning (ERP) applications started in the manufacturing industry, and have evolved to where they are very integrated, extremely customizable from a process perspective, and enable the business to leverage processes and information to meet customers' requirements. Healthcare has not been so lucky. Compared to ERP in manufacturing, "enterprise" systems in healthcare are far from meeting the needs of an enterprise in an integrated fashion. Electronic medical information systems may not be integrated with Supply Chain Management applications from a supply inventory control, charging, and billing perspective. The Materials Management side of Supply Chain Management may not be integrated with the Inventory Control or Point of Use functionality. The Emergency Department Bed Board System may not be integrated with the Hospital Bed Board System. The transportation system may not be integrated with the Hospital Bed Board or the room cleaning application. The Cardiovascular Lab system may not "talk" to the Operating Room System. There may be an Outpatient Scheduling System, but no similar Inpatient Scheduling System. The patient may be able to schedule their labs or outpatient diagnostic test and procedures, but if you become an inpatient, you have no such luxury of knowing when your inpatient procedures and tests are scheduled.

The need for integrated process and technology is not abating. There is the need for:

- Integrated Enterprise-Wide Information Systems
- Electronic Medical Record
- Business Process Management Systems
- User Friendly systems with streamlined processes

How can Lean Six Sigma help? The approach discussed in this book in Chap. 1 to build the Strategic Business Process Architecture models can enable Lean Six Sigma by methodically documenting, analyzing, and prioritizing processes and process improvement efforts. Lean Six Sigma must be elevated to the enterprise-wide process view aligned to the organization's strategic goals and objectives. Metrics must continue to evolve to align to business drivers and focus on reducing

the cost of doing business, enable improving revenues by tapping new markets, and ensuring customer satisfaction through measurement and improvement. Data and information must support the business, not exist for its own goals. The place for technology must be identified based on the business strategies and the processes that they must support. Leadership will play an even more critical part, and be necessary throughout the organization, not just at the top, but in the middle and at the grassroots of our organizations. Enterprise Business Architecture is an emerging framework that fundamentally begins with the needs of the customers and the business to align the strategies, organizations, information, global locations, processes, and timing of all of these elements to enable rapid and controlled change.

New and Varied Problem Solving Approaches

With the integration of Lean, Six Sigma, Systems Engineering, and Supply Chain methodologies new and varied problem solving approaches are warranted. There is no longer one size fits all methodology that can solve the ever-increasing complex problems that are evolving in today's healthcare environment. We recommend incorporating the flexibility to apply various problem solving methodologies that can support varying levels of complexity of variables and processes, need for cross-functional integration, and the need for different levels and types of analytical tools.

Different levels could include:

- The typical DMAIC Six Sigma problem solving methodology, for strategically important, unstructured, complex, and cross-functional problems, that should take from 4 to 6 months to complete.
- Rapid Process Improvement projects that are shorter in duration, usually within one department, are not as complex, and can be completed in two to three months.
- Kaizen Events are another approach which are small focused improvement efforts, where little data collection is needed, or it has already been done within a larger Six Sigma project, where the 2 to 4 weeks can be spent designing and piloting a new or improved process.
- Lean projects focusing on 5S, Lean Wastes, and other Lean tools.
- Design for Six Sigma which can be used to design and innovate new processes for new services.

Process Improvement in healthcare should continue to focus on mistake proofing, identifying, and preventing potential failure modes before they occur, and performing quick and effective root cause analysis when errors do occur.

Process Innovation Through Design for Six Sigma and TRIZ

Our organizations, processes, and information systems must be designed in the most agile ways to support innovation and speed to market. Functional silos must be eliminated to provide a cross-functional view of the businesses that we

support. Design for Six Sigma and Theory of Inventive Problem Solving (TRIZ) can be used to design innovative processes that better integrate patient care across the healthcare continuum (TRIZ Journal). We need to better integrate patient and healthcare information across provider networks, while protecting patient data. We need to balance an innovation focus while still ensuring compliance with accreditation, regulatory, and ethical challenges.

Customer-Focus and Engagement: Voice of the Customer and Quality Function Deployment

The focus on the customer, not just competitors will need to grow each day where we more fully engage and align with our customers' needs. Customization must become a way of life, where we can reach out to each customer to understand their needs and customize our offerings to meet each of their needs in a reachable and cost effective manner. Quality Function Deployment can be used to align the customer requirements to the process requirements. We should leverage Customer Relationship Management (CRM) systems to collect, track, and trend customer requirements and satisfaction data.

Teamwork and Engagement

Ultimately, we cannot do any of the above without first considering the needs of our people, empowering them, enabling them with the training, skills, and tools to effectively do their jobs. We need to engage the entire supply chain, our physician partners, suppliers, vendors, as well as our associates to innovate, solve problems, and streamline the delivery of our processes and services.

Quality Management System Incorporating Business Process Management

To further integrate and manage our enterprise we need to design or enhance our quality management systems to include the following elements:

- Leadership
- Strategic Planning
- Customer Focus
- Workforce Management
- Process Management
- Performance Measurement, Information, and Knowledge Management

Conclusions

Lean Six Sigma and the Enterprise Performance Excellence methodologies and tools can leverage our ability to manage our enterprises.

We challenge the reader and student of Lean Six Sigma to understand the underlying principles embedded in Lean Six Sigma to be part of the revolution of the tools and philosophies that will continue the evolution of these amazing bodies of knowledge. The best of luck in your Lean Six Sigma and Enterprise Performance Excellence endeavors.

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Dr. Furterer received her Ph.D. in Industrial Engineering with a specialization in Quality Engineering from the University of Central Florida in 2004. Dr. Furterer developed a state-of-the art framework and roadmap for integrating Lean and Six Sigma for service industries and implemented the framework in a local government's financial services department. She received an MBA from Xavier University, and a Bachelor and Master of Science in Industrial and Systems Engineering from The Ohio State University.

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non-profit organizations streamline their processes and implement information systems.

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