A Thesis

Entitled

Systems Process Engineering for Renal Transplants at The University of Toledo Medical Center Utilizing the Six Sigma Approach

By

Kyle W. Bedal

Submitted as partial fulfillment of the requirements for

The Master of Science in Industrial Engineering

________________________________________________________

Advisor: Dr. Steven Kramer

________________________________________________________

College of Graduate Studies

The University of Toledo

December 2008
I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Kyle W. Bedal

Entitled Systems Process Engineering for Renal Transplants at The University of Toledo Medical Center Utilizing the Six Sigma Approach

BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science in Industrial Engineering

Thesis Advisor: Dr. Steven Kramer

Thesis Co-advisor: Dr. Matthew Franchetti

Recommendation concurred by Committee

Dr. Abdollah Afjeh

On Final Examination

Dean, College of Engineering
An Abstract of

Systems Process Engineering for Renal Transplants at The University of Toledo Medical Center Utilizing the Six Sigma Approach

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Six Sigma is a comprehensive and flexible system for achieving, sustaining and maximizing business success. It strives to improve quality, productivity, and bottom line success using statistical tools. Six Sigma’s methodology consists of five phases: Define, Measure, Analyze, Improve, and Control (DMAIC). In manufacturing, Six Sigma has been used extensively with great success. The application of Six Sigma to the healthcare field is in its early stages and, hence, has not been fully explored. This research investigated the use of Six Sigma with the goal of improving the renal implant process and demonstrating the positive impact of Six Sigma on the healthcare industry. The objective of the research was to improve the process for renal transplants at The University of Toledo Medical Center utilizing Six Sigma. This included aligning and optimizing processes and the removal of process-generated defects and errors.
Improvements will primarily focus on: optimizing cycle times, enhancing customer satisfaction, improving efficiencies, reducing costs, streamlining administrative processes, elimination of errors, and improving protocol execution and effectiveness.

This research identified ten improvements which could be applied to the renal transplant process. Implementing improvements could reduce the total process time by 45 days (20%) from 227 days to 182 days, and could also improve productivity, communication, and customer satisfaction.
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Chapter 1
Introduction

1.1 Six Sigma

Six Sigma is a comprehensive and flexible system for achieving, sustaining and maximizing business success. It is uniquely driven by a close understanding of customer needs; disciplined use of facts, data, and statistical analysis; and diligent attention to managing, improving, and reinventing business processes (8). Six Sigma strives to improve quality, productivity, and bottom line success. It can be related to lean manufacturing in that the goal is to decrease non-value added time and drive up profits and customer satisfaction; however, it also provides a methodology to implement these successes. Six Sigma also relies heavily on data, facts, and the use of statistical tools to find out if improvement has been made. These statistical tools are powerful to not only conduct experiments and compare data, but to provide important information about a process to find the causes of problems in order to draw conclusions to solve the problems. Six Sigma is not just a shift in statistical means, it is a new paradigm of customer satisfaction based on a statistically based measurement scale, and is also a methodology by which quality can be improved (13).

1.2 Need for Research

Medical errors became a national issue in 1999, when the Institute of Medicine issued a highly published report stating that “in the United States medical errors contributed to
more than 1 million injuries and 98,000 deaths”. Medical errors cost more than $65,000 per incident, so it is critical to reduce errors from a financial standpoint as well (4).

Improving healthcare quality and reducing costs are important, but a better reason for improving healthcare is to save lives. Six Sigma has had success in manufacturing (discussed in Chapter 2) and the same methodology can be applied to healthcare. Introducing Six Sigma as a business model into the healthcare industry can reduce mistakes and save lives.

A defect is a lack of something in regards to completeness or is an imperfection. Currently, most non-production processes fail to meet three sigma level, which is about 2,700 defects per million opportunities. The goal of Six Sigma is to reduce errors to 3.4 defects per million opportunities (4). Essentially, when measuring errors in terms of lives, a goal of zero errors is ideal. Realistically, Six Sigma or any system of improvement will never actually prevent all medical error deaths. Even increasing from three sigma to four sigma would be an improvement in healthcare.

1.3 Research Objective

Six Sigma has not been used in healthcare to the extent it has been in manufacturing. The objective of this research is to investigate the application and benefits of Six Sigma in the healthcare industry. Specifically, the objective of the project is to improve the process for renal transplants at the University of Toledo Medical Center utilizing Six Sigma. The project will target pre-operational processes. This includes aligning and optimizing
processes, and the removal of process generated defects and errors. These improvements primarily focus on:

- Optimizing cycle times
- Enhancing customer satisfaction
- Improving efficiency
- Reducing costs
- Streamlining administrative processes
- Elimination of errors
- Improving protocol execution and effectiveness

1.4 Results Expected

The results expected from this research are that Six Sigma will increase the productivity of the transplant team, improve the process, reduce costs, and increase customer satisfaction. As the renal transplant center continues to grow, the transplant team will need to become more productive and efficient. After applying the methodology, the process will have standards, whereby the redundancies and bottlenecks will be identified and eliminated. Also, the transplant team expects to make the process more efficient and patient friendly in order to enhance customer satisfaction. Implementing Six Sigma will ultimately help to reduce the time it takes to be listed for a kidney transplant.
2.1 Six Sigma History

Six Sigma was first introduced and implemented in the 1980’s by Motorola as a means to compete with Japanese competitors. The president of Motorola directed that all processes should have a ten-fold improvement within a five-year period. Motorola was “in a world of hurt” and had no quality program (8). This call for such radical change created a quality program that is now known as “Six Sigma”. It was originally intended for manufacturing but its methodology was applied to all areas of the company. Motorola formed a research center and created reference books known as the “Encyclopedia of Six Sigma” which contains three main parts (4):

- A collection of statistical tools
- Application case studies
- Descriptive, specific optimization methods.

Motorola also established a recognition system for individuals who progress through various levels designated as:

- **Green belts**: Individuals who have completed the training.
- **Black Belts**: Individuals highly competent to serve as the on-site consultants for applications of Six Sigma methodologies.
• **Master Black Belts:** Individuals who have mastered the Six Sigma process and are capable of teaching the process to others (4).

In statistics the probability distribution curve is known as the normal distribution (bell curve). Standard deviation is the measure of dispersion of a sample and is signified by Sigma. One sigma is 68% of samples are acceptable, where two sigma is 95% of samples are acceptable. Six Sigma is 99.9% of samples are acceptable. To show the effect of Six Sigma a sigma level of 3 is approximately 1.94 hours of power outage per month, whereas a sigma level of 6 is approximately 0.005 seconds of power outage per month (4). This shows the importance of companies striving to improve to six sigma.

### 2.2 Success Examples

Six Sigma success stories in manufacturing include General Electric when Jack Welch launched the Six Sigma program with 200 projects 1995. The program expanded to 6,000 projects in 1997 and savings were estimated to be about $320 million (4).

Systrand Manufacturing Corporation has implemented a Six Sigma initiative which led to a root cause of inefficient equipment. An amount of $500,000 was invested in new state-of-the-art equipment and scrap rates were reduced from 14% to 1% (11).

The United States Postal Service used Six Sigma to enhance customer service by improving on-time delivery at the Columbus Air Mail Processing Center (AMC). Before Six Sigma implementation 8.7% of all letters in the Columbus AMC were not delivered
on-time based on an organizational goal of 90%. After implementing Six Sigma and its methodology, on-time delivery increased 95.6% creating an improvement of 14.3%. This project resulted in 715,000 additional on-time letters and an annual cost savings of $15,000. Tools used in the analysis were Pareto chart, Chi squared tests, vital X analyses and control charts which can play important roles in Six Sigma (2).

Six Sigma is currently being applied in the healthcare industry. One example of this is a case study at a Florida hospital to reduce the Central Venous Catheters (CVC) related bloodstream infections. CVC’s provide critically ill patients with necessary fluids, medication, nutrition, and monitoring. The use of CVCs, however, presents a risk of bloodstream infection (BSI) with treatments ranging from $34,508 to $56,000. With the implementation of Six Sigma, the team was able to reduce the BSI by 20% (4).

Qualtec, a company which identified these problems as to why companies suffer (12):

- There is not enough time to solve all the problems
- Solutions are incomplete
- Problems recur and cascade
- Urgency supersedes importance
- Many problems become crises

There are three ways to overcome these issues: tactical, strategic and cultural (12). Six Sigma uses all three of these methods to help avoid crises points of “firefighting” problems. An example of a tactical method is creating a team to solve a problem. A
strategic method is training employees to use statistical methods. The cultural method comes with the drive of Six Sigma and assign everyone ownership in the improvements.
Chapter 3
Methodology

3.1 Overview

The following chapter discusses the methodology and fundamentals of Six Sigma. Six Sigma methodologies are broken into six fundamentals (4):

- Define products or services
- Know customers and their critical needs
- Identify critical needs to meet customers’ critical needs
- Establish a process of doing work consistently
- Error-proof the process to eliminate waste
- Measure and analyze performance

To achieve these six fundamental goals Six Sigma has five main phases (4):

- Define
- Measure
- Analyze
- Improve
- Control

Six Sigma has three overall targeted solutions: process improvement, process design and redesign, and process management. Process improvement refers to a strategy of fixing a
problem while leaving the basic structure of the process intact. Process design and redesign is a strategy used not to fix a process, but to replace the process to fix the problem. “Process management” refers to the integration of Six Sigma methods into everyday business. This includes (8):

- Processes are documented and managed “end-to-end,” and responsibility has been assigned in such a way as to ensure cross-functional management of critical processes.
- Customer requirements are clearly defined and regularly updated.
- Measures of outputs, process activities, and inputs are thorough and meaningful.
- Managers and associates use the measures and process knowledge to assess performance in “real time” and take action to address problems and opportunities.
- Process improvement and process design and redesign are used to constantly raise the company’s levels of performance, competitiveness, and profitability

3.2 Define

The define stage is used to gather sufficient information to clarify the opportunity for improvement, learn about the process, learn about the organization’s barriers to solving the problem, and develop a plan to address the problem (4). Common tools which are used throughout the define stage are:

- Listening to Customers
  - Kano’s model
  - Affinity Diagram
  - Pareto Analysis
The Kano model is a tool developed to compare the relationship between customer satisfaction and customer requirements. The requirements are broken into three different groups: assumed requirements (unspoken), marketplace requirements (spoken), and love-to-have requirements (unspoken). Most often, many of the requirements of the customer are unspoken; indentifying the “love-to-have requirements” makes businesses world class as shown in Figure 1 (4).
The Affinity Diagram is a method used to obtain input from various stakeholders. Suggestion boxes often get overlooked, and sometimes meetings are taken over by a few outspoken individuals; whereas this method allows everyone to contribute (4). Using this method, a group can generate ideas quickly. Once ideas have been generated they are grouped. Themes of ideas are developed for identifying action items so solutions can be created from the ideas.

The Pareto analysis is a tool used to make decisions based on importance instead of convenience. It is known as the 80:20 rule which means that usually 80% of the problems come from 20% of the processes. The Pareto chart is a bar chart showing attributes of the problem on the x-axis and the frequency of occurrence on the y-axis always shown in decreasing order as shown in Figure 2.

![Figure 2 Pareto Chart Example](image)

Process mapping sometimes called a flowchart is a way to identify the various activities of the process and show the relationships. A well defined map must address the following (4):

• Process has a purpose.

• Process has beginning and end states.

• Process has needs or inputs.

• Process must have a clear target performance.

• Process output does vary due to uncontrolled sources of variation.

• Process must be evaluated based on its mean or typical performance, as well as range between worse and better performance levels

See Figure 3 for example.

The SIPOC (Supplier, Input, Process, Output, and Customer) is used to expand the process map to identify players in the operation. The benefit of this tool is to identify all variables which affect the performance of the process and then prioritize them (4). This is shown in Figure 4.
A work study shows how an employee spends his/her time working on different tasks. The analyst records a tally every minute in a specified area and observes the employee for a specified time. After the allotted time the analyst then records each task, which shows the percentage of each time the employee spends on each task. The data obtained are then translated into a bar graph for visual analysis (Figure 5).

The force field analysis is a method to identify supportive and resistive resources that could be effectively utilized towards the process goals. The objective is to identify factors to accelerate change or resistive resources which would slow process change (4). Figure 6 is an example of a force field analysis.
A project charter compiles the problem definition, goals, objectives, and action plans to achieve them. It is a roadmap that:

- Justifies the project efforts with financial impact
- Describes the problem and its scope to be addressed by the project in the specified timeframe.
- Declares the goal, objectives, and measures of success.
- Defines the roles of the team members.
- Establishes the timeline, milestones, and key deliverables.
- Identifies required critical resources

### 3.3 Measure

The measure phase is to identify correct measures, establish a baseline, and eliminate trivial variables. The following tools are important for this phase:
There are two types of statistics: descriptive and inferential. The descriptive statistics summarize the historical data. Basic descriptive statistical analysis consists of the mean, median, mode, range, variance, and standard deviation of a data set. Also, measuring the cost of quality is critical, because high variations and inconsistencies can cause high cost and waste valuable resources. Inferential statistics is based on analysis of the sample to infer performance of the process (4). It is generally concerned with the source of the data and seeks to make generalizations beyond the data at hand (8). Inferential statistics can include regression analysis and hypothesis testing, among many others.

3.4 Analyze

The analyze phase begins the convergence of possibilities toward the root cause of the problem. Key analyses tools are (4):
• Multi-vary analysis
• Cause and effect diagrams
• Regression analysis
• Failure modes and effects analysis (FMEA)

The cause and effect diagram is used to identify the source of the problem of the process and shows each branch of the process and the inputs related (4). From the diagram one is then able to notice the different contributors to the problem or process. Figure 7 is an example.

![Cause and Effect Diagram Example](image)

**Figure 7 Cause and Effect Diagram Example**

The regression analysis helps to identify causes and shows correlations between variables (4). Often, to solve problems involving many variables, an inherent relationship must be recognized. Regression is a way to estimate variable “y” if there is “x” amount of variable “z”. There are independent and dependent variables. Dependent variables are the responses and the independent variables are the causes. Relationships are not always
deterministic; for example, “x” does not always give the same value for “y”. As a result, relationships cannot be exact, and regression methods are used to predict relationships. The relationship is as follows: \( Y = \alpha + \beta x + \varepsilon \). In the equation “\( \alpha \)” and “\( \beta \)” are unknown intercept and slope parameters and \( \varepsilon \) is a random variable assumed to be normally distributed (15).

Multi-vary analysis is a method to reduce the number of potential causes by removing the trivial ones (4). Many data sets have hidden or not easily recognized similarities, patterns, or structures (3). Different techniques that can be used to address this are cluster analysis, two-factor analysis of variance, and three-factor experiments.

The failure mode and effect analysis (FMEA) is used to show the potential failures reducing the critical failures of the process (4). Usually when creating a failure mode and effect analysis, each potential failure is ranked from one to ten in relation to the damage the failure could cause. Then solutions are developed to prevent each failure, putting priority on the highest ranked failure.

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Severity</th>
<th>Occurrence</th>
<th>Detection</th>
<th>RPN (Risk Priority)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing Appointment</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>Improper Treatment</td>
<td>10</td>
<td>2</td>
<td>4</td>
<td>80</td>
</tr>
</tbody>
</table>

Figure 8 FMEA Example
3.5 Improve

The “improve” phase is designed to identify actions remedying the root cause of the waste or inefficiency of a process. The following tools can be implemented to solve a problem (4):

- Systems thinking
- Testing of hypothesis
- Comparative experiments
- Design of experiments

Systems thinking is making a decision based on data and facts. Often decisions are based on thoughts, and studies are not done to find the true causes of problems. Systems thinking consists of conducting tests and using tools to find these problems, and then fix the problems based on these facts.

A statistical hypothesis is an assertion or conjecture concerning one or more populations (15). Testing of hypothesis is an inferential technique used to make a statement about an activity or process based on its output (4). One can either fail to reject a hypothesis or reject it. Failing to reject implies that the data does not give sufficient evidence; however, rejection implies the sample evidence refutes the hypothesis. Rejecting the hypothesis means when the hypothesis is true there is a small probability of that sample occurring again; which means the data does not reflect the population. There are always two hypotheses: the null and the alternative. The test is against the null; if the test is rejected
then the alternative is accepted. A typical set up for this would be $H_0: u = u_1$ or $H_1: u = u_2$ (15). “H” represents the hypotheses and “u” represents the mean.

Comparative experiments is measuring a control group, then conducting an experiment and seeing if there is a difference in results (4). An example of a comparative experiment is the t-statistic, which tests a single mean, with the variance unknown. The t-test tests to find a change in the mean from the old process to the new process; as little as six sample points are needed.

The design of experiments relates to comparative experiments. It is a non-biased way of creating an experiment while getting the desired answers to the problem. The three goals of an experiment are:

1. The experimenter should clearly set forth the objectives before proceeding with the experiment.
2. The experiment should be described in detail. The treatments should be clearly defined.
3. An outline of the analysis should be drawn up before the experiment is started (3) (Figure 9).
3.6 Control

The control phase is designed to maintain the benefits of the improved process (4). Tools which are commonly used throughout this process are:

- Control Charts
- Documentation
- Change management
- Communication
- Reward and recognition
- Check sheets

Control charts are used to identify variation, whether the variation is random or assignable (4). Control charts record a task over a given amount of time and are plotted against the specification limits to observe if the process is under control. The center line is generally the average of the sample. The upper control limit (UCL) is the average plus the appropriate range. The lower control limit (LCL) is the average minus the appropriate range. The following example (Figure 10) shows the center line at zero and the UCL at
three and the LCL at negative three. There are various equations that can be used depending on what needs to be plotted.

![Standardized Chart](image)

**Figure 10 Control Chart Example**

Documentation is the recording of the new process steps to provide standards and guidelines for the employees (4). This keeps the employees focused, and if any questions arise about the new process an answer can be easily found. One example of documentation is ISO 9000. ISO 9001 is the International Organization for Standardization used to rate companies.

Communication is essential throughout the process, however, when implementing a new process, communication is vital to the success of the start up of the process. Without communication nothing will run smoothly, and the new process will slowly fail. Rewarding and providing recognition to every individual involved is also important in order to give everyone a sense of pride in the hard work put into the project. This helps to improve morale and often refreshes workers for the projects to come.
Check sheets can be used to show where different problems could arise, and can keep track of different steps throughout the process or times that different products arrive. These are a good way to monitor a process and can be used for various aspects of tasks. Figure 11 shows an example of a check sheet.

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Number of Defects Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Grinding</td>
<td>III</td>
</tr>
<tr>
<td>2- Turning</td>
<td>I</td>
</tr>
<tr>
<td>3- Polishing</td>
<td>IIII</td>
</tr>
<tr>
<td>4- Assembly</td>
<td></td>
</tr>
</tbody>
</table>

Figure 11 Check Sheet Example
Chapter 4

Define

4.1 Project Team and Goals

The members of the Six Sigma team are Steven Selman M.D., Matthew Franchetti P.h.D., P.E., Melissa Korb R.N., and Kyle Bedal. The objective of the project is to improve the process for Renal Transplants at The University of Toledo Medical Center Utilizing Six Sigma. This includes aligning and optimizing processes and the removal of process generated defects and errors. The improvements will focus on:

- Optimizing cycle times
- Enhancing customer satisfaction
- Improving efficiencies
- Reducing costs
- Streamlining administrative processes
- Eliminating errors
- Improving protocol execution and effectiveness

The project will target pre-operational processes.

4.2 Timeline

The team established the following timeline for the project to be completed:
Define: January 2008- Define and clarify the project goal and timeline with the focus placed on the patients. Establish the joint team between the College of Engineering and the Health and Science Campus.

Measure: February, March 2008- Define the current state and the current processes including the development of a process flow map to baseline the system and to identify bottlenecks. Collect and display data including task time, resources required and process statistics.

Analyze: April, May 2008- Determine process capability and speed utilizing statistical tools and charts. Determine sources of variation and subsequent time bottlenecks. Identify and quantify value added and non-value added activities.

Improve: June, July 2008- Generate ideas, including the development of a compressive waiting list database which contains the status of all patients throughout the screening and evaluation process. Develop a standardized rating system to rank the success potential for a renal transplant that is tied into the database. The team plans to conduct experiments and validate improved processes and develop action plans and standard operating procedures.

Control: August, September 2008- Develop a control plan, monitor performance and mistake-proof processes.
The Gnatt chart in Figure 12 shows the schedule.

<table>
<thead>
<tr>
<th>Year</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>January</td>
</tr>
<tr>
<td>Clarify Goal and Define Team</td>
<td></td>
</tr>
<tr>
<td>Define current system</td>
<td></td>
</tr>
<tr>
<td>Collect Data</td>
<td></td>
</tr>
<tr>
<td>Determine Process Capability</td>
<td></td>
</tr>
<tr>
<td>Determine Sources of Variation</td>
<td></td>
</tr>
<tr>
<td>Generate and Implement New Ideas</td>
<td></td>
</tr>
<tr>
<td>Control New Process</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 12 Timeline**
4.3 Process Overview

Figure 13 shows the process map.
4.3.1 Start of Process

The process begins when patients are referred to the renal transplant center. The transplant team then mails a letter acknowledging the patients’ referrals and encourages them to sign up for orientation. Upon making an appointment for orientation, the patients are required to fill out background information to see if they qualify to be a transplant candidate. If necessary, the coordinator can call and cancel the patient’s appointment for orientation. The required topics of background information are given in appendix B.

4.3.2 Orientation

At orientation the patient is educated on the fundamentals of the transplant which includes:

- Transplant costs
- Risks and benefits of surgery
- Information about the clinical evaluation
- Alternatives to renal transplant
- Information required to be considered for transplantation
- Information about the transplant
- Information about post transplant
- Brief introduction of the terms and tests
- Overall process

Labs that are required are the Tuberculosis skin test, a chest x-ray, an EKG (cardiac stress test), blood work, and dental clearance. Other labs could be required depending on what
the physician requires on an individual basis. The following tests are part of the blood work:

- Cytomegalovirus (CMV)
- HIV (human immunodeficiency virus)
- hepatitis profile, and EBV (Barr virus)
- ABO (blood type)
- HLA (human leukocyte antigens)
- RH (antigen in blood)
- PRA (panel reactive antibody).

The patients are given a form requesting to have blood work drawn and checked for CMV, IgG (most common antibody), IGM (antibody), ABO, and RH. If they prefer they can have the tests done at their primary care center. Next they are informed that they must have a BMI (body mass index) of less than thirty five for living donors and less than thirty two for deceased donors.

The renal transplant and the first year costs are estimated to be $226,400 (9). The patients are made aware of this and are required to fill out the necessary financial information to make sure that they can afford the costs of the transplant. After transplant the patient will be on some medications that are permanent and these can cost up to $4,000 a month; thus the patient must also be able to afford them. This gives the financial officer the ability to cancel the patient’s evaluation if they are not able to afford the transplant.
A lab request form is handed out so they may schedule some of the required tests at their convenience. The patients may also make an appointment for a clinical evaluation. Orientation takes about an hour to complete. The forms used at orientation are in appendix B.

4.3.3 Clinical Evaluation

At the clinical evaluation the patients are asked the required information that is used to decide whether the patient is fit to be a kidney recipient. They are also informed about the kidney transplant process and what is required form them before proceeding to the transplant committee. The patients meet with the social worker, financial advisor, doctor and coordinator.

The social worker makes sure that the patients are aware of the costs of the transplant and gives an evaluation of the patients to see if they are psychologically ready to have a transplant. The evaluation is shown in appendix B.

The financial officer meets the patients, and has them sign a waiver saying that the patients have read the costs of the transplant and can pay for it. The patient can talk about and financial concerns at this time.

The coordinator reviews current and past medical history. They explain their role in the process (to help the patient get presented to the transplant committee) and will be the patients’ main contact point. Any paperwork needed to be signed by the patients is
explained by the coordinator, and they are informed of all lab work that needs to be completed. The forms used by the coordinator are shown in appendix B.

The doctor asks many similar questions when the meeting occurs and explains the procedure and any questions the patient might have. Note, however, there is a standard form which the doctor uses, (Appendix B) due to the uniqueness of each patient it is not always followed. In other words, many processes are common for other staff members but the doctor may have different concerns based on an individual basis. The doctor orders any tests necessary to ensure that the patient is a good candidate for a kidney.

Throughout the evaluation, the patients are informed about what happens before, during, and after the transplant. They are then informed of other tests that may be required. Any questions the patients might have are answered.

If the patient does not meet the necessary standards they will be put on inactive work up (hold); which means until all the requirements are met they cannot continue in the pre-operational process.

If the patients meet the necessary requirements, they are put on active work up. This means once all required information is collected, their profile can go before the transplant committee. Any missing information throughout the process or needed information puts the patient into the hold category. Until that information comes in, they are unable to be presented before the transplant committee.
The patients can have tests completed on the day of their clinical at the medical center. The clinical evaluation is scheduled, patients are told to allow for 4-5 hours when scheduling the clinical evaluation.

The clinical evaluation is performed in two ways depending on the doctor. One way is with paper and pen and the other utilizes a computer database. The topics of information gathered at the clinical evaluation are shown in Appendix B.

4.3.4 Active Work Up

Once the clinical evaluation is completed, all the information is gathered, and the required tests are completed, the patient’s profile is then presented to the transplant committee. The transplant committee meets once a week and decides which patients are suitable candidates for renal transplants. The only information used to decide this is medical and financial information. There is no quota for the committee; all patients listed are qualified candidates. Upon the committee’s decision, the patient is either not listed or listed, and then notified.

If listed, the patient must keep an updated profile with the center until the kidney transplant takes place. After the transplant, the proper precautions are taken and the patient is required to take weekly and monthly tests and is monitored for the rest of the functioning kidney’s life. Upon not being qualified to be listed the patient is informed of the circumstances and is put on hold. The patient can return at a later date if the reason for not being approved/listed is resolved.
The coordinators are responsible for keeping track of patients’ profiles and contacting the patient before and after the transplant. Currently there are three different systems used by the coordinators to track the patients before transplant. To keep the patients’ medical records, the database called “Tracker” is used. It keeps track of all notes, medical history and personal health information. An Excel spread sheet is used to track patients’ labs which are still needed to complete their work up. The other system that is used is their email scheduler, which keeps track of when the coordinator contacted a patient or was contacted by the patient. The patient’s folder is the main source for the information, and the other systems are created based off the folder.

The social worker evaluations are stored in the patient’s profiles, but the information derived is not used coherently with the coordinators. As a result, questions are often repeated and information can sometimes be redundant.

The financial officers’ information is kept in the patients’ profile. Minimal information is kept on the computer. The information kept by the financial worker is any information that the patient needs to get approved, bills from labs completed at other places paid for by the University and total charges that are met by a transplanted patient. Any other information is kept on a hardcopy in the patients’ profile.

Currently, the system used for keeping track of patients’ status is not standardized. There are no clear requirements for what each staff member’s role is, and the tasks that are done by each member are done to the best of the staff’s abilities. As a result, there may be a
lack of organization and communication between staff members. There are standard questions for the patients to be asked at the clinical evaluation, but each member of the transplant staff uses their own set of questions. These issues can decrease customer satisfaction and slow the process as happened in the past.
Chapter 5
Measure

5.1 Introduction

The measure phase is used to identify correct measures, establish a baseline, and eliminate trivial variables (4). It is also used to gauge the current process to understand where improvements can be made. Tools that were used in this project are:

- Pareto Chart
- Basic Statistics
- Responsibility Matrix
- Work Study
- Scheduling Chart
- Survey

5.2 Pareto Chart

Data from the patients in active work-up was taken. This data corresponds to incomplete tests which need to be before being presented to the transplant committee. Patients can have multiple missing results. One hundred and sixteen patients were used in the data set (which is most of the patients in active work-up) and the following Pareto analysis (Figure 14) shows what test results were needed most frequently.
As shown, cardiac clearance, a CT or CTA scan, and dental clearance were the most frequent results needed before the patient could be presented to the transplant committee. Note, however, that the CT/CTA scan is usually performed last because the medical center pays for this test and is it expensive to complete. The main issues of the “other” category consist of urology, neurology clearance, and blood work.

5.3 Process Measurement

Data was collected from patients who are listed for kidneys and from patients who are in active work up. This is to show how long each step in the renal transplant process took. For example, Table 1 shows the average time from being referred to the transplant team to sending the patient a letter stating that they were accepted the referral, Table 1. The
team also looked at the overall process time of patients in the process—the results are shown below without the outliers. A box plot was used on the original data to find outliers and compensate for them. The outliers are shown by the stars in Figure 15.

![Boxplot of Process Times](image)

**Figure 15 Box Plot (Process Measurement)**

<table>
<thead>
<tr>
<th>Step Description</th>
<th>Average Days</th>
<th>St. Dev (Days)</th>
<th>Average Months</th>
<th>St. Dev (Months)</th>
<th># of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Referred and Letter</td>
<td>5</td>
<td>6</td>
<td>0.16</td>
<td>0.19</td>
<td>91</td>
</tr>
<tr>
<td>Letter and Orientation</td>
<td>40</td>
<td>22</td>
<td>1.34</td>
<td>0.72</td>
<td>81</td>
</tr>
<tr>
<td>Orientation and Evaluation</td>
<td>68</td>
<td>27</td>
<td>2.27</td>
<td>0.89</td>
<td>97</td>
</tr>
<tr>
<td>Transplant Committee and Listed</td>
<td>102</td>
<td>82</td>
<td>3.39</td>
<td>2.74</td>
<td>136</td>
</tr>
<tr>
<td>Referred and Listed</td>
<td>13</td>
<td>15</td>
<td>0.42</td>
<td>0.50</td>
<td>104</td>
</tr>
<tr>
<td>Total Process Time</td>
<td>227</td>
<td>45.6</td>
<td>7.58</td>
<td>1.52</td>
<td>509</td>
</tr>
</tbody>
</table>
To estimate the total process time the means were summed. To estimate the total process variance the pooled variance formula was used $S^2 = \frac{1}{n-k} \sum \sum (Y_{ij} - Y_i)^2$ (3).

5.4 Responsibility Matrix

The following RACI table shows who is responsible for each task at each step. The letters stand for the following:

- **Responsible** - Those who do work to achieve the task. There can be multiple resources responsible.

- **Accountable** - (Also Approver) the resource ultimately answerable for the correct and thorough completion of the task. There must be exactly one “A” specified for each task.

- **Consulted** - Those whose opinions are sought; this is two-way communication.

- **Informed** - Those who are kept up-to-date on progress; this is one-way communication.
Table 2 RACI Diagram

<table>
<thead>
<tr>
<th>Patient Received</th>
<th>Patient</th>
<th>Coordinator</th>
<th>Doctor</th>
<th>Review Board</th>
<th>Social Worker</th>
<th>Financial Officer</th>
<th>Outside Doctor</th>
<th>Secretary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Sent to Patient</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R,A</td>
<td></td>
</tr>
<tr>
<td>Initial Contact</td>
<td>R, A</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td>R, A</td>
<td>R, I</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Create Profile</td>
<td>R, A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical</td>
<td>R, A</td>
<td>R</td>
<td>C</td>
<td></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>I</td>
</tr>
<tr>
<td>Scheduling Labs</td>
<td>R, A</td>
<td>R, I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labs Completed and Submitted</td>
<td>R, A</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Presented</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A,C</td>
<td>I</td>
</tr>
<tr>
<td>Listed</td>
<td>I</td>
<td>R, A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
</tbody>
</table>

Table 2 shows the relationships of the coordinator and the patient to the process. The coordinator and the patient play the two biggest roles in the transplant process and are responsible for most of the issues along the way. In the pre-operational process the doctors’ roles are consultants to the patient and to the coordinator. The doctors are informed of patients’ status as needed.

It is important to notice that the social worker and financial officer only play a small role in the totality of the process and are usually not a factor in slowing the process down.

This table helps to show how patient dependent the process is in making motivation an important factor for completing the process. It also shows the importance of the coordinator, in that if a coordinator needs time off or is overloaded with patients, the process will likely suffer.
5.5 Work Study

A coordinator was work studied as shown in Figure 16. The majority of the coordinator’s time was spent preparing and reviewing the patients’ files which consist of organizing information, filling out and getting required information, updating patient’s medical history and information, reviewing results of the patient, and sending patients the necessary information. The other column consists of sending and receiving emails, checking mail, organizing and scheduling, reviewing meeting notes, and other miscellaneous activities. Figure 16 shows that 34% of the coordinators time is spent preparing patients’ files. Meaning one-third of their time is preparing to see patients.

![Work Study](image)

**Figure 16 Work Study**

5.6 Clinical Evaluation Scheduling Chart

The general order of the staff schedule for the patients’ clinical evaluation is shown in Figure 17. Each bar represents fifteen minutes, in which at least five patients are typically scheduled.
As shown, the coordinator is first to see the patient, followed by the doctor, financial officer, social worker, and the coordinator who then finishes with the patient. Figure 17 shows the ideal situation. However, if any staff member takes more time than expected the schedule is interrupted. This can keep the coordinator in idle for a significant amount of time waiting for other staff members to finish with the patients.

It is important to note that the coordinator is at the clinical evaluation for an extended amount of time due to the fact that he/she must see the patient at the beginning of the evaluation and at the end.

Figure 17 Clinical Evaluation Diagram

5.7 Survey

To determine what the patients thought of the process directly from the patients, a survey was created which is shown in Appendix C. It researches what the patients thought about
orientation, the clinical evaluation, and the process overall. Results differ from staff member to staff member in regards to what patients like, so it is important to get accurate information directly from the patients with no bias. The results of the survey will be discussed in the analyze portion of the paper.

5.8 Lab Measurement

The team wanted to investigate if a certain lab took consistently longer than other labs. To measure this, the team time stamped labs results when the results were received. The data are shown in Table 3. The table shows the time from the clinical evaluation to when the patients’ results were received. These results will be discussed in chapter six.

<table>
<thead>
<tr>
<th></th>
<th>Time between Clinical Evaluation and Tb skin</th>
<th>Time between Clinical Evaluation and Dental Clearance</th>
<th>Time between Clinical Evaluation and Cardiac Clearance</th>
<th>Time between Clinical Evaluation and CT/CTA Scan</th>
<th>Time between Clinical Evaluation and Colonoscopy</th>
<th>Time between Clinical Evaluation and Mammogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples</td>
<td>18</td>
<td>18</td>
<td>13</td>
<td>11</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Average (Days)</td>
<td>13</td>
<td>19</td>
<td>51</td>
<td>6</td>
<td>101</td>
<td>71</td>
</tr>
<tr>
<td>Standard Deviation (Days)</td>
<td>9</td>
<td>36</td>
<td>51</td>
<td>10</td>
<td>113</td>
<td>40</td>
</tr>
<tr>
<td>Average (Months)</td>
<td>0.4</td>
<td>0.6</td>
<td>1.7</td>
<td>0.2</td>
<td>3.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Standard Deviation (Months)</td>
<td>0.3</td>
<td>1.2</td>
<td>1.7</td>
<td>0.3</td>
<td>3.8</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Chapter 6

Analyze

6.1 Process Overall

This high variation in the process is due to a variety of reasons. To show these reasons a fish bone diagram was constructed.

![Figure 18 Cause and Effect Diagram](image)

**Figure 18 Cause and Effect Diagram**

**Method** - The process takes longer due to the complexity of the process, limited quality control, the amount of patients, standard operating procedures, and the time needed to prepare for each patient. Currently, the process is not able to be easily monitored to
measure the performance for the system, and the current procedures do not account for redundancies. The system is complex with many tests and labs, making it important for the coordinator able to track progress efficiently. The current system also makes it challenging to prepare for new patients due to the amount of data which needs to be entered into the system and the time it takes to do so.

**Staff**- The only issues with the staff are the lack of communication and availability. If a coordinator must take time off for instance, it is difficult for someone to cover the shift due to a lack of standards or an immediate replacement.

**Patient**- The patient aspect of the process can influence the variation of the process dramatically. This factor is mainly due to the patient’s motivation. The process can be extremely smooth if the patient is forthright, and wants to get the labs completed in a timely fashion. Other problems that can occur are financial problems, not knowing what step to take next, and the patients’ ability to complete their labs, perhaps due to transportation or time constraints.

**Database**- This is a crucial factor to improving the current kidney transplant process. It does not affect the patient as much as the staff. However, improving this system would allow the staff to spend less time entering data, and this would improve communication among staff members. This could allow for the staff to handle more patients and may increase the process speed due to the increased communication. The current database is not user friendly, requiring the staff to complete redundant tasks.
6.2 Analyzing Process Measurement

Upon analyzing the data of time for each step throughout the process, the time from the patient being referred and the letter sent out to patients seems reasonable with an average of five days and a standard deviation of six days. The variation could be due to the mailing system and the workload of the secretary at the time.

The time between the letter and orientation also seems reasonable because orientation is only offered once a month. There is going to be idle time because of the inability of patients to make orientation only on that day. The standard deviation seems to be for the same reason. If the patient cannot make the orientation that month he or she goes to the next, which is generally about a month away, hence the twenty two day standard deviation.

The time between the orientation and clinical evaluation also seems reasonable due to the fact that patients prefer certain days over others, and due to the high number of patients the transplant center has. Decreasing the time between orientation and the clinical evaluation may be improved if the clinic could be opened another day of the week.

The time between the clinical evaluation and transplant committee has such a high average (102 days) and high standard deviation (82 days) because the patient must complete all of the requirements. Some patients are required to complete less than others, and some have more time or are more motivated than others, thereby completing the requirements much sooner. In this stage the responsibility is on the patient. The high
average and deviation could also be caused by the patient forgetting, or not being aware of what needs to be completed to be presented to the transplant committee.

The average time and standard deviation between the transplant committee and being listed seem higher than expected. The patient should be able to get listed within a few days with approximately a week’s standard deviation. This high average time and standard deviation appear to be caused from the workload that the coordinators take on.

6.3 Analyzing the Pareto Chart

The top four factors for delaying the presentation to the transplant committee were:

- 57% of patients needed a cardiac clearance.
- 40% of patients needed dental clearance.
- 40% of patients needed a CT or CTA scan.
- 35% of patients need a colonoscopy.

The cardiac clearance was the top factor in delaying presentation to the transplant committee. This is due to the number of different tests ordered by the doctor depending on the health of the patient. Due to the number of tests required it can take an extended amount of time to get cleared.

Dental clearance is tied for the next highest labs which are not being completed. This seems to be due to the lack of funds or insurance to pay for it. Many of the patients only
get one improvement done at a time due to the cost, and with many improvements to
make and schedule every so often, this can be a lengthy task.

The CT or CTA scan is ranked high in not being completed because it is generally paid
for by the university and is costly. Thus it is usually the last test done.

The colonoscopy is a lab that many patients need to have completed. There is no
evidence linking this test to be an expensive or demanding test, but the high percentage of
incomplete is merely the number of patients needing the test.

6.4 Analyzing the Work Study

<table>
<thead>
<tr>
<th>Value Added</th>
<th>Non-Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Contact at clinic</td>
<td>Waiting for patient/co-worker</td>
</tr>
<tr>
<td>Phone patients/providers</td>
<td>Input patient data</td>
</tr>
<tr>
<td></td>
<td>Prepare/Review patient files</td>
</tr>
<tr>
<td></td>
<td>Meeting</td>
</tr>
</tbody>
</table>

Figure 19 Value Added Chart
Upon analyzing the work study, the coordinator has idle time for roughly an hour a week waiting for other transplant members to complete their evaluations with the patient. This is non-value added time and keeps the coordinator from doing more important tasks. Data entry should be minimal for the coordinator. Figure 19 shows the value added tasks and non-value added tasks of the coordinator. Figure 20 shows the percentage of work that is value added. The main focus of the coordinator should be working with the patients and to coordinate labs and tests for the patient, so the patient can be presented as soon as possible. Tasks which should be focused to reduce are: waiting for patient/co-worker, inputting patient data, and preparing/reviewing patient files.

6.5 Analyzing the Clinical Evaluation Scheduling

The clinical evaluation schedule seems to be fluent; however, normally it does not occur as shown in the figure. With the current process the coordinator usually has idle time waiting for other staff members to finish with the patient. Many of the questions which
are repeated are also non-value added and may cause the patient to be frustrated due to repeated answering of questions. Often the doctor wishes to not see the patient until the second patient has arrived, thus causing the first patient to sit idle for long amounts of time.

6.6 Survey Results

Currently surveys are still being collected although some surveys have been analyzed.

The survey used is shown below.

Rate from 1-5, 5=Strongly agree, 4=Agree, 3=No opinion, 2=Disagree, 1=Strongly disagree

**Orientation**

1. Orientation was informative about a kidney transplant and its process. ____
2. After orientation I knew what was required of me to be a kidney recipient. ____
3. Orientation clearly defined what I needed to do next to become a kidney recipient. ____
4. I felt overwhelmed at all the information that was given to me at orientation. ____
5. The orientation staff was friendly and courteous. ____
6. Orientation was useful and I would highly recommend it. ____

**Clinical Evaluation**

1. I felt many of the same questions were repeated throughout the clinical? ____
   a. How many siblings?
   b. The health of your family?
2. I felt well informed about the kidney transplant after attending the clinical? ____
3. I clearly understood what was required of me after attending the clinical? ____
4. The clinical staff was friendly and courteous. ____
5. The transplant team made it clear what tests needed to be completed before being presented to the review board. ____
6. I felt that I had enough time with the doctor so that all my questions were answered. ____

Answer with a Yes or No.

**Miscellaneous Questions**

1. Where you ever directed to the website? Yes/No
2. If more information was made available through the internet would you use it? Yes/No
3. Would you feel comfortable giving the required background information through the internet? Yes/No
   a. Past medical information
   b. Medications
   c. Age, Sex, The number of siblings
4. Did you like only going to the hospital once to meet with the doctor, coordinator, social worker, and financial officer at the clinical? Yes/No

Rate from 1-5, 5=Excellent, 4=Good, 3=No opinion, 2=Average, 1=Poor

**Quality Questions**

1. The kidney transplant team’s knowledge about the kidney transplant process and/or questions you may have had was ____.
2. The transplant team’s promptness in returning questions or concerns was ____.
3. The overall quality of your interactions with the transplant team was ____.
4. Overall I felt the punctuality of the staff was ____.

**Open Ended Questions**

1. In terms of quality for the pre-operational kidney transplant process what is most important as a patient?

2. Is there anything that you can think of that could help improve the renal transplant process?

---

**Table 4 Survey Results**

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Results</th>
<th>Clinical Evaluation</th>
<th>Results of Questions</th>
<th># of Yes</th>
<th>Quality Questions</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>5</td>
<td>Question 1</td>
<td>2</td>
<td>Question 1</td>
<td>2</td>
<td>Question 1</td>
</tr>
<tr>
<td>Question 2</td>
<td>5</td>
<td>Question 2</td>
<td>4.8</td>
<td>Question 2</td>
<td>5</td>
<td>Question 2</td>
</tr>
<tr>
<td>Question 3</td>
<td>4.8</td>
<td>Question 3</td>
<td>4.8</td>
<td>Question 3</td>
<td>2</td>
<td>Question 3</td>
</tr>
<tr>
<td>Question 4</td>
<td>2.6</td>
<td>Question 4</td>
<td>5</td>
<td>Question 4</td>
<td>5</td>
<td>Question 4</td>
</tr>
<tr>
<td>Question 5</td>
<td>4.6</td>
<td>Question 5</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 6</td>
<td>5</td>
<td>Question 6</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4 shows the current results of the survey. Open ended answers for question one include absorbing all the information, knowing the pros and cons of the procedure, and educating the patient. No one answered question two in that section.
It was considered that too much information was being given at orientation. However, answers to question four in the orientation section show that patients disagree with that statement. Three out of five patients were not directed to the website and only two patients responded that they would be comfortable giving the required background information via internet.

6.7 Analyzing Lab Measurement

Figure 21 enabled the team to identify any labs that are bottlenecks. From the data gathered the colonoscopy appears to be the primary bottleneck. This could be due to patient’s bad attitude or own personal fears. The test itself is not time consuming and thus could be accomplished within a reasonable time frame. Cardiac clearance is another possible bottleneck and this is due to the amount of tests that can be needed to receive clearance. Per Table 3, several tests had less than 30 data points, decreasing the reliability.
of the data. The time stamped data will be of better use for a later project when more data points are available. Also note that dental clearance was one of the highest incomplete labs, but here it is shown that it gets completed very quickly. This is also due to the lack of data points. The box plot (Figure 21) gives an example of this. The stars represent the outliers and the box represents data points that are in upper and lower control limits.

6.8 Confidence Interval

For each of the sections the following confidence intervals were created to estimate the true mean of the processes. Confidence intervals show how the process means can vary within the data. This can be useful to the medical center to give patients time estimates and gives the medical staff a benchmark performance in regards to process time and variation. This test was being 95% confident that the true mean is between the upper and lower bound. The process mean was 227 days and we can be 95% confident that the true mean of the whole population mean is between 223 and 231 days. The z-statistic was used to create the confidence intervals. The equation is as follows (15):

\[
X_{\text{bar}} - z_{\alpha/2} \times \frac{S}{\sqrt{n}} < \mu < X_{\text{bar}} + z_{\alpha/2} \times \frac{S}{\sqrt{n}}
\]

when \(n\) is greater than 30. The z-statistic was used because the population variance was not known and there were greater than 30 samples. Table 5 shows confidence intervals.
Table 5 Confidence Interval

<table>
<thead>
<tr>
<th>95% Confidence (Days)</th>
<th>Time Between Referred and Letter</th>
<th>Time Between Letter and Orientation</th>
<th>Time Between Orientation and Clinical Evaluation</th>
<th>Time Between Clinical Evaluation and Transplant Committee</th>
<th>Time Between Transplant Committee and Listed</th>
<th>Total Process Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>z-value</td>
<td>1.96</td>
<td>1.96</td>
<td>1.96</td>
<td>1.96</td>
<td>1.96</td>
<td>1.96</td>
</tr>
<tr>
<td>Interval</td>
<td>1.23</td>
<td>4.79</td>
<td>5.37</td>
<td>13.78</td>
<td>2.88</td>
<td>3.96</td>
</tr>
<tr>
<td>Upper Bound</td>
<td>6</td>
<td>45</td>
<td>73</td>
<td>116</td>
<td>16</td>
<td>231</td>
</tr>
<tr>
<td>Average</td>
<td>5</td>
<td>40</td>
<td>68</td>
<td>102</td>
<td>13</td>
<td>227</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>4</td>
<td>35</td>
<td>63</td>
<td>88</td>
<td>10</td>
<td>223</td>
</tr>
</tbody>
</table>

6.9 Prediction Interval

A prediction interval is used to predict a value of a future observation. The purpose of this test is to predict the time it would take a new patient to complete the process. This gives the patient and staff expectations to complete each step of the process. These predictions were made with 95% confidence. This means that there is a 95% chance that a future observation will be in the upper and lower bounds of the interval. The prediction intervals were created with the t-statistic. The t-statistic was used because population variance was not known. Table 6 shows the intervals. The formula used is:

\[ X_{\text{bar}} - t_{\alpha/2}S(1 + 1/n)^{1/2} < x_0 < X_{\text{bar}} + t_{\alpha/2}S(1 + 1/n)^{1/2} \]

with \( v = n-1 \) degrees of freedom for a 95% confidence interval.

Table 6 Prediction Interval

<table>
<thead>
<tr>
<th>95% Confidence (Days)</th>
<th>Time Between Referred and Letter</th>
<th>Time Between Letter and Orientation</th>
<th>Time Between Orientation and Clinical Evaluation</th>
<th>Time Between Clinical Evaluation and Transplant Committee</th>
<th>Time Between Transplant Committee and Listed</th>
<th>Total Process Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-value</td>
<td>1.99</td>
<td>1.99</td>
<td>1.99</td>
<td>1.98</td>
<td>1.99</td>
<td>1.96</td>
</tr>
<tr>
<td>Interval</td>
<td>12.01</td>
<td>44.05</td>
<td>54.01</td>
<td>162.96</td>
<td>29.99</td>
<td>89.46</td>
</tr>
<tr>
<td>Upper Bound</td>
<td>17</td>
<td>84</td>
<td>122</td>
<td>265</td>
<td>43</td>
<td>316</td>
</tr>
<tr>
<td>Average</td>
<td>5</td>
<td>40</td>
<td>68</td>
<td>102</td>
<td>13</td>
<td>227</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>138</td>
</tr>
</tbody>
</table>
Table 6 shows the total process time for a future observation will mostly likely range from 138 days to 316 days.

### 6.10 Multiple Regression

A Multiple regression model was created to examine if any labs correlate to the time it takes a patient to be listed from the clinical evaluation date. Multiple Regression relates dependent variables to the independent variables. The following is the equation:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} + \epsilon_i$$

Where “y” is the independent variable and there are “k” dependent variables, expressed by “x”. “β” denotes the regression coefficients to show the variables relationships and “ε” denotes the random error associated with the response “y”. The method used by the analysis is the method of least squares. The model took into account the following dependent variables:

- TB Skin Test (variable $x_1$)
- Dental Clearance (variable $x_2$)
- Cardiac Clearance (variable $x_3$)
- Colonoscopy (variable $x_4$)
- Mammogram/Papsmear (variable $x_5$)
- CT/CTA Scan (variable $x_6$)
- Other Tests (variable $x_7$)
- Age (variable $x_8$)
- Gender (variable $x_9$)
- Distance (variable $x_{10}$)
• Patient Listed Elsewhere (variable $x_{11}$)

A stepwise regression was used to evaluate the data. This method was used for the following reasons:

• Accounts for correlation between dependent variables
• Selects most efficient variables for model
• Evaluates the addition or removal of each dependent variable at the specified confidence interval.

The Table 7 shows the results.

<table>
<thead>
<tr>
<th>Number of Steps</th>
<th>Variable</th>
<th>Step Constant</th>
<th>Days added to Step Constant</th>
<th>Total List Time</th>
<th>T-value</th>
<th>P-value</th>
<th>S-value</th>
<th>R-sq value</th>
<th>R-sq [adj]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CT/CTA scan</td>
<td>61</td>
<td>87</td>
<td>148</td>
<td>3.31</td>
<td>0.003</td>
<td>28.18</td>
<td>25.6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CT/CTA scan</td>
<td>79</td>
<td>79</td>
<td>118</td>
<td>3.02</td>
<td>0.005</td>
<td>33.61</td>
<td>28.7</td>
<td></td>
</tr>
<tr>
<td>Listed elsewhere</td>
<td></td>
<td>-40</td>
<td>118</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CT/CTA scan</td>
<td>135</td>
<td>94</td>
<td>118</td>
<td>3.55</td>
<td>0.001</td>
<td>40.95</td>
<td>34.1</td>
<td></td>
</tr>
<tr>
<td>Listed elsewhere</td>
<td></td>
<td>-57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB test</td>
<td></td>
<td>-67</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7 shows that if the patient needs a CT/CTA scan it would add 87 days creating a listed time of 148 days. If the variable “Being Listed Elsewhere” is brought into the data then 40 days would be taken off the 158 (79 + 79) days estimating the process time to be 118. If the patient needed a CT/CTA scan and was listed elsewhere the total amount of days predicted would be 172 days. Add in the TB test and the model reduces the time it takes to be listed by 67 days bringing the total down to 105. This could be due to the fact that these patients may be in critical condition due to needing a kidney, which could give them more motivation to complete the process. S denotes the standard deviation and R
(adjusted) is the percent of variation that can be accounted for. After three steps 34% of the variation was accounted for; which leaves 66% unaccounted. Other possible contributing factors to the variation unaccounted for could be financial, family support, attitude, and location among other reasons. To improve the accuracy of this model more data would need to be collected and analyzed. The equations used to formulate the regression results were:

1) \[ SST = \sum_{i=1}^{n} (y_i - \bar{y})^2 = \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2 + \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \]

2) \[ SST = SSR + SSE \] (Sum of square total = Sum of square regression + Sum of Square error) where:

\[ SST = \sum_{i=1}^{n} (y_i - \bar{y})^2 = \text{total sum of squares} \]

and

\[ SSR = \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2 = \text{regression sum of squares} \]

3) \[ f = \frac{SSR / k}{SSE / (n - k - 1)} = \frac{SSR / k}{s^2} \]

4) \[ SSE = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \]

5) \[ R^2 = \frac{SSR}{SST} = \frac{\sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2} \]

Table 8 Multiple Regression Formulas

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>Computed f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>SSR</td>
<td>k</td>
<td>SSR</td>
<td>(SSR/k)/s^2</td>
</tr>
<tr>
<td>Error</td>
<td>SSE</td>
<td>n - k - 1</td>
<td>SSE/(n - k - 1)</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>SST</td>
<td>n - 1</td>
<td>n - 1</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 7

Improve

7.1 Data Interpretation

Upon reviewing the data the following problem areas were exposed:

- Lack of Staff Communication
- Orientation Availability
- Orientation Screening
- Clinical Evaluation Schedule
- Dental Clearance (Bottleneck)
- Lack of Performance Measures

The transplant staff often operates as individuals and not as a team. This causes communication issues and redundancies. Orientation is only offered once a month and until it is completed the patients cannot move forward with the process. This causes unnecessary delays in the process. During the orientation more information could be gathered so the patient would have less to do at the clinical evaluation and the transplant team would have more information about the patients earlier. The clinical evaluation schedule often creates a bottleneck for the transplant coordinator. Dental clearance is a cause of delaying the process and is often due to the cost of the procedures. The process also lacks any process measures so the transplant team has no feedback in regards to performance.
7.2 Proposed Solutions

On May 22, 2008 the team met to discuss and generate improvement ideas. The following ideas were presented to the transplant team:

- Creation and implementation of a patient database to provide information and to generate custom reports (i.e. incomplete tests, status).
- Modification to orientation schedule based on patients’ needs.
- Modification to orientation process to include computerized data input to reduce redundant data input and errors.
- Modification to clinical schedule to improve efficiency of medical staff, reduce patient cycle time and provide more scheduling flexibility to patient.
- Develop dental assistance program to identify potential doctors/costs and assist with scheduling for patient.
- Continuous monitoring system branched from database. Send report out to patient to verify information at a determined interval (3 months, 4 months).
- Develop standard operating procedures (SOP) for the entire process, to ensure uniformity and consistent work.
- Develop a tracking system to monitor performance to make sure targets are met based on timelines (tests, process performance, communication between staff and patient).

7.3 Quantify Solutions

On September 2, 2008 the team met to discuss the improvement ideas. The following ideas and recommendations were created:
• Creation and implementation of a patient database to provide information and to generate custom reports (incomplete tests, status).

• Tracking system in database to monitor performance to make sure targets are met based on timelines (tests, process performance, communication between staff and patient).

• Consideration to use a video for orientation instead of presentation (mailed or web based). If used, consider not starting any paperwork until patient is signed up for evaluation.

• Consideration to use a pre-sheet process (given at orientation or clinical, overview of process).

• Modification to the clinical schedule to improve efficiency of medical staff, reduce patient cycle time (establish evaluation so coordinator only has to see the patient at the end). This would allow coordinator to spend less time at clinical evaluation and more time to contact patients (contact person to break barriers). Consideration to move social worker into different office to conduct evaluation.

• At end of clinical evaluation give a simplified handout/contract describing process and expectations with timeline.

• The time it takes between orientation and the clinical evaluation is high. Consider offering clinical evaluations an additional day of the week.

• Develop dental assistance program to identify potential dentists/costs and assist with scheduling for patient.

• Continuous monitoring system branched from database. Send report out to patient to verify information at a determined interval (i.e. 2 weeks, 4 months).
• Develop Standard Operating Procedures for the process to ensure uniformity and consistent work.

7.4 Implementation

On September 9, 2008 the six sigma team presented the recommendations to the transplant team and transplant administrators. The implementation of these ideas is at the discretion of the transplant team. The transplant team has decided to buy a database and is waiting for funding to purchase it. The database will have the ability to track important data and performance measures. They are also working with different dental offices to allow for decreased dental costs to patients who cannot afford it. Standard operating procedures will be recreated once the database is implemented because it will significantly change the tasks of each staff member.

The team has shown interest in the addition of pre-sheet process overview, and moving the financial officer and social worker to see patients after the doctor and coordinator are finished with them which may be done in a different room. The transplant team will examine their current handout/contract describing the process and expectations and make revisions as they feel necessary. The team does not currently have enough staff to offer clinical evaluations another day but they have agreed to add another patient to each day which they do offer evaluations.

The transplant team is also considering implementing a “solution center”. This would create a position to take incoming calls about the transplant process. This station would
need employees who are able to be on the database to look up information and answer common questions. If they cannot answer a question they are to direct the patient to the appropriate staff member. This would free up the coordinators’ time and allow the coordinator to focus more on helping patients become listed faster. It would also make the process more personal to the patient because the patient would only have to call one number to have his/her questions answered. This could potentially avoid the frustration of patients calling many different places and not getting an answer. The solution center would serve as a barrier breaker and could further personalize service.

7.5 Estimated Improvements

Table 9 shows the estimated quantified and qualified improvements that could be made from the process if the recommendations were completely implemented.

<table>
<thead>
<tr>
<th>Process Issue</th>
<th>Proposed Change</th>
<th>Quantified Estimated TPTR</th>
<th>Qualified Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of communication and organization</td>
<td>Use a database</td>
<td>1% (2 days)</td>
<td>Improved staff efficiency and communication</td>
</tr>
<tr>
<td>No performance tracker</td>
<td>Use a database</td>
<td>0%</td>
<td>Improved staff efficiency and communication</td>
</tr>
<tr>
<td>Frequency of orientation</td>
<td>Develop a video</td>
<td>7% (16 days)</td>
<td>Improved customer satisfaction</td>
</tr>
<tr>
<td>Unclear process expectations</td>
<td>Use pre-sheet process overview</td>
<td>1% (2 days)</td>
<td>Improved customer satisfaction</td>
</tr>
<tr>
<td>Idle time at clinic</td>
<td>Change clinical schedule</td>
<td>0%</td>
<td>Improved use of staff time</td>
</tr>
<tr>
<td>UnClear requirements</td>
<td>Simplify contract/handout</td>
<td>1% (2 days)</td>
<td>Improved customer satisfaction</td>
</tr>
<tr>
<td>Frequency of clinical evaluation</td>
<td>Offer clinic more</td>
<td>8% (18 days)</td>
<td>Improved customer satisfaction</td>
</tr>
<tr>
<td>Dental lab incompleteness</td>
<td>Offer dental assistance program</td>
<td>2% (6 days)</td>
<td>Improved customer satisfaction</td>
</tr>
<tr>
<td>No patient continuous monitoring system</td>
<td>Use a database</td>
<td>0%</td>
<td>Improved patient feedback</td>
</tr>
<tr>
<td>No current standard operating procedure</td>
<td>Create standard operating procedures</td>
<td>0%</td>
<td>Improved staff efficiency and communication</td>
</tr>
</tbody>
</table>
*Total Process Time Reduction (TPTR)

It was estimated that with the implementation of the database coordinators would have more time to help patients schedule labs and finish requirements due to the increased organization and availability of information. Therefore the total process time can be reduced by 2 days (1%).

Offering an orientation video would significantly bring the total process time down because patients can only schedule once a month for orientation due to its availability. Orientation as a video can help offset this and also allow them to watch it again for any information that may have been missed or unclear. This could also give the patient the ability to make one less trip to the hospital, which could increase customer satisfaction. It is estimated that the total process time would be reduced by 16 days (7%) because of scheduling conflicts.

After orientation potential patients leave with a great deal of information, including booklets, a copy of the orientation presentation, and paperwork. This information contains the required next steps; however, a clear process sheet is not given to patients outlining expectations. Informing patients of expectations and setting standards for them could reduce the total process time drastically but is estimated to be two days (1%) of the total process time.

During the clinical evaluation patients are given more information about the process and are told what tests, labs, and any other information needs to be completed. There is a
sheet given to them which describes the incomplete tests that need to be completed but it does not describe expectations and it is not patient friendly. The modification of this sheet or creating a new sheet would give more clarity to the requirements and could potentially reduce the total process time by two days (1%).

The clinic only offers evaluations twice a week. Adding another patient on each of those days will help in reducing scheduling time. However offering clinic another day out of the week would allow more patients to be seen and give the patients more flexibility when scheduling. It is estimated that it would reduce the total process time by 18 days (8%).

Dental clearance was one of the major labs that patients did not have complete. This is thought to be due to the cost of getting treated. A study was not conducted on this but upon speaking with the transplant team it was a major concern. To help patients cope with this, the transplant center could work with an office to create a dental assistance program could help get patients needing this lab done faster. If implemented it is estimated that it would reduce the total process time by five days (2%).

It is estimated that implementing the proposed solutions would decrease the total process time by 45 days (20%). This would bring the process average down from 182 days to 227 days.
Chapter 8
Control

8.1 Overview

This project will not consist of this phase, however, useful tools that could be used to see if process improvements were made are:

- T-test
- Pareto Chart
- Basic Statistics
- Work Study
- Patient Surveys
- RACI Table
- Confidence Interval
- Prediction Interval
- Multiple Regression Analysis
- Process Tracking Tools
- Monthly Meetings

The t-test tests to find if there was a change in the mean from the old process to the new process; with as little as 6 sample points are needed. This could be a good indicator to determine if total process time was reduced.
The Pareto Chart could be used to measure what labs patients have incomplete. This would show if dental clearance was still a problem even after implementing the assistance program.

Basic Statistics could be used to measure time between events and the time that different labs take to be completed. This would give a clear indication to show if the process time was reduced.

A Work Study could be conducted and compared to the first one to notice if coordinators are spending more time coordinating patients rather than at the clinical or preparing patient files.

A Patient Surveys could be used to get input from patients to see how well they like the new system.

RACI Table could be used to see how the responsibilities shifted with the implementation of the improvements.

A Confidence Interval could be used to indicate whether the mean has shifted compared to the old process mean.
A Prediction Interval could be used to notice if a future observed value would drop in between a range. It is hoped that the range would be lower than the range described previously in this work.

Multiple Regression Analysis could be used to see if there are any new labs that are correlated with the new system. This analysis would show if certain parameters relate to the time it takes to get through the process.

Process Tracking Tools could be used so the staff could see any progress made or bottlenecks in the process. This could be used with an excel sheet or a database to record the necessary information.

Monthly Meetings could be used to keep staff communication high and to discuss changes. This gives the staff the opportunity to bring up any issues the new system may bring.
Chapter 9

Conclusion

9.1 Final remarks

This project showed that utilizing Six Sigma could improve the renal transplant process. The DMAIC approach helped identify bottlenecks and barriers to the process. It has helped to clearly define process problems to correctly solve the problems of the process. It is estimated that the total process time could be reduced by 45 days (20%) from 182 days to 227 days. These improvements would also increase customer satisfaction, increase productivity, and staff communication. Improvements are currently under consideration or being implemented by administration.

Positive methods that worked well throughout the research were support and involvement from the staff, and going through the process as a patient. The staff did an outstanding job giving ideas, feedback, and cooperation throughout the research. Actually going through the process helped to understand the jobs of the transplant staff and understand what the patient goes through during the process.

Issues that made the research difficult were data collection, meetings and administrative setup of the hospital. Data collection was difficult to do because the records were not standardized. Meetings were difficult to schedule and when meetings took place only a
limited amount of time was allotted to the project. The administrative setup made it difficult to accomplish tasks due to the lack of empowerment or the number of people that needed to be involved in the decision.

This methodology and research could be used to improve renal transplant centers around the country, and the world. This work also applies to other transplant centers for different organs around the world. This could be done because the processes are similar. Different labs would be required but the concepts of this research would be the same.

9.2 Future Research

A phase 2 of this project would be ideal to implement. The objective of the research may be to implement and control the process for renal transplants at The University of Toledo Medical Center utilizing Six Sigma. This includes aligning and optimizing processes and the removal of process-generated defects and errors. This phase could consist of:

Improvement plan finalization:

- Align processes with proposed information system and database.
- Finalize process improvement initiatives based on results in this project.
- Write the process improvement plan document and gain approval from key stakeholders from all processes.

Implementation:

- Identify the implementation team.
- Develop the implementation plan and timeline.
- Create Standard Operating Procedure (SOP) documents for all processes.
- Execute implementation plan and assist with employee training.
- Track progress of implementation.

Process control:
- Gather feedback from stakeholders for continuous improvement.
- Develop control plan.
- Monitor performance.
- Implement mistake-proof processes.

To achieve these tasks one could collect more surveys, collect more data for the regression model, collect more time-stamped data, develop control charts, develop the database, create standard operating procedures, assist in creating an patient pre-process sheet and clinical evaluation handout, and gather basic data for statistical control. Another phase should be sufficient time to fully implement the recommendations and measure the improvements this research.
References


Appendix A

Current Forms Used

RENAL TRANSPLANT EVAL

Demographic Information:

<table>
<thead>
<tr>
<th>Date:</th>
<th>Med. Record #:</th>
<th>D.O.B.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Full Name (inc. middle and maiden)

SSN#:

Address:

County of Residence:

Telephone: ___________________ Cell Phone: ___________________

Sex: ___________________ Age: ______ Race: ______ Ht: ______ Wt: ______

Marital Status: ___________________ Spouse’s Name: ___________________

Emergency Contact:

Relationship: ___________________ Telephone: ___________________

Cell Phone: ___________________

Alternate Contact:

Relationship: ___________________ Telephone: ___________________

Cell Phone: ___________________

Employer:

Address: ___________________

Telephone: ___________________

Length of time there:

If not working: ___________________ Date of last employment: ___________________

Current source of income:

Amount: ___________________

Summary of previous jobs:

Spouse: Occupation: ___________________

Employer: ___________________

Age: ______

Medical Condition: ___________________
Medical History

Doctors:
PCP: 
Nephrologist: 

Date first told had kidney disease: 
Presenting symptoms: 

Cause of kidney disease: 
Progression of kidney disease: 

Other medical problems: 

Transplant in the past: Y N How many: Where: When: 

On dialysis now: Y N 
Date started: 
Type: 
Where: 
Date and time of dialysis: 

Insurance Information:

Medicare: Part A: Y N Effective Date: 
Part B: Y N Effective Date: 
Medicaid: Y N Amount of spend-down: 
Commercial insurance: 
Prescription benefits: 
Preferred Pharmacy: 

2
### Personal and Family History

**Birthplace:**

**Other places of residence:**

**Citizenship/Immigration Status:**

**Parents:**

- **Mother:**
  - Name: ___________________________  Age: ________
  - Still living: Y  N
  - Medical condition/Cause of death: ___________________________

- **Father:**
  - Name: ___________________________  Age: ________
  - Still living: Y  N
  - Medical condition/Cause of death: ___________________________

**Parent's marital status:**

**By whom raised:**

**Significant childhood events:**

<table>
<thead>
<tr>
<th>Siblings</th>
<th>How many</th>
<th>Birth order</th>
</tr>
</thead>
<tbody>
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<td>1. Name:</td>
<td>Location:</td>
<td></td>
</tr>
<tr>
<td>Age:</td>
<td>Medical Condition:</td>
<td></td>
</tr>
<tr>
<td>2. Name:</td>
<td>Location:</td>
<td></td>
</tr>
<tr>
<td>Age:</td>
<td>Medical Condition:</td>
<td></td>
</tr>
<tr>
<td>3. Name:</td>
<td>Location:</td>
<td></td>
</tr>
<tr>
<td>Age:</td>
<td>Medical Condition:</td>
<td></td>
</tr>
<tr>
<td>4. Name:</td>
<td>Location:</td>
<td></td>
</tr>
<tr>
<td>Age:</td>
<td>Medical Condition:</td>
<td></td>
</tr>
<tr>
<td>5. Name:</td>
<td>Location:</td>
<td></td>
</tr>
<tr>
<td>Age:</td>
<td>Medical Condition:</td>
<td></td>
</tr>
<tr>
<td>6. Name:</td>
<td>Location:</td>
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</tr>
<tr>
<td>Age:</td>
<td>Medical Condition:</td>
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</tr>
</tbody>
</table>
Marital History: _____________________________________________________________

Children: Y  N  How many: ________________________________________________

1. Name: ______________________ Location: _______________________________
   Age: ______________________
   Medical condition: __________

2. Name: ______________________ Location: _______________________________
   Age: ______________________
   Medical condition: __________

3. Name: ______________________ Location: _______________________________
   Age: ______________________
   Medical condition: __________

4. Name: ______________________ Location: _______________________________
   Age: ______________________
   Medical condition: __________

5. Name: ______________________ Location: _______________________________
   Age: ______________________
   Medical condition: __________

6. Name: ______________________ Location: _______________________________
   Age: ______________________
   Medical condition: __________

Grandchildren: Y  N  How many: _________________________________________

Current family constellation: _____________________________________________

Housing situation: _______________________________________________________

Length of time at current residence: _______________________________________

Education: __________________________________________________________________

Military history: __________________________________________________________________

Religious involvement: __________________________________________________________________

Interests/Hobbies: __________________________________________________________________
Transplantation

Adjustment to kidney disease:

Compliance to medical regime:
  Dialysis schedule:
  Medications:
  Diet:
  Fluid restriction:
How learned about transplantation:

Reason want transplant:

Commitment to transplant:
Family’s attitude toward transplant:
Primary support person:
  Name:
  Availability to assist:
Potential donors:

Expectations following transplant:
Psychosocial Assessment

Do you smoke: Y N
If not now, did you in the past: Y N
When did you quit: ________________________________

Do you drink alcohol: Y N
If yes, how much: ________________________________
If no, when did you stop: __________________________
Ever had a problem with alcohol: ___________________

Any DUI's: ________________________________
Ever been treated for alcoholism: Y N
When: ___________________ Where: ______________

Do you use illicit drugs: Y N
If not now, did you in the past: Y N
If yes, what kinds of drugs: ________________________________
   How often: ________________________________
   Any legal problems related to this use: ________________________________
   When did you stop: ________________________________
   Any treatment received: Y N
   If yes, when: ________________________________
   where: ________________________________

Any medications for emotional/psychiatric problems: Y N
Any therapy/counseling for emotional/psychiatric problems: Y N
Any hospitalizations for emotional/psychiatric problems: Y N
If yes, for what diagnosis: ________________________________
   What medications: ________________________________
   For how long: ________________________________
   When hospitalized or received treatment: ________________________________
   Where: ________________________________
   Any suicide attempts: Y N When: ________________________________

Any legal problems: Y N
If yes, for what: ________________________________
When: ________________________________
Results: ________________________________
Social Work Evaluation

The following issues were addressed in the psychosocial evaluation:

_____ Social, personal, housing, vocational, financial, and environmental supports.

_____ Coping abilities and strategies.

_____ Understanding of the risks and benefits of transplantation.

_____ Ability to adhere to a therapeutic regimen.

_____ Mental health history, including substance or alcohol use or abuse and how it may impact the success or failure of organ transplantation.

______________________________
Signature

77
**Renal Transplant History Form**

Name: ___________________________  Age: ________

Who referred you for transplantation? ________________________________

What is the cause of your kidney failure? ________________________________

Are you on dialysis?  Yes  No  (circle)

If yes, Hemodialysis or Peritoneal Dialysis  (circle)

If Hemodialysis, which days? ________________________________________

Do you still make urine?  Yes  No  (circle)  how much? ________________

Do you have a potential living donor?  Yes  No  (circle)

**Past Medical History** (please check all that apply)

- Diabetes
- High blood pressure
- Heart problems
- Asthma/lung problems
- Strokes
- Blood Clots
- Kidney stones
- Urinary infections
- Blood in urine
- Hepatitis
- Bleeding disorders
- Vascular disease
- Lupus
- Cancer
- Stomach problems
- Intestinal problems
- Other ________________________________
List all of your surgeries:


List all of your medications:


List all of your allergies:


Social History

Occupation:

Married _____ Single _____ Divorced _____

Children? _____ If so how many: _____

Do you smoke? _____ if yes, how many packs per day? _____

Previous smoker? _____ if yes when did you quit? _____

Do you use alcohol? _____ if yes how much? _____

Do you use recreational drugs? _____ if yes, which? _____
List your family medical problems:

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RENAI TRANSPLANT PATIENT INFORMATION FORM

PATIENT NAME ____________________________

DATE OF BIRTH __________________________ SOCIAL SECURITY ____________________________

HOME ADDRESS __________________________ APT OR LOT # ____________________________

CITY __________________________ STATE __________________________ ZIP CODE ____________________________

HOME PH __________________________ CELL PH __________________________

MARITAL STATUS __________________________ RELIGIOUS PREFERENCE ____________________________

EMPLOYER NAME __________________________

ADDRESS __________________________ CITY __________________________

STATE __________________________ ZIP CODE __________________________ PHONE ____________________________

IF YOU ARE ON DIALYSIS, WHAT WAS YOUR START DATE? ____________________________

NEPHROLOGIST __________________________ PCP / FAMILY PHYSICIAN ____________________________

MEDICARE # __________________________ EFF. DATE-PART A __________ PART B __________

OHIO OR MICHIGAN MEDICAID # __________________________

COMMERCIAL INSURANCE - NAME __________________________

ADDRESS __________________________ CITY __________________________

STATE __________________________ ZIP CODE __________________________ PH ____________________________

POLICY # __________________________ GROUP # __________________________

POLICY HOLDER NAME (IF DIFFERENT FROM PATIENT) __________________________

DATE OF BIRTH __________________________ SOCIAL SECURITY ____________________________

EMPLOYER __________________________

PRESCRIPTION COVERAGE - COMPANY __________________________

PHONE __________________________ AMOUNT OF CO-PAY ____________________________

EMERGENCY CONTACT __________________________

NAME/ RELATIONSHIP __________________________

ADDRESS __________________________ APT OR LOT # __________________________

CITY __________________________ STATE __________________________ ZIP CODE ____________________________

HOME PH __________________________ CELL OR BUSINESS PH __________________________

**PLEASE USE BACK OF FORM IF ADDITIONAL SPACE IS NEEDED**

T / Renal / Orientation / Monthly Meeting information / Renal Transplant Information Form
Transplantation
Review of Systems

Patient Name:__________________________
Primary Physician:______________________
Endocrinologist:_______________________
Gastroenterologist:_____________________
Cardiologist:__________________________

TO BE COMPLETED BY PATIENT
Please complete both sides of this form to the best of your knowledge.
If you have any question concerning any of the items listed, please ask a clinic assistant for help.

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<td>Loss / Gain Amt.</td>
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<td>Change in color of nails/ nail texture / clubbing</td>
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<td>Lymph Node Problems</td>
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<tr>
<td>Headache / facial Pain</td>
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<td>Stiffness / limited Neck Motion</td>
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<td>Glasses to read</td>
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<td>Glasses to drive</td>
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<td>Dizziness</td>
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| Nose Bleeds |
| No |
| Yes |

| Flu |
| No |
| Yes |

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<td>Murmur</td>
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<td>Palpitations</td>
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<td>Shortness of breath</td>
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<td>at rest</td>
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<td>exertion</td>
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<td>Difficulty breathing when flat</td>
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<td>Ankle swelling</td>
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<td>Pain in calves of legs</td>
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<td>Cold extremities</td>
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<td>Blood clots in legs</td>
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<td>Problems with clogged dialysis Fistula</td>
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<td>Coughing up blood</td>
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<td>Sputum production</td>
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<td>Night sweats</td>
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<td>h/o asthma / wheezing</td>
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<td>TB had exposed</td>
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<td>Flu Shot</td>
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Flight of stairs: ________________________
Transplantation
Review of Systems

Gastrointestinal
☐ No ☐ Yes Abdominal pain / nausea / vomiting
☐ No ☐ Yes Problem with CAPD Peritonitis
☐ No ☐ Yes Heartburn / Acid Reflux
☐ No ☐ Yes Recurrent Vomiting
☐ No ☐ Yes Peptic Ulcer Disease
☐ No ☐ Yes Black tarry stools
☐ No ☐ Yes Diarrhea / Constipation /
Change in bowel habit
☐ No ☐ Yes Chronic Diarrhea

Genito-Urinary
☐ No ☐ Yes Frequent Urination
☐ No ☐ Yes Urinating at Night
☐ No ☐ Yes Urgency
☐ No ☐ Yes Difficulty starting urine
☐ No ☐ Yes Dribbling
☐ No ☐ Yes Incontinence
☐ No ☐ Yes Blood in Urine
☐ No ☐ Yes Stones in Urine
☐ No ☐ Yes Urinary Tract Infection

Psychiatric
☐ No ☐ Yes Psychosis
☐ No ☐ Yes Depression
☐ No ☐ Yes Anxiety
☐ No ☐ Yes Treatment

Neurologic
☐ No ☐ Yes Numbness in extremities
☐ No ☐ Yes Weakness in extremities
☐ No ☐ Yes Memory loss
☐ No ☐ Yes Confusion
☐ No ☐ Yes Unsteady gait
☐ No ☐ Yes Stroke / Mini-stroke
☐ No ☐ Yes Seizure / Fits

Musculo-Skeletal
☐ No ☐ Yes Foot Ulcers
☐ No ☐ Yes Broken Ankle
☐ No ☐ Yes Broken Foot
☐ No ☐ Yes Arthritis
☐ No ☐ Yes Weak bones

Male
☐ No ☐ Yes Pain
☐ No ☐ Yes Dark Urine
☐ No ☐ Yes Pain with Urination
☐ No ☐ Yes Urethral discharge
☐ No ☐ Yes Testicular pain

Female
Age at Menopause
☐ No ☐ Yes Post menopausal bleeding
Last pap smear
Results:
Last Mammogram
Results:
Birth Control Method:
☐ No ☐ Yes Significant breast enlargement
☐ No ☐ Yes Lumps
☐ No ☐ Yes Pain
☐ No ☐ Yes Discharge
☐ All Other Systems Negative

Signature ___________________________ Print Name ___________________________ Date/Time ___________________________
KIDNEY TRANSPLANT RECIPIENT INFORMATION

Demographic Information:

Date: ____________________ Med Record #: ____________________ DOB: ____________________

Full Name (incl. middle and maiden): ____________________

Address: ____________________

County of Residence: ____________________ SSN: ____________________

Telephone: ____________________ Cell phone: ____________________ Pager: ____________________

Sex: ____________________ Age: ____________________ Race: ____________________ Ht: ____________________ Wt: ____________________

Marital Status: ____________________ Spouse's name: ____________________

Emergency contact: ____________________ Relationship: ____________________ Phone Number: ____________________

Employer: ____________________

Address: ____________________

Phone: ____________________ Length of time there: ____________________

If not working, date of last employment: ____________________

Current source of income: ____________________

Employment history last 10 yrs.

Insuranc Information: Medicare Part A Part B Effective Date: ____________________

Medicaid Amount of Spend-down: ____________________

Commercial insurance: ____________________

Prescription benefits: ____________________

Spouse's occupation: ____________________

Spouse's employer: ____________________

Health insurance: ____________________

Medical condition: ____________________

Doctors: PCP: ____________________

Nephrologist: ____________________

Date first told had kidney disease: ____________________

Cause of kidney disease: ____________________

Transplant in the past: Y N How many: ____________________ When: ____________________

On dialysis now: Y N Date started: ____________________ Type: ____________________

Where: ____________________ Phone: ____________________

Date and times of dialysis: ____________________ Dry Wt: ____________________

__________________________________________

Signature
Psychosocial Evaluation:

Birthplace ____________________________

Parents:
- Mother: Name ____________________________ Age: ________
  Still living Y N Occupation: ____________________________
  Comments: ____________________________
- Father: Name ____________________________ Age: ________
  Still living Y N Occupation: ____________________________
  Comments: ____________________________

Parents marital status ____________________________

Siblings: How many: ________
1. Name ____________________________ Age: ________
   Illnesses: ____________________________
2. Name ____________________________ Age: ________
   Illnesses: ____________________________
3. Name ____________________________ Age: ________
   Illnesses: ____________________________
4. Name ____________________________ Age: ________
   Illnesses: ____________________________
5. Name ____________________________ Age: ________
   Illnesses: ____________________________
6. Name ____________________________ Age: ________
   Illnesses: ____________________________

Birth order: ____________________________

Marital History: ____________________________

Quality of Relationship: ____________________________

Children: Y N How many: ________
1. Name ____________________________ Age: ________
2. Name ____________________________ Age: ________
3. Name ____________________________ Age: ________
4. Name ____________________________ Age: ________
5. Name ____________________________ Age: ________
6. Name ____________________________ Age: ________
7. Name ____________________________ Age: ________

Grandchildren: Y N How many: ________

Current family constellation: ____________________________

Housing Situation: ____________________________

Length of time at current residence: ____________________________

__________________________
Signature
Educational level:

Military History:

Religious Involvement:

Interests/Hobbies:

Adjustment to kidney disease and reason want transplant:

Commitment to transplant:

Family's attitude toward transplant:

Expectations following transplant:

Do you smoke: Y N How much: # of years:
If not now, did you in the past: Y N (If yes, answer above questions)

Do you drink alcohol: Y N How much: # of years:
Ever been treated for alcoholism: Y N When:

Do you use illicit drugs: Y N What kind:
How much: How often:
Ever been treated for drug addiction: Y N When:
What:

Have you ever been treated for psychiatric problems: Y N
What: When:
MD:

Have you ever had problems with the law: Y N
What: When:
Results:

Comments:

Social Worker Evaluation:


Signature
**Medical Information:**

Allergies: 

Medications:
1) 
2) 
3) 
4) 
5) 
6) 
7) 
8) 
9) 
10) 
11) 
12) 

List all surgical procedures and dates:

List all serious accidents and injuries and dates:

Blood Type: ___________ Ever had a blood transfusion: Y N
How many: ___________ When: ___________

Ever been treated for a urinary tract infection: Y N
When and treatment: ___________
MD: ___________

Do you have high blood pressure: Y N How many yrs: ___________
How is it controlled: ___________
MD: ___________

Signature
Have you ever been told you have heart disease: Y N
When 1st diagnosed: ____________________________ Type of problem: ____________________________
Cardiologist: ____________________________________________________________

Do you have a family history of diabetes: Y N Who: ____________________________
Are you diabetic: Y N How long: ______ How is it controlled: ____________________________
MD: ____________________________

Have you ever been treated for cancer: Y N What type: ____________________________
Date diagnosed: ____________________________ Treatment: ____________________________
MD: ____________________________

Have you ever been treated for gastrointestinal problems: Y N
What treatment: ____________________________ When: ____________________________
MD: ____________________________

Have you ever been treated for colon disease: Y N Diverticulitis: Y N
When and treatment: ____________________________________________________________
MD: ____________________________

Have you ever been treated for a GI bleed: Y N When: ____________________________
Treatment: ____________________________
MD: ____________________________

Have you ever been treated for liver disease: Y N Hepatitis: Y N
When and treatment: ____________________________
MD: ____________________________

Have you ever been treated for a deep vein thrombosis: Y N
When and treatment: ____________________________
MD: ____________________________

Do you have menstrual periods: Y N How often: ____________________________
If no, describe: ____________________________
Number of pregnancies: ______ Live births: ______ Miscarriages: ______

Do you gain wt. between dialysis treatments: Y N How much: ____________________________
Do you have trouble with your blood pressure dropping during or at the end of dialysis:
Y N Solution: ____________________________
Do you have problems with your lab values being abnormal between dialysis treatments:

__________________________ ____________________________
Signature
Have you ever had a kidney biopsy:  Y  N  When: ______________________
Open:  ___________  Closed:  ___________

Was the original disease treated with immunosuppression:  Y  N
What: ___________________________
How much urine do you make a day: ___________________________
Void more at night or during the day: ___________________________

Are there any family or friends willing to be worked up to donate a kidney?

1) ___________________________
2) ___________________________
3) ___________________________
4) ___________________________
5) ___________________________
6) ___________________________

Signature
## Appendix B

Forms Used to Gather Information

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<th>Job Description</th>
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Rate from 1-5, 5=Strongly agree, 4=Agree, 3=No opinion, 2=Disagree, 1=Strongly disagree

**Orientation**

1. Orientation was informative about a kidney transplant and its process. ____
2. After orientation I knew what was required of me to be a kidney recipient. ____
3. Orientation clearly defined what I needed to do next to become a kidney recipient. ____
4. I felt overwhelmed at all the information that was given to me at orientation. ____
5. The orientation staff was friendly and courteous. ____
6. Orientation was useful and I would highly recommend it. ____

**Clinical Evaluation**

1. I felt many of the same questions were repeated throughout the clinical? ____
   a. How many siblings?
   b. The health of your family?
2. I felt well informed about the kidney transplant after attending the clinical? ____
3. I clearly understood what was required of me after attending the clinical? ____
4. The clinical staff was friendly and courteous. ____
5. The transplant team made it clear what tests needed to be completed before being presented to the review board. ____
6. I felt that I had enough time with the doctor so that all my questions were answered. ____

Answer with a Yes or No.

**Miscellaneous Questions**

1. Where you ever directed to the website? Yes/No
2. If more information was made available through the internet would you use it? Yes/No
3. Would you feel comfortable giving the required background information through the internet? Yes/No
   a. Past medical information
   b. Medications
   c. Age, Sex, The number of siblings
4. Did you like only going to the hospital once to meet with the doctor, coordinator, social worker, and financial officer at the clinical? Yes/No

Rate from 1-5, 5=Excellent, 4=Good, 3=No opinion, 2=Average, 1=Poor

**Quality Questions**

1. The kidney transplant team’s knowledge about the kidney transplant process and/or questions you may have had was ____.
2. The transplant team’s promptness in returning questions or concerns was ____.
3. The overall quality of your interactions with the transplant team was ____.
4. Overall I felt the punctuality of the staff was ____.

**Open Ended Questions**

1. In terms of quality for the pre-operational kidney transplant process what is most important as a patient?

2. Is there anything that you can think of that could help improve the renal transplant process?