
The Role of Continuous Improvement in Health Care

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Agenda

- ▶ The Role of Continuous Improvement
 - *The NAE/IOM report (2005)*
 - *The Role of Statistics and Lean techniques*
- ▶ Success Stories
 - *Systems engineering at MD Medical Cancer Center*
 - *Lean applications at Virginia Mason*
 - *Six Sigma at Charleston Area Medical Center*
- ▶ Examples
 - *QFD, VSM, SPC, Predictive modeling, FMEA, Optimization, Scheduling, Forecasting, Autocorrelated data (ARIMA)*

The NAE/IOM Report

- ▶ Healthcare expenditures will reach \$3.30 trillion by 2013 [National Health Expenditure Data Projections].
- ▶ *Building a Better Delivery System: A New Engineering/Health Care Partnership* [Reid et al.]
- ▶ The report concluded the need to include new techniques that could lead to meaningful and sustained improvements in healthcare.
- ▶ Some of these techniques include: QFD, Tools for failure analysis, Modeling and simulation, Optimization tools, Predictive modeling, SPC, scheduling, etc.

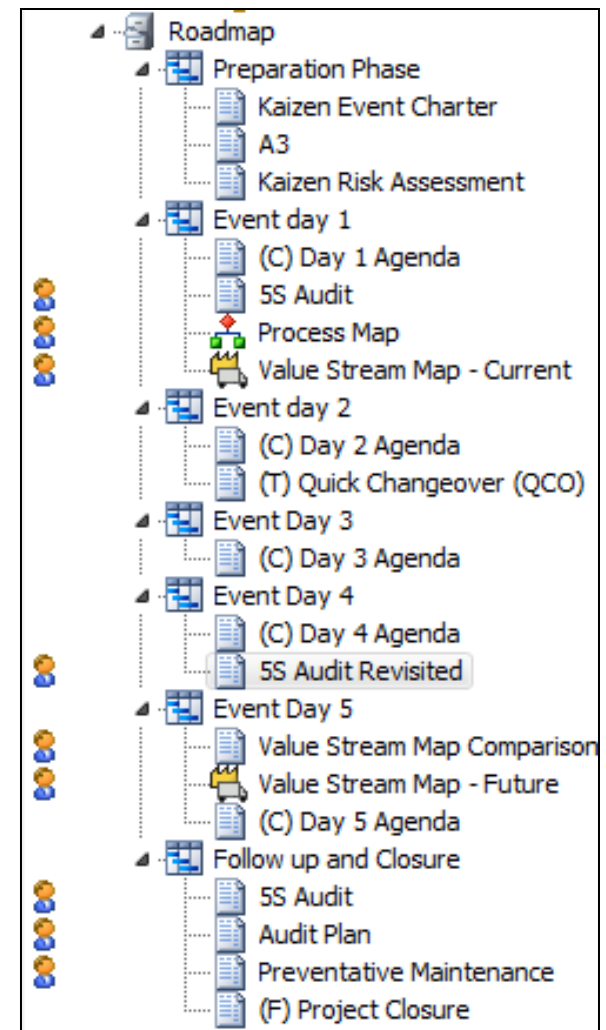
The Role of Lean in Healthcare

- ▶ Design a better layout
- ▶ Reduce patient wait times
- ▶ Eliminate non-value added steps to improve efficiency, reduce cost
- ▶ Design processes to be mistake-proof
- ▶ Balancing work, Leveling
- ▶ Quick changeover (SMED)
- ▶ Kanban, 5 S (visual workplace)
- ▶ From push to pull

The Role of Lean in Healthcare

What are the benefits of a Lean program?

1. It's easier to implement
2. May not necessarily require capital investment
3. Can lead to standardization of activities originally performed differently by each surgeon (Stanford hospital)
4. Help streamline a process that is traditionally linear (patient visit)



The Role of Lean (Muda)

Table 1 Seven mudas (wastes) of the healthcare industry Jimmerson (2007).

Muda (waste)	Description
Confusion	People doing the work are not confident of the way to perform the tasks. For example: Unclear M.D. orders, same activities performed in different ways by different people.
Motion	Movement of people that does not add value. For example: Materials/tools located far from the work, looking for people.
Waiting	Idle time created when people, information, equipment or materials are not at hand. For example: Waiting for other people at meetings, surgeries, procedures.
Inventory	To have obsolete duplicated or unnecessarily stored materials or to have patients waiting can be considered inventory. For example: Patients waiting in the emergency department.
Processing	All activities that do not add value from the patient/customer perspective. For example: clarifying orders, redundant information gathering/charting, missing medications.
Defects	Work that contains errors or lack of something of value. For example: Medication errors, rework and variation in outcomes.
Overproduction	Redundant work. For example: Duplicate charting, multiple forms, with the same information

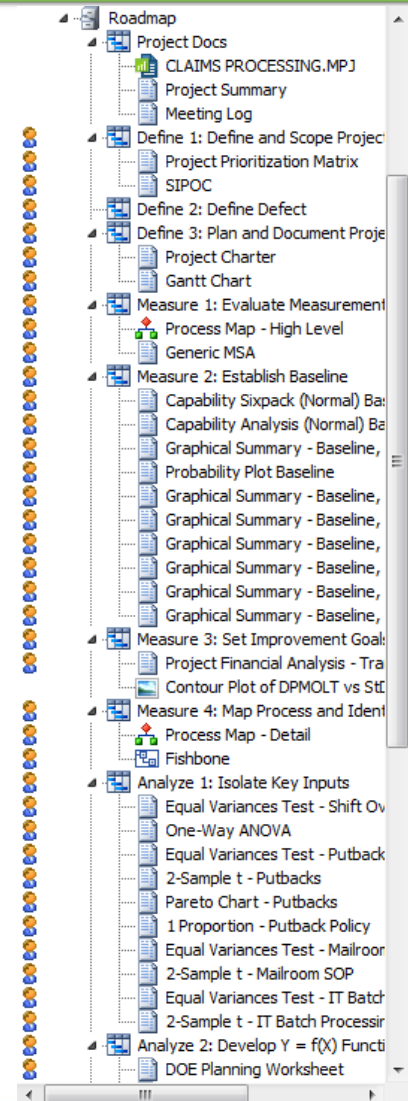
The Role of Statistics in Healthcare

- ▶ Process improvement with Design of Experiments.
Challenge: Most systems cannot be interrupted and need to continue to run. (Discrete Event Simulation)
- ▶ Predict the volume of work (i.e. the number of patients)
- ▶ Reduce the variation in a process
- ▶ Monitor the stability of an important single or set of quality characteristics
- ▶ Usually, requires a more quantitative approach, problems could be more challenging than those in Lean projects
- ▶ The DMAIC methodology naturally relies on the good use of Statistics to solve problems

The Role of Statistics in Healthcare

What are the benefits of a Six Sigma program?

1. Its benefits have been shown in both manufacturing and service industries
2. Tools are available for most practitioners
3. Several successful case studies published and available in the literature



Success Stories

These is just a small sample of the vast number of improvement efforts in Healthcare.

1. MD Anderson Cancer Center – Systems Engineering
2. Virginia Mason – Lean
3. Charleston Area Medical Center – Six Sigma

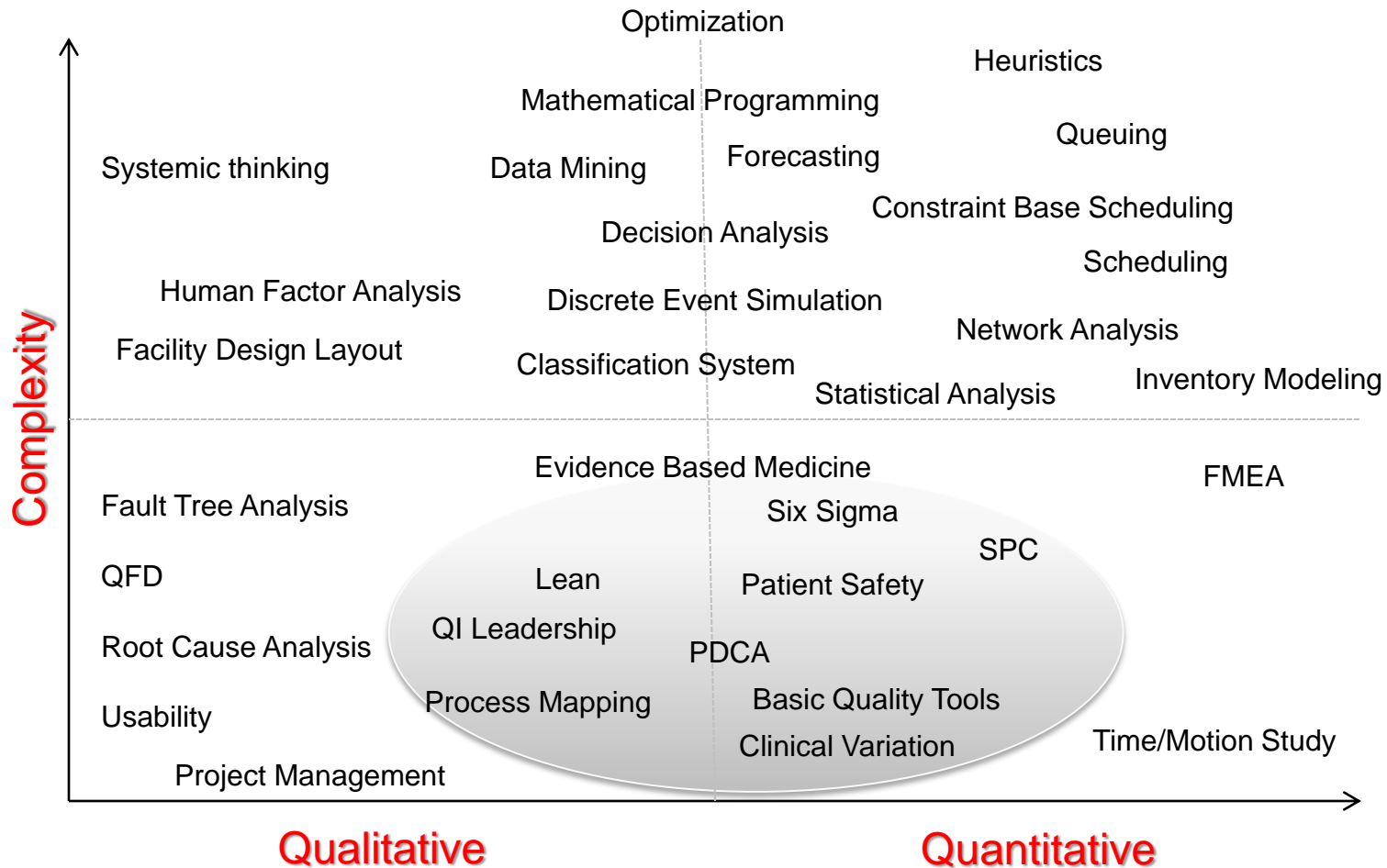
Success Stories (MD Anderson)

For eight of the past 10 years, including 2011, MD Anderson has ranked No. 1 in cancer care in the "America's Best Hospitals" survey published in *U.S. News & World Report*.

Components of Systems Engineering:

1. Frontline improvement initiatives (6 σ , Lean, Standardize)
2. QE Methods (SPC, Reliability, Engineering Economics)
3. Process Optimization (Scheduling, simulation, staffing)
4. Human Factors (Ergonomics, Safety)
5. Logistics (Facility layout, Supply chain, Inventory)
6. Data Mining and Analytics (Clinical informatics, DM)

Success Stories (MD Anderson)



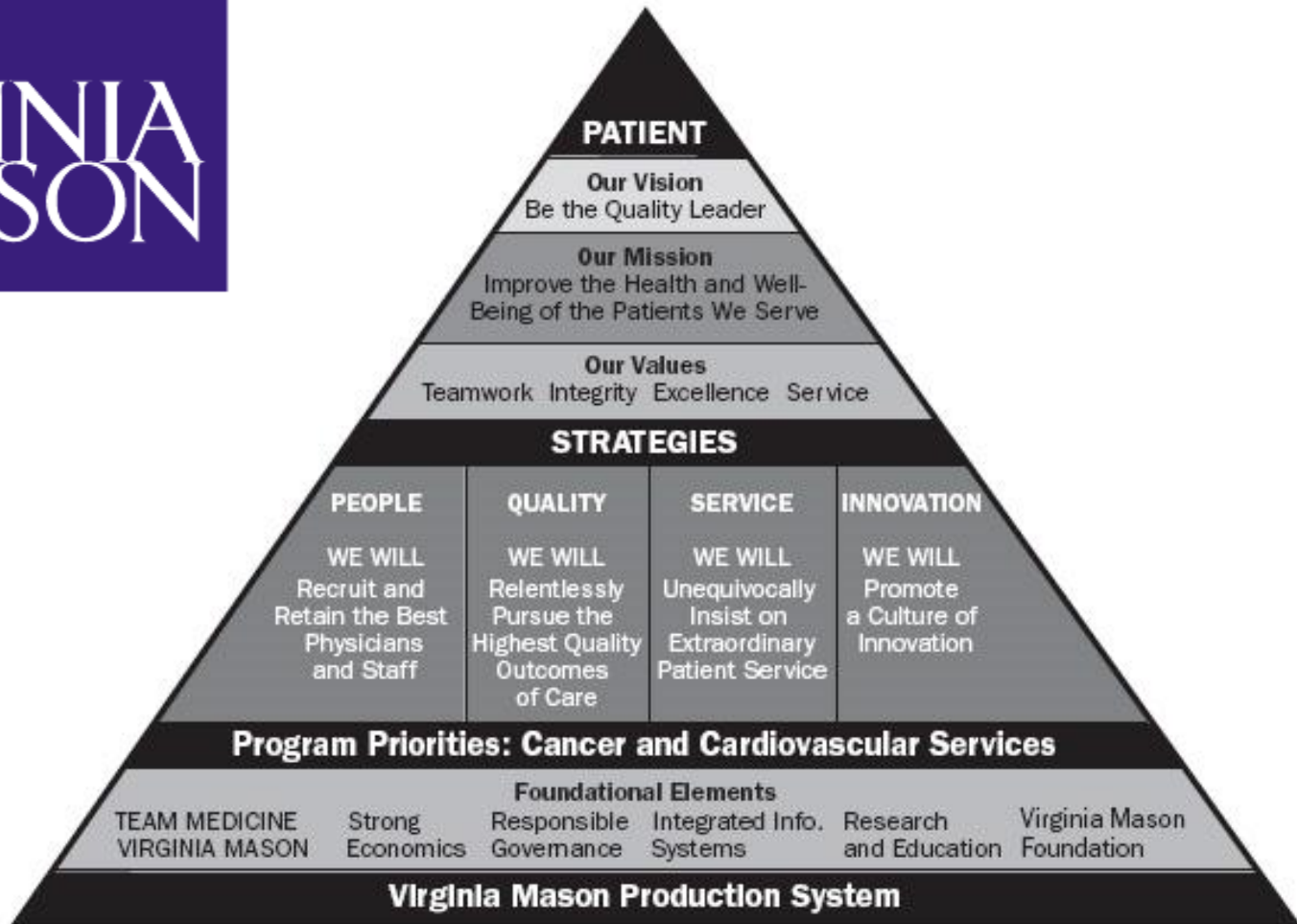
Adapted from *Systems Engineering in Healthcare and How Statistics Plays a Role* by Dr. Victoria Jordan

Success Stories (MD Anderson)

Several Six Sigma projects have been completed at UT MD Anderson Cancer Center.

1. Decrease expired drugs in outpatient pharmacies.
2. Reduce the number of On Demand Inventory Picks for the central pharmacy.
3. Increase material scanning compliance in ICU supply rooms.
4. New process in Leukemia Center reduced patient walking distance by 89%, and patient wait time by 36%.

Success Stories (Virginia Mason)



Success Stories (Virginia Mason)

In 2002, Virginia Mason started a Lean initiative and since then they have achieved various improvements. Some of them are listed below:

1. Savings between \$12-15 million dollars
2. Reduction of inventory by over 50%
3. Reduction of lead time by 65%
4. Distance traveled by people (44% down)

Success Stories (Charleston Area MC)



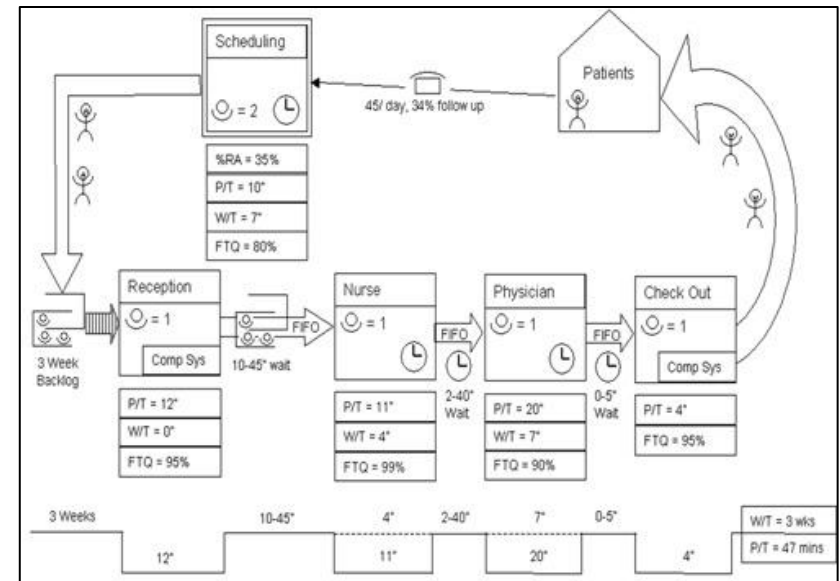
1. Overall goal to identify and address inefficiencies in workflow processes related to patient flow and staffing.
2. Reduced waiting times for appointments.
3. Reduced length of clinic visits and increased patient satisfaction, clinic volume, and revenues.
4. Specifically waiting times for an obstetric appointment decreased from 38 to 8 days, the wait for a new gynecologic appointment declined from 60 to 25 days.

Some Classic Lean Tools

Value Stream Mapping

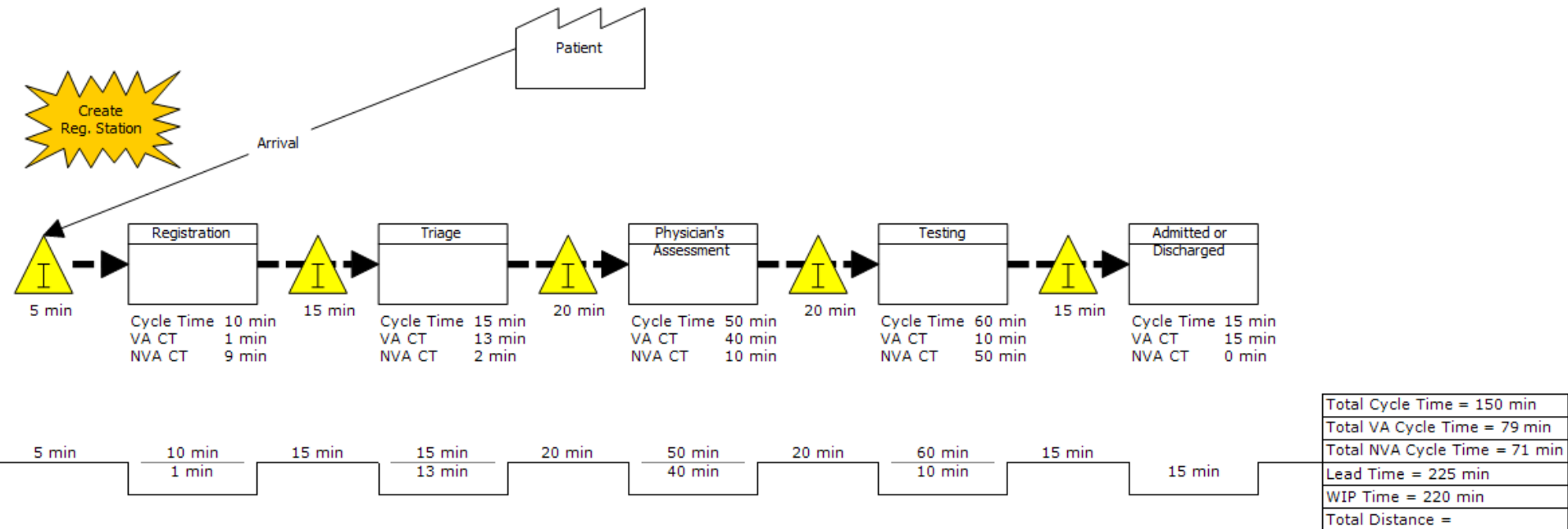
Five Basic Principles:

1. Precisely specify value for each process
2. Identify the value stream for each process
3. Make value flow without interruption
4. Let customer pull value
5. Pursue perfection



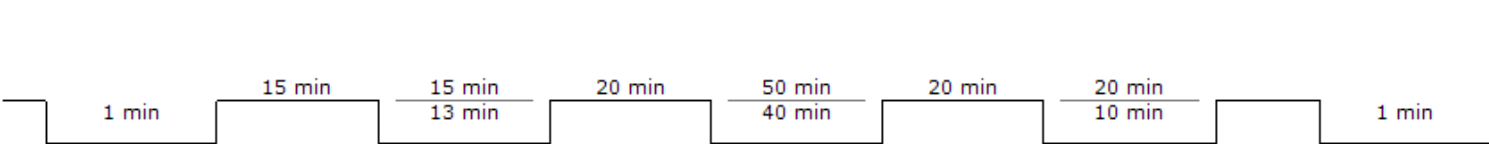
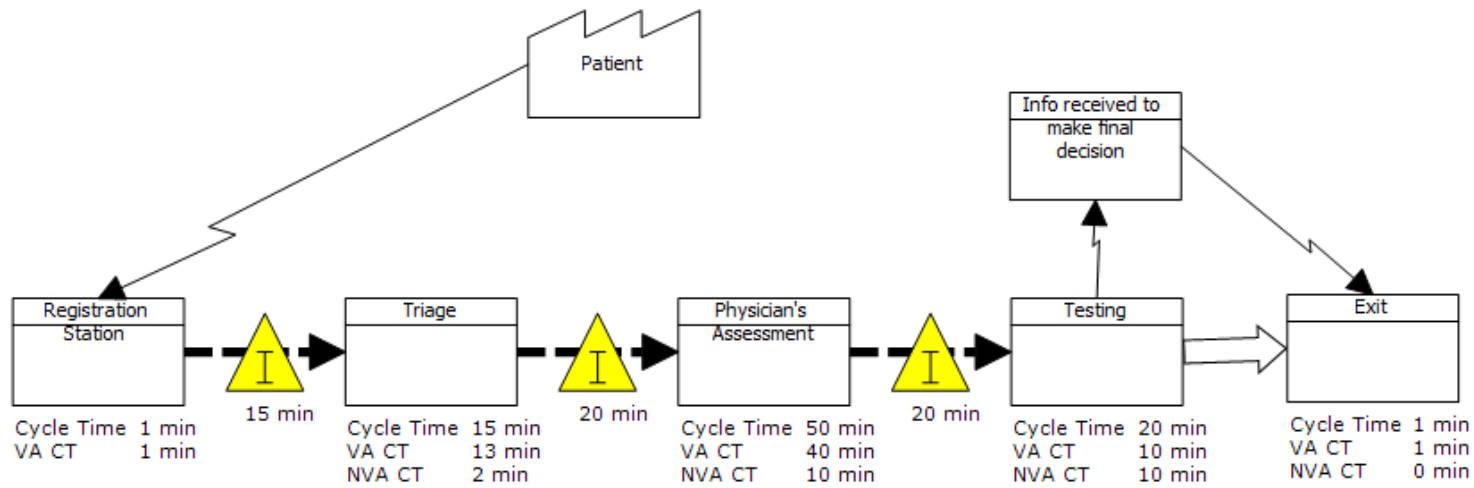
Value Stream Mapping

Current State of an Emergency Room



Value Stream Mapping

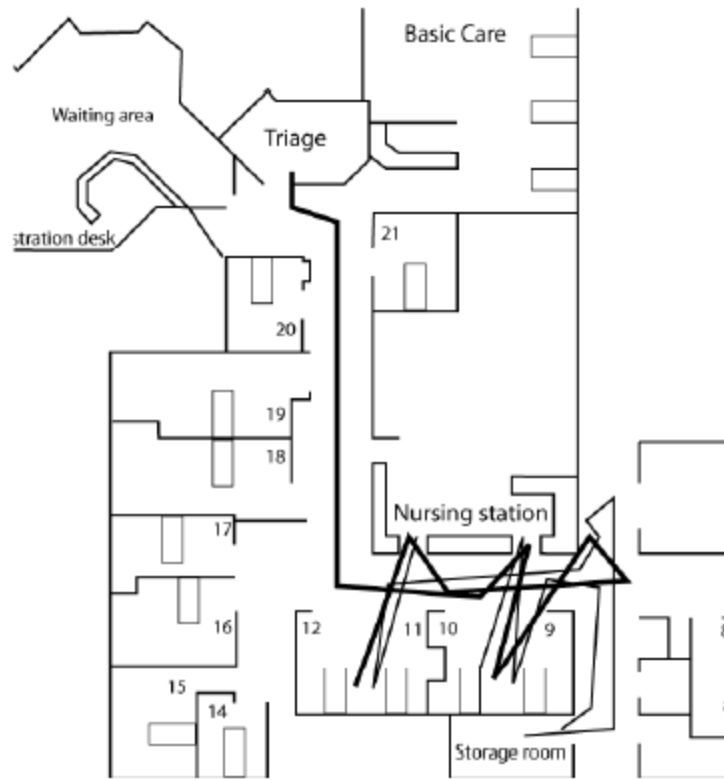
Future State of an Emergency Room:



Total Cycle Time = 87 min
Total VA Cycle Time = 65 min
Total NVA Cycle Time = 22 min
Lead Time = 142 min
WIP Time = 142 min
Total Distance =

Spaguetti Diagram

Helps track visually a path taken by a patient or employee in a given timeframe while performing their assigned duties.



Spaguetti Diagram

An A3 Report is a mechanical tool that embodies the PDCA thought process that underlies all LEAN implementations.

I.- Issue <p>After a problem is identified, an A3 report should be started immediately. In this section the person developing the A3 should write a brief description of the problem.</p>	V.- Target condition <p>In this section, the team brainstorms on a future state for the organization and draws the appropriate Value Stream Map to describe that state (Sobek & Jimmerson, 2007). The drawn "future state map" uses information gathered in the previous sections of the A3 Report and assumes that the suggested changes in activities will be accomplished in a period of not longer than one year. If management believes a change should be made in an activity for the immediate benefit of the organization, regardless of the cost or time for its implementation, then an "ideal state map" is drawn in addition to the future state map (Nash & Poling, 2008). According to Sobek, Sobek, & Smalley (2008) the goals in this section should be specific and measurable, and include a target date.</p>
II.- Background <p>This section contains information of the problem and its context.</p>	VI.- Countermeasures <p>This section describes the proposed countermeasures for addressing the root causes of the problem. This can be done by brainstorming or researching in the literature for solutions to a similar problem.</p>
III.- Current condition <p>This section is supported by the use of a Value Stream Map. The first step in a LEAN implementation is to go and observe the activities of an organization firsthand (Sobek & Jimmerson, 2007). During the observation, it is important to draw a current state map that portrays how the organization performs its activities today. The current state map should allow visualizing possible sources of waste that may be reduced or eliminated with the help of LEAN tools (Locher & Keyte, 2004).</p> <p>It is highly recommended that organization staff, including management and workers, review the current state depiction and confirm that it is accurate. As part of review process, the information used to populate the Value Stream Map should be checked for accuracy and updated as necessary. This accurate and updated information will help to set goals and quantify the expected improvements after implementation.</p>	VI.-Implementation plan <p>After a future state map is finished and countermeasures defined, this section records a work/action plan detailing the required improvements (commonly referred to as Kaizen events) necessary for realizing the future state (Locher & Keyte, 2004). According to Dixon (2008), this plan should carefully prioritize and schedule all required activities. In the end, success of the project will depend on the correct implementation of this work plan (Locher & Keyte, 2004).</p>
IV.- Cause Analysis <p>This section in the A3 Report documents the main source of the problem, which often is not obvious. If this step is not performed correctly, it will lead to an invalid solution, which will not improve the performance of the organization. Sobek and Jimmerson (2007) recommend the use of the "Five Whys" method to encourage a problem solver to go further in depth (at least five iterations) when identifying the root cause or origin of a problem and to avoid assumptions. According to Garavaglia (2008) failing to properly isolate the root cause of a problem will do nothing more than produce wrong answers.</p>	VI.- Follow up <p>In this section is indicated how and when the improvement of the process will be measured. A realistic and quantified prediction of how the new system will perform should be included.</p>

Some Classic Statistical Tools

Healthcare Challenges

- ▶ Samples correspond to finite populations
- ▶ Data is not always collected automatically
- ▶ Some data (related to patients) is difficult to obtain
- ▶ The environment is so dynamic, and constantly changing that it is difficult to study data at common cause level.

Control Charts

SPC is one of the most common applications used to monitor the stability of a process over time. However, several challenges can be presented.

1. Individual value control charts are frequently used because rational subgrouping is impossible
2. Assumptions in control charts about the true parameter being constant over the time frame are not always valid.
3. Often, no distribution model fits the data nor can the data be transformed.

G and T charts

- ▶ Rare event control charts
- ▶ Used to monitor time or opportunities between rare events
- ▶ Typically used in healthcare for:
 - Infections (e.g. nosocomial)
 - Medication errors
 - Patient falls
 - Ventilator-associated pneumonias
 - And other rare adverse events



Difference between G and T charts

▶ G chart

- Days between rare events
- Opportunities (e.g. surgeries or doses) between rare events
- Inputs:
 - Dates of events
 - Number of opportunities

▶ T chart

- Time between rare events
- Inputs:
 - Dates/times of events
 - Elapsed time between events

G chart example

- ▶ Each year, nosocomial infections cause millions of hospital days and thousands of deaths nationally.

↓	C1-D Infection Date
1	6/1/2010
2	6/6/2010
3	6/11/2010
4	6/20/2010
5	6/23/2010
6	6/25/2010
7	7/6/2010
8	7/11/2010
9	7/24/2010
10	7/25/2010
11	8/3/2010
12	8/4/2010

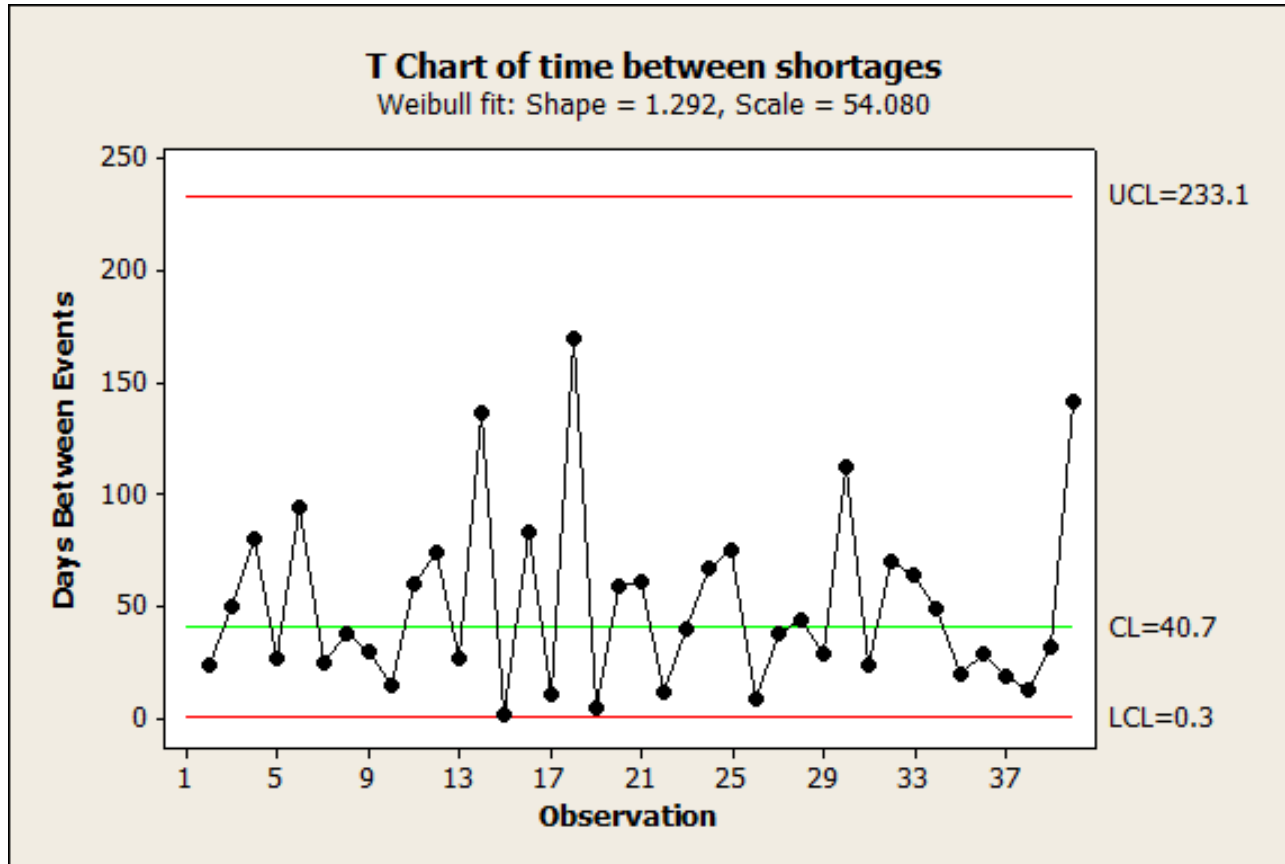


- ▶ Suppose we work for a hospital and want to monitor these infections so we can detect changes and react appropriately if our process goes out of control.

T chart example

The Agency for Healthcare Research & Quality estimates the incident rate for an adverse drug event (ADE) at less than seven per 100 hospital admissions nationwide, with a mean cost of \$4,685 per event (www.ahrq.gov/qual/errorsix.htm). Consider the time between errors made in medication.

T chart example



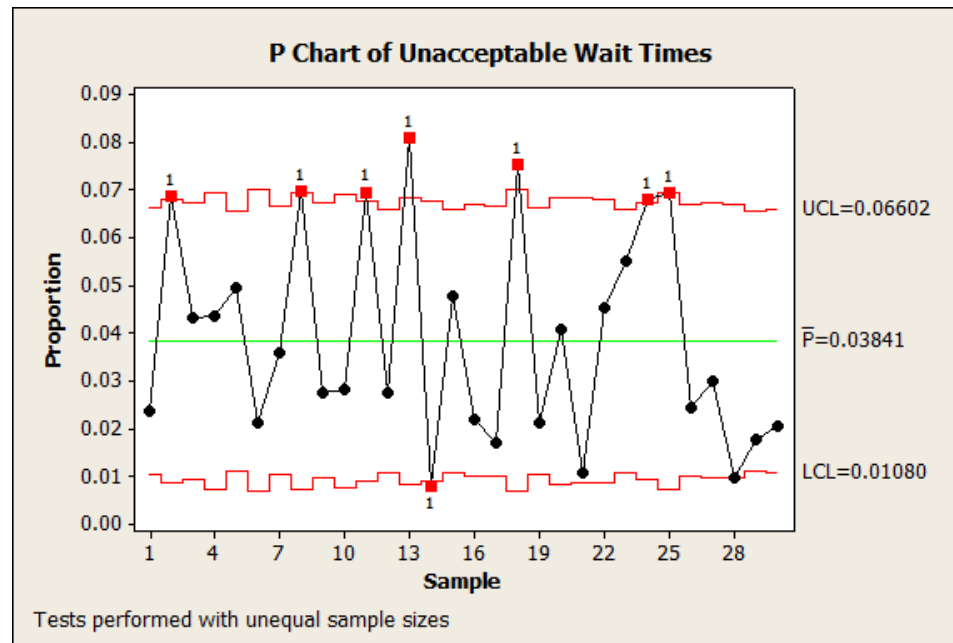
Dates
6/16/2006 12:33:40 AM
7/10/2006 4:09:35 AM
8/28/2006 3:41:45 PM
11/16/2006 9:36:52 AM
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3/17/2007 10:44:20 AM
4/11/2007 2:49:24 PM
5/19/2007 12:06:56 AM
6/17/2007 5:55:18 AM
7/1/2007 12:53:34 PM
8/30/2007 10:55:27 PM
11/12/2007 10:59:03 PM
12/9/2007 5:16:43 PM
4/23/2008 10:13:05 PM
4/24/2008 10:36:21 PM
7/16/2008 5:42:44 PM
7/27/2008 7:28:04 AM
1/13/2009 3:42:23 PM
1/17/2009 6:01:53 PM
3/17/2009 5:49:08 AM

P' and U' charts (Laney charts)

- ▶ Similar to P and U charts:
 - P' charts for defectives
 - U' charts for defects
- ▶ For large subgroup sizes where data exhibit “overdispersion” – excessive variation
- ▶ For case where true proportion of defectives/defects varies slightly over time, creating “overdispersion”

P' and U' charts – the problem

- ▶ Overdispersion occurs when binomial (P) or Poisson (U) distribution assumption is not valid
- ▶ Result is P and U charts with tight control limits and many out-of-control points



P' and U' charts – the solution

- ▶ Laney charts correct high false alarm rate by **expanding** the control limits so only important deviations are detected.

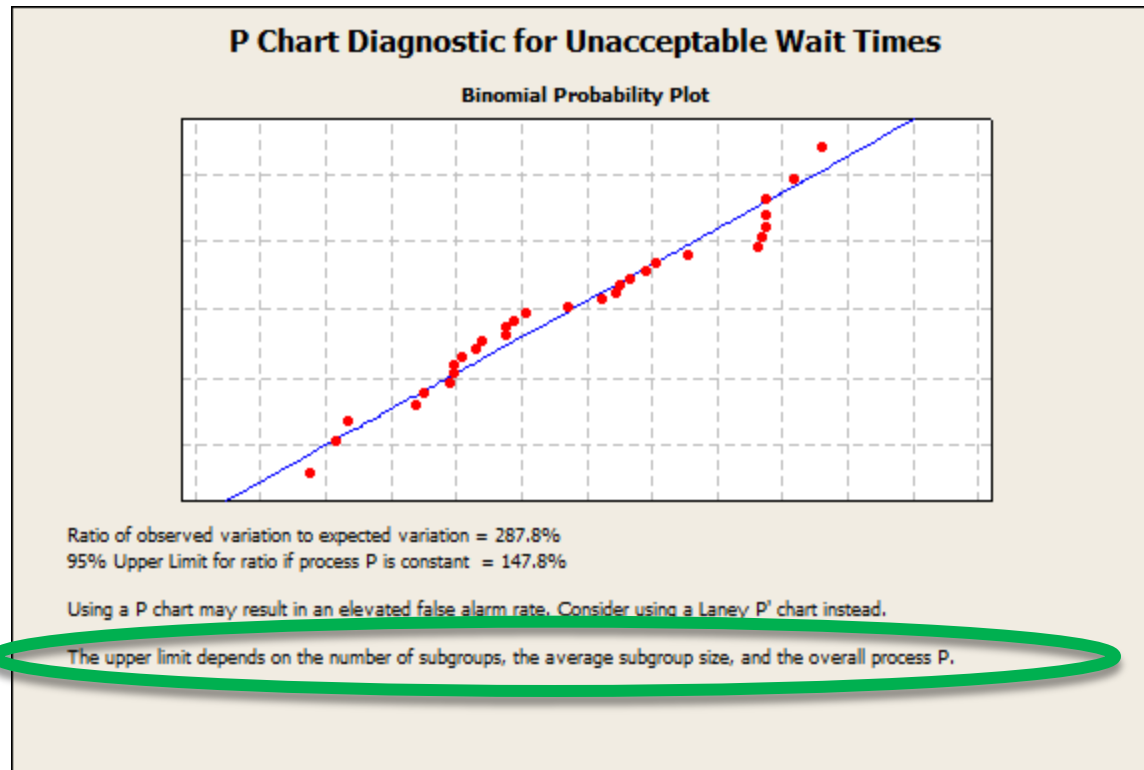
P' chart example

- ▶ Suppose we record the number of patients in a day that wait for too long, according to some internal maximum waiting time allowed. Hospital personnel need to evaluate the stability of the process to ensure it is in control and detect any special cause variation.

Unacceptable Wait Times	Subgroup Size
10	422
26	378
17	394
15	344
22	445
7	332
15	419
24	344
11	400
10	353
27	388
12	437
30	370
3	384
21	439
9	409
7	412

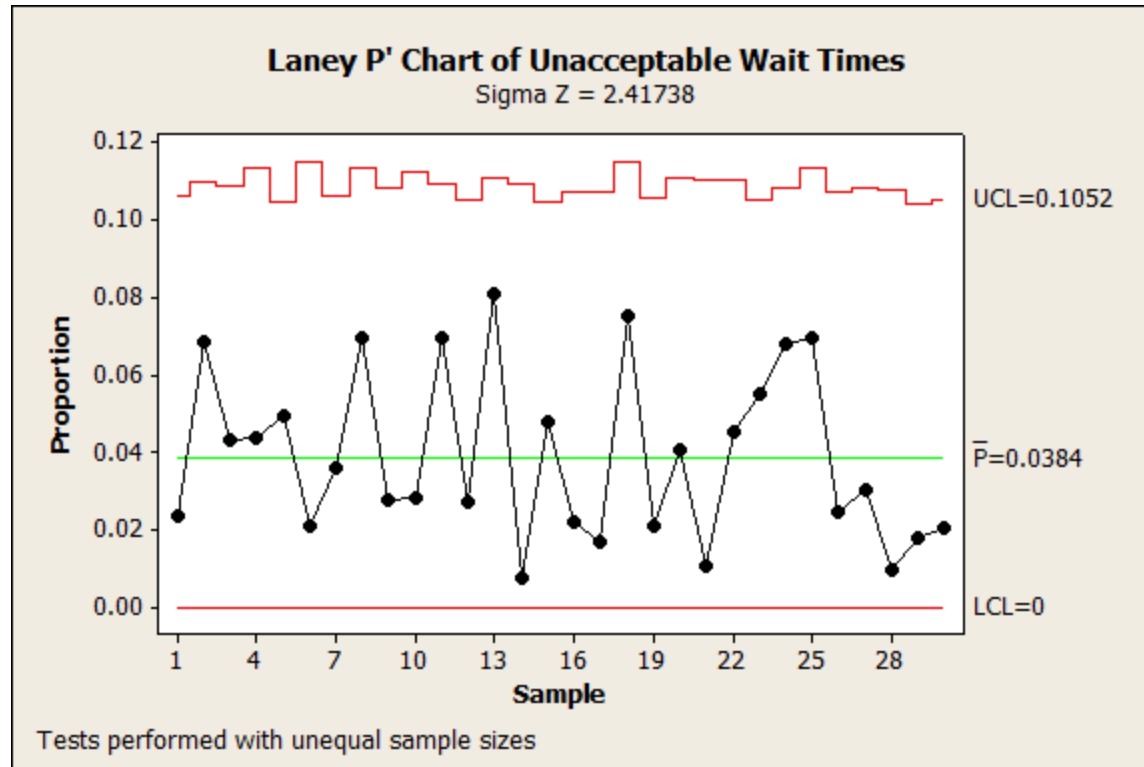
P' chart example – diagnostic

- ▶ Ratio of observed (within and between subgroup) to expected (within subgroup only) variation $> 147.8\%$
- ▶ Recommendation ▶ use a P' chart



P' chart interpretation

- ▶ Process is stable and in control

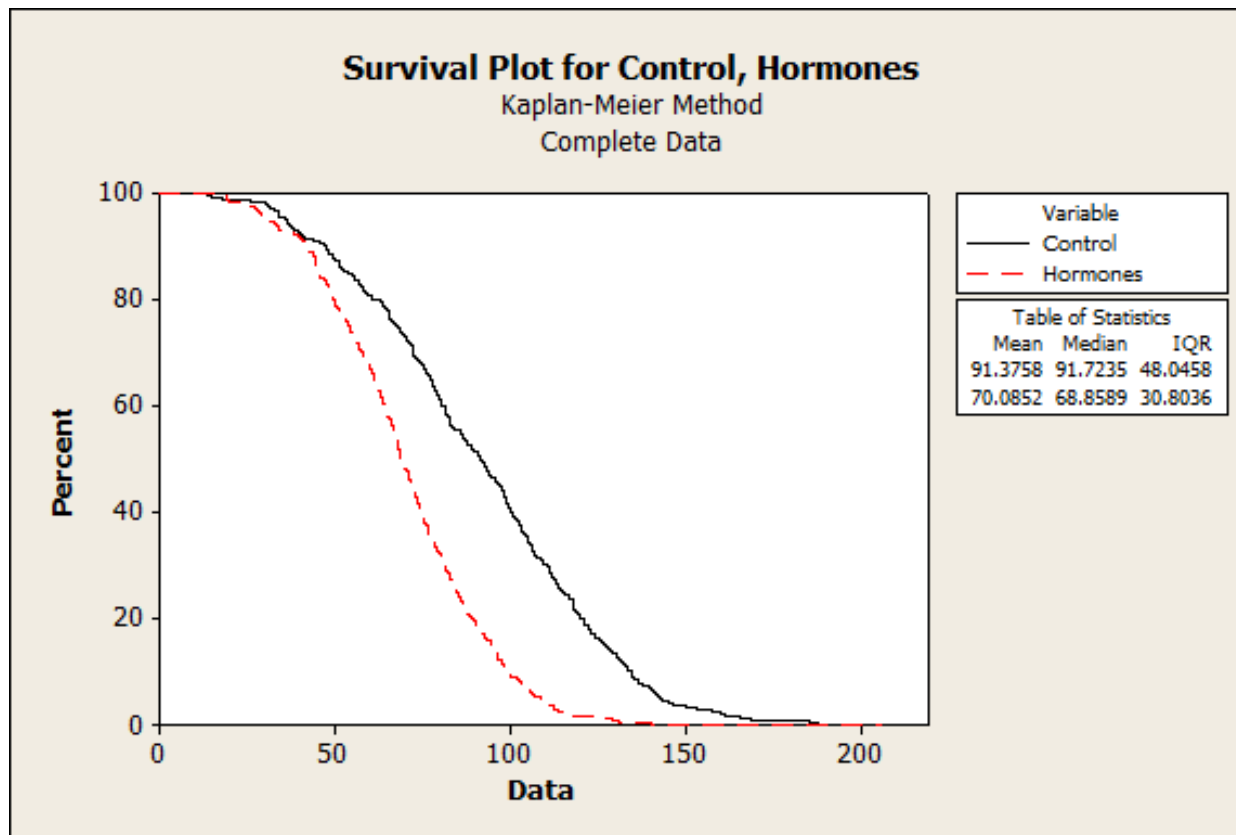


P' chart example – summary

- ▶ Large subgroup sizes ▶ tight limits on the P chart
- ▶ Diagnostic test ▶ more variation in data than expected
- ▶ P' chart uses both within *and between* subgroup variation to construct proper control limits
- ▶ Conclusion: process is stable

Clinical Trials

How Do I Know If a Recommended Treatment Works: An Introduction to a Clinical Trial, by Nancy Geller



Mixed Models (ANOVA)

A healthcare facility treats patients prior to knee surgery. They want to know the effect of giving patients a massage prior to surgery on the flexibility of the knee. So, half of the patients received massages, half did not and they recorded the flexibility of the two groups.

Mixed Models (ANOVA)

General Linear Model: Flexibility versus Treatment, Time, Massage

Factor	Type	Levels	Values
Time(Treatment)	random	3	0, 5, 15
Massage(Treatment)	fixed	3	None, AM, PM
Treatment	fixed	2	Control, Massage

Analysis of Variance for Flexibility, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Time(Treatment)	1	63.42	63.42	63.42	4.57	0.041
Massage(Treatment)	1	59.69	59.69	59.69	4.30	0.047
Treatment	1	518.73	518.73	518.73	5.88	0.280 x
Error	28	388.49	388.49	13.87		
Total	31	1030.33				

x Not an exact F-test.

S = 3.72485 R-Sq = 62.30% R-Sq(adj) = 58.26%

References

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