




1F – Introduction to SPC and Shewhart Control Charts

QHN Summer Camp for QI
July 14-15 • Alliston, ON
Richard Scoville, PhD

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Objectives



- Recognize the natural variation in all process data
- Understand Shewhart control charts as a tool for understanding process variation
- Avoid common management decisions
- Understand that a successful change changes the process and data


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The Manager's Dilemma

SHN
QUALITY HEALTHCARE
NETWORK

In order to manage a system, we are required to make **predictions** about its future performance.




Budgets
Hiring
Impact
Capacity
Planning
Accountability
Funding

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The Hazards of Tampering

SHN
QUALITY HEALTHCARE
NETWORK

- Medication Errors



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Medication Errors

The VP of Quality Improvement receives this report of med errors compiled by week. Of a sample of 1000 audited prescriptions, it shows those with errors: 21 in the week of Feb 7!

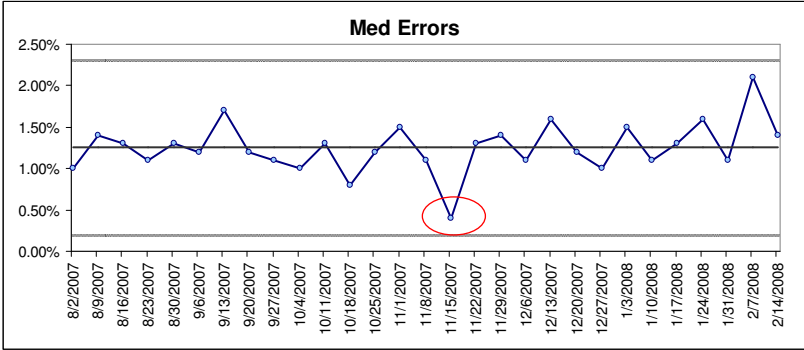
2-Aug	10
9-Aug	14
16-Aug	13
23-Aug	11
30-Aug	13
6-Sep	12
13-Sep	17
20-Sep	12
27-Sep	11
4-Oct	10
11-Oct	13
18-Oct	8
25-Oct	12
1-Nov	15
8-Nov	11
15-Nov	4
22-Nov	13
29-Nov	14
6-Dec	11
13-Dec	16
20-Dec	12
27-Dec	10
3-Jan	15
10-Jan	11
17-Jan	13
24-Jan	16
31-Jan	11
7-Feb	21
14-Feb	14

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“Why Can’t You Always Do This Well?”



- Does this low value represent a stellar performance that merits an award?



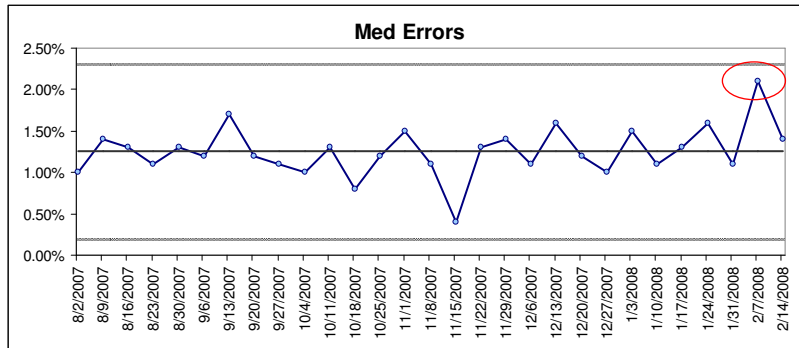
Date	Error Rate (%)
8/2/2007	1.00
8/9/2007	1.40
8/16/2007	1.30
8/23/2007	1.10
8/30/2007	1.30
9/6/2007	1.20
9/13/2007	1.70
9/20/2007	1.20
9/27/2007	1.10
10/4/2007	1.00
10/11/2007	1.30
10/18/2007	0.80
10/25/2007	1.20
11/1/2007	1.50
11/8/2007	1.10
11/15/2007	0.40
11/22/2007	1.30
11/29/2007	1.40
12/6/2007	1.10
12/13/2007	1.60
12/20/2007	1.20
12/27/2007	1.00
1/3/2008	1.50
1/10/2008	1.10
1/17/2008	1.60
1/24/2008	1.10
1/31/2008	2.10
2/7/2008	1.40
2/14/2008	1.40

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“What’s The Problem Here?”



- Any set of measures has a high and low value!
Does this high value mean that something needs “fixing?”



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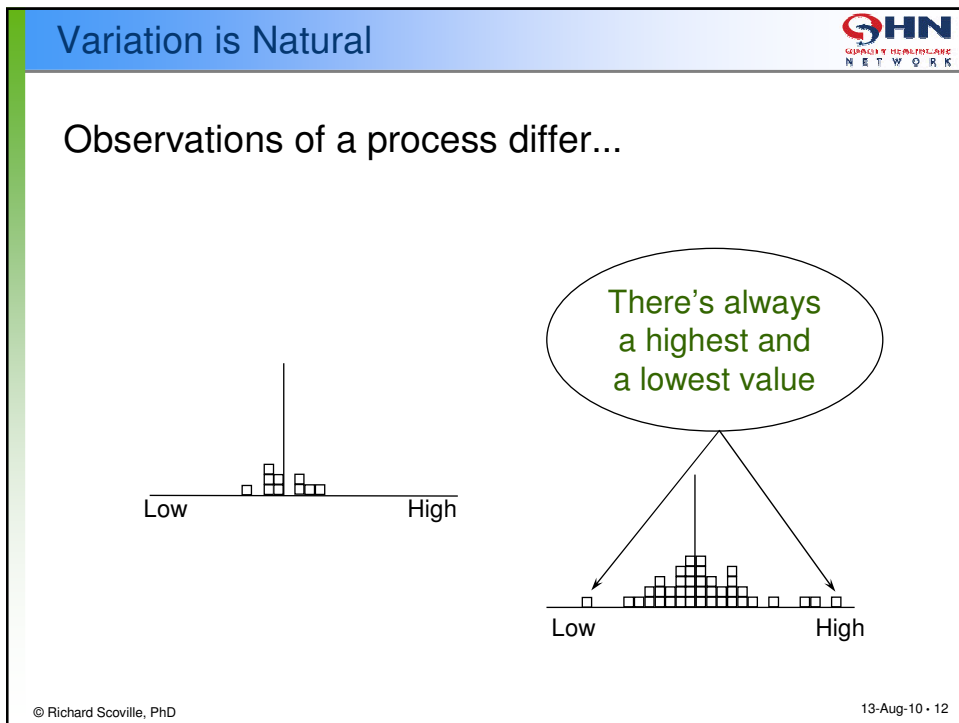
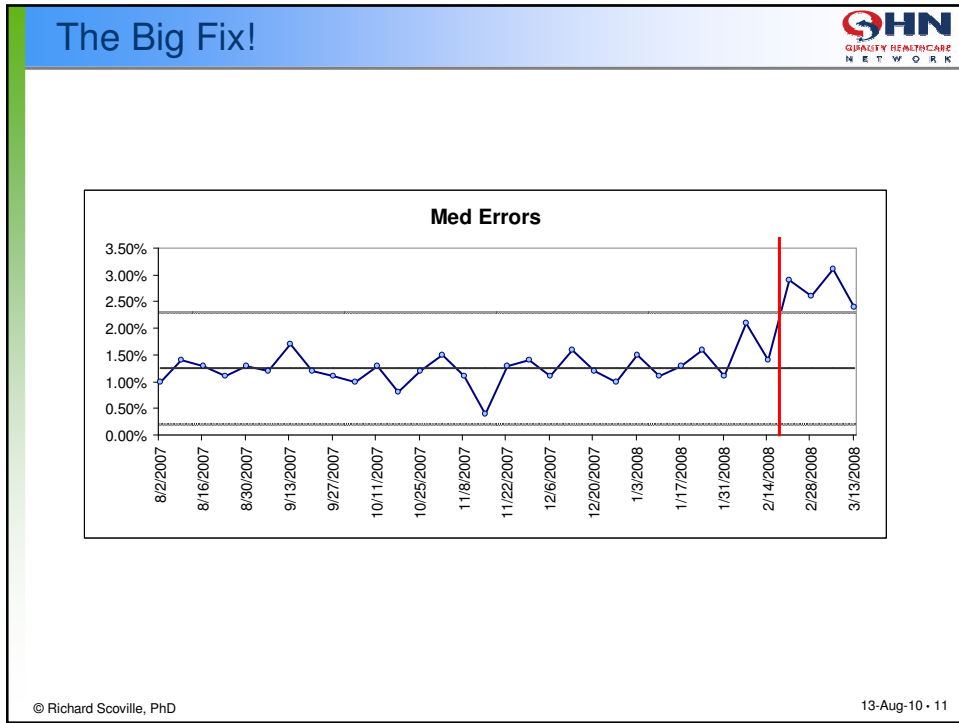
The Big Fix



- The nurse previously responsible for medications on the shift where most of the errors occurred was reassigned and the head nurse took over. As fate would have it ...

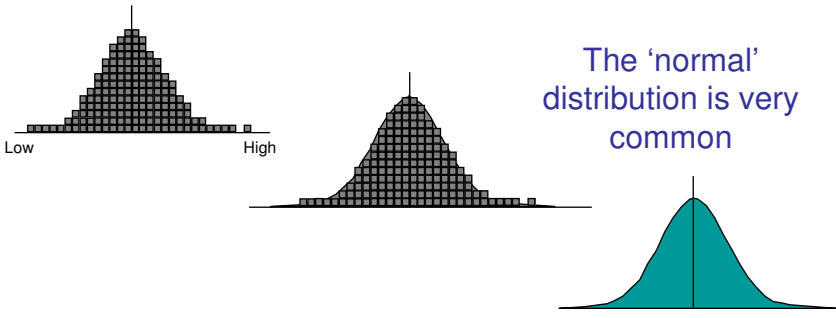
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Variation is Natural

... the pattern that the values form over time is called a *distribution*.



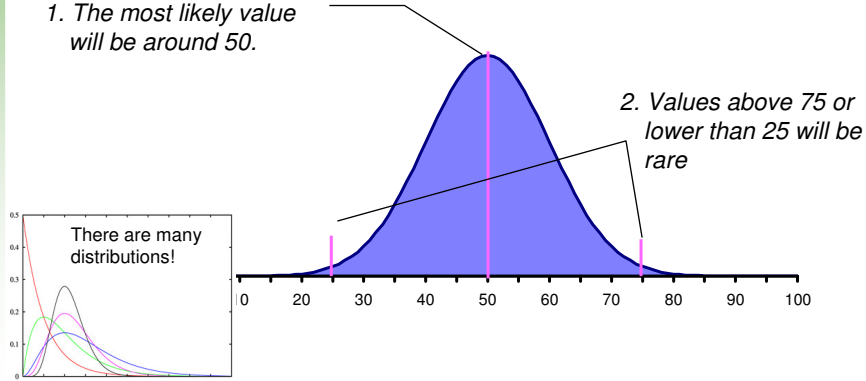
The 'normal' distribution is very common

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Distributions Allow Prediction

If the process that produces these measures operates pretty much the same in the future, we can predict that

1. The most likely value will be around 50.
2. Values above 75 or lower than 25 will be rare

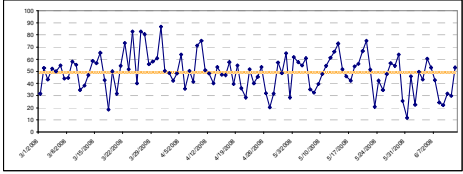


There are many distributions!

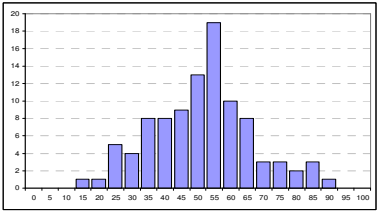
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Dynamic & Static Views of a Process

Run chart 'tells the story' over time

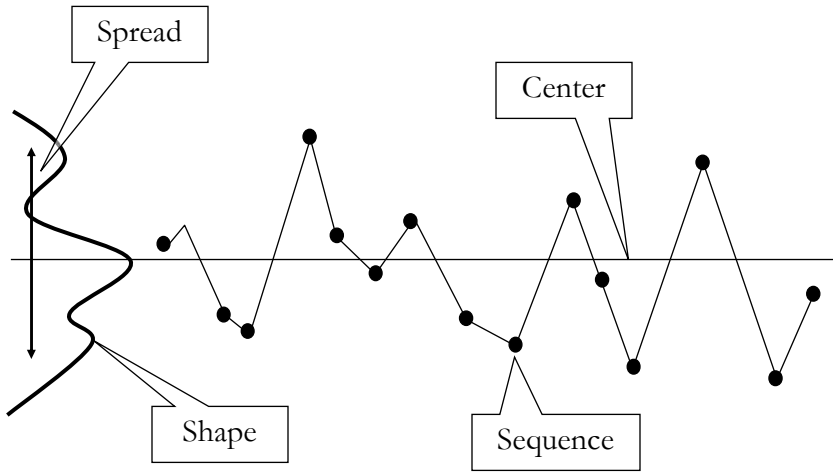


Histogram shows the distribution of values during a period of time



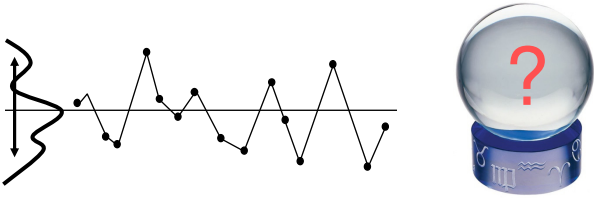

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Four Dimensions of Variation



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Predicting the Future



- *Center*: What's my best guess for the future?
- *Spread*: How far off am I likely to be?
- *Shape*: What are other likely values? Is this a single, coherent process?
- *Sequence*: Are things getting better? Worse? Is the process predictable?

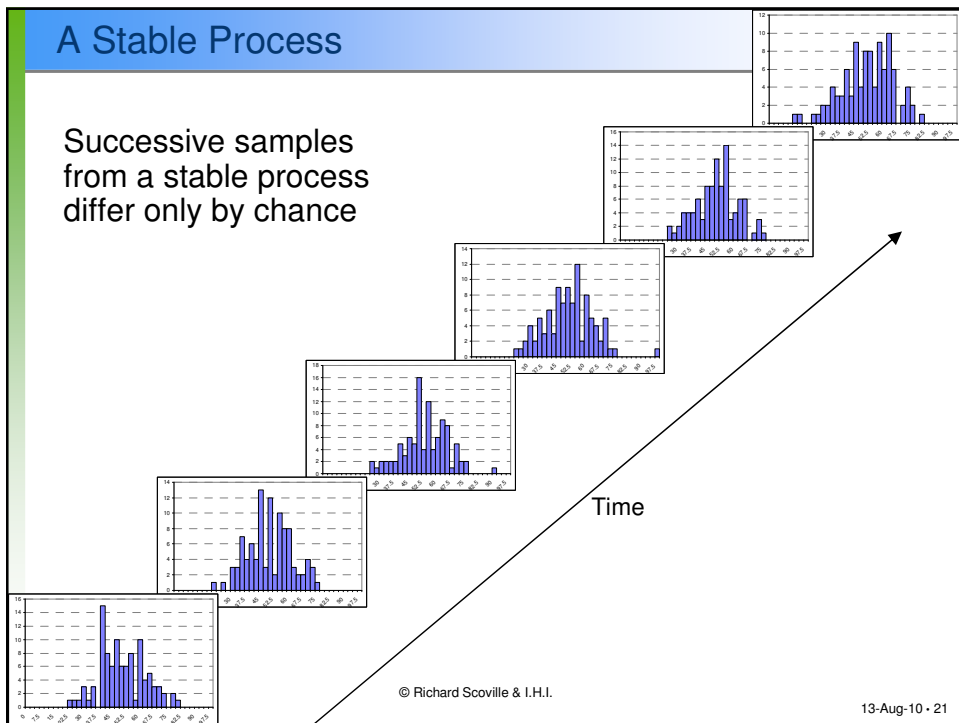
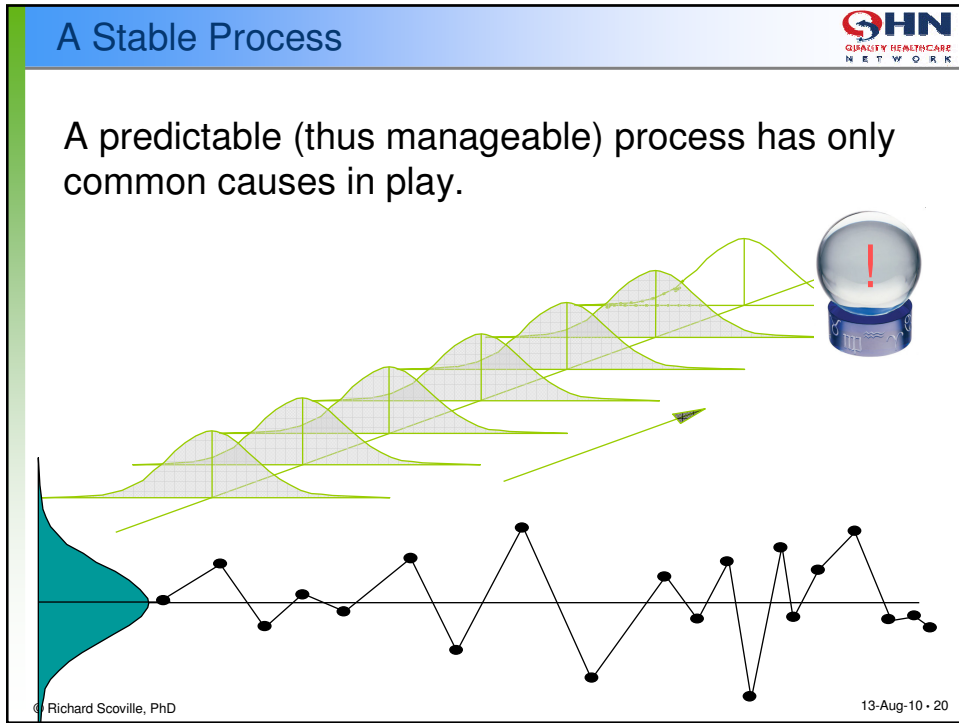
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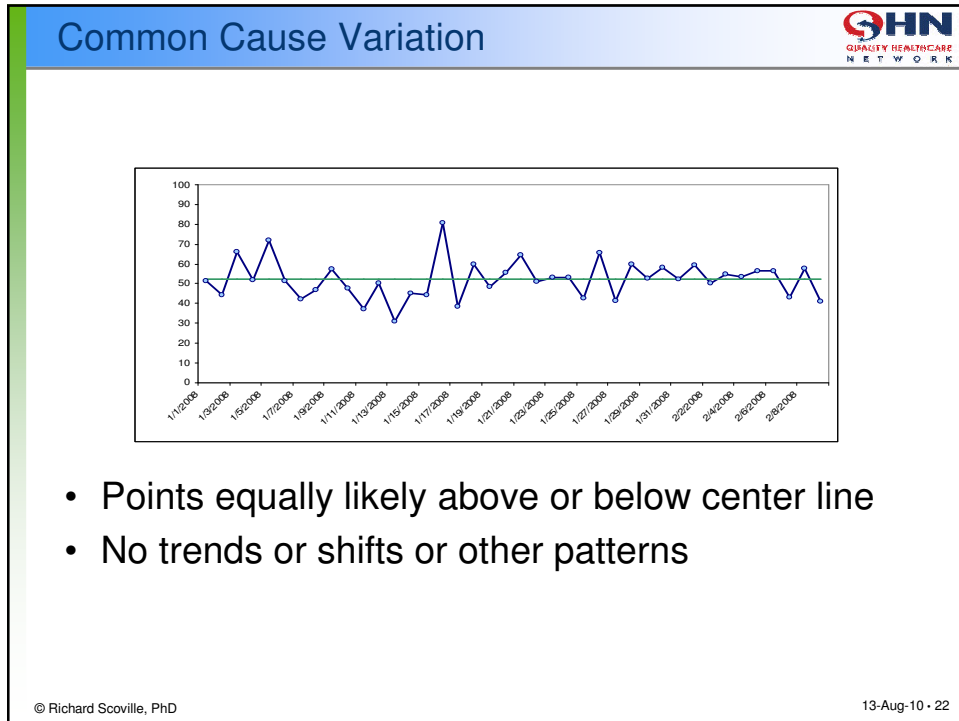
Two Types of Variation



<p>Common Cause</p> <ul style="list-style-type: none">• Is inherent in the design of the process• Reflects the 'business as usual' state of the process• Is due to regular, natural or ordinary causes• Affects all the outcomes of a process• Results in a "stable" distribution that is predictable• Also known as random or unassignable variation	<p>Special Cause</p> <ul style="list-style-type: none">• Due to irregular or unnatural causes that are not inherent in the design of the process• Reflects a "different mode" of the process• Affects some, but not necessarily all aspects of the process• Results in an "unstable" process that is not predictable• Also known as non-random or assignable variation
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- Points equally likely above or below center line
- No trends or shifts or other patterns

A Stable Process is Predictable

Thus you can confidently

- Counsel patients about what to expect
- Plan for the future
- Inform management
- **Use PDSA testing to improve it!**

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Stable ≠ “OK”

A process may be operating in a stable, predictable fashion but still produce unacceptable results!

“All the shops in Soviet Union were limited to 2-3 types of merchandise, all over country, in every city or a small village same things were sold, produced on a few Russian state owned plants.”

Source: www.englishrussia.com

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Special Causes

Intentional

When we're trying to change the system

Month	Patient #	Minutes
February	1	22.5
February	2	18.5
February	3	20.0
February	4	14.0
February	5	16.5
February	6	18.0
February	7	22.0
February	8	20.5
February	9	22.5
February	10	15.5
February	11	20.5
February	12	16.5
February	13	20.5
February	14	16.5
February	15	19.5
February	16	18.5
April	17	15.5
April	18	11.5
April	19	13.5
April	20	11.5
April	21	10.5
April	22	11.5
April	23	10.5
April	24	9.5
April	25	10.5
April	26	8.5
April	27	10.5
April	28	11.5
April	29	10.5
April	30	9.5
April	31	10.5
April	32	9.5

An unstable system!

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Where Do Special Causes Come From?



- Inherent instability in the process
 - ✓ Lack of standardization – a chaotic process
 - ✓ Changes in personnel, equipment, management, etc.
- Unusual extrinsic events
 - ✓ Catastrophes, breakdowns, accidents, personnel issues
- Entropy
 - ✓ Equipment wear, desensitization, habit, emerging culture
- Intentional changes – part of an improvement initiative

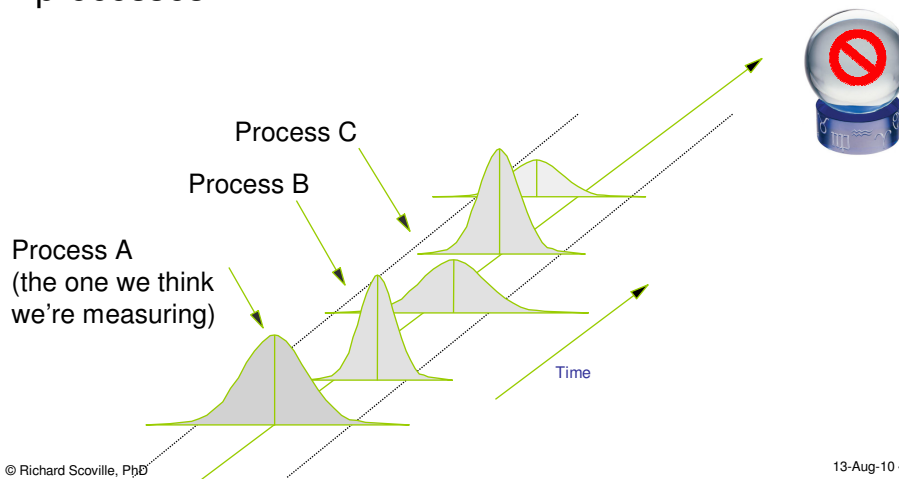
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Special Causes ⇒ Unpredictability



An unstable process is subject to special causes. These represent fluctuations in underlying processes.



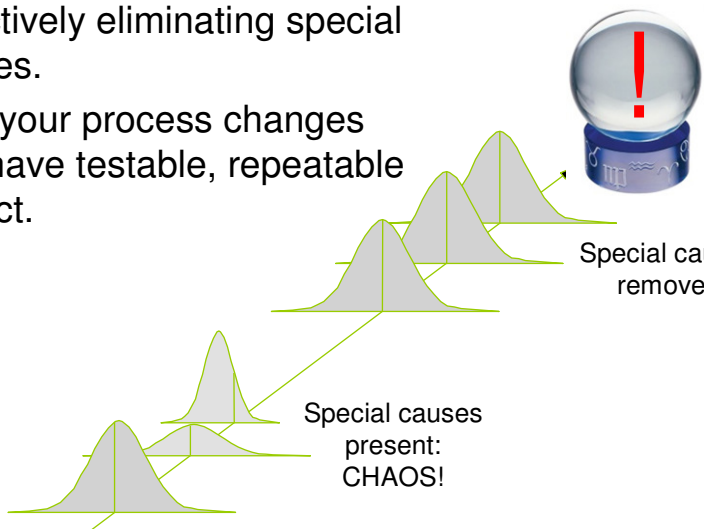
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Removing Special Causes



Standardize the process by selectively eliminating special causes.

Now your process changes can have testable, repeatable impact.



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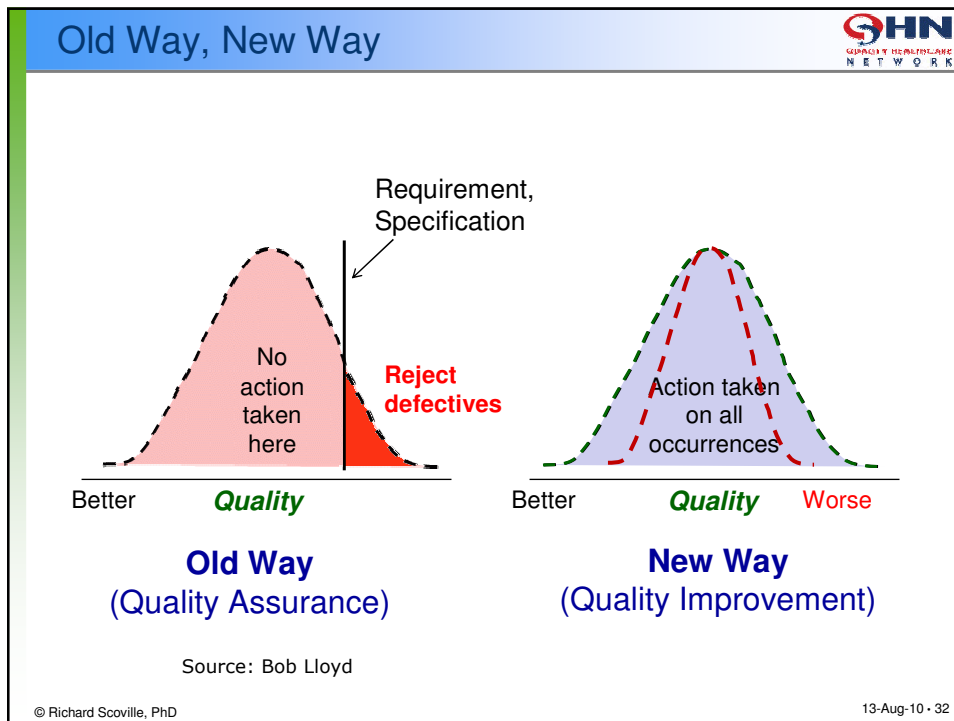
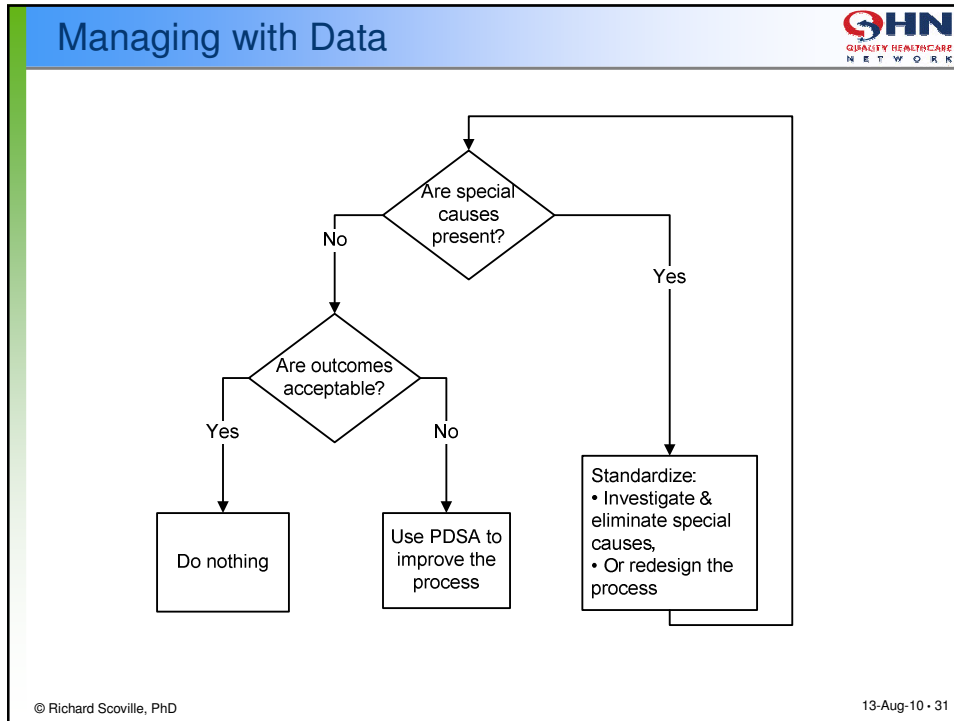
Stabilize, Then Improve

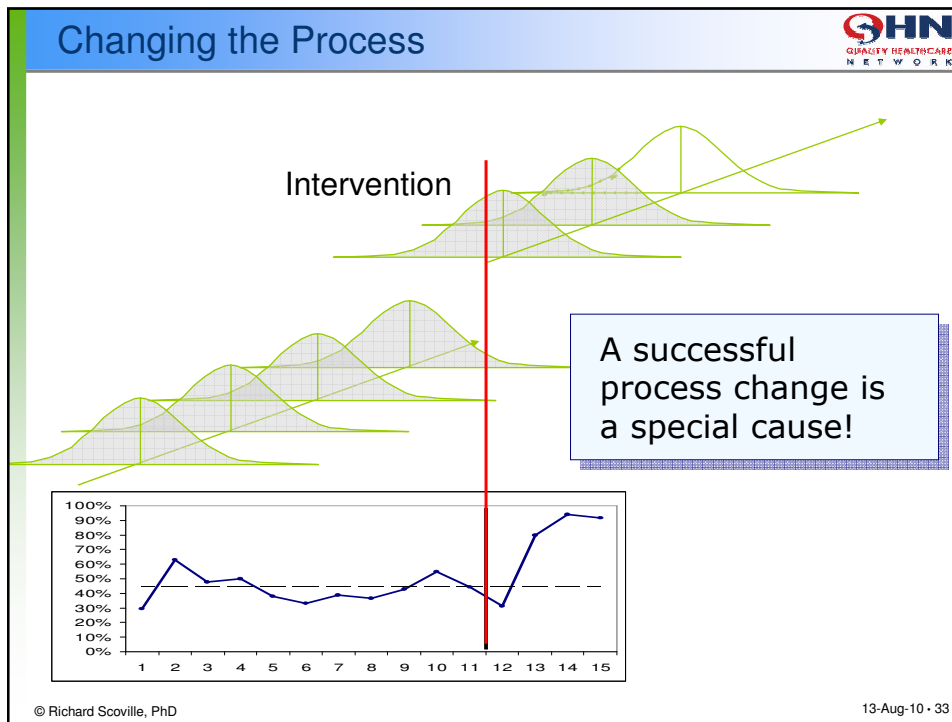


If you can't predict the future behavior of the process, you're improvements won't stick!

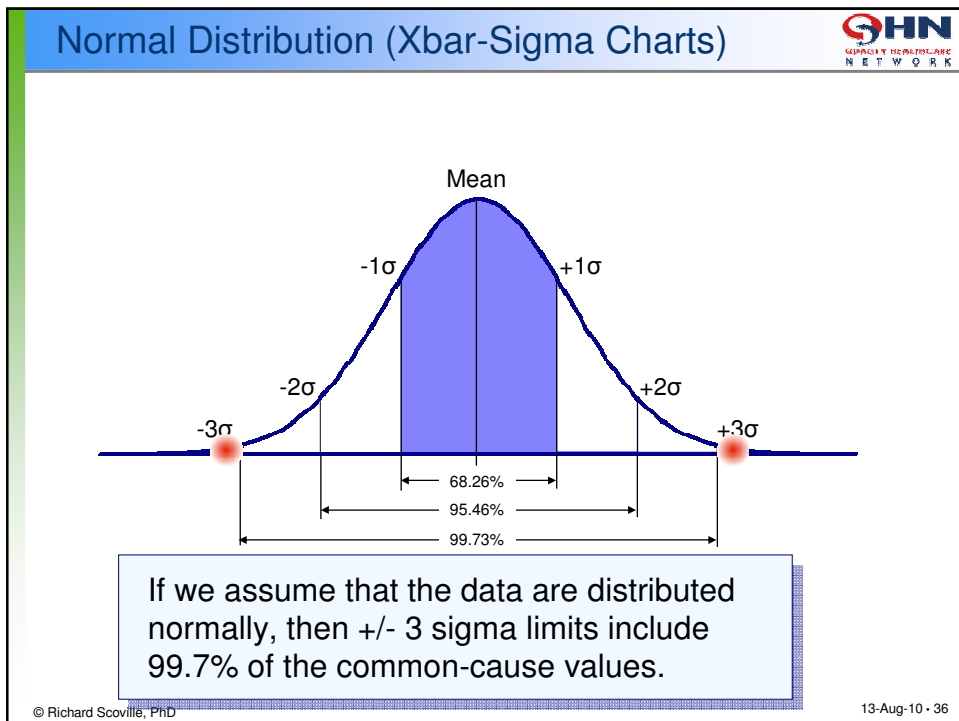
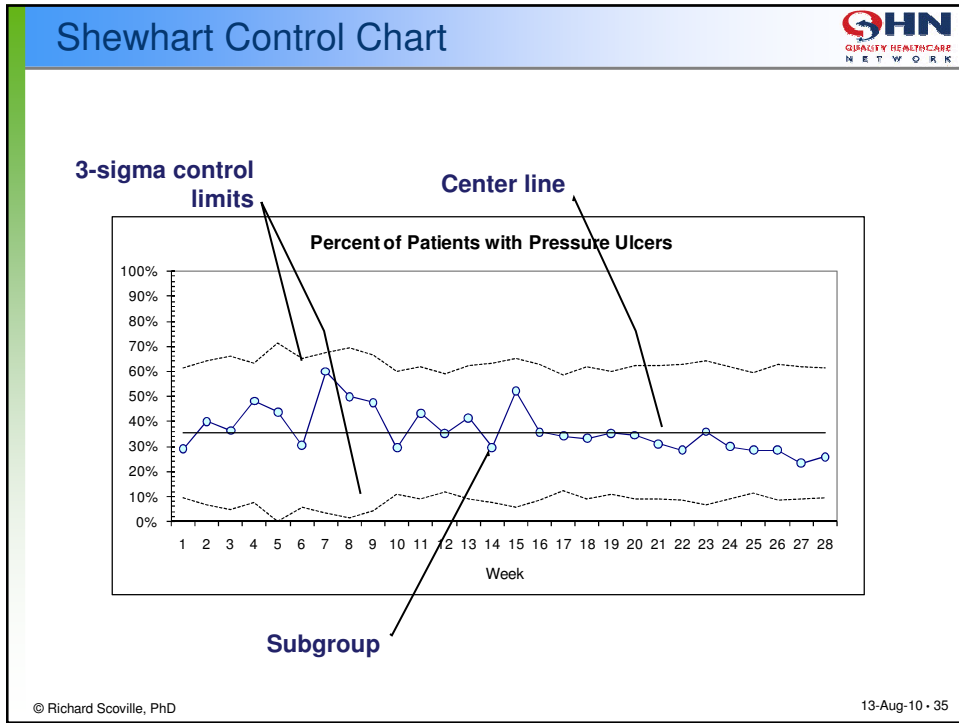
Once the process is stable, your changes can have a predictable, repeatable impact.

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- ### Tools for Detecting Change
- **Line Charts**
 - ✓ No decision rules
 - ✓ 'Ocular' tests only
 - **Run Charts**
 - ✓ Decision rules based on '50/50' principle
 - ✓ Minimum of 6 points to detect an improvement shift
 - **Control Charts**
 - ✓ Most sensitive tools for detecting special causes including successful change
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Proceed with Caution

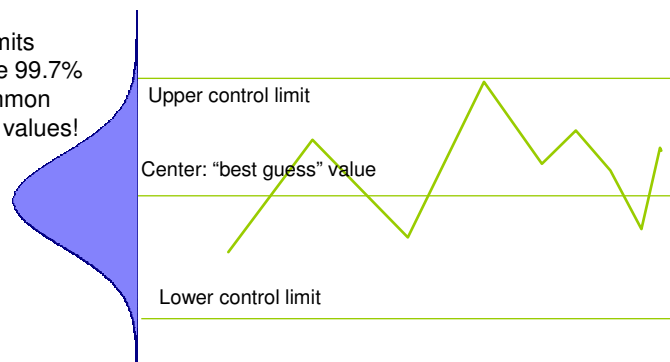


- There are many types of control charts, which are appropriate for different types of data.
- Calculation methods are specific to the type of chart, but interpretation is the same for most chart types.
- You cannot create a valid control chart using a simple standard deviation calculation.

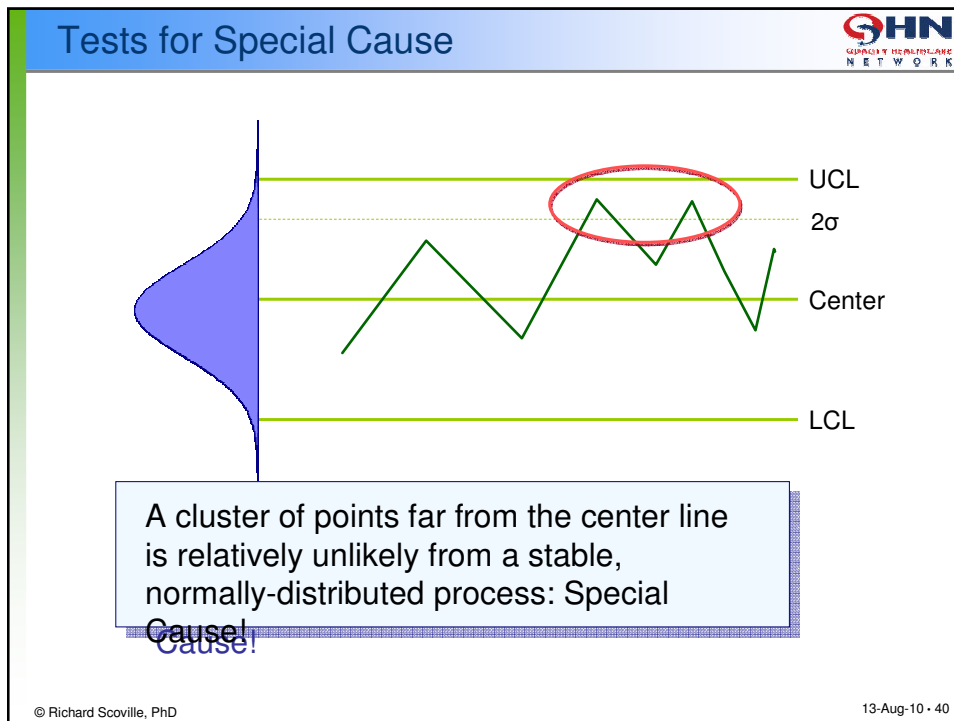
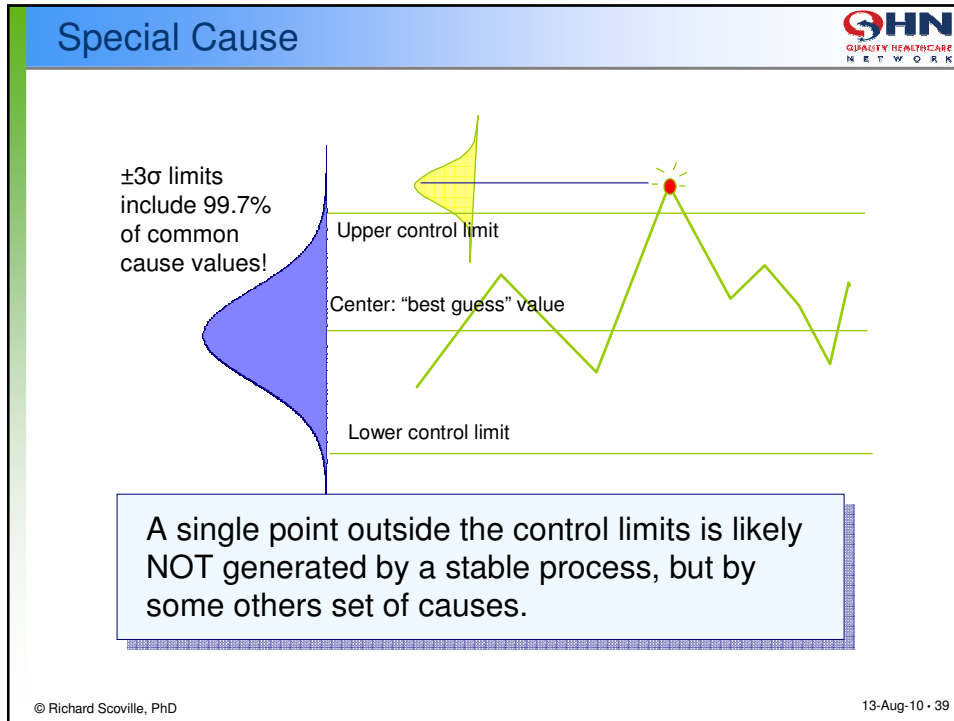
Shewhart Control Chart




$\pm 3\sigma$ limits
include 99.7%
of common
cause values!

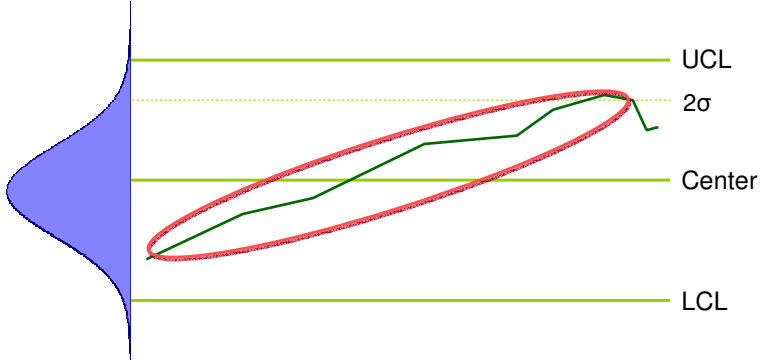


A Shewhart chart is a 'special cause detector'
– a statistical display that helps you infer the
presence of special causes in a process,
beyond a reasonable doubt.



Tests for Special Cause






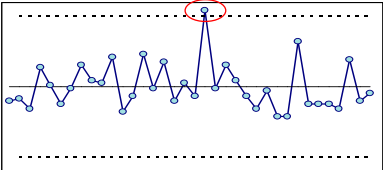
So are other non-random patterns. These too are evidence of special causes.

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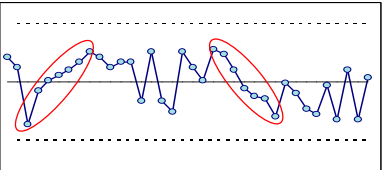
API Rules for Detecting Special Cause



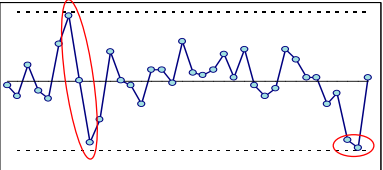
A single point outside the control limits



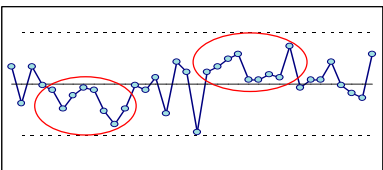
Six consecutive points increasing (trend up) or decreasing (trend down)



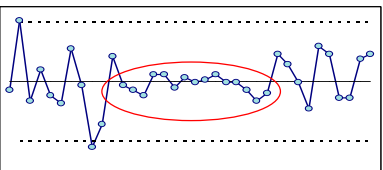
Two out of three consecutive points near a control limit (outer one-third)



Eight or more consecutive points above or below the centerline



Fifteen consecutive points close to the centerline (inner one-third)



2

Tests for Special Cause



- **Outside of limits:** A data point that falls outside the limits on the chart, either above the upper limit or below the lower limit
- **Shift:** Eight or more consecutive POINTS either all above or all below the mean. Skip values on the mean and continue counting points. Values on the mean DO NOT make or break a shift
- **Trend:** Six points all going up or all going down. If the value of two or more successive points is the same, ignore one of the points when counting; like values Do Not make or break a trend
- **Two Out of Three:** Two out of three consecutive points in the outer third of the chart. The two out of three consecutive points can be on the same side, or on either side of the center line.
- **15 points Hugging the Centerline:** 15 consecutive points close to (within inner third of limits) centerline

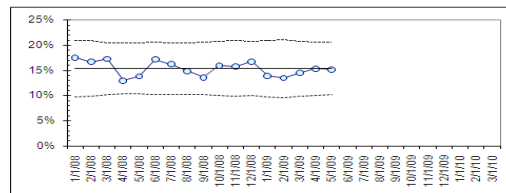
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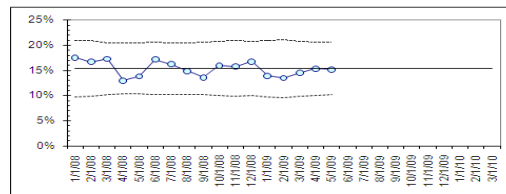
Testing a Change with a Shewhart Chart



1. Plot the baseline data & calculate limits




2. Extend the limits (centerline only for some charts)



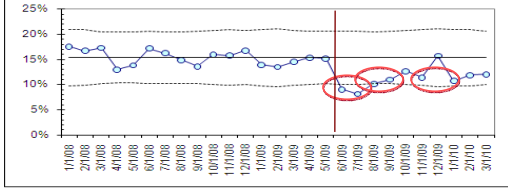
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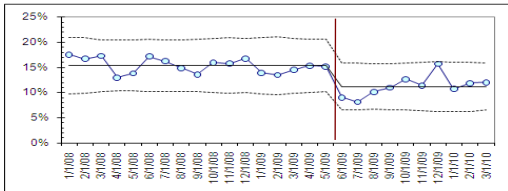
Testing a Change with a Shewhart Chart



3. Plot new data using baseline limits (centerline)
Apply decision rules for special cause




4. If change is confirmed, plot limits for new phase of process



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DVT Data

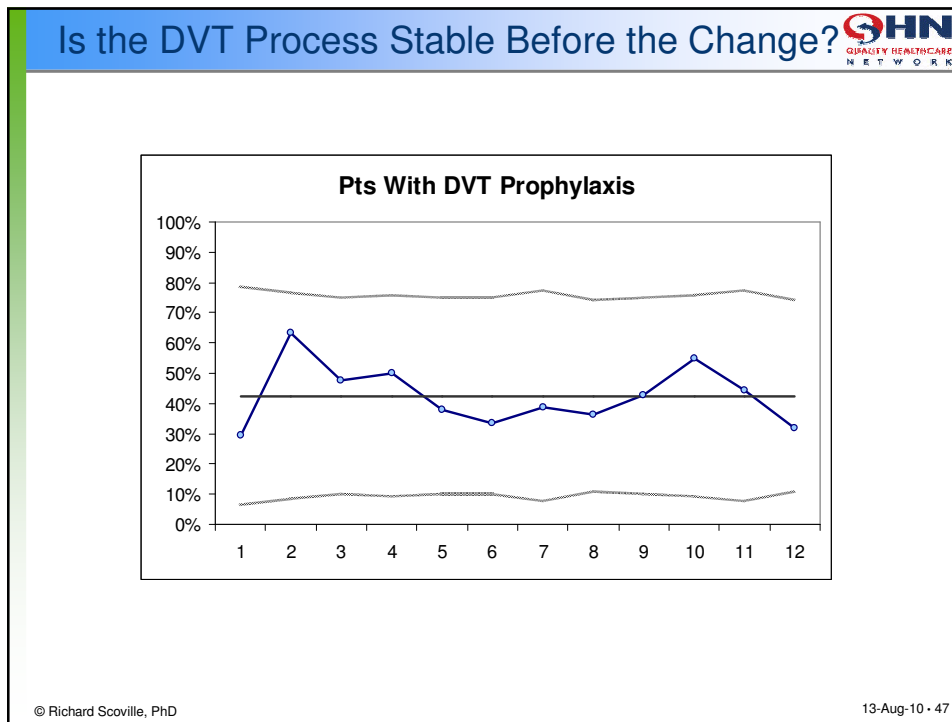


Let's build a control chart to illustrate how it works.

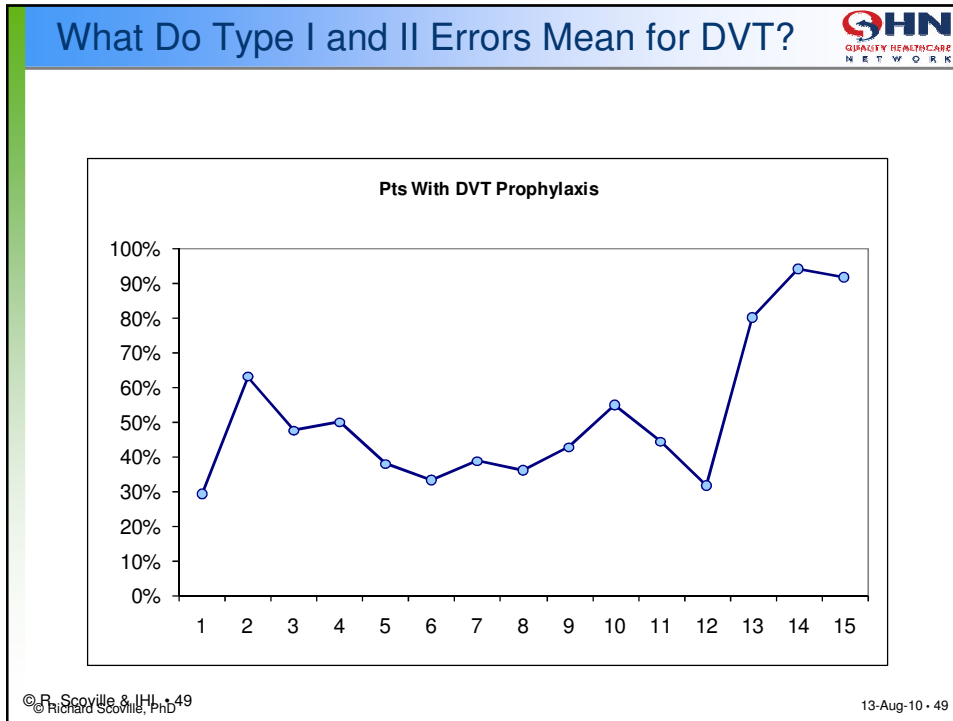
Obs	Number of Patients	Number with appropriate DVT
1	17	5
2	19	12
3	21	10
4	20	10
5	21	8
6	21	7
7	18	7
8	22	8
9	21	9
10	20	11
11	18	8
12	22	7
SUM	240	102

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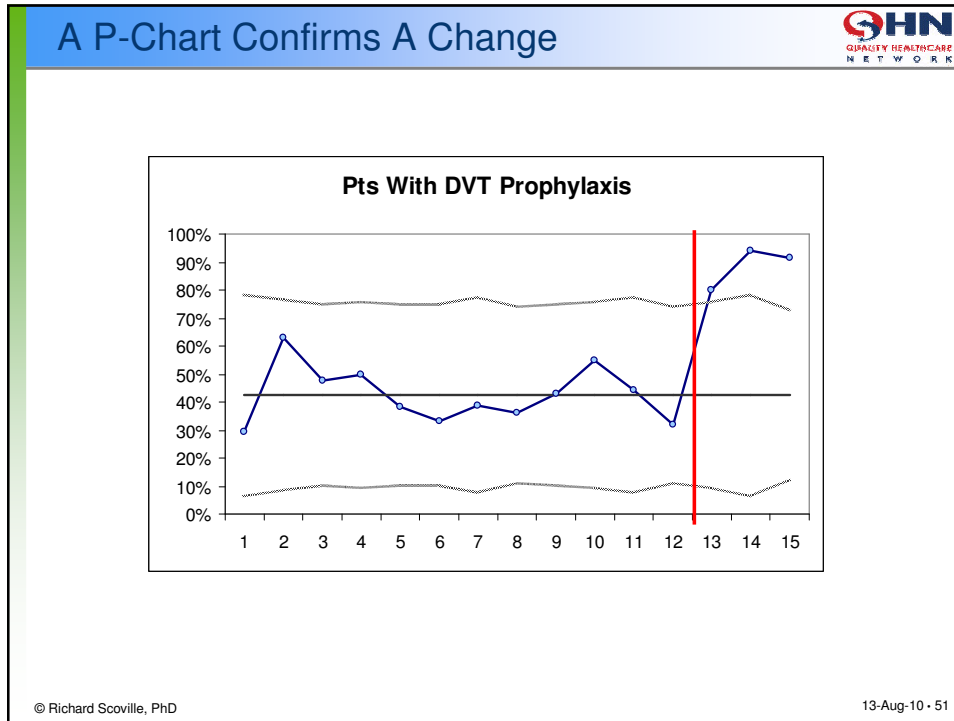


- ### Two Mistakes to Avoid
- ‘Jumping the Gun’ (Type I Error or False Positive)
Responding to a data point as if it were a special cause when, in fact, the system is stable
 - Failure to Detect (Type II Error or False Negative)
Ignoring a data point that indicates a special cause when, in fact, the system of causes has changed
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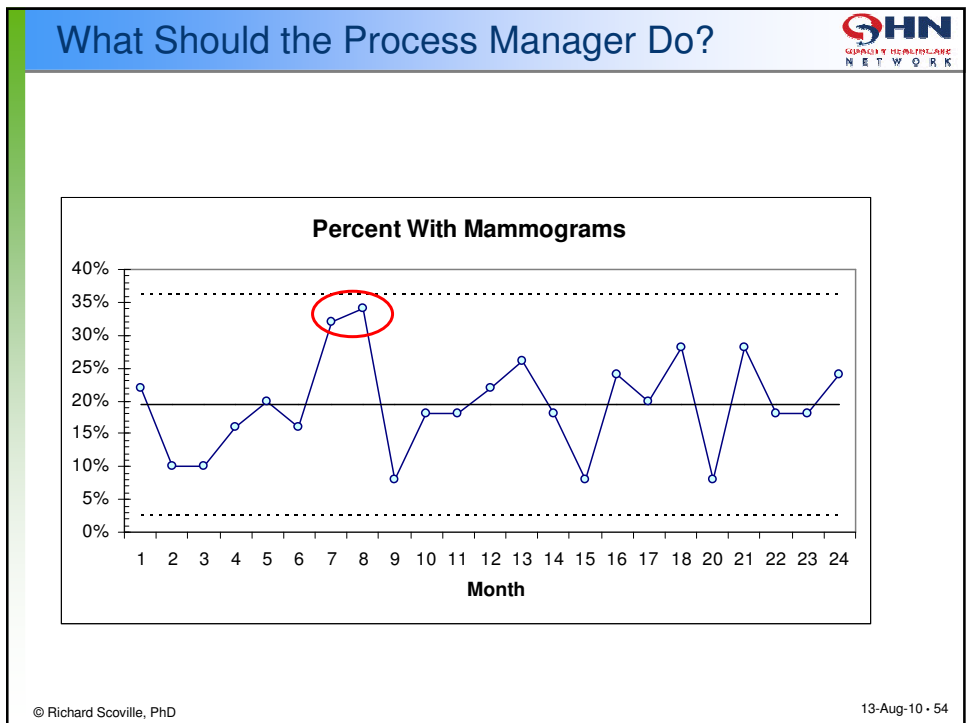
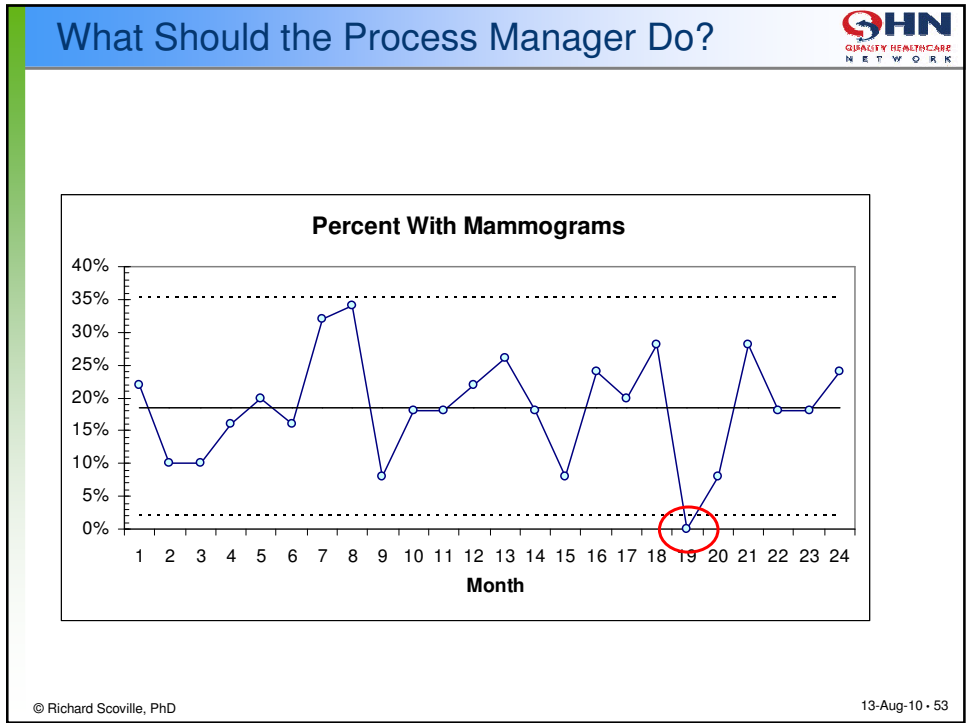


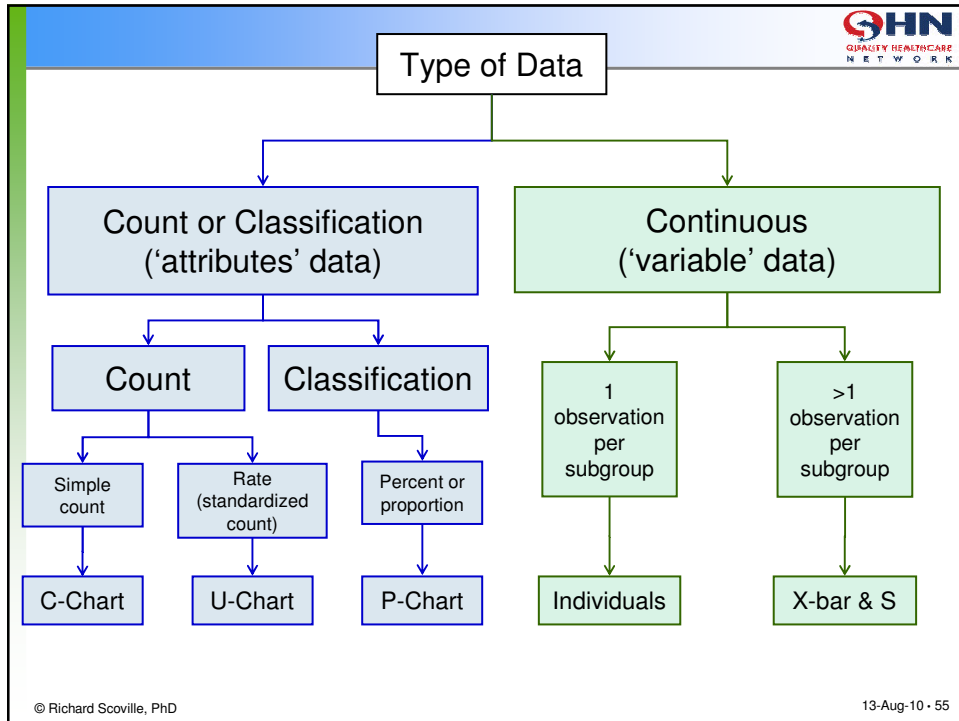
Obs	Number of Patients	Number with appropriate DVT	% Approp	Mean	SD	UCL	LCL
1	17	5	29.4%	0.425	0.120	0.785	0.065
2	19	12	63.2%	0.425	0.113	0.765	0.085
3	21	10	47.6%	0.425	0.108	0.749	0.101
4	20	10	50.0%	0.425	0.111	0.757	0.093
5	21	8	38.1%	0.425	0.108	0.749	0.101
6	21	7	33.3%	0.425	0.108	0.749	0.101
7	18	7	38.9%	0.425	0.117	0.775	0.075
8	22	8	36.4%	0.425	0.105	0.741	0.109
9	21	9	42.9%	0.425	0.108	0.749	0.101
10	20	11	55.0%	0.425	0.111	0.757	0.093
11	18	8	44.4%	0.425	0.117	0.775	0.075
12	22	7	31.8%	0.425	0.105	0.741	0.109
13	20	16	80.0%	0.425	0.111	0.757	0.093
14	17	16	94.1%	0.425	0.120	0.785	0.065
15	24	22	91.7%	0.425	0.101	0.728	0.122
SUM	301	156					

50



- ### Mammography Screening
- Measure: Percent of women over 50 in a sample of 50 who obtain documented mammograms within 3 months of receiving reminder
 - Data for subgroups collected by month reminder is sent out
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Software

- CHARTrunner
Single user: \$990, \$245/yr
www.pqsystems.com
- QI-Charts
Single user: \$69, \$0/yr
www.pipproducts.com

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Thank You!

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richard@rscoville.net