Better Quality
Through Better Measurement:
Run Charts

Robert Lloyd, Ph.D.
Executive Director Performance Improvement
Institute for Healthcare Improvement
Discussion Topics

• The Quality Measurement Journey
• Understanding variation conceptually
• Understanding variation with Run Charts
• Linking measurement to improvement
The Quality Measurement Journey

AIM (Why are you measuring?)

- Concept
- Measures
- Operational Definitions
- Data Collection Plan
- Data Collection
- Analysis

The Quality Measurement Journey

AIM (Why are you measuring?)

Concept

Measures

Operational Definitions

Data Collection Plan

Data Collection

Analysis → ACTION

You have performance data!

Now, what the heck do you do with it?
“If I had to reduce my message for management to just a few words, I’d say it all had to do with reducing variation.”

W. Edwards Deming
The Problem

Aggregated data presented in tabular formats or with summary statistics, will not help you measure the impact of process improvement/redesign efforts. Aggregated data can only lead to judgment, not to improvement.
“What is the variation in one system over time?”

Walter A. Shewhart - early 1920’s, Bell Laboratories

Every process displays variation:

- **Controlled variation**
  - stable, consistent pattern of variation
  - “chance”, constant causes

- **Special cause variation**
  - “assignable”
  - pattern changes over time

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<table>
<thead>
<tr>
<th>Types of Variation</th>
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<tr>
<td><strong>Common Cause Variation</strong></td>
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<tr>
<td>- Is inherent in the design of the process</td>
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<td>- Is due to regular, natural or ordinary causes</td>
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<td>- Affects all the outcomes of a process</td>
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<td>- Results in a “stable” process that is predictable</td>
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<td>- Also known as random or unassignable variation</td>
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<tr>
<td><strong>Special Cause Variation</strong></td>
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<td>- Is due to irregular or unnatural causes that are not inherent in the design of the process</td>
</tr>
<tr>
<td>- Affect some, but not necessarily all aspects of the process</td>
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<tr>
<td>- Results in an “unstable” process that is not predictable</td>
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<tr>
<td>- Also known as non-random or assignable variation</td>
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## Appropriate Responses to Common & Special Causes of Variation

<table>
<thead>
<tr>
<th>Type of variation</th>
<th>Is the process stable?</th>
<th>Right Choice</th>
<th>Wrong Choice</th>
<th>Consequences of making the wrong choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only Common</td>
<td>YES</td>
<td>Change the process</td>
<td>Treat normal variation as a special cause (tampering)</td>
<td>Increased variation!</td>
</tr>
<tr>
<td>Special + Common</td>
<td>NO</td>
<td>Investigate the origin of the special cause</td>
<td>Change the process</td>
<td>Wasted resources!</td>
</tr>
</tbody>
</table>

- **Is the process stable?**
  - YES
  - NO

- **Right Choice**
  - Change the process

- **Wrong Choice**
  - Treat normal variation as a special cause (tampering)

- **Consequences of making the wrong choice**
  - Increased variation!
  - Wasted resources!
How can I depict variation?

**STATIC VIEW**
- Descriptive Statistics
- Mean, Median & Mode
- Minimum/Maximum/Range
- Standard Deviation
- Bar graphs/Pie charts

**DYNAMIC VIEW**
- Run Chart
- Control Chart
- (plot data over time)
- Statistical Process Control (SPC)
How do we analyze variation for quality improvement?

Run and Control Charts are the best tools to determine if our improvement strategies have had the desired effect.
How many data points?

*Typically* you should have *between* 15 – 20 data points before constructing a chart

- 15 – 20 patients
- 15 – 20 days
- 15 – 20 weeks
- 15 – 20 months
- 15 - 20 quarters…?
Elements of a Run Chart

The centerline (CL) on a Run Chart is the Median

\( \tilde{X} \) (CL)

Four simple run rules are used to determine if special cause variation is present.
Why Median Rather Than Mean?

Mean = arithmetic average of data
Median = middle value of ordered data (50th percentile)

\[
(n + 1)/2 = \text{Median Position which leads you to the Median Value}
\]

- \(8, 10, 11, 14, 16, 18, 20\)
  \(\text{Mean} = 13.8\)
  \(\text{Median} = 14\)

- \(8, 10, 11, 14, 16, 18, \underline{95}\)
  \(\text{Mean} = 24.5\)
  \(\text{Median} = 14\)

- \(1, 10, 11, 14, 16, 18, 20\)
  \(\text{Mean} = 12.8\)
  \(\text{Median} = 14\)

But how do you compute the Median when you have an even number of data points?
The Median with an **even** number of data points?

\[(n + 1)/2 = \text{Median Position} \text{ which leads you to the Median Value}\]

- **8, 10, 11, 14, 16, 18, 20, 35**
  - Mean = 16.5
  - Median Position = 4.5
  - Median = 15

- **8, 10, 11, 14, 16, 18, 30, 95**
  - Mean = 25.3
  - Median Position = 4.5
  - Median = 15

- **1, 10, 11, 14, 14, 18, 19, 20**
  - Mean = 13.4
  - Median Position = 4.5
  - Median = 14
Run Chart: Medical Waste

How do you find the median?

\[(n + 1)/2\]

\[(29 + 1)/2 = 30/2 = 15\]

When you slide a piece of paper down, you reveal the dots in descending order. When you have revealed the 15th data point, you have found where the median lives.

But, the median value = 4.6

The median lives here at the 15th data point.
How do we analyze a Run Chart

How will I know what the Run Chart is trying to tell me?

There are 4 simple run chart rules that help you decide if your data reflect a random or non-random pattern.
First, you need to determine the number of Runs

What is a Run?

- One or more consecutive data points on the same side of the Median
- Do not include data points that fall on the Median

How do we count the number of runs?

- Draw a circle around each run and count the number of circles you have drawn
- Count the number of times the sequence of data points crosses the Median and add “1”
How many runs are on this chart?

Points on the Median
(don't count these when counting the number of runs)
How many runs are on this chart?

4 runs

Points on the Median
(don’t count these when counting the number of runs)
Rules to Identify non-random patterns in the data displayed on a Run Chart

- Rule #1: A shift in the process, or too many data points in a run (6 or more consecutive points above or below the median)

- Rule #2: A trend (5 or more consecutive points all increasing or decreasing)

- Rule #3: Too many or too few runs (use a table to determine this one)

- Rule #4: An “astronomical” data point
Non-Random Rules for Run Charts

**Rule 1**
A Shift: 6 or more

**Rule 2**
A Trend 5 or more

**Rule 3**
Too many or too few runs

**Rule 4**
An astronomical data point

Is this a trend?
Non-Random Rules for Run Charts

**Rule 1:**
- **A Shift:** 6 or more

**Rule 2:**
- **A Trend:** 5 or more

**Rule 3:**
- Too many or too few runs

**Rule 4:**
- An astronomical data point

Rule #3: Too few or too many runs

Use this table by first calculating the number of "useful observations" in your data set. This is done by subtracting the number of data points on the median from the total number of data points. Then, find this number in the first column. The lower number of runs is found in the second column. The upper number of runs can be found in the third column. If the number of runs in your data falls below the lower limit or above the upper limit then this is a signal of a special cause.

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<th>Total number of data points on the run chart that do not fall on the median</th>
<th>Lower limit for the number of runs (&lt; than this number runs is “too few”)</th>
<th>Upper limit for the number of runs (&gt; than this number runs is “too many”)</th>
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Table 3-3: Checking for Too Many or Too Few Runs on a Run Chart
Non-Random Rules for Run Charts

A Shift: 6 or more

A Trend 5 or more

Too many or too few runs

An astronomical data point

Rule #4: An Astronomical Data Point

What do you think about this data point? Is it astronomical?
Are there any non-random patterns present?

Total data points = 21
Data points on the Median = 1
Number of “useful observations” = 20 (should be between 6 &16 runs)
The number of runs = 4
Number of times the data line crosses the Median = 3 + 1 = 4

Points on the Median (don’t count these when counting the number of runs)
Rule #3: Too few or too many runs

Use this table by first calculating the number of "useful observations" in your data set. This is done by subtracting the number of data points on the median from the total number of data points. Then, find this number in the first column. The lower number of runs is found in the second column. The upper number of runs can be found in the third column. If the number of runs in your data falls below the lower limit or above the upper limit then this is a signal of a special cause.

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Points on the Median
(don’t count these when counting the number of runs)
Exercise
Interpreting Run Charts

1. % of patients with Length of Stay shorter than six days

2. Average Length of Stay DRG373

3. Number of Acute Surgical Procedures

Source: Peter Kammerlind, (Peter.Kammerlind@lj.se), Project Leader Jönköping County Council, Jonkoping, Sweden.
% of patients with Length of Stay shorter than six days

Antal patienter med vårdtid < 6dygn i % vid primär elektiv knäplastik (operationsdag= dag1)

Source: Peter Kammerlind, (Peter.Kammerlind@lj.se), Project Leader Jönköping County Council, Jonkoping, Sweden.
% of patients with Length of Stay shorter than six days

Source: Peter Kammerlind, (Peter.Kammerlind@lj.se), Project Leader, Jönköping County Council, Jonkoping, Sweden.

Median=52

Rule 1 & 3

18 useful observations
Rule 1: 2 runs (6-14 runs), not OK
Rule 2: OK
Rule 3: OK
Rule 4: OK
Average Length of Stay DRG373

Source: Peter Kammerlind, (Peter.Kammerlind@lj.se), Project Leader Jönköping County Council, Jonkoping, Sweden.
Average Length of Stay DRG373

Rule 3
Median = 2.35
22 useful observations
Rule 1: 12 runs (7-17 runs), OK
Rule 2: not OK
Rule 3: OK
Rule 4: OK

Source: Peter Kammerlind, (Peter.Kammerlind@lj.se), Project Leader Jönköping County Council, Jonkoping, Sweden.

Grundläggande statistik och analys
Number of Acute Surgical Procedures

Source: Peter Kammerlind, (Peter.Kammerlind@lj.se), Project Leader Jönköping County Council, Jonkoping, Sweden.
Number of Acute Surgical Procedures

Source: Peter Kammerlind, (Peter.Kammerlind@lj.se), Project Leader
Jönköping County Council, Jonkoping, Sweden.

20 useful observations
Rule 1: 13 runs (6-16 runs), OK
Rule 2: OK
Rule 3: OK
Rule 4: OK

Median = 115.5

Antal operationer

Månad

Grundläggande statistik och analys
Your next move…

…to gain more knowledge about Shewhart Charts
(a.k.a. control charts)
Why are Shewhart Charts preferred over Run Charts?

Because Shewhart Charts...

1. Are more sensitive than run charts
   - A run chart cannot detect special causes that are due to point-to-point variation (median versus the mean)
   - Tests for detecting special causes can be used with Shewhart charts

2. Have the added feature of control limits, which allow us to determine if the process is stable (common cause variation) or not stable (special cause variation).

3. Can be used to define process capability.

4. Allow us to more accurately predict process behavior and future performance.
Elements of a Shewhart Chart

- **X (Mean)**
  - UCL = 44.855
  - CL = 29.250
  - LCL = 13.645

An indication of a special cause

- Elements of a Shewhart Chart
  - Measure
    - Number of Complaints
  - Time
    - Month
  - An indication of a special cause

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Run and Shewhart Charts don’t tell you

• The reasons(s) for a Special Cause

• Whether or not a Common Cause process should be improved (Is the performance of the process acceptable?)

• How the process should actually be improved or redesigned
A Simple Improvement Plan

1. Which process do you want to improve or redesign?

2. **Does the process contain non-random patterns or special causes?**

3. How do you plan on actually making improvements? What strategies do you plan to follow to make things better?

4. **What effect (if any) did your plan have on the process performance?**

---

Run & Shewhart Charts will help you answer Questions 2 & 4. YOU need to figure out the answers to Questions 1 & 3.
The Sequence of Improvement

Developing a change

Implementing a change

Testing a change

Test under a variety of conditions

Make part of routine operations

Sustaining and Spreading a change to other locations

Theory and Prediction

Act

Plan

Study

Do

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“Quality begins with intent, which is fixed by management.”

W. E. Deming, *Out of the Crisis*, p.5
General References on Quality


References on Measurement


References on Measurement
(continued)


Robert Lloyd, Ph.D.

Executive Director Performance Improvement

can be reached at:

The Institute for Healthcare Improvement

(630) 717-5383 Chicago office

(630) 717-8564 fax

rlloyd@ihi.org