BY WHAT METHOD?

HOW UNDERSTANDING VARIATION TRANSFORMS PERFORMANCE

David M. Williams, Ph.D.
Nothing to Disclose

I have no relevant financial or nonfinancial relationship(s) within the services described, reviewed, evaluated or compared in this presentation.
COVID Vaccination

Image: Steve Cornfield via Unsplash


Shewhart Chart: Rocco Perla
Will Haynie
@willhaynie

Chic Fil A manager Jerry Walkowiak donating his professional drive thru experience to help our vaccination program in Mt Pleasant today. When you need help, call the pros.

9:49 AM - Jan 22, 2021
Historical Stages in the History of Quality Control

Global Standardization

Quality Characteristic (x) vs Limits (L1, L2)
Western Electric at the Hawthorne Works

Shewhart Chart

Two Interpretations of Variation

Variation is Acceptable or Unacceptable

- Excessive Variation
  - Permissible
    - Acceptable
  - Variation
    - Outcomes
  - Excessive Variation

Focus: On the outcomes of the process (product or service)
Aim: Classify outcomes as acceptable or unacceptable
Basis: What the customer wants or needs.
Methods: Specification budgets, goals, expectations

Variation Due to Common or Special Causes

- Unstable Process
  - Stable
    - Variation due to Common Causes
  - Unstable Process

Focus: On causes of variation in the process:
- machine
- work methods
- materials
- environment
- workers
- management
- measurement system
Aim: Provide a basis for action on the process
Basis: What the process is actually delivering
Methods: Shewhart charts
Common and Special Cause Variation?

- **Common Causes**—those causes inherent in the system over time, affect everyone working in the system, and affect all outcomes of the system.
- **Special Causes**—those causes *not* part of the system all the time or do not affect everyone, but arise because of specific circumstances.

Chance Causes VS Assignable Causes

How Do We Tell if Solely Common Cause or if also Special Cause?

**FIGURE 4.8** Shewhart Charts Common Cause and Special Cause Systems

Again, why do we care?
To minimize the mistakes made in attempts to improve

- **MISTAKE 1**: React to an outcome as if it came from a special cause, when actually it came from common causes of variation.
- **MISTAKE 2**: Treat an outcome as if it came from common causes of variation, when actually it came from a special cause.

<table>
<thead>
<tr>
<th>ACTION</th>
<th>ACTUAL SITUATION OF SYSTEM</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Common Causes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take action on individual outcome; Treat as a <strong>special cause variation</strong>.</td>
<td>- $</td>
<td>Mistake 1</td>
<td></td>
</tr>
<tr>
<td>Treat outcome as part of system; work on changing the system-Treat as <strong>common cause variation</strong></td>
<td>+ $</td>
<td>Correct Decision</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Special Causes Occurring</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ $</td>
<td>Mistake 2</td>
</tr>
</tbody>
</table>

FIGURE 4.1 Using Shewhart Charts to Give Direction to an Improvement Effort

- Select a Key Measure Related to the Aim of the Improvement Effort

- Develop an Appropriate Shewhart Chart for the Measure

- Change the System (Remove Common Cause(s)
  Responsibility (ordered by importance)
  1. Management
  2. Technical Experts

- Learn from and Act on Special Cause(s)
  Responsibility (ordered by importance)
  1. Local supervision
  2. Technical experts
  3. Management
  4. Workers in the system

- Is the System Stable Relative to this Measure?
  - Yes
    - Identify Common Cause(s)
      Tools/Methods:
      • Planned Experimentation
      • Rational Subgrouping
      Responsibility (ordered by importance)
      1. Technical experts
      2. Supervisors
      3. Workers in the system
  - No
    - Identify Special Cause(s)
      Tools/Methods:
      • Shewhart Charts
      • Cause and Effect Diagram
      • Rational Subgrouping
      • Planned Experimentation
      Responsibility (ordered by importance)
      1. Workers in the system
      2. Supervisors
      3. Technical experts

Old Way, New Way

**Old Way**
(Quality Assurance, Enumerative Model)

**New Way**
(Quality Improvement, Analytical Model)

By what method?

• Everyone has aims, hopes, plans. But a goal that lies beyond the means of its accomplishment will lead to discouragement, frustration demoralization. In other words, there must be a method to achieve an aim. By what method?
API Definition of the Science of Improvement

The science of improvement includes the interaction of systems thinking, understanding variation, psychology of change, and the theory of knowledge that are applied to improve the performance of processes, products, services, organizations, and communities. The proper application of this science requires integration of a set of improvement methods and tools with knowledge of subject matter to develop, test, implement, and spread changes.
Organization as a System

Design & Redesign of Processes, Products & Services

Plan to Improve

Market Research

Measurement & Feedback

Outcome for Clients

Support Process

Production of Product or Service

Distribution

Need Purpose of the Organization

Mainstay Process

Drivers

Support Process

Suppliers

©API, Inc. 2002 All Rights Reserved
Deming, Out of the Crisis, pg. 4
Conceptual View of a Health Care System

STAGE 0 – UNDERSTANDING THE NEED

• Define the need
• Observe
• Generate Ideas
• Synthesize and screen
AIM STATEMENT
Reduce the surgical site infection rate by 50 percent by January 2021

Family of Measures
The Surgical Site Infection

<table>
<thead>
<tr>
<th>Types of Measures</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>The voice of the customer or patient. How is the system performing? What is the result?</td>
</tr>
<tr>
<td>Process</td>
<td>The voice of the workings of the process. Are the parts or steps in the system performing as planned.</td>
</tr>
<tr>
<td>Balancing</td>
<td>Looking at a system from different directions or dimensions. What happened to the system as we improved the outcome and improvement measures?</td>
</tr>
</tbody>
</table>


Shewhart Chart Selection Guide

Type of Data

Count or Classification (Attribute Data)
Qualitative data in terms of an integer (number of errors, nonconformities, or number of items that passed or failed, and so on)

Count (Nonconformities)
1, 2, 3, 4, and so on

Classification (Nonconforming)
Either/Or, Pass/Fail, Yes/No

Continuous (Variable Data)
Quantitative data in the form of a measurement (time, money, scaled data, volume counts, and so on)

Each subgroup is composed of a single data value

Subgroup Size of 1 (n=1)

Equal or Unequal Subgroup Size
Subgroup Size (n>1)

Equal or Unequal Area of Opportunity

Unequal Area of Opportunity

Equal Area of Opportunity

C Chart

U Chart

P Chart

I Chart (also known as an X Chart)

X and S Chart

Number of Nonconformities

Nonconformities per Unit

Percent Nonconforming

Individual Measurement

Average and Standard Deviation

Data for Accountability vs Improvement
Attribute vs Variable


Bennett B. & Provost L. What's your theory? Driver diagram serves as tool for building and testing theories for improvement. Quality Progress. 2015 Jul;36-43
Figure A.1 Complete List of Change Concepts

1. Eliminate things that are not used
2. Eliminate multiple entry
3. Reduce or eliminate overkill
4. Reduce controls on the system
5. Recycle or reuse
6. Use substitution
7. Reduce classifications
8. Remove intermediaries
9. Match the amount to the need
10. Use Sampling
11. Change targets or set points
12. Synchronize
13. Schedule into multiple processes
14. Minimize handoffs
15. Move steps in the process close together
16. Find and remove bottlenecks
17. Use automation
18. Smooth workflow
19. Do tasks in parallel
20. Consider people as in the same system
21. Use multiple processing units
22. Adjust to peak demand
23. Match inventory to predicted demand
24. Use pull systems
25. Reduce choice of features
26. Reduce multiple brands of the same item
27. Give people access to information
28. Use proper measurements
29. Take Care of basics
30. Reduce de-motivating aspects of pay system
31. Conduct training
32. Implement cross-training
33. Invest more resources in improvement
34. Focus on core process and purpose
35. Share risks
36. Emphasize natural and logical consequences
37. Develop alliances/cooperative relationships
38. Listen to customers
39. Coach customer to use product/service
40. Focus on the outcome to a customer
41. Use a coordinator
42. Reach agreement on expectations
43. Outsource for “Free”
44. Optimize level of inspection
45. Work with suppliers
46. Reduce setup or startup time
47. Set up timing to use discounts
48. Optimize maintenance
49. Extend specialist’s time
50. Reduce wait time
51. Standardization (Create a Formal Process)
52. Stop tampering
53. Develop operation definitions
54. Improve predictions
55. Develop contingency plans
56. Sort product into grades
57. Desensitize
58. Exploit variation
59. Use reminders
60. Use differentiation
61. Use constraints
62. Use affordances
63. Mass customize
64. Offer product/service anytime
65. Offer product/service anyplace
66. Emphasize intangibles
67. Influence or take advantage of fashion trends
68. Reduce the number of components
69. Disguise defects or problems
70. Differentiate product using quality dimensions
71. Change the order of process steps
72. Manage uncertainty, not tasks


TOOLS FOR UNDERSTANDING VARIATION

- Motor Assembly Check Sheet
- Waiting Time for Clinic Visit
- Relationship Between Long Waits and Capacity
- Clinic Wait Times > 30 days
- Distribution of Wait Times
The Drill Down Pathway

How do we drill down to learn, you ask?

ASQ's Mr. Pareto Head

FIGURE 9.6  Shewhart Chart at the Aggregate Level

* Is the process stable?

Same ADE Data Subgrouped by Hospital

**FIGURE 9.7** Shewhart Chart Displaying All Eight Hospitals on the Same Chart

ADE Rate Drill Down by Organization
Quarterly Data

Rational Subgrouping on Adverse Drug Event (ADE) Rate (U chart)

Figure 4.21: ADE Data Rationally Subgrouped by Day of the Week

ADE Rate by Day of Week
Common Cause Hospitals Subgrouped in 6 Month Increments

Subgrouping on Adverse Drug Event (ADE) Rate (U chart)

FIGURE 4.22  ADE Data Rationally Subgrouped by Shift

ADE Rate Subgrouped by Shift
Common cause Hospitals by Quarter

ADE/1000 Doses

D1 D2 D3 D4 D5 D6 E1 E2 E3 E4 E5 E6 N1 N2 N3 N4 N5 N6
Could you provide us with a little more detail on step two?
OBJECTIVE: To determine the best method for reminder calls made prior to clinic appointments in order to reduce the no-show rate for pediatric outpatient clinic appointments.
Pediatric Clinic No-Show Study

Model for Improvement

What are we trying to accomplish?

How will we know that a change is an improvement?

What change can we make that will result in improvement?

Can Effective Reminder calls reduce no-shows?

Baseline data on no-shows

Reduction in No-shows

Follow-up Factorial Design

Initial Factorial Design

Business Case and Implementation

DATA

Reducing No-Shows for Pediatric Outpatient Clinic Appointments

Average no-show rate,

Parent satisfaction with calls

Reminder Calls

API, 2015
Establishing Baselines

**Pulmonary / Allergy**

<table>
<thead>
<tr>
<th>Month</th>
<th>NoShow Rate</th>
<th>Lower Control Limit</th>
<th>Center Line</th>
<th>Upper Control Limit</th>
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<tbody>
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<td></td>
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<td>09/2005</td>
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<tr>
<td>06/2006</td>
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</table>

**Nephrology**

<table>
<thead>
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<th>NoShow Rate</th>
<th>Lower Control Limit</th>
<th>Center Line</th>
<th>Upper Control Limit</th>
</tr>
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<tr>
<td>06/2006</td>
<td></td>
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</tr>
</tbody>
</table>

API, 2015
No-Show Reminder Calls Experimental Variables

- **Experimental Unit - Clinics**
- **Response Variables**
  - Change in no-show rate over baseline
  - Parent satisfaction with call (balancing measure)
- **Factors Under Study (Levels)**
  - Source of phone call (Human, Computer)
  - # of days call is made before appointment (2 days, 5 days)
  - Time of day reminder call is made (3-4 PM, 6-7 PM)
- **Background Variables**
  - Current no-show rate
  - % Medicaid visits in clinic
  - Clinic Volume (Workload Impact)
  - Current reminder call practice
Experimental Pattern for First No-show experiment

• Three Factors at Two Levels Each
  • Source of phone call (Human, Computer)
  • Number of business days reminder call made prior to appointment (2 days , 5 days)
  • Time of day reminder call is made (3–4 PM, 6–7 PM)

• Blocking
  • Current no-show rate, which is highly correlated with percent Medicaid visits, was included as a blocking variable.

• Replication
  • Two clinics were randomly assigned to each combination of measures after being stratified into high and low volume (blocks for replication)

Experimental Pattern: Replicated, Blocked $2^3$ Factorial
Factorial Experiment Design

3 Factors, 2 levels each

Experimental Pattern

<table>
<thead>
<tr>
<th>F2</th>
<th>F1</th>
<th>F3</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
| +  | +  | -  | 2³ design, 8 runs

Design Matrix

<table>
<thead>
<tr>
<th>TEST</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>+</td>
<td>-</td>
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<tr>
<td>5</td>
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<td>-</td>
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<tr>
<td>6</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>8</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

2³ design, 8 tests

<table>
<thead>
<tr>
<th>Clinic</th>
<th>Source</th>
<th># Days</th>
<th>Time of Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pediatric Rehabilitation</td>
<td>human</td>
<td>2</td>
<td>6 to 7</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>comp</td>
<td>2</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Plastic Surgery*</td>
<td>human</td>
<td>5</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>comp</td>
<td>5</td>
<td>6 to 7</td>
</tr>
<tr>
<td>Cardiology</td>
<td>human</td>
<td>2</td>
<td>6 to 7</td>
</tr>
<tr>
<td>Orthopaedics*</td>
<td>comp</td>
<td>2</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Endocrinology</td>
<td>human</td>
<td>5</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Urology</td>
<td>comp</td>
<td>5</td>
<td>6 to 7</td>
</tr>
<tr>
<td>Gastroenterology</td>
<td>comp</td>
<td>5</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Pulmonary/Allergy</td>
<td>human</td>
<td>5</td>
<td>6 to 7</td>
</tr>
<tr>
<td>Nephrology</td>
<td>comp</td>
<td>2</td>
<td>6 to 7</td>
</tr>
<tr>
<td>Hopple Street Clinic</td>
<td>human</td>
<td>2</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>comp</td>
<td>5</td>
<td>3 to 4</td>
</tr>
<tr>
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<td>5</td>
<td>6 to 7</td>
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<tr>
<td>Teen Health Center</td>
<td>comp</td>
<td>2</td>
<td>6 to 7</td>
</tr>
<tr>
<td>Neurology</td>
<td>human</td>
<td>2</td>
<td>3 to 4</td>
</tr>
</tbody>
</table>

Yellow highlight:  Low no-show rates       Green:  High no-show rates
Bold:  Higher volume clinics  *Clinic had no current reminder call practice in place
Results: Factor Effects

Low volume clinics

High volume clinics
Meaningful Factors Low Volume Clinics

![Graph showing the change in Source (Human, Computer) and Time (3-4 PM, 6-7 PM) with corresponding data points.]

**Change**

<table>
<thead>
<tr>
<th>Source</th>
<th>3-4 PM</th>
<th>6-7 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>0.31</td>
<td>-0.56</td>
</tr>
<tr>
<td>Computer</td>
<td>-4.31</td>
<td>-3.44</td>
</tr>
</tbody>
</table>

**Source**

<table>
<thead>
<tr>
<th>Source</th>
<th>3-4 PM</th>
<th>6-7 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>2.70</td>
<td>-2.08</td>
</tr>
<tr>
<td>Computer</td>
<td>-3.83</td>
<td>-4.80</td>
</tr>
</tbody>
</table>
Meaningful Factors: Higher Volume Clinics

Source: Human – Solid Line
Source: Computer – Dashed Line

Change(2)

<table>
<thead>
<tr>
<th>Source</th>
<th>2 Days</th>
<th>5 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>-3.51</td>
<td>1.34</td>
</tr>
<tr>
<td>Computer</td>
<td>-1.11</td>
<td>-1.37</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Days</th>
<th>2 Days</th>
<th>5 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>-2.31</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

API, 2015
No Show Rate

Note: Includes all visits for the 16 clinics included in the experiment.

<table>
<thead>
<tr>
<th>Month</th>
<th>% of Scheduled Appointments that were No Shows</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/2005 (n=1864)</td>
<td>22%</td>
</tr>
<tr>
<td>8/2005 (n=22497)</td>
<td>18%</td>
</tr>
<tr>
<td>9/2005 (n=20108)</td>
<td>14%</td>
</tr>
<tr>
<td>10/2005 (n=21725)</td>
<td>16%</td>
</tr>
<tr>
<td>11/2005 (n=21701)</td>
<td>22%</td>
</tr>
<tr>
<td>12/2005 (n=19468)</td>
<td>20%</td>
</tr>
<tr>
<td>1/2006 (n=20840)</td>
<td>24%</td>
</tr>
<tr>
<td>2/2006 (n=20737)</td>
<td>26%</td>
</tr>
<tr>
<td>3/2006 (n=22842)</td>
<td>30%</td>
</tr>
<tr>
<td>4/2006 (n=20829)</td>
<td>28%</td>
</tr>
<tr>
<td>5/2006 (n=22491)</td>
<td>22%</td>
</tr>
<tr>
<td>6/2006 (n=10315)</td>
<td>20%</td>
</tr>
</tbody>
</table>

NOTE: Baseline Control Limits Calculated from July, 2005-May, 2006

Data Source: Tempus/HBOC
Recommendations for Next PDSA

• Use the results from this experiment to **increase our “degree of belief”** by conducting a more focused experiment
• Execute another planned experimentation
  • Computer calls only
  • Exclude clinics with high Medicaid populations
  • New variable: Test the effectiveness of making two calls prior to the appointment
• Develop a different approach for clinics with high Medicaid populations
• Identify segments of the population for which the cost of a no-show is high and test targeted interventions
No Show Rate
Phase III (Sustainability & Implementation)
Population: Divisions in Experiment

- Divisions Excluded: PPC, Hopple Street, Teen Health Center, Ophthalmology

Data Source: Tempus
Building Knowledge Sequentially

Test across a wide variety of anticipated conditions. Learning from data

Theories, hunches, current best practices

Collect Data
Develop Change
Test in Prototype
Test Change
Implement
Spread
Improved outcomes

Degree of Belief in Future Results
FIGURE 4.9  Shewhart Chart Revealing Process or System Improvement

![Shewhart Chart Image]

Evidence of Improvement

- Good
- UL 35.16
- Mean 18.64
- LL 2.12

United States: Adjusted Daily Reported COVID-19 Deaths

http://www.ihi.org/Topics/COVID-19/Pages/COVID-19-Data-Dashboard.aspx
THANK YOU

DavidMWilliamsPhD.com